# DRAFT ENVIRONMENTAL ASSESSMENT– Groundwater Plume Treatment Facility for the Dump Road Area Martin State Airport 701 Wilson Point Road Middle River, Maryland

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September 10, 2014

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# DRAFT ENVIRONMENTAL ASSESSMENT — GROUNDWATER PLUME TREATMENT FACILITY

**for the**

# DUMP ROAD AREA

**AT**

**MARTIN STATE AIRPORT**

**MIDDLE RIVER, MARYLAND**

**PREPARED FOR:**

**MARYLAND AVIATION ADMINISTRATION**

**September 2014**


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# ACRONYMS

| | |
|---|---|
| AC | Advisory Circular |
| ACHP | Advisory Council on Historic Preservation |
| ALP | airport layout plan |
| APE | area of potential effect |
| ANG | Air National Guard |
| APHIS | Animal and Plant Health Inspection Service |
| AWOS | automated weather observing system |
| AZP | airport zoning permit |
| BGE | Baltimore Gas and Electric |
| BGEPA | Bald and Golden Eagle Protection Act |
| bgs | below ground surface |
| BMC | Baltimore Metropolitan Council |
| BMP | best management practice |
| BTEX | benzene, toluene, ethylbenzene, and xylenes |
| BWI Marshall | Baltimore/Washington International Thurgood Marshall International Airport |
| CAA | Clean Air Act |
| CAC | Critical Area Commission |
| CBCA | Chesapeake Bay Critical Area |
| cDCE | *cis*-1,2-dichloroethene |
| CEQ | Council on Environmental Quality |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| CF | cubic feet |
| CFR | Code of Federal Regulations |
| CHS | controlled hazardous substance |
| *cis*-1,2-DCE | *cis*-1,2-dichloroethene |
| CO | carbon monoxide |
| COC | chemical(s) of concern |
| COMAR | Code of Maryland Regulations |
| cVOCs | chlorinated volatile organic compounds |
| CWA | Clean Water Act |
| CY | cubic yards |

| | |
|---|---|
| CZMA | Coastal Zone Management Act |
| CZMP | Coastal Zone Management Program |
| dB | decibels |
| DNL | day-night average sound level |
| DR 3.5 - 16 | density residential (zoning designation) |
| DRA | Dump Road Area |
| E2 | estuarine wetland (Cowardin classification) |
| EA | environmental assessment |
| EFH | essential fish habitat |
| ERA | ecological risk assessment |
| ESD | environmental site design |
| FCWMA | Flood Control and Watershed Management Act |
| FAA | Federal Aviation Administration |
| FAR | Federal Aviation Regulation |
| FEMA | Federal Emergency Management Agency |
| FHWA | Federal Highway Administration |
| FIDS | forest interior dwelling species |
| FIRM | flood insurance rate maps |
| FMCs | fishery management councils |
| FMPs | fishery management plans |
| FPPA | Farmland Protection Policy Act |
| FS | feasibility study |
| ft/day | feet per day |
| GHG | greenhouse gas |
| GIS | geographic information system |
| gpm | gallons per minute |
| HCA | high concentration area |
| HDPE | high-density polyethylene |
| HHRA | human health risk assessment |
| HPAs | habitat protection areas |
| HVAC | heating, ventilation, and air conditioning |
| IDA | intensely developed areas |
| IRA | interim remedial action |
| ISR | cyber/intelligence, surveillance, and reconnaissance |
| JPA | joint permit application (for CWA permitting) |
| LDA | Limited Development Area |
| lf | linear feet |

| | |
|---|---|
| Lockheed Martin | Lockheed Martin Corporation |
| LOD | limit(s) of disturbance |
| LRS | Logistics Readiness Squadron |
| MAA | Maryland Aviation Administration |
| MARMAP | Marine Resources Monitoring, Assessment, and Prediction |
| MCL(s) | maximum contaminant level(s) |
| MCLG(s) | maximum contaminant level goals |
| MDANG | Maryland Air National Guard |
| MDE | Maryland Department of the Environment |
| MDHSRP | Maryland Hazardous Substance Response Plan |
| MDNR | Maryland Department of Natural Resources |
| MDOT | Maryland Department of Transportation |
| MEP | maximum extent practicable |
| MHT | Maryland Historical Trust |
| MHW | mean high water |
| MHWL | mean high water line |
| $\mu/m^3$ | micrograms per cubic meter |
| MOA | Memorandum of Agreement |
| MSL | mean sea level |
| MSPGP-4 | Maryland State Programmatic General Permit–4 |
| MTN | Martin State Airport |
| MSFCMA | Magnuson-Stevens Fishery Conservation and Management Act |
| NAAQS | National Ambient Air Quality Standards |
| NAVAIDs | navigational aids |
| NEPA | National Environmental Policy Act |
| NFPA | National Fire Protection Association |
| NHPA | National Historic Preservation Act |
| NMFS | National Marine Fisheries Service |
| $NO_2$ (or $NO_x$) | nitrogen dioxide (or nitrogen oxides) |
| NOAA | National Oceanic and Atmospheric Administration |
| NOI | Notice of Intent |
| NPDES | National Pollutant Discharge Elimination System |
| NRCS | Natural Resource Conservation Service |
| NRHP | National Registry of Historic Places |
| NWG | Network Warfare Group |
| $O_3$ | Ozone |
| O&M | operation and maintenance |

| | |
|---|---|
| OSHA | Occupational Safety and Health Administration |
| Pb | lead |
| PEM | palustrine emergent wetland (Cowardin classification) |
| PL | public law |
| $PM_{10}$ | respirable particulate matter |
| $PM_{2.5}$ | fine particulate matter |
| POTW | publically-owned treatment works |
| POW | palustrine open water (Cowardin classification) |
| PRG(s) | preliminary remediation goal(s) |
| PTC | permit to construct |
| PTO | permit to operate |
| PUB | palustrine unconsolidated bottom wetland (Cowardin classification) |
| RAO(s) | remedial action objective(s) |
| RCA | Resource Conservation Area |
| RCRA | Resource Conservation, Compensation, and Recovery Act |
| RCP | reinforced concrete pipe |
| RI | remedial investigation |
| RTE | rare, threatened, or endangered (species) |
| SCIF | Sensitive Compartmented Information Facility |
| sf | square feet |
| SFA | Sustainable Fisheries Act |
| SIP | State Implementation Plan |
| SPCC | spill prevention control and countermeasure |
| $SO_2$ | sulfur dioxide |
| TIPs | transportation improvement plans |
| TCE | trichloroethene |
| TMDL | total maximum daily load |
| TPH DRO | total petroleum hydrocarbons – diesel range organics |
| TPH GRO | total petroleum hydrocarbons – gasoline range organics |
| TSCA | Toxic Substances Control Act |
| TSDF | treatment, storage and disposal facility ( |
| USACE | United States Army Corps of Engineers |
| USC | United States Code |
| USCG | United States Coast Guard |
| USDA | United States Department of Agriculture |
| USDA-WS | United States Department of Agriculture, Animal and Plant Health Inspection Services, Wildlife Services |
| USDOI | United States Department of the Interior |

| | |
|---|---|
| USDOT | United States Department of Transportation |
| USEPA | United States Environmental Protection Agency |
| USFWS | United States Fish and Wildlife Service |
| USGS | United States Geological Survey |
| VC | vinyl chloride |
| VOC | volatile organic compound |
| VGAC | vapor phase granulated activated carbon |
| WHA | wildlife hazard assessment |
| WHMP | wildlife hazard management plan |

# Section 1
# Introduction and Background

## 1.1 INTRODUCTION

Lockheed Martin Corporation (Lockheed Martin) proposes to construct and operate a facility at the Dump Road Area (DRA) at Martin State Airport (MTN) in Middle River, Maryland to limit the off-site migration of contaminated groundwater from the DRA. Past site investigations conducted over the several years have determined that groundwater in the DRA is currently impacted by elevated levels of volatile organic compounds (VOCs), petroleum hydrocarbons, 1,4-dioxane, and heavy metals. Recently, the groundwater plume containing these contaminants was found to be migrating into adjacent Frog Mortar Creek, a tidal estuary of Chesapeake Bay. Based on this, the Maryland Department of the Environment (MDE) has issued a water contact advisory for Frog Mortar Creek, near the DRA.

The proposed facility will pump and extract groundwater from the DRA in order to gain hydraulic control of the contamination plume and limit the migration of the plume into Frog Mortar Creek. Extracted groundwater will be treated to reduce the level of contaminants to acceptable levels before being discharged to Frog Mortar Creek. This action will address MDE's current public water contact advisory and mitigate potential risks to human health by limiting the migration of the contaminated groundwater plume into Frog Mortar Creek. Pumping/extracting groundwater from the DRA is not intended to directly address the groundwater contamination itself, nor is it intended to address the source of the groundwater contamination; it is simply the means by which hydraulic control over the groundwater plume will be achieved, preventing migration of the plume into Frog Mortar Creek.

The proposed system will be in place for an indefinite period, possibly as long as several decades. Although indefinite in duration, the United States Environmental Protection Agency (USEPA) typically refers to this type of action as an interim remedial action (IRA). An IRA is taken at a contaminated site to reduce the chances of human or environmental exposure to site contaminants, and to protect public health before a full remedial investigation of the site is complete. A separate feasibility study, scheduled to be completed following the final site investigation in 2015, will evaluate possible measures for addressing other possible

contamination issues in the DRA, such as existing soil and buried waste contamination. However, these issues are separate from, and not directly associated with, the groundwater plume migrating into Frog Mortar Creek. In addition, potential future measures for addressing other contamination issues in the DRA, including the source of the groundwater contamination and the groundwater contamination itself, are not currently known and may require no action.

The project area consists of the DRA, an approximately 25-acre area between Taxiway T and Frog Mortar Creek on the east side of the airport property, and a narrow utility corridor extending south from Eastern Boulevard along Lynbrook Road to the DRA (Figure 1-1). The Maryland Aviation Administration (MAA), the airport authority of the Maryland Department of Transportation, owns and operates Martin State Airport (MTN), a Federal Aviation Administration (FAA) Part 139-certified facility in Baltimore County, Maryland located approximately 8 miles north of Baltimore City. As a tenant, Lockheed Martin has prepared this environmental assessment (EA) for MAA to evaluate the impacts to the environment associated with construction and operation of the proposed remediation project. This EA has been prepared in compliance with the National Environmental Policy Act (NEPA) (42 United States Code [USC] 4321 et seq.) and the Council on Environmental Quality (CEQ) implementing regulations (40 *Code of Federal Regulations* (CFR) 1500-1508), and follows guidelines for EA preparation contained in Federal Aviation Administration (FAA) Orders 1050.1E, Change 1, *Environmental Impacts: Policies and Procedures* (FAA, 2006a); and 5050.4B, *National Environmental Policy Act Implementing Instructions for Airport Actions* (FAA, 2006b) as supplemented by FAA's *Environmental Desk Reference for Airport Actions* (FAA, 2007a). References for this EA are found in Appendix A. Documentation of agency consultation is included in Appendix B.

## 1.2 BACKGROUND AND HISTORY OF THE PROPOSED ACTION

The DRA was historically used as an industrial landfill where waste material from former aircraft manufacturing activities was deposited. Environmental issues associated with the DRA site were initially identified in July 1991 when MAA encountered four buried drums adjacent to Taxiway T during trenching to install an electrical cable. Discovery of the buried drums led to a remedial investigation (RI) of the surrounding area. That investigation currently includes data from more than 500 groundwater, soil, surface water and sediment samples, site geophysical surveys, and hydrologic modeling to determine the nature and extent of soil and groundwater

contamination. An RI report and accompanying human health risk assessment (HHRA) and ecological risk assessment (ERA) was prepared in 2010 to summarize the results of the investigation and identify specific chemicals of concern (COC) (Tetra Tech 2012b); a summary of the RI results follows:

- DRA groundwater is impacted by a range of chemicals of concern associated with former nearby industrial operations, including: chlorinated volatile organic compounds (cVOCs) such as trichloroethene (TCE), *cis*-1,2-dichloroethene (*cis*-1,2-DCE), and vinyl chloride (VC) all exceeding United States Environmental Protection Agency (USEPA) federal maximum contaminant levels (MCLs) and Maryland groundwater cleanup standards.

- 1,4-Dioxane is at relatively high concentrations based on current USEPA guidance.

- Concentrations of the metals cadmium, chromium, lead, and mercury in groundwater exceed USEPA MCL and Maryland groundwater cleanup standards in some samples.

- Concentrations of benzene, toluene, ethylbenzene, and xylene (BTEX), associated with petroleum constituents in groundwater, exceed USEPA MCLs and Maryland groundwater cleanup standards in some samples.

- Total petroleum hydrocarbons-diesel range organics (TPH-DRO) total petroleum hydrocarbons-gasoline range organics (TPH-GRO) in groundwater exceed Maryland standards in the upper surficial aquifer

In addition, groundwater sampling from monitoring wells set at various depths revealed that the groundwater contaminant plume extends from the water table to a depth of approximately 90 to 100 feet below ground surface (bgs). This plume was determined to be migrating east-southeast toward Frog Mortar Creek. Figures 1-2 through 1-5 provide a graphic representation of the groundwater plume and the concentrations of the cVOCs (TCE, cis 1,2-DCE, and VC) and BTEX within the DRA.

Also, beginning in 2004, surface water samples along the shoreline of Frog Mortar Creek were collected to evaluate surface water for COC that might have migrated from the DRA (Tetra Tech, 2012c [http://www.lockheedmartin.com/content/dam/lockheed/data/corporate/documents/remediation/

msa/SWReport2012-062013.pdf]). Concentrations of TCE, VC, and/or xylene have been found to exceed applicable water quality criteria in some surface water samples, including site-specific swimming screening criteria that were developed using accepted USEPA and MDE protocols. As a result, MDE issued a water contact advisory for the portion of Frog Mortar Creek adjacent to the DRA (see Appendix C, and MDE, 2012 [http://www.mde.state.md.us/programs/Land/MarylandBrownfieldVCP/ERRP_Superfund/Pages/FrogMortarCreekWaterContactAdvisory.aspx ])

The water contact advisory indicates that some surface water samples were found to contain COC concentrations that exceed lifetime risk screening levels; however, these estimates, which are based on lifetime exposures, are inherently conservative and do not represent any short-term health hazard. In addition, the water contact advisory states that while the contaminants are not at levels that represent an acute health risk and there is no "ban" on swimming in the area, out of an abundance of caution, MDE has issued the water contact advisory to make the public aware of the potential risks and limit their exposure through swimming or wading in the waters adjacent to MTN on the western shore of Frog Mortar Creek. The advisory also states that until lateral migration of contaminants from the DRA can be limited through the proposed groundwater extraction/treatment system and reductions in surface water concentrations are confirmed, the advisory will remain in effect. Text included on the signs posted in Frog Mortar Creek adjacent to the DRA states:

> "Water Contact Advisory – Limit Swimming Exposure – The Maryland Department of the Environment (MDE) has determined that the levels of hazardous substances along portions of the Martin Airport shoreline may at times exceed MDE's recommended lifetime health-risk levels from repeated exposure due to swimming or other activities. MDE recommends limiting exposure through swimming or wading in these waters".

In 2012, following the completion of the RI report, Lockheed Martin prepared an *Interim Remedial Action Feasibility Study for the Groundwater Operable Unit at the Dump Road Area Site* (groundwater plume FS) to identify a preferred strategy and technology for minimizing off-site migration of contaminants, thus addressing the most immediate concern regarding potential impacts to human health and the environment. Note that a separate feasibility study, scheduled to

be completed following the final site investigation in 2015, will evaluate possible measures for addressing other possible contamination issues in the DRA such as existing soil and buried waste contamination. However, these issues are separate from, and not directly associated with, the groundwater plume migrating into Frog Mortar Creek. In addition, potential future measures for addressing other contamination issues in the DRA, including the source of the groundwater contamination, are not currently known and may involve no action.

The groundwater plume feasibility study (FS) developed overall remedial action objectives (RAOs), and, based on standardized evaluation criteria, a suitable remediation strategy.

RAOs developed during the groundwater plume FS included:

1. limiting the lateral migration of contaminated groundwater toward Frog Mortar Creek at concentrations that would cause exceedances of ambient water quality or risk-based exposure criteria

2. preventing human exposure (through showering, drinking, or irrigation) to groundwater containing COC concentrations greater than preliminary remediation goals (PRGs)

3. preventing worker exposures to volatile organic compounds (VOCs) through vapor intrusion into buildings

To address RAO No. 1, the groundwater plume FS evaluated five alternative strategies/technologies for limiting lateral migration of contaminated groundwater. Based on standardized evaluation criteria, the groundwater plume FS determined that the most practicable strategy/technology for achieving RAO No. 1 is to limit groundwater migration by extracting groundwater using groundwater extraction wells, treating the extracted groundwater in an aboveground treatment facility, then discharging the treated groundwater to existing surface waters. As shown in the hydrological analysis and groundwater modeling completed as part of the RI, pumping and extracting groundwater within the DRA will establish hydraulic control of the contaminant plume and limit groundwater flow toward Frog Mortar Creek. The groundwater plume FS also determined that RAOs Nos. 2 and 3 will be achieved primarily through future land use restrictions.

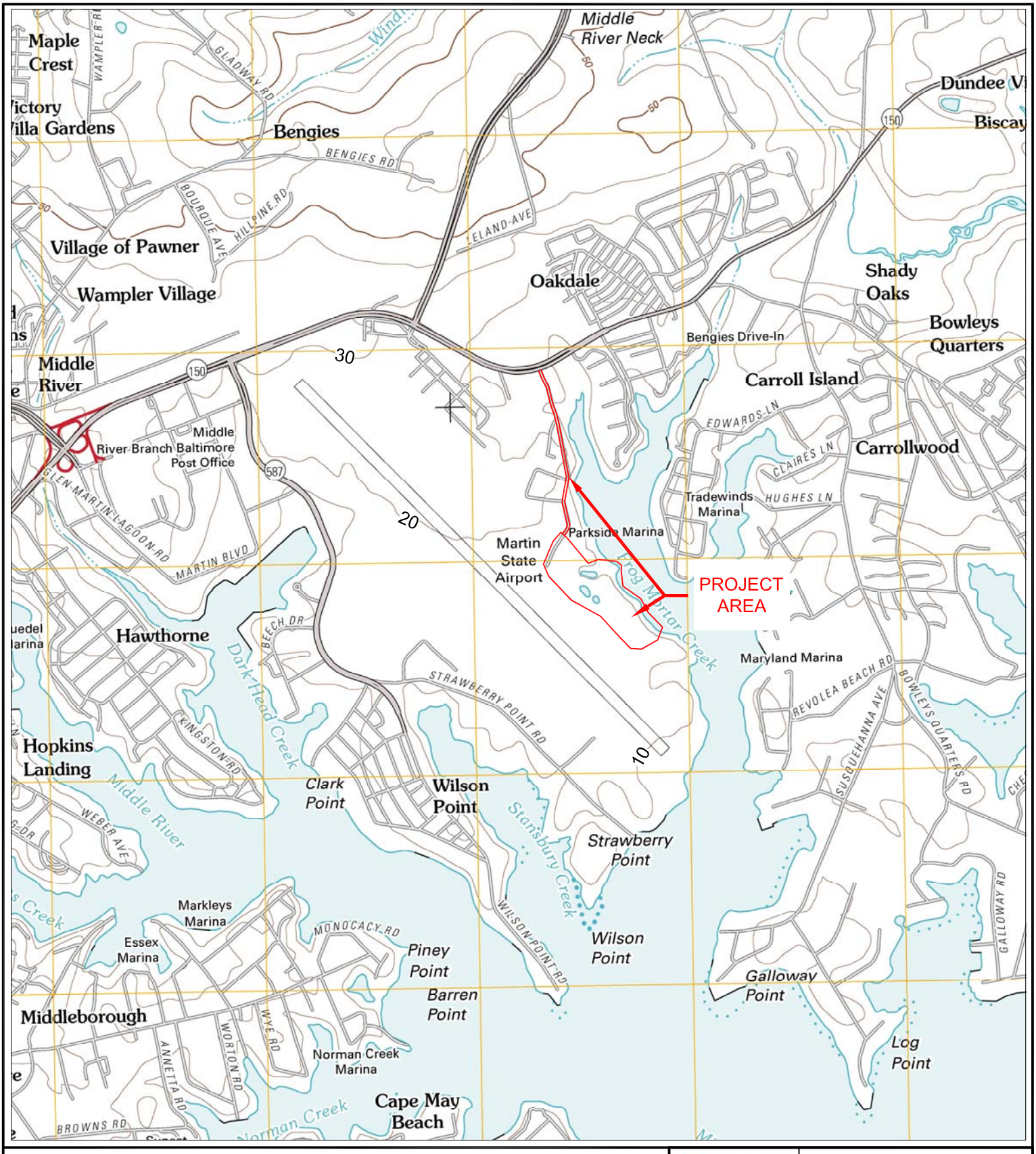
The groundwater plume FS was reviewed by MDE to verify that the evaluations and recommendations made within were consistent with state and federal guidelines and requirements. Following MDE review, the local community was engaged by Lockheed Martin through presentations to local civic organizations, and through a formal public notification and comment period. A Proposed Plan was developed and published to present the alternatives and selected strategy from the groundwater plume FS to the public. An initial public information session on February 8, 2012 was followed by a formal public meeting and 30-day public-comment period from February 8 to March 8, 2012. MDE monitored and participated in the public review process and supports the final selection of the strategy/technology for limiting lateral migration of contaminated groundwater from the DRA. Both the groundwater plume FS and the proposed plan are included in Appendix D.

Following selection of the strategy/technology for preventing off-site migration of contaminated groundwater, Lockheed Martin prepared a *DRA Building Location and Remedial Action Plan Review Memorandum* (Appendix E) to identify a preferred location for the treatment building/facility. Specific build options that were evaluated for the groundwater treatment building/facility included 1) extracting groundwater within the DRA and piping this groundwater to an off-site treatment building, 2) extracting groundwater within the DRA and piping this groundwater to an on-site treatment building. On-airport locations were limited by a lack of available space within the developed portion of the Air National Guard leasehold at the airport, a lack of suitable nearby locations within other areas of the airport, and no available parcels nearby the airport that could be purchased or leased to accommodate the treatment building. Any off-airport location would be at least one mile distant, introducing additional risks associated with conveying contaminated water off-site. The most feasible build option was therefore determined to be to construct the treatment building/facility on-site, within the DRA.

The selected remediation strategy (limiting lateral migration of contaminated groundwater by extracting/treating groundwater to establish hydraulic control) and treatment plant build option (constructing the treatment building on-site) have therefore been identified as being the preferred action alternative to be evaluated, along with the no action alternative under this EA. No other remediation strategy/technology (action alternative) was found to fully meet the standardized evaluation criteria identified in the groundwater plume FS (see Section 3— Alternatives Analysis). In addition, the selected remediation strategy (limiting lateral migration of

contaminated groundwater by extracting and treating groundwater) has been reviewed and approved by MDE per regulations found in the Maryland Hazardous Substance Response Plan (Code of Maryland Regulations [COMAR], Title 26, Subtitle 14).

Figure 1-1 and figure 1-2, 1-3, 1-4, 1-5.




MIDDLE RIVER, MD

2011

SCALE 1:24 000

CONTOUR INTERVAL 10 FEET
NORTH AMERICAN VERTICAL DATUM OF 1988

MARYLAND

MN
11° 16′
200 MILS
GN
0° 55′
16 MILS

UTM GRID AND 2011 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

MARTIN STATE AIRPORT

*Environmental Assessment for Groundwater Remediation at the Dump Road Area*

PROJECT AREA AND VICINITY MAP

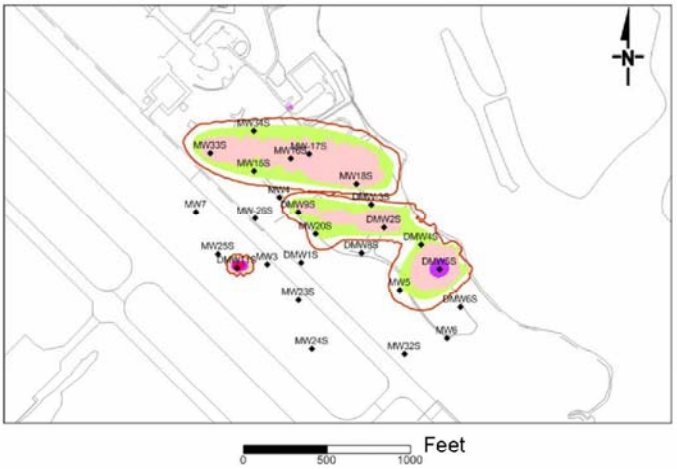
TETRA TECH

SCALE: AS SHOWN

FIGURE: 1-1

S:\03-Projects\Commercial\LMC\103IP2599 Task 13 (permitting)-DRA-GWTP\NEPA EA\DWG\ Figure 1-1.dwg

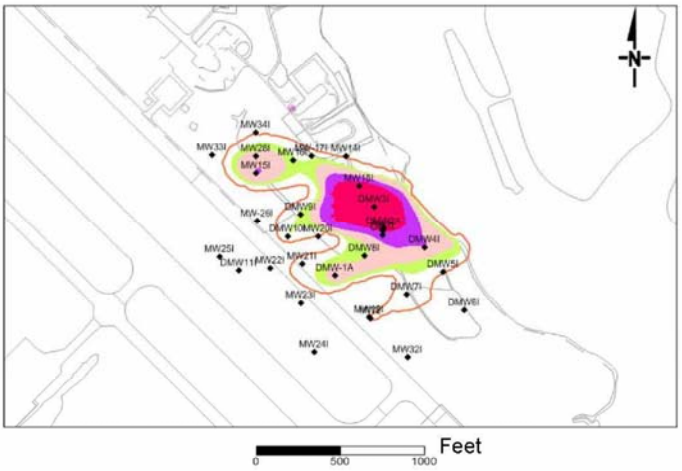
TCE - Upper Surficial Aquifer




TCE Concentration ug/L

10000
5000
1000
500
100

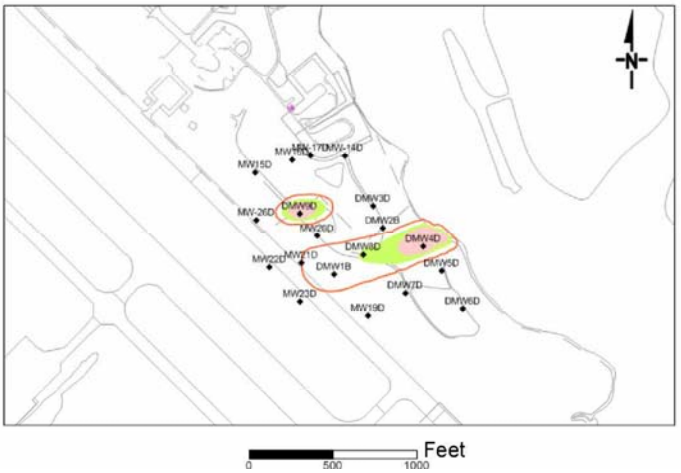
TCE - Intermediate Surficial Aquifer




TCE Concentration ug/L

10000
5000
1000
500
100

TCE - Lower Surficial Aquifer




TCE Concentration ug/L

10000
5000
1000
500
100

MARTIN STATE AIRPORT

*Environmental Assessment for Groundwater Remediation at the Dump Road Area*

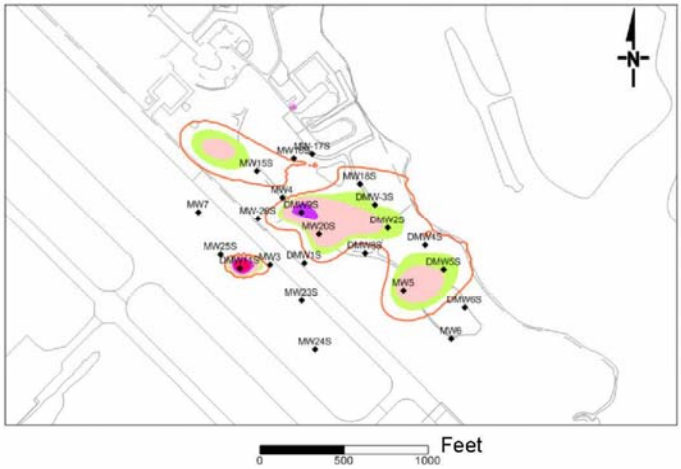
# Contour Plots of TCE for the Upper, Intermediate, and Lower Surficial Aquifers - August - September 2009

TETRA TECH

SCALE: AS SHOWN

FIGURE: 1-2

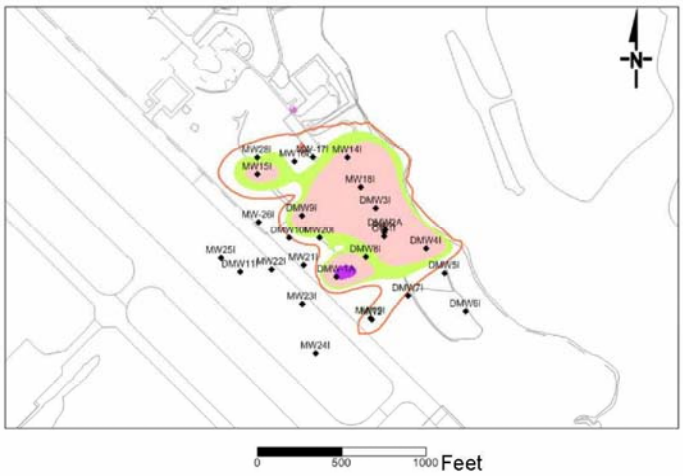
CIS-1,2-DCE - Upper Surficial Aquifer




cDCE Concentration ug/L

10000
5000
1000
500
100

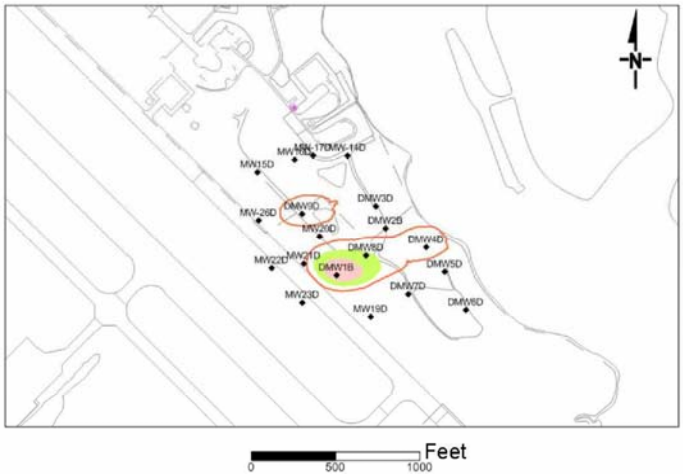
CIS-1,2-DCE - Intermediate Surficial Aquifer




cDCE Concentration ug/L

10000
5000
1000
500
100

CIS-1,2-DCE - Lower Surficial Aquifer




cDCE Concentration ug/L

10000
5000
1000
500
100

MARTIN STATE AIRPORT

*Environmental Assessment for Groundwater Remediation at the Dump Road Area*

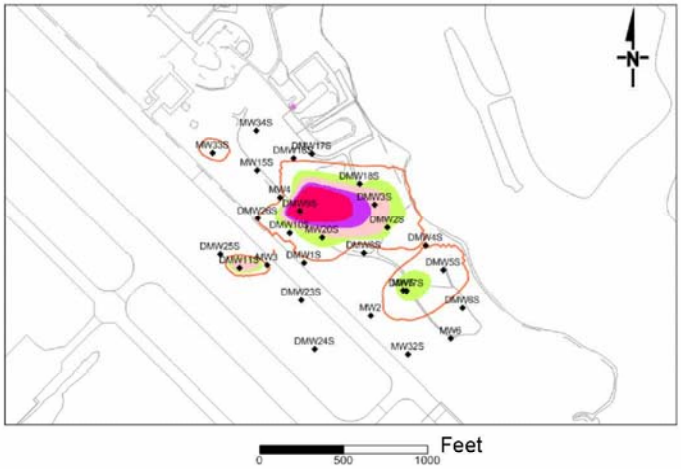
# Contour Plots of cDCE for the Upper, Intermediate, and Lower Surficial Aquifers - August - September 2009

TETRA TECH

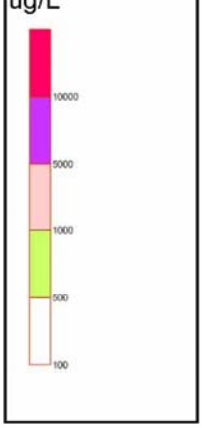
SCALE: AS SHOWN

FIGURE: 1-3

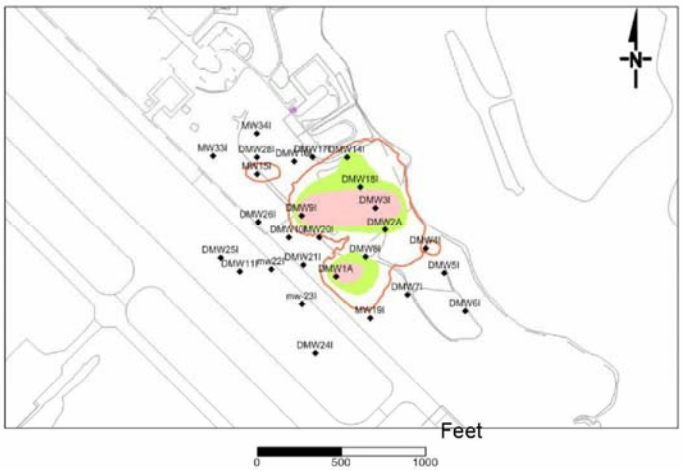
VINYL CHLORIDE - Upper Surficial Aquifer



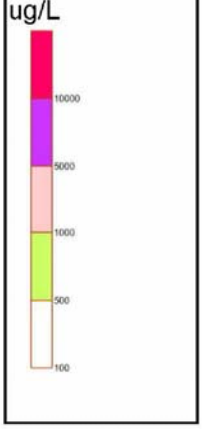

Vinyl Chloride Concentration ug/L



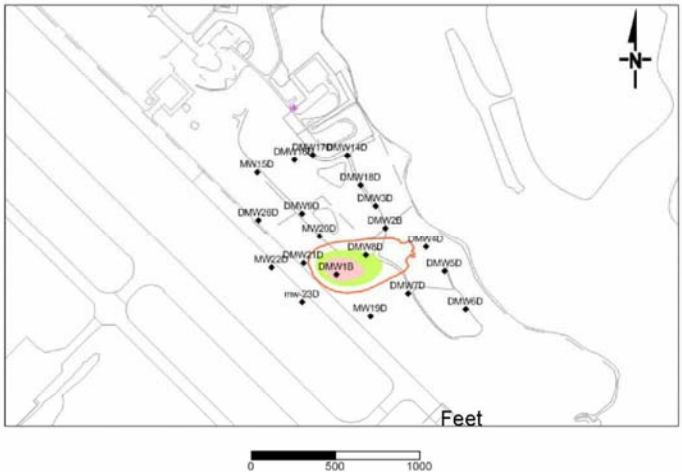

VINYL CHLORIDE - Intermediate Surficial Aquifer



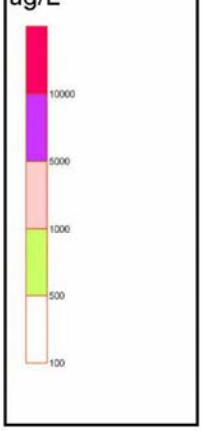

Vinyl Chloride Concentration ug/L




VINYL CHLORIDE - Lower Surficial Aquifer




Vinyl Chloride Concentration ug/L




MARTIN STATE AIRPORT

*Environmental Assessment for Groundwater Remediation at the Dump Road Area*

# Contour Plots of Vinyl Chloride for the Upper, Intermediate, and Lower Surficial Aquifers - August - September 2009

TETRA TECH

SCALE: AS SHOWN

FIGURE: 1-4

MW34S
MW34I
MW33S
MW33I
Gate
MW28I
MW27D
MW16S
MW16I
MW16D
MW17S
MW17I
MW17D
MARYLAND AIR NATIONAL GUARD
Gate
MW14I
MW14D
Conrad's Ruth Villa
POND #2
MW15S
MW15I
MW15D
MW18S
MW18I
MW18D
FROG MORTAR CREEK
MW4
PETROLEUM HYDRO-CARBON AREA
MW7
MW26S
MW26I
MW26D
DMW9S
DMW9I
DMW9D
POND #1
DMW3S
DMW3I
DMW3D
DMW2A
DMW2B
RW1I
OW1I
RW1I
OW1I
DMW2S
DMW10S
DMW10I
MW20S
MW20I
MW20D
DMW8S
DMW8I
DMW8D
DMW4S
DMW4I
DMW4D
MW25S
MW25I
MW3
MW21I
MW21D
MW22I
MW22D
DMW1S
DMW1A
DMW1B
DMW5S
DMW5I
DMW5D
DMW11S
DMW11I
MW23S
MW23I
MW23D
DRUM AREA
MW5
DMW7S
DMW7I
DMW7D
DMW6S
DMW6I
DMW6D
MW19I
MW19D
MW2
TAXIWAY TANGO
AIRPORT RUNWAY
MW1
Gate
MW6
MW24S
MW24I
MW32S
MW32I
MW30D
MW29D
MW31D

## Legend

- Groundwater Well Location
- Ponds
- 0 - 5
- >=5 - 50
- >=50 - 500
- >=500 - 5000
- >= 5000

Ranges are based on Micrograms Per Liter (ug/l)

***Lockheed Martin Martin State Airport***
***Middle River, Maryland***

0 50 100 200 Feet

N

DATE MODIFIED: 12/12/09

CREATED BY: BJ

MARTIN STATE AIRPORT

*Environmental Assessment for Groundwater Remediation at the Dump Road Area*

BTEX Concentrations in Groundwater (2007-2009 Maximum Concentration)

TETRA TECH

SCALE: AS SHOWN

FIGURE: 1-5

S:\03-Projects\Commercial\LMC\103IP2599 Task 13 (permitting)-DRA-GWTP\NEPA EA\DWG\ Figure 1.0-2.3.4.5.dwg

# Section 2
# Purpose and Need

## 2.1 PURPOSE

The primary purpose of the proposed project is to control migration of contaminated groundwater from the DRA at concentrations that can lead to exceedances of water quality standards in Frog Mortar Creek. This action will also comply with the regulatory requirements of the Maryland Hazardous Substance Response Plan (MDHSRP). With respect to meeting the requirements of MDHSRP, the purposes of the proposed project are to:

- assist in compliance with COMAR Title 26, Subtitle 14
- fulfill the intent of the initial cleanup phase of the MDHSRP process, which is to achieve the applicable cleanup criteria at the property, as defined by the groundwater plume FS.

## 2.2 NEED

As demonstrated in the RI report and the groundwater plume FS, concentrations of COC in DRA groundwater exceed federal/Maryland ambient water quality standards or risk-based exposure criteria. Individually, or taken together, these impacts render the groundwater in the affected area a risk to human health and the environment which requires remedial action. Remediation of the site is also necessary to address the VOC levels in Frog Mortar Creek, and to comply with COMAR Title 26, Subtitle 14.

To satisfy both purpose and need, Lockheed Martin proposes to limit the lateral migration of contaminated groundwater to Frog Mortar Creek by constructing a groundwater extraction and treatment system that will gain hydraulic control of contaminated water migrating towards Frog Mortar Creek, thereby reducing risk to human health and the environment to regulatory acceptable levels. Implementation of the project constitutes an effective remedy to alleviate the potential for off-site migration and potential human exposure, and complies with MDHSRP requirements.

# Section 3
# Alternatives Analysis

## 3.1 INTRODUCTION

This section provides a description of the preferred action and no action alternatives that were selected as a result of the Groundwater plume FS and associated public comment process. In addition, this section contains a summary of the formal evaluation of remedial action alternatives included in the groundwater plume FS, the rationale for the selection of the preferred action alternative, and the rationale for the elimination of the remaining alternatives from further consideration. This section therefore demonstrates compliance with the provisions of Federal Aviation Administration (FAA) Order 5050.4B, which requires that all reasonable alternatives that could either avoid or minimize adverse environmental impacts, or enhance the quality of the environment, be explored.

## 3.2 PREFERRED ACTION ALTERNATIVE

The preferred alternative consists of extracting groundwater from the portion of the plume adjacent to Frog Mortar Creek to gain hydraulic control over the contaminated groundwater plume beneath the DRA. Extracted groundwater will then be conveyed to the nearby treatment facility located within the DRA, where it will undergo a multi-stage treatment process to reduce COC concentrations to permissible discharge standards. Treated water from the facility will then be discharged to the nearby surface water in Frog Mortar Creek. This alternative will include the installation of groundwater extraction wells, construction of the treatment facility, placement of an outfall discharge in Frog Mortar Creek, widening of access roads, trenching of utilities, and development of a stormwater management system (Figure 3–1). The total area within the limits of disturbance (LOD) for the project will be approximately 25 acres. The following sections provide a detailed description of both the construction and overall operations of the groundwater treatment system.

### 3.2.1 Extraction Wells and Treatment Plant

An array of 16 groundwater extraction wells will be installed within the DRA parallel to and near Frog Mortar Creek (Figure 3–2). Well installation will include clearing and grading an

approximately 100 square foot (sf) area for each well. The wells will be advanced to a depth of up to 80 feet below ground surface (bgs) using standard drilling techniques and equipment including a rotosonic drill rig. Each well will also be fitted with a pump. Extracted groundwater will be conveyed to the treatment plant through pipe installed in trenches beneath the access roadbed.

The constructed treatment plant will be a maximum of 80 feet wide by 180 feet long (14,400 sf), and will be 30 feet tall at the roof peak. The building will be an engineered steel and concrete panel structure located near the center of the DRA in close proximity to the groundwater extraction wells. The building will contain all operational components of the treatment system, including a feed tank to which extracted groundwater will be pumped. The final elevations of the treatment building are estimated as follows:

- finished grade elevation — maximum 30 feet above mean sea level
- finished floor elevation — maximum 31 feet above mean sea level
- top of building elevation — maximum 61 feet above mean sea level

The treatment building itself will be within an approximately one-acre fenced compound. The additional space adjacent to the plant will be paved and used for parking, access, deliveries, storage, maintenance, and truck turnaround.

### 3.2.2 Treatment Plant Operations

Extracted groundwater will first be pumped to a feed tank located inside the treatment building. The treatment plant will be sized to accommodate an average flow rate of 50 gallons per minute (gpm) and a maximum flow rate of 100 gpm to allow for future system expansion. Based on groundwater modelling conducted as part of the FS, operation of this pump-and-treat system is expected to last 50 years or longer; however, if project goals are met prior to this time system operation will be discontinued and the treatment system dismantled. The extracted water will be transferred from the feed tank and treated in a two-step process: the first step will pre-treat and filter water to remove inorganics (metals) and suspended solids, and the second step will remove organics using advanced oxidation, air stripping, and liquid phase activated carbon. Air emissions from the air stripper will be treated through vapor-phase carbon prior to discharge, and

regulated through an MDE-required permit. Sludge generated by the pre-treatment process will be thickened and dewatered using a sludge thickener and filter press system. The dewatered solids will be characterized in accordance with relevant state and federal solid waste and hazardous waste regulations for appropriate off-site disposal at an MDE-approved disposal facility (COMAR Title 26, Subtitle 13); the disposal facility will be identified at a later date, prior to system start-up. Figure 3–3 provides a flow diagram of overall treatment plant processes and unit operations.

Chemicals used to treat groundwater will include sulfuric acid, caustic, and hydrogen peroxide, each of which will be stored in separate tanks or containers within the treatment building. Chemical storage tanks and containers will be provided with secondary containment to meet all National Fire Protection Association (NFPA) and spill prevention control and countermeasure (SPCC) requirements. The monthly chemical requirements are estimated at 3,000 gallons of caustic, 400 gallons of sulfuric acid, and 1,500 gallons of hydrogen peroxide. Following treatment, the treated groundwater will be tested for COC concentrations and discharged to Frog Mortar Creek. The treatment plant will be designed to meet Maryland's National Pollution Discharge Elimination System (NPDES) discharge permit requirements, ambient water quality standards, and/or drinking water MCLs, as appropriate. Discharge samples collected to show NPDES compliance will be collected via a sample port located on the effluent line in the treatment building.

### 3.2.3 Outfall Discharge

The outfall discharge will consist of a six-inch high-density polyethylene (HDPE) discharge pipe extending approximately 200 feet from the treatment facility to Frog Mortar Creek. An 80-foot portion of the discharge pipe will extend below the mean high water line (MHWL) of Frog Mortar Creek. Three two-inch Tideflex® diffusers will be installed on the end of the discharge pipe, and will be anchored to the bottom of Frog Mortar Creek. The diffusers will be submerged at least one foot below the low-tide water level.

### 3.2.4 Infrastructure

Existing access roads within the DRA will be widened and improved to accommodate construction vehicles and to facilitate access to the treatment plant and groundwater extraction wells for maintenance and fire protection, as required by the Baltimore County Fire Department.

The existing 1,500-foot long dirt/gravel access road will be widened from its current width (of eight feet) to 20 feet, and will be paved with asphalt. Road improvements will also include replacing the existing 36-inch reinforced concrete pipe (RCP) culvert that crosses over the existing intermittent tributary at the north end of the DRA with a suitable substitute that accommodates the widening of the road to 20 feet. All road improvements will take place on roads within the MAA property boundary. No improvements/work will be done on publicly owned roadways.

The new building will have an asphalt-paved parking and truck maneuvering area. The building footprint and its surrounding asphalt area will occupy approximately one acre. Existing paths near the proposed well locations will be improved (widened to 12 feet) and/or extended, and will be converted to reinforced grass turf. Access to each well location from the existing path will also be cleared and reinforced with reinforced grass turf as necessary.

### 3.2.5 Stormwater Management System

A stormwater management system will be required to mitigate stormwater runoff from the additional impervious areas created for the preferred action alternative, which includes the treatment plant, parking area, and access roads. Each wellhead pad is about 100 sf, for a total new impervious area of about 1670 sf. Stormwater management of traditional site development areas (building and asphalt) will include non-rooftop disconnects (filter strips), bioretention, grass swales, and a storm sewer system that will discharge to a swale located between the DRA and Taxiway T. This discharge swale is part of the existing MTN stormwater management system. The access roads to the extraction wells will themselves provide stormwater management via the reinforced grass turf. Stormwater management will be designed per MAA design standards so as to not be a wildlife attractant pursuant to FAA Advisory Circular (AC) 150/3200-33B.

### 3.2.6 Utility Installation

Utilities including water, electric, and communication will be installed via open trench along Lynbrook Road and the DRA access road to the treatment plant (Figure 3–1). The maximum length of new trenching is 4,000 linear feet (lf). Utility installation will involve tapping into existing utilities, open cut trenching, and restoration of the surfaces. Multiple trenches will be required in existing areas because separation of some utilities is required, and because tapping

will be within existing asphalt roads or within 10 feet of either side of the roads. Utilities will be installed under the improved road in the DRA area, which will be 20 feet wide. In addition, the HDPE piping and electrical conduits from the groundwater extraction wells and the treatment facility, which will be installed under or adjacent to the reinforced grass turf access roads, will be installed in trenching extending about 1,200 lf.

### 3.2.7 Initial Construction and Overall Facility Operations, Traffic, Transportation

Facility construction will use standard practices and will follow FAA/MAA plans for site development including those defined in the Airport Zoning Permit (MAA-010), Notice of Construction or Alteration (FAA Form 7460-1), and MAA Trenching and Excavation Permit to be submitted for approval prior to construction. Facility operation will follow the process described in Section 3.2.2, and the treatment facility will operate continuously using a small (two-to four-person) staff, with the exception of brief shut downs for scheduled maintenance activities. All construction and operational activities will follow approved SPCC, NFPA, and NPDES plans for chemical containment and water discharges. In addition, construction and operations will comply with the requirements of any necessary state and federal air permits.

Vehicles will enter the DRA through Maryland Air National Guard (MDANG) via existing roads. Vehicle use and frequency at DRA during facility operation is expected to be as follows:

- four to five standard personal vehicles or work trucks per day
- FedEx/United Parcel Service type delivery trucks twice a week
- medium-sized chemical delivery and carbon change-out trucks thrice a month
- drill rigs for well redevelopment once a quarter (includes access to wells)
- provisions for emergency vehicle access (e.g., fire trucks)

## 3.3 ALTERNATIVE 2 – NO ACTION

The no-action alternative would not address groundwater migration in any way. No facilities would be constructed, the current migration of groundwater contamination towards Frog Mortar

Creek will remain as is, and the concentrations of COC in Frog Mortar Creek surface water that led to the MDE water contact advisory would not be mitigated.

Based on the evaluation of action alternatives conducted as part of the 2012 Groundwater plume FS, the alternatives for the project that are being analyzed further under this NEPA analysis are limited to the Preferred Action and No Action alternatives as described above.

For completeness, the following sections provide an overview/summary of the evaluations conducted during the Groundwater plume FS and the treatment building location review, and the rationale for selecting the Preferred Action Alternative.

## 3.4 EVALUATION OF ACTION ALTERNATIVES CONDUCTED AS PART OF THE GROUNDWATER PLUME FS

Details of the comparison of action alternatives can be found in the Dump Road Area groundwater feasibility study in Appendix D; however, the following provides a summary of the findings and determination from the Groundwater plume FS.

The Groundwater plume FS evaluated five strategies/technologies (action alternatives) for limiting lateral migration of contaminated groundwater from the DRA to Frog Mortar Creek. These included:

***Alternative G-2*** **—** hydraulic control by extraction, *ex situ* treatment of groundwater, discharge to publicly owned treatment works/surface water, monitoring, and land use controls

***Alternative G-3*** **—** hydraulic control by extraction, *ex situ* treatment of groundwater, reinjection of groundwater, discharge to publicly owned treatment works/surface water, monitoring, and land use controls

***Alternative G-4*** **—** hydraulic control by extraction in high concentration areas, *ex situ* treatment of groundwater, reinjection of groundwater, discharge to publicly owned treatment works/surface water monitoring, and land use controls

***Alternative G-5*** **—** hydraulic control by extraction, *ex situ* treatment of groundwater, *in situ* bioremediation of high concentration areas, discharge to publicly owned treatment works/surface water, monitoring, and land use controls

***Alternative G-6*** **—** installation of a zero-valent iron permeable reactive barrier (PRB), monitoring, and land use controls

Alternative G-2 was developed as a base case with hydraulic control of the plume only. Groundwater contaminants upgradient of the extraction wells would eventually flow to the extraction wells, but the design did not incorporate provisions that could have been used to accelerate groundwater cleanup.

Alternative G-3 was an enhanced version of Alternative G-2, in that some of the treated groundwater could, during future operations, would have been amended with an electron-donor compound and then reinjected upgradient of areas of the site containing high COC concentrations to promote biological remediation. The treatment system in this alternative was sized for a larger flow rate to address the potential for flexibility in future operations. Alternative G-4 was a more aggressive extraction and treatment approach that included extraction, treatment of highly contaminated groundwater, and reinjection of treated groundwater (with amendments to promote biological activity). Treating additional groundwater would reduce the time required to restore groundwater quality.

Alternative G-5 was similar to Alternative G-4 in that highly contaminated groundwater would be treated. In Alternative G-5, highly contaminated groundwater in the High Concentration Area HCAs would be treated *in situ* by enhanced bioremediation to reduce the time to restore groundwater quality, but extracted groundwater would have not been reinjected. The treatment system in this alternative was also sized for a larger flow rate to permit flexibility in future operations.

Alternative G-6 proposed using a PRB for passive treatment instead of a groundwater extraction and treatment system. Specialized construction equipment and techniques would be utilized to excavate a trench to depths as deep as 90 feet below grade, and then the trench would be filled with a mixture of reactive material that could passively treat COCs in-situ.

A detailed evaluation and comparison of each of the above alternatives was conducted with respect to the following standardized evaluation criteria set forth in EPA's *National Oil and Hazardous Substances Pollution Contingency Plan* (NCP) [40 CFR, Part 300]: (1) Overall Protection of Human Health and the Environment; (2) Compliance with Applicable, or Relevant

and Appropriate Requirements (ARARs); (3) Long-Term Effectiveness and Permanence; (4) Reduction of Toxicity, Mobility, or Volume of Contaminants through Treatment; (5) Short-Term Effectiveness; (6) Implementability; (7) Sustainability; and (8) Cost. The following is a summary of these criteria:

(1) Protection of Human Health and the Environment - remedial alternatives were assessed for adequate protection of human health and the environment, in both the short and long term, from unacceptable risks posed by hazardous substances or contaminants at the site. This is accomplished by eliminating, reducing, or controlling exposure to contaminant levels exceeding remediation goals. Overall protection draws on the assessments pursuant to other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs.

(2) Compliance with Applicable, or Relevant and Appropriate Requirements – remedial alternatives were evaluated for compliance with all regulatory guidance and requirements with jurisdiction over the project. For the DRA project the applicable regulations fall under the Maryland Hazardous Substance Response Plan.

(3) Long-Term Effectiveness and Permanence - Alternatives were assessed for the long-term effectiveness and permanence they offer, along with the degree of certainty that the alternative would prove successful.

(4) Reduction of Toxicity, Mobility, or Volume of Contaminants through Treatment - The degree to which an alternative uses recycling or treatment to reduce the toxicity, mobility, or volume of contaminants was assessed, including how treatment addresses principal threats posed by the site.

(5) Short-Term Effectiveness - Short-term effects of each alternative was evaluated for short-term risks that might be posed to the community during implementation, potential effects on workers during remedial action and the effectiveness and reliability of protective measures, and potential environmental effects of the remedial action and the effectiveness and reliability of mitigation measures during implementation

(6) Implementability - The ease or difficulty of implementing each alternative was evaluated.

(7) Sustainability - The sustainability of each alternative was evaluated considering the following factors:

- *Environmental factors*, such as energy use and greenhouse gas emissions
- *Resource consumption*
- *Waste generation* as compared to recycling and reuse of materials. The percentage of contaminants destroyed rather than removed is also considered under this category. This component is evaluated as part of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) criteria, under the "Reduction of Toxicity, Mobility, or Volume through Treatment" criterion
- *Economic factors*, such as life cycle costs, and the development potential of the site after remediation. Costs are considered as part of the CERCLA criteria, under the "Cost" criterion
- *Social factors*, such as traffic and noise. These factors are also considered as part of the CERCLA criteria, under the "Short-Term Effectiveness" criterion

(8) Cost - Capital costs, including both direct and indirect costs, and annual operation and maintenance (O&M) costs were evaluated for each alternative.

Table 3-1 provides a summary of the comparison of each alternative that was conducted as part of the groundwater plume FS. Based on that comparison, Alternative G-3 (hydraulic control by extraction, *ex situ* treatment of groundwater, reinjection of groundwater, discharge to publically-owned treatment works (POTW)/surface water, monitoring, and LUCs) was selected as the remedial action to address lateral migration of the groundwater contamination plume at the DRA Site. This alternative was found to meet the remedial action requirement in that it would provide hydraulic containment to limit migration of site COC to the surface water. It would also provide additional groundwater treatment capacity so that the groundwater extraction system can be expanded in the future, as a potential component to a future remedy or remedies to address contaminated groundwater and other media in the DRA.

This alternative is economical and provides both effective treatment of all COC and operational flexibility. Alternative G-3 is moderately sustainable, but this sustainability is comparable to the levels of Alternatives G-2, G-4, and G-5.

Alternative G-2 was not selected primarily because it offers too little flexibility for future operations if higher flow rates or extraction of groundwater from other areas is required. In addition, the overall time to meet PRGs under Alternative G-2 is the second-longest. Alternative G-6 was not selected because 1,4-dioxane, DRO, and GRO would not be affected and the level of treatment of metals is uncertain (although treatment of the COC associated with the MDE water contact advisory has been well-proven). Alternative G-6 has the highest capital cost, and installation of the PRB to the required depth would be very difficult. Alternative G-6 would also likely cause the largest disturbance, requiring clearing and grading of several acres of the DRA during construction. Alternatives G-4 and G-5 were not selected because they require a commitment to a greater capital expenditure before the effects of the hydraulic barrier can be fully evaluated.

Alternatives G-4 and G-5 also include features such as additional extraction wells and injection wells that may need to be abandoned and re-installed as part of the soil and landfill waste remediation. Finally, after several years of Alternative G-3 system operation, components of Alternatives G-4 and/or G-5 could be optimally phased in using data and observations from the Alternative G-3 system operation and knowledge of the details of the final DRA remedy. Therefore, Alternative G-3 was selected to provide hydraulic containment and to allow for a phased approach to remediation of other parts of the DRA.

## 3.5 EVALUATION OF TREATMENT BUILDING LOCATIONS

Following the selection of Alternative G-3 as the optimal treatment strategy, an additional analysis evaluated the most suitable location for the treatment building. This evaluation is detailed in Appendix E. Building location options evaluated included locating the building off-site outside the DRA and airport property as well as three potential locations within the DRA. The three on-site locations evaluated included (a) constructing the facility near the boundary of the DRA on the MDANG leasehold, (b) locating the facility at the south end of the DRA, and (c) constructing the facility near the center of the DRA, near the groundwater extraction wells.

The evaluation compared each alternative by assessing the overall advantages and disadvantages of each option. Based on this evaluation it was determined that an off-site location for the treatment building outside the DRA would not be favorable. Disadvantages included a lack of available land parcels near the DRA portion of the airport, significant maintenance challenges due to piping runs that could approach two miles in length, the need to construct over large distances across public ways, and risks associated with piping contaminated groundwater across uncontaminated areas owned by other parties. Piping contaminated groundwater across uncontaminated areas could potentially introduce contamination off-site in the event of a leak.

Constructing the facility on-site near the boundary of the DRA on the MDANG leasehold was found to have the primary disadvantage of being on land currently under MDANG control. Locating the treatment building on MDANG leasehold would require modifying a federal lease between the United States government and MAA, and it is unknown how readily such a modification could be accomplished. MDANG also indicated the most suitable locations could also interfere with future MDANG operations and expansion.

Locating the treatment building at the south end of the DRA was found to have the primary disadvantage of being located in a wooded portion of the site. This would require tree clearing, which must be minimized for all work within the Chesapeake Bay Critical Area. Additionally, this option would require longer piping and utility trenches than would be required for a location closer to the center of the DRA.

Locating the facility near the center of the DRA was determined to be the most advantageous location for the treatment building. The advantages over the other two locations include shorter piping distances, the lack of need for a pumping station necessary for off-site locations, and the fact that minimal tree removal or other impacts to protected resources would be required as the proposed building location is in a currently cleared, upland area.

In addition, various alternatives for discharging the treated water were considered. These alternatives included (a) discharging to a POTW, (b) discharging to Frog Mortar Creek, (c) spray irrigation, and (d) reinjection.

Discharge to the local POTW was eliminated from consideration because of POTW capacity concerns. Discussions with Baltimore County Public Works, Engineering and Regulation

Division, indicated that the County would allow discharge only as a last resort. A consent order is in place between the United States Environmental Protection Agency (USEPA) and Baltimore County that is intended to eliminate sanitary sewer overflows, primarily during wet weather. The consent order is still in force and is applicable to this project.

Two other discharge options considered were spray irrigation and reinjection. Spray irrigation of treated water was eliminated because it cannot be used during cooler weather (late fall, winter, and early spring), or approximately five months per year. Reinjection of treated groundwater in order to enhance the biodegradation of contaminants may be possible in the future. However, the volume of reinjected water must be limited in order to capture the contaminant plume and maintain general groundwater flow.

The outfall discharge alternatives evaluated include discharging to either Frog Mortar Creek or to the existing stormwater outfall/drainage ditch. Direct discharge to a storm swale would impose more strict discharge criteria per Maryland stormwater management regulations (Code of Maryland Regulations [COMAR] 26.17.02) that may be beyond the technological limits of the treatment equipment. Moreover, the storm swale is already regulated through existing stormwater permits that are not suited to be amended for an industrial discharge. Therefore, the selected treatment plant design includes a treated water discharge to Frog Mortar Creek, which would be regulated by a National Pollutant Discharge Elimination System (NPDES) permit.

The aforementioned studies led to the conclusion that the alternate strategies/technologies for limiting lateral migration of contaminated groundwater into Frog Mortar Creek and alternate building site locations are not feasible or reasonable alternatives, or are less effective than the Preferred Action Alternative. Although the alternatives considered throughout the screening process (and eliminated prior to this EA) would likely accomplish, at least in part, the goal of restricting off-site migration of the groundwater contamination plume, the Preferred Action Alternative more fully meets all designated criteria. Therefore, the Preferred Action Alternative and the No Action Alternative are further evaluated in Sections 4 and 5 of this document.

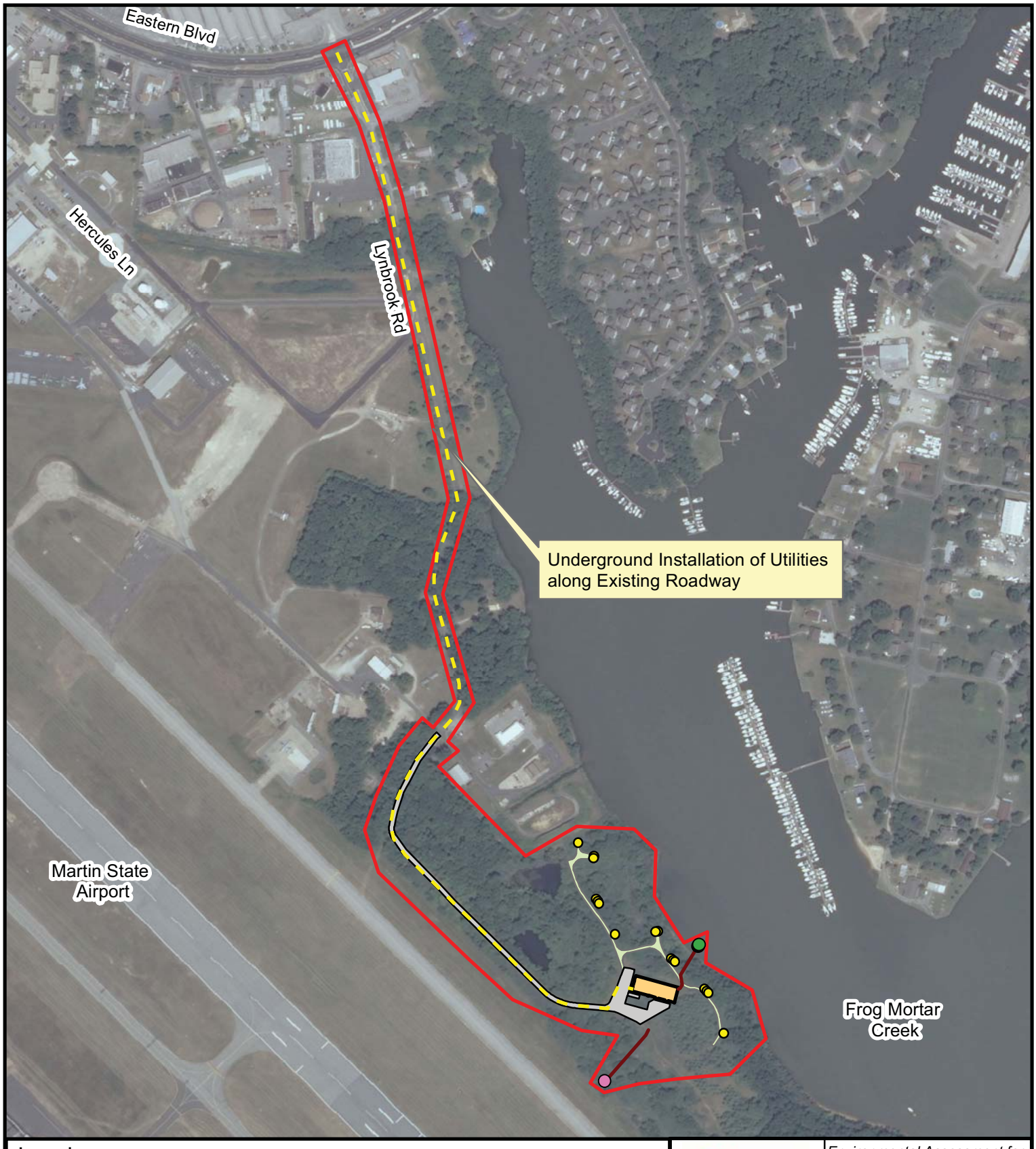
Table 3-1 provides a summary of the preliminary analysis of remediation strategies, including treatment facility location and configuration options.

**Table 3–1**

**Summary of Preliminary Alternative Development and Analysis**
**Dump Road Area, Martin State Airport**

| Evaluation Criterion | Alternative G-1: No Action | Alternative G-2: Hydraulic Control by Extraction, *Ex Situ* Treatment of Groundwater, Discharge to Publicly Owned Treatment Works / Surface Water, Monitoring, and Land Use Controls | Alternative G-3: Hydraulic Control by Extraction, *Ex Situ* Treatment of Groundwater, Re-injection of Groundwater, Discharge to Publicly Owned Treatment Works / Surface Water, Monitoring, and Land Use Controls | Alternative G-4: Hydraulic Control by Extraction, Extraction of High Concentration Areas, *Ex Situ* Treatment of Groundwater, Re-injection of Groundwater, Discharge to Publicly Owned Treatment Works / Surface Water, Monitoring, and Land Use Controls | Alternative G-5: Hydraulic Control by Extraction, Ex-Situ Treatment of Groundwater, *In Situ* Bioremediation of High Concentration Areas, Discharge to Publicly Owned Treatment Works / Surface Water, Monitoring, and Land Use Controls | Alternative G-6: Zero-Valent Iron Permeable Reactive Barrier, Monitoring, and Land Use Controls |
|---|---|---|---|---|---|---|
| Implementability | Technical and administrative implementation would be extremely simple because there would be no action to implement. | Easy to implement extraction, treatment, and monitoring. Less difficult to implement than Alternatives G-3 through G-6. Land use controls (LUCs) would be relatively easy to develop and implement. Permit for discharge to POTW still needs to be negotiated. Use of property may be affected by extraction wells. | Easy to implement extraction, treatment, injection, and monitoring. More difficult to implement than Alternative G-2. Less difficult to implement than Alternatives G-4 through G-6. LUCs would be relatively easy to develop and implement. Permit for discharge to POTW still needs to be negotiated. Use of property may be affected by extraction and injection wells. | Easy to implement extraction, treatment, injection, and monitoring. More difficult to implement than Alternatives G-2 and G-3. Less difficult to implement than Alternatives G-5 and G-6. LUCs would be relatively easy to develop and implement. Permit for discharge to POTW still needs to be negotiated. Use of property may be affected by extraction, HCA, and injection wells. | Easy to implement extraction, treatment, injection, in-situ bioremediation, and monitoring. More difficult to implement than Alternatives G-2, G-3, and G-4. Less difficult to implement than Alternative G-6. LUCs would be relatively easy to develop and implement. Permit for discharge to POTW still needs to be negotiated. Use of property may be affected by extraction, in-situ bioremediation of HCA, and injection wells. | Difficult to install deep PRBs, but monitoring is easy to implement. Most difficult alternative. Bench-scale treatability testing would be required. LUCs would be relatively easy to develop and implement. Use of property may be affected by PRB. Management of excavated soil as hazardous waste requires Resource Conservation, Compensation, and Recovery Act (RCRA) treatment, storage, and disposal facility (TSDF) permit. Corrective action may be triggered. |
| Sustainability | Would be highly sustainable. No energy or resources consumed. No greenhouse gas (GHG) or wastes generated. No traffic or noise. Site development would be limited by the contaminated groundwater. | Would be moderately sustainable. Consumes energy and resources, and generates GHG and wastes. Slight increase in traffic and noise. More sustainable than G-3, G-4, and G-5. | Would be moderately sustainable. Consumes energy and resources, and generates GHG and wastes. Slight increase in traffic and noise. Less sustainable than G-2 and G-5. More sustainable than G-4. | Would be moderately sustainable. Consumes energy and resources, and generates GHG and wastes. Slight increase in traffic and noise. Less sustainable than G-2, G-3, and G-5. | Would be moderately sustainable. Consumes energy and resources, and generates GHG and wastes. Slight increase in traffic and noise. Less sustainable than G-2. More sustainable than G-3 and G-4. | Would be moderately to highly sustainable. Consumes energy and resources, and generates GHG and wastes during PRB installation. Slight increase in traffic and noise during construction periods. |
| Costs: Capital NPW of Annual Costs NPW Current Value | $0 $0 $0 $0 | $12,000,000 $8,200,000 (30-Year) $20,200,000 (30-Year) $37,000,000 | $12,900,000 $8,600,000 (30-Year) $21,500,000 (30-Year) $38,700,000 | $13,100,000 $11,700,000 (30-Year) $24,800,000 (30-Year) $46,900,000 | $14,000,000 $8,800,000 (30-Year) $22,800,000 (30-Year) $40,000,000 | $13,300,000 $5,700,000 (30-Year) $19,000,000 (30-Year) $33,500,000 |

Figures 3-1- 3-3




**Legend**

- Extraction Well
- Outfall Diffusers
- SWM Outfall
- Discharge Pipe
- Utility Line
- Project Area
- MainAccessRoad
- WellAccessRoad
- Groundwater Treatment Plant (GWTP)

0 250 500 1,000 Feet

N

MARTIN STATE AIRPORT

*Environmental Assessment for Groundwater Remediation at the Dump Road Area*

# PROJECT OVERVIEW

TETRA TECH

SCALE: AS SHOWN

FIGURE: 3-1

Map Document: (S:\03-Projects\Commercial\LMC\103IP2599 Task 13 (permitting)-DRA-GWTP\NEPA EA\DWG\Figure_2-1.mxd)
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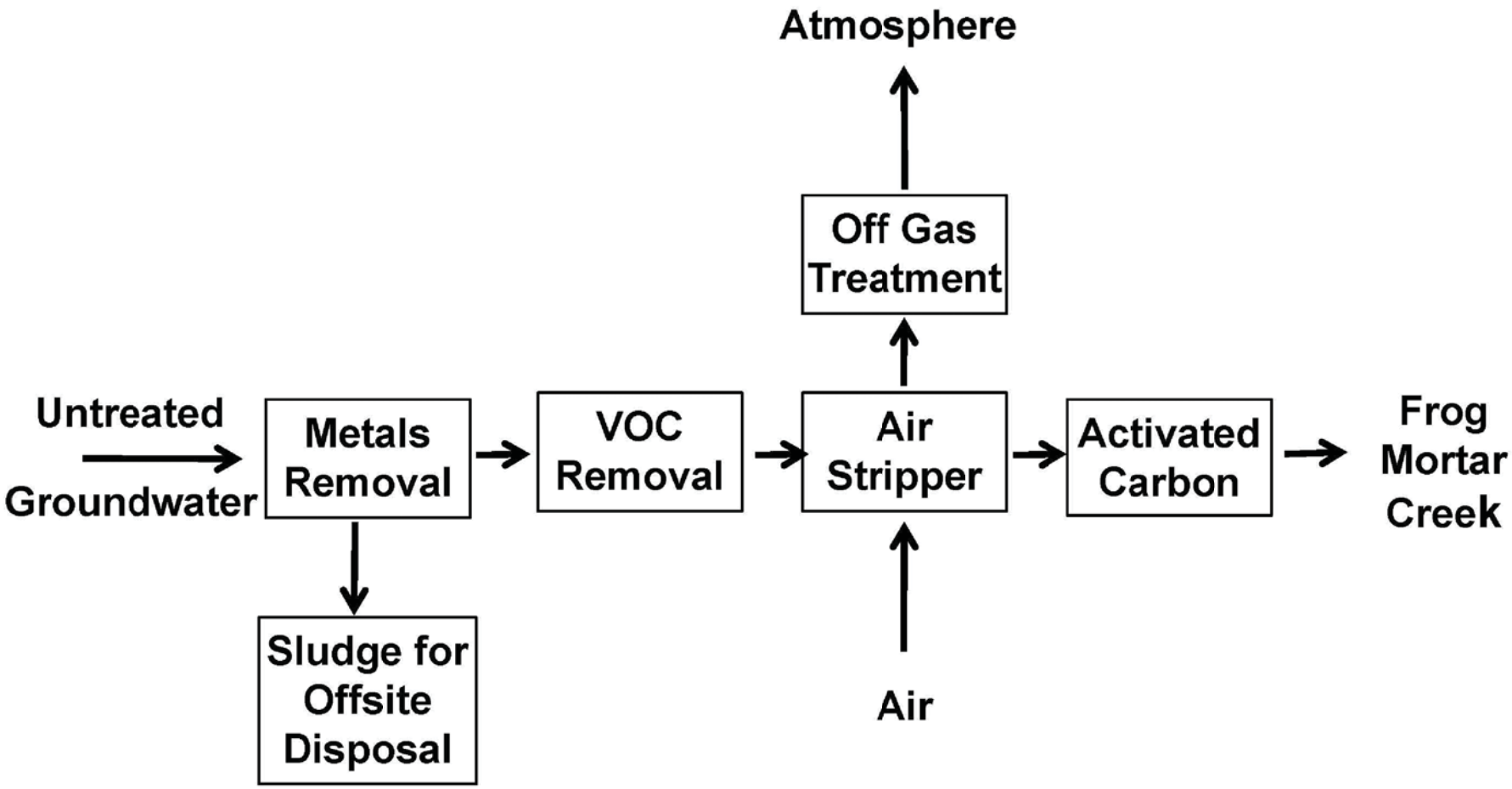
MDANG
SWM Areas
EW-1S
EW-3S
EW-2I
EW-4D
EW-6I
EW-5S
Frog Mortar Creek
EW-7D
EW-9I
EW-8S
GWTP Outfall Location
EW-10S
EW-12D
EW-11I
EW-13I
EW-15S
EW-14D
GWTP
EW-16S
Taxiway Tango
SWM Outfall Location
N
W
E
S
0
100
200
400 Feet
Legend
Extraction Well
Groundwater Treatment Plant (GWTP)
Main Access Road and Parking Lot (Asphalt)
Well Access Road (Reinforced Turf or equal)
Stormwater Management Area (SWM)
Limit Of Disturbance (LOD)
MARTIN STATE AIRPORT
Environmental Assessment for Groundwater Remediation at the Dump Road Area
DUMP ROAD AREA LAYOUT
TETRA TECH
SCALE: AS SHOWN
FIGURE: 3-2




| | |
|---|---|
| MARTIN STATE AIRPORT | *Environmental Assessment for Groundwater Remediation at the Dump Road Area* |
| TREATMENT PROCESS | |
| TETRA TECH | SCALE: AS SHOWN / FIGURE: 3-3 |

S:\03-Projects\Commercial\LMC\103IP2599 Task 13 (permitting)-DRA-GWTP\NEPA EA\DWG\ Figure 2-3.dwg

# Section 4
# Affected Environment

## 4.1 INTRODUCTION

This section identifies the existing resource values and uses near the Dump Road Area (DRA) that would be affected by the preferred action alternative and the no action alternative. The existing resource conditions presented here establish a resource baseline against which the effects of the alternatives are evaluated.

To provide a basis for evaluating existing conditions at the DRA, a study area was established. This study area encompasses the physical limits of disturbance of the preferred action alternative as described in Section 2.0, all of which is located within the DRA and adjacent Martin State Airport (MTN) property.

In accordance with *FAA Order 1050.1E,* the following 18 categories have been evaluated as part of the affected environment:

- Air quality
- Coastal resources
- Compatible land use
- Construction
- Section 4(f)
- Farmlands
- Fish, wildlife and plants
- Floodplains
- Hazardous materials, pollution prevention, and solid waste
- Historic, cultural, and archaeological resources
- Light emissions and visual effects energy supplies, natural resources, and sustainable design
- Noise
- Secondary (induced) impacts
- Socioeconomic impacts, environmental justice, and children's health and safety
- Water quality
- Wetlands
- Wild and scenic rivers

## 4.2 AIR QUALITY

This section contains summary information pertaining to existing air quality conditions in Baltimore County including the DRA and MTN. Information provided below includes a

description of relevant air quality regulations, air quality standards, management agencies, and current air quality conditions in the project region.

### 4.2.1 Air Quality Regulations and Standards

To safeguard human health and environmental welfare against the harmful effects of outdoor air pollution, the United States Environmental Protection Agency (USEPA) has issued National Ambient Air Quality Standards (NAAQS) under the Clean Air Act (CAA) that create threshold levels for ambient (i.e. outdoor) air concentrations of six criteria air pollutants: carbon monoxide (CO), lead (Pb), nitrogen dioxide ($NO_2$), ozone ($O_3$), respirable particulate matter ($PM_{10}$), fine particulate matter ($PM_{2.5}$), and sulfur dioxide ($SO_2$). While individual states have the prerogative to issue stronger standards than those listed in the CAA, Maryland has opted to retain the NAAQS.

### 4.2.2 Air Quality Management Agencies

The USEPA promulgates national clean air regulations and sets air NAAQS under the authority of the CAA. In Maryland, the responsibility of enforcing these regulations and ensuring that these standards are met falls upon the Maryland Department of Environment (MDE). Pursuant to this responsibility, the MDE prepares state-wide strategies and programs (called the State Implementation Plan [SIP]) to meet air quality goals and standards. The local metropolitan planning organization, the Baltimore Metropolitan Council (BMC), assists the MDE with SIP development and compliance with transportation conformity regulations for air quality

The Maryland Department of Transportation (MDOT) is involved in air quality management of Maryland's surface transportation facilities in coordination with the BMC and Federal Highway Administration (FHWA). The agencies also coordinate to develop transportation improvement plans (TIPs) and strategies that can be used to adhere to the transportation conformity rules. Finally, FAA is the primary agency involved in and responsible for ensuring that air quality impacts associated with proposed airport projects adhere to the reporting and disclosure requirements of NEPA and to the CAA general conformity rule.

### 4.2.3 Attainment/Non-attainment Designations

According to the USEPA Green Book website (USEPA, 2013), last updated February 7, 2013, Baltimore County is currently in attainment for CO, $NO_2$, Pb, $SO_2$ and $PM_{10}$, but has

non-attainment status for the ozone 1-hour standard, moderate non-attainment for the ozone 8-hour standard, and non-attainment for the $PM_{2.5}$ 24-hour standard. National, which are the same as Maryland, ambient air quality standards are listed in Table 4-1.

## 4.3 COASTAL RESOURCES AND COASTAL ZONE MANAGEMENT PROGRAM

FAA is required to comply with regulations set forth in the Coastal Zone Management Act of 1972 (CZMA), as amended by the 1996 Coastal Zone Protection Act through Public Law (PL) 104-105. CZMA requires that each state with coastal boundaries establish a Coastal Zone Management Program (CZMP). In Maryland, the CZMP is administered by the MDE and Maryland Department of Natural Resources (MDNR). These governing agencies are charged with identifying land uses that (individually or cumulatively) may cause or contribute significantly to the degradation of coastal waters, especially where there is a failure to attain or maintain applicable water quality standards or protect designated uses. Maryland's CZMP identifies all of Baltimore County as being within Maryland's coastal zone.

**Coastal Barriers** – The DRA project area is located in the upper Chesapeake Bay where no barrier islands are found.

## 4.4 COMPATIBLE LAND USE

### 4.4.1 Existing Land Use

The DRA is located entirely within the MTN 775-acre property in Middle River, Baltimore County, Maryland. MTN is approximately eight miles east of the city of Baltimore. The DRA is in the southeastern portion of the airport property and is bounded on the west by Taxiway T, on the north by the Maryland Air National Guard (MDANG) leasehold, and on the east and south by Frog Mortar Creek. The proposed utility corridor will be along Lynbrook Road from Eastern Boulevard south to the DRA, and will be bounded on both sides by portions of the airport property and MDANG leasehold. The DRA and utility corridor encompass approximately 25 acres.

Baltimore County describes the land use in the DRA and the airport property as commercial (Figure 4-1). The airport property includes all runways, taxiways, safety areas, aircraft parking

aprons, navigational and lighting aids, utilities, service roads, support facilities, maintenance facilities, and lands within the MDANG leasehold.

This discussion of surrounding land use focuses on lands and parcels immediately adjacent to and contiguous with the DRA, including the airport property located north, west, and south of the DRA, and the off-airport lands to the east bordering Frog Mortar Creek. The lands located to the north, west, and south of the DRA, as well as the DRA land itself, are owned by the Maryland Aviation Administration (MAA) and are part of MTN.

The area north of DRA is part of the MDANG leasehold, which consists of several MDANG buildings/facilities, access roads and parking areas, mowed areas, and small woodland or forest stands. The MDANG munitions facility is immediately north of and adjacent to the DRA. The main MTN runway and Taxiway T are west of the DRA. Navigational and lighting aids are present in mowed areas. The airport compass rose, a woodland, and tidal wetlands associated with Frog Mortar Creek are south of the DRA.

Land use designations for off-airport areas east of the DRA (across Frog Mortar Creek) are designated low and medium density residential by Baltimore County; single-family homes and a few commercial establishments are located in this area. The Baltimore County 2020 Master Plan indicates that the county plans to encourage mixed use development east of the airport along Frog Mortar Creek, while protecting sensitive natural and tidal areas (Baltimore County Planning and Zoning, 2010).

### 4.4.2 Hazardous Wildlife Attractants

FAA's Advisory Circular 150/5200-33B, *Hazardous Wildlife Attractants on or Near Airports* (FAA, 2007), provides guidance on certain land uses on/near airports, including recommendations to discourage the placement of new stormwater management facilities, wetlands, streams, or forest that have the potential to attract hazardous wildlife on/near public-use airports. As part of this advisory circular, FAA recommends that the design of water management facilities includes a maximum 48-hour detention period, and that no plant species known to attract potentially hazardous wildlife are used on the airport. The circular also states that airport operators should develop a wildlife hazard assessment (WHA) and wildlife hazard management plan (WHMP) to protect aviation safety. MAA has engaged the United States

Department of Agriculture (USDA), Animal and Plant Health Inspection Services, Wildlife Services (USDA-WS) to comply with this advisory circular.

## 4.5 UNITED STATES DEPARTMENT OF TRANSPORTATION (USDOT) SECTION 4(F) RESOURCES

Section 4(f) lands are publicly owned public parks, recreation lands, or wildlife and waterfowl refuges located adjacent to the existing highways and roads. Pursuant to the Department of Transportation Act [49 United States Code [USC] §303(c)], the Secretary of Transportation will not approve any program or project that requires the use of Section 4(f) lands or the use of land from an historic site of national, state, or local significance. If there is no feasible and prudent alternative to the use of land or program, the project must include all possible planning to minimize harm resulting from its use. These policies are widely known as "Section 4(f)" matters.

No Section 4(f) properties are located within the DRA project area, and the closest Section 4(f) properties (Chesapeake Village Park and Kingston Point Park) are located over one mile west of the DRA.

## 4.6 FARMLANDS

The Farmland Protection Policy Act (FPPA), Public Law 97-98, 7 USC 4201-4209, was enacted as part of the Agriculture and Food Act of 1981. FPPA's intent is to minimize the extent to which federal programs contribute to unnecessary and irreversible conversion of farmland to nonagricultural uses. Important farmlands include all pasturelands, croplands, and forestlands that are considered to be prime, unique, and statewide- or locally- important lands. The USDA's Natural Resource Conservation Service (NRCS) has defined prime farmland as land that has chemical and physical characteristics that support food production, feed, and/or fiber production. Statewide important soils are Maryland's most productive soils for agriculture and forestry. Unique soils are classified as those that are unique to the region and are used for specific agriculture or industrial purposes. FPPA does not apply to land that is already committed to urban development, regardless of whether it has been classified as prime or statewide- important farmland by the NRCS. A review of the Baltimore County soil data via the NRCS Web Soil Survey did not identify any prime farmland soils, unique soils, or statewide- or locally-important soils in the vicinity of the proposed action (Figure 4-2). MTN, including the DRA, is predominately underlain with Mattapex-urban and Lenoir-urban land complexes; these soils are

not considered important farmland soils. Additionally, no active farmland exists on or near MTN.

## 4.7 FISH, WILDLIFE, AND PLANTS

### 4.7.1 Habitat Types in the Dump Road Area

A visual survey of field conditions conducted by Tetra Tech in 2013 found that the majority of the DRA (approximately 90%) consists of early successional forest that has recently colonized the site following large-scale soil disturbance (i.e., associated with fill material historically placed in the DRA) in the disposal area. Much of the remaining area in the DRA contains open stands of common reed (*Phragmites australis*). Other habitats include small areas of scrub-shrub wetlands, two man-made ponds, and tidal shoreline and open tidal waters associated with adjacent Frog Mortar Creek. Given the disturbed nature of the site the DRA appears to support plant and wildlife species common to the region. However, the waters of adjacent Frog Mortar Creek may provide anadramous fish spawning habitat.

### 4.7.2 Habitat Protection - Regulatory Context

Because the entire DRA is located within the Chesapeake Bay Critical Area, impacts to habitats are regulated by provisions in the Chesapeake Bay Protection Act (Natural Resources Articles 8-1801 and 8-1814). The Chesapeake Bay Critical Area Act was passed by the Maryland General Assembly in 1984 in response to the decline in the Chesapeake Bay natural resources. The Act required the 16 counties surrounding the bay to implement a land use and resource management program to mitigate the damaging impact of water pollution and the loss of wildlife habitat. The Maryland General Assembly designated all areas 1,000 feet landward from the tidal waters and wetlands of the Chesapeake Bay and its tributaries as the Chesapeake Bay Critical Area (CBCA); in addition, the area 100 feet landward of the Critical Area that serves as a habitat protection area was designated as the Critical Area Buffer.

In 1986, the State of Maryland approved the final regulation and guidelines (Subtitle 8-1801-1816) establishing the Critical Area Commission (CAC), and promulgated criteria for compliance with the CBCA Act (COMAR 14.15). The CBCA Act provides the CAC authority to regulate activities within the critical area so that water quality and habitats in the bay area improve. Subtitle 1 of the CBCA Act requires local governments within the CBCA to develop

and implement a management plan to protect critical area forests, tidal waters, riparian habitat, and wetlands. Subtitle 2 of the Act provides similar compliance criteria, but for state projects on state-owned land, and requires direct coordination with and approval by CAC. As such, projects at MTN (including the proposed action) must comply with Subtitle 2.

Land uses for areas within the CBCA are classified into three categories. Regulations associated with development for each category vary according to land use, as follows:

Intensely Developed Areas (IDA) are areas where residential, commercial, institutional, and industrial development predominate. Public water and sewer serve the area. CBCA regulations (COMAR 27.02.05.03) state that development required within the CBCA should be directed to IDA whenever possible. Development in an IDA must comply with the 10% rule for stormwater that states that post-construction runoff must be 10% lower than pre-construction values.

Limited Development Areas (LDA) are areas currently developed at low to moderate density. The quality of runoff in these areas is not substantially impaired. Public water and/or sewer serve the area.

Resource Conservation Areas (RCA) are areas characterized by wetlands, forests, abandoned fields, agriculture, forestry, fisheries, and residential density of less than one unit per five acres.

The entire DRA project area is located within the CBCA boundary classified as IDA.

The CBCA Act also requires establishing a buffer of natural vegetation landward from the mean high water line of tidal waters, or from the edge of tidal wetlands and tributary streams. This buffer must be at least 100 feet landward, and may be expanded where it is contiguous with protected features or resources such as steep slopes and wetlands. No disturbance or new development within the buffer is authorized unless it is free of impacts to water quality, plants, fish, or wildlife habitats, including the clearance of forested areas. The only exception allowed is for access of water-dependent facilities.

In addition to the 100-foot buffer, the CBCA Act regulates and protects certain habitat types within the Critical Area. These areas are called habitat protection areas (HPAs) and include:

- 100-foot tidal buffer (as described above)

- non-tidal wetlands
- state and federally listed species habitat
- anadromous fish spawning areas
- steep slopes
- significant plant and wildlife habitat
    - colonial waterbird nesting areas
    - aquatic areas of historic waterfowl concentrations
    - riparian forests
    - large forest tracts (50 to 100 acres or more) and forest interior dwelling species (FIDS) habitat

### 4.7.3 Protected Habitats in the DRA – Habitat Protection Areas

Existing HPAs, including the 100-foot buffer, in the DRA have been either delineated in the field (wetlands and streams) or plotted using geo-referenced software (the 100-foot tidal buffer and steep slopes). As depicted in Figure 4-3**,** HPAs that occur in the DRA include a 100-foot tidal buffer, several non-tidal wetlands, and areas of steep slopes.

### 4.7.4 Forest Resources in the DRA

Forest resources were identified qualitatively in the field and by reviewing aerial photographs and using geographic information system (GIS) to map their spatial extent within the DRA. As stated in Section 4.7.1, approximately 90% of the 25-acre DRA project area is forested (see Figure 4-3). These forest areas are primarily young, early successional stands that have recently regenerated following large-scale soil disturbance (i.e., associated with fill material historically placed in the DRA) in the disposal area. Forest stands also contain a relatively large percentage of non-native and invasive vegetation, again due to previous disturbance at the site. An approximately two-acre stand of planted white pine trees are located near the center of the project area. None of the forested areas in the DRA meet criteria as being large interior forest tracts (50 to 100 acres) or areas that would support breeding FIDS species per critical area guidelines.

### 4.7.5 Threatened and Endangered Species

Section 7(c) of the Endangered Species Act of 1973 (16 USC 1531 et seq.) requires the identification of rare, threatened, and endangered (RTE) species of flora and fauna and their critical habitats, so that adverse impacts to these species can be avoided. Consultation with the United States Fish and Wildlife Service (USFWS) and MDNR Wildlife Heritage Division was conducted to determine the potential for RTE species to occur within or near the study area (see Appendix B).

In their letter dated May 9, 2013, the MDNR Wildlife and Heritage Service indicated that there were no records of state listed species in the project area, and further stated that they therefore have "no specific comments or requirements pertaining to protection measures for the project." In a letter dated June 12, 2013, the USFWS stated that "except for occasional transient individuals, no federally proposed or listed endangered or threatened species are known to exist in the project area. Therefore, no Biological Assessment or further Section 7(c) consultation with the U.S. Fish and Wildlife Service is required."

In a letter dated June 3, 2013, the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS) indicated that while there are currently no records of federally listed aquatic species under NMFS jurisdiction in Frog Mortar Creek or the associated tidal river communities abutting the DRA, the endangered shortnose sturgeon (*Acipenser brevirostrum*) and all five distinct population segments of the endangered Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) are known to occur in the Maryland portion of the Chesapeake Bay. In addition, four sea turtle species, including leatherback (*Dermochelys coriacea*), Kemp's ridley (*Lepidochelys kempi*), loggerhead (*Caretta caretta*), and green (*Chelonia mydas*) sea turtles, are also known to occur within the Chesapeake Bay, particularly during the spring, summer, and fall when water temperatures are warm. A brief discussion of these species follows:

- Atlantic sturgeon are currently known to spawn in the James River tributary of Chesapeake Bay (NMFS, 1998). They have also historically spawned in the Potomac River and possibly other nearby tributary rivers. Atlantic sturgeon prefers to spawn in deeper portions of large, clean rivers between the salt front (the location of where salt water and fresh water converge) and the Fall Line; however, when not spawning they can be found throughout the

estuary and in coastal waters. Because suitable habitat for this species in Frog Mortar Creek is generally lacking, it is unlikely that Atlantic sturgeon use the creek during spawning; however, transient or foraging individuals could occur in the general vicinity.

- Shortnose sturgeon are currently known to spawn in the Potomac River and estuarine area of the Chesapeake Bay (United States Geological Survey [USGS], 2007). This species has also been recorded in many other river systems on the east coast. Like Atlantic sturgeon, the shortnose sturgeon prefers to spawn in large, clean rivers; however, they can be found throughout the estuary and in coastal waters when not spawning. Because suitable habitat for this species in Frog Mortar Creek is generally lacking, it is unlikely that shortnose sturgeon use the creek during spawning; however, transient or foraging individuals could occur in the general vicinity.

- Sea turtles have been found in the Chesapeake Bay, and occur primarily during times when water temperatures are warm in the spring, summer, or fall. Occurrences of the four sea turtle species have mostly been recorded in the lower bay, with occurrences north of the Potomac River being considered rare (MDNR, 2011).

### 4.7.6 Bald Eagle

The Bald and Golden Eagle Protection Act (BGEPA) of 1940 (16 U.S.C. 668-668d, 54 Stat. 250) provides for the protection of the bald eagle and the golden eagle by prohibiting, except under certain specified conditions, the taking, possession and commerce of such birds. The term "taking" refers to both direct killing of the birds, as well as causing disturbance to nest locations and other important habitats and aspects of their life history. The USFWS further defines "disturb" as "agitating or bothering an eagle to a degree that causes, or is likely to cause, injury, or either a decrease in productivity or nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior" (50 CFR 22.3). If a project may cause disturbance to a bald eagle, the National Bald Eagle Management Guidelines must be consulted and followed to avoid a take, if possible. Based on the National Bald Eagle Management Guidelines, activities that may cause disturbance are typically those that occur within 660 feet of a bald eagle nest (USFWS, 2011).

In 2009, the USFWS promulgated a final rule on two new permit regulations, 50 CFR 22.26 and 50 CFR 22.27, that specifically authorize the take of eagles and eagle nests in certain situations under BGEPA. The permits authorize limited, non-purposeful take of bald and golden eagles, thus authorizing individuals, companies, government agencies (including tribal governments), and other organizations to disturb or otherwise take eagles in the course of conducting lawful activities. Applicants for permits under 50 CFR 22.26 (non-purposeful eagle take) are required to avoid and minimize the take of eagles to the maximum degree practicable. Therefore, a permit can be issued for taking eagles when the take is associated with, but not the purpose of, an activity, and cannot practicably be avoided.

A single bald eagle nest occurs along the shoreline of Frog Mortar Creek at MTN, approximately 1,500 feet north of the DRA. The nest, which is located in a large tree near the edge of Frog Mortar Creek, has been used by a mating pair for several years (Koppie, 2013). An existing road (Lynbrook Road) passes by and is 80 feet from the nest at its closest point.

### 4.7.7 Essential Fish Habitat

Essential fish habitat (EFH) is defined under the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) (Public Law [PL] 94-265), as amended by the Sustainable Fisheries Act (SFA) of 1996 (PL 104-267), as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." The SFA requires that EFH be identified for species actively managed under federal fishery management plans (FMPs). This includes species managed by the eight regional fishery management councils (FMCs) established under the MSFCMA, and those managed by NMFS under FMPs developed by the Secretary of Commerce. NOAA's NMFS Guide to Essential Fish Habitat Designations in the Northeastern United States (NMFS, 1999) and the agency's associated website (http://www.nero.noaa.gov/ro/doc/webintro.html) provide a geographic guide to "the species and life stages of fish, shellfish, and mollusks for which EFH has been designated in a particular area" (NMFS, 2013).

EFH designations emphasize the importance of habitat protection to healthy fisheries and serve to protect and conserve the habitat of marine, estuarine, and anadromous finfish; mollusks; and crustaceans. EFH includes both the water column (including its physical, chemical, and biological growth properties) and its underlying substrate (including sediment, hard bottom, and

other submerged structures). Under the EFH definition, necessary habitat is the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem. EFH is designated for a species' complete life cycle, including spawning, feeding, and growth to maturity, and may be specific for each life stage (eggs, larvae, juvenile and adult). EFH designations are based on various levels of information available for a species' life stage distribution, abundance, and habitat-productivity relationships. Information levels include: presence/absence (Level 1); habitat-related densities (Level 2); growth, reproduction, and survival rates within habitats (Level 3); and production rates by habitat types (Level 4). Several long-standing and comprehensive sources of information are available to develop EFH designations, including the NMFS bottom trawl survey (1963-97) conducted for NMFS Marine Resources Monitoring, Assessment, and Prediction (MARMAP).

EFH has been designated for the mainstem of the Chesapeake Bay for juvenile and adult life stages of windowpane flounder, bluefish, summer flounder, clearnose skate, little skate, winter skate, king mackerel, Spanish mackerel, cobia, and red drum (NMFS, 2010). The Chesapeake Bay has also been designated EFH for larval phase of summer flounder (*Paralichthys dentatus*), juvenile and adult stage of black sea bass (*Centropristis striata*), and the egg, larval, juvenile, and adult stages of the Atlantic butterfish (*Peprilus triacanthus*). The EFH description for each of these species follows:

Windowpane flounder (juvenile and adult) – bottom substrate of mud to fine-grained sand in depths from one to 100 meters and salinity from 5.5% to 36%

Bluefish (juvenile and adult) – waters of the mixing and seawater zone

Summer flounder (larval, juvenile, and adult) – salt water creeks, mudflats, and open bay estuaries of the mixing and seawater salinity zones

Skates (juvenile and adult) – bottom substrate of mud, sand, gravel in the estuarine zone

King mackerel, Spanish mackerel, and cobia (juvenile and adult) – seawater zones of sandy shoals, offshore bars, bays, and estuaries having submerged aquatic vegetation.

Red drum – juvenile EFH is shallow backwaters of the Chesapeake Bay, while adult EFH is somewhat deeper bay areas and oyster reefs; salinity is generally mixing to seawater with depth being less than 50 meters

Black sea bass (egg. larval, juvenile, and adult) – mixing and seawater salinity zones of all in shore estuaries

Atlantic butterfish (egg. larval, juvenile, and adult) – mixing and seawater salinity zones of all in-shore estuaries from one to 1,820 meters in depth

Based on the EFH descriptions for each of the above species, it appears that Frog Mortar Creek, including the portion with the DRA project area, may contain EFH for windowpane flounder, summer flounder, skates, red drum, black sea bass, and Atlantic butterfish. Essential Fish Habitat for these species includes shallow water areas of inshore estuaries and tidal creeks of low to moderate salinity, habitat that is found in Frog Mortar Creek. However, as stated above, EFH for king mackerel, Spanish mackerel, and cobia is limited to seawater zones of sandy shoals and offshore bars or estuaries with submerged aquatic vegetation. Because Frog Mortar Creek is a tidal creek located relatively far from areas with higher salinity levels it is unlikely to provide conditions suitable for EFH for these species.

## 4.8 FLOODPLAINS AND FLOODWAYS

Executive Order 11988 – Floodplain Management defines floodplains as the "lowland and relatively flat areas adjoining inland and coastal waters including flood prone areas of offshore islands, including at a minimum, the area subject to a one percent or greater chance of flooding in a given year." Order 11988 directs federal agencies to avoid (to the extent possible) adverse impacts associated with the occupancy and modification of flood plains, and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative. Agencies are to take action to minimize the impact of floods on human safety, health, and welfare, and restore and preserve the natural and beneficial values served by floodplains. Maryland regulates construction activities within floodplains under COMAR 26.17.04 (Construction on Nontidal Waters and Floodplains). The Federal Emergency Management Agency (FEMA) has adopted the 100-year floodplain as the base flood for floodplain management. This is a flood that has a one

(1) percent probability of occurring in any given year. Flood insurance rate maps (FIRM) show the floodplain areas and define those areas as "zones".

According to MDE's *Floodplain Management Plan, Five-Year Work Plan* (MDE, 2004), Maryland passed the Flood Control and Watershed Management Act (FCWMA) of 1976 to provide the foundation for watershed planning and flood management. Five goals were established: (1) reduction of existing flood hazards; (2) prevention of future flood hazards; (3) adequate emergency preparedness; (4) preservation of the environmental quality of watersheds; and (5) reduction of economic and social losses. FCWMA also stated the need for better coordination among agencies that have flood hazard mitigation responsibilities, and mandated the preparation of local flood management plans and the development of a list of priority watersheds to be studied for the 100-year flood.

Under Executive Order 11988 and USDOT Order 5650.2 – Floodplain Management and Protection, before FAA takes any action that may encroach on a 100-year floodplain, they must find that there is no practicable alternative. Encroachment is defined as any action that would cause the 100-year water surface profile to rise by one foot or more.

**Project Area Floodplains—**State and federal properties in the state of Maryland are not mapped by FEMA; therefore, the national FEMA flood maps (FIRMs) for the Middle River area do not show floodplains at MTN. However, MDNR has indicated that MTN is located within the Middle River tidal floodplain. According to the Baltimore County Department of Public Works, the 100-year floodplain elevation for Middle River is approximately 9 feet msl. This same technique was applied to determine the location of the 500-year floodplain at MTN, using the 500-year elevation at approximately 12 feet msl (Figure 4-4).

## 4.9 HAZARDOUS MATERIALS

### 4.9.1 Definition and Policy

USEPA has developed regulations and oversees the primary laws governing the handling and disposal of hazardous materials, chemicals, substances and wastes. The two statutes of most relevance to implementation of the proposed alternative are the Resource Conservation and Recovery Act (RCRA) and CERCLA. Regulations for identifying and listing hazardous waste (40 CFR Part 261, Subpart C) define hazardous wastes (sometimes called "characteristic

wastes") as solid wastes that are ignitable, corrosive, reactive, or toxic. In addition, 40 CFR Part 261 Subpart D contains a list of solid wastes that USEPA has deemed hazardous (sometimes called "listed wastes"). CERCLA [42 USC § 9601(14)] defines hazardous substances broadly:

- hazardous wastes, hazardous air pollutants, and hazardous substances designated as such pursuant to the Clean Water Act (CWA) and the Toxic Substances Control Act (TSCA)
- elements, compounds, mixtures, solutions, or substances listed in 40 CFR Part 302 that pose substantial harm to human health or environmental resources

Petroleum and natural gas substances and material are not classified as hazardous substances under CERCLA. RCRA generally focuses on the use, storage, and disposal of hazardous waste, while CERCLA focuses on management and remediation of media contaminated with hazardous substances. The DRA is not on the CERCLA National Priority List.

### 4.9.2 Hazardous Materials Assessment

The primary objectives of this environmental assessment are to identify and evaluate sites, facilities, or properties where hazardous materials (including previous environmental contamination) could hinder or affect proposed projects. The existing facilities and land uses at MTN are typical of a standard airport: servicing and refueling of aircraft; aircraft deicing facilities; ground vehicle operations; a control tower and operations center; parking lots or garages; general aviation facilities; fire and rescue facilities; and aircraft maintenance facilities.

No active use, handling, storage or disposal of hazardous materials occurs within the DRA. Only previously disposed hazardous materials found at the site are considered for this assessment because the DRA is in a wooded "non-active" portion of the airport. Historical practices and activities in the project area consisted of the disposal of waste materials and chemicals associated with former aircraft manufacturing. Disposal of these materials has led to contamination of both soil and groundwater in the DRA, with the contamination appearing to migrate from groundwater into Frog Mortar Creek.

As stated in Section 1.2, soil and groundwater sampling and associated geophysical investigations within the DRA over the past two decades have identified waste material (and associated soil and groundwater contamination) over approximately 25 acres. These investigations are detailed in the remedial investigation report for this site (Tetra Tech, 2012a).

Soils at the site contain VOCs, semivolatile organic compounds, polychlorinated biphenyls, and metals. Groundwater at the DRA is currently impacted by elevated levels of VOCs, cVOCs, and heavy metals. Section 1.2 includes more detailed descriptions of the nature and extent of soil and groundwater contamination at the site. Because the hazardous materials at the site are associated with a former landfill, an inventory of hazardous materials and/or solid wastes cannot be made.

### 4.9.3 Solid Waste

Nonhazardous solid waste currently found within the DRA has not been evaluated or inventoried due to the nature of contamination at the site, but may include scrap, paper, aluminum, plastic, textiles, rubber, construction and demolition debris, and natural wood wastes. No facilities currently operate within the DRA, and no other solid wastes are currently generated.

## 4.10 HISTORICAL, ARCHITECTURAL, ARCHAEOLOGICAL, AND CULTURAL RESOURCES

Under Section 106 of the National Historic Preservation Act (NHPA) of 1966, as amended (16 USC 470-470w-6), the FAA must take into account the effect any project may have on any property listed or eligible for listing in the National Registry of Historic Places (NRHP). In addition, the FAA must afford the Advisory Council on Historic Preservation (ACHP) an opportunity to comment on the project or the license or permit for the project. All this must be completed before approval of an airport layout plan (ALP) and issuance of a grant for (and funding of) proposed airport improvements.

The NHPA has established four basic criteria to evaluate properties for the NRHP:

**Criteria A:** properties associated with events that have made a significant contribution to the broad pattern of American history

**Criteria B:** properties associated with the lives of people who are significant in American history

**Criteria C:** properties that embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction

**Criteria D:** properties that have yielded, or may be likely to yield, information important in prehistory or history

### 4.10.1 Area of Potential Effect

For aboveground historic structures, an area of potential effect (APE) is defined as "the geographic area or areas within which an undertaking may directly or indirectly cause alterations in the character or use of historic properties" (36 CFR§ 800.16[d]). The APE includes potential direct or indirect impacts to historic resources from project activities, such as acquisition of property, property easements, and/or visual and audible effects. Such changes may include [36 CFR § 800.5(a)(2)]:

- physical destruction, damage, or alteration of a property
- change of the property's character, use, or physical features within its setting that contribute to its historic significance
- introduction of visual, atmospheric, or audible elements that diminish the integrity of the property's significant historic features

Based on these factors, and the nature and location of the proposed remediation project, the APE associated with historic architectural and archaeological resources is defined as the project's physical limits of disturbance.

### 4.10.2 Historic and Archaeological Investigations

Maryland Historical Trust (MHT) was consulted to document any known historic resources within the project's APE. According to MHT, no listed properties occur within the APE, and no properties eligible for listing on the NRHP occur within the APE (see Appendix B). Portions of MTN are considered eligible for listing in the NRHP by MHT, including the Glenn L. Martin Airport and Glenn L. Martin Production Plant. Both are currently eligible for listing on the NRHP under Criteria A, B, and C. However, both sites and properties occur outside the DRA and the APE.

Several additional studies have been conducted to evaluate the possible archaeological and historic resources at MTN; no significant archaeological resources were found during these investigations. A summary of these studies and their locations follow:

***Phase I Archaeological Survey of the Runway 4/22 Area*** (Engineering Science, Inc., 1990a): This survey was centered on the southwestern portion of former Runway 4-22 in the area south of the main terminal area of the airport. The purpose of the survey was to determine the presence of archaeological sites within the area so that the impact of planned development on any site can be assessed. No significant archaeological resources were discovered during the survey.

***Phase I Archaeological Survey of MTN Shoreline*** (Waporo, Inc., 1990): This survey was conducted along the banks of Frog Mortar Creek at Strawberry Point before erosion control work began to determine if archaeological sites were present in the area; no significant archaeological resources were discovered during the survey.

***Phase I Archaeological Survey of Runway 14/32 and the Midfield Complex*** (Engineering Science, Inc. 1990b): The Midfield Complex and runway 14/32 areas were surveyed to determine if archeological sites existed. Eight locations were found to contain cultural materials. Of these, one (site 18Ba398) was identified as possibly eligible for listing in the NRHP. A Phase II archaeological survey was conducted as a result (discussed below).

***Phase II Archaeological Investigation at Site 18Ba398*** (Joseph Hopkins Associates, 1999): Site 18Ba398 represented a historic occupation from the mid-nineteenth century and appeared to have been in use through at least the first half of the twentieth century. Earlier grading, possibly associated with construction of MTN, destroyed much of the site. The study concluded that the site was not eligible for inclusion in the NRHP.

***Evaluation and Synthesis of Existing Information*** **(**AD Marble, Inc., 2000): This investigation evaluated existing information, including previously conducted studies, surveys, and information contained within the MHT data files. Historic and archeological resource recommendations for the site were also provided. AD Marble found that no potentially significant resources existed within the proposed area of airport expansion, including the proposed corporate hangers, T hangers, and parking areas.

## 4.11 LIGHT EMISSIONS AND VISUAL EFFECTS

Existing light emissions within the MTN property are consistent with the emissions from a typical regional airport. Existing light emission sources include the runway, control tower, and aircraft, as well as standard lighting associated with airport hangers, cargo loading/unloading

areas, and airport parking facilities. There are no light emission sources found within the DRA portion of MTN.

## 4.12 EXISTING NOISE

MAA has extensively evaluated and measured the existing noise environment at MTN. MAA found that noise levels from airport operations and aircraft activity were acceptable in nearby residential areas, using criteria from the United States Department of Housing and Urban Development in 24 CFR Part 51b. These criteria set noise restrictions to protect citizens against excessive noise in their residences and communities. No excessive noise levels extend beyond the airport property in areas that would impact people or residences.

## 4.13 SOCIOECONOMICS, ENVIRONMENTAL JUSTICE, AND CHILDREN'S HEALTH AND SAFETY

This section addresses social, economic, and demographic characteristics in the DRA/airport region. Potential socioeconomic impacts evaluated are any that could be associated with the preferred alternative, including any relocation of residences and businesses in and around the neighborhoods immediately surrounding the DRA and MTN. Community disruption to social institutions and services, including the alteration of surface transportation patterns adjacent to the airport, are also considered.

### 4.13.1 Community Profile

Baltimore County is broken down into specific "Revitalization Areas" within which the County has identified strategies to improve the regional economy. Within these revitalization areas are "Commercial Revitalization Districts", developed to foster business growth and appropriate quality redevelopment via direct technical and financial assistance. A healthy regional economy contributes to county resident employment and helps to maintain standards of living. According to the Baltimore County Master Plan 2020, Middle River is located within the "Eastern Revitalization Area."

United States census data (2010) for the DRA and its adjacent and contiguous parcels are presented below; data is segregated by census tracts and block groups. Census Tract 451600, Block Group 1 covers the entire airport property, including the DRA and adjacent areas to the north and west, while Census Tract 451802 Block Group 1 covers the east side of Frog Mortar

Creek (see Figure 4-5). According to information provided by the 2010 census, 681 and 1,350 residents (respectively) have homes within these tracts. No hospitals, churches, childcare facilities, and/or schools are located within the DRA or adjacent parcels.

### 4.13.2 Children's Environmental Health and Safety Risks

Pursuant to Executive Order 13045, Protection of Children from Environmental Health and Safety Risks (April 21, 1997), the FAA recently revised their policies and procedures for compliance with NEPA (FAA Order 1050.1E) to include the assessment of environmental health and safety risks. According to FAA Order 1050.1E, airport development projects may pose disproportional risks to children including "risks to health and safety that are attributable to products or substances that a child is likely to come in contact with or ingest, such as air, food, drinking water, recreational waters, soil, or products they might use or be exposed to" (FAA, 2006a). Current operations at MTN and the DRA are not associated with any known source that adversely impacts the health or safety of children in the Middle River area.

### 4.13.3 Environmental justice

The proposed project will limit lateral migration of contaminated groundwater in the DRA and would therefore have no impact on the economic development of the communities that exist in the vicinity of DRA. In addition, by containing the off-site migration of groundwater contamination, the proposed project will have a positive impact on the health and safety of nearby communities.

## 4.14 WATER QUALITY

MTN and DRA lie within the Middle River/Browns watershed (Maryland 8-digit watershed code 02130807), which is part of the larger Gunpowder-Patapsco watershed of Chesapeake Bay. The Maryland 12-digit sub-watershed code for the study area is 021308070291; sub-watershed boundaries are shown on Figure 4-6.

### 4.14.1 Surface Water

The Middle River/Browns watershed, in which the DRA is located, is listed as a Category 5 Water on the *Integrated Report of Surface Water Quality in Maryland* [303(d) list] (MDE, 2010a). Category 5 Waters are impaired waters that do not attain water quality standards.

Pollution abatement such as establishing a total maximum daily load (TMDL) is required for discharge into these waters. A TMDL is an estimate of the maximum pollutant volume (from point and non-point sources) that a water body can receive without violating ambient water quality standards.

Surface waters within the DRA are limited to the tidal stream Frog Mortar Creek, an unnamed intermittent/ephemeral tributary stream, and two ponds that are remnants of past filling and waste disposal practices. Frog Mortar Creek is a relatively large tidal stream on the east side of the project area that flows into the Middle River and ultimately to the Chesapeake Bay. Frog Mortar Creek is classified by MDE as a "Use I" stream. Use I waters are defined as being suitable for water contact sports; fishing, propagation of fish (excluding trout), other aquatic life and wildlife; and use as an agricultural and industrial water supply (COMAR 26.08.02.02 B[1]).

An unnamed tributary to Frog Mortar Creek at the north end of the DRA was identified in 2010 as documented in the *Waters of the US Delineation Report, Martin State Airport, Wetland Verification* (Chesapeake Environmental Management, Inc., 2012). Other than the description of this feature found in the comprehensive wetland inventory, no additional characterization or water quality data for this stream are available. This is also true for the two manmade ponds at the site.

Several wetland areas were also identified within the project area. A more detailed description of delineated wetlands and waterways within the project area is provided in Section 4.15.

The DRA project area is located within the Frog Mortar Creek stormwater drainage area. The drainage areas in the DRA vicinity were evaluated and identified for the *Draft Site Development Phase, Stormwater Management Report* (Tetra Tech, 2013); this study revealed that a number of drainage paths or areas drain to Frog Mortar Creek. Stormwater within these drainage areas follows small drainage paths entering wetlands, channels, or culverts that ultimately discharge into Frog Mortar Creek (Tetra Tech, 2013).

### 4.14.2 Surface Water Sampling and Monitoring

As described in Section 1.2, surface water samples have been collected along the shoreline of Frog Mortar Creek since 2004 to evaluate migration of groundwater COC to the creek. Surface water sampling of Frog Mortar Creek has identified concentrations of TCE and/or vinyl chloride

and/or xylene exceeding applicable water quality criteria, including site-specific swimming screening criteria that were developed using accepted USEPA and MDE protocols (Tetra Tech, 2012c). Surface water sampling results from 2012 can be found at http://www.lockheedmartin.com/content/dam/lockheed/data/corporate/documents/remediation/msa/SWReport2012-062013.pdf. The source of the surface water contamination appears to be groundwater migrating from the DRA to Frog Mortar Creek. MDE issued a water contact advisory (See Appendix C) for the portion of Frog Mortar Creek adjacent to the DRA (MDE, 2012) after reviewing the surface water sampling results. Currently, the portion of Frog Mortar Creek adjacent to DRA does not conform to the MDE Use I stream classification for this creek because it currently fails to meet the Use I definition of a "water contact for recreation" stream.

### 4.14.3 Groundwater Quality

The principal source of groundwater in Baltimore County is the Patuxent formation of the Potomac group of aquifers (Maryland Geological Survey, 1969). The Patuxent formation ranges between 100 and 300 feet thick and consists of sand, gravel, and variegated clay. The Patuxent aquifer dips southeasterly at a rate of 85-90 feet per mile. The Patuxent aquifer outcrops in bands several miles wide roughly parallel to the Fall Line. The formation crops out in a belt in the central part of the County, west of the DRA project area and MTN. The Patapsco aquifer is used as a water supply in Baltimore County and typically occurs above the Patuxent aquifer.

Groundwater quality in Baltimore County varies within different areas of the same aquifer. Some County groundwater may be used without treatment, although high mineral content may require some treatment before use. No federal or state standards have been established for raw (i.e., pre-extraction) groundwater. Drinking water standards exist for public water sources, but these are applied within the water distribution system, and are not applicable for groundwater. The Water Management Administration of MDE regulates the discharge of pollutants to groundwater sources.

Geologic mapping of Baltimore County shows that MTN and the DRA project area is underlain by the Potomac group, a Lower Cretaceous-age inter-bedded gravel, sand, silt, and clay unit ranging from 0 to 800 feet thick. The Potomac group at the site consists of three units (from the top elevation down and thus from the youngest to oldest): the Patapsco formation, the Arundel Clay, and the Patuxent formation. Potomac group sediments were deposited in a river delta

environment (Hansen, 1969). The Patapsco formation includes the surficial aquifer underlying the project area. The Arundel Clay likely acts as an impermeable barrier (i.e., the aquifer is confined) to the downward movement of groundwater to the underlying Patuxent formation. The Patuxent formation is a multi-aquifer unit because of its various inter-bedded sand and silt/clay layers, and the rapid changes (over short distances) of deposited material types (Glaser, 1969).

The hydrogeological system beneath MTN consists of relatively continuous zones of sand and gravel that provide the primary pathways for groundwater flow and contaminant transport. These zones are interlayered with zones of lower permeability sediments, resulting in a relatively complex stratigraphic sequence. Water from these units (primarily via natural infiltration of precipitation [i.e., recharge]) infiltrates through shallow fill material to the water table. Groundwater then migrates along various pathways depending on location, with some groundwater flowing vertically downward to recharge units below the water table. Eventually, most groundwater flows laterally through permeable zones, and discharges to estuaries surrounding the peninsula. The estuary of relevance at DRA is Frog Mortar Creek.

Site data indicate that the surficial aquifer is divided into three hydraulically connected monitoring zones: upper (shallow), intermediate, and lower (deep). The surficial aquifer is underlain at approximately 75 to 85 feet below mean sea level (msl) by a relatively thick clay unit that acts as a basal confining unit. Deep borings at the site indicate deeper sand zones that are confined above and below by clay units. These are most likely from the Arundel formation, a regionally extensive, thick, dense, clay confining unit.

Frog Mortar Creek is influenced by tidal fluctuations, with average amplitudes of approximately 1.2 feet and thus a tidal range of about 2.4 feet. Water level recordings for the upper surficial aquifer zone indicate that tidal fluctuation amplitudes decrease to less than 0.1 foot within a few hundred feet from Frog Mortar Creek. This damping effect is most likely due to the relatively high storage coefficient of the water table aquifer: primary storage space just above the water table readily fills and drains. In the intermediate and lower surficial aquifer zones, tidal fluctuations diminish less rapidly with distance from the creek because these zones are semi-confined or confined by Arundel Clay. Much less damping of tidal variation occurs under these conditions because the aquifer units are fully saturated and under artesian pressure.

Groundwater flow in the surficial aquifer is generally easterly toward Frog Mortar Creek. At monitoring well clusters, the concurrently measured water levels for a given cluster indicate that groundwater vertical head differences in the surficial aquifer are generally downward in the upland areas and near Frog Mortar Creek.

Slug tests at the site yielded hydraulic conductivity estimates ranging from 5 to 20 feet per day (ft/day) (sand zones) to 0.01 to 0.2 ft/day (clay zones) [Tetra Tech, 2004]. Pumping tests were performed in both the upper and intermediate zones of the surficial aquifer. Pumping tests for the intermediate surficial aquifer zone indicate an average horizontal hydraulic conductivity ranging from 42 to 140 ft/day, with a mean of 68 ft/day (Tetra Tech, 2010a). No pumping tests have been performed in the lower zone.

No designated sole source aquifers are reported in the vicinity of the DRA according to USEPA's Sole Source Aquifer Program website (USEPA, 2012). USEPA defines a sole- or principal-source aquifer as one which supplies at least 50% of the drinking water consumed. The only sole-source aquifers in Maryland are the Maryland Piedmont aquifer in Montgomery, Howard, and Carroll Counties, and the Maryland Poolesville aquifer extension of the Maryland Piedmont aquifer in Montgomery County.

Groundwater within the DRA project area is not currently used for drinking water or as a source for the public water supply, and no drinking water wells are present on airport property. Municipal drinking water supplies the study area; the public water supply is drawn from three surface water reservoirs. Groundwater in the surficial aquifer (within the Patapsco Formation) beneath the DRA project area currently contains elevated levels of volatile organic compounds (VOCs), chlorinated volatile organic compounds (cVOCs), and heavy metals; based on groundwater samples collected from several deep wells installed in the DRA, the lower, confined Patuxent aquifer is believed to not be impacted by contamination due to the overlying and confining clay layer associated with the Arundel Formation.

## 4.15 WETLANDS

Wetlands are areas characterized by hydric soils, hydrophytic vegetation, and frequent flooding or inundation during the growing season. They are included in the broad definition of "Waters of the United States" in the Clean Water Act (CWA) which includes lakes, rivers, streams,

mudflats, sandflats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, and natural ponds.

### 4.15.1 State and Federal Regulations

Federal and Maryland regulations address activities conducted in wetlands and Waters of the United States to minimize the continuing degradation of these resources and achieve a no net loss policy. Maryland's Non-tidal Wetland Protection Act (1991) is based on Section 404 of the CWA, and the United States Army Corps of Engineers' (USACE) implementation regulations (33 CFR, Parts 320- 330). In addition, Executive Order 11990 directs all federal agencies to avoid, then minimize, the destruction, loss and degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands and waters of the United States. The Wetland and Waterways Division of MDE is tasked with administering Section 404 of the CWA at the state level, and coordinates with USACE to determine the jurisdictional status of wetlands and waterways (COMAR § 26.23 and § 26.24). The Wetland and Waterways Program encompasses two regulatory divisions: the Nontidal Wetlands and Waterways Division, and the Tidal Wetlands Division. Maryland nontidal law is somewhat broader in its jurisdiction and differs from federal law through its regulation of isolated wetlands, vegetation and hydrology alteration; and the inclusion of a 25-foot wetland buffer. This regulated wetland buffer is increased to 100 feet for nontidal wetlands of Special State Concern. These are wetlands the state designates as having exceptional statewide ecological or educational value. No nontidal wetlands of Special State Concern are present within the DRA or surrounding MTN property.

In 1970, the Maryland General Assembly enacted the Tidal Wetlands Act to manage tidal wetlands to provide reasonable use while furnishing essential resource protection. Regulated activities include: shoreline protection projects including marsh creations, stone revetments and bulkheads; piers; dredging; boat ramps; jetties; cable crossings; storm drain systems; groins; breakwaters; vegetative stabilization; and stormwater discharges. Tidal wetlands do not include a standard 25-foot buffer as do non-tidal wetlands.

### 4.15.2 Wetland Delineation

MAA continuously updates the wetland inventory for MTN and closely coordinates with both the MDE and USACE regarding the jurisdictional status of their wetland resources. A complete wetland delineation of MTN property, including the DRA, was completed between July and

September 2011. A preliminary Jurisdictional Determination was performed by USACE and MDE in 2012. Detailed information regarding the wetlands and waterways delineated at MTN can be found in the *"Waters of the US" Report, Martin State Airport, Wetland Verification* (Chesapeake Environmental Management, Inc., 2012) (Appendix F). Boundaries of jurisdictional wetlands delineated within the DRA are depicted on Figure 4-7.

Identified wetlands were field delineated using routine on-site methodology in accordance with the 1987 *USACE Wetland Delineation Manual* (USACE, 1987) and the 2010 *Regional Supplement to the Manual: Atlantic and Gulf Coastal Plain* (Regional Supplement). All potential wetland areas were examined for appropriate hydrophytic vegetation, hydric soils, and wetland hydrology. No wetlands of Special State Concern are found within the DRA or within the surrounding airport property. Tidal wetlands within the DRA are limited to the mean high water (MHW) line of Frog Mortar Creek. The MHW line in this area is about elevation 0.6; this elevation is based upon the conversion of NOAA data to North American Vertical Datum of 1988. All other wetlands and waterways delineated within the DRA were found to be non-tidal.

Information regarding wetland areas delineated within DRA is presented in Table 4-2. These wetlands/waterways are classified as palustrine emergent (PEM), palustrine open water (POW), palustrine unconsolidated bottom wetland (PUB), and estuarine wetlands (E2).

## 4.16 WILD AND SCENIC RIVERS

The Wild and Scenic Rivers Act (October 2, 1968) declares that certain selected rivers of the United States that possess outstandingly remarkable scenic, recreational, geologic, fish, wildlife, historic, cultural and other similar values, will be preserved in free-flowing condition. It further states that these rivers and their immediate environments must be protected for the benefit and enjoyment of present and future generations. The United States Department of the Interior's (USDOI's) National Park Service maintains a national inventory of river segments that may qualify for inclusion in the National Wild and Scenic River System; Maryland has no rivers on this list (USDOI, 2009). Maryland created its own Scenic and Wild Rivers System in 1968. This program maintains an inventory of rivers in Maryland that possess remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values. Like the USDOI website, the MDNR Scenic and Wild Rivers System website also indicates that no

federal- or state-designated wild and scenic rivers (or potentially eligible rivers) are in the MTN vicinity (MDNR, 2013).

**Table 4-1**

**National and Maryland Ambient Air Quality Standards [a]**
**Dump Road Area, Martin State Airport**

| Pollutant | Averaging Time | Primary Standards [b] | | Secondary Standards [b] | |
|---|---|---|---|---|---|
| | | $\mu/m^3$ | ppm | $\mu/m^3$ | ppm |
| CO | 1-hour | 40,000 | 35 | 40,000 | 35 |
| | 8-hour | 10,000 | 9 | 10,000 | 9 |
| Ozone | 1-hour | 235 | 0.12 | 235 | 0.12 |
| | 8-hour | N/A | 0.08 | N/A | 0.08 |
| $NO_x$ | Annual | 100 | 0.05 | 100 | 0.05 |
| $SO_2$ | 3-hour | None | None | 1,300 | 0.5 |
| | 24-hour | 365 | 0.14 | None | None |
| | Annual | 80 | 0.03 | None | None |
| $PM_{2.5}$ | 24-hour | 35 | | 35 | |
| | Annual | 12 | | 15 | |
| $PM_{10}$ | 24-hour | 150 | | 150 | |
| | Annual | 50 | | 50 | |
| Lead | Quarterly | 1.5 | | 1.5 | |

***Sources:*** CRF, Title 40, Part 50, Section 121 and Title 26 of the Code of Maryland Regulations, Subtitle 11, Chapter 4

[a] National and Maryland standards, except for annual means, are not to be exceeded more than once per year

[b] The tabulated thresholds are for primary standards, which are for the protection of public health. Secondary standards are for the protection of public welfare. All secondary standards are the same as primary standards, except for the 3-hour $SO_2$, which is a secondary standard only.

***Abbreviations:***
CO – carbon monoxide
$\mu/m^3$ - micrograms per cubic meter
NOx – nitrogen oxides (or nitrogen dioxide)
$PM_{2.5}$ - fine particulate matter
$PM_{10}$ - respirable particulate matter
ppm – parts per million
$SO_2$ – sulfur dioxide

**Table 4-2**

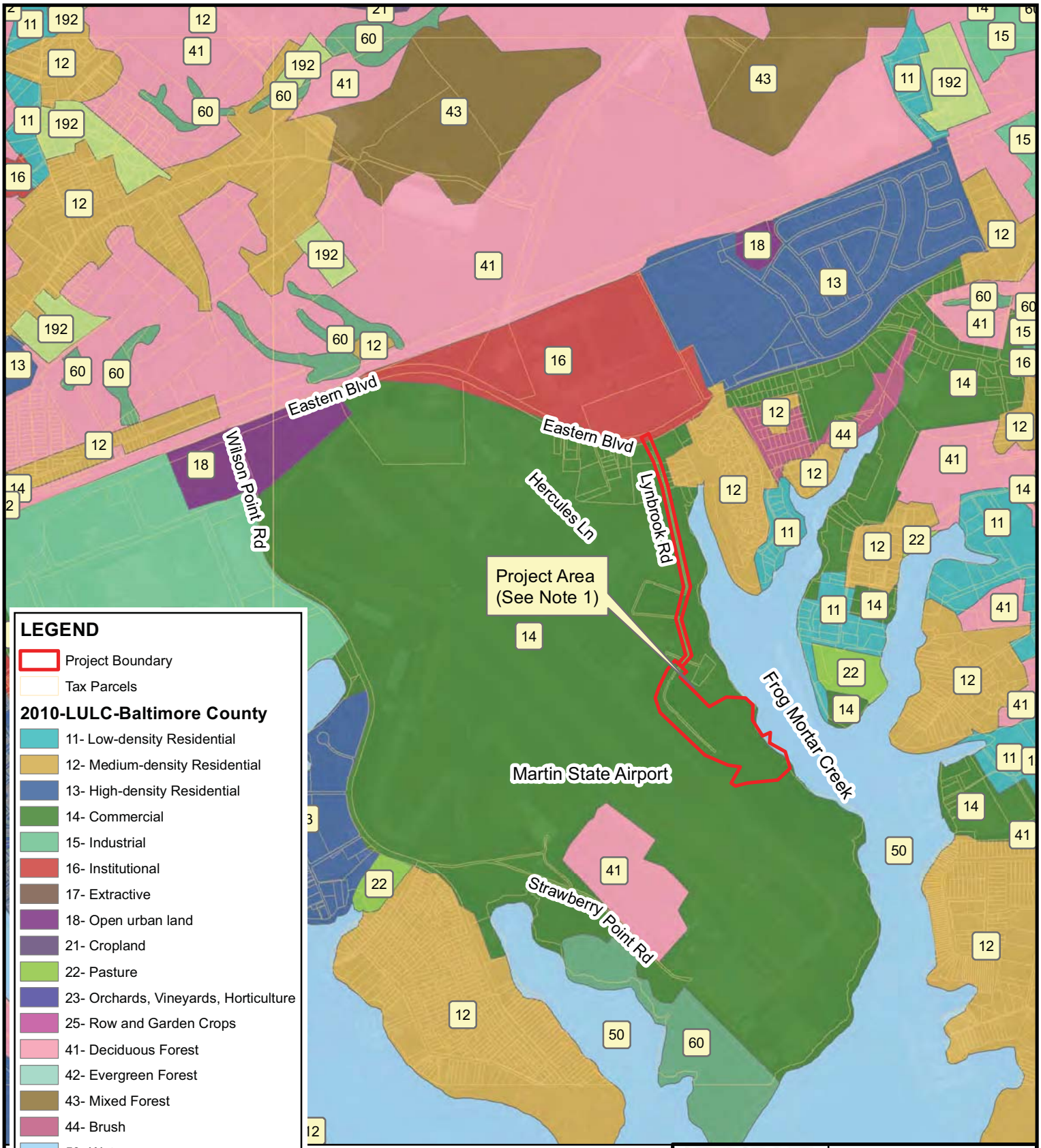
**Delineated Wetlands and Waterways**
**Dump Road Area of Martin State Airport**

| Wetland identification | Wetland type and classification 1 | Tidal/ nontidal | General description |
|---|---|---|---|
| Wetland PP | PEM | nontidal | isolated phragmites dominated wetland |
| Wetland V | PEM, POW, PUB | nontidal | excavated pond with adjacent wetland |
| Wetland NN | PEM, POW | nontidal | excavated pond with adjacent wetland |
| Wetland TT | PEM | nontidal | phragmites dominated emergent wetland – highly disturbed by past land disturbance activities |
| Wetland OO | PEM | nontidal | phragmites dominated emergent wetland that drains to Frog Mortar Creek |
| Frog Mortar Creek | E2 | tidal | includes Frog Mortar Creek seaward from the mean high water line |
| Stream WL6 | ephemeral unnamed stream | nontidal | likely a manmade or altered small drainage channel that flows into Wetland V |
| Stream WL7 | intermittent unnamed stream | nontidal | small stream channel that drains the emergent wetland portion of Wetland NN and flows into Wetland V |

1. Based on the *Classification of Wetlands and Deepwater Habitats of the United States* (Cowardin et al, 1979):

PEM – Palustrine Emergent
POW – Palustrine Open Water
PUB – Palustrine Unconsolidated Bottom Wetland
E2 – Estuarine Wetlands

Figures 4-1 through 4-7




MARTIN STATE AIRPORT

*Environmental Assessment for Groundwater Remediation at the Dump Road Area*

# EXISTING LAND USE / LAND COVER

TETRA TECH

SCALE: AS SHOWN

FIGURE: 4-1

Map Document: (S:\03-Projects\Commercial\LMC\103IP2599 Task 13 (permitting)-DRA-GWTP\NEPA EA\DWG\Figure_3-1.mxd)
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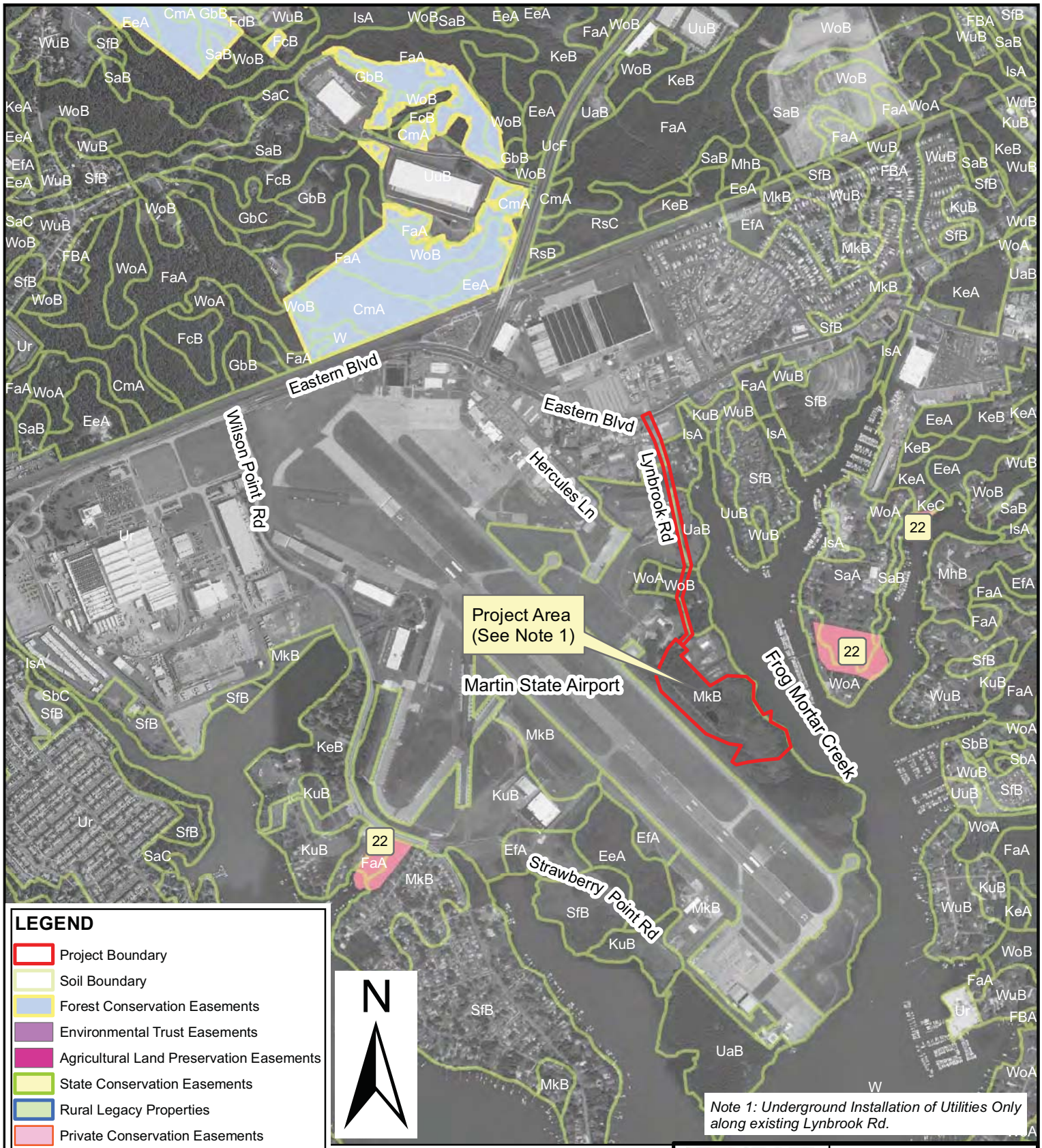


## LEGEND

- Project Boundary
- Soil Boundary
- Forest Conservation Easements
- Environmental Trust Easements
- Agricultural Land Preservation Easements
- State Conservation Easements
- Rural Legacy Properties
- Private Conservation Easements

### 2010-LULC-Baltimore County

- 21-Cropland (None)
- 22-Pasture
- 23-Orchards/vineyards/horticulture (None)
- 25-Row and garden crops (None)
- 241-Feeding operations (None)
- 242-Agricultural building (None)
- 191-Large lot subdivision w/ Ag (None)

Soil Boundary Source: U.S. Department of Agriculture, Natural Resources Conservation Service (2010) Soil Survey Geographic (SSURGO) database for Baltimore County, MD (2010)
Protected Lands Source: Maryland Department of Natural Resources

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# PRIME AND UNIQUE FARMLANDS

TETRA TECH

SCALE: AS SHOWN

FIGURE: 4-2

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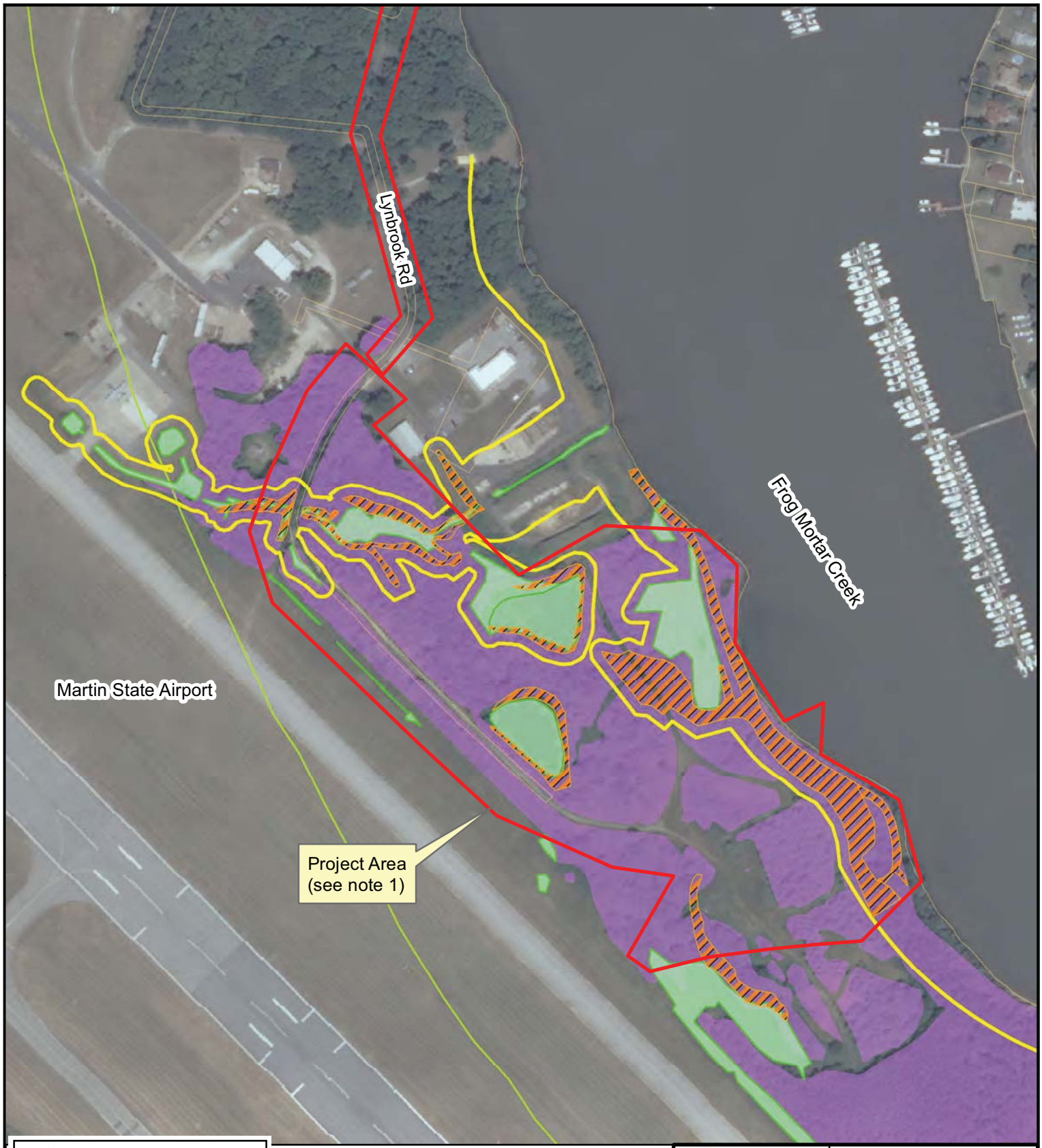


**LEGEND**

- Project Boundary
- Tax Parcels
- SteepSlopes 10% or Greater
- Expanded Tidal Buffer
- Site-Specific Wetlands Study
- Forest Area, April 2012 Mapping
- Critical Area - Baltimore County

*Note 1: Underground Installation of Utilities Only along existing Lynbrook Rd.*

Protected Lands Source: Maryland Department of Natural Resources
LULC Source: State of Maryland Department of Planning (2010)
Critical Area Boundary Source: Maryland Department of Natural Resources

N

0 150 300 600 Feet

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# FORESTS AND OTHER PROTECTED HABITATS

TETRA TECH

SCALE: AS SHOWN

FIGURE: 4-3

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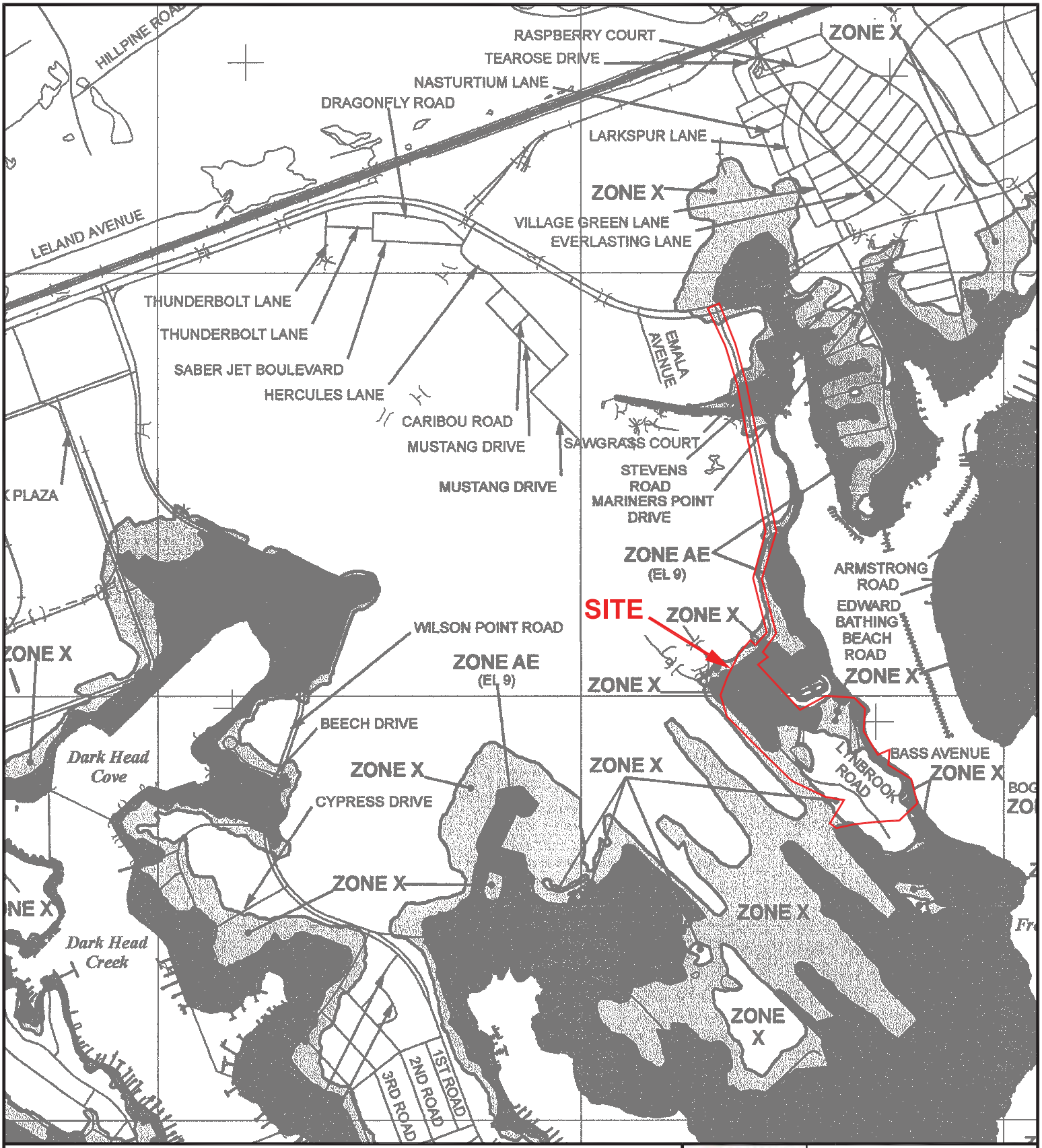


**BALTIMORE COUNTY**
**MARYLAND**
**UNINCORPORATED AREAS**

**PANEL 435 OF 580**

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

| COMMUNITY | NUMBER | PANEL | SUFFIX |
|---|---|---|---|
| BALTIMORE COUNTY | 240010 | 0435 | F |

**MAP NUMBER**
**2400100435F**

**MAP REVISED**
**SEPTEMBER 26, 2008**

**Federal Emergency Management Agency**

N

DATE: 07-18-2013

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FEMA FLOOD INSURANCE RATE MAP (FIRM)

0' 1000' 2000'

TETRA TECH

SCALE: AS SHOWN

FIGURE: 4-4

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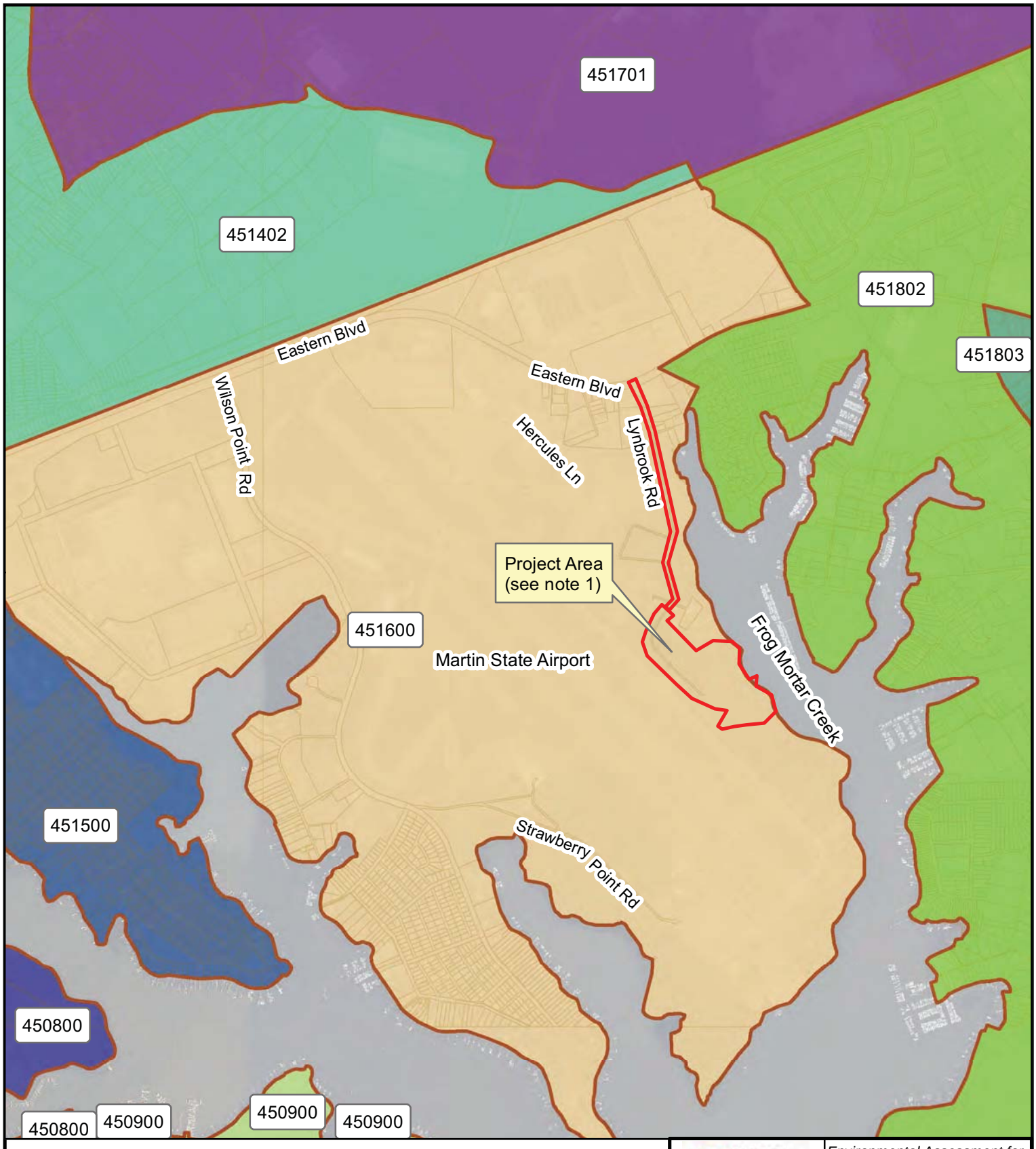


*Note 1: Underground Installation of Utilities Only along existing Lynbrook Rd.*

**LEGEND**

- Project Boundary
- Tax Parcels

Sources: Census Tract from Maryland State Planning Data Center

0 750 1,500 3,000 Feet

N

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# CENSUS TRACTS

TETRA TECH

SCALE: AS SHOWN

FIGURE: 4-5

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**LEGEND**

- Project Boundary
- Tax Parcels
- Watersheds

Source: Baltimore County

*Note 1: Underground Installation of Utilities Only along existing Lynbrook Rd.*

0 750 1,500 3,000 Feet

N

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**SUB-WATERSHEDS (WATERSHEDS)**

TETRA TECH

SCALE: AS SHOWN

FIGURE: 4-6

Map Document: (S:\03-Projects\Commercial\LMC\103IP2599 Task 13 (permitting)-DRA-GWTP\NEPA EA\DWG\Figure_3-4.mxd)
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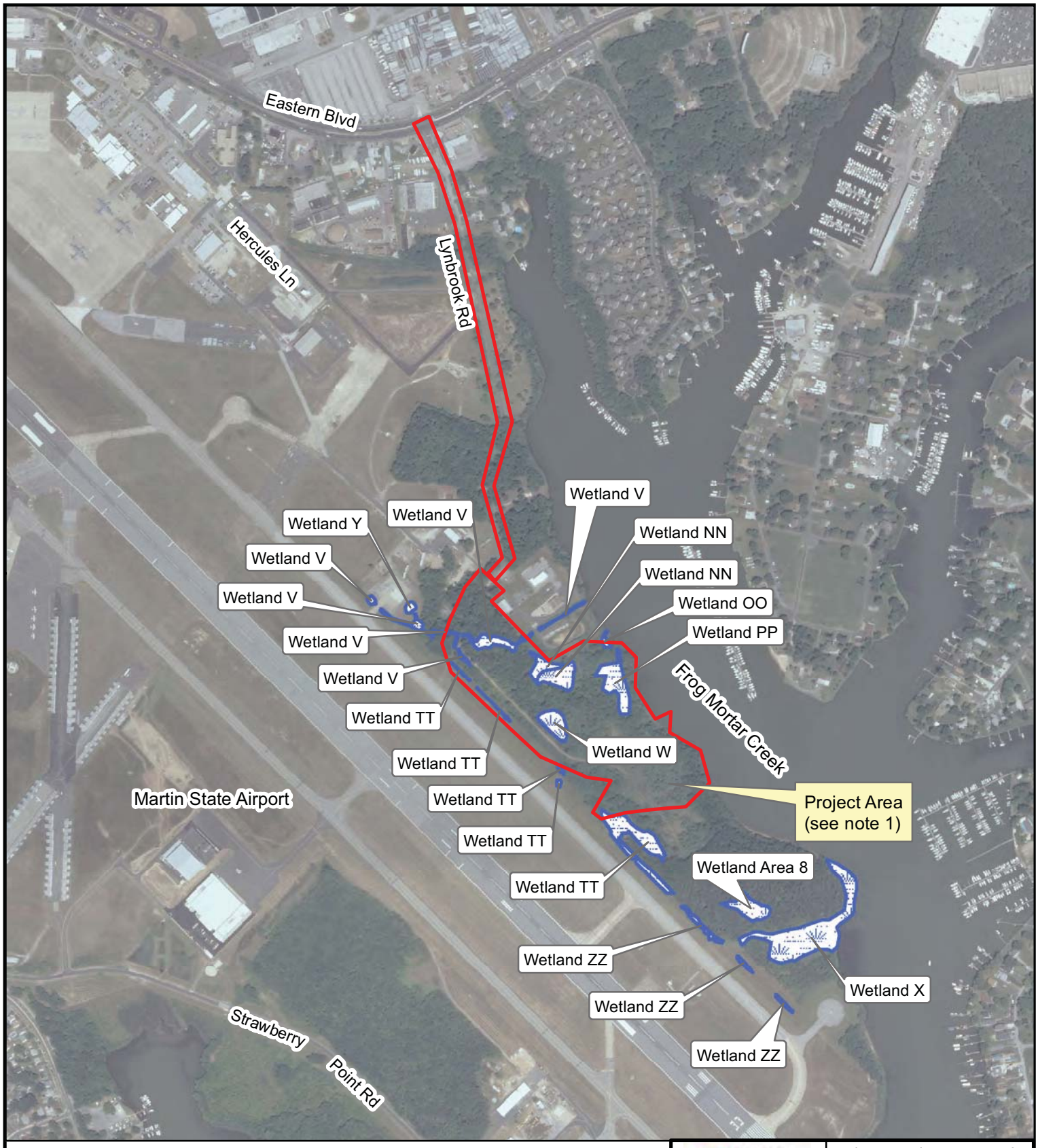


**LEGEND**

- Project Boundary
- Site-Specific Wetlands Determination

N

*Note 1: Underground Installation of Utilities Only along existing Lynbrook Rd.*

0 375 750 1,500 Feet

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# SITE SPECIFIC WETLANDS SURVEY

TETRA TECH

SCALE: AS SHOWN

FIGURE: 4-7

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# Section 5
# Environmental Consequences

This section presents an assessment of the environmental impacts associated with the proposed project alternatives. An evaluation of the environmental impacts associated with both the preferred alternative (proposed action) and the no-action alternative are presented for each resource category or topic. Mitigation strategies that can be used to avoid and minimize the identified impacts are also presented, where appropriate. An analysis of potential impacts for each of the resource categories described as part of the Affected Environment section above (Section 4.0) is presented below.

## 5.1 AIR QUALITY

This analysis involves the evaluation of the USEPA priority pollutants (and their precursors) associated with the proposed remediation project, and include VOCs, nitrogen oxides ($NO_x$), sulfur dioxide ($SO_2$), carbon monoxide (CO), and particulate matter ($PM_{10}$ and $PM_{2.5}$).

### 5.1.1 Impact Potential – Preferred Alternative

MTN, including the DRA, is located within Baltimore County, which is designated as being in non-attainment status for the ozone one-hour standard, in "moderate" non-attainment for the ozone 8-hour standard, and in non-attainment for the $PM_{2.5}$ 24-hour standard. The applicability of the federal Clean Air Act (CAA) General Conformity Rule (40 CFR 90 Sec 153) has been evaluated because of these designations. The Rule defines *de minimis* levels (i.e., minimum threshold levels) for standard criteria pollutants for which a conformity determination must be performed. A summary of the estimated construction related air emissions inventory associated with the proposed action is found in Table 5-1. These estimates are based on EPA's *AP-42, Compilation of Air Pollutant Emissions Factors* (AP-42). Due to the small area of ground disturbance (<3.5 acres) associated with proposed construction and plans to employ standard dust control measures, site-specific modeling of construction emissions was not warranted.

An applicability analysis was conducted to evaluate *de minimis* thresholds, and the estimated construction-related emissions using AP-42 were found to be within the General Conformity Rule *de minimis* levels for $PM_{2.5}$, for $NO_x$ and $SO_2$ precursors, and for ozone ($O_3$) precursors of $NO_x$ and VOCs. Therefore, the proposed project automatically conforms to the State Implementation Plans (SIP) for $PM_{2.5}$ and $O_3$ and no further assessment is necessary.

While there are no anticipated changes to aircraft operations (e.g., number of operations, fleet mix, delay periods) or significant motor vehicle increases attributable to the implementation of the proposed project, air emissions associated with operation of the Groundwater plume treatment facility on MTN property would include minor emissions of certain VOCs including methylene chloride; however, the facility will treat emissions prior to discharge and any emissions will be small percentage of the treated mass. As depicted in Table 5-1, the expected emissions of methylene chloride from the groundwater treatment process following treatment using vapor phase granulated activated carbon (VGAC) will be less than 1 pound per year. This estimated annual emission level would not be detectable in ambient air surrounding the DRA; therefore, no significant effect on local or regional air quality would occur and dispersion modeling and more detailed estimates of airborne concentrations are not warranted.

### 5.1.2 Impact Potential – No Action Alternative

The no action alternative does not involve construction or operation of a remediation facility, nor does it affect the operational characteristics of the airport. Therefore, it would have no impact on the existing air quality conditions at the airport.

### 5.1.3 Mitigation Measures

Emissions associated with the remediation facility are anticipated to be below state and federal exceedance levels. A permit to construct (PTC) and (potentially) a permit to operate (PTO) must be acquired before construction and operation of the facility for the air stripper. The PTC/PTO will include any necessary mitigation in the form of emission minimization measures to be employed to ensure that emissions are within permissible levels. Other minor emissions, such as VOCs coming off mixing tanks, will be below permit thresholds and will be managed with small carbon vessels. So therefore for air quality, no mitigations measures are required according to 4.2.1. “This estimated annual emission level would not be detectable in ambient air surrounding

the DRA; therefore, no significant effect on local or regional air quality would occur and dispersion modeling and more detailed estimates of airborne concentrations are not warranted".

## 5.2 COASTAL RESOURCES AND COASTAL ZONE MANAGEMENT PROGRAM

MAA is required to comply with the regulations set forth and administered by the MDE and MDNR. These governing agencies are charged with identifying land uses which, individually or cumulatively, may cause or contribute significantly to the degradation of coastal waters where there is a failure to attain or maintain applicable water quality standards or protect designated uses.

### 5.2.1 Impact Potential – Preferred Alternative

The proposed project area is located within the Maryland Coastal Zone. Therefore, MDE is required to conduct a project review and determination of consistency for the project, referencing the goals and objectives of the Maryland Coastal Zone Management Program (CZMP). In Maryland, this review and determination process is conducted following submittal of state and/or federal permit applications such as the Joint Permit Application (JPA). The state's permit decision constitutes the states' consistency determination. Permit applications will be made in accordance with the Maryland regulatory review process. MAA will work with MDE to ensure that the project is consistent with the goals and objectives of the Maryland CZMP.

### 5.2.2 Impact Potential – No Action Alternative

The no action alternative would cause no impact to the coastal waters and water quality within the Maryland coastal zone; however, groundwater contamination from the DRA would continue to impact Frog Mortar Creek.

### 5.2.3 Mitigation Measures

Proposed mitigation measures for impacts to water quality (Section 4.14) and wetlands (Section 4.15) are discussed below. MDE will review the draft EA document and will provide any additional mitigation recommendations that will be required to ensure consistency with the Maryland CZMP.

## 5.3 COMPATIBLE LAND USE

According to FAA environmental policy and procedures (FAA, 2006a), the compatibility of existing and planned land use in the vicinity of airports is typically associated with the extent of the airport's future noise impacts. If the noise analysis conducted in support of a project concludes that there are no significant noise impacts, the same conclusion can generally be drawn regarding the compatibility of land use in the areas around the airport. As described below, noise levels would not be affected by the proposed action.

In addition, a July 2003 interagency Memorandum of Agreement (MOA) addressing wildlife hazards to airports states that any proposed project near an airport must not create a wildlife hazard for airport operations (Appendix G). Because the proposed DRA project would not create additional wildlife attractants (e.g., wetlands), and would, in fact, decrease the available wildlife habitat in the vicinity of the airport (due to the removal of trees and brush for the building and access roads), it would not create a wildlife hazard. In addition, the United States Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS), Wildlife Service has stated in a letter dated November 9, 2012 that they "do not see anything at this time that would pose an increased threat to aircraft safety resulting from the proposed project" (see Appendix B).

## 5.4 CONSTRUCTION IMPACTS

The construction of the preferred action alternative would cause temporary impacts associated with roadway construction, utility construction, and building construction. Anticipated temporary impacts would include construction noise, dust and noise from heavy equipment traffic, disposal of construction debris, and air and water pollution. Specific construction related impacts are discussed in greater detail under each of the individual resource categories in this section.

Mitigation for construction impacts would be addressed by using the guidelines established for Erosion and Sediment Control as defined by the *2010 Maryland Standards and Specifications for Soil Erosion and Sediment Control* (Draft October 2009), MDE - Water Management Administration - *Maryland Stormwater Design Manual, Volumes I & II*, and *General Permit for Stormwater Associated with Construction Activity* effective January 1, 2009) and other best management practices for avoiding/minimizing/mitigating construction related impacts to air, water, and soils.

## 5.5 SECTION 4(F) RESOURCES

No Section 4(f) properties are located within the DRA project area, and the closest Section 4(f) properties (Chesapeake Village Park and Kingston Point Park) are located over one mile west of the DRA. As such, the proposed project would have no direct or indirect impact on Section 4(f) resources.

## 5.6 FARMLANDS

No agricultural zoned areas, existing agricultural land uses, or farmlands are located within the vicinity of the proposed project. Therefore, no farmlands would be converted to non-agricultural use, and the proposed project would not be subject to the provisions of the Farmland Protection Policy Act (FPPA). In addition, a review of the Baltimore County soil data via the NRCS Web Soil Survey did not identify any prime farmland soils. Lastly, implementation of the preferred alternative would not be affected by FPPA because MTN qualifies as an urban development area.

## 5.7 FISH, WILDLIFE, AND PLANTS

For this analysis, impacts to biotic resources, including fish, wildlife, and plants were considered by evaluating the expected impact to habitats and forested areas within the DRA. To quantify these impacts the limits of both Habitat Protection Areas (HPAs) and forest boundaries were compared with the proposed limits of disturbance for the project.

### 5.7.1 Habitat Protection Areas - Impact Potential – Preferred Alternative

Portions of HPAs including non-tidal wetlands, non-tidal wetland buffers, steep slopes, steep slope buffers, as well as areas within the 100-foot tidal buffer that will be impacted by project activities are depicted in Figure 5-1. The 100-foot buffer has been expanded to include contiguous wetland or steep slope areas (referred to as the “expanded tidal buffer”). In addition, the 25-foot buffer surrounding both the non-tidal wetlands and steep slopes are shown on Figure 5-1. Most of these habitats have been highly disturbed in the past and contain mostly disturbance-oriented species.

Table 5-2 presents the proposed impacts to these HPAs and the 100-foot buffer. Impacts located within and outside of the expanded tidal buffer are indicated in the table. The exact nature and

extent of these impacts to HPAs and the 100-foot buffer will be refined and minimized to the extent practicable during the final design of the project.

***Access road crossing of unnamed tributary —*** Impacts in this area will be within the 100-foot expanded tidal buffer and will include clearing and grading a small wetland area and a steep slope area. These areas will be disturbed when the existing road is widened and at the stream channel crossing during culvert installation. The total impact area is 11,990 square feet (sf), and includes a small emergent wetland and its surrounding 25-foot buffer, an area of steep slopes and the surrounding 25-foot steep slope buffer, and 30 linear feet of stream channel.

This impact is unavoidable because the road must be widened to meet construction traffic needs and to meet local/airport safety and fire protection requirements. Crossing the unnamed tributary stream is also necessary for DRA access. These changes will have a permanent impact; however, given the relatively small nature of the impacted area, previous disturbance in the DRA, and lack of unique wildlife habitat, no significant ecological impact to the habitat in the general vicinity is expected to occur as a result of this activity.

***Access road south of unnamed tributary —*** Impacts in this area are related to widening the road and include clearing and grading of a small wetland area and a steep slope area. Affected areas are outside the 100-foot expanded tidal buffer. The total impacted area is 2,490 sf and includes impacts to a small emergent wetland and its surrounding 25-foot wetland buffer, and an area of steep slopes and its 25-foot buffer.

This impact is unavoidable as it is necessary to widen the road to meet construction traffic needs and local/airport safety and fire protection requirements. This will be a permanent impact; however, given the relatively small nature of the impacted area, previous disturbance at the DRA, and the lack of unique wildlife habitat, no significant ecological impacts to habitat in the general vicinity is expected to occur as a result of this activity.

***Stormwater discharge pipe —*** Impacts in this area would be outside the 100-foot expanded tidal buffer, and will include clearing and grading of a small steep slope area to install the pipe. The total impact area is 3,040 sf and includes impact to an area of steep slopes and its surrounding 25-foot buffer. A narrow clearing for the stormwater discharge corridor will cause minor forest

clearing, but will be necessary to minimize the length of corridor needed to convey stormwater to a discharge location.

***Northern well access —*** Impacts in this area will be within the 100-foot expanded tidal buffer, and will include clearing and grading of a small wetland area and steep slope area to widen the paths to the well locations. The total impact area is 470 sf and includes impact to a small emergent wetland and an area of steep slopes; each of these areas includes a surrounding 25-foot buffer.

The proposed project will require clearing along the edge of existing DRA paths or trails to allow for piping and equipment transport to and from the well locations. Minor forest clearing along the expanded tidal buffer boundary is necessary because groundwater wells must be located near Frog Mortar Creek in order to capture migration of the groundwater plume.

***Central well access —*** Impacts in this area will be within the 100-foot expanded tidal buffer and will include clearing and grading of a small steep slope area to widen the paths to the well locations. The total area of impact is 8,670 sf and includes a small area of steep slopes and its surrounding 25-foot buffer. Minor forest clearing along the expanded tidal buffer boundary is necessary because groundwater wells must be located near Frog Mortar Creek in order to capture migration of the groundwater plume.

***Treatment plant perimeter and outfall discharge pipe —*** Impacts in this area will also be within the 100-foot expanded tidal buffer and include clearing and grading of a small steep slope area to widen the access paths to the well locations near the treatment plant and to install the outfall discharge pipe. The total impacted area is 12,530 sf and includes a small area of steep slopes and its 25-foot buffer. Minor forest clearing along the expanded tidal buffer boundary in this area is necessary because groundwater wells must be located near Frog Mortar Creek in order to capture migration of the groundwater plume, and for placement of the outfall discharge pipe.

***Southern well access —*** Impacts in this area will be within the 100-foot expanded tidal buffer, and include clearing and grading of a small steep slope area to widen the paths to the well locations. The total impact area is 4,700 sf and includes a small area of steep slopes and their 25-foot buffer. Minor forest clearing along the expanded tidal buffer boundary is necessary

because groundwater wells must be located near Frog Mortar Creek in order to capture migration of the groundwater plume.

### 5.7.2 Habitat Protection Areas - Impact Potential – No Action Alternative

Because the no action alternative would leave the site in its current condition, there would be no impacts to critical area resources (including HPAs) or the 100-foot tidal buffer.

### 5.7.3 Habitat Protection Areas - Avoidance, Minimization, and Mitigation Measures

**Avoidance and Minimization Measures —** The preferred action alternative avoids critical area resources to the maximum extent practicable. The treatment plant, parking area, and the vast majority of the well pads and infrastructure have been intentionally placed outside the boundaries of critical area HPAs to avoid and minimize impacts to these resources. Remaining impacts associated with the main access road are unavoidable due to the need for widening the existing road for safety/emergency vehicle traffic and because no other access to the site exists. The remaining impacts associated with the well pad locations are likewise unavoidable due to the physical limitations of the site and the need to locate the wells where groundwater flow modeling indicates is necessary to provide capture of migrating groundwater. Finally, the remaining impacts to Frog Mortar Creek resulting from installation of the outfall discharge pipe are unavoidable due to the need for the pipe to extend below mean low water to allow for proper mixing with ambient water and to comply with the requirements of the NPDES permit for the project. In addition, all remaining impacts to HPAs will be minimized through use of best management practices to be implemented under an approved MDE erosion and sediment control and stormwater management plan.

**Mitigation Measures —** Compliance with Chesapeake Bay Critical Area Commission guidelines requires mitigation measures to offset the lost functions and values within HPAs. MAA has been coordinating with staff of the Critical Area Commission to identify impacts to critical area resources and determine the appropriate level of mitigation for these impacts for compliance with Critical Area Act requirements. Appendix B provides a description of the agency consultation and coordination efforts conducted as part of the preparation of this EA, which have included conducting an initial agency scoping/pre-application meeting to gain early feedback on proposed project plans, as well as a subsequent Joint Evaluation Committee meeting

to review specific design details and resource impacts. MAA will continue to coordinate with the appropriate agencies to finalize avoidance and minimization measures, develop a final, detailed mitigation plan to offset anticipated impacts, and ensure compliance with the critical area act. Implementation of, and adherence to the final CAC approved avoidance/minimization measures and mitigation requirements will ensure that impacts resulting from the preferred action alternative are offset and are therefore below significance. It should be noted that mitigation of impacts to critical area resources will be conducted off-site to avoid creation of wildlife attractants in accordance with *FAA AC 150/5200-33B, Hazardous Wildlife Attractants On or Near Airports* and will be accomplished by planting, preservation, in lieu fee, or a combination of these measures. In accordance with the provisions of the Critical Care Act, the final mitigation measures will be established in consultation with the Critical Area Commission; these measures are not finalized until final design drawings can be submitted to the Commission, and the full measure of impacts can be quantified.

### 5.7.4 Forest Resources – Impact Potential – Preferred Alternative

As described in Section 4.7.4, forested areas in the DRA are mostly early successional stands comprised of disturbance-oriented species. These stands are relatively young and have matured following use of the area for disposal. Since the project area is within an area classified as an intensely developed area (IDA), and DRA forest stands are less than 50 acres in size, none of the forested areas in the DRA qualify as forest interior dwelling species (FIDS) habitat. The location of the treatment facility was chosen to be in the largest non-forested area available on-site, thus minimizing forest-related impacts to the maximum extent practicable.

The limits of forest resources identified within the DRA were compared with the proposed limits of disturbance for preferred alternative. Several forest stands will be impacted by the proposed remediation project (Figure 5-2). However, most of these stands consist of relatively young forest and contain mostly disturbance-oriented species.

Table 5-3 presents the proposed impacts to existing forest stands. Because the entire DRA is located within the Chesapeake Bay Critical Area, the impacts within the expanded buffer are separated from those outside the buffer. Forest clearing associated with the preferred alternative is expected to total approximately 124,890 sf (2.7 acres), 95,700 sf (2.2 acres) of which is outside the expanded tidal buffer, with the remaining 21,190 sf (0.49 acres) occurring within the

expanded tidal boundary. The exact nature and extent of these impacts to existing forest stands will be refined and minimized to the extent practicable during the final design of the project.

***Access Road North of Unnamed Tributary —*** Forest clearing in this area would include 7,630 sf outside of the expanded tidal buffer, and is necessary to widen the road to meet construction traffic needs and local/airport safety and fire protection requirements. This impact will be permanent, but only a narrow portion of forest "edge" along the existing road would be affected. Clearing is not expected to significantly impact wildlife, particularly to species preferring interior forest. Although runoff and infiltration functions will be lost in the cleared area, design plans will include best management practices (BMPs) for stormwater management, environmental site design (ESD) to the maximum extent practicable (MEP), and compliance with the CAC 10% rule for reducing post development sediment loads to offset these lost functions and values.

***Access Road Crossing of Unnamed Tributary —*** Forest clearing in this area will include 6,520 sf within the expanded tidal buffer. Forest clearing surrounding the unnamed stream crossing will be necessary to widen the road to meet the needs for truck construction traffic and local/airport safety and fire protection requirements. This will be a permanent impact; however, given that only a narrow portion of the forest edge along the existing road will be affected, it is not expected that any significant wildlife impacts, particularly to species preferring interior forest, will occur. Also, runoff and infiltration functions will be lost in the cleared area; however, stormwater management design plans that will include BMPs, ESD to the MEP, and compliance with the Critical Area 10% rule for reducing post development sediment loads will offset these lost functions and values. In addition, while this clearing will occur within the expanded tidal buffer it is unavoidable due to the need to cross the unnamed tributary stream to access the DRA.

***Access Road South of Unnamed Road and Treatment Facility —*** Forest clearing in this area will include 83,250 sf outside of the expanded tidal buffer. Forest clearing along the edge of the existing road will be necessary to widen the road to meet the needs for truck construction traffic and local/airport safety and fire protection requirements. This will be a permanent impact; however, given that only a narrow portion of the forest edge along the existing road would be affected, it is not expected that any significant wildlife impacts, particularly to species preferring interior forest, will occur. Also, runoff and infiltration functions will be lost in the cleared area;

however, stormwater management design plans that will include BMPs, ESD to the MEP, and compliance with the Critical Area 10% rule for reducing post development sediment loads will offset these lost functions and values.

In addition, this impact area will include some clearing of the forest edge surrounding the location of the treatment facility, as well as a narrow corridor for the stormwater discharge location. These will be permanent impacts. The treatment facility location was chosen to be located in the largest non-forested area available on site and therefore to minimize the amount of forest related impacts to the maximum extent practicable. The amount of forest clearing surrounding the edge of the treatment facility is necessary to accommodate parking and storage areas and was likewise reduced in size to the maximum extent practicable to minimize tree clearing. A narrow clearing for the stormwater discharge corridor will cause minor forest clearing but will be necessary to minimize the length of corridor needed to convey stormwater to a discharge location.

***Well Access Roads and Outfall Discharge Pipe*** **—** Forest clearing will be 27,490 sf, both within and outside of the expanded tidal buffer. Access from the treatment facility to the groundwater wells will require clearing along the edge of existing paths or trails in the DRA to allow for piping and equipment transport to and from the well locations. Several hundred square feet of forest clearing is needed for installation of the outfall discharge pipe between the treatment plant and Frog Mortar Creek. Much of this impact is within the expanded tidal buffer. Minor forest clearing along the expanded tidal buffer boundary is unavoidable because groundwater wells must be located near Frog Mortar Creek in order to capture the migrating groundwater plume.

### 5.7.5 Forest Resources – Impact Potential – No Action Alternative

Because the no action alternative would leave the site in its current condition, there would be no impacts to forest resources.

### 5.7.6 Forest Resources – Avoidance, Minimization and Mitigation Measures

**Avoidance and Minimization Measures** **—** The preferred action alternative avoids forest resources to the maximum extent practicable. The treatment plant, parking area, and the vast majority of the well pads and infrastructure have been intentionally placed outside the

boundaries of forested areas to avoid and minimize impacts to these resources. Remaining impacts associated with the main access road are unavoidable due to the need for widening the existing road for safety/emergency vehicle traffic and because no other access to the site exists. The remaining impacts associated with the well pad locations is likewise unavoidable due to the physical limitations of the site and the need to locate the wells where groundwater flow modeling indicates is necessary to provide capture of migrating groundwater. Finally, the remaining impacts resulting from installation of the outfall discharge pipe are unavoidable due to the need for the pipe to discharge to Frog Mortar Creek to allow for proper mixing with ambient water and to comply with the requirements of the NPDES permit for the project. In addition, all remaining impacts to forested areas will be minimized through use of best management practices to be implemented under an approved MDE erosion and sediment control and stormwater management plan.

**Mitigation Measures —** Compliance with Chesapeake Bay Critical Area Commission guidelines requires mitigation measures to offset tree and forest removal. MAA has been coordinating with staff of the Critical Area Commission to identify impacts to these resources and determine the appropriate level of mitigation for these impacts for compliance with Critical Area Act requirements. Appendix B provides a description of the agency consultation and coordination efforts conducted as part of the preparation of this EA, which have included conducting an initial agency scoping meeting to gain early feedback on proposed project plans, as well as a subsequent Joint Evaluation Committee meeting to review specific design details and resource impacts. MAA will continue to coordinate with the appropriate agencies to finalize avoidance and minimization measures, develop a final, detailed mitigation plan to offset anticipated impacts, and ensure compliance with the critical area act. Implementation of, and adherence to the final CAC approved avoidance/minimization measures and mitigation requirements will ensure that impacts resulting from the preferred action alternative are offset and are therefore below significance. It should be noted that mitigation of impacts to forest resources will be conducted off-site to avoid creation of wildlife attractants in accordance with *FAA AC 150/5200-33B, Hazardous Wildlife Attractants On or Near Airports* and will be accomplished by planting, preservation, in lieu fee, or a combination of these measures. In accordance with the provisions of the Critical Care Act, the final mitigation measures will be established in consultation with the Critical Area Commission; these measures are not finalized

until final design drawings can be submitted to the Commission, and the full measure of impacts can be quantified.

### 5.7.7 Rare, Threatened and Endangered Species

As noted in Section 4.7.5, the Maryland Department of Natural Resources (MDNR) Wildlife and Heritage and the United States Fish and Wildlife Service (USFWS) stated that no state or federally proposed or listed endangered or threatened species are known to exist in the project area. Therefore, no further consultation with these agencies is required, and it is expected that the proposed remediation project would have no effect or impact on listed species under MDNR and USFWS jurisdiction.

The National Marine Fisheries Service (NMFS) indicated that while there are currently no records of federally listed aquatic species under NMFS jurisdiction in Frog Mortar Creek, the endangered shortnose sturgeon and all five distinct population segments of the endangered Atlantic sturgeon are known to occur in the Maryland portion of the Chesapeake Bay. In addition, four sea turtle species, including leatherback, Kemp's riddle, loggerhead, and green sea turtles are also known to occur within Chesapeake Bay, particularly during the spring, summer, and fall, when water temperatures are warm.

While not listed under the Endangered Species Act, the bald eagle is currently protected by the USFWS under the Bald and Golden Eagle Protection Act (BGEPA). Also, as noted previously, an existing bald eagle nest is located adjacent to Frog Mortar Creek approximately 1,500 feet north of the DRA project area and approximately 80 feet east of utility installations planned for Lynbrook Road.

Frog Mortar Creek appears to contain EFH for several species and life stages as listed in Section 4.7.7 above. This includes the portion of the DRA where the proposed outfall discharge system would be located.

An analysis of potential impacts to shortnose sturgeon, Atlantic sturgeon, and sea turtles under the Endangered Species Act, as well as an analysis of potential impacts to the bald eagle under the BGEPA and EFH under the MSA for both the preferred and no action alternatives, is provided below.

### 5.7.8 Rare, Threatened and Endangered Species - Impact Potential – Preferred Alternative

**Threatened and Endangered Species —** Both shortnose and Atlantic sturgeon typically spawn in deeper portions of large rivers such as the Potomac River and other sizeable river systems in the Chesapeake Bay. Given the relatively small size and general lack of suitable habitat within the project area, it is unlikely that Atlantic sturgeon will use Frog Mortar Creek during spawning; however, occasional transient individuals could occur in the general vicinity.

The proposed project primarily affects terrestrial habitats adjacent to Frog Mortar Creek; however, construction and operation of the treatment facility and related stormwater and outfall discharges do have the potential to impact aquatic resources. All stormwater management in the project area will comply with MDE stormwater permitting requirements and will employ BMP and ESD to the MEP; therefore, stormwater runoff in the project area is not expected to significantly impact the adjacent tidal and estuarine habitats.

Installation and operation of the outfall discharge pipe below the mean high water line and the release of treated groundwater into Frog Mortar Creek could cause physical disruption of creek bottom habitat. However, the spatial extent (footprint) of the pipe and anchoring system would be small (approximately 700 sf and 80 linear feet [lf]); therefore, impact to available bottom habitat along the shoreline of Frog Mortar Creek should be minimal. Discharge of treated groundwater must be in compliance with NPDES and TMDL requirements to maintain water quality standards. Therefore, it is not expected that any significant chemical or discharge-related impacts would occur to Frog Mortar Creek or the nearby estuarine habitat.

Because any sturgeon that may occur in the DRA vicinity would be occasional and transient, any physical and chemical impacts to Frog Mortar Creek sturgeon are expected to be minor, as little, if any, impact to sturgeon would occur as a result of project activities. While a point source discharge of treated groundwater will result from implementation of the groundwater remediation project, the overall water quality in the portion of Frog Mortar Creek adjacent to the DRA should be improved by the proposed project due to the reduction of contamination from groundwater discharge.

Several sea turtles are known to use portions of the Chesapeake Bay; however, use of the bay is typically during spring, summer, and fall when water temperatures are warm. As with the

shortnose and Atlantic sturgeon, sea turtle occurrence in Frog Mortar Creek adjacent to the DRA is most likely transient; so little if any impact to its estuarine habitat is expected. MAA will finalize consultation with NMFS to determine the nature and extent of any effects to sturgeon and sea turtle species prior to implementing the proposed action. However, it is expected that NMFS will concur with the above determination of "no effect" or "may effect, but not likely to adversely affect" these species.

**Bald Eagle —** The existing bald eagle nest located 1,500 feet north of the DRA is outside the standard distance of 660 feet that is defined as the distance at which potential disturbance to nesting can occur. Given the distance from the nest, construction activities in the DRA would not affect the eagle nest or nesting behavior. In addition, operation of the groundwater plume treatment facility would include only low level noise, little or no air emissions, and minimal human activity. Therefore, operation of the facility would also have no effect on the eagle nest.

Trenching of utilities during construction along Lynbrook Road has the potential to disturb nesting bald eagles, because the road is less than 100 feet from the nest. However, construction activity will not take place during the nesting/fledgling season (time of year restriction) in accordance with the National Bald Eagle Management Guidelines, to avoid disturbance to the nesting pair. Therefore, no impact to nesting bald eagles is expected from proposed utility construction work.

Only a minor increase in the number of vehicles traveling along Lynbrook Road will occur during facility operation. A small amount of vehicle traffic already occurs on Lynbrook Road, and any additional vehicles will include only transport and delivery vehicles. Therefore, no impact to nesting bald eagles is expected due to the minor increase in traffic along the existing road.

The nesting bald eagle pair likely forages in Frog Mortar Creek and nearby Middle River and the Chesapeake Bay. Therefore, construction and operation of the outfall discharge has potential to affect foraging eagles. However, because construction is temporary, will use best management practices, and will take place over a relatively small portion of the available foraging habitat in Frog Mortar Creek, construction is expected to have little or no effect on eagle foraging habitat and prey species in the area. In addition, operation of the outfall discharge will comply with the appropriate NPDES discharge permit, thereby minimizing any negative impact on water quality

and prey species. In fact, it is expected that the outfall discharge from the treatment facility will actually improve water quality in Frog Mortar Creek near the DRA. Therefore, no adverse impact to bald eagle foraging habitat is expected.

**Essential Fish Habitat —** NMFS (2004) EFH guidance provides the following definition of adverse effects:

"Adverse effect means any impact that reduces quality and/or quantity of EFH, including direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality and/or quantity of EFH. Adverse effects to EFH may result from actions occurring within EFH or outside of EFH and may include site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810(a))."

Potential impacts to EFH are limited to direct physical disturbance of tidal bottom habitat and indirect effects of increased sedimentation due to installation of the outfall discharge. The physical size and footprint of the outfall discharge would eliminate a small (approximately several hundred square feet) area of shallow bottom habitat in comparison to the amount of existing bottom habitat found in Frog Mortar Creek. In addition, increases in sedimentation would be minimal based on the use of BMPs.

A letter to the NMFS requesting scoping on the EA including coordination and review of potential effects on EFH was sent to the NMFS on April 14, 2013. Currently, no response has been received from NMFS regarding issues or concerns related to potential effects on EFH from the proposed action.

### 5.7.9 Rare, Threatened and Endangered Species - Impact Potential – No Action Alternative

Because the no action alternative would leave the site in its current condition there would be no impacts associated with stormwater runoff, installation of the outfall discharge, and no discharge of treated groundwater to nearby estuarine habitat would occur. However, the contaminated groundwater plume would continue to migrate toward Frog Mortar Creek, thereby reducing the quality of the aquatic system in the vicinity of the DRA for these sensitive species.

### 5.7.10 Rare, Threatened and Endangered Species - Mitigation Measures

As stated above, time of year restrictions will be used for construction on Lynbrook Road and stormwater management and in-water construction BMPs will be employed to reduce or eliminate sediment migration into Frog Mortar Creek during construction and operation of the remediation facility. In addition, treated groundwater discharges will comply with all conditions and requirements of an MDE NPDES permit, thereby maintaining water quality standards. Therefore, no significant or adverse effects are expected to threatened and endangered species, bald eagle, and EFH.

## 5.8 FLOODPLAINS AND FLOODWAYS

Executive Order 11988 directs federal agencies to take action to avoid/minimize the risk of flood loss; to minimize potential flood impacts of floods to human safety, health, and welfare, and to restore and preserve the natural and beneficial values served by floodplains. Agencies are required to make a finding that there is no practicable alternative before starting an action that would encroach the base 100-year floodplain. Impacts to the 100-year floodplain can occur in two forms: directly through the changes to volumetric capacity of the floodplain, or indirectly through an increase in the total volume of water arriving at, and being conveyed by, the floodplain.

### 5.8.1 Impact Potential – Preferred Alternative

State and federal properties in the State of Maryland are not mapped by Federal Emergency Management Agency (FEMA); therefore, the FEMA national flood insurance rate maps (FIRM) for the Middle River area do not show specific floodplains at MTN. Coordination with MDNR indicated that MTN is located within the Middle River tidal floodplain. According to the Baltimore County Department of Public Works, the 100-year floodplain elevation for Middle River is approximately 9 feet above msl. While the airport property is not specifically included on FIRM maps, a review of these maps was conducted to identify the surrounding floodplain locations. The proposed limits of disturbance for the proposed project was compared to floodplain limits to determine the extent of encroachment, and the only floodplain encroachment anticipated involves a small portion of the Frog Mortar Creek tidal floodplain that will be impacted by installation of the outfall discharge pipe.

Discharge of treated groundwater is a necessary component of the proposed action, and discharging to Frog Mortar Creek is the only feasible discharge location. Every attempt to minimize impacts to the creek will be made during final design. Placement of fill will not be expected below the floodplain boundary; therefore, no changes to floodplain elevation are anticipated. Final grades for the outfall discharge pipe grading and associated installation within the floodplain will be maintained at existing elevations to the maximum extent practicable, thereby minimizing potential impacts to 100-year flood elevations.

### 5.8.2 Impact Potential – No Action Alternative

With implementation of the No Action Alternative, no development would occur; therefore, there would be no impact to floodplains.

### 5.8.3 Avoidance, Minimization, and Mitigation Measures

**Avoidance and Minimization Measures —** While floodplains in the study area are tidal, and are therefore not formally regulated under either Section 404 of the CWA or MDE regulations associated with alteration of wetlands, waterways, or floodplains, the preferred action alternative avoids floodplains in the project area to the maximum extent practicable. The treatment plant, parking area, and the vast majority of the well pads and infrastructure have been intentionally placed outside of floodplain boundaries to avoid and minimize impacts to these resources. Remaining impacts associated with the main access road are unavoidable due to the need for widening the existing road for safety/emergency vehicle traffic and because no other access to the site exists. The remaining impacts associated with the well pad locations is likewise unavoidable due to the physical limitations of the site and the need to locate the wells where groundwater flow modeling indicates is necessary to provide capture of migrating groundwater. Finally, the remaining impacts resulting from installation of the outfall discharge pipe are unavoidable due to the need for the pipe to discharge to Frog Mortar Creek to allow for proper mixing with ambient water and to comply with the requirements of the expected NPDES permit for the project. In addition, all remaining impacts to floodplain areas will be minimized through use of best management practices to be implemented under an approved MDE erosion and sediment control and stormwater management plan.

**Mitigation Measures —** Anticipated impacts to floodplains are not considered a significant encroachment, as there is no likelihood of loss of human life, no adverse effect on the safe

operation of the airport, and no notable adverse effect on the natural and beneficial value of the floodplain. Also, any impacts to the floodplain will be confined to MAA-owned property. Therefore, no mitigation is expected to be required by the CAC or other relevant agencies.

## 5.9 HAZARDOUS MATERIALS, POLLUTION PREVENTION, AND SOLID WASTE

As described in Section 1.0, groundwater and soils in the DRA are contaminated by VOCs, petroleum hydrocarbons, 1,4-dioxane, and heavy metals. Contaminated groundwater also appears to be migrating off-site into Frog Mortar Creek. A complete summary of hazardous materials found in soil and groundwater in the DRA can be found in Section 1.0. An RI report and accompanying human health risk assessment (HHRA) and ecological risk assessment (ERA) was prepared in 2010 to summarize the results of the investigation and identify specific COC (Tetra Tech 2012b); The RI was reviewed and approved by MDE, a summary of the RI results follows:

- DRA groundwater is impacted by a range of chemicals of concern associated with former nearby industrial operations, including: chlorinated volatile organic compounds (cVOCs) such as trichloroethene (TCE), *cis*-1,2-dichloroethene (*cis*-1,2-DCE), and vinyl chloride (VC) all exceeding United States Environmental Protection Agency (USEPA) federal maximum contaminant levels (MCLs) and Maryland groundwater cleanup standards.

- 1,4-Dioxane is at relatively high concentrations based on current USEPA guidance.

- Concentrations of the metals cadmium, chromium, lead, and mercury in groundwater exceed USEPA MCL and Maryland groundwater cleanup standards in some samples.

- Concentrations of benzene, toluene, ethylbenzene, and xylene (BTEX), associated with petroleum constituents in groundwater, exceed USEPA MCLs and Maryland groundwater cleanup standards in some samples.

- Total petroleum hydrocarbons-diesel range organics (TPH–DRO) total petroleum hydrocarbons-gasoline range organics (TPH-GRO) in groundwater exceed Maryland standards in the upper surficial aquifer

As described in the RI report, contamination of soil and groundwater currently exceeds certain state/federal criteria. The immediate remedial focus that is represented by the Preferred Alternative is to mitigate potential human exposure due to the apparent migration of contaminated groundwater into Frog Mortar Creek. Potential alternatives for addressing other

impacted media in the DRA will be evaluated in a feasibility study currently scheduled for completion in 2015.

FAA Order 1050.1E, Change 1 requires consideration of a pollution prevention plan for actions that involve hazardous materials and solid wastes. Federal, state, and local laws strictly regulate the handling and disposal of hazardous substances and hazardous materials. Currently, no facilities or operations occur within the DRA. While no waste is normally generated at the DRA, site investigation activities do generate wastes (groundwater from well sampling activities, soil cuttings from soil borings, decontamination fluids, etc.) that are containerized, characterized, and properly disposed of off-site. Occasionally some of this waste is characterized as hazardous in accordance with RCRA.

Solid waste will also be generated during the operation of the treatment plant. Solid waste will be produced during the pre-treatment process, where filtration will remove inorganics (metals) and suspended solids. The resulting sludge generated by the pre-treatment process will be thickened and dewatered, and dewatered solids will be characterized for appropriate off-site disposal in accordance with all applicable state, federal, and local laws at an MDE approved disposal facility. The solids will be primarily iron, but will also include other metals removed from the treated groundwater. If the solids are characterized as hazardous, they will be managed as described above. Should they be non-hazardous, they will be managed as described in Section 5.9.4. Waste characterization will not be possible until the treatment facility begins operation. The expected volume of solid waste generated during the pre-treatment process is approximately 12 cubic feet (CF) per day, or approximately 3 CY per week.

### 5.9.1 Impact Potential – Preferred Alternative

While the proposed project is intended to remediate groundwater contamination at the site, potential impacts could result if construction activities disturb existing hazardous materials or contaminated soil, causing them to be released into the surrounding environment. However, best management practices will be used to contain soils in place to the maximum extent practicable under an MDE approved erosion and sediment control plan. Also, an approved construction stormwater permit will be obtained from MDE that will include measures for treatment and/or containment and disposal of stormwater runoff that comes into contact with contaminated soils. Plans will be in place to ensure any spills that occur during construction or any waste that is

generated are properly managed to prevent impacts. Appendix B provides a description of the consultation and coordination with MDE's erosion and sediment control and stormwater management divisions that has been conducted as part of the development of this EA. MAA will continue to coordinate with MDE during the erosion and sediment control and stormwater permitting process to implement proper mitigation measures and to gain permit approval for this activity, thereby ensuring that impacts on the environment associated with soil disturbance are reduced to a level below significance.

Impacts could also occur via introduction and use of hazardous materials (sulfuric acid, caustic, and hydrogen peroxide) associated with the operation of the treatment facility. Estimated monthly chemical requirements are approximately at 3,000 gallons for caustic, 400 gallons for sulfuric acid, and 1,500 gallons for hydrogen peroxide.

The use and volume of these hazardous materials could increase the risk of accidental spills or leaks, resulting in the release of these products into the environment. Procedures such as ensuring proper equipment maintenance and functionality, best management practices such as containment and double-walled tanks, containing or treating, as necessary, on-site stormwater during construction, developing standardized operating procedures for material handling and storage, and providing spill prevention and control measures will greatly reduce the likelihood of any potential releases.

Pollution prevention, in accordance with the Federal Pollution Prevention Act, involves source reduction, and recycling, treating, and disposing of materials in an environmentally safe manner. Maryland regulations support reduction, recovery, and re-use practices to reduce the generation of hazardous materials [COMAR 14.14.05B(1)].

The proposed project will have requirements for the handling of hazardous wastes. Prevention methods may include, but are not limited to, oil spill prevention (40 CFR 112) and stormwater discharge (COMAR 26.08.04). Construction requires documentation that all hazardous materials will be disposed of in accordance with local, state, and federal requirements. In addition, construction contracts and plans will require appropriate measures that protect the health and safety of all employees involved with the proposed improvements. Environmental hazards may require contractors to have additional training or certification (such as Occupational Safety and Health Act [OSHA] hazardous material worker training), and specialized equipment.

Worker certification, and specialized personal protective equipment, particularly when disturbing soil and working with groundwater in the DRA, may also be needed.

### 5.9.2 Impact Potential – No Action Alternative

The no action alternative does not involve the construction of any new facilities within the DRA, nor does it affect the operational characteristics of the MTN. Therefore, it would have no impact on the existing hazardous waste and solid waste in the DRA. Existing wastes would remain in place, and contaminated groundwater would continue migrating into Frog Mortar Creek.

### 5.9.3 Avoidance, Minimization, and Mitigation Measures

All hazardous materials and wastes will be managed in accordance with applicable state and federal regulations and guidelines to avoid and minimize associated impacts. In addition, solid waste generated during construction and during the treatment process will be disposed of at an appropriate facility designated by the state for disposal of such materials. The MAA Division of Environmental Compliance must be consulted before construction on contaminated soils begins to determine if any mitigation measures will be needed for site development.

### 5.9.4 Solid Waste/Pollution Prevention

Solid waste will also be generated during the operation of the treatment plant. Solid waste will be produced during the pre-treatment process, where filtration will remove inorganics (metals) and suspended solids. The resulting sludge generated by the pre-treatment process will be thickened and dewatered, and dewatered solids will be characterized for appropriate off-site disposal at an MDE approved disposal facility. The expected volume of solid waste generated during the pre-treatment process is approximately 12 cubic feet (CF) per day, or approximately 3 CY per week.

In addition, activated carbon will need to be periodically replaced. This will include approximately 6,000 pounds per year of liquid-phase activated carbon and approximately 5,000 pounds of vapor phase carbon every nine months. Carbon waste will be disposed of at an approved regeneration or disposal facility.

Other solid waste will include standard office and bathroom trash including paper, boxes, and other similar rubbish. The volume of this material is expected to be approximately 1 CY per week. This material will be disposed of at the local municipal facility or will be recycled.

The operation of the Proposed Action once constructed, would not generate a significant amount of solid waste compared to solid waste already generated by adjacent airport operations and would therefore not burden either the local municipal landfill or the approved disposal facility to be used for disposal of hazardous solid waste.

During construction, the developer/contractor will use disposal methods in accordance with state and local regulations. Any solid waste generated from the project will be temporary and relatively minor and will be properly disposed of at a permitted solid waste facility, or recycled, if possible and would therefore not burden the permitted solid waste facility. MAA will advise the selected developer/contractor to consider Executive Order 13514, *Federal Leadership in Environmental, Energy, and Economic Performance,* during construction and implementation of the Proposed Action. The Order sets forth Federal energy requirements in several areas and states that Federal agencies should enhance efforts toward sustainable buildings and communities.

## 5.10 HISTORIC AND ARCHEOLOGICAL RESOURCES

The Maryland Historical Trust (MHT) was consulted in order to document historic resources within the project's area of potential effect (APE). Coordination with the MHT indicated that no listed historic properties (or properties eligible for listing) on the National Register of Historic Places (NRHP) occur within the DRA APE (see Appendix B). In addition, based on extensive historic and archaeological investigations conducted at the airport, only two nearby sites are currently eligible for listing in the NRHP: the Glenn L. Martin Airport and Glenn L. Martin production plant. Both of these sites and properties occur outside the DRA APE, and would therefore not be affected by the proposed project. MHT indicated on April 30, 2014, that the project will have no adverse effect on historic properties (see Appendix B).

## 5.11 LIGHT EMISSIONS AND VISUAL EFFECTS

The proposed project would include only standard lighting associated with a business or commercial building, with no high intensity lighting being required. In addition, the treatment facility and its outdoor lights are not expected to be directly visible to the surrounding area, as the facility would be mostly surrounded by forest, and its height will not exceed 30 feet above ground surface at the roof peak. Light fixtures will use standard shielding to direct lighting to

target areas and minimize light emissions to the surrounding region. Given that much of the surrounding area consists of residential and commercial development, the proposed development would add little to the existing light emissions in the area and would not detract from the area's visual quality.

## 5.12 NATURAL RESOURCES, ENERGY SUPPLIES, AND SUSTAINABLE DESIGN

Energy requirements associated with the proposed project normally fall into two categories: those related to increased consumption from stationary facilities (i.e., buildings that require heating, cooling, and other energy consuming systems), and those involving substantial increases in ground vehicle movement and their related fuel consumption. Direct and indirect increases in energy consumption caused by the planned remediation project are not anticipated to be significant, and would be accommodated by the regional power supply company and the extension of existing utility lines. The proposed project would not involve the use of any unusual or scarce materials and/or resources. In addition, there are no known deposits of valuable natural resources located on or in the vicinity of the DRA that would be affected by the proposed project. In addition, MAA will advise the selected contractor to consider Executive Order 13514, *Federal Leadership in Environmental, Energy, and Economic Performance,* during construction and implementation of the Preferred Action. The order sets forth federal energy requirements in several areas and states that Federal agencies should enhance efforts toward sustainable buildings and communities.

## 5.13 NOISE

FAA policy (FAA, 2006a) dictates that a complete noise analysis must be completed for general aviation activities involving use or increases in aircraft operations, runway improvements, and helicopter traffic. Because the proposed project would not involve any of these activities, a noise analysis is therefore not required.

However, noise from non-aviation sources must also be considered for purposes of cumulative impacts analyses. Those noise sources include, but are not limited to, project-related construction activities and/or surface transportation in the project area. To determine surface transportation impacts, the Federal Highway Administration's (FHWA) *Procedures for Abatement of Highway*

*Traffic Noise and Construction Noise* (23 Code of Federal Regulations [CFR] Part 772) was used (FHWA, 2011).

FAA Order 1051.1E defines noise impacts associated with build alternatives as being significant if they cause noise sensitive areas to experience an increase of 1.5 decibels (dB) or more in day-night Average Sound Level (DNL), at or above the "acceptable" 65 dB DN. Noise associated with construction of the proposed remediation facility would be temporary and cause only minor increases in noise. Noise sources during operation of the remediation facility would include groundwater and treatment pumps and other electrical equipment; however, generated noise would mostly be contained within the treatment building and would therefore be well below the threshold of significance, and would not contribute to a measurable increase over current background noise levels.

Also, because the DRA is located in a portion of MTN where no potential noise receptors or residential areas are located, noise levels associated with implementing the preferred alternative at the DRA are not expected to produce unacceptable noise levels.

## 5.14 INDUCED SOCIOECONOMIC IMPACTS

As stated in FAA Order 1050.1E, Change 1, Appendix A, Section 15, induced socioeconomic impacts are normally not significant unless there are also significant impacts in other categories, especially with regard to noise, land use, or direct social impacts. Implementing the proposed remediation project at the DRA would not affect existing noise (see Section 4.12) or land use (see compatible land use section above) and would lead to only minor social impacts. Therefore, no affect is expected resulting from induced socioeconomic impacts.

## 5.15 SOCIAL IMPACTS AND CHILDREN'S HEALTH AND SAFETY

The analysis of socioeconomic impacts evaluates the proposed project's effects on the social and economic characteristics of affected communities. An analysis of significant potential socioeconomic impacts was performed using the following guidelines as thresholds:

- The project causes extensive relocation of the population, but sufficient replacement housing is unavailable

- The project causes extensive relocation of community businesses that would cause severe economic hardship for affected communities
- The project causes a disruption of local traffic patterns that substantially reduces the level of service of roads serving the airport and its surrounding communities
- The project causes a substantial loss in community tax base

An analysis of potential socioeconomic impacts was performed to determine whether the proposed projects would cause relocation of residences without sufficient available replacement housing; extensive relocation of community businesses creating a severe economic hardship for the community; disruption of local traffic patterns that would substantially reduce the Level of Service of roads serving the Airport and its surrounding communities; or a substantial loss in community tax base.

In addition, the analysis also considered potential effects on children's health and safety. Executive Order 13045, *Protection of Children from Environmental Health Risks and Safety Risks*, defines the risks to children's safety as those risks that are attributable to products or substances that the child is likely to touch or ingest. Per FAA's *Environmental Desk Reference for Airport Actions*, environmental documents should assess project-related impacts such as the generation of substances with the potential to have a disproportionate effect on children's environmental health or safety.

### 5.15.1 Impact Potential – Preferred Alternative

The proposed project will not cause the relocation of residences; disruption of local traffic patterns that would substantially reduce the service level of roads in the airport vicinity and its surrounding communities; or a substantial loss in community tax base. No residential or commercial areas, other than the airport itself, are adjacent to the DRA. In addition, the proposed project will not generate significant levels of noise, or visual or ecological impacts that could affect nearby communities. Implementation of the proposed action should actually enhance the water quality of Frog Mortar Creek, a water body used for local recreation. Therefore, the project will not cause the relocation of residences, land acquisition, or a subsequent loss in the community tax base.

The existing road (Lynbrook Road) that links the DRA with the surrounding airport and off-airport road system will see only a minor increase in traffic during facility operation. These increases would include:

- four to five standard personal vehicles or work trucks per day
- FedEx/United Parcel Service type delivery trucks twice a week,
- medium-sized chemical delivery and carbon change-out trucks thrice a month
- drill rigs for well redevelopment once a quarter (includes access to wells)
- provision for emergency vehicle access (fire trucks)

The proposed action also includes upgrades to the south end of Lynbrook Road; the current dirt road will be upgraded to accommodate the vehicle traffic described above. Because this increase in vehicle traffic would be minor, particularly in proportion to the expected increase in vehicle traffic as part of MDANG's plan to make this a main entrance/exit road for their operations, implementation of the proposed action will not significantly add to or disrupt local traffic patterns on airport service roads and roads in the surrounding communities.

***Children's health and safety risk*** **–** The proposed project would not expose children to be in contact with or ingest substances that would affect their health and safety. In fact, the proposed project would reduce the potential for children to be exposed to toxic substances by containing the migration of existing contaminants in groundwater in the DRA to Frog Mortar Creek.

### 5.15.2 Impact Potential – No Action Alternative

Because the No Action Alternative does not involve the construction, modification, or relocation of any new or existing facilities; it does not affect aircraft operation. In addition, no land acquisition would be required. Therefore there would be no socioeconomic impacts attributable to the no action alternative, although water quality would remain unchanged and the water quality advisory would remain in effect, which may continue to adversely affect recreational activities (e.g., jet skiing and boating) and users associated with the local marinas and residents.

## 5.16 WATER QUALITY

### 5.16.1 Impact Potential – Preferred Alternative

A segment of the unnamed tributary stream located within the DRA, as well as a small area below the mean high water line (tidal boundary) of Frog Mortar Creek will be impacted by the proposed project. Widening of the existing access road where it crosses the unnamed tributary requires removing and replacing the existing culvert and realigning the stream channel. These impacts will alter the stream channel, potentially altering hydrology at the site, and its upstream and/or downstream locations. Hydrological changes may destabilize the channel and stream banks, increase erosion and sediment loads in the stream, and affect downstream water quality and aquatic habitats that support macroinvertebrates and fish.

Approximately 30 linear feet of the unnamed tributary stream in the DRA will be affected by widening the existing roadbed from eight to 20 feet. Road widening will include removing the existing 36-inch RCP culvert and replacing it with a bottomless box culvert. The unnamed tributary is an intermittent/ephemeral stream that ranges in width from four to 12 feet; depths range from zero inches during dry periods to several inches during runoff events. The unnamed tributary mostly runs perpendicular to the existing roadbed, but parallels the road for a short distance south of the crossing. The use of best management practices including silt fencing will be employed to reduce sedimentation in the channel during construction. In addition, a bottomless box culvert helps to maintain a more natural stream bottom and hydrologic regime. Small swale wetlands adjacent to the stream channel will be impacted by road widening at and near the stream crossing. A more detailed description of wetland impacts is in Section 5.17.

Construction and placement of the proposed six-inch outfall discharge pipe in Frog Mortar Creek will impact a relatively small area below the mean high water (tidal) line. Introducing treated groundwater from a point discharge at this newly constructed outfall could destabilize the channel and banks, impact tidal bottom habitat, increase sediment loads and turbidity. This discharge will require compliance with National Pollutant Discharge Elimination System (NPDES) and TMDL requirements for Frog Mortar Creek.

A maximum of 80 linear feet of six-inch pipe and bottom anchoring will be placed below the mean high water line of Frog Mortar Creek. The total width of the pipe and bottom anchoring

system is not expected to exceed 10 feet. Pipe will be placed in Frog Mortar Creek at a level that is at least one-foot under water at low tide. Pipe will be installed on a marginally abrupt section of shoreline; no emergent or other wetlands extend below the mean high water line in this area. Also, a cofferdam or Portadam™ will be used during construction to greatly reduce any sedimentation of the water column around the installation area. In addition, operation of the outfall will result in a reduction in the amount of contamination flowing into Frog Mortar Creek via groundwater.

Small portions of non-tidal wetlands V, W, and NN (see Figure 4-7) will be impacted by access road widening and well installation. These impacts will reduce the typical functions and values of wetlands of this type, including attenuation of sediment loads and runoff, groundwater recharge, and wildlife habitat. An analysis of the impacts to wetlands is found in Section 5.17.

Approximately 3.5 acres of ground disturbance within the 25 acre study area (LOD) are required to grade and construct the facility and infrastructure for the proposed action. Temporary impacts to water quality during construction may occur due to stream diversion, erosion, or vegetation removal. An additional one acre of impervious surfaces will be added to the DRA after construction is completed, resulting in increased runoff. Stormwater treatment will be required for the increased impervious area including the treatment plant, parking area, and access roads and to address any TMDL requirements that will be imposed. As described in Section 3.2.5, stormwater management of traditional site development areas (building and asphalt) will include non-rooftop disconnects (filter strips), bioretention, grass swales, and a storm sewer system that will discharge to a swale that is part of the existing MTN stormwater management system.

Table 5-4 presents the proposed impacts to existing streams, including the tidal portion of Frog Mortar Creek. Impacts to existing streams and tidal areas will be refined and minimized to the extent practicable during the final design of the project.

### 5.16.2 Impact Potential – No Action Alternative

Because this alternative does not involve construction, modification, or relocation of any new or existing facilities within the DRA, there would be no water quality impacts associated with these construction activities; however, there would be no reduction in contamination entering Frog

Mortar Creek from the DRA or the contamination's associated impacts on the aquatic environment.

### 5.16.3 Avoidance, Minimization, and Mitigation Measures

The FAA *Environmental Desk Reference for Airport Actions* (FAA, 2007a) defines an action significant when it has the "potential to exceed water quality standards, there are water quality problems that cannot be avoided or satisfactorily mitigated, or there would be difficulty in obtaining a permit or authorization, there may be a significant impact".

Pursuant to Section 404 of the Clean Water Act (CWA) and the Maryland Nontidal Wetlands Protection Act, a Joint Federal/State Permit for the Alteration of any Floodplain, Waterway, Tidal or Nontidal Wetland in Maryland will be obtained from the United States Army Corps of Engineers (USACE) and MDE before any surface water resources are disturbed. The permitting process ensures that water quality concerns are addressed, and that mitigation plans, if required, are incorporated into the final design of the proposed project.

The Maryland Aviation Administration (MAA) has been coordinating with the USACE and MDE regarding the proposed project and has been seeking continued guidance and support through the Section 404 permitting process of the CWA (as amended) for unavoidable impacts to wetlands and waters of the United States (see Appendix B). MAA anticipates obtaining authorization or this project under the Maryland State Programmatic General Permit (MSPGP-4). No compensatory mitigation under Section 404 of the CWA is anticipated, because impacts to streams and wetlands are limited.

Work within Frog Mortar Creek will be restricted to certain times of year to protect the spawning and nursery periods of migratory fish. Generally, no in-stream work is permitted by MDE in Use I streams between March 1 and June 15, inclusive, of any year.

Short-term construction stormwater impacts will be minimized by strict adherence to erosion and sediment control procedure. An erosion and sediment control plan will be developed during the final design phase in accordance with MDE guidelines; its implementation will avoid and/or minimize erosion and sedimentation. Appropriate drainage, infiltration, and sediment control measures will be planned and implemented to minimize disturbance to the area and reduce the

risk of contamination to water resources. All construction related stormwater planning will also comply with an MDE Construction General Permit.

Long-term stormwater impacts will also be avoided and minimized through strict adherence to the *Maryland Stormwater Management Guidelines for State and Federal Projects* (MDE, 2010b). Design of the preferred alternative will be in compliance with the stormwater management regulations (Code of Maryland Regulations [COMAR] 26.17.02) and the *Maryland Stormwater Design Manual, Volumes I and II* and its latest supplement (MDE, 2000). These regulations require the use of environmental site design (ESD) to the maximum extent practicable (MEP). The stormwater design manual details methods of providing ESD. The revised stormwater management guidelines provide the necessary information needed to submit stormwater management plans to the MDE Water Management Administration for review and approval. The guidelines also include an additional requirement: a stormwater management concept report. The project design will comply with these regulations and this will be included as part of all MDE and Critical Area stormwater permitting for the project.

Stormwater management planning will also comply with the "10% rule" for projects occurring within an intensely developed area (IDA) of the Chesapeake Bay Critical Area (Critical Area Commission [CAC], 2003). This guidance states that projects must use practices that are capable of reducing stormwater pollutant loads to a level at least 10% below the load prior to development. Long-term stormwater discharges, including the stormwater discharge to the existing swale located between the DRA and Taxiway T will be subject to and comply with the existing NPDES stormwater management permit for MTN.

Additionally, an NPDES permit for the point source discharge from the outfall discharge must be acquired from MDE/USEPA. Acquisition and adherence to the conditions (if any) imposed by this permit will ensure that discharges from the outfall discharge will not exceed state and federal water quality standards.

## 5.17 WETLANDS

A wetland delineation was conducted in the project area in accordance with the *United States* Army Corps of Engineers (USACE) Wetlands Delineation Manual, Technical Report Y-87-1 (USACE, 1987), and Interim Regional Supplement to the Corps of Engineers Wetland

Delineation *Manual: Atlantic and Gulf Coastal Plain Region* (USACE, 2008). The limits of the identified wetlands were then compared to the limits of disturbance for the proposed project.

### 5.17.1 Impact Potential – Preferred Alternative

Several unavoidable impacts to wetland areas and wetland buffers will result from implementation of the proposed project (Figure 5-3). Table 5-5 details the proposed impacts to wetlands and wetland buffers. For the purposes of this assessment, it is assumed that all wetlands located within the limits of disturbance (a worst case scenario) will be impacted by the proposed project, and that these impacts will be permanent. However, the final project design will use BMPs to avoid or minimize impacts.

***Unnamed Tributary Stream Crossing*** **–** The proposed project will require road widening over the unnamed tributary crossing so access to the DRA can meet construction traffic needs and local/airport safety and fire protection requirements. Impacts to the stream and adjacent wetlands will be avoided and minimized to the maximum extent practicable, so that the overall impact necessary is minimal. Total impacts would be 1,540 sf of wetland impact, 9,220 sf of buffer impact, and 30 lf of culvert replacement.

The proposed impact to the stream channel will include removal of the existing 36-inch RCP culvert and installation of an open-bottom box culvert. Thirty linear feet of the channel will be placed within the new box culvert. Impacts to the adjacent wetland and its buffer are unavoidable because the road must be widened to the required 20-foot width.

While the proposed action will increase the length of stream channel within the culvert, the use of an open-bottom box culvert will maintain a natural stream bottom and associated aquatic habitat. Also, the design of culvert system will be such that the natural hydrologic regime of the stream is maintained. While impacts such as increased sedimentation and disturbance to the riparian area will certainly occur, these impacts will primarily be temporary and will be managed using BMPs.

***Access Road South of Unnamed Tributary*** **–** The proposed project will require widening of the access road to meet construction traffic needs and local/airport safety and fire protection requirements. Impacts to the wetland buffer adjacent to the existing road will be avoided and minimized to the maximum extent practicable, so that the overall impact is minimal. The

proposed impact to the wetland buffer will include grading/filling approximately 600 sf, a relatively small portion of the outer perimeter of the Wetland W buffer. Although a portion of the wetland buffer will be affected, the wetland area itself will not be disturbed. Impacts to the Wetland W buffer will be managed using BMPs.

***Well Installation Area –*** The proposed project will require widening of the existing path to allow for access and installation of groundwater wells. Impacts to the adjacent wetland buffer will be avoided and minimized to the maximum extent practicable, and the overall impact to the area will be minimal. The proposed impact to the wetland buffer will include grading/filling approximately 320 sf, a relatively small portion of the outer perimeter of the Wetland NN buffer. Although a portion of the wetland buffer will be affected, the wetland area itself will not be disturbed. Impacts to the Wetland NN buffer will be managed using BMPs.

***Outfall Discharge Pipe –*** The proposed project will require installation of an 80-foot, six-inch diameter outfall discharge pipe with end diffusers and bottom anchoring system below the mean high water (tidal) line of Frog Mortar Creek. Impacts below the tidal boundary line will be avoided and minimized to the maximum extent practicable to minimize overall impact to the creek. The preferred alternative's impact on bottom habitat will be approximately 400 sf. A marker, buoy, or other aid to navigation may be placed near the discharge pipe to alert boaters to the location of this structure; a final determination of the need for this feature will be made in coordination with the United States Coast Guard (USCG). If a navigation aid is required, this feature will be employed in full compliance with USCG regulations under 33 CFR Part 66.

While the action will disturb bottom habitat, the impacts would be minor, as the overall affected footprint is small in comparison to the amount of existing shoreline habitat in the general vicinity. In addition, installation will be completed using BMPs and diffusers to minimize sedimentation in Frog Mortar Creek, and operation of the facility will be in full compliance with applicable NPDES requirements to minimize overall turbidity.

***Potential Wetland Dewatering –*** The proposed project will require installation of 16 groundwater extraction wells that may create a draw-down, or dewatering effect on the wetland area located nearest the wells (Wetland #3). De-watering could lower the water level in this wetland, and may, over time, reduce the amount of area meeting wetland criteria along the perimeter of this wetland.

An analysis for potential for dewatering of this wetland was conducted; results are provided in Appendix H. As described in the analysis, soil logs from the project area indicate that soils are mostly low permeability clays. As such, it is likely that most of the hydrology in Wetland #3 is from direct precipitation and runoff from the surrounding landscape, and that little interaction with groundwater occurs. In addition, preliminary modeling (using the assumption of 0.1 foot of dewatering to be the level of significance) found that the likely low vertical hydraulic conductivity of the sediments beneath Wetland #3 (less than $1 \times 10^{-8}$ centimeters per second) indicates that the water balance of the recovery well system will not impact the wetland (< 0.1 foot decrease). Therefore, no significant impact or reduction in wetland area would occur resulting from groundwater extraction.

### 5.17.2 Impact Potential – No Action Alternative

Because the no action alternative does not involve construction of any new facilities within the DRA, there would be no impacts to wetlands; however, groundwater contamination would continue to impact tidal wetlands.

### 5.17.3 Avoidance, Minimization, and Mitigation Measures

**Avoidance and Minimization Measures —** The preferred action alternative avoids wetland resources to the maximum extent practicable. The processing plant, parking area, and the vast majority of the well pads and infrastructure have been intentionally placed outside the boundaries of delineated wetland areas to avoid and minimize impacts to these resources. Remaining impacts associated with the main access road are unavoidable due to the need for widening the existing road for safety/emergency vehicle traffic and because no other access to the site exists. The remaining impacts associated with the well pad locations is likewise unavoidable due to the physical limitations of the site and the need to locate the wells in close proximity to Frog Mortar Creek to ensure capture of migrating groundwater. Finally, the remaining impacts resulting from installation of the outfall discharge pipe are unavoidable due to the need for the pipe to discharge to a minimum depth in Frog Mortar Creek to allow for proper mixing with ambient water and to comply with the requirements of the NPDES permit for the project. In addition, all remaining impacts to wetland areas will be minimized through use of best management practices to be implemented under an approved MDE erosion and sediment control and stormwater management plan.

**Mitigation Measures —** Pursuant to Section 404 of the CWA and the Maryland Tidal and Nontidal Wetlands Protection Acts, a Joint Federal/State Permit for the Alteration of any Floodplain, Waterway, Tidal or Nontidal Wetland in Maryland must be obtained from the USACE and MDE before any wetland resources are disturbed. The permitting process will ensure that proper avoidance, minimization, and mitigation requirements are addressed, and will ensure that all measures to avoid and minimize impacts are incorporated into the final design of the proposed project.

MAA has been coordinating with both MDE and USACE to identify impacts to wetland resources and determine the appropriate level of mitigation for these impacts for compliance with Section 404 CWA and MDE Tidal and Non-tidal Wetland Protection Act requirements. Appendix B provides a description of the agency consultation and coordination efforts conducted as part of the preparation of this EA, which have included conducting an initial agency scoping meeting to gain early feedback on proposed project plans, as well as a subsequent Joint Evaluation Committee meeting to review specific design details and resource impacts. Based on this coordination, it is anticipated that the project will meet criteria for coverage under MSPGP-4. This general permit applies to projects that have relatively minimal impacts to waters of the United States and the state of Maryland.

MAA will continue to coordinate with the appropriate agencies to finalize avoidance and minimization measures, develop a final, detailed mitigation plan to offset anticipated impacts, and ensure compliance with all wetland protection acts. Implementation of, and adherence to the final MDE/USACE approved avoidance/minimization measures and mitigation requirements will ensure that impacts resulting from the preferred action alternative are offset and are therefore below significance. It should be noted that mitigation of impacts to wetland resources will be conducted off-site to avoid creation of wildlife attractants in accordance with *FAA AC 150/5200-33B, Hazardous Wildlife Attractants On or Near Airports* and will be accomplished by planting, preservation, in lieu fee, or a combination of these measures. As all of the proposed impacts to wetlands and their associated buffers are considered to be minimal and qualify for coverage under the MSPGP-4 and/or can be adequately mitigated to meet USACE and MDE requirements, wetland impacts are not considered significant. The resulting function and value loss of the proposed impacts will either meet *de mimimis* criteria, or will be offset through mitigation, and will be subject to approval of the appropriate regulatory agencies.

## 5.18 WILD AND SCENIC RIVERS

There are no federal- or state-designated or potentially eligible wild and scenic rivers in the vicinity of MTN. The Severn River, located over 20 miles southeast of MTN, is the closest state-designated scenic river. The relatively small physical footprint of the proposed remediation facility would not affect the visual, scenic, or recreational values of this river. The Severn River is located in a separate watershed from MTN, so the proposed remediation project would neither positively or negatively impact water quality in this river system. Therefore, the proposed project would have no effect on any federal or state protected wild and scenic rivers.

## 5.19 SUMMARY OF POTENTIAL NATURAL RESOURCE IMPACTS

The potential environmental impacts for each proposed project element and the Sponsor's Preferred Alternative have been discussed in detail in this section. Table 5-6 provides an overview of the proposed impacts to streams, forests, floodplains, wetlands, and wetland buffers associated with the preferred alternative. The proposed impacts to these resources will be mitigated in coordination with the appropriate Federal and State agencies during the permit process.

## 5.20 CUMULATIVE IMPACTS

In accordance with Council of Environmental Quality (CEQ) regulations (Title 40 CFR Part 1508.7), this EA was prepared to consider both the direct and cumulative impacts of the preferred action alternative as well as other reasonably foreseeable projects in the area of MTN. Cumulative impacts represent the "impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time

The analysis of cumulative impacts has been limited to an evaluation of potential projects occurring within the DRA and immediately adjacent and contiguous portions of MTN for a distance of 500 feet from the DRA boundary. The rationale for this cumulative effects study area boundary is based on the range and extent of potential impacts on the affected environment from

the proposed action, which are limited primarily to physical disturbance of the immediate landscape. Little, if any, effects of the project (such as impacts on visual or air quality) would extend beyond the boundaries of the DRA.

### 5.20.1 Cumulative Projects

This section describes those environmental resources or impact categories (as described in Sections 5.1 – 5.18) that could potentially be impacted by cumulative projects (past, present, and reasonably foreseeable actions).

A review of several information sources (noted in the individual discussions below) was conducted to determine past, present, and reasonably foreseeable development actions at MTN and surrounding areas. This review identified potential improvement projects. The information sources included the project description for the environmental assessment for Phase I development projects at MTN (in process), which depicts proposed development at the airport and MDANG's description of proposed projects for a supplemental EA (in process). Other sources of information included contacting the Baltimore County Planning and Public Works Departments to identify any upcoming County Capital Improvement projects.

The analysis of cumulative impacts in this EA considered the potential impacts of the proposed project and other development actions on the airport property that are related in terms of time or proximity

### 5.20.2 On-airport Projects

MAA continuously manages the planning, design and construction of various airport projects at MTN to improve the functionality of the airport as well as maintaining its economic vitality. Currently proposed projects are identified in the Environmental Assessment for Phase I Development Projects at Martin State Airport that is currently being prepared by MAA. Airfield projects identified in that EA are designed to improve the functional use and geometry of runways, taxiways, and holding aprons; lighting, marking, and signage of runways and taxiways; navigational aids (NAVAIDs); visual approach aids, instrument approach procedures, and Federal Aviation Regulation (FAR) Part 77 obstructions. General aviation and support facility projects identified in the Phase I Development Projects EA are designed to provide additional aircraft hangars and improved aircraft traffic control facilities. Landside facility/land use projects

identified in the EA are designed to improve airport infrastructure and parking facilities and remove identified Part 77 related obstructions.

As part of the Phase I Development Projects, several areas of tree clearing will occur within and along the border of the DRA adjacent to Taxiway T. Tree clearing in this area is primarily due to the relocation of certain NAVAIDS including the glide slope and automated weather observing system (AWOS) station. Relocation of the glide slope requires a cleared critical surface in which to operate, and the AWOS will require tree clearing in order to function properly. Also, tree clearing in this area includes Part 77 obstruction removal to clear transitional surfaces for both the runway and taxiway. Relocation of the NAVAIDS is necessary to comply with the FAA Advisory Circular 5300-13A.

In addition to MAA, MDANG currently has a lease on a portion of MTN property and operates military facilities on site. MDANG projects currently proposed include developing an Intelligence/Reconnaissance and Surveillance Facility, expanding existing roads and parking areas, and construction of flight simulator, vehicle inspection, and warehouse buildings. Table 5-7 contains a list of recently completed and future projects in order to qualitatively assess potential cumulative impacts.

### 5.20.3 Potential Cumulative Impacts

The following is a qualitative assessment of environmental resources and impact categories in which the potential for cumulative impact associated with the projects described previously is considered along with the proposed action. These categories include air quality; compatible land use; construction; fish, wildlife, and plants; floodplains; water resources, and wetlands. These categories were chosen based on the nature of the proposed activities and the resources that may be affected.

#### 5.20.3.1 Air Quality

The total amounts of air emissions within the DRA and surrounding airport are not expected to increase appreciably with or without the proposed remediation project. This outcome is largely attributable to the fact that overall air traffic is not expected to greatly increase over the next several years (MAA, 2013). Also, no additional significant emissions sources are planned at the airport. In general, most increases in air emissions at the airport over the next several years

would likely come as population continues to rise along with an accompanying rise in motor vehicle traffic. Therefore, the minor air emissions resulting from the proposed remediation project combined with little additional new emission sources planned in the vicinity would not have a significant cumulative impact on air quality.

### 5.20.3.2 Compatible Land Use

The proposed remediation project along with proposed future MTN and MDANG projects would not create significantly incompatible land uses. This is primarily due to the fact that these projects would be confined to the airport with little, if any effect on surrounding land use, and the projects should be consistent with the industrial nature of current property uses. Also, proposed projects at MTN and MDANG would necessarily comply with FAA and Air National Guard (ANG) requirements for ensuring land use compatibility. Land use impacts would likely occur from off-airport land development projects; however, no major projects appear to be currently planned. Also, for any off-airport projects that may be planned or proposed in the near future, it is expected that these cumulative projects would comply with the land use and transportation goals of Baltimore Counties Development Plan which would reduce the potential for significant land use impact.

### 5.20.3.3 Construction

Overall, construction of the cumulative projects would have a moderate potential to result in significant construction impacts. In general, construction activities associated with the cumulative projects at MTN would consist of land clearing, roadway and building construction, mostly occurring during daylight hours. Impacts from construction would include increased noise from construction operations, temporary minor increase in water turbidity, temporary minor increase in air emissions and disposal and management of construction and/or demolition wastes. Also, not all construction activities will be taking place during the same time period.

Grading and scraping operations are the noisiest activities, with equipment generating noise levels as high as 70 to 95 dBA within 50 feet of their operations. However, distance would rapidly attenuate noise levels so area residences would only experience a slight increase in ambient background conditions.

Temporary increases in water turbidity in drainage areas could occur during the period when excavated areas are exposed prior to paving or cover stabilization. It is expected that runoff from construction projects would be minimized by BMPs that would limit sediment transport. In addition, it is expected that efforts would be made to schedule construction operations to minimize the exposure of excavated areas and re-vegetate them as soon as possible after grading and all work will include employing an MDE accepted erosion and sediment control plan.

Construction equipment emissions and fugitive dust pollution from excavated areas can result in temporary impacts to ambient air quality. However, it is expected that these impacts would be minimized by the use of BMPs to minimize air quality impacts by treating excavated areas with water, and covering graded areas with stabilizing materials.

Land clearing and grading operations associated with the construction of the cumulative projects could generate air emissions, with particulate matter (dust) having the greatest potential for impact. Most of this dust would redeposit close to the source, since it is generated low to the ground. Heavy construction equipment utilized would emit exhaust that contains CO, NOx, VOCs, and PM. Temporary air quality impacts associated with these sources would vary depending on the local weather conditions, level of construction activity, and the nature of the construction operation. The types of waste generated by construction activities could include materials such excess asphalt or excess concrete washed out of mixer trucks, excess wiring, conduits, and other electrical materials, excess soil, and empty construction supply containers. These materials are not anticipated to significantly impact existing waste handling and disposal at MTN or at regional waste management facilities. During construction of the proposed remediation project additional pollution prevention measures will be implemented, as needed, to avoid or minimize any potential impacts.

The impacts discussed above would be temporary in nature, and not all projects would be carried out during the same timeframe. Temporary pollution controls employed by MAA would include limiting work activities to normal business hours; wetting of active equipment work areas; covering of all trucks hauling loose materials; use of stabilizing materials, mulch, sandbags, slope drains, sediment checks, artificial covering, and berms. All applicable local, state, and Federal environmental construction controls should be incorporated into the specifications and

construction plans necessary for the individual cumulative projects. These controls would help minimize temporary construction impacts.

### 5.20.3.4 Fish, Wildlife, and Plants

No rare, threatened or endangered plant or animal species are known to occur within the proposed project area; however, as noted above, the NMFS has indicated that two species of sturgeon and several sea turtle species have been found in the Chesapeake Bay, tidal rivers, and estuaries. It is not expected that there will be any impact on these species from the proposed remediation project. Also, based on the fact that all cumulative projects are to be carried out in terrestrial areas and that it is expected that all projects will necessarily comply with standard stormwater and erosion and sediment control requirements that no significant cumulative impacts would occur to these aquatic species.

In addition, a bald eagle nest is located north of the DRA along Frog Mortar Creek. As noted above, the remediation project is not likely to cause disturbance to the eagles due to its distance from the nest (more than 1,500 feet) and very minor changes to activity along Lynbrook Road. Also, because all cumulative projects at MTN are to be carried out under the National Bald Eagle Guidance Act and minimize and avoid disturbance, no significant cumulative impacts would occur to this species.

Additional tree clearing along the DRA border resulting from implementation of the MAA Phase I Development Projects will result in additional cumulative impact to forest resources in the cumulative effects study area by removing a relatively large proportion of the forest cover in and immediately surrounding the DRA. However, the additional clearing will represent only a relatively minor portion of the forest cover in the Middle River area and will be carried out under regulations pursuant with the Critical Area Act to minimize and/or mitigate impacts to forest resources. Also, because the DRA and surrounding area is part of an operational airport, tree cover and other wildlife attractants must be reduced when there is potential to interfere with airport safety.

### 5.20.3.5 Floodplains

The cumulative projects have a low potential to result in impacts to 100-year floodplains. Potential impacts would occur from the creation of additional impervious surface, and the

subsequent increase in stormwater runoff within the floodplains of the region. The increased stormwater runoff has the potential to flow into a floodplain. This could result in increased flooding and flood-related hazards during moderate to high-intensity storm events. However, potential floodplain encroachment associated with the cumulative projects could be avoided, and if unavoidable, mitigated, during the planning and design phases of the cumulative projects such that changes to the 100-year flood elevations would be minimized.

### 5.20.3.6 Water Resources

Implementation of the cumulative projects would result in localized, temporary impacts to water resources. These impacts would result from land clearing and temporary construction activities and primarily consist of potential increases in sediment runoff and transport, siltation, and changes in storage volumes, flow velocities and pollutant levels in receiving water bodies. All airport construction activities should adhere to the design standards and guidelines contained in state and local specifications. These standards would help minimize any cumulative water quality impacts.

As described previously, the point discharge for the proposed remediation project will discharge treated groundwater to Frog Mortar Creek and will comply with all applicable NPDES requirements to ensure that water quality standards are maintained. Therefore, it is not expected that this discharge along with the other cumulative projects will have a significant impact on surface water resources.

The cumulative projects are not anticipated to have any impact on groundwater resources or quality; however, the proposed remediation project would contain the flow of contaminated groundwater into Frog Mortar Creek.

As described previously, implementation of the proposed project would impact 30 linear feet of an intermittent tributary and 80-feet of the tidal bottom of Frog Mortar Creek. A Joint Federal/State Permit for the Alteration of any Floodplain, Waterway, Tidal or Nontidal Wetland in Maryland will be obtained from the USACE and MDE prior to the disturbance of any jurisdictional surface water resource. Along with best management practices, adherence to the Maryland Stormwater Management and Chesapeake Bay Critical Area Guidelines for State and

Federal Projects, and an NPDES permit, potential water resources impacts of the proposed remediation project and cumulative projects would be minimized.

### 5.20.3.7 Wetlands

Implementation of the preferred alternative will result in impacts to four wetlands and/or their 25-foot buffers. This includes a total of approximately 1,540 sf of impact to a non-tidal wetland, 710 sf of impact to the tidal portion of Frog Mortar Creek, and 10,190 sf of impact to the 25-foot buffer.

MAA will coordinate with the USACE and state agencies to obtain the necessary permits and certifications. Data for other airport development projects was not available to fully quantify wetland impacts in proximity to the DRA. However, each project would be subject to Clean Water Act requirements. It would be the responsibility of the project's sponsoring agency, corporation, or individual to avoid wetlands and other waters of the U.S. where possible, and where impacts are unavoidable, to minimize the impacts, and then provide mitigation for unavoidable impacts. Required mitigation would presumably result in no net loss of wetlands within the region, consistent with Federal policies. The sponsoring agency, corporation, or individual would be required to obtain the necessary Federal and/or state permits and certifications prior to the initiation of construction activities. Therefore, the potential cumulative impact to wetland resources as a result of implementing the proposed remediation project and cumulative projects is considered low.

### 5.20.3.8 Summary of Potential Cumulative Impacts

Through the use of BMPs and mitigation measures, the potential impacts of the proposed remediation project will be in accordance with all Federal, state, and local laws and regulations and therefore not result in a significant impact. As described previously, the cumulative projects would result in environmental impacts. The government agency responsible for the development of each cumulative project will be responsible for obtaining all necessary approvals and permits to minimize impacts. Based on the types of cumulative projects planned for the area surrounding MTN, MAA has concluded that the implementation of the proposed project along with the cumulative projects would not result in a significant cumulative impact.

**Table 5-1**

**Air Emissions Inventory**
**Dump Road Area, Martin State Airport**

| Emissions Source | Source area or discharge type | Emissions Factor [1] | Estimated Emissions – Pre-treatment | Control Measure | Total Emissions – Post Treatment |
|---|---|---|---|---|---|
| Construction related dust | ~ 3.5 acres of total ground disturbance during construction | 1.2 tons/per acre/per month for total suspended particulate (TSP) | 4.2 tons/month[2] | 1 ton/acre/month wet suppression | 0.7 tons/month[3] |
| Treatment Plant Emissions | Methylene Chloride from groundwater treatment process | Not applicable | <10 pounds/year | ~ 90% removal using vapor phase granular activated carbon (VGAC) | ~ 1 pound/year |

1. Based on **AP-42,** ***Compilation of Air Pollutant Emission Factors***
2. Using 3.5 (acres of disturbance) X 1.2 (emissions factor) = tons/acre/month
3. Using 3.5 (acres of disturbance) X (1.2 [emissions factor] – 1.0 [control factor]) = tons/acre/month

**Table 5-2**

**Critical Area Impacts to Habitat Protection Areas and the 100-foot Tidal Buffer**
**Dump Road Area, Martin State Airport**

| Impact location | Description | Impact area –within the expanded tidal buffer (in square feet)[1] | Impact area –outside the expanded tidal buffer (in square feet)[1] |
|---|---|---|---|
| Access road crossing of unnamed tributary | Impacts to wetland, stream crossing, steep slopes, and 25-foot buffer for culvert installation and grading and widening the existing road crossing the unnamed tributary stream | 11,990 | 0 |
| Access road south of unnamed tributary | Impacts to wetlands, steep slopes, and 25-foot buffer for grading and widening the existing road | 0 | 2,490 |
| Stormwater discharge pipe | Impacts to steep slopes and 25-foot buffer for clearing/grading for placement of the stormwater discharge pipe | 0 | 3,040 |
| Northern well access | Impacts to wetlands, steep slopes, and 25-foot buffer for grading to widen access to well locations | 470 | 0 |
| Central well access | Impacts to wetlands, steep slopes, and 25-foot buffer for grading to widen access to well locations | 8,670 | |
| Treatment plant perimeter and outfall discharge pipe | Impacts to steep slopes and 25-foot buffer for clearing/grading for placement of the outfall discharge pipe | 12,530 | |
| Southern well access | Impacts to wetlands, steep slopes, and 25-foot buffer for grading to widen access to well locations | 4,700 | |
| SUBTOTAL | | 38,360 | 5,530 |
| **Total Area** | **43,890 square feet** | | |

1. The exact nature and extent of impacts will be refined and minimized to the extent practicable during final design.

**Table 5-3**

**Forest Impacts**
**Dump Road Area, Martin State Airport**

| Impact Location | Description | Impact area –within the expanded tidal buffer (in square feet) [1] | Impact area –outside the expanded tidal buffer (in square feet) [1] |
|---|---|---|---|
| Access road north of unnamed tributary | Tree clearing along existing access road for road widening | 0 | 7,630 |
| Access road crossing of unnamed tributary | Tree clearing along existing access road for road widening | 6,520 | 0 |
| Access road south of unnamed road and treatment facility | Tree clearing along existing access road for road widening, clearing for grading around treatment building, clearing for stormwater outfall | 0 | 83,250 |
| Well access road | Tree clearing for road widening and grading to access well locations | 22,670 | 4,820 |
| SUBTOTAL | | 29,190 | 95,700 |
| **TOTAL Area** | **124,890 square feet** | | |

4. The exact nature and extent of impacts will be refined and minimized to the extent practicable during final design.

**Table 5-4**

**Stream Impacts**
**Dump Road Area Martin State Airport**

| Impacted Stream | Type | Impacts [1] | Description |
|---|---|---|---|
| Unnamed tributary | Intermittent/ephemeral non-tidal channel | 30 linear feet – permanent | Resulting from widening of the existing access road over stream. Includes removal and replacement of existing culvert |
| Frog Mortar Creek | Tidal perennial stream | 10 linear feet – permanent | Installation of 6-inch diameter outfall discharge pipe extending 80 feet beyond the mean high water line. Will include bottom anchoring system |

1. The exact nature and extent of impacts will be refined and minimized to the extent practicable during final design.

**Table 5-5**

**Impacts to Wetlands and Other Waters of the United State and the State of Maryland**
**Dump Road Area, Martin State Airport**

| Location | Wetland Identification | Tidal/ Non-tidal | Impact Description | Impact Amount | |
|---|---|---|---|---|---|
| | | | | Wetland (square feet.)/ stream (linear feet) [1] | 25-foot buffer (square feet) [1] |
| Existing road crossing unnamed tributary | Wetland V | Non-tidal | Removal of existing 36-inch culvert, box culvert installation in stream channel, and grading and fill in adjacent wetland area to widen existing road | 1,540 / 30 | 9,220 |
| Access road south of unnamed tributary stream | Wetland W | Non-tidal | Grading and fill in wetland to widen existing road | not applicable (N/A) | 600 |
| Well installation area | Wetland NN | Non-tidal | Grading and fill to widen existing path for access to well locations | N/A | 370 |
| Outfall discharge pipe | Frog Mortar Creek | Tidal | Installation of 6-inch diameter discharge pipe and bottom anchoring system below the tidal boundary | N/A | 710 |
| **Total Area** | | | | **1,540/30** | **11,000** |

1. The exact nature and extent of impacts will be refined and minimized to the extent practicable during final design.

**Table 5-6**

**Summary of Natural Resource Impacts for the Preferred Alternative**
**Dump Road Area, Martin State Airport**

| Wetlands | | | Streams | | Forest | | HPAs | |
|---|---|---|---|---|---|---|---|---|
| | **Wetland Area (sf)** | **Buffer (sf)** | **Non-tidal (lf)** | **Tidal (lf/sf)** | **Inside 100-foot Buffer (sf)** | **Outside 100-foot Buffer (sf)** | **Inside 100-foot buffer (sf)** | **Outside 100-foot buffer (sf)** |
| | 1,540 | 10,190 | 30 | 25/710 | 29,190 | 95,700 | 38,360 | 5,530 |
| **Totals [1]** | **11,730 (0.27 acres)** | | **55 lf/710 sq** | | **124,890 (2.7 acres)** | | **43,890 (1.0 acres)** | |

1. The exact nature and extent of impacts will be refined and minimized to the extent practicable during final design.

**Table 5-7**

**Martin State On-Airport Cumulative Projects**
**Dump Road Area, Martin State Airport**
**Page 1 of 3**

| | Project Name | Year | Description |
|---|---|---|---|
| Recently Completed or Ongoing | MTN Taxiway K Pavement | 2010 | Taxiway paving |
| | MDANG Operation and Medical Training Facility (Building F-34) | 2013 | Construction of a new MDANG operation and training facility on MDANG leasehold within MTN. |
| | MDANG Fire and Rescue Facility Complete – no building # on ALP. | 2011 | Construction of a new MDANG Fire and Rescue Facility on MDANG leasehold within MTN. |
| Future | MAA Phase I Development Including Runway 33/15, Hangars (Buildings F-2 through F-7, F-11, F-25, F-31, F-32), Traffic Control Tower (Building F-1), and Infrastructure Improvements | 2016 | Runway 15/33 improvements including runway modifications/extensions, tree clearing associated with Part 77 obstruction removal, taxiway modifications/creation, NAVAID modifications/improvements, relocated existing hangars, develop new hangars, construct new air traffic control tower, and construct new parking areas. |
| | MDANG Cyber/Intelligence, Surveillance, and Reconnaissance (ISR) Facility (Building F-36) | 2014 | The project would construct a single-or two-story facility with reinforced concrete foundation and floor slab, with steel-framed masonry walls and a steel roof structure. The project would include interior infrastructure and utilities. A portion of the facility would be designed to meet Sensitive Compartmented Information Facility (SCIF) requirements. Exterior work includes installation of utilities and parking and pavements, site and drainage improvements, and installation of communication support |
| | MDANG to Expand Hercules Road Project (Labeled on ALP, but no building #) | 2016 | The project would widen and lengthen the current roadway by an additional 30,346 sf. The project would include resurfacing and widening of the road bed and reconstruction of associated shoulders and drainage structures |
| | MDANG to Construct new Mobile Fuel Tanker Parking Area (Building F-43) | 2016 | The project would construct a new 32,280 sf, concrete-paved parking area to store the five R-11 mobile fuel tankers. The parking area would be designed with integral secondary containment to capture potential releases of petroleum. Approximately half (16,140 sf) of the proposed parking area would be constructed on existing pavement |

**Table 5-7**

**Martin State On-Airport Cumulative Projects**
**Dump Road Area, Martin State Airport**
**Page 2 of 3**

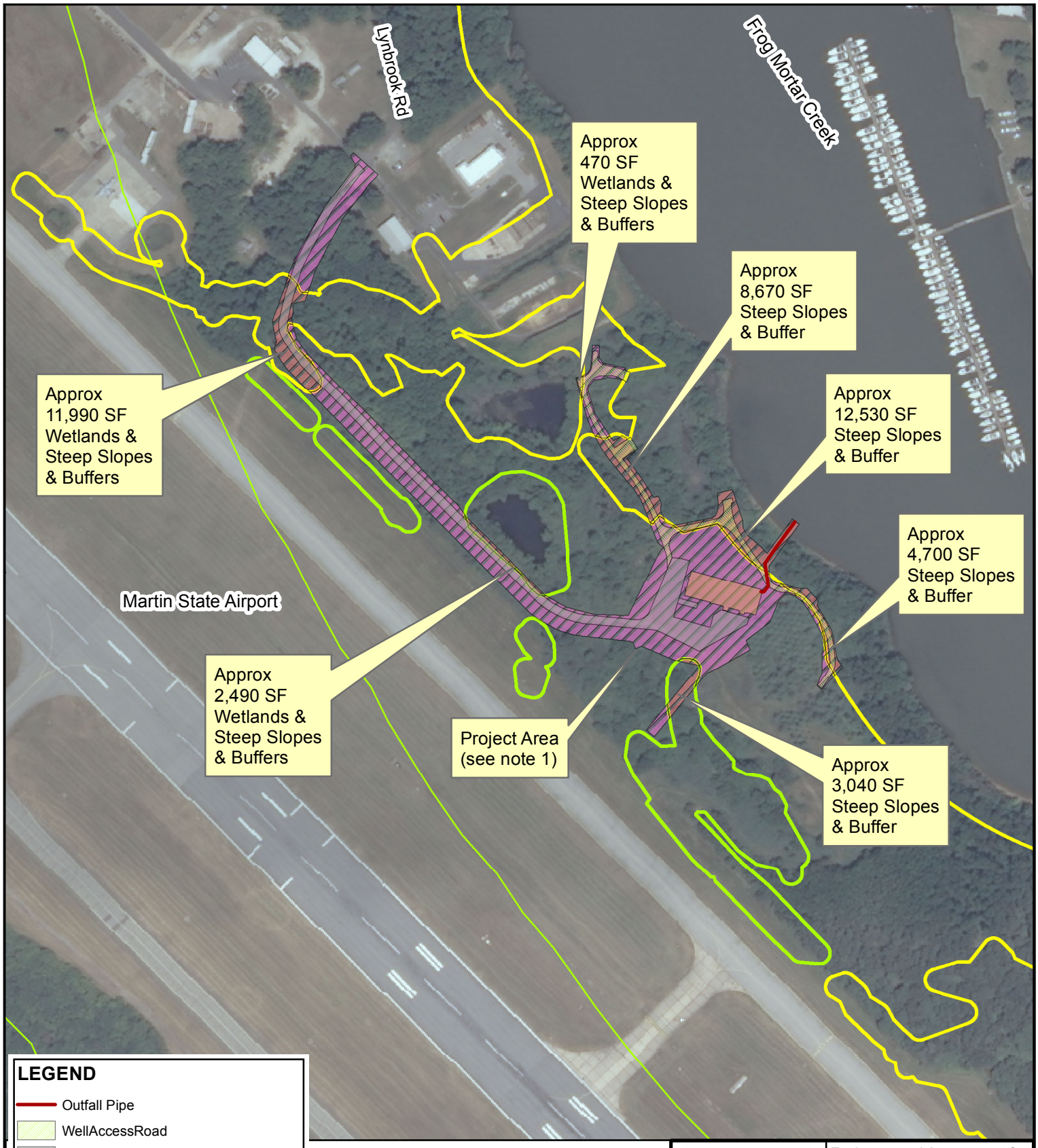
| | Project Name | Year | Description |
|---|---|---|---|
| Future Cont. | MDANG to Construct Vehicle Inspection Area at Lynbrook Gate (Canopy Project) (Labeled on ALP, but no building #) | 2015 | The project would construct a new 5,000 sf inspection area near the gate entry point. The new asphalt-paved area would be constructed adjacent to the existing roadway |
| | MDANG to Construct Vehicle Parking Areas (Labeled on ALP, but no building #) | 2015 | The project would construct three new vehicle parking areas capable of accommodating 25 (4,250 sf), 50 (8,500 sf), and 75 (12,750 sf) vehicles. Two of the parking areas (for 25 and 75 vehicles) would be constructed on existing pavement at the current location of Buildings 1080 and 1120, which are being demolished |
| | MDANG Temporary SCIF Bldg. Project (Building F-39) | 2014 | The base requires adequately sized and appropriately configured space for the temporary establishment of a new Cyber/ISR Squadron and Network Warfare Group (NWG) while awaiting a MILCON project of a permanent facility. The facility will provide Air Force Intelligence Surveillance Agency with a limited surge-to-war capability accomplished through the use of Digital Network Intelligence at Martin State Airport/Warfield. The project includes a 5,000 sf facility with a perimeter equaling 12,600 sf secured with fencing. This facility is temporary, with expected removal in Fiscal Year 2015. |
| | MDANG Taxiway T Mill and Overlay (Labeled on ALP, but no building #) | 2015-2016 | |

**Table 5-7**

**Martin State On-Airport Cumulative Projects**
**Dump Road Area, Martin State Airport**
**Page 3 of 3**

| | Project Name | Year | Description |
|---|---|---|---|
| Future Cont. | MDANG A-10 Flight Simulator. Bldg. 2042 (Building F-30) | 2014 | The purpose of this facility is to house and facilitate the operation of two A-10 flight simulators. Space is provided for a two-bay simulator room, instructor and technician stations, and two debriefing rooms. Each bay will be designed to accommodate an eight-channel, 360-degree full field of view display with adequate space for servicing. Adjacent to the flight simulator bay will be an office for an instructor and a separate office for a technician. Both of these rooms will have interior windows viewing the simulator bay |
| | MDANG Logistics Readiness Squadron (LRS) Warehouse Facility Bldg. 4020 (Building F-42) | 2014 | The project involves installing a prefabricated and insulated metal building with overhead roll up doors, interior lights, heating, ventilating, and air conditioning (HVAC) and fire protection. Exterior work includes constructing access pavement and a loading dock; installing utilities, communications and fire protection support; and construction of proper stormwater runoff and drainage measures |
| | MDANG Repair A-10 Drop Tank Storage Area/Access Road (Existing area/facility improvement – no ALP #) | TBD | The project will repair an asphalt storage lot with required environmental spill protection and site clearances. The maximum size of the asphalt area to be repaired will be 1,280 square yards |

Figures 5-1 thru 5-3

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MARTIN STATE AIRPORT

*Environmental Assessment for Groundwater Remediation at the Dump Road Area*

# FOREST CLEARING AND IMPACTS

TETRA TECH

SCALE: AS SHOWN

FIGURE: 5-2

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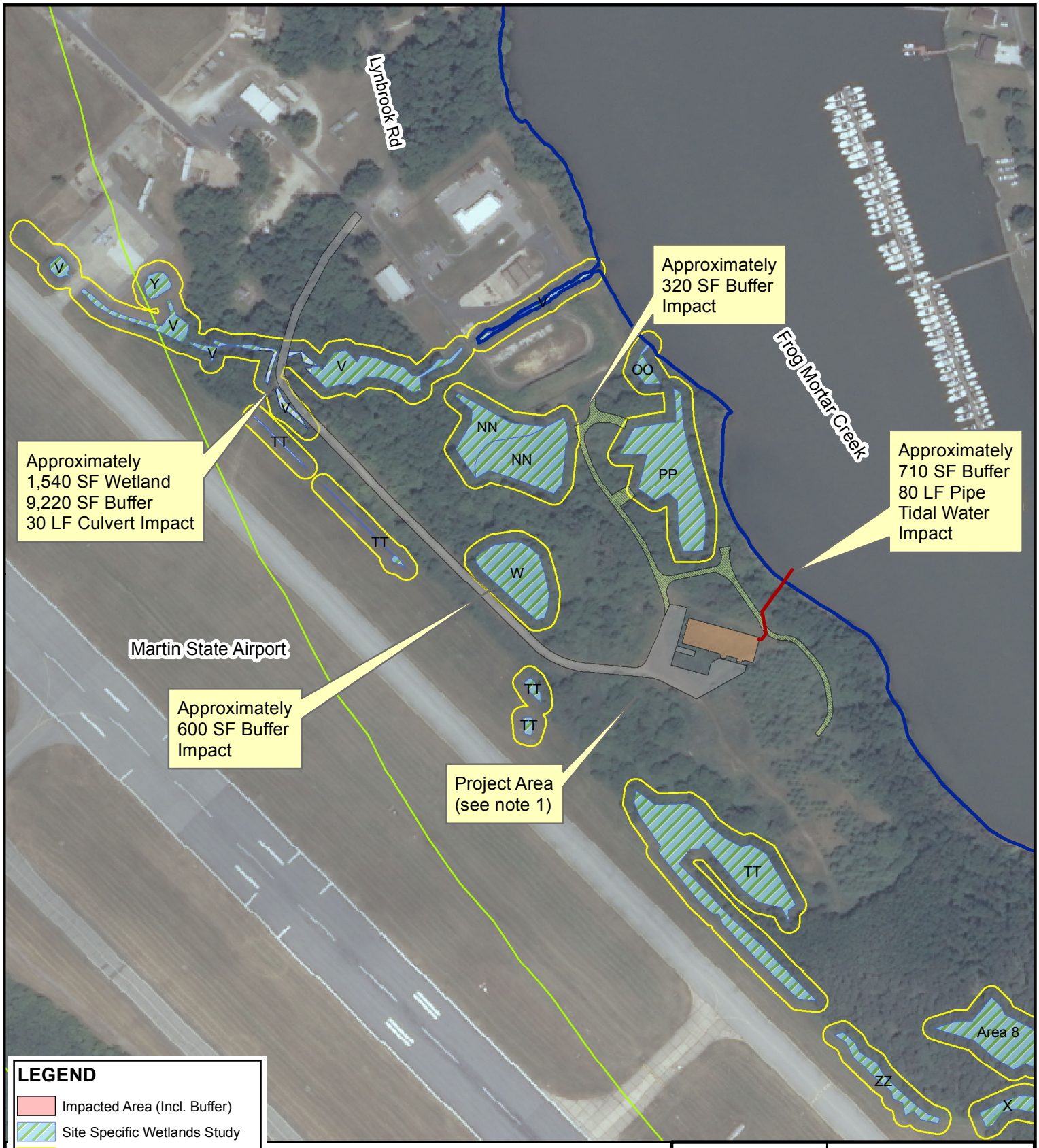


**LEGEND**

- Impacted Area (Incl. Buffer)
- Site Specific Wetlands Study
- 25-ft Wetland Buffer
- Outfall Pipe
- Project Area
- WellAccessRoad
- MainAccessRoad
- Groundwater Treatment Plant
- Mean High Water Line
- Critical Area - Baltimore County

*Note 1: Underground Installation of Utilities Only along existing Lynbrook Rd.*

Protected Lands Source: Maryland Department of Natural Resources

N

0 150 300 600 Feet

MARTIN STATE AIRPORT

*Environmental Assessment for Groundwater Remediation at the Dump Road Area*

# IMPACTS TO WETLANDS AND WATERS

TETRA TECH

SCALE: AS SHOWN

FIGURE: 5-3

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## Section 6

# List of Preparers

The following personnel have had primary responsibility in preparing this National Environmental Policy Act (NEPA) environmental assessment (EA).

**Table 6-1**

**List of Authors**

| Personnel | Title | Years of Experience | Project Responsibilities |
|---|---|---|---|
| Maryland Aviation Administration | | | |
| Robin Bowie | Manager, Division of Environmental Planning | 23 | Project Manager |
| John Hurt | Environmental Analyst | 26 | Quality Assurance/ Quality Control |
| Tetra Tech, Inc. | | | |
| Paul Myers | Senior Environmental Scientist | 20 | Alternatives Analysis, Affected Environment, Environmental Consequences |
| Joe Lucas | Senior Environmental Scientist | 20 | Air Quality |
| CDM Smith, Inc. | | | |
| Laura Burbage | Environmental Scientist | 12 | Technical Review/ Quality Assurance/ Quality Control |
| Mark Salvetti | Project Engineer | 29 | Technical Review/ Quality Assurance/ Quality Control |

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# Section 7
# Required Permits and Regulatory Approvals

The following table provides a list of the regulatory statutes that pertain to activities associated with the proposed remediation project. This table also contains the associated permits and regulatory approvals that will be necessary for project implementation, and provides a description of the public involvement process for each permit.

**Table 7-1**

**Required Permits and Regulatory Approvals**
**Dump Road Area, Martin State Airport**
**Page 1 of 9**

| Regulation/Statute | Agency | Permit Description | Contact | Public Comment Process |
|---|---|---|---|---|
| Section 404 Clean Water Act (33 United States Code [USC] 1344)<br>United States Army Corps of Engineers (USACE) Regulations 33 Code of Federal Regulations (CFR) Part 320-330 | United States Army Corps of Engineers (USACE) and Environmental Protection Agency (USEPA) | Section 404 Clean Water Act Joint Permit: Dredge and Fill of Waters of the U.S. Including Wetlands | Abbie Hopkins<br>410-962-6080<br>abbie.hopkins@usace.army.mil<br><br>Jon Romeo<br>410-692-6079<br>jon.romeo@usace.army.mil | 30 day public comment period following submittal of draft joint application (JA) |
| Section 10 Rivers and Harbors Act -33 USC 401, et seq. | USACE and USEPA | Section 10 Rivers and Harbors Act Joint Permit: Work in Navigable Waters of the United States | Abbie Hopkins<br>410-962-6080<br>abbie.hopkins@usace.army.mil<br><br>Jon Romeo<br>410-692-6079<br>jon.romeo@usace.army.mil | 30 day public comment period following submittal of draft JA |
| Markers for Navigation - 33 CFR, chapter I, subchapter C, part 66 | United States Coast Guard (USCG) | USCG review authority for potential impacts on navigation and installation of markers for navigation | Ron Houck<br>(410)-576-2674<br>Ronald.L.Houck@uscg. mil. | 30 day public comment period following submittal of draft JA |

**Table 7-1**

**Required Permits and Regulatory Approvals**
**Dump Road Area, Martin State Airport**
**Page 2 of 9**

| Regulation/Statute | Agency | Permit Description | Contact | Public Comment Process |
|---|---|---|---|---|
| Essential Fish Habitat - Section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act | National Oceanic and Atmospheric Administration (NOAA) fisheries | Essential fish habitat (EFH) consultation and review: potential impacts on EFH | Kristy Beard<br>410-267-5675<br>Kristy.beard@noaa.gov | Not applicable (N/A) |
| Section 7 Endangered Species Act Consultation | United States Fish and Wildlife Service (USFWS) and the NMFS | Section 7 Endangered Species Act consultation and review: potential impacts to listed species and/or critical habitat | Bob Zepp<br>410-573-4536<br>bob_zepp@fws.gov<br><br>Cherry Keller<br>410-573-4532<br>cherry_keller@fws.gov<br><br>Kristy Beard<br>410-267-5675<br>kristy.beard@noaa.gov | N/A |
| Bald and Golden Eagle Protection Act (16 USC 668-668c), enacted | United States. Fish and Wildlife Service | USFWS review of potential impacts on bald eagle | Craig Koppie<br>410-573-4534<br>craig_koppie@fws.gov | N/A |
| Maryland Department of the Environment (MDE) Tidal Wetlands Protection Act Code of Maryland Regulations (COMAR) 26.24 | Maryland Department of the Environment (MDE)/Board of Public Works | MDE Tidal Wetlands Protection Act License Joint Permit: Impacts to Tidal Wetlands and Waters of the State | Robert Rushlow<br>410-537-4023<br>rrushlow@mde.state.md.us | 30 day public comment period following submittal of draft JA |
| MDE Non-Tidal Wetlands Protection Act COMAR 26.23 | MDE Wetlands/Waterways Division | MDE Non-Tidal Wetlands Protection Permit: Impacts to Non-tidal Wetlands and Waters of the State | Cheryl Kerr<br>410-537-3911<br>ckerr@mde.state.md.us | 30 day public comment period following submittal of draft JA |

**Table 7-1**

**Required Permits and Regulatory Approvals**
**Dump Road Area, Martin State Airport**
**Page 3 of 9**

| Regulation/Statute | Agency | Permit Description | Contact | Public Comment Process |
|---|---|---|---|---|
| Section 307 Federal Coastal Zone Management Act | Maryland Department of Natural Resources (MDNR) | Section 307 Federal Coastal Zone Management, Coastal Zone Consistency: Federal actions must be consistent with state's coastal management program | Elder Ghigiarelli<br>410-537-3763<br>eghigiarelli@mde.state.md.us | 30 day public comment period following submittal of draft JA |
| Section 401 Water Quality Certification | MDE | Section 401 Water Quality Certification: State certifies that Section 404 permit meets state water quality standards | Cheryl Kerr<br>410-537-3911<br>ckerr@mde.state.md.us | 30 day public comment period following submittal of draft JA |
| Section 402 Clean Water Act (33 USC 1342) and 40 CFR 122.26; Maryland Environment Article, Title 9, Subtitle 3: COMAR 26.08.04 | MDE Construction Stormwater Division | Section 402 Clean Water Act, Construction General Permit for Construction Stormwater: discharges to waters of the United States. and state | Karen Smith<br>ksmith@mde.state.md.us | 30 - 45 day public comment period following submittal of notice of intent (NOI) |
| Section 402 Clean Water Act National Pollutant Discharge Elimination System (NPDES) - 40 CFR Part 122 through 125, and 131 | MDE NPDES Program | Section 402 Clean Water Act NPDES Discharge Permit: treated outfall discharges to waters of the United States | Ed Gertler<br>410-537- 3651<br>egertler@mde.state.md.us | Public comment following notification of draft permit |
| Section 402 Clean Water Act (33 USC 1342) and 40 CFR 122.26; Environment Article, Title 4, Subtitle 1 for erosion and sediment control and Subtitle 2 for stormwater management (COMAR 26.17.01 and 26.17.02) | MDE Stormwater Management Program | Stormwater management plan approval: stormwater management and sedimentation impacts to waters of the state | Amanda Malcolm<br>410-537-3551<br>Amanda.malcolm@maryland.gov | N/A |

**Table 7-1**

**Required Permits and Regulatory Approvals**
**Dump Road Area, Martin State Airport**
**Page 4 of 9**

| Regulation/Statute | Agency | Permit Description | Contact | Public Comment Process |
|---|---|---|---|---|
| Section 106 of the National Historic Preservation Act (Public Law 89-665; 16 USC. 470 et seq.) | Maryland Historical Trust | Section 106 of the National Historic Preservation Act Historic/Cultural Resource Review: Potential impacts to any district, site, building, structure, or object that is included in or eligible for inclusion in the National Register | Beth Cole<br>410-514-7631<br>bcole@mdp.state.md.us | N/A |
| Maryland Nongame and Endangered Species Conservation Act (Annotated Code of Maryland 10-2A-01; also, COMAR 08.03.08 | Maryland DNR | Nongame and Endangered Species Conservation Act, Listed Species and Habitat Review: Potential impacts to state listed species and habitat | Marian Honeczy<br>410-260-8511<br>mhoneczy@dnr.state.md.us | N/A |
| MDE Groundwater Appropriation and Use Permit, Environment Article, Title 5, §5-203 and §5-501 through §5-516 and §5-5B-01 through §5-5B-05, Annotated Code of Maryland; COMAR 26.17.06 and COMAR 26.17.07. | MDE | For extraction of groundwater | Norman Lazarus<br>410-537-4167<br>nlazarus@mde.state.md.us | Public notice for request for public hearing for period of 14 days following submission of complete application. Public hearing date TBD if a hearing is requested |

**Table 7-1**

**Required Permits and Regulatory Approvals**
**Dump Road Area, Martin State Airport**
**Page 5 of 9**

| Regulation/Statute | Agency | Permit Description | Contact | Public Comment Process |
|---|---|---|---|---|
| Section 7-222 of the Environmental Article and COMAR 26.14 | MDE Controlled Hazardous Substance (CHS) Enforcement Division | Oversees assessment and cleanup of hazardous waste sites | Art O'Connell<br>410-537-3493<br>aoconnell@mde.state.md.us | N/A |
| MDE Permit to Construct (PTC) and Permit to Operate (PTO)Environment Article, Title 2, Subtitle 4; COMAR 26.11.02 – | MDE | Air emissions permit | Nolan Penney<br>410-537-3230<br>npenney@mde.state.md.us | MDE issues draft air permit available for public review at local library. Also, public notice is prepared indicating a public hearing. |

**Table 7-1**

**Required Permits and Regulatory Approvals**
**Dump Road Area, Martin State Airport**
**Page 6 of 9**

| Regulation/Statute | Agency | Permit Description | Contact | Public Comment Process |
|---|---|---|---|---|
| Critical Area Commission, Title 8, Subtitle 18 of the Natural Resources Article of the Annotated Code of Maryland | Chesapeake Bay Critical Area Commission | Critical Area Plan/permit approval: potential impacts to critical area resources | Julie Roberts<br>410-260-3476<br>jroberts@dnr.state.md.us | Opportunities for public participation during critical area commission project review meeting(s) |
| Maryland Aviation Administration (MAA) – building permit | MAA | An MAA Building Permit is required for all new construction, renovation, alteration, or site improvement work on State-owned property under the jurisdiction of MAA. Any installation that affects the existing electrical, mechanical, plumbing, or structural systems also requires a Building Permit. As part of obtaining a Building Permit, approvals from the Federal Aviation Administration (FAA), other Federal, State and local regulatory agencies may be required. | MAA | N/A |

**Table 7-1**

**Required Permits and Regulatory Approvals**
**Dump Road Area, Martin State Airport**
**Page 7 of 9**

| Regulation/Statute | Agency | Permit Description | Contact | Public Comment Process |
|---|---|---|---|---|
| MAA – Airport Zoning Permit | MAA | The purpose of the Airport Zoning Permit (AZP) is to identify land uses, obstructions, and wildlife attractants that are incompatible with airport operations. The AZP application must be submitted for projects within a certified noise zone and/or airport zoning district (the area defined by a four-mile radius of Baltimore Washington International [BWI] or a three-mile radius of Martin State Airport [MTN]). For any construction or modification that will increase the height, change the use, or alter the exterior finish of an existing structure, or create a new structure, the applicant must obtain an Airport Zoning Permit (Maryland Aviation Administration [MAA]-010) before an MAA building permit will be issued. In addition, applicants may be required to file a Notice of Construction or Alteration (Federal Aviation Administration [FAA] Form 7460-1) requesting that the FAA perform an obstruction evaluation. | MAA | N/A |

**Table 7-1**

**Required Permits and Regulatory Approvals**
**Dump Road Area, Martin State Airport**
**Page 8 of 9**

| Regulation/Statute | Agency | Permit Description | Contact | Public Comment Process |
|---|---|---|---|---|
| Federal Aviation Administration (FAA) – Notice of Construction or Alteration | MAA | Notifies the FAA of construction or alteration that might affect navigable airspace (49 CFR part 77) | MAA | N/A |
| MAA – Trenching and Excavation Permit | MAA | Required before any trenching and excavation work can proceed The Contractor must obtain "Utility Modification/Digging Authorization" form that has been signed off by MAA utilities, MAA facilities department, MAA IT department, and FAA. This part of the approval process is coordinated through tenant improvement section's inspectors. In the second step, the contractor, acting on his/her own, is required to get the form signed off by Baltimore Gas and Electric (BGE) and Miss Utility | MAA | N/A |

**Table 7-1**

**Required Permits and Regulatory Approvals**
**Dump Road Area, Martin State Airport**
**Page 9 of 9**

| Regulation/Statute | Agency | Permit Description | Contact | Public Comment Process |
|---|---|---|---|---|
| MDE/Baltimore County – Well Construction Permit | MDE | A well construction permit is required before installing any well that will explore for water, obtain or monitor ground water, or inject water into any underground formation from which ground water may be produced. The well construction permit is obtained by the well driller from the local health department.<br>Permits are obtained through a well driller licensed in the State of Maryland<br>Environment Article Section 9-1307 allows up to $160 per permit. Each county establishes the fee, but may not exceed $160 per permit | MDE - Barry Glotfelty<br>410-537-3784<br>bglotfelty@mde.state.md.us | N/A |

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# APPENDIX B—AGENCY CONSULTATION

# APPENDIX B—AGENCY CONSULTATION

This appendix contains documentation of all agency consultation conducted during development of this EA. This includes documents pertaining to two separate agency scoping meetings conducted to coordinate with relevant resource agencies, an initial scoping meeting conducted on December 13, 2012 and a full Joint Evaluation Committee Meeting conducted March 27, 2013. Other documents in this appendix include agency review request letters and responses/comments received from the agencies.

The initial scoping meeting was held at MTN and included staff from the following agencies:

- Maryland Critical Area Commission
- Maryland Tidal Wetlands Division
- Maryland Non-tidal Wetlands Division
- Maryland Department of the Environment Remediation
- United States Army Corps of Engineers
- Maryland Aviation Administration

The initial scoping meeting included a presentation of the conceptual plan for the preferred action alternative and an overview of expected resource impacts. The initial scoping meeting also included receiving comments and suggestions from agency staff in attendance. Documents related to this meeting including the presentation given, meeting minutes, and list of attendees are included as part of this appendix.

The full JEC meeting was a follow up to the initial agency meeting and presented a more refined preferred action plan based on comments received during the initial agency review. The full JEC meeting was attended by a wide spectrum of agency staff representing all of the resource disciplines associated with permitting and environmental review for the project. Agencies represented at the JEC meeting included:

- United States Army Corps of Engineers
- NOAA Fisheries
- U.S. Fish and Wildlife Service

- MDE Tidal Wetlands Division
- MDE Non-tidal Wetlands Division
- MDE Stormwater and E&S Control
- Maryland Department of Natural Resources
- Maryland State Superfund
- Maryland Critical Area Commission and to gain early feedback and to provide

The JEC meeting included a presentation of the updated plan for the preferred action alternative and an overview of expected resource impacts. The initial scoping meeting also included receiving comments and suggestions from agency staff in attendance. Documents related to this meeting including the presentation given, meeting minutes, and list of attendees are included as part of this appendix.

Agency review request letters were sent to the following agencies. A copy of the review request letter is included in this appendix:

- US Fish and Wildlife Service (Protected Species Division)
- US Fish and Wildlife Service (Bald and Golden Eagle Act Coordinator)
- NOAA Fisheries (Protected Resources Division)
- NOAA Fisheries (Essential Fish Habitat Protection Division)
- US Coast Guard
- US Army Corps of Engineers
- MDE Federal Consistency Program
- Maryland DNR
- Maryland Historical Trust
- Maryland Critical Area Commission
- MDE Air Quality Planning and Monitoring Program
- USDA APHIS
- Baltimore County Department of Environmental Protection and Sustainability

Agency responses were received from the following agencies. A copy of these responses is included in this appendix:

- NOAA Fisheries, Protected Resources Division
- Maryland Historical Trust
- USDA APHIS
- Maryland DNR

# APPENDIX C—MDE WATER CONTACT ADVISORY FOR FROG MORTAR CREEK

Maryland Department of the Environment

# FACTS ABOUT:

## FROG MORTAR CREEK WATER CONTACT ADVISORY

The Maryland Department of the Environment's (MDE) Land Restoration Program, through its Controlled Hazardous Substance Enforcement Division, is overseeing Lockheed Martin Corporation's (Lockheed Martin) environmental assessment and cleanup activities related to the release of chlorinated solvents and metals from areas around Martin State Airport in Middle River, Baltimore County, Maryland. In connection with this assessment, MDE is issuing a water contact advisory for the waters adjacent to the shoreline of the airport.

### What is the problem with Frog Mortar Creek near Martin State Airport?

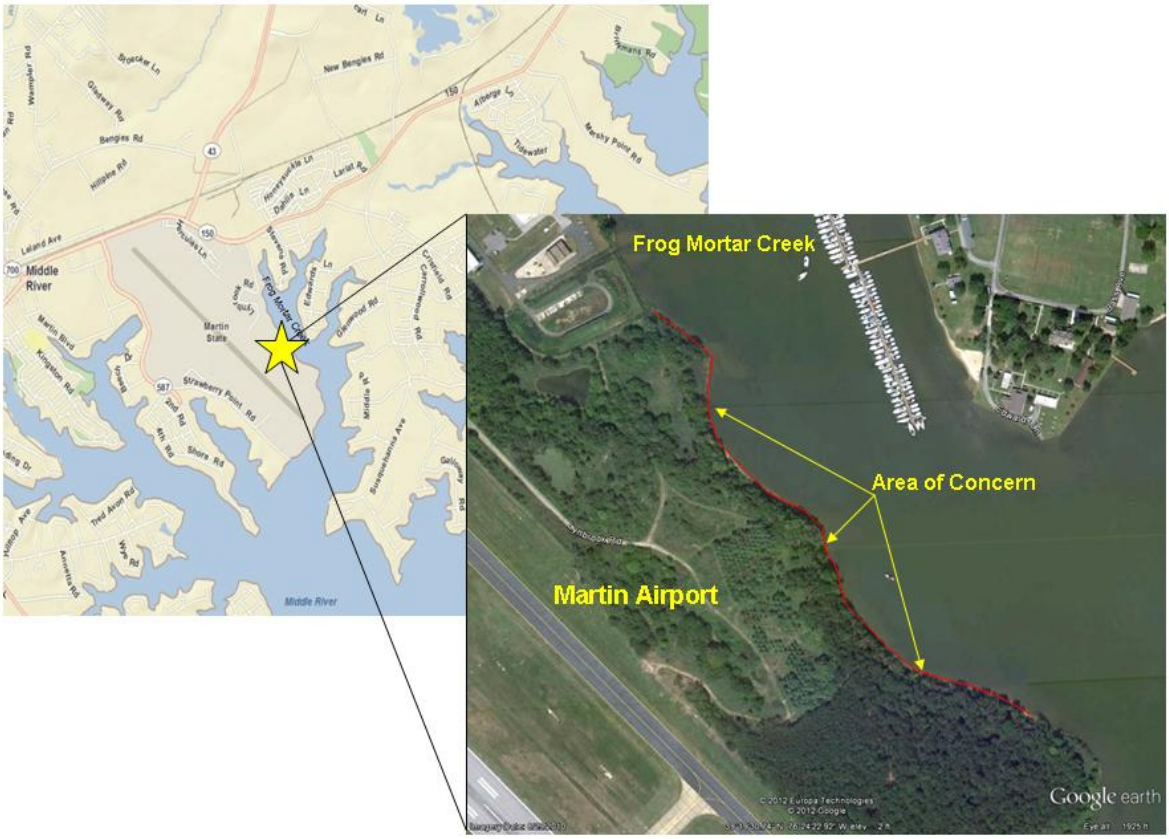
Under MDE's oversight, Lockheed Martin has conducted environmental assessment activities at and around Martin State Airport. As part of those activities, Lockheed Martin collected surface water samples in March 2011 from the shoreline along Frog Mortar Creek. The chlorinated solvents Trichloroethene (TCE), cis -1,2 Dichloroethene (CIS-1,2) and Vinyl Chloride (VC) were identified in some surface water samples at levels that exceed MDE recommended lifetime risk screening levels. These risk estimates, which are based on lifetime exposures, are inherently conservative and do not represent any short-term health hazards.

MDE requested that Lockheed Martin sample the surface water more frequently to determine the extent of the problem and whether seasonal trends exist. The data collected over the past year indicates that contaminant levels are highest during cooler weather, from fall through late spring and lower during the summer months, but the discharge of the three chlorinated solvents from the subsurface into the surface water is constantly changing. As the discharge is affected by wind, rainfall and temperature, it is impossible to predict for any given day whether levels of contamination will exceed lifetime risk levels.

### Why is MDE issuing a water contact advisory? What does this mean?

Out of an abundance of caution, MDE is issuing a water contact advisory. MDE recommends that people be aware of the potential risks and limit their exposure through swimming or wading in the waters adjacent to Martin Airport on the south shore of Frog Mortar Creek. The area of concern begins at the beach immediately adjacent to the

southern end of the Air National Guard structures and continues in a southeasterly direction for 2,000 feet. The map below shows the area for which MDE is issuing its advisory.




Signs will be placed on the shoreline in the affected area to advise boaters and swimmers. The advisory will be on MDE's website, and the Department will issue public notice as appropriate. We anticipate posting the advisory in February 2012.

Lockheed Martin is proposing a treatment system to capture and treat groundwater prior to it entering the creek. Until the system can be approved and constructed, and reductions in surface water concentrations are confirmed, the water contact advisory will remain in place and monitoring will continue to be used to evaluate whether additional steps are needed to protect the health of people using the creek.

## Is this a ban on swimming in this area?

No. The contaminants in the sampling results are not at a level that merits a prohibition against swimming in this area. The contaminants at the levels measured do not present an acute health risk. They represent lifetime risk estimates and are developed to be conservative and protective of all potential users.

## How often would I be able to swim there and still be safe?

The calculations assume that someone beginning as a small child who spends four hours a day in the water, 70 days a year over 30 years could have a slightly greater cancer risk, based on a statistical analysis. Swimming less frequently than this estimate will lower the potential health risks. MDE generally requires remedial measures be put in place for cancer risks in excess of 1 in 100,000 over the course of a lifetime. Based on the current contaminant concentrations in the area of concern, reducing swimming activities to less than four hours a day and approximately 20 days a year during the summer months would result in risk levels within the MDE acceptable lifetime cancer risk range. Any person should choose the risk level with which they feel comfortable. This is personal decision.

## What are the levels of these compounds that have been detected, and what levels are allowed as safe?

The swimming screening levels that are currently being used for this site for cis-1,2-Dichloroethene, TCE and vinyl chloride are 300 ppb, 10 ppb and 0.7 ppb, respectively. The levels of each of the three compounds have varied seasonally and between sampling locations. The average cis-1,2-Dichloroethene and TCE concentrations were below their swimming screening values in all three 2011 swimming season rounds. The highest level of vinyl chloride has been 140 parts-per-billion (ppb), found adjacent to the Dump Road Area shoreline in March 2011, when swimming was unlikely due to the time of year. The highest observed summertime level of vinyl chloride has been 32 ppb, identified in July 2010. The average vinyl chloride concentration in June met the screening level of 0.7 ppb, the combined average of June and August results was 0.9 ppb and the combined average of June, August and September results was 1.8 ppb. The overall summertime average increased primarily due to an elevated concentration of vinyl chloride of 21 ppb at location SW-38 in September 2011.

## What are the potential health impacts of TCE, cis-1,2 dichloroethene, and vinyl chloride?

Trichloroethene, known as TCE, breaks down and forms “daughter” byproducts. TCE and two such byproducts, cis-1,2-dichloroethene and vinyl chloride, are found in groundwater at Martin State Airport and in Frog Mortar Creek. Vinyl chloride is the most toxic of the “daughter” compounds, so the vinyl chloride levels that regulators consider to

be safe – or "allowable" – are extremely low.

Studies have shown that some people exposed to high concentrations of these chemicals may have an increased risk of cancer. People can potentially be exposed to these chemicals while swimming by accidentally ingesting water and by direct skin contact.

For additional information on the potential health impacts of TCE, cis-1,2-dichloroethene and vinyl chloride, the federal Agency for Toxic Substances and Disease Registry (ATSDR) provides summaries about TCE, cis-1,2-dichloroethene and vinyl chloride and their health effects. These fact sheets can also be obtained directly from ATSDR at:

- Trichloroethene (TCE) - http://www.atsdr.cdc.gov/tfacts19.pdf;
- cis -1,2 Dichloroethene (CIS-1,2) - http://www.atsdr.cdc.gov/tfacts87.pdf; and
- Vinyl Chloride (VC) - http://www.atsdr.cdc.gov/tfacts20.pdf.

Any personal health-related questions should be consulted with a personal physician.

## What happens to the chemicals when they reach Frog Mortar Creek?

The nature of these chemicals is to evaporate, or volatilize, which is why they are known as volatile organic compounds, or VOCs. Sampling indicates these chemicals appear to be entering Frog Mortar Creek in the sediments closest to the shoreline near the Dump Road Area. Through dilution, dispersion, and volatilization, the concentrations generally decrease further away from the airport shoreline. Higher water and air temperatures and tidal movements cause volatilization and mixing, continuing the process of lessening the effects of these VOCs.

## My family and I have been swimming at Frog Mortar Creek for years. Should we be concerned?

Historical information suggests that contamination sources present along the perimeter of Frog Mortar Creek have existed for some time but have only recently been discovered due to advances in screening technologies and extensive efforts to identify and clean up historical sources of contamination.

Based on the current contaminant concentrations in the area of concern, reducing swimming activities to less than four hours a day and approximately 20 days a year during the summer months would result in risk levels within the MDE acceptable lifetime cancer risk range.

## What happens next? Will there be more sampling? What if conditions worsen?

Sampling will continue, particularly during the boating and swimming season. Should conditions worsen, MDE, Lockheed Martin and the property owner, the Maryland Aviation Administration, will work to establish additional measures to protect public safety. This could include playing buoys or fencing off areas of the creek to prevent public access. Any such actions would be communicated to the public.

Maryland Department of the Environment
1800 Washington Boulevard | Baltimore, MD 21230-1718 | www.mde.state.md.us
410-537-3000 | 800-633-6101 | TTY Users: 800-735-2258
Martin O'Malley, Governor | Anthony G. Brown, Lt. Governor | Robert M. Summers, Ph.D., Secretary

# APPENDIX D—DUMP ROAD AREA GROUNDWATER FEASIBILITY STUDY AND PROPOSED PLAN

# Interim Remedial Action - Feasibility Study for the Groundwater Operable Unit at the Dump Road Area Site at Martin State Airport Middle River, Maryland

Prepared for:

Lockheed Martin Corporation

Prepared by:

Tetra Tech, Inc.

December 2012

Michael Martin, P.G.
Regional Manager

Christopher Pike
Project Manager

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# ACRONYMS

| | |
|---|---|
| AOP | advanced oxidation process |
| ARAR | applicable or relevant and appropriate requirement |
| atm-L/mole | atmosphere-liter per mole |
| bgs | below ground surface |
| BMP | best management practice |
| BTEX | benzene, toluene, ethylbenzene, and total xylenes |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| cfm | cubic feet per minute |
| CFR | *Code of Federal Regulations* |
| COC | chemical of concern |
| COMAR | *Code of Maryland Regulations* |
| COPC | chemical of potential concern |
| CSF | cancer slope factor |
| CWA | Clean Water Act |
| cVOC | chlorinated volatile organic compound |
| DCE | dichloroethene |
| DHC | dehalococcoides |
| DNAPL | dense non-aqueous phase liquid |
| DO | dissolved oxygen |
| DOJ | United States of Department of Justice |
| DPT | direct push technology |
| DRA | Dump Road Area |
| DRO | diesel range organics |
| EBCT | empty bed contact time |
| ED | electron donor |
| EM | electromagnetic |
| EOS | emulsified oil substrate |
| EPA | United States Environmental Protection Agency |
| ERA | ecological risk assessment |

| | |
|---|---|
| FS | feasibility study |
| $ft^3$ | cubic foot (feet) |
| GAC | granular activated carbon |
| gpd | gallons per day |
| gpm | gallons per minute |
| GRA | general response action |
| GRO | gasoline range organics |
| HCA | high concentration area |
| HHRA | human health risk assessment |
| HI | hazard index |
| hp | horsepower |
| IE | ion exchange |
| ILCR | incremental lifetime cancer risk |
| kW-hr | kilowatt-hour |
| lb | pound(s) |
| lb/day | pounds per day |
| Lockheed Martin | Lockheed Martin Corporation |
| LUC | land use control |
| MAA | Maryland Aviation Administration |
| MDANG | Maryland Air National Guard |
| MCL | maximum contaminant level |
| MCLG | maximum contaminant level goal |
| MDE | Maryland Department of the Environment |
| µg/L | micrograms per liter |
| MNA | monitored natural attenuation |
| MSA | Martin State Airport |
| msl | mean sea level |
| NCP | *National Oil and Hazardous Substances Pollution Contingency Plan* |
| NPDES | National Pollutant Discharge Elimination System |
| NPW | net present worth |
| O&M | operation and maintenance |
| ORC® | oxygen release compound |
| ORP | oxidation reduction potential |

| | |
|---|---|
| OSHA | Occupational Safety and Health Administration |
| PAH | polynuclear aromatic hydrocarbon |
| PCB | polychlorinated biphenyl |
| PFD | process flow diagram |
| POTW | publicly owned treatment works |
| PPE | personal protective equipment |
| PPZ | potassium permanganate impregnated zeolite |
| PRB | permeable reactive barrier |
| PRG | preliminary remediation goal |
| RAO | remedial action objective |
| RCRA | Resource Conservation and Recovery Act |
| RD | remedial design |
| RfD | reference dose |
| RI | remedial investigation |
| SVOC | semivolatile organic compound |
| TCE | trichloroethene |
| TCLP | Toxicity Characteristic Leaching Procedure |
| TOC | total organic carbon |
| TPH | total petroleum hydrocarbons |
| TSDF | treatment, storage, and disposal facility |
| Tetra Tech | Tetra Tech, Inc. |
| USGS | United States Geological Survey |
| UV | ultraviolet |
| VCP | Voluntary Cleanup Program |
| VOC | volatile organic compound |
| VSA | vacuum swing adsorption |
| WQC | water quality criteria |
| ZVI | zero-valent iron |

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# GLOSSARY

**1,4-dioxane —** A clear, flammable volatile organic compound mainly used as an industrial solvent or solvent stabilizer in a variety of manufacturing processes, including electronics, metal finishing, fabric cleaning, pharmaceuticals, herbicides, pesticides, antifreeze, and paper. It is also found in household products such as detergents, shampoos, body lotions, dishwashing soap, and cosmetics. It does not break down naturally in the environment, so it tends to linger in soil and groundwater for a very long time.

**Anaerobic reductive dechlorination —** A natural breakdown or treatment process in which anaerobic bacteria (i.e., bacteria that do not require oxygen) remove chlorine from chlorinated compounds (such as trichloroethene). Once all possible chlorine atoms are taken away, a chemical called 'ethene' is formed, which is not harmful to human health or the environment.

**Applicable or relevant and appropriate requirements (ARARs) —** Environmental cleanup standards and requirements (federal and state laws and regulations) that must be attained upon completion of remedial actions subject to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

**Aquifer —** An underground layer of rock, sand, silt, or clay that contains water in sufficient amounts to serve as sources of groundwater for wells and springs.

**Bioaugmentation —** A treatment technology in which specialized bacteria that consume organic compounds are added to the subsurface. Chemicals and/or nutrients are often added to promote biological activity.

**Biodegradation —** A natural process whereby naturally occurring bacteria decompose or break down contaminants or chemicals.

**Biostimulation —** A treatment technology in which chemicals and/or nutrients are added to the subsurface to increase the activity of naturally occurring bacteria that consume organic compounds.

**Bulk density —** A soil property defined as "the mass of a soil sample" divided by "the volume of the soil and its pore spaces (open spaces between sediment particles, or 'bubbles' and cracks in rock) and void spaces." The bulk density of a soil can change depending on the degree of compaction. More compaction results in a higher bulk density value.

**Chemical of concern (COC) —** Chemicals that are identified by a regulatory agency (such as EPA or a state environmental agency) that are found at concentrations higher than those considered to be safe, and must be cleaned up and/or monitored.

**Chemical of potential concern (COPC) —** Chemicals identified during a remedial investigation (RI) that are at concentrations that have the potential to harm human health and/or the environment.

**Coagulation —** In wastewater treatment, the promotion of the settling of fine suspended particles by the addition of chemicals.

**Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) —** Commonly called Superfund, a federal law enacted in 1980 and amended in 1986 by the Superfund Amendments and Reauthorization Act to address remediation of abandoned hazardous waste sites.

**Consent Order —** A legally enforceable agreement between an environmental regulator and a responsible party.

**Containment —** A technology that prevents the movement of contaminants from a site but does not necessarily treat or remove the contaminants.

**Dechlorination —** The breakdown process of a chlorinated organic compound that contaminates soil and groundwater. This process removes chlorine atoms from the chemical during biological degradation. For example, the complete dechlorination of trichloroethene (TCE) creates ethene.

**Dense non-aqueous phase liquids (DNAPLs) —** An accumulation of liquid chemicals, like solvents, in the ground that are denser than water, and tend to sink. Dense non-aqueous phase liquids are difficult to remove and can be an ongoing source of groundwater contamination.

**Drawdown —** A lowering of the water table of an unconfined aquifer or the potentiometric surface of a confined aquifer by pumping groundwater from wells. The drawdown is the vertical distance between the original water level and the new water level in the well.

**Effective porosity —** A measure of the pore spaces (open spaces between sediment particles, or "bubbles" and cracks in rock) that are interconnected in the subsurface, and that effectively allow fluids to flow through the rock or sediment. Because some of the pores are dead end, and some of the groundwater will cling on to the sediment or rock surfaces and not drain, the "effective porosity" is less than the "total porosity."

***Ex situ* —** Away from the original location or place where pollutants are found; in this report, *ex situ* means on-site and at the surface, but not in place.

**Feasibility study (FS) —** A report presenting the development, analysis, comparison, and selection of cleanup alternatives.

**Fines —** Very small solid particles that slowly settle out of water.

**Flocculation —** In wastewater treatment, the formation of clusters of fine suspended particles to improve settling using gentle mixing. This step typically follows coagulation.

**Fraction of organic carbon —** The measure of the total weight of organic carbon in a soil sample relative to the total weight of the soil sample.

**Groundwater —** Water found beneath the ground surface that fills open spaces between particles such as sand, soil, and gravel, or that fills cracks and fractures in rock.

**Human health risk assessment (HHRA)** — A study that evaluates the harmful effects and risks from eating, breathing or touching a chemical (current and future).

**Hydraulic conductivity —** The rate at which water can move through a permeable medium, like an aquifer.

**Hydraulic gradient —** The slope of the water table (in an unconfined aquifer) or potentiometric surface (in a confined aquifer) that controls the general direction of where groundwater flows (e.g., groundwater flows from high elevations to lower elevations).

***In situ* —** In this report, *in situ* means on-site and in place.

***In situ* enhanced bioremediation —** A treatment technology in which chemicals and/or nutrients are added to groundwater in situ (as opposed to extracted groundwater) to increase the activity of naturally occurring bacteria that consume and degrade organic compounds. Bioaugmentation is often included if the naturally occurring bacteria are not present in sufficient quantity to breakdown the compounds.

**Maximum contaminant level (MCL) —** The highest level (concentration) of a chemical allowed in drinking water, set by the EPA.

**Model domain —** The modeling area of interest (with boundaries defined by the model's boundary conditions).

***National Oil and Hazardous Substances Pollution Contingency Plan* (NCP) —** The federal government's plan for responding to oil spills and hazardous substance releases.

**Net present worth (NPW) —** A present worth analysis evaluates costs over a specific period of time by discounting all future costs to a common base year. It represents the amount of money that, if invested in the base year and dispersed as needed, would be sufficient to cover all costs associated with the remedial action over its planned life. Net present worth considers both capital (construction) and annual (such as maintenance and labor) costs.

**Permeable reactive barrier (PRB) —** Reactive materials placed in the subsurface (by trenching or drilling) to catch contaminated groundwater and change contaminants, as they pass through the barrier, into less harmful, environmentally acceptable products.

**Plume —** A body of contaminated groundwater moving away from its source. The movement of contaminants is influenced by such factors as local groundwater flow patterns, aquifer characteristics, and the nature and type of contaminant.

**Potentiometric surface —** The imaginary surface for an aquifer representing the level to which water will rise in a well installed within that aquifer. The water table represents the potentiometric surface of an unconfined aquifer while the potentiometric surface of a confined aquifer (one that is capped by a less permeable layer) may rise above the actual top of the aquifer.

**Preliminary remediation goal** (**PRG) —**Contaminant concentration goals for soil, sediment, water, and air, listed by land use option, that are considered to be protective to human health and the environment. Customarily used at Superfund, Federal Facilities, Brownfield and RCRA sites, and complies with all ARARs. Preliminary remediation goals serve as a target during the initial development, analysis and selection of cleanup alternatives.

**Pumping test —** A test that is conducted to determine groundwater or well characteristics that involves the removal/pumping of groundwater from a well or other extraction point and measuring the resultant drop in water levels.

**Remedial action —** The actual construction or implementation phase of the selected remedial alternative.

**Remedial action objectives (RAOs**) — Objectives that specify contaminants to be cleaned up, the level of cleanup, the area and media of cleanup, and the time required to achieve cleanup to protect human health and the environment.

**Remedial investigation —** An in-depth study of a site that gathers data needed to determine the nature and extent of contamination, assess risk to human health and the environment, establish cleanup criteria, identify preliminary remedial action alternatives, and provide a technical and cost analysis of the alternatives.

**Remediation —** The process of correcting and/or cleaning up environmental contamination. Remediation involves taking action to reduce, isolate, or remove contamination from environmental media (e.g., soil, air, groundwater, surface water), with the goal protecting human health and the environment.

**Residual —** A modeling term that represents the difference between the model-computed and field measured values (like hydraulic head or groundwater flow rate).

**Retardation —** A chemical and physical reaction in the subsurface that changes the average speed of movement of some kinds of contaminant plumes, so that the plume travels much slower than groundwater. Retardation is primarily due to adsorption of contaminants to soil and natural organic material that effectively holds contaminants back, and limits its ability to move at the same speed as the groundwater.

**Slug test —** A test that is conducted to determine hydraulic conductivity that involves the sudden addition or removal of a known volume (typically a large cylinder) from a well and measuring the resultant change in water level.

**Soil-water partition coefficient —** A measure of how much a chemical clings (sorbs) to soil versus how much dissolves in the surrounding water. Expressed as a ratio of “the amount of chemical that adsorbs to soil solids” to “the amount that dissolves in water” (in liters per kilogram [L/kg]).

**Sorb, sorption —** A chemical process where water-borne contaminants adhere or bond to solid particles, effectively removing the contaminants from water; also referred to as *adsorption*.

**Specific yield —** The ratio of the volume of water that an aquifer will yield (give up) to the volume of rock or sediment when it is allowed to drain under the force of gravity. The specific yield is a property of unconfined aquifers.

**Storativity —** The amount of water an aquifer releases from (or takes into) storage (per unit area per unit change in hydraulic head), for example, when water is pumped from a well.

**Steady-state model —** A model of an aquifer system that is in equilibrium (or in balance) with respect to groundwater that flows into and out of the model areas of interest. In a steady-state model simulation, the groundwater head and flux conditions do not change over time.

**Stratigraphy —** The study and classification of rock layers using their physical and geochemical characteristics, and geologic age.

**Supernatant —** Water that remains after solids settle out from a mixture of solids and water.

**Total porosity —** A measure of the total volume of pore spaces (open spaces between sediment particles, or "bubbles" and cracks in rock) in the subsurface that can contain groundwater. Because some of the pores are dead ends, and some of the groundwater will cling on to the sediment or rock surfaces and not drain, the "total porosity" is greater than the "effective porosity."

**Transient model** (time-dependent) **—** A model of an aquifer system that is not in equilibrium with respect to groundwater that flows into and out of the model area of interest. In a transient-state model simulation, the groundwater head and flux conditions are changing over time.

**Trichloroethene (also known as TCE or trichloroethylene**) — A nonflammable, colorless liquid chemical with a slightly sweet odor, commonly used as a industrial solvent and metal degreaser. Trichloroethene is also used in household and consumer products such as typewriter correction fluid, paint removers, adhesives, and spot removers.

**Vapor intrusion —** The movement (migration) of chemical vapors from under the ground into overlying buildings.

**Volatile organic compounds (VOCs**) — A group of chemicals (organic compounds) that will vaporize or evaporate at room temperature into the atmosphere. They often have a sharp smell and can come from many products such as office equipment, adhesives, carpeting, upholstery, paints, petroleum products, solvents, and cleaning products. Trichloroethene is an example of a VOC.

**Zero-valent iron (ZVI) —** A type of pure iron, typically in the form of small particles, used in the construction of subsurface reactive walls to treat and reduce the levels of contamination in groundwater.

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# Executive Summary

Tetra Tech, Inc. has prepared this *Interim Remedial Action - Feasibility Study for the Groundwater Operable Unit at the Dump Road Area Site at Martin State Airport, Middle River, Maryland* for Lockheed Martin Corporation. Martin State Airport is located at 701 Wilson Point Road in Middle River, Maryland, and is bounded by Frog Mortar Creek to the east and Stansbury Creek to the west. Both creeks join Chesapeake Bay at the southern side of the airport. The Dump Road Area Site is located in the southeast portion of the airport and is bounded by Frog Mortar Creek to the east and the main airport runway to the west (Figure ES-1).

The purpose of the Feasibility Study is to evaluate technologies for the interim remediation of groundwater at the site, with the primary goal of minimizing off-site migration of contaminants. The extensive treatment of areas of the site with high concentrations of contaminants in groundwater is not a primary goal of this remedial action and will be further addressed in future documents. Additional investigations for several areas of the site with high concentrations of contaminants are planned for 2012.

As part of this evaluation, an interim remedial action is recommended. Following approval of the Feasibility Study and subsequent Proposed Plan, Lockheed Martin Corporation will implement the recommended interim remedial action.

Groundwater remedial actions in addition to those presented in this Feasibility Study may be considered along with final remedies for the contaminated soil and waste material in the final Feasibility Study for the Dump Road Area Site; these will be based on existing site data and the additional data to be collected in 2012.

Environmental issues with the Dump Road Area Site were originally discovered in July 1991. As part of the investigations of these environmental issues, more than 540 groundwater samples have been collected from 85 permanent monitoring wells and 125 temporary monitoring wells and more than 320 soil samples have been collected from approximately 180 borings and 65

test pits or trenches. These sample collection activities, and associated geophysical investigations, identified waste material (and associated soil and groundwater contamination) at the Dump Road Area Site over an area of approximately 25 acres. These investigations are detailed in the Remedial Investigation Report for this site (Tetra Tech, 2010b).

Soil contamination at the site includes volatile organic compounds, semivolatile organic compounds, polychlorinated biphenyls, and metals. The soil contamination and associated waste material will be addressed in a separate Feasibility Study.

This Feasibility Study is based on groundwater sampling results from 2007 through 2009. Over 200 groundwater samples were collected during this time period. The results of these samples show significant contamination at various depth intervals throughout the Dump Road Area Site. The contaminated aquifer is divided into upper (from the ground surface to an elevation 15 feet below mean sea level), intermediate (from 15 feet below to 45 feet below mean sea level), and deep (from 45 feet below to 73 feet below mean sea level) zones. The deep zone is underlain by a very competent clay layer (see report Section 1.2.3.2).

The following is a summary of the nature and extent of the contamination in groundwater (for selected contaminants) at the Dump Road Area Site:

- Concentrations of chlorinated volatile organic compounds (such as trichloroethene, cis-1,2-dichloroethene, and vinyl chloride) exceeded federal and Maryland groundwater standards throughout a large portion of the investigation area and at multiple depths. Figure ES-2 shows the groundwater trichloroethene concentrations at various depth intervals; the other chlorinated volatile organic compounds listed above follow similar patterns.

- The compound 1,4-dioxane was primarily detected in groundwater samples from the upper and intermediate surficial aquifer zones. It is generally present in areas containing the highest concentrations of chlorinated volatile organic compounds. Figure ES-3 shows the groundwater 1,4-dioxane concentrations at various depth intervals.

- Concentrations of cadmium exceeded the Maryland groundwater standards in 20 percent of samples, and the greatest concentrations of cadmium are associated with high levels of volatile organic compounds in the intermediate surficial aquifer.

- Petroleum-related compounds such as benzene were detected less frequently and at lower concentrations with respect to groundwater standards than the chlorinated volatile organic compounds.

For more information on site groundwater contaminants, see report Section 1.2.5.

Chemicals of concern in groundwater, which include the chemicals listed above, were selected based primarily on the human health risk assessment prepared as part of the Remedial Investigation Report (see report Section 1.2.7.1). A preliminary remediation goal was then developed for each of these contaminants. Preliminary remediation goals that are protective of human health were selected from among Maryland Groundwater Cleanup Criteria, United States Environmental Protection Agency drinking water standards, or risk-based criteria. The groundwater contaminants of concern are presented in Section 2.1, and their respective preliminary remediation goals are presented in Section 2.4 and Table 2-4 of this Feasibility Study.

In order to determine the basis for selecting the appropriate interim remedial action for groundwater, objectives for the interim remedial action were developed. These Remedial Action Objectives for the interim remedial action for groundwater are listed below:

| Remedial Action Objective | Description |
|---|---|
| 1 | Prevent lateral migration of contaminated groundwater toward Frog Mortar Creek at concentrations that would cause exceedance of ambient water quality criteria or risk-based criteria. |
| 2 | Prevent human exposure (including via showering, drinking, and irrigation) to groundwater containing chemical of concern concentrations greater than preliminary remediation goals. |
| 3 | Prevent exposure of industrial workers and construction workers to volatile organic compounds resulting from vapor intrusion into buildings that cause unacceptable risk. |

After identifying the Remedial Action Objectives, the evaluation of interim remedial alternatives for groundwater was conducted (see Section 3.1 of the Feasibility Study). Initially, a total of 22 process options, separated into 7 general response actions categories, were considered. The general response action categories included no action, limited action, containment, removal, *in situ* treatment, *ex situ* treatment, and disposal (see Table 3-1 of the Feasibility Study for more information).

A detailed screening of the process options was conducted and the remaining options were combined into the following six remedial alternatives to be further evaluated:

- ***Alternative G-1 —*** No action.
- ***Alternative G-2 —*** Hydraulic control by extraction, *ex situ* treatment of groundwater, discharge to publicly owned treatment works/surface water, monitoring, and land use controls.
- ***Alternative G-3 —*** Hydraulic control by extraction, *ex situ* treatment of groundwater, reinjection of groundwater, discharge to publicly owned treatment works/surface water, monitoring, and land use controls.
- ***Alternative G-4 —*** Hydraulic control by extraction, extraction in high concentration areas, *ex situ* treatment of groundwater, reinjection of groundwater, discharge to publicly owned treatment works/surface water monitoring, and land use controls.
- ***Alternative G-5 —*** Hydraulic control by extraction, *ex situ* treatment of groundwater, *in situ* bioremediation of high concentration areas, discharge to publicly owned treatment works/surface water, monitoring, and land use controls.
- ***Alternative G-6 —*** Zero-valent iron permeable reactive barrier, monitoring, and land use controls.

Alternative G-1 was developed and analyzed as a baseline against which the other alternatives could be compared.

Alternative G-2 was developed as a base case with hydraulic control of the plume only (to minimize off-site migration of contaminants). Extracted groundwater is then treated to remove contaminants prior to discharge. Groundwater contaminants upgradient of the extraction wells will eventually flow to the extraction wells, but the design does not incorporate acceleration of the overall groundwater cleanup.

Alternative G-3 is an enhanced version of Alternative G-2, in that some of the treated groundwater will be amended with an electron-donor compound and then reinjected upgradient of the high concentration areas to promote biological remediation. The treatment system in this alternative is sized for a larger flow rate to address the potential for flexibility in future operations, including the final site groundwater remedy.

Alternative G-4 is a more aggressive extraction and treatment approach that includes extraction and treatment of highly contaminated groundwater from the high concentration areas, and

reinjection of treated groundwater (with amendments to promote biological activity). Treating additional groundwater may reduce the time required to restore groundwater quality.

Alternative G-5 is similar to Alternative G-4 in that highly contaminated groundwater in the high concentration areas is treated. However, in Alternative G-5, highly contaminated groundwater in the high concentration areas is treated *in situ* by enhanced bioremediation to reduce the time to restore groundwater quality, and extracted groundwater is not reinjected. The treatment system in this alternative is also sized for a larger flow rate to permit flexibility in future operations.

Alternative G-6 uses a permeable reactive barrier for passive treatment of groundwater contaminants instead of a groundwater extraction and treatment system. A description and detailed analysis of these alternatives are presented in Sections 4.2.1 through 4.2.6 of the Feasibility Study. The key features of each alternative are summarized in Table 4-1 of the document.

A detailed evaluation of each alternative was conducted with respect to the following evaluation criteria: Overall Protection of Human Health and the Environment; Compliance with Applicable, or Relevant and Appropriate Requirements; Long-Term Effectiveness and Permanence; Reduction of Toxicity, Mobility, or Volume of Contaminants through Treatment; Short-Term Effectiveness; Implementability; Sustainability; and Cost (see report Sections 4.2.1 through 4.2.6). A comparison of the alternatives based on these criteria was then completed (see Table 5-1 of the Feasibility Study).

Based on this evaluation, Alternative G-3 (hydraulic control by extraction, *ex situ* treatment of groundwater, reinjection of groundwater in high concentration areas, discharge to publicly owned treatment works/surface water, monitoring, and land use controls) was selected as the interim remedial action for groundwater at the Dump Road Area Site. This alternative meets the interim remedial action requirement in that it provides containment to minimize off-site migration of trichloroethene, 1,4-dioxane, and cadmium. It also provides additional groundwater treatment capacity so that the groundwater extraction system can be expanded in the future, particularly after the soil and landfill waste have been remediated.

Future expansion of this alternative could include groundwater recirculation and *in situ* bioremediation in the high concentration areas to provide some destruction of chlorinated

volatile organic compounds, and such expansion could be designed for implementation in conjunction with the soil/landfill waste remedy. This alternative is economical and provides both effective treatment of all chemicals of concern and operational flexibility. The general site layout for Alternative G-3 is shown in Figure ES-4. More details on the criteria for selection are included in Section 5.3 of the report.

As part of Lockheed Martin Corporation's "Go Green" program, sustainability was a factor in selecting the recommended remedial alternative, and sustainability practices will be included in the design, installation, and operation of the interim remedial action for groundwater. Sustainability practices in general are those that consider economic and natural resources, ecology, human health and safety, quality of life, and reduction of the overall environmental "footprint". Details on these practices as they relate to this Feasibility Study are included in Section 5.4 of the report.

The interim remedial action-groundwater feasibility study was presented and submitted to the on site stakeholders for their review: the Maryland Aviation Administration and the Maryland Air National Guard. Comments from these stakeholders were incorporated in this revised report.

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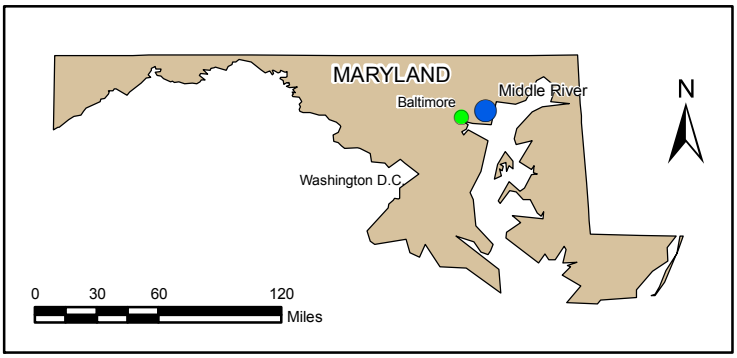


**Figure ES-1**

**Dump Road Area Site Location Map**

***Lockheed Martin, Martin State Airport***
***Middle River, Maryland***

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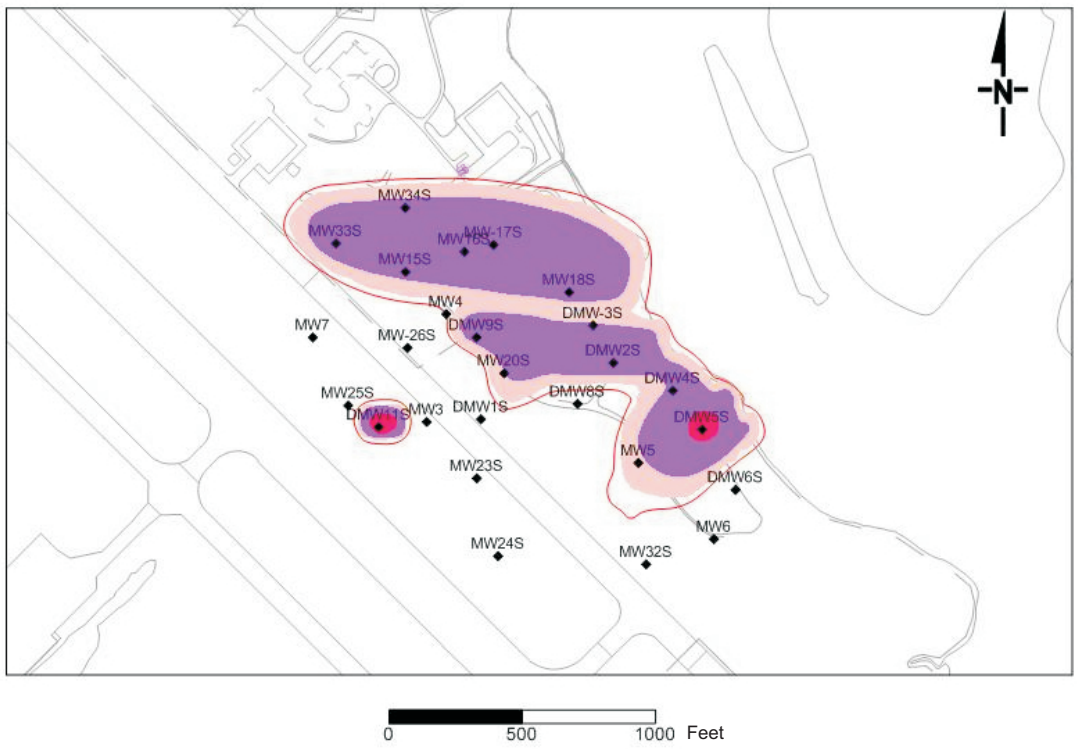
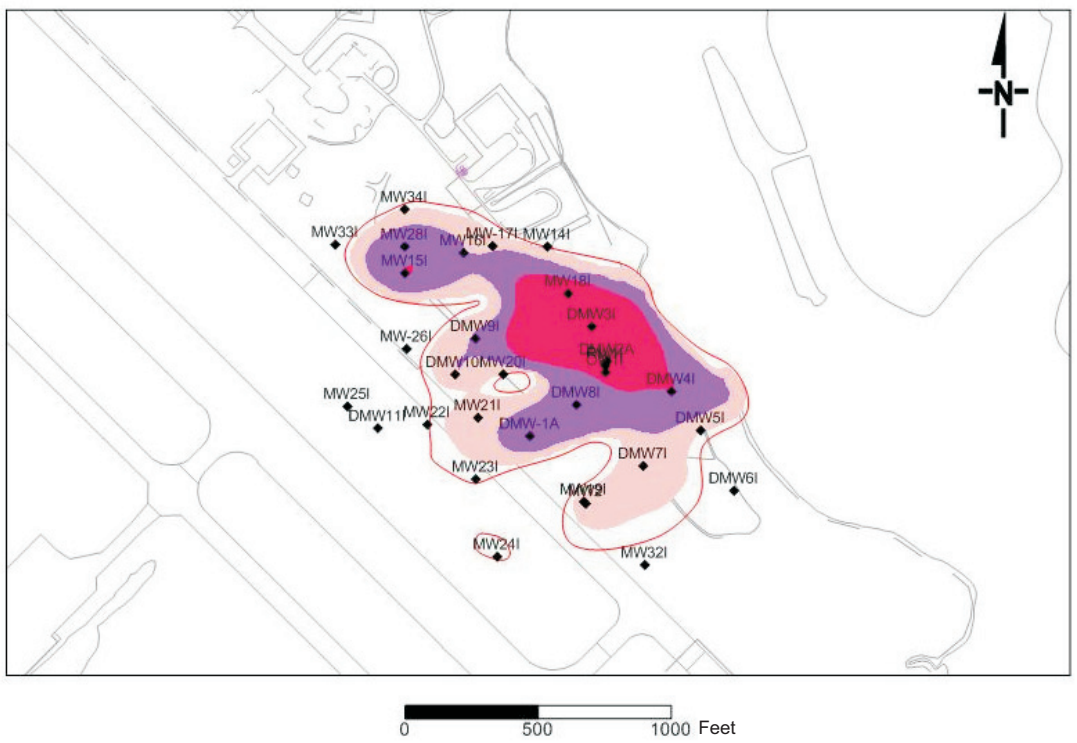
| 8/03/10 | MP |

Tetra Tech, Inc.

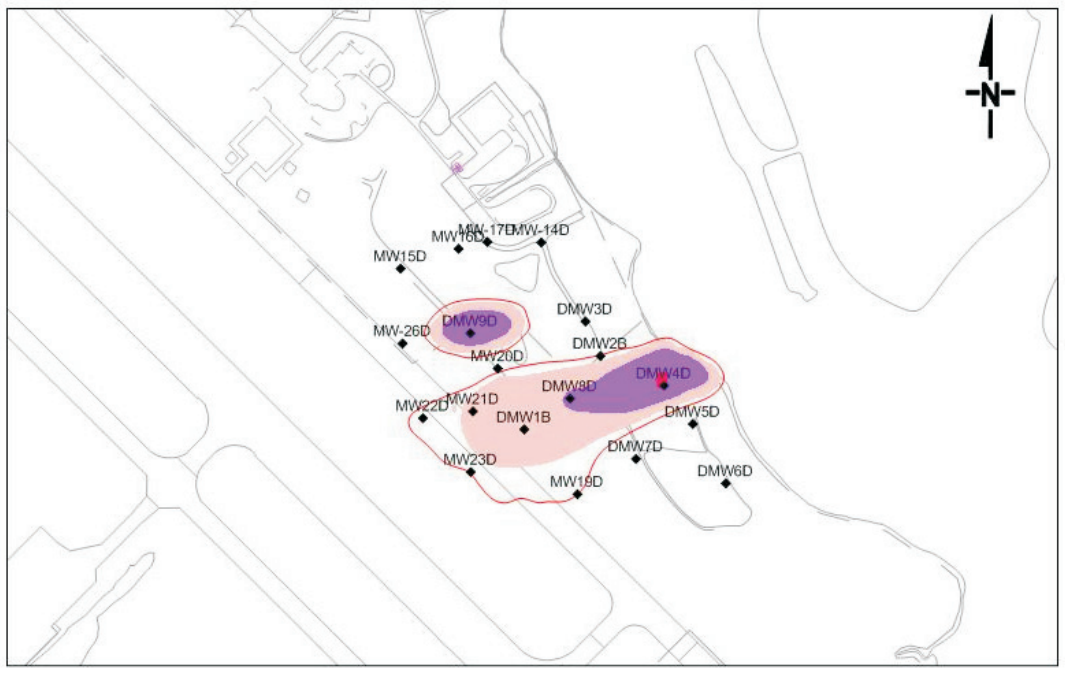
## Upper Surficial Aquifer




## Intermediate Surficial Aquifer




## Lower Surficial Aquifer




Concentration ug/L

5000

500

50

5

5 ug/L

Note: Contours generated by groundwater model

Tetra Tech NUS, Inc

# Groundwater Plume - Trichloroethene
# Dump Road Area Site
# Lockheed Martin, Martin State Airport
# Middle River, Maryland

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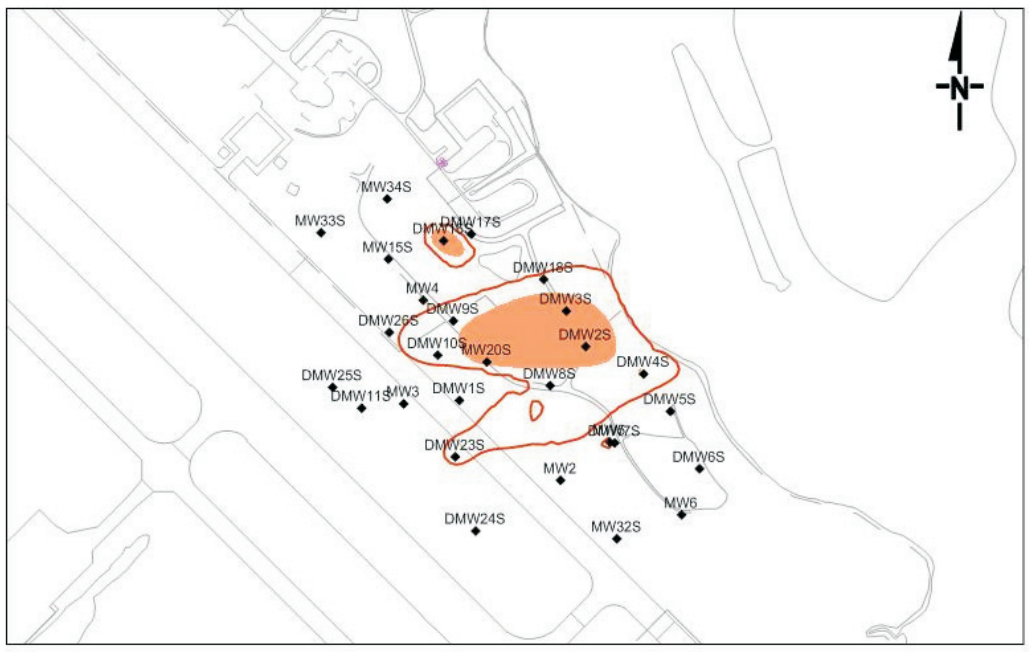
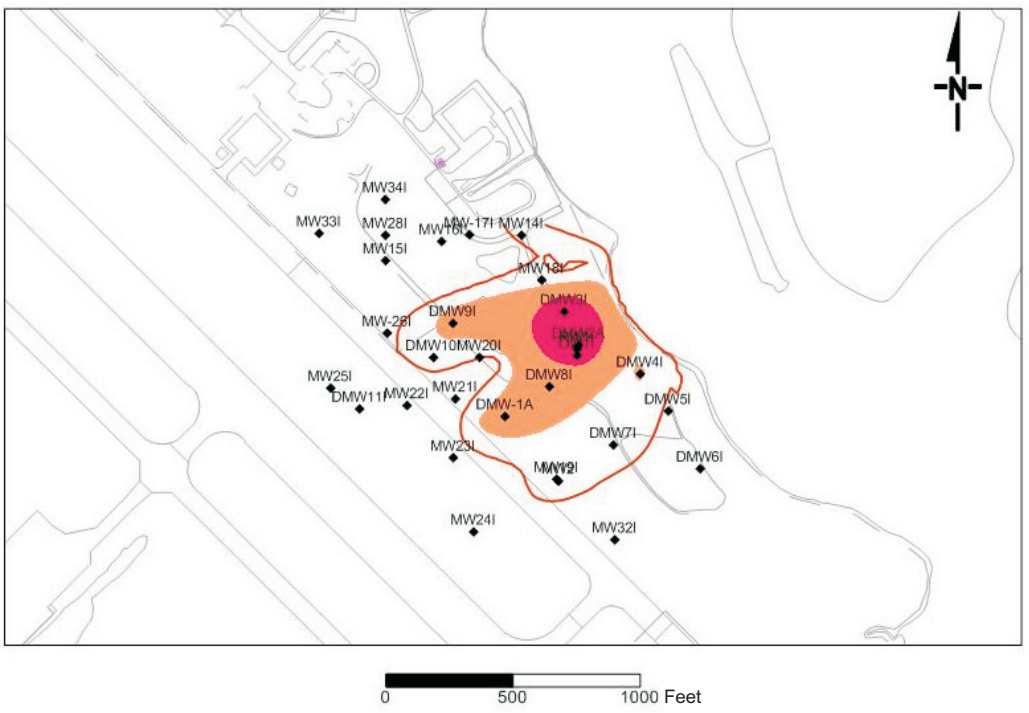
## Upper Surficial Aquifer




## Intermediate Surficial Aquifer




## Lower Surficial Aquifer




Concentration ug/L




6 ug/L

Note: Contours generated by groundwater model

Tetra Tech NUS, Inc

# Groundwater Plume - 1,4- Dioxane
# Dump Road Area Site
# Lockheed Martin, Martin State Airport
# Middle River, Maryland

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|---|---|
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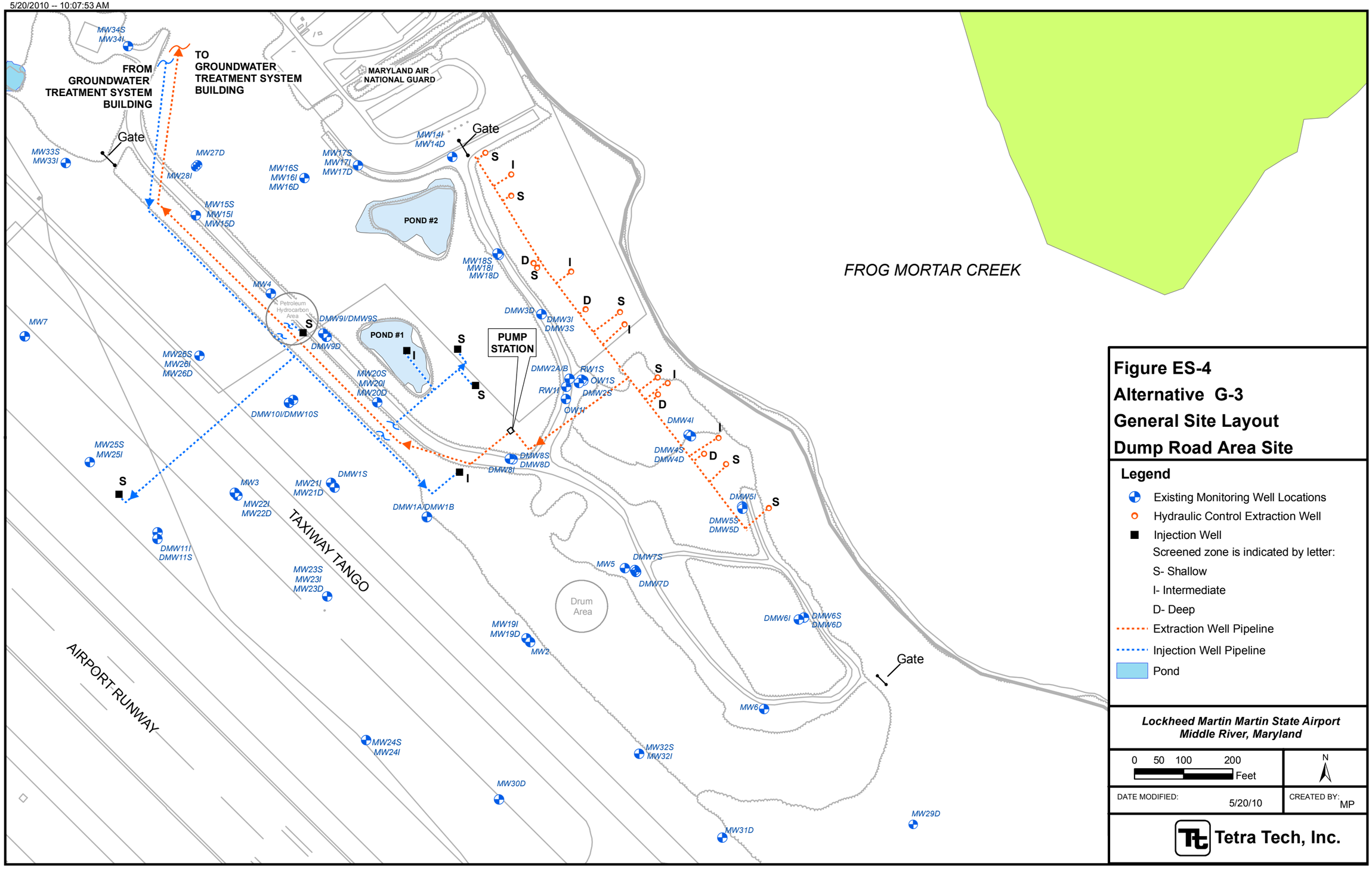


**Figure ES-4**
**Alternative G-3**
**General Site Layout**
**Dump Road Area Site**

**Legend**

- Existing Monitoring Well Locations
- Hydraulic Control Extraction Well
- Injection Well
  Screened zone is indicated by letter:
  S- Shallow
  I- Intermediate
  D- Deep
- Extraction Well Pipeline
- Injection Well Pipeline
- Pond

***Lockheed Martin Martin State Airport***
***Middle River, Maryland***

0 50 100 200 Feet

N

DATE MODIFIED: 5/20/10

CREATED BY: MP

Tetra Tech, Inc.

# Section 1
# Introduction

## 1.1 REPORT PURPOSE AND ORGANIZATION

### 1.1.1 Purpose

Tetra Tech, Inc. (Tetra Tech) has prepared this *Interim Remedial Action - Feasibility Study (FS) for the Groundwater Operable Unit at the Dump Road Area (DRA) Site at Martin State Airport (MSA), Middle River, Maryland* (Groundwater FS herein) for Lockheed Martin Corporation (Lockheed Martin) to evaluate alternatives for an interim remedial action, primarily considering containment of contaminated groundwater at the DRA Site. Containment alternatives that include limited source area treatment are also evaluated. This FS is not a comprehensive evaluation of groundwater remediation across the entire DRA Site, as intensive source treatment is not a primary consideration.

A comprehensive evaluation of groundwater remedies will be included in a separate FS, along with remedies for contaminated soil and landfill waste associated with this site. The FS for the contaminated soil and landfill waste, as well as the comprehensive evaluation of the site groundwater, will be completed in consultation with the current property owner [Maryland Aviation Authority (MAA)] and tenant [Maryland Air National Guard (MDANG)]. Additional investigations in several areas of the site containing high concentrations of contaminants are planned for 2012, and will be used in the preparation of the separate FS.

This document was prepared following the requirements for a feasibility study as outlined in the United States Environmental Protection Agency's (EPA) *National Oil and Hazardous Pollution Contingency Plan* (NCP). Although the site does not fall under the federal Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the NCP process was nevertheless followed in this feasibility study to provide information in a recognized format and to fully evaluate options to properly contain groundwater contamination caused by waste disposed at the DRA Site. The FS process is aimed at gathering and evaluating

information sufficient to select an appropriate interim remedial action for DRA Site groundwater. This Groundwater FS establishes remedial action objectives (RAOs) and cleanup goals and screens remedial action technologies that may be suitable for addressing areas of groundwater at the DRA Site with contaminant concentrations greater than cleanup goals. It assembles, evaluates, and compares several remedial action alternatives for such groundwater, and then recommends one of these as the best interim remedial action for the DRA Site.

This Groundwater FS was prepared for review and approval by the Maryland Department of the Environment (MDE) and is subject to the regulatory requirements of Maryland's Hazardous Substance Response Plan (Code of Maryland Regulations Title 26, Subtitle 14). Maryland's Hazardous Substance Response Plan grants MDE the authority to choose how a cleanup will be performed.

This Groundwater FS is based on data collected during a series of investigations conducted from 1992 to 2010 and on the results and conclusions of the remedial investigation (RI) report, including the human health and ecological risk assessments (Tetra Tech, 2010b). In this Groundwater FS report, the results of previous investigations and risk assessments are used to develop and evaluate potential remedial action alternatives that will permanently and significantly reduce risks to human health and the environment that have been identified at the site. The proposed alternatives provide cost-effective and sustainable methods to mitigate the risks identified in the human health and ecological risk assessments.

The interim remedial action selected will be designed and implemented so that it does not interfere with future parallel soil and landfill waste remediation projects at this site. The design of the groundwater containment system includes flexibility to treat additional groundwater if site conditions should change in the future. Lockheed Martin will implement the preferred interim remedial action subsequent to MDE concurrence with this Groundwater FS.

### 1.1.2 Report Organization

This Groundwater FS is organized to meet the general format requirements specified in EPA's remedial investigation/feasibility study guidance document (EPA, 1988). This FS report is organized as follows:

Section 1.0: Introduction - Describes the purpose of the Groundwater FS, the site background, and summarizes the findings of previous site investigations and risk assessments.

Section 2.0: Remedial Action Objectives and General Response Actions - Provides remedial action objectives, chemicals of concern (COCs), environmental media of concern, applicable or relevant and appropriate requirements (ARARs) and other guidance criteria, groundwater cleanup goals and associated general response actions (GRAs), and estimates of the volumes of contaminated groundwater and mass of contaminants.

Section 3.0: Technology Screening and Process Options - Describes a two-tiered process for screening potentially applicable groundwater remediation technologies and assembling them into remedial action alternatives.

Section 4.0: Assembly and Detailed Analysis of Remedial Action Alternatives - Describes evaluation criteria and detailed analyses of the groundwater interim remedial action alternatives, in accordance with the CERCLA process. This section also makes optimization recommendations to enhance the sustainability of the selected interim remedial action.

Section 5.0: Comparative Analysis of Remedial Action Alternatives - Compares groundwater remedial action alternatives on a criterion-by-criterion basis and selects the recommended alternative.

Section 6.0: Future Actions - Summarizes future activities to address environmental issues at the DRA Site.

Section 7.0: References - Lists documents used to prepare this Groundwater FS.

Appendix A presents selected figures and tables from the MSA RI report (Tetra Tech, 2010b). Appendix B is the groundwater modeling report. Appendix C contains volume computations of groundwater contaminants identified at the site at concentrations greater than cleanup goals. Appendix D describes the screening of remediation technologies and process options. Appendix E presents preliminary design calculations and detailed process descriptions for interim remedial action alternatives. Appendix F presents cost estimates for the remedial action alternatives.

## 1.2 SITE BACKGROUND

The following subsections provide background information about the DRA Site. Figure 1-1 is a general location map; Figure 1-2 is a site map showing general site features. Figure 1-3 shows the main site features (such as areas of concern where previous investigations were conducted), and Figure 1-4 shows site monitoring well locations.

### 1.2.1 Site Description

Martin State Airport is located at 701 Wilson Point Road in Middle River, Maryland, and is bounded by Frog Mortar Creek to the east and Stansbury Creek to the west (Figure 1-2). Both creeks join Chesapeake Bay at the southern side of the airport. The DRA Site is on the southeast portion of MSA and is bounded by Frog Mortar Creek to the east and Taxiway Tango and the main airport runway to the west.

Martin State Airport was owned and operated by the Glenn L. Martin Company (a predecessor firm of Martin Marietta Corporation) from approximately 1929–1975. Runways and hangars were built in 1939–1940. The Glenn L. Martin Company consolidated with American Marietta Corporation in September 1961 to form Martin Marietta Corporation. Lockheed Corporation and Martin Marietta merged in 1996 to form Lockheed Martin Corporation. In July 1955, the MDANG began leasing the property from the Glenn L. Martin Company. In September 1975, the MAA purchased the land now used as the airfield.

Environmental issues associated with the DRA Site were initially identified in July 1991, when MAA encountered four drums adjacent to Taxiway Tango during trenching to install an electrical cable. These drums were subsequently disposed of off-site. Discovery of these buried drums led to investigation of the surrounding area for possible soil and groundwater contamination. These investigations also showed that the DRA Site had been used as a landfill for wastes associated with aircraft manufacturing.

### 1.2.2 Previous Investigations

The Maryland Aviation Administration (1991–1997) and Lockheed Martin (1998–2009) performed 20 site investigations and/or sampling events to outline the extent of environmental contamination at the DRA Site. The early investigations identified four areas of concern (see Figure 1-3):

- Taxiway Tango Median Anomaly
- Drum Area
- Two ponds
- Petroleum Hydrocarbon Area

They were identified as areas of concern based on earlier analyses of soil samples and observations of debris and waste material found at these locations. Site investigations included

monitoring well installation, soil and groundwater sampling, test pit excavations, and geophysical surveys. These investigations also identified the extent of historical landfilling and waste disposal. More than 540 groundwater samples were collected from approximately 85 permanent monitoring wells, 125 temporary monitoring wells, and temporary groundwater sampling points. More than 324 soil samples were collected from approximately 180 borings and 65 test pits or trenches. The results of these investigations are summarized in reports listed in Section 7, References, below.

An RI was conducted to refine the lateral and vertical extent of landfill material to support the remedial design for the landfill area and to quantify subsurface contaminant mass for groundwater remediation. Fieldwork for the RI was performed in late 2009, and the RI report was completed in May 2010 (Tetra Tech, 2010b). A secondary objective of the RI was to identify the northern extent of groundwater contamination. The RI provides an evaluation of the nature and extent of environmental contamination at the DRA Site and includes a human health risk assessment (HHRA) and an ecological risk assessment (ERA). The results of the RI are used in this Groundwater FS to establish current environmental conditions and to help choose an appropriate remedial action. Select figures and tables from the RI are included in Appendix A to supplement this Groundwater FS.

### 1.2.3 Geology and Hydrogeology

#### 1.2.3.1 Regional Geology and Hydrogeology

Martin State Airport is on the Western Shore of Chesapeake Bay and situated within the westernmost portion of the Coastal Plain Physiographic Province. Geologic mapping of Baltimore County shows that the site is underlain by the Potomac Group, a lower Cretaceous age inter-bedded gravel, sand, silt, and clay unit ranging from 0 to 800 feet thick. The Potomac Group at the site consists of three units (from the top down, and thus from the youngest to oldest): the Patapsco Formation, the Arundel Clay, and the Patuxent Formation. Potomac Group sediments were deposited in a river delta environment (Hansen, 1969).

The Patapsco Formation, the formation of primary interest in this investigation, is composed primarily of silty sands, fine-grained to medium-grained sands, silty clays, clayey silts, and plastic clay characteristic of back swamps and floodplain deposits. The Arundel Clay is

composed of dark gray and maroon lignitic clays ranging between 25 to 200 feet thick beneath the site. The Arundel Clay probably acts as an impermeable barrier to the downward movement of any constituents found in the overlying groundwater. Below the Arundel Formation is the Patuxent Formation. It is a multi-aquifer unit, due to various inter-bedded sand and silt/clay layers and the rapid changes of deposited material types over short distances (Glaser, 1969).

#### 1.2.3.2 Dump Road Area Site Geology and Hydrogeology

Previous and recent investigations at the DRA Site indicate that the subsurface is characterized by inter-bedded zones of heterogeneous sand, silt, and clay deposits from the Patapsco Formation. Figure 1-5 depicts a generalized cross-section of the surficial aquifer at the DRA Site. Boring logs and cross-sections across the site indicate the presence of relatively continuous layers of sand and gravel that are locally separated by silts and clays. These shallow permeable zones form the surficial aquifer. Both regional information (Andreasen, 2007; Fleck and Vroblesky, 1996; Chapelle, 1985) and recent deep borings at the DRA Site indicate the presence of a thick clay unit approximately 120 feet below the site, which may be the top of the Arundel Formation.

The hydrogeologic system beneath MSA consists of relatively continuous zones of sand and gravel that provide the primary pathways for groundwater flow and contaminant transport. These zones are interlayered with zones of lower permeability sediments, resulting in a relatively complex stratigraphic sequence. Water enters these units [primarily via natural infiltration of precipitation (i.e., recharge)] through the shallow fill materials, and then reaches the water table. From there, the groundwater migrates along various pathways depending on location, with some of the groundwater flowing vertically downward to recharge units below the water table. Eventually, almost all of the groundwater flows laterally through permeable zones, and discharges to estuaries surrounding the peninsula on which MSA is located. In the Dump Road Area, the estuary of relevance is Frog Mortar Creek. Site data indicate that the surficial aquifer is divided into three hydraulically connected monitoring zones: upper (shallow), intermediate, and lower (deep).

The surficial aquifer is underlain at approximately 75 to 85 feet below mean sea level (msl) by a relatively thick clay unit that acts as a basal confining unit. Cross-sections of the surficial

aquifer are presented along various transects in Appendix A. Deep borings at the site indicate the presence of deeper sand zones, which are confined above and below by clay units. These are most likely from the Arundel Formation, which is a regionally extensive, thick, dense, clay confining unit.

Frog Mortar Creek is influenced by tidal fluctuations with average amplitudes of approximately 1.2 feet, and thus a tidal range of about 2.4 feet. In the upper zone, water level recordings indicate that tidal fluctuation amplitudes decrease to less than 0.1 foot within a few hundred feet from Frog Mortar Creek. This damping effect is most likely due to the relatively high storage coefficient of the water table aquifer, in which primary storage space just above the water table can readily fill and drain. In the intermediate and lower zones, tidal fluctuations diminish less rapidly with distance from Frog Mortar Creek because of the semi-confined or confined conditions in these zones. Much less damping of tidal variation occurs under these conditions because the aquifer units are fully saturated and under artesian pressure.

Groundwater flow in the upper zone is generally to the east toward Frog Mortar Creek. A similar flow direction is seen in the intermediate and lower zones. At monitoring well clusters, the concurrently measured water levels for a given cluster indicate that groundwater vertical head differences in the surficial aquifer are generally downward in the upland areas and upward near Frog Mortar Creek.

Slug tests at the site yielded hydraulic conductivity estimates ranging from 5 to 20 feet/day in sand zones to 0.01 to 0.2 feet/day in clay zones (Tetra Tech, 2004). Pumping tests were performed in both the upper and intermediate zones of the surficial aquifer. Intermediate zone pumping tests indicate an average horizontal hydraulic conductivity ranging from 42 to 140 feet/day, with a mean of 68 feet/day (Tetra Tech, 2010a). No pumping tests have been performed in the lower zone. Figures 4-4 through 4-14 in the RI report (see Appendix A) show geologic cross-sections that illustrate the lithologic characteristics of the subsurface.

#### 1.2.3.3 Surface Water Hydrology

The eastern, southern, and western boundaries of MSA are bordered by Frog Mortar Creek and Stansbury Creek, which are wide, brackish, tidal tributaries of the middle Chesapeake Bay. Surface water runoff from MSA enters these creeks via localized gullies in the eastern and

western undeveloped portions of the site, or via storm sewers that drain the airport runway, taxiways, and developed portions of the facility. In the DRA, six drainage areas direct flow from the runway, taxiways, and wooded areas and discharge to Frog Mortar Creek on the east side of MSA.

Two small ponds and adjacent pond margin wetlands are in the DRA, and a storm water management pond is near the Fire Pump House in the western portion of MSA. These ponds and wetlands are contained in each drainage area and do not discharge to Frog Mortar Creek. Comparisons of the pond water surface elevations to the groundwater table elevation suggest that the ponds are not well connected to the surficial aquifer. Additional investigations are being undertaken in 2012 to determine the level of hydaulic connection between the surface water and groundwater, and to evaluate the potential effect groundwater withdrawal may have on the water level in the ponds.

A site-wide wetlands identification and mapping study has been prepared by the MAA.

### 1.2.4 Nature and Extent of Contamination — Soil

Chemical analyses of numerous soil samples and several pond sediment samples indicate the presence of volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), and several metals in soil and pond bottom sediment at concentrations exceeding EPA human health and ecological risk-based screening levels and MDE soil cleanup standards. The primary VOCs detected in soil and pond sediment samples are trichloroethene (TCE), TCE degradation products such as cis-1,2-dichloroethene (DCE) and vinyl chloride, and benzene, toluene, ethylbenzene, and xylenes (BTEX). Semivolatile organic compounds detected in soil and sediment include polynuclear aromatic hydrocarbons (PAHs), which are a group of compounds derived from the combustion of materials. Metals detected in soil and pond sediment at the site include antimony, arsenic, cadmium, copper, chromium, lead, mercury, nickel, and zinc.

A detailed description of the nature and extent of soil contamination at the site is provided in the RI report (Tetra Tech, 2010b). Remedial action for soil at the DRA Site will be addressed later in a separate report, which will evaluate appropriate remedial technologies such as soil excavation, capping, and consolidation.

### 1.2.5 Nature and Extent of Contamination — Groundwater

Groundwater sampling results evaluated in this section consist of data from three sampling events in 2007, 2008, and 2009. Analyses of these samples focus on contaminants that had been frequently detected during previous sampling events, specifically VOCs, 1,4-dioxane, and total and dissolved metals. Analyses for perchlorate and hexavalent chromium were also performed on a subset of the samples.

As with site soils, contaminants detected in groundwater are common to aircraft manufacturing. The 2007 and 2008 sampling events included all installed wells. In 2009, six newly installed wells and a subset of existing wells were sampled. Upper surficial aquifer well samples were analyzed in 2009 for total petroleum hydrocarbons (TPH), diesel range organics (DRO), and gasoline range organics (GRO). The maximum contaminant concentrations detected in each aquifer zone are shown in Table 1-1. Selected wells were also analyzed for natural attenuation parameters such as:

- alkalinity
- chemical oxygen demand
- dissolved gasses (methane, ethane, ethene, hydrogen, oxygen, and carbon dioxide)
- anions
- total organic carbon

Up to 200 groundwater samples were collected between 2007 to 2009 for the upper, intermediate, and lower surficial aquifers and deep confined aquifer. The nature and extent of groundwater contamination is described in the RI report (Tetra Tech, 2010b). Tables and figures summarizing analytical results from the RI are included in Appendix A. The extent of TCE, cis-1,2-DCE, vinyl chloride, and 1,4-dioxane in each surficial aquifer zone is shown in Figures 1-6, 1-7, 1-8, and 1-9, respectively. As presented in the RI report, the nature and extent of COCs are summarized below:

- Concentrations of chlorinated volatile organic compounds (cVOCs) (such as TCE and cis-1,2-DCE) exceeded federal and Maryland groundwater standards throughout an area of approximately 30 acres and at multiple depths. Multiple cVOC sources at the site have resulted in cVOC-contaminated groundwater extending to areas north of Pond 2 and south to wells DMW6I and DMW7I (see RI Figures 5-14 through 5-17 in Appendix A).

- Concentrations of cVOCs in groundwater have generally decreased as compared to the 2004 analytical results. Reductions of TCE concentrations and high concentrations of the chemical daughter products cis-1,2-DCE, vinyl chloride, and ethene indicate that TCE degradation has occurred at the site and may continue.

- The compound 1,4-dioxane was detected primarily in groundwater samples from the upper and intermediate surficial aquifer zones. It is generally collocated in areas with the highest concentrations of cVOCs, primarily near and east of Pond 1 (see RI Figures 5-23 and 5-24 in Appendix A).

- Concentrations of cadmium exceeded the maximum contaminant level (MCL) in 20 percent of samples, and the greatest concentrations of cadmium are associated with high levels of VOCs in the intermediate surficial aquifer at wells DMW1A, DMW2A, DMW8I, and DMW3I, south and east of Pond 1. Concentrations of metals such as chromium, hexavalent chromium, lead, mercury, and zinc exceeded MCLs in less than 10 percent of samples, ranging from one exceedance each for mercury and zinc to five exceedances for lead. Dissolved lead and mercury concentrations did not exceed MCLs.

- The BTEX compounds associated with petroleum constituents were detected less frequently and at lower concentrations with respect to federal and state groundwater standards than cVOCs. Well DMW9S (near the Petroleum Hydrocarbon Area) had the greatest concentrations of BTEX (see RI Figure 5-18 in Appendix A).

- In 2009, groundwater samples from the upper surficial aquifer were analyzed for TPH DRO (which was detected in more than half of the samples), with the greatest concentration reported for well DMW20S in the upper surficial aquifer, south of the Petroleum Hydrocarbon Area (Figure 1-3). Nearly all of the samples had detectable levels of TPH-GRO, with the greatest concentration reported for well DMW9S in the upper surficial aquifer, south of the Petroleum Hydrocarbon Area. Substantially lower concentrations of TPH-DRO and TPH-GRO were reported for wells near the Drum Area and Taxiway Tango.

- Concentrations of TCE were detected at levels greater than 1 percent of its solubility, which suggests the presence of dense non aqueous phase liquid (DNAPL) in the subsurface. However, no DNAPL was observed.

The primary objective of the interim remedial action alternatives addressed in this Groundwater FS is containment. However, active remediation of groundwater with the highest contaminant concentrations would decrease containment duration. Therefore, limited remediation of the high concentration areas (HCAs) is also considered in developing some of the remedial alternatives in this Groundwater FS. High concentration areas are areas where concentrations of TCE, cis-1,2-DCE, or vinyl chloride are greater than 5,000 micrograms per liter (µg/L), or, in the case of 1,4-dioxane, greater than 100 µg/L. High concentration areas for TCE, cis-1,2-DCE,

and vinyl chloride are shown in red in Figures 1-6 through 1-8 (at the end of Section 1), and HCAs for 1,4-dioxane are shown in orange areas in Figure 1-9.

Additional investigations are being conducted in several of the HCAs. The purpose of these investigations is to better characterize and delineate the areas of the site with the highest contaminant concentrations in order to focus potential future remedial actions. The results of these investigations will be submitted in future documents and will be used to plan potential remedial actions conducted subsequent to this IRA. The HCAs being investigated further include the vicinity of DMW-11S, the area in and around Pond 1, the Drum Area, and the vicinity of boring TA-1.

### 1.2.6 Contaminant Fate and Transport

Historical waste disposal has contaminated groundwater at the DRA Site. Very little information about past waste disposal practices is available. At one time, the two ponds on-site were used to dispose of acid wastes. At the other three areas of concern, evidence of waste disposal (such as drums and discolored soil) has been observed at the surface. Geophysical surveys and test pits also suggest that waste disposal occurred here.

Contaminants from these wastes eventually migrated through the soil to groundwater, since the topography is generally flat. Precipitation passing through the soil would have likewise carried contaminants to the groundwater. From there, contaminants migrated vertically downward and topographically downgradient toward Frog Mortar Creek. Natural biological activity has since degraded some VOCs and cVOCs.

Groundwater modeling was performed in support of the Groundwater FS and the groundwater modeling report is provided in Appendix B. Groundwater flow numerical models were developed based on field observations, tests, and laboratory analyses. Groundwater modeling supports the development of alternatives for an interim remedial action to address VOC and 1,4-dioxane contamination in groundwater at the DRA Site, focusing on containment (that is, on preventing contaminated groundwater from migrating off-site toward Frog Mortar Creek). Additional model simulations examined the effect of placing injection and extraction wells in the HCAs. Modeling results indicated that the site's contaminated groundwater could be effectively controlled via groundwater extraction.

### 1.2.7 Baseline Risk Assessments

#### 1.2.7.1 Human Health Risk Assessment

An HHRA was conducted in 2010 and included in the RI report. It used the RI results to evaluate risk to potential human receptors under current and likely future land uses, and in accordance with EPA and MDE guidelines. The HHRA primarily considers receptor exposure under non-residential (e.g., industrial, recreational) land use scenarios. Although the site is not expected to be used for residential purposes in the foreseeable future, residential land uses also were evaluated. The HHRA also developed preliminary cleanup goals for site soil and groundwater contaminants that significantly contribute to the estimated cancer risk and/or hazard index.

The predominant chemicals evaluated for human health risk, based on direct contact exposure, are cVOCs (via direct contact with soils, groundwater, and sediments), BTEX (via soils and groundwater), substituted benzene compounds (via soils and groundwater), PAHs (via soils and sediments), perchlorate (via groundwater), and several heavy metals (i.e., cadmium, lead, copper, chromium, nickel) (via soils and groundwater). Ingestion of groundwater at the DRA Site is expected to be limited to exposures that might occur under a future residential scenario. Incidental ingestion of groundwater by construction workers might occur during construction/excavation activities. Future workers could be exposed to unacceptable concentrations of VOCs via vapor intrusion into buildings built over the contaminant plume. Trespassers/visitors could incidentally ingest surface water while on-site. However, only one surface water chemical was detected, and no COCs were identified for surface water. Trespassers could also be exposed to contaminants in pond sediments through incidental ingection and dermal contact.

Groundwater is not currently used as a source of potable or industrial water at the site, nor is such use likely in the future. The groundwater user survey also indicates the possibility of wells near MSA, but these wells, if they exist, would be upgradient of MSA and would not be affected by any on-site contaminant sources. Groundwater remediation at this site is appropriate due to the risks identified in the HHRA and the presence of groundwater contaminants at concentrations greater than EPA and MDE standards.

### 1.2.7.2 Ecological Risk Assessment

An ERA was also conducted in 2010 as part of RI activities, in accordance with EPA guidelines to evaluate risk to potential ecological receptors in surface soil, sediment, and groundwater (evaluated as surface water). The central area of the site northwest of Pond No. 1 appears to be the area of greatest ecological risk, based on current sampling data. Surface soil ecological chemicals of potential concern (COPCs) for invertebrates and plants include:

- TCE
- cis-1,2-DCE
- antimony
- chromium
- copper
- manganese
- molybdenum
- zinc

PAHs are COPCs only for soil invertebrates, whereas cadmium, lead, nickel, and selenium were retained as COPCs only for plants. Further evaluation of surface soil identified several metals (mercury, cadmium, lead, and molybdenum) as risks to wildlife (e.g., quail, shrews, robins). Volatile organic compounds, PAHs, PCBs, and several metals were retained as COPCs for Pond No. 1 sediment. For groundwater evaluated as surface water, several VOCs and metals exceeded surface water criteria. Even with dilution factors as high as 50-fold applied to chemical concentrations, numerous chemicals in groundwater still exceeded surface water criteria. Therefore, risks to aquatic biota are possible from detected concentrations of VOCs and metals in groundwater, assuming up to a 50-fold dilution of groundwater discharging into a water body at the groundwater/surface water interface.

**Table 1-1**

**Maximum Detection Results of Contaminants - DRA Site Groundwater Feasibility Study**
**Lockheed Martin, Martin State Airport**
**Middle River, Maryland**


| Location | Upper Surficial Aquifer | Intermediate Surficial Aquifer | Lower Surficial Aquifer | Deep Confined Aquifer | Maximum Contaminant Level (1) |
|---|---|---|---|---|---|
| **Parameter** | **Maximum Result** | **Maximum Result** | **Maximum Result** | **Maximum Result** | |
| **Volatile Organics (ug/l)** | | | | | |
| 1,1,2,2-TETRACHLOROETHANE | 20 | ND | ND | ND | 0.066* |
| 1,1-DICHLOROETHANE | 83.3 | 21.7 | 4.4 | ND | 2.4* |
| 1,1-DICHLOROETHENE | 222 | 83 | 18.8 | ND | 7 |
| 1,2,3-TRICHLOROBENZENE | 3 | 115 | 3.5 | ND | 5.2* |
| 1,2,4-TRICHLOROBENZENE | 29 | 730 | 22.4 | ND | 70 |
| 1,2,4-TRIMETHYLBENZENE | 375 | 30 | 0.8 | 0.4 | 15* |
| 1,2-DICHLOROETHANE | 113 | 160 | 32.6 | ND | 5 |
| 1,3,5-TRIMETHYLBENZENE | 190 | 11 | 2.2 | ND | 87* |
| BENZENE | 570 | 41 | 15.2 | ND | 5 |
| CARBON TETRACHLORIDE | 96.9 | 430 | 3.2 | ND | 5 |
| CHLOROBENZENE | 720 | 270 | 4.8 | ND | 100 |
| CHLOROFORM | 1,870 | 100 | 310 | 20 | 0.19* |
| CIS-1,2-DICHLOROETHENE | 41,000 | 17,000 | 6,310 | ND | 70 |
| ETHYLBENZENE | 2,610 | 18 | ND | 0.2 | 700 |
| METHYLENE CHLORIDE | 34.1 | 140 | 135 | ND | 5 |
| TETRACHLOROETHENE | 32.7 | 41 | 16 | ND | 5 |
| TOLUENE | 6,500 | 220 | 154 | 1.2 | 1,000 |
| TOTAL XYLENES | 28,500 | 113 | 16 | 0.98 | 10,000 |
| TRANS-1,2-DICHLOROETHENE | 376 | 57 | 40 | ND | 100 |
| TRICHLOROETHENE | 41,100 | 20,000 | 6,590 | ND | 5 |
| VINYL CHLORIDE | 56,000 | 4,300 | 4,000 | ND | 2 |
| **Semivolatile Organics (ug/l)** | | | | | |
| 1,4-DIOXANE | 1,800 | 1,500 | 870 | ND | 6.1** |
| NAPHTHALENE | 63.3 | 14.2 | 0.32 | ND | 0.14* |

**Table 1-1**

**Maximum Detection Results of Contaminants - DRA Site Groundwater Feasibility Study**
**Lockheed Martin, Martin State Airport**
**Middle River, Maryland**


| Location | Upper Surficial Aquifer | Intermediate Surficial Aquifer | Lower Surficial Aquifer | Deep Confined Aquifer | Maximum Contaminant Level (1) |
|---|---|---|---|---|---|
| **Parameter** | **Maximum Result** | **Maximum Result** | **Maximum Result** | **Maximum Result** | |
| **Inorganics (ug/l)** | | | | | |
| ANTIMONY | 2.9 | 1.7 | 0.9 | 0.67 | 6 |
| ARSENIC | 79.6 | 49.9 | 82.2 | 19.6 | 10 |
| BARIUM | 1,610 | 138 | 156 | 278 | 2000 |
| BERYLLIUM | 9.9 | 9.5 | 5.1 | 3.8 | 4 |
| CADMIUM | 242 | 1,130 | 997 | 1.4 | 5 |
| CHROMIUM | 158 | 349 | 889 | 42.8 | 100 |
| COBALT | 724 | 606 | 437 | 13.9 | 4.7* |
| COPPER | 172 | 534 | 161 | 37.2 | 1,300 |
| IRON | 275,000 | 73,500 | 52,900 | 24,400 | 11,000* |
| MANGANESE | 13,400 | 9,940 | 6,300 | 1,270 | 320* |
| MERCURY | 0.11 | 2.6 | 13.2 | 0.83 | 2 |
| NICKEL | 991 | 228 | 149 | 21.3 | 300* |
| SELENIUM | 149 | 41.7 | 36.2 | 2.7 | 50 |
| THALLIUM | 0.5 | 0.5 | 0.4 | 0.18 | 2 |
| VANADIUM | 116 | 66.9 | 139 | 52.6 | 78* |
| ZINC | 3,150 | 1,780 | 646 | 882 | 4,700* |

**Table 1-1**

**Maximum Detection Results of Contaminants - DRA Site Groundwater Feasibility Study**
**Lockheed Martin, Martin State Airport**
**Middle River, Maryland**


| Location | Upper Surficial Aquifer | Intermediate Surficial Aquifer | Lower Surficial Aquifer | Deep Confined Aquifer | Maximum Contaminant Level (1) |
|---|---|---|---|---|---|
| **Parameter** | **Maximum Result** | **Maximum Result** | **Maximum Result** | **Maximum Result** | |
| **Filtered Inorganics (ug/l)** | | | | | |
| ANTIMONY | 1.3 | 1.3 | 0.9 | 0.61 | 6 |
| ARSENIC | 77.3 | 39.2 | 20.8 | 7.9 | 10 |
| BARIUM | 1,720 | 137 | 148 | 72.9 | 2,000 |
| BERYLLIUM | 9 | 10.4 | 4.7 | 0.44 | 4 |
| CADMIUM | 238 | 1,070 | 956 | ND | 5 |
| CHROMIUM | 24.9 | 260 | 229 | 4.5 | 100 |
| COBALT | 692 | 589 | 415 | 14.3 | 4.7* |
| COPPER | 157 | 136 | 67.8 | 6.5 | 1,300 |
| IRON | 284,000 | 70,900 | 34,300 | 6,300 | 11,000* |
| MANGANESE | 12,600 | 10,700 | 6,960 | 1,370 | 320* |
| MERCURY | 0.19 | 0.14 | 0.34 | ND | 2 |
| NICKEL | 942 | 211 | 143 | 21.8 | 300* |
| SELENIUM | 139 | 44 | 37.4 | 0.8 | 50 |
| THALLIUM | 0.4 | 0.22 | 0.3 | ND | 2 |
| VANADIUM | 141 | 27.4 | 4.8 | 2.9 | 78* |
| ZINC | 2,860 | 533 | 461 | 22.4 | 4,700* |
| **Miscellaneous Parameters (ug/l)** | | | | | |
| NITRATE | 15,000 | 3,600 | 2,800 | ND | 10,000 |
| NITRITE | 2,100 | 1,700 | ND | ND | 1,000 |
| PERCHLORATE | 4 | 8 | 5.8 | 0.09 | 15 |

1 - If no Maximum Contaminant Level is available, an alternative criterion is provided as noted.
* - United States Environmental Protection Agency Regional Screening Level.
** - United States Environmental Protection Agency Guidance.
COC - Chemical of concern.
ND - Not detected.
µg/l - Micrograms per liter.

Map Document: (K:\GProject\MartinStateAirport-LMC\MapDocs\MXD\Maps\MSA Location Map_080310.mxd)
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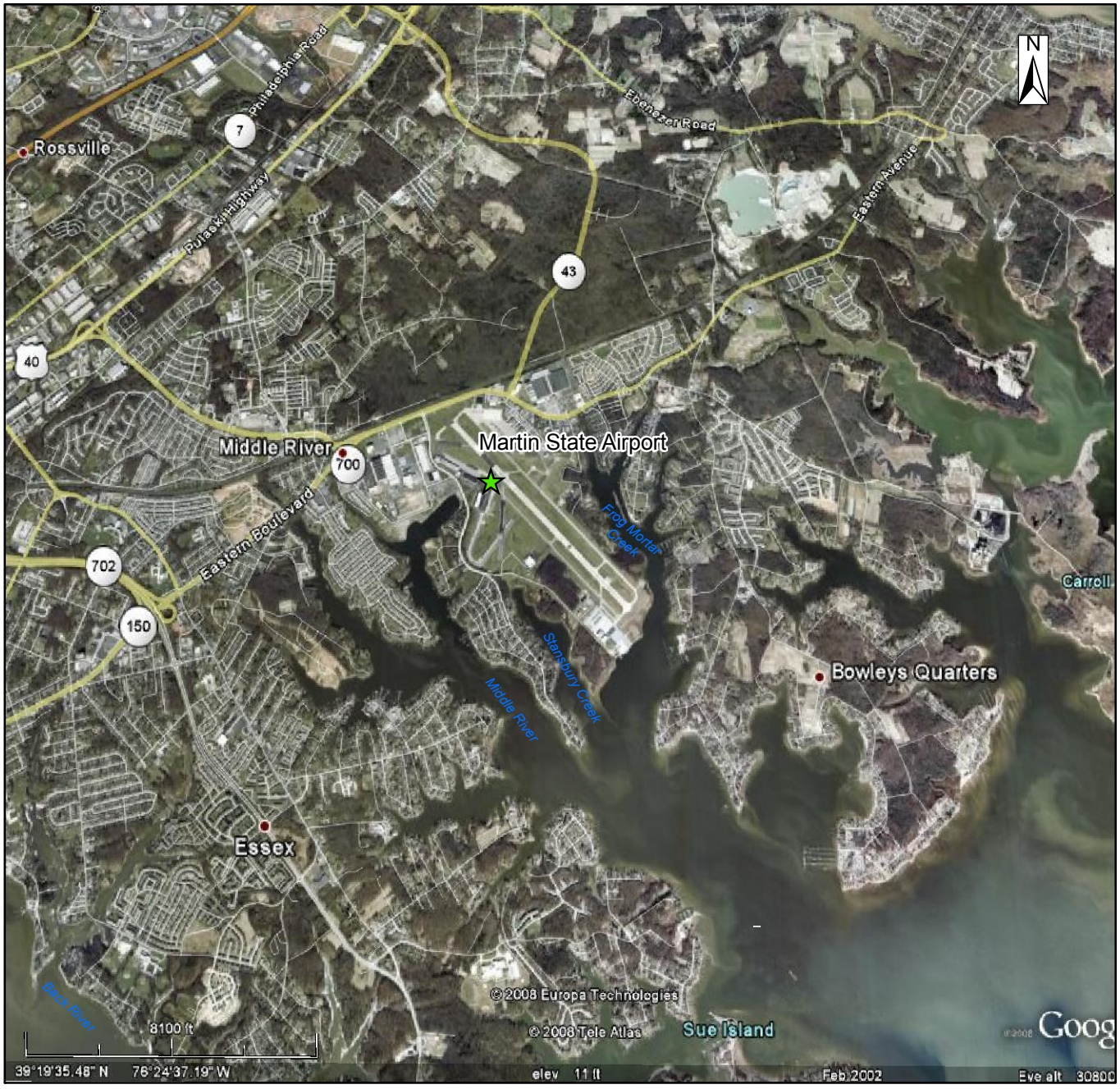


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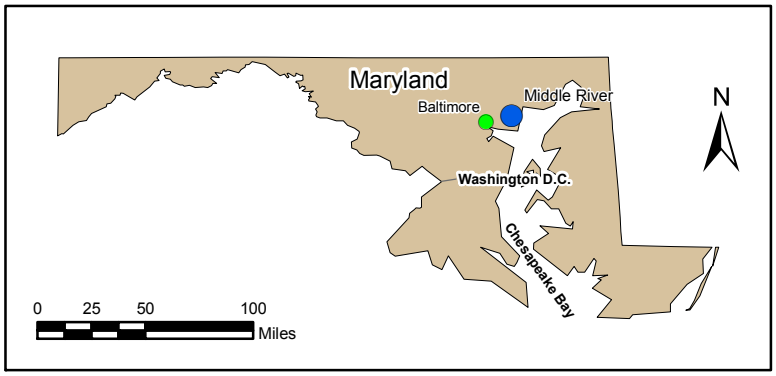


# Figure 1-1

## Martin State Airport Location Map

***Lockheed Martin, Martin State Airport***
***Middle River, Maryland***

| DATE MODIFIED: | 8/03/10 | CREATED BY: | MP |
|---|---|---|---|

Tetra Tech, Inc.

Map Document: (K:\GProject\MartinStateAirport-LMC\MapDocs\MXD\Maps\Dump Road Area Location Map.mxd)
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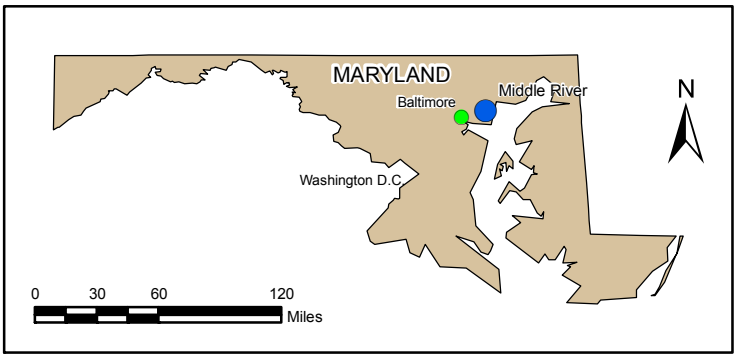


**Figure 1-2**

**Dump Road Area Site Location Map**

***Lockheed Martin, Martin State Airport***
***Middle River, Maryland***

| DATE MODIFIED: | CREATED BY: |
|---|---|
| 8/03/10 | MP |

Tetra Tech, Inc.

Map Document: (K:\GProject\MartinStateAirport-LMC\MapDocs\MXD\Maps\MSA Dump Road Fig 1-3.mxd)
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**Figure 1-3**

**Site Features and Early Areas of Concern Dump Road Area Site**

**Legend**

Pond

*Lockheed Martin, Martin State Airport*
*Middle River, Maryland*

0 50 100 200 Feet

N

DATE MODIFIED: 8/03/10

CREATED BY: MP

Tetra Tech, Inc.

Map Document: (K:\GProject\MartinStateAirport-LMC\MapDocs\MXD\Maps\Groundwater monitoring well locs_figure 1-4.mxd)
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MW34S
MW34I
MARYLAND AIR NATIONAL GUARD
Gate
MW33S
MW33I
MW27D
MW28I
MW16S
MW16I
MW16D
MW17S
MW17I
MW17D
MW14I
MW14D
Gate
MW15S
MW15I
MW15D
POND #2
MW18S
MW18I
MW18D
FROG MORTAR CREEK
MW4
Petroleum Hydrocarbon Area
DMW9I/DMW9S
DMW9D
DMW3I
DMW3S
DMW3D
MW7
MW26S
MW26I
MW26D
POND #1
DMW2A/B
RW1S
OW1S
RW1I
DMW2S
OW1I
DMW10I/DMW10S
MW20S
MW20I
MW20D
DMW4I
DMW4S
DMW4D
MW25S
MW25I
DMW8I
DMW8S
DMW8D
MW3
MW21I
MW21D
DMW1S
MW22I
MW22D
DMW1A/DMW1B
DMW5I
DMW5S
DMW5D
TAXIWAY TANGO
DMW11I
DMW11S
TT-11
MW23S
MW23I
MW23D
MW5
DMW7S
DMW7D
Drum Area
DMW6I
DMW6S
DMW6D
MW19I
MW19D
MW2
AIRPORT RUNWAY
TT-12
TT-14
MW1
Gate
MW6
TT-13
MW24S
MW24I
MW32S
MW32I
MW30D
MW29D
MW31D

## Figure 1-4

## Groundwater Monitoring Well Locations Dump Road Area Site

### Legend

- Monitoring Well
- Ponds

***Lockheed Martin Martin State Airport***
***Middle River, Maryland***

0 50 100 200 Feet

N

DATE MODIFIED: 8/03/10

CREATED BY: MP

Tetra Tech, Inc.

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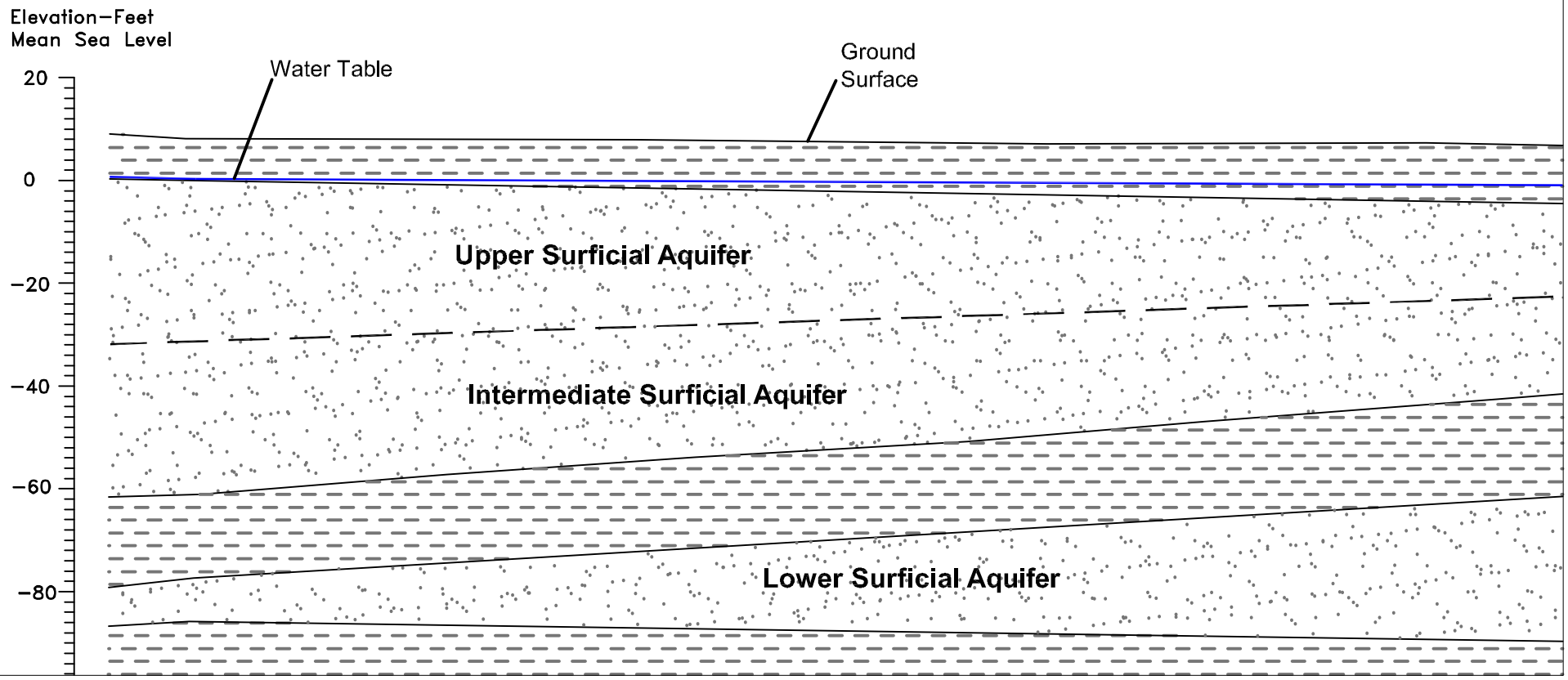



LEGEND

SAND AND-SAND SILT MIXTURES

CLAY AND CLAY MIXTURES

# Figure 1-5
# Generalized Cross-Section of Surficial Aquifer Dump Road Area Site

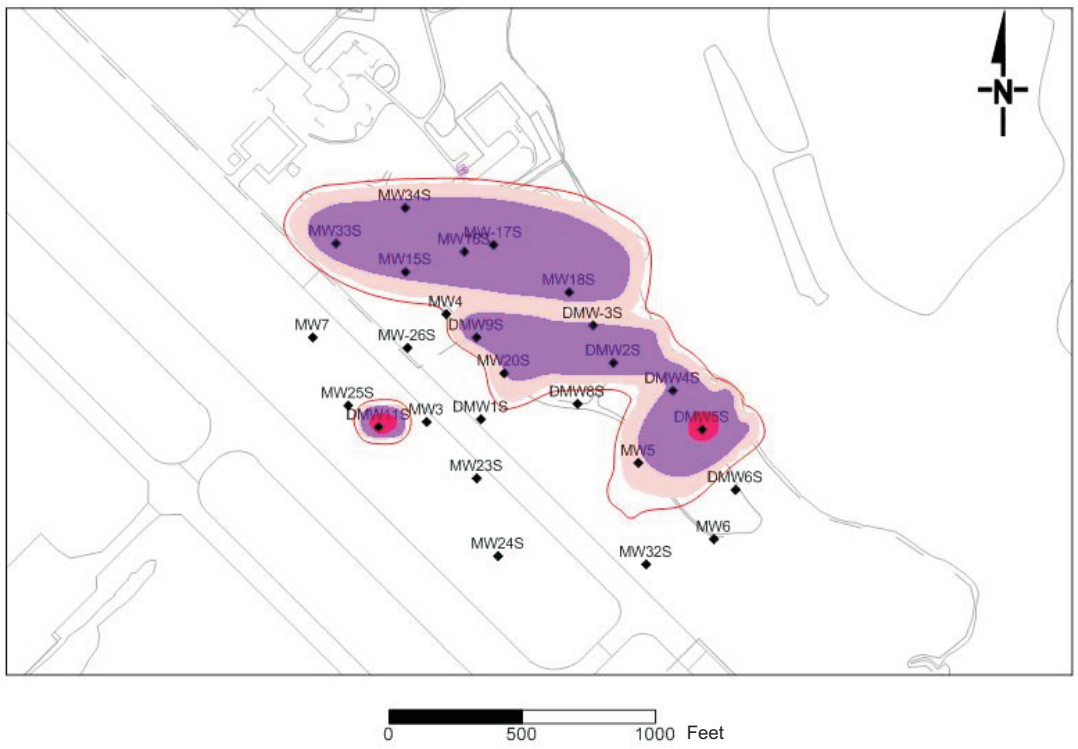
*Lockheed Martin, Martin State Airport, Middle River, Maryland*

DATE MODIFIED
8/10/10

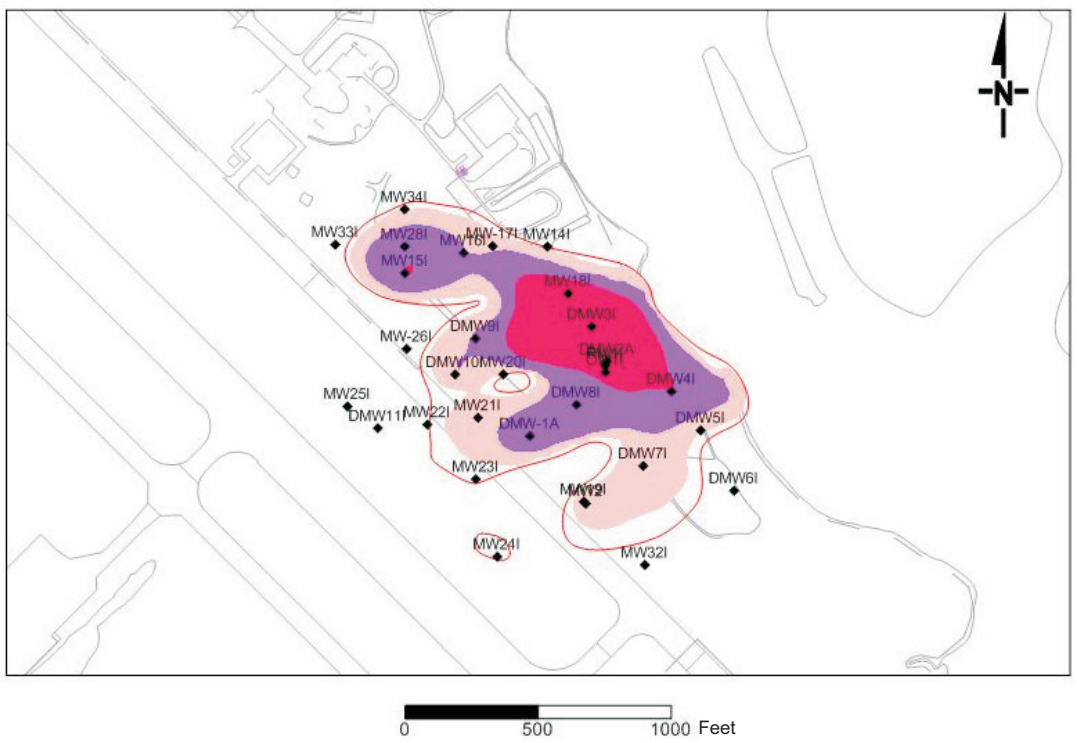
CREATED BY
MP

Tetra Tech, Inc.

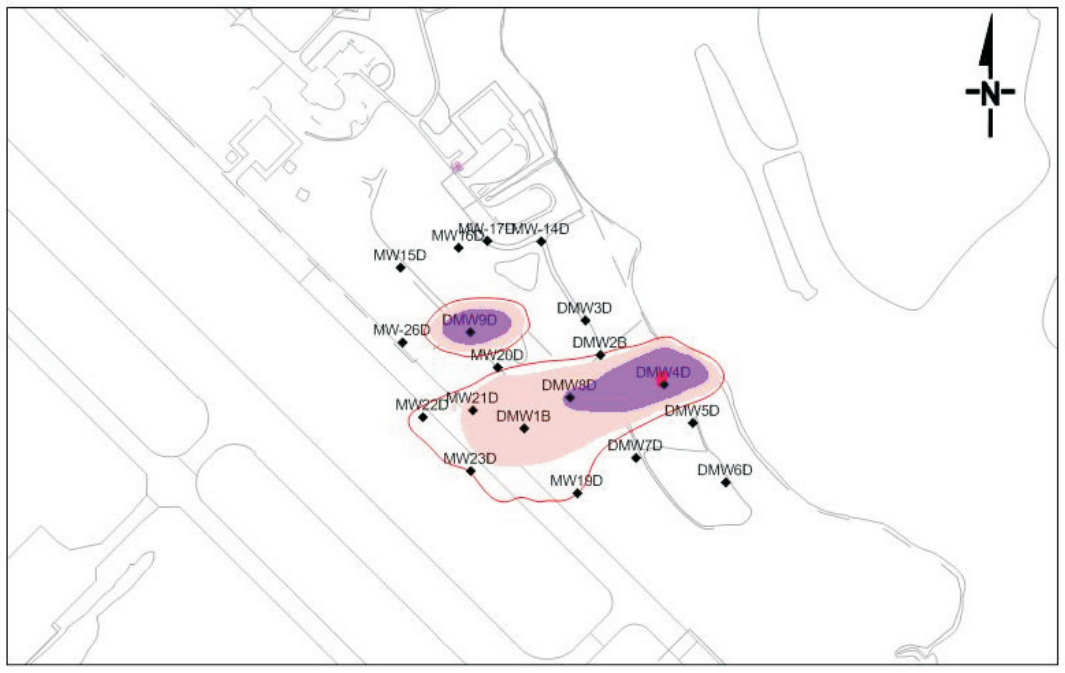
## Upper Surficial Aquifer




## Intermediate Surficial Aquifer




## Lower Surficial Aquifer




Concentration ug/L

5000

500

50

5

5 ug/L

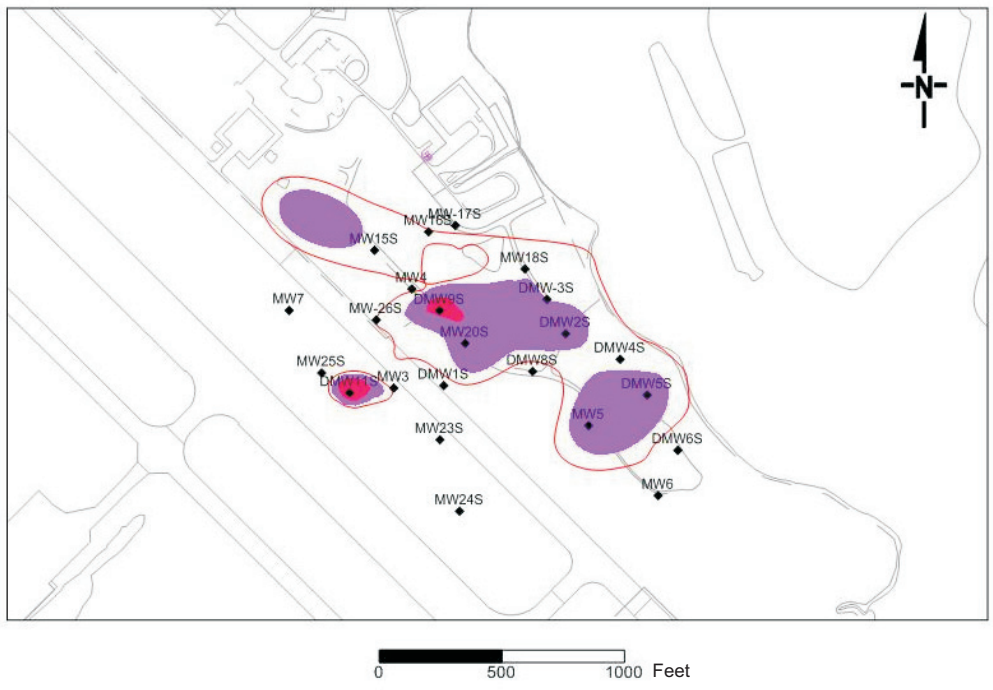
Note: Contours generated by groundwater model

Tetra Tech NUS, Inc

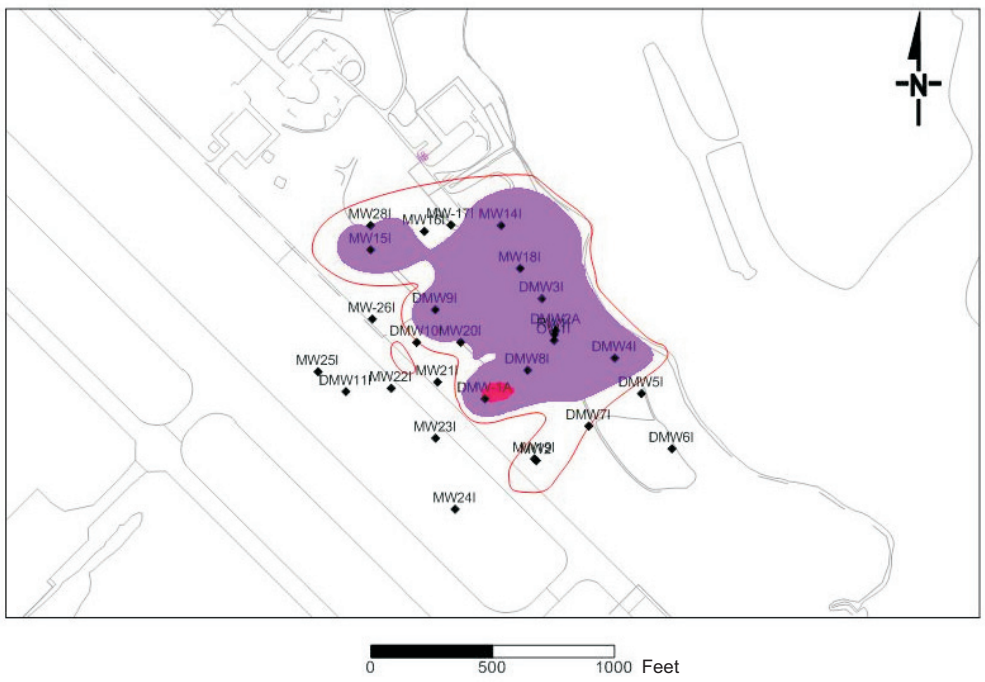
# Groundwater Plume - Trichloroethene
# Dump Road Area Site
# Lockheed Martin, Martin State Airport
# Middle River, Maryland

| | |
|---|---|
| SCALE | AS NOTED |
| FILE | K:\Graphics\Lockheed\MSA\TCE_ figure 1-6.cdr |
| REV | 0 |
| DATE | 2/10/10 |
| FIGURE NUMBER | 1-6 |

## Upper Surficial Aquifer




## Intermediate Surficial Aquifer




Concentration ug/L

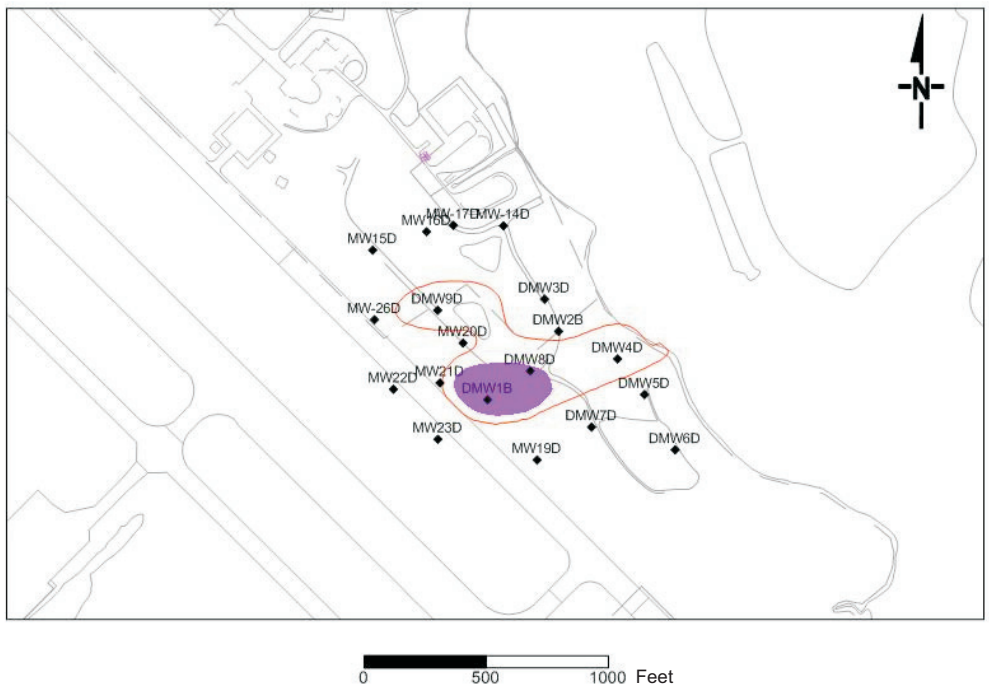
5000

500

70

70 ug/L

## Lower Surficial Aquifer



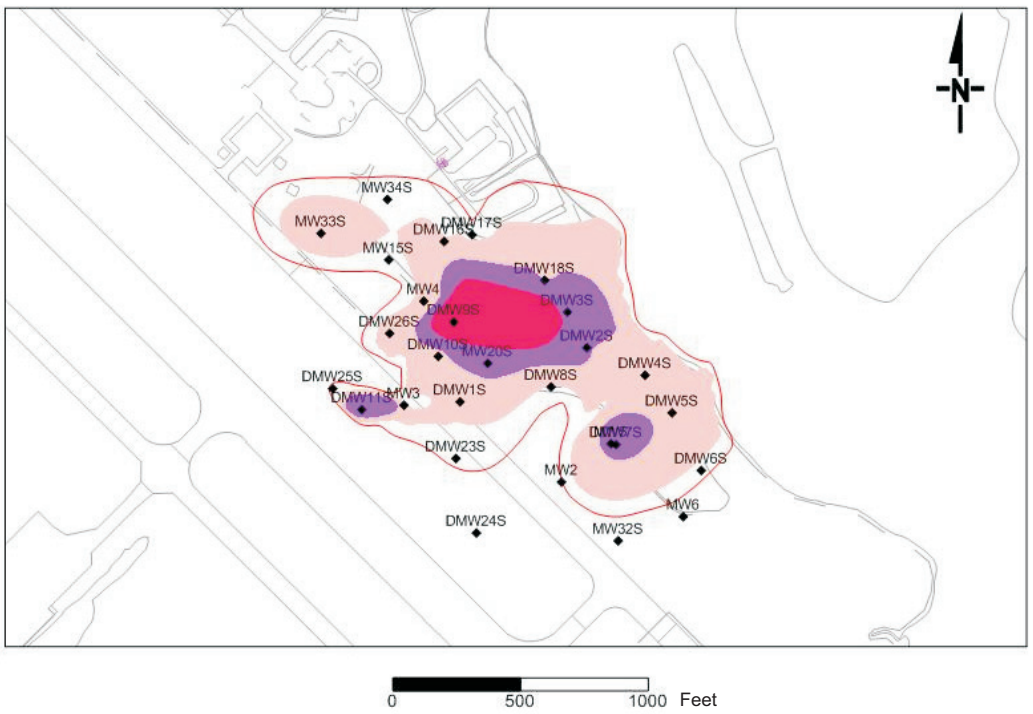

Note: Contours generated by groundwater model

**Tetra Tech NUS, Inc**

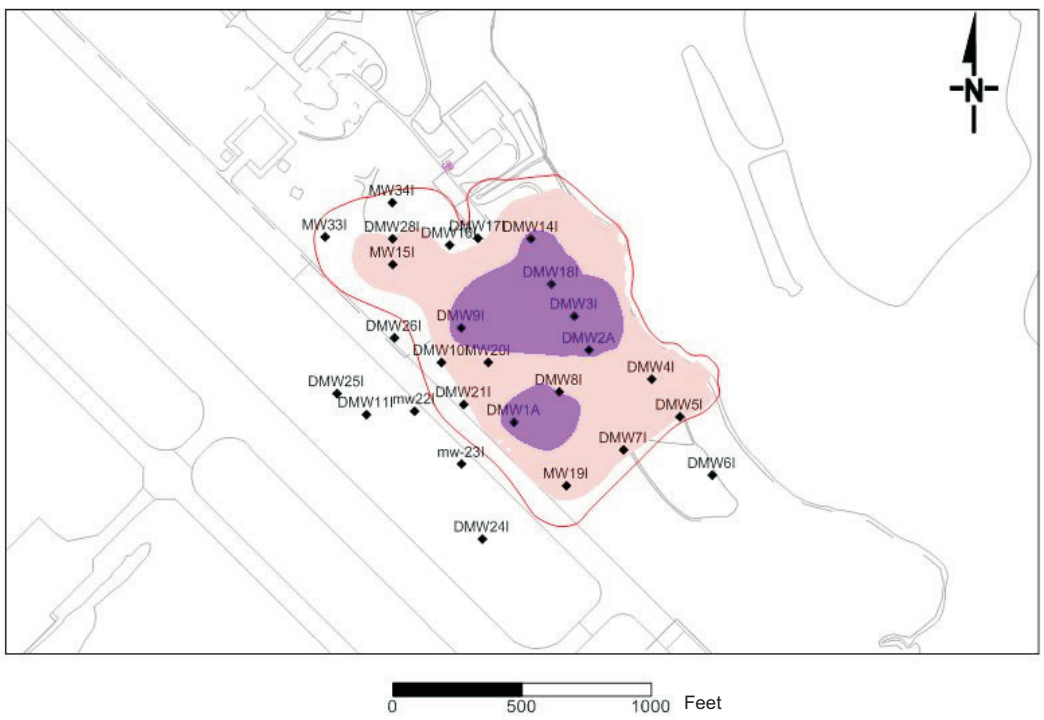
Groundwater Plume - cis- 1,2- Dichloroethene
Dump Road Area Site
Lockheed Martin, Martin State Airport
Middle River, Maryland

| | |
|---|---|
| SCALE | AS NOTED |
| FILE | K:\Graphics\Lockheed\MSA\DCE_figure 1-7.cdr |
| REV | 0 |
| DATE | 8/9/10 |
| FIGURE NUMBER | 1-7 |

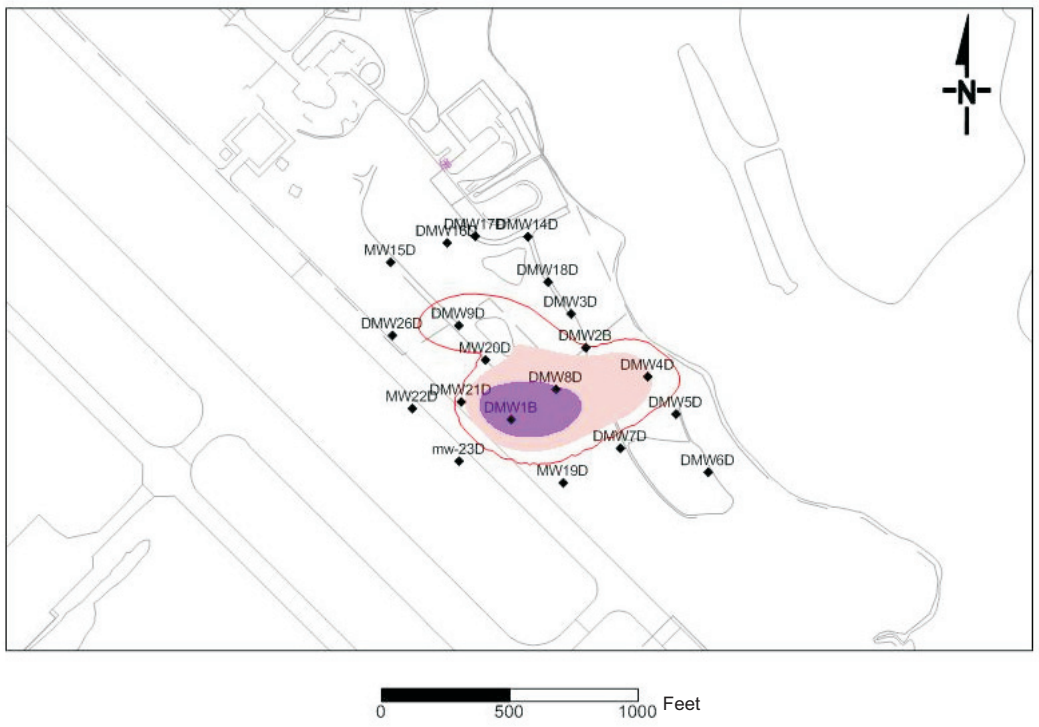
## Upper Surficial Aquifer




## Intermediate Surficial Aquifer




## Lower Surficial Aquifer




Concentration ug/L

5000

500

50

2

2 ug/L

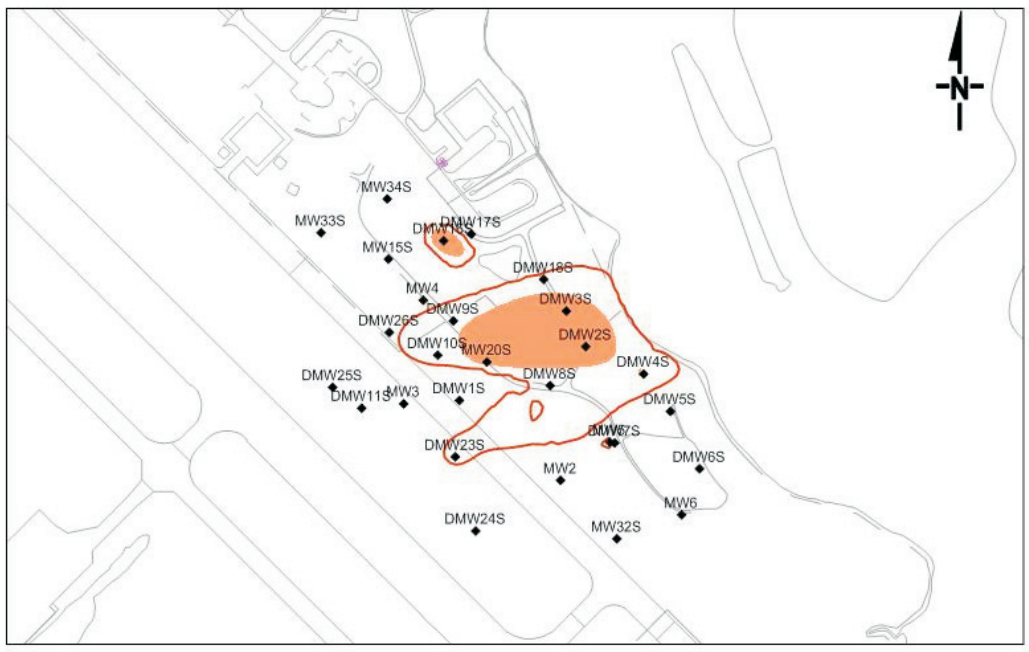
Note: Contours generated by groundwater model

Tetra Tech NUS, Inc

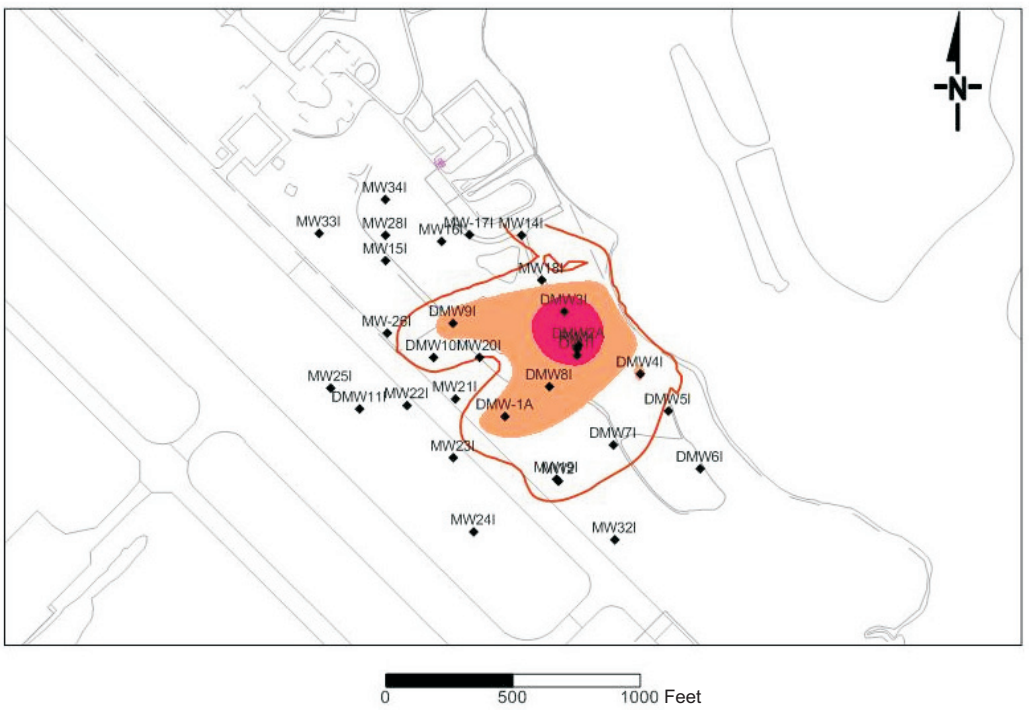
# Groundwater Plume - Vinyl Chloride
# Dump Road Area Site
# Lockheed Martin, Martin State Airport
# Middle River, Maryland

| | |
|---|---|
| SCALE | AS NOTED |
| FILE | K:\Graphics\Lockheed\MSA\VC_ figure 1-8.cdr |
| REV | 0 |
| DATE | 8/9/10 |
| FIGURE NUMBER | 1-8 |

## Upper Surficial Aquifer




## Intermediate Surficial Aquifer




## Lower Surficial Aquifer




Note: Contours generated by groundwater model

Concentration ug/L




6 ug/L

Tetra Tech NUS, Inc

# Groundwater Plume - 1,4- Dioxane
# Dump Road Area Site
# Lockheed Martin, Martin State Airport
# Middle River, Maryland

| | |
|---|---|
| SCALE | AS NOTED |
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| REV | 0 |
| DATE | 8/9/10 |
| FIGURE NUMBER | 1-9 |

# Section 2
# Remedial Action Objectives and General Response Actions

The development of remedial action objectives (RAOs) and cleanup goals for contaminated groundwater is presented in this section. Regulatory requirements and guidance [e.g., applicable or relevant and appropriate requirements (ARARs)] that may potentially govern remedial activities are also presented in this section. In addition, chemicals of concern (COCs), the conceptual pathways through which these COCs may affect human health and the environment, and general response actions (GRAs) that may be suitable to achieve the cleanup goals are presented. Finally, estimates of the volumes of contaminated groundwater present at the site are provided.

## 2.1 ENVIRONMENTAL MEDIA OF CONCERN

This document addresses contaminated groundwater at the Dump Road Area (DRA) Site, based on the discussions in Section 1. Chemicals of concern migrating as vapor from groundwater to indoor air could potentially expose occupants of a future residence or industrial building above the groundwater plume. Although no buildings exist above the plume now, the site could be developed in the future.

## 2.2 CHEMICALS OF CONCERN FOR REMEDIATION

The DRA Site is currently undeveloped and consists of open space adjacent to the airport taxiway. Consistent with airport operations, current site use would be considered commercial/industrial. Anticipated future land use is not expected to change and so would remain classified as commercial/industrial. However, the Maryland Aviation Administration (MAA) may consider the site for future development or expansion of the Maryland Air National Guard (MDANG) leasehold.

Chemicals of concern in groundwater were identified based on the human health risk assessment (HHRA) prepared during the remedial investigation (RI) (Table 2-1). Perchlorate was also evaluated in the HHRA, but no unacceptable risk was identified. Several COCs were also detected at concentrations that would lead to unacceptable risk based on the vapor intrusion pathway. The exposure pathway (direct exposure and/or vapor intrusion) for each COC is/are noted in Table 2-1.

## 2.3 REMEDIAL ACTION OBJECTIVES

The RAOs are medium-specific goals that define the objective of conducting remedial actions to protect human health and the environment. They specify the COCs, potential exposure routes and receptors, and acceptable concentrations (i.e., cleanup goals) for the site. Developing cleanup goals requires consideration of chemical-specific ARARs and guidance documents when promulgated criteria are unavailable. Section 2.3.2 identifies ARARs and other relevant guidance for groundwater remediation.

### 2.3.1 Statement of Remedial Action Objectives

The following RAOs were developed for groundwater for the interim remedial action at the DRA Site:

- ***Groundwater RAO No. 1 —*** Prevent the lateral migration of contaminated groundwater toward Frog Mortar Creek at concentrations that would cause exceedance of ambient water quality criteria or risk-based exposure criteria.

- ***Groundwater RAO No. 2 —*** Prevent human exposure (including via showering, drinking, and irrigation) to groundwater containing COC concentrations greater than preliminary remediation goals (PRGs).

- ***Groundwater RAO No. 3 —*** Prevent exposure of industrial workers and construction workers to VOCs resulting from vapor intrusion into buildings that cause unacceptable risk (total incremental lifetime cancer risk (ILCR) greater than $1 \times 10^{-5}$ or hazard index (HI) greater than 1).

### 2.3.2 Applicable or Relevant and Appropriate Requirements and Guidance Criteria

For a site regulated under (or, in the present case, being addressed according to) the federal Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), remediation requirements generally consist of existing cleanup or control standards or

environmental protection requirements, criteria, or limitations promulgated under other federal or state environmental laws and regulations. Requirements may be directly applicable to the actions or conditions at a particular site, or they may be interpreted as relevant and appropriate because the situation is sufficiently similar to the intended application of the requirements. In addition to laws and regulations, other advisories, criteria, or guidance developed by EPA, other federal agencies, or states must be considered in developing CERCLA remedies. These applicable or relevant and appropriate requirements are referred to as ARARs.

Note that the DRA site is not a CERCLA site, so the only regulatory requirements that must be considered are those that are "applicable." Maryland Department of the Environment (MDE) regulations, such as Maryland's Hazardous Substance Response Plan, are considered applicable. Interpretations of regulations that might be "relevant and appropriate" are not required.

ARARs fall into three categories: chemical-specific ARARs are health- or risk-based numerical values or methodologies that establish concentration or discharge limits for particular contaminants. Location-specific ARARs restrict actions or contaminant concentrations in certain environmentally sensitive areas, such as floodplains or wetlands. Action-specific ARARs are technology- or activity-based requirements, limitations on actions, or conditions for specific activities, such as closure requirements for hazardous waste treatment, storage, or disposal facilities.

Federal and Maryland chemical-specific ARARs and groundwater guidance are presented in Table 2-2. Federal and Maryland location-specific ARARs and groundwater guidance are presented in Table 2-3. Action-specific ARARs and guidance are discussed along with GRAs in Section 2.5.2.

## 2.4 PRELIMINARY REMEDIATION GOALS

Preliminary remediation goals (PRGs) were developed to establish target cleanup goals for remedial actions to reduce COC concentrations in DRA Site groundwater and to mitigate unacceptable risks to human health and the environment associated with this groundwater. Preliminary remediation goals must protect current and anticipated future receptors identified at the site, and should be reasonable and practical to implement. These goals can be developed

based on chemical-specific ARARs (when available) or risk-based factors. The presence of COCs at concentrations greater than background is also considered in developing PRGs. However, a site-specific background data set for groundwater has not been developed for the DRA Site, and no generic state-wide background values are available. Thus, background concentrations will not be used to develop PRGs. The methods used to develop candidate PRGs are discussed below.

### 2.4.1 Applicable or Relevant and Appropriate Requirements and Guidance-Based Preliminary Remediation Goals

Federal maximum contaminant levels (MCLs) and non-zero MCL goals (MCLGs) have been identified as potential chemical-specific ARARs for groundwater at the DRA Site. These values are included in Table 2-4. Maximum contaminant levels are promulgated, legally enforceable standards for drinking water. Available MCLs and non-zero MCLGs were considered in selecting PRGs for groundwater because the site is underlain by a potential drinking water source area.

Maryland Department of the Environment cleanup standards were also identified as potential chemical-specific ARARs for groundwater at the site. These values are included in Table 2-4. Maryland Department of the Environment cleanup standards may be used at the discretion of the site owner. Property-specific cleanup standards may be developed using approved risk assessment techniques. Maryland Department of the Environment groundwater cleanup standards were considered for COCs lacking MCLs or MCLGs.

### 2.4.2 Human Health Risk-Based Preliminary Remediation Goals

Chemicals with unacceptable human health risks were identified as COCs for human receptors in Section 2.2. Human health risk-based PRGs were developed for the COCs. Human health risk assessment risk calculations are provided in the RI report (Tetra Tech, 2010b). The methodology used to derive PRGs is described below.

To develop a range of options for reducing human health risks at the site, potential groundwater PRGs representing human cancer risk levels of $1 \times 10^{-4}$, $1 \times 10^{-5}$, and $1 \times 10^{-6}$, and non-cancer hazard indices of 0.1 and 1, were calculated for each COC, based on the RI report. Risk-based PRGs were calculated using exposure assumptions developed for residential and construction

worker exposure to site groundwater. The residential scenario is considered because of uncertainty about future site use.

The RI report contained risks calculated for the vapor intrusion pathway for residential and industrial scenarios. Preliminary remediation goals for vapor intrusion for residential and industrial scenarios were developed for a $1 \times 10^{-6}$ cancer risk level and an HI of 1. However, only the industrial scenario for vapor intrusion was considered in overall PRG selection, due to current and expected land use. If residential uses are ever proposed for the site, additional remedial actions to address vapor intrusion will need to be evaluated at that time.

The range of potential cancer and non-cancer risk-based groundwater PRGs for human health COCs is presented in Table 2-4. Consistent with MDE methodology for developing cleanup standards, the lower of the values representing the $10^{-6}$ cancer risk level and an HI of 0.1 for each COC was selected as the human health risk-based PRG. These conservative values were selected so that the overall site risks would be less than a $10^{-5}$ cancer risk level and an HI of 1.

### 2.4.3 Selection of Preliminary Remediation Goals

The selected PRGs are the COC concentrations that would provide the greatest level of protection of human health and the environment, while still being reasonably achievable by current remediation techniques. The rationale for PRG selection is described below. Potential and selected PRGs for each COC and their basis for selection are presented in Table 2-4.

PRGs were selected from ARARs (either MCLs or non-zero MCLGs), if available. If an MCL or non-zero MCLG was not available, then the residential risk-based PRG and MDE cleanup standard were considered. Residential risk-based PRGs were considered consistent with MCLs, which are also based on residential use. The larger of the two values was selected because both represent comparable exposure scenarios (since the residential risk-based PRGs are comparable to the MDE cleanup standards). However, the following exceptions (for iron and manganese) were made to this approach. For iron and manganese, USEPA Regional Sreening Levels were used because the secondary drinking water criteria (used to develop MDE cleanup standards) are based on aesthetic considerations. The less conservative values were selected because the groundwater would not be used as a potable water source.

For cobalt, the risk-based PRG (based on an HI of 0.1) is very low. Cobalt is not a priority pollutant, and has no MCL. Therefore, a more reasonable and slightly less conservative PRG based on an HI of 1 was used.

The selected PRGs for groundwater are summarized in Table 2-4. A comparison of site data with the proposed PRGs for groundwater is provided in Table 2-5, which shows the maximum concentrations and the number of times each COC was detected at a concentration greater than the PRG. The number of exceedances of the PRGs provides an indication of the extent of contamination.

## 2.5 GENERAL RESPONSE ACTIONS AND ACTION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

General response actions are broadly defined remedial approaches that may be used (either by themselves or in combination with one or more of the others) to attain RAOs. Action-specific ARARs and guidance are those regulations, criteria, and guidance that must be complied with or considered during remedial activities at a site.

### 2.5.1 General Response Actions

The following GRAs will be considered for the interim remedial action for groundwater at the DRA Site:

- No action
- Limited action (such as natural attenuation, land use controls (LUCs), and monitoring)
- Containment
- Removal
- *In situ* (in place) treatment
- *Ex situ* (on-site) treatment
- Disposal

### 2.5.2 Action-Specific Applicable or Relevant and Appropriate Requirements

Table 2-6 includes federal and state action-specific ARARs and guidance for groundwater.

## 2.6 ESTIMATED VOLUME OF CONTAMINATED GROUNDWATER AND MASS OF CONTAMINANTS

### 2.6.1 Volume of Contaminated Groundwater

Trichloroethene (TCE), cis-1,2-dichloroethene (DCE), vinyl chloride, and 1,4-dioxane are referred to as primary COCs because they are detected frequently throughout the site at concentrations significantly greater than their PRGs. The extent of contaminated groundwater in each zone of the surficial aquifer for the primary COCs is shown in Figures 1-6 through 1-9. These figures also show selected intermediate concentration contours. The plume extends from the water table to a depth of approximately 90 to 100 feet below ground surface (bgs). The porosity value, based on site investigation data, is 0.28.

The volume of groundwater in the plume is approximately 210 million gallons, as calculated in the groundwater model (see Appendix B) based on TCE, cis-1,2-DCE, vinyl chloride, and 1,4-dioxane concentrations greater than 5 micrograms per liter (µg/L). This volume also includes additional COCs and other contaminants, such as cadmium, petroleum hydrocarbons, diesel range organics (DRO), and gasoline range organics (GRO).

### 2.6.2 Masses of Contaminants— Dissolved and Adsorbed Phases

The masses of contaminants in groundwater and adsorbed to saturated soil were estimated using investigation data and the groundwater model. Partition coefficients were obtained from the scientific literature, and the value for organic carbon in the soil was estimated from site data. The mass of each primary COC in groundwater (TCE, cis-1,2-DCE, vinyl chloride, and 1,4-dioxane) is summarized at right. These calculations are included in Appendix C. Although other contaminants are present (see Table 2-1), their masses were not quantified because their concentrations and/or frequencies of detections are low compared to the primary COCs (see Table 2-5).

| Contaminant | Mass (lb) |
|---|---|
| TCE | 6,400 |
| cis-1,2-DCE | 3,300 |
| Vinyl chloride | 5,800 |
| 1,4-Dioxane | 280 |

**Table 2-1**

**Contaminants of Concern in Groundwater - DRA Site Groundwater Feasibility Study**
**Lockheed Martin, Martin State Airport**
**Middle River, Maryland**

| Contaminant | Direct Exposure | Vapor Intrusion |
|---|---|---|
| **Organic Compounds** | | |
| 1,1- Dichloroethene | X | |
| 1,1- Dichloroethane | X | |
| 1,1,2,2 -Tetrachloroethane | X | |
| 1,2- Dichloroethane | X | X |
| 1,2,3 - Trichlorobenzene | X | |
| 1,2,4 - Trichlorobenzene | X | |
| 1,2,4 - Trimethylbenzene | X | |
| 1,3,5 - Trimethylbenzene | X | |
| 1,4-Dioxane | X | |
| Benzene | X | X |
| Carbon tetrachloride | X | X |
| Chlorobenzene | X | |
| Chloroform | X | X |
| cis-1,2-Dichloroethene | X | |
| Ethylbenzene | X | X |
| Methylene chloride | X | |
| Naphthalene | X | |
| Tetrachloroethene | X | |
| Toluene | X | |
| trans-1,2- Dichloroethene | X | X |
| Trichloroethene | X | X |
| Vinyl chloride | X | X |
| Xylenes | X | X |
| **Inorganics** | | |
| Antimony | X | |
| Arsenic | X | |
| Barium | X | |
| Beryllium | X | |
| Cobalt | X | |
| Copper | X | |
| Cadmium | X | |
| Chromium | X | |
| Iron | X | |
| Manganese | X | |
| Mercury | X | |
| Nickel | X | |
| Nitrate | X | |
| Nitrite | X | |
| Perchlorate | X | |
| Selenium | X | |
| Thallium | X | |
| Vanadium | X | |
| Zinc | X | |

Notes:
An “X” indicates the exposure pathway.

**Table 2-2**

**Chemical-Specific Applicable or Relevant and Appropriate Requirements and Other Guidance – Groundwater**
**DRA Site Groundwater Feasibility Study**
**Lockheed Martin, Martin State Airport**
**Middle River, Maryland**


| Requirement | Citation | Status | Synopsis | Evaluation/Action to be Taken |
|---|---|---|---|---|
| **Federal** | | | | |
| Safe Drinking Water Act (SDWA) Regulations, Maximum Contaminant Levels (MCLs) | 40 Code of Federal Regulations (CFR) Part 141 subparts B and G | Applicable | Establishes enforceable standards for potable water for specific contaminants that have been determined to adversely affect human health. | Would be used as protective levels for groundwater that are current or potential drinking water sources. |
| Cancer Slope Factors (CSFs) | NA | To Be Considered | CSFs are guidance values used to evaluate the potential carcinogenic hazard caused by exposure to contaminants. | CSFs would be considered for development of human health protection preliminary remediation goals (PRGs) for groundwater at this site. |
| Reference Doses (RfDs) | NA | To Be Considered | RfDs are guidance values used to evaluate the potential non-carcinogenic hazard caused by exposure to contaminants. | RfDs would be considered for development of human health protection PRGs for groundwater at this site. |
| **State** | | | | |
| Regulation of Water Supply, Sewage Disposal, and Solid Waste Drinking Water Quality | Code of Maryland Regulations (COMAR) 26.04.01 | Applicable | Establishes drinking water standards for public water systems. | Would be used as protective levels for groundwater that are current or potential drinking water sources. |

**Table 2-2**

**Chemical-Specific Applicable or Relevant and Appropriate Requirements and Other Guidance – Groundwater**
**DRA Site Groundwater Feasibility Study**
**Lockheed Martin, Martin State Airport**
**Middle River, Maryland**


| Requirement | Citation | Status | Synopsis | Evaluation/Action to be Taken |
|---|---|---|---|---|
| Ground Water Quality Standards | COMAR 26.08.02.09 | Applicable | For the purpose of controlling the pollution of the ground waters of the state, aquifer types are identified and ground water quality standards are established. | These standards would be used to determine which cleanup standards to apply to groundwater. |

**Table 2-3**

**Location-Specific Applicable or Relevant and Appropriate Requirements and Other Guidance – Groundwater**
**DRA Site Groundwater Feasibility Study**
**Lockheed Martin, Martin State Airport**
**Middle River, Maryland**


| Requirement | Citation | Status | Synopsis | Evaluation/Action to be Taken |
|---|---|---|---|---|
| **Federal** | | | | |
| Endangered Species Act Regulations | 50 CFR Parts 81, 225, and 402 | Applicable | This act requires federal agencies to take action to avoid jeopardizing the continued existence of federally listed endangered or threatened species. | If remediation could potentially affect an endangered species or its habitat, these regulations would apply (no endangered species or associated habitats have been identified at MSA, although bald eagles are known to nest in the general vicinity). |
| Coastal Zone Management Act | 16 United States Code (U.S.C.) Parts 1451 et. seq. | Applicable | Requires that any actions must be conducted in a manner consistent with state-approved management programs. | The site is located in a coastal zone management area: therefore, applicable coastal zone management requirements need to be addressed. |
| **State** | | | | |
| Coastal Zone Management Program | Maryland Executive Order 01.01.1978.05 Coastal Zone Management | Applicable | Maryland's Coastal Program is based on existing state laws and policies designed to protect coastal and marine resources. | The site is located in a coastal zone management area: therefore, applicable coastal zone management requirements need to be addressed. |
| Threatened and Endangered Species | Code of Maryland Regulations (COMAR) 03.08 | Applicable | Provides for conservation of threatened and endangered species of animal and plants. | If remediation could potentially affect an endangered species or its habitat, these regulations would apply (no endangered species or associated habitats have been identified at MSA, although bald eagles are known to nest in the general vicinity). |

**Table 2-3**

**Location-Specific Applicable or Relevant and Appropriate Requirements and Other Guidance – Groundwater**
**DRA Site Groundwater Feasibility Study**
**Lockheed Martin, Martin State Airport**
**Middle River, Maryland**


| Requirement | Citation | Status | Synopsis | Evaluation/Action to be Taken |
|---|---|---|---|---|
| **State (continued)** | | | | |
| Critical Area Act | Annotated Code of Maryland 8-1808(d); COMAR 27 | Applicable | The Act regulates and restricts land development to: minimize adverse impacts on water quality; conserve fish, wildlife, and plant habitat; and establish land-use policies for development that accommodate growth. Commission reviews developments in critical areas of the Chesapeake and Atlantic Coastal Bay. Administered on the county level. | According to the county classification mapping, the site classification is an intensely developed area which is the least restrictive classification. |

**Table 2-4**

**Selection of Human Health Risk-Based Groundwater PRGs - DRA Site Groundwater Feasibility Study**
**Lockheed Martin, Martin State Airport**
**Middle River, Maryland**


| Chemical | USEPA RSL[(1)] (ug/L) | Con Workers | | Child Res | | Adolescent Res | | Adult Res | | Lifelong Res | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Cancer Risk Level $10^{-6}$ (ug/L) | Hazard Index = 0.1 (ug/L) | Cancer Risk Level $10^{-6}$ (ug/L) | Hazard Index = 0.1 (ug/L) | Cancer Risk Level $10^{-6}$ (ug/L) | Hazard Index = 0.1 (ug/L) | Cancer Risk Level $10^{-6}$ (ug/L) | Hazard Index = 0.1 (ug/L) | Cancer Risk Level $10^{-6}$ (ug/L) | Hazard Index = 0.1 (ug/L) |
| 1,1-Dichloroethane | 2.4 | NA | NA | 30 | 290 | 24 | 390 | 18 | 680 | 7.6 | NA |
| 1,1-Dichloroethene | 260 | NA | NA | NA | 69 | NA | 95 | NA | NA | NA | NA |
| 1,2-Dichloroethane | 0.15 | NA | NA | 1.9 | 8.9 | 1.5 | 12 | 1.2 | 21 | 0.5 | NA |
| 1,1,2,2-Tetrachloroethane | 0.066 | NA | NA | 0.81 | 28 | 0.67 | 38 | 0.61 | 65 | 0.23 | NA |
| 1,2,3-Trichlorobenzene | 5.2 | NA | NA | NA | 0.5 | NA | 0.82 | NA | 1.2 | NA | NA |
| 1,2,4-Trichlorobenzene | 3.9 | 460 | 880 | 2.8 | 6.9 | 2.6 | 11 | 2.7 | 3.4 | 0.89 | NA |
| 1,2,4-Trimethylbenzene | 15 | NA | NA | NA | NA | NA | NA | NA | 11 | NA | NA |
| 1,3,5-Trimethylbenzene | 87 | NA | NA | NA | 8.8 | NA | 13 | NA | 20 | NA | NA |
| Benzene | 0.39 | NA | NA | 2.9 | 5.4 | 2.4 | 7.5 | 2.1 | 9.5 | 0.81 | NA |
| Carbon Tetrachloride | 0.39 | 550 | 400 | 2.1 | 5 | 1.7 | 70 | 1.8 | 11 | 0.62 | NA |
| Chlorobenzene | 72 | NA | NA | NA | 23 | NA | 33 | NA | 32 | NA | NA |
| Chloroform | 0.19 | 1,070 | 6000 | 5.4 | 14 | 4.4 | 20 | 2.1 | 28 | 1.1 | NA |
| cis-1,2-Dichloroethene | 28 | NA | 1600 | NA | 2.8 | NA | 3.8 | NA | 6.5 | NA | NA |
| trans-1,2-Dichloroethene | 86 | NA | NA | NA | 28 | NA | 38 | NA | 37 | NA | NA |
| Ethylbenzene | 1.3 | NA | NA | 10 | 99 | 9.2 | 140 | 7.6 | 200 | 3.0 | NA |
| Methylene Chloride | 84 | NA | NA | 16 | 9 | 24 | 12 | 87 | 21 | 8.8 | NA |
| Naphthalene | 0.14 | NA | NA | NA | 19 | NA | 28 | 3.5 | 6.1 | 3.5 | NA |
| Tetrachloroethene | 35 | NA | NA | 55 | 6 | 48 | 8.7 | 47 | 12 | 0.19 | NA |
| Toluene | 860 | NA | NA | NA | 93 | NA | 130 | NA | 210 | NA | NA |
| Trichloroethene | 2.6 | 1,300 | 36 | 1.8 | 0.67 | 0.062 | 0.93 | 3.0 | 1.1 | 4.0 | NA |
| Total Xylenes | 190 | NA | NA | NA | 200 | NA | 300 | NA | 110 | NA | NA |
| Vinyl Chloride | 0.015 | 97 | 0.0046 | 0.051 | 4.5 | 0.22 | 6 | 0.26 | 9.5 | 0.049 | NA |
| 1,4-Dioxane | 0.67 | 970 | 4200 | 1.8 | 47 | 1.5 | 62 | 1.8 | 110 | 0.6 | NA |
| Antimony | 6 | NA | NA | NA | 0.6 | NA | 0.81 | NA | 1.4 | NA | NA |
| Arsenic | 0.045 | 62 | 40 | 0.12 | 0.47 | 0.097 | 0.62 | 0.12 | 1.1 | 0.037 | NA |
| Barium | 2900 | NA | NA | NA | 286 | NA | 396 | NA | 679 | NA | NA |
| Beryllium | 16 | NA | NA | NA | 1.6 | NA | 2.7 | NA | 4.2 | NA | NA |
| Cadmium | 6.9 | NA | 30.6 | NA | 0.69 | NA | 0.97 | NA | 1.7 | NA | NA |
| Chromium | 0.031 | 32 | 450 | 0.045 | 3.1 | 0.075 | 4.8 | 0.26 | 7.7 | 0.025 | NA |

**Table 2-4**

**Selection of Human Health Risk-Based Groundwater PRGs - DRA Site Groundwater Feasibility Study**
**Lockheed Martin, Martin State Airport**
**Middle River, Maryland**


| Chemical | USEPA RSL[(1)] (ug/L) | Con Workers | | Child Res | | Adolescent Res | | Adult Res | | Lifelong Res | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Cancer Risk Level $10^{-6}$ (ug/L) | Hazard Index = 0.1 (ug/L) | Cancer Risk Level $10^{-6}$ (ug/L) | Hazard Index = 0.1 (ug/L) | Cancer Risk Level $10^{-6}$ (ug/L) | Hazard Index = 0.1 (ug/L) | Cancer Risk Level $10^{-6}$ (ug/L) | Hazard Index = 0.1 (ug/L) | Cancer Risk Level $10^{-6}$ (ug/L) | Hazard Index = 0.1 (ug/L) |
| Cobalt | 4.7 | NA | 40 | NA | 0.47 | NA | 0.62 | NA | 1.1 | NA | NA |
| Copper | 620 | NA | NA | NA | 62 | NA | 83 | NA | 145 | NA | NA |
| Iron | 11000 | NA | NA | NA | 1090 | NA | 1450 | NA | 2540 | NA | NA |
| Lead | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Manganese | 320 | NA | NA | NA | 32 | NA | 46 | NA | 78 | NA | NA |
| Mercury | 4 | NA | NA | NA | 0.43 | NA | 0.59 | NA | NA | NA | NA |
| Nickel | 300 | NA | NA | NA | 30 | NA | 41 | NA | 71 | NA | NA |
| Selenium | 78 | NA | NA | NA | 7.8 | NA | 10 | NA | 18 | NA | NA |
| Thallium | 0.16 | NA | NA | NA | 0.0055 | NA | 0.01 | NA | 0.015 | NA | NA |
| Vanadium | 78 | NA | NA | NA | 7.8 | NA | 10 | NA | 18 | NA | NA |
| Zinc | 4700 | NA | NA | NA | 467 | NA | 624 | NA | 1090 | NA | NA |
| Nitrate | 25000 | NA | NA | NA | 2500 | NA | 3340 | NA | 5840 | NA | NA |
| Nitrite | 1600 | NA | NA | NA | 156 | NA | 208 | NA | 365 | NA | NA |
| Perchlorate | 11 | NA | NA | NA | 1.1 | NA | 1.5 | NA | 2.5 | NA | NA |
| TPH - GRO | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| TPH - DRO | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

**Table 2-4**

**Selection of Human Health Risk-Based Groundwater PRGs - DRA Site Groundwater Feasibility Study**
**Lockheed Martin, Martin State Airport**
**Middle River, Maryland**


| Chemical | USEPA RSL[1] (ug/L) | Minimum Con Risk (ug/L) | Minimum Res Risk (ug/L) | Basis for Min Res Risk | USEPA MCL[2] (ug/L) | MDE Cleanup Standard (ug/L) | VI - Ind (ug/L) | Selected PRG (ug/L) | PRG Selection Basis |
|---|---|---|---|---|---|---|---|---|---|
| 1,1-Dichloroethane | 2.4 | NA | 7.6 | LL-C | NA | 90(3) | NA | 90 | MDE |
| 1,1-Dichloroethene | 260 | NA | 69 | CR-NC | 7 | 7 | NA | 7 | MCL |
| 1,2-Dichloroethane | 0.15 | NA | 0.5 | LL-C | 5 | 5 | NA | 5 | MCL |
| 1,1,2,2-Tetrachloroethane | 0.066 | NA | 0.23 | LL-C | NA | 0.053(3) | NA | 0.23 | Res risk |
| 1,2,3-Trichlorobenzene | 5.2 | NA | 0.5 | CR-NC | NA | NA | NA | 0.5 | Res risk |
| 1,2,4-Trichlorobenzene | 3.9 | 460 | 0.89 | LL-C | 70 | 70(3) | NA | 70 | MCL |
| 1,2,4-Trimethylbenzene | 15 | NA | 11 | AR-NC | NA | NA | NA | 11 | Res risk |
| 1,3,5-Trimethylbenzene | 87 | NA | 8.8 | CR-NC | NA | NA | NA | 8.8 | Res risk |
| Benzene | 0.39 | NA | 0.81 | LL-C | 5 | 5 | 120 | 5 | MCL - VI |
| Carbon Tetrachloride | 0.39 | 400 | 0.62 | LL-C | 5 | 5 | 32 | 5 | MCL - VI |
| Chlorobenzene | 72 | NA | 23 | CR-NC | 100 | 100 | NA | 100 | MCL |
| Chloroform | 0.19 | 1070 | 1.1 | LL-C | NA | 80(3) | 48 | 80 | MDE - VI |
| cis-1,2-Dichloroethene | 28 | 1600 | 2.8 | CR-NC | 70 | 70 | NA | 70 | MCL |
| trans-1,2-Dichloroethene | 86 | NA | 28 | CR-NC | 100 | 100 | NA | 100 | MCL |
| Ethylbenzene | 1.3 | NA | 3 | LL-C | 700 | 700 | 350 | 700 | MCL - VI |
| Methylene Chloride | 84 | NA | 8.8 | LL-C | 5 | 5 | NA | 5 | MCL |
| Naphthalene | 0.14 | NA | 3.5 | LL-C | NA | 0.65(3) | NA | 3.5 | Res risk |
| Tetrachloroethene | 35 | NA | 0.19 | LL-C | 5 | 5 | NA | 5 | MCL |
| Toluene | 860 | NA | 93 | CR-NC | 1000 | 1000 | NA | 1000 | MCL |
| Trichloroethene | 2.6 | 36 | 0.062 | AdR-C | 5 | 5 | 290 | 5 | MCL - VI |
| Total Xylenes | 190 | NA | 110 | AR-NC | 10000 | 10000 | NA | 10000 | MCL |
| Vinyl Chloride | 0.015 | 0.0046 | 0.049 | LL-C | 2 | 2 | 15 | 2 | MCL - VI |
| 1,4-Dioxane | 0.67 | 970 | 0.6 | LL-C | 6.1** | NA | NA | 6.1 | EPA guidance |
| Antimony | 6 | NA | 0.6 | CR-NC | 6 | 6 | NA | 6 | MCL |
| Arsenic | 0.045 | 40 | 0.037 | LL-C | 10 | 10 | NA | 10 | MCL |
| Barium | 2900 | NA | 286 | CR-NC | 2000 | 2000 | NA | 2000 | MCL |
| Beryllium | 16 | NA | 1.6 | CR-NC | 4 | 4 | NA | 4 | MCL |
| Cadmium | 6.9 | 31 | 0.69 | CR-NC | 5 | 5 | NA | 5 | MCL |
| Chromium | 0.031 | 32 | 0.025 | LL-C | 100 | 100 | NA | 100 | MCL |

**Table 2-4**

**Selection of Human Health Risk-Based Groundwater PRGs - DRA Site Groundwater Feasibility Study**
**Lockheed Martin, Martin State Airport**
**Middle River, Maryland**


| Chemical | USEPA RSL[1] (ug/L) | Minimum Con Risk (ug/L) | Minimum Res Risk (ug/L) | Basis for Min Res Risk | USEPA MCL[2] (ug/L) | MDE Cleanup Standard (ug/L) | VI - Ind (ug/L) | Selected PRG (ug/L) | PRG Selection Basis |
|---|---|---|---|---|---|---|---|---|---|
| Cobalt | 4.7 | 40 | 0.47 | CR-NC | NA | NA | NA | 4.7 | RSL (HI = 1) |
| Copper | 620 | NA | 62 | CR-NC | 1300 | 1300 | NA | 1300 | MCL |
| Iron | 11000 | NA | 1090 | CR-NC | NA | 300(3) | NA | 11000 | RSL (HI = 1) |
| Lead | NA | NA | NA | NA | 15 | 15 | NA | 15 | MCL |
| Manganese | 320 | NA | 32 | CR-NC | NA | 50(3) | NA | 320 | RSL (HI = 1) |
| Mercury | 4 | NA | 0.43 | CR-NC | 2 | 2 | NA | 2 | MCL |
| Nickel | 300 | NA | 30 | CR-NC | NA | 73(3) | NA | 73 | MDE |
| Selenium | 78 | NA | 7.8 | CR-NC | 50 | 50 | NA | 50 | MCL |
| Thallium | 0.16 | NA | 0.0055 | CR-NC | 2 | 2 | NA | 2 | MCL |
| Vanadium | 78 | NA | 7.8 | CR-NC | NA | 3.7(3) | NA | 7.8 | Res risk |
| Zinc | 4700 | NA | 467 | CR-NC | NA | 5000(3) | NA | 5000 | MDE |
| Nitrate | 25000 | NA | 2500 | CR-NC | 10000 | 10000 | NA | 10000 | MCL |
| Nitrite | 1600 | NA | 156 | CR-NC | 1000 | 1000 | NA | 1000 | MCL |
| Perchlorate | 11 | NA | 1.1 | CR-NC | 15 | 2.6(3) | NA | 15 | MCL |
| TPH - GRO | NA | NA | NA | NA | NA | 47(3) | NA | 47 | MDE |
| TPH - DRO | NA | NA | NA | NA | NA | 47(3) | NA | 47 | MDE |

Notes:
NA - Not applicable.
LL - Lifelong resident
AdR - Adolescent resident
AR - Adult resident
CR - Child resident
C - Cancer risk
NC - Non-cancer risk
VI - Vapor instrusion
Ind - Industrial
Res - Residential
Con - Construction

1 - USEPA Regional Screening Levels for Chemical Contaminants at Superfund Sites, November 2011. [Cancer benchmark value = 1E-06, Hazard index (HI) = 1.0.

2 - 2009 Edition of the Drinking Water Standards and Health Advisories (USEPA, October 2009).

3 - MDE Cleanup Standards for Soil and Groundwater, 2008. Guidance only.

** - There is no MCL for 1,4-dioxane. This value is EPA guidance.

**Table 2-5**

**Comparison of Groundwater Data with Proposed PRGs - DRA Site Groundwater Feasibility Study**
**Lockheed Martin, Martin State Airport**
**Middle River, Maryland**


| COC | PRG | Max Detect | Exceedances/ Sample Count |
|---|---|---|---|
| **Volatile Organics (ug/l)** | | | |
| 1,1-DICHLOROETHANE | 90 | 83.3 | 0/200 |
| 1,1-DICHLOROETHENE | 7 | 222 | 22/200 |
| 1,1,2,2-TETRACHLOROETHANE | 0.23 | 20 | 1/200 |
| 1,2-DICHLOROETHANE | 5 | 160 | 28/200 |
| 1,2,3-TRICHLOROBENZENE | 0.5 | 115 | 5/200 |
| 1,2,4-TRICHLOROBENZENE | 70 | 730 | 8/200 |
| 1,2,4-TRIMETHYLBENZENE | 11 | 375 | 6/200 |
| 1,3,5-TRIMETHYLBENZENE | 8.8 | 190 | 4/62 |
| BENZENE | 5 | 570 | 24/200 |
| CARBON TETRACHLORIDE | 5 | 430 | 7/200 |
| CHLOROBENZENE | 100 | 720 | 7/200 |
| CHLOROFORM | 80 | 1,870 | 11/200 |
| CIS-1,2-DICHLOROETHENE | 70 | 41,000 | 88/200 |
| ETHYLBENZENE | 700 | 2,610 | 3/200 |
| METHYLENE CHLORIDE | 5 | 140 | 18/200 |
| TETRACHLOROETHENE | 5 | 40.9 | 10/200 |
| TOLUENE | 1000 | 6,500 | 6/200 |
| TOTAL XYLENES | 10000 | 28,500 | 3/200 |
| TRANS-1,2-DICHLOROETHENE | 100 | 376 | 7/200 |
| TRICHLOROETHENE | 5 | 41,100 | 101/200 |
| VINYL CHLORIDE | 2 | 56,000 | 108/200 |
| **Semivolatile Organics (ug/l)** | | | |
| 1,4-DIOXANE | 6.1 | 1,800 | 79/199 |
| NAPHTHALENE | 3.5 | 63.3 | 5/208 |

**Table 2-5**

**Comparison of Groundwater Data with Proposed PRGs - DRA Site Groundwater Feasibility Study**
**Lockheed Martin, Martin State Airport**
**Middle River, Maryland**


| COC | PRG | Max Detect | Exceedances/ Sample Count |
|---|---|---|---|
| **Inorganics (mg/l)** | | | |
| ANTIMONY | 0.006 | 0.0029 | 0/200 |
| ARSENIC | 0.01 | 0.0822 | 43/200 |
| BARIUM | 2 | 1.61 | 0/200 |
| BERYLLIUM | 0.004 | 0.0099 | 22/200 |
| CADMIUM | 0.005 | 1.13 | 41/200 |
| CHROMIUM | 0.1 | 0.889 | 8/200 |
| COBALT | 0.0047 | 0.724 | 143/200 |
| COPPER | 1.3 | 0.534 | 0/200 |
| IRON | 11 | 275 | 87/138 |
| MANGANESE | 0.32 | 13.4 | 102/138 |
| MERCURY | 0.002 | 0.0132 | 4/200 |
| NICKEL | 0.073 | 0.991 | 39/200 |
| SELENIUM | 0.05 | 0.149 | 2/200 |
| THALLIUM | 0.002 | 0.0005 | 0/200 |
| VANADIUM | 0.0078 | 0.139 | 45/200 |
| ZINC | 5 | 3.15 | 0/200 |
| **Filtered Inorganics (mg/l)** | | | |
| ANTIMONY | 0.006 | 0.0013 | 0/199 |
| ARSENIC | 0.01 | 0.0773 | 34/199 |
| BARIUM | 2 | 1.72 | 0/199 |
| BERYLLIUM | 0.004 | 0.0104 | 23/199 |
| CADMIUM | 0.005 | 1.07 | 34/199 |
| CHROMIUM | 0.1 | 0.26 | 3/199 |
| COBALT | 0.0047 | 0.692 | 139/199 |
| COPPER | 1.3 | 0.157 | 0/199 |
| IRON | 11 | 284 | 87/149 |
| MANGANESE | 0.32 | 12.6 | 99/137 |
| MERCURY | 0.002 | 0.00034 | 0/199 |
| NICKEL | 0.073 | 0.942 | 38/199 |
| SELENIUM | 0.05 | 0.139 | 1/199 |
| THALLIUM | 0.002 | 0.0004 | 0/199 |
| VANADIUM | 0.0078 | 0.141 | 16/199 |
| ZINC | 5 | 2.86 | 0/199 |

**Table 2-5**

**Comparison of Groundwater Data with Proposed PRGs - DRA Site Groundwater Feasibility Study**
**Lockheed Martin, Martin State Airport**
**Middle River, Maryland**


| COC | PRG | Max Detect | Exceedances/ Sample Count |
|---|---|---|---|
| **Miscellaneous (mg/l)** | | | |
| NITRATE | 10 | 15 | 1/12 |
| NITRITE | 1 | 2.1 | 5/12 |
| PERCHLORATE | 0.015 | 8 | 19/90 |
| **Petroleum Hydrocarbons (mg/l)** | | | |
| DIESEL RANGE ORGANICS | 0.047 | 1.3 | 13/23 |
| **Petroleum Hydrocarbons (ug/l)** | | | |
| GASOLINE RANGE ORGANICS | 47 | 70,000 | 15/23 |

Max Detect - Maximum concentration detected.
PRG - Preliminary remediation goal.
Exceedances /Sample Count - Number of sample detections with concentrations greater than the PRG.

**Table 2-6**

**Action-Specific Applicable or Relevant and Appropriate Requirements and Other Guidance – Groundwater**
**DRA Site Groundwater Feasibility Study**
**Lockheed Martin, Martin State Airport**
**Middle River, Maryland**


| Requirement | Citation | Status | Synopsis | Evaluation/Action to be Taken |
|---|---|---|---|---|
| **Federal** | | | | |
| Resource Conservation and Recovery Act (RCRA) Regulations, Identification and Listing of Hazardous Wastes | 40 Code of Federal Regulations (CFR) Part 261 Subparts A, B, C, and D | Applicable | Defines the listed and characteristic hazardous wastes subject to RCRA. Appendix II contains the Toxicity Characteristic Leaching Procedure (TCLP). | These regulations would apply when determining whether or not groundwater and treatment residuals are hazardous, either by being listed or by exhibiting a hazardous characteristic. |
| RCRA Regulations, Standards Applicable to Generators | 40 CFR 262, Subparts A, B, C, and D | Applicable | Establishes manifesting, pre-transport, and recordkeeping requirements for hazardous waste. | These regulations would apply to investigative-derived waste (IDW) and side streams [such as spent granular activated carbon (GAC)]. |
| RCRA Regulations, Standards Applicable to Transporters of Hazardous Waste | 40 CFR 263 | Applicable | Establishes manifesting and recordkeeping requirements for transport of hazardous waste. | These regulations would apply to the transportation for off-site disposal of hazardous waste, such as spent GAC. |

**Table 2-6**

**Action-Specific Applicable or Relevant and Appropriate Requirements and Other Guidance – Groundwater**
**DRA Site Groundwater Feasibility Study**
**Lockheed Martin, Martin State Airport**
**Middle River, Maryland**


| Requirement | Citation | Status | Synopsis | Evaluation/Action to be Taken |
|---|---|---|---|---|
| **Federal (continued)** | | | | |
| RCRA Regulations, Permitting Exemptions | 40 CFR 264.1(g)(6) and 270.1(c)(2)(v) | Applicable | Exempts treatment systems that meet the RCRA definition of wastewater treatment unit from RCRA permitting and TSDF requirements of 40 CFR 264. | Because the groundwater is a hazardous waste, the treatment system must be designed to meet the exemption provisions. |
| RCRA Regulations, Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities (TSDFs). | 40 CFR Part 264 | Applicable | Establishes minimum national standards defining the acceptable management of hazardous wastes for owners and operators of facilities that treat, store, or dispose of hazardous wastes. | If response actions involve management of RCRA wastes (such as spent GAC) at an off-site TSDF. |
| RCRA Regulations, Use and Management of Containers | 40 CFR Part 264, Subpart I | Applicable | Sets standards for the storage of containers of hazardous waste. | This requirement would apply to storage of a hazardous waste (for example, contaminated soil or groundwater from monitoring well installation) in containers prior to disposal. |

**Table 2-6**

**Action-Specific Applicable or Relevant and Appropriate Requirements and Other Guidance – Groundwater**
**DRA Site Groundwater Feasibility Study**
**Lockheed Martin, Martin State Airport**
**Middle River, Maryland**


| Requirement | Citation | Status | Synopsis | Evaluation/Action to be Taken |
|---|---|---|---|---|
| **Federal (continued)** | | | | |
| RCRA Regulations, Corrective Action Management Units (CAMUs) | 40 CFR Part 264.552 | Applicable | CAMUs are special units created to facilitate treatment, storage, and disposal of hazardous wastes managed for implementing cleanup. | If hazardous waste must be managed on the ground at the site (such as excavations for groundwater barriers), then CAMUs may be used without other RCRA permits. MDE has not adopted this rule. |
| Migratory Bird Treaty Act | 16 USC 703-711 | Applicable | Protects migratory birds and their nests. | Proposed response action shall not kill migratory birds or destroy their nests and eggs. Bald eagles have been observed nesting in the vicinity of the airport. |
| Clean Water Act National Pollutant Discharge Elimination System | 40 CFR Part 122 through 125, and 131 | Applicable | NPDES permits are required for any discharges to navigable waters. | Any alternative that includes discharges into any navigable water would require compliance with these regulations. |

**Table 2-6**

**Action-Specific Applicable or Relevant and Appropriate Requirements and Other Guidance – Groundwater**
**DRA Site Groundwater Feasibility Study**
**Lockheed Martin, Martin State Airport**
**Middle River, Maryland**


| Requirement | Citation | Status | Synopsis | Evaluation/Action to be Taken |
|---|---|---|---|---|
| **State** | | | | |
| Maryland Hazardous Substance Response Plan | Code of Maryland Regulations (COMAR) 26.14.01 and 26.14.02 | Applicable | The Hazardous Substances Response Plan establishes the framework for conducting assessment and cleanup activities. The required work is broken into three phases: Assessment; Cleanup; and Operation and Monitoring. MDE evaluates the remedial alternatives and then selects the remedy that is determined to be the most appropriate solution. | These regulations would apply to the evaluation and selection of the remedial alternative. |
| Maryland Hazardous Waste Management System – Identification | COMAR 26.13.02 | Applicable | Identifies definitions and methods of identification of hazardous waste. | These regulations would apply when determining whether or not groundwater and treatment residuals are hazardous, either by being listed or by exhibiting a hazardous characteristic. |
| Maryland Hazardous Waste Management System – Generators | COMAR 26.13.03 | Applicable | Establishes manifesting, pre-transport, and recordkeeping requirements for hazardous waste. | These regulations would apply to IDW and side streams (such as spent GAC). |

**Table 2-6**

**Action-Specific Applicable or Relevant and Appropriate Requirements and Other Guidance – Groundwater**
**DRA Site Groundwater Feasibility Study**
**Lockheed Martin, Martin State Airport**
**Middle River, Maryland**


| Requirement | Citation | Status | Synopsis | Evaluation/Action to be Taken |
|---|---|---|---|---|
| **State (continued)** | | | | |
| Maryland Hazardous Waste Management System – Transport | COMAR 26.13.04 | Applicable | Establishes manifesting and recordkeeping requirements for transport of hazardous waste. | These regulations would apply to the transportation for off-site disposal of hazardous waste, such as spent GAC. |
| Maryland Hazardous Waste Management System - TSDF | COMAR 26.13.05 | Applicable | Requires compliance with regulations on the storage of the waste and specifies procedures to prevent the occurrence of circumstances that would threaten human health or the environment. | If response actions involve management of RCRA wastes (such as spent GAC) at an off-site TSDF. |
| Maryland General Permit for Construction Activity | COMAR 26.17 | Applicable | Establishes requirements for stormwater management and erosion and sediment control at construction sites. | Response actions involving excavation would require submittal of an erosion and sediment control plan and a stormwater management plan during wastewater treatment plant construction. |
| Water Pollution Surface Water Quality Criteria | COMAR 26.08.02.03 | Applicable | Establish minimum standards for surface water quality for each designated use. Standards are available for the protection of human health and the protection of aquatic life. | Considered for determining extent of surface water contamination and discharge criteria for alternatives that involve discharges to surface water. |

**Table 2-6**

**Action-Specific Applicable or Relevant and Appropriate Requirements and Other Guidance – Groundwater**
**DRA Site Groundwater Feasibility Study**
**Lockheed Martin, Martin State Airport**
**Middle River, Maryland**


| Requirement | Citation | Status | Synopsis | Evaluation/Action to be Taken |
|---|---|---|---|---|
| **State (continued)** | | | | |
| Maryland Water Management Erosion and Sediment Control | COMAR 26.17.01 | Applicable | Contains requirements for erosion and sediment control during construction. | Remedial actions involving excavation would require submittal of an erosion and sediment control plan and a stormwater management plan during wastewater treatment plant construction. |
| Maryland Water Management Stormwater Management | COMAR 26.17.02 | Applicable | Establishes requirements for stormwater discharges to protect the surface waters of the state. | Remedial actions would consider the impact of the stormwater discharges during wastewater treatment plant construction. |
| Air Pollution Control; General Administrative Provisions, and Permits, Approvals, and Registration | COMAR 26.11.01 and 26.11.02 | Applicable | Establishes permitting requirements for all sources of air pollution. | These regulations would be applied to an air stripper. Permits to construct and operate would be required. (Note that Title V requirements are unlikely to apply because emission rate would be expected to be much less than the permitting thresholds. |
| Air Quality Toxic Air Pollutants | COMAR 26.11.15 and 26.11.16 | Applicable | Establishes standards for industries that emit toxic air pollutants, including sources regulated by NESHAPs. | Hazardous air pollutants may be discharged during groundwater treatment activities, such as air stripping. |

**Table 2-6**

**Action-Specific Applicable or Relevant and Appropriate Requirements and Other Guidance – Groundwater**
**DRA Site Groundwater Feasibility Study**
**Lockheed Martin, Martin State Airport**
**Middle River, Maryland**


| Requirement | Citation | Status | Synopsis | Evaluation/Action to be Taken |
|---|---|---|---|---|
| **State (continued)** | | | | |
| Regulation of Water Supply, Sewage Disposal, and Solid Wastes Well Construction | COMAR 26.04.04 | Applicable | Contains design standards and procedures for construction of wells. | The requirements would apply to new monitoring wells, injection wells, and extraction wells. |
| Maryland Water Pollution Permits | COMAR 26.08.04 | Applicable | Contains requirements for discharges to surface water | Any alternative that includes a discharge to surface water would comply with these requirements. |
| Underground Injection Control | COMAR 26.08.01 | Applicable | Establishes a State Underground Injection Control Program consistent with federal requirements to preserve the quality of the groundwater of the state. | These regulations would apply to remedial actions involve underground injection, such as an electron donor for bioremediation or reinjection of treated groundwater. |

**Table 2-6**

**Action-Specific Applicable or Relevant and Appropriate Requirements and Other Guidance – Groundwater**
**DRA Site Groundwater Feasibility Study**
**Lockheed Martin, Martin State Airport**
**Middle River, Maryland**


| Requirement | Citation | Status | Synopsis | Evaluation/Action to be Taken |
|---|---|---|---|---|
| **State (continued)** | | | | |
| Maryland Pollutant Discharge Elimination System: Water Quality, Discharge Limitations, Discharge Permit Limits, and Pretreatment Requirements to POTWs | COMAR 26.08.02, 26.08.03, 26.08.04.02, and 26.08.08 | Applicable | These standards govern discharge of water into surface waters and POTWs. | Extracted groundwater would be treated as required prior to discharge to either surface water or POTW. |

**Table 2-6**

**Action-Specific Applicable or Relevant and Appropriate Requirements and Other Guidance – Groundwater**
**DRA Site Groundwater Feasibility Study**
**Lockheed Martin, Martin State Airport**
**Middle River, Maryland**


| Requirement | Citation | Status | Synopsis | Evaluation/Action to be Taken |
|---|---|---|---|---|
| **Local** | | | | |
| Baltimore County Department of Public Works and Development Management – Permit to Discharge to Sanitary Sewer | NA | Applicable | Establishes limitations on contaminant concentrations, flow rates, and monitoring requirements. | This permit will be required if treated groundwater is discharged to the POTW. |
| Baltimore County Grading Permit | NA | Applicable | A grading permit is required for grading or land disturbance greater than 5,000 square feet. | The permit may be needed for the construction of the groundwater treatment plant. |

# Section 3
# Technology Screening and Process Options

Information that describes the identification, screening, and evaluation of potential technologies and process options that may apply to the selection of remedial alternatives for contaminated groundwater at the Dump Road Area (DRA) Site are provided in this section. The primary objective of this phase of the Groundwater Feasibility Study (FS) is to develop an appropriate range of remedial technologies and process options to be used in developing remedial alternatives. This includes completing the following analytical steps:

- Identification and screening of remedial technologies and process options
- Evaluation and selection of representative process options

Various technologies and process options are identified under each general response action (GRA) and are then screened (assessed). The screening is first conducted at a preliminary level to focus on relevant technologies and process options, and then the screening is conducted at a more detailed level based on certain evaluation criteria. Finally, process options are selected to represent technologies that have passed the detailed evaluation and screening.

The evaluation criteria for detailed screening of technologies and process options that have been retained after the preliminary level screening are effectiveness, implementability, and cost:

- ***Effectiveness***
    - Protection of human health and the environment; reduction in toxicity, mobility, or volume of contaminants; and permanence of the solution
    - Ability of the technology to address the estimated areas or volumes of contaminated media

- Ability of the technology to attain the preliminary remediation goals (PRGs) required to achieve the remedial action objectives (RAOs)
- Technical reliability (innovative versus well-proven) with respect to contaminants and site conditions

- ***Implementability***
  - Overall technical feasibility at the site
  - Availability of vendors, mobile units, storage and disposal services, etc.
  - Administrative feasibility
  - Special long-term maintenance and operation requirements
- ***Cost (qualitative)***
  - Capital cost
  - Operation and maintenance (O&M) costs

## 3.1 PRELIMINARY SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS

The results of the identification and screening of remediation technologies and process options for groundwater at a preliminary stage based on implementation with respect to site-specific conditions and chemicals of concern (COCs) are provided in this section. The results of this preliminary screening process are summarized in Table 3-1. It presents the GRAs, identifies the technologies and process options, and provides a brief description of each process option followed by comments about the results of the screening process. The following groundwater technologies and process options remain for detailed screening and are included in Appendix D:

| General response action | Technology | Process options |
|---|---|---|
| No action | None | Not applicable |
| Limited action | Land use controls (LUCs) | Groundwater use restrictions, construction restrictions |
| | Monitoring | Sampling and analysis |
| | Monitored natural attenuation | Sampling and analysis |
| Containment | Vertical barrier (physical) | Cut-off walls, grout curtain, sheet piling |
| | Vertical barrier (hydraulic) | Extraction wells |
| Removal | Groundwater extraction | Extraction wells |
| *In situ* treatment | Biological | Enhanced bioremediation with an electron-donor compound |
| | Chemical | Permeable reactive barrier (PRB) with zero-valent iron (ZVI) |
| *Ex situ* treatment | Physical | Filtration |
| | | Air stripping |
| | | Liquid-phase granular activated carbon (GAC) adsorption |
| | | Vapor-phase GAC adsorption |
| | | Vapor-phase potassium permanganate impregnated zeolite (PPZ) adsorption |
| | | Sedimentation |
| | Chemical | Coagulation/flocculation |
| | | Neutralization/pH adjustment |
| | | Ion exchange |
| | | Advanced oxidation |
| Disposal | Surface discharge | Direct surface water discharge |
| | | Indirect discharge to publicly owned treatment works (POTW) |
| | Subsurface discharge | Reinjection |

## 3.2 SELECTION OF REPRESENTATIVE TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER

The following technologies and process options, under the GRAs as noted, were retained for further development of groundwater containment remedial alternatives, based on the analysis in Appendix D:

- *No action*
- *Containment*: hydraulic barrier
- In situ *treatment*:
  enhanced bioremediation,
  ZVI PRB
- Ex situ *treatment*: filtration,
  air stripping,
  liquid-phase GAC adsorption,
  vapor-phase GAC adsorption,
  vapor-phase PPZ adsorption,
  neutralization/pH adjustment,
  coagulation/flocculation,
  sedimentation,
  ion exchange,
  advanced oxidation
- *Limited action*: LUCs, monitoring
- *Removal*: extraction
- *Disposal*: indirect discharge to POTW,
  reinjection,
  direct discharge

The purpose of this FS is to evaluate containment of and eliminating exposure to contaminated groundwater, which must consider the overall depth of the contaminated groundwater (approximately 90 to 100 feet below ground surface [bgs]) and the wide variety of contaminants (for example, cVOCs, metals, and 1,4-dioxane). Therefore, the number of processes and technologies that can be applied is limited. The primary objective of containment also limits the selection of processes, and contaminant removal technologies that might be applied throughout the plume were not considered. All remediation technologies and processes will be revisited when the FS for the site-wide soil and groundwater remedy is prepared.

**Table 3-1**

**Preliminary Screening of Remedial Technologies and Process Options for Groundwater**
**DRA Site Groundwater Feasibility Study**
**Lockheed Martin, Martin State Airport**
**Middle River, Maryland**


| General Response Action | Technology | Process Options | Description | Screening Comment |
|---|---|---|---|---|
| No Action | None | Not Applicable | No activities conducted at site to remedy or monitor contamination. Site is released for unrestricted development. | Retain. No action is retained as a baseline for comparison with other technologies. |
| Limited Action | Monitoring | Sampling and Analysis | Periodic sampling and analysis of groundwater to track changes in the extent of contamination. | Retain. This technology could assess migration of contaminants and evaluate progress of active remediation. |
| | Land Use Controls | Active Controls: Physical Barriers/ Security Guards | Fencing, markers, and warning signs to restrict site access. | Retain. Restrictions would be used to prevent damage to cover and wells. Exposure to groundwater would also be restricted. |
| | | Passive Controls: Deed and Land Use Restrictions | Administrative action using LUCs to restrict future site use and to prohibit use of groundwater as a source of drinking water. | Retain. Groundwater is currently not used as a drinking water source, and this technology will limit all future uses of groundwater. |

**Table 3-1**

**Preliminary Screening of Remedial Technologies and Process Options for Groundwater**
**DRA Site Groundwater Feasibility Study**
**Lockheed Martin, Martin State Airport**
**Middle River, Maryland**


| General Response Action | Technology | Process Options | Description | Screening Comment |
|---|---|---|---|---|
| Limited Action (continued) | Natural Attenuation | Naturally Occurring Biodegradation. Sorption, Dispersion, Volatilization, and Dilution | Monitoring groundwater to assess the reduction in concentrations of COCs through natural processes. | Retain. This technology may decrease concentrations of TCE and other VOCs that may have already migrated beyond the containment. Natural attenuation will occur within the contained area, but only to a limited extent. |
| Containment | Vertical Barriers | Slurry Wall | Low-permeability wall formed in a perimeter trench to restrict horizontal migration of groundwater. | Retain. Depth to confining layer is approximately 90 feet limiting installation to specialty equipment. Some groundwater treatment required. |
| | | Sheet Piling | Metal or HDPE sheet piling driven/vibrated into the ground to restrict horizontal migration of groundwater. | Retain. This method is effective in the sand, silts, and clays at the site. Shallow surface excavation will be needed to remove debris. Some groundwater treatment required. |
| | | Grout Curtain | Pressure injection of grout to form a low-permeability perimeter wall to restrict horizontal migration of groundwater. | Retain. This method is effective in the sand, silts, and clays at the site. Shallow surface excavation will be needed to remove debris. Some groundwater treatment required. |

**Table 3-1**

**Preliminary Screening of Remedial Technologies and Process Options for Groundwater**
**DRA Site Groundwater Feasibility Study**
**Lockheed Martin, Martin State Airport**
**Middle River, Maryland**


| General Response Action | Technology | Process Options | Description | Screening Comment |
|---|---|---|---|---|
| Containment (continued) | Vertical Barriers (continued) | Hydraulic Barrier | Use of extraction wells and/or collection trenches to restrict horizontal migration of groundwater. | Retain. Common method applicable to sandy soil. Heterogeneity would affect capture of groundwater and well design. Requires groundwater treatment. |
| | Horizontal Barriers | Physical Barrier | Injection of bottom-sealing grout beneath source to minimize vertical migration of groundwater. | Eliminate. Confining unit prevents further downward migration of contaminants. |
| Removal | Groundwater Extraction | Extraction Wells | Series of vertical pumping wells or horizontal wells used to remove contaminated groundwater. | Retain. Would be needed to remove water from infiltration and flow from upgradient area. May be effective in reducing contaminant concentrations in combination with ex-situ treatment. Because of levels of contaminant concentrations, MCLs are unlikely to ever be reached. |
| | | Collection Trench | A permeable trench used to intercept and collect groundwater. | Eliminate. A deep trench would be needed to capture the full depth of the plume. Heterogeneity and aquicludes would limit effectiveness. Depth of trench would be 50 to 80 feet. |

**Table 3-1**

**Preliminary Screening of Remedial Technologies and Process Options for Groundwater**
**DRA Site Groundwater Feasibility Study**
**Lockheed Martin, Martin State Airport**
**Middle River, Maryland**


| General Response Action | Technology | Process Options | Description | Screening Comment |
|---|---|---|---|---|
| In-Situ Treatment | Biological | Anaerobic/ Aerobic | Enhancement of biodegradation of organics in an anaerobic (oxygen-deficient) or aerobic (oxygen-rich) environment by injection of electron-donor compounds or oxygen source. Microorganism cultures may need to be added. | Retain. Anaerobic reductive dechlorination is effective at removing TCE and other chlorinated VOCs. Would not directly affect inorganics. Sulfides formed during anaerobic activity may precipitate metals. Effectiveness of bioremediation on 1,4-dioxane is uncertain. |
| | Physical/ Biological | Air Sparging (AS) or AS/ Soil Vapor Extraction (SVE) | Volatilization and enhancement of biodegradation of organic compounds by supply of air with or without capture and treatment of volatilized compounds. | Eliminate. Well and piping installation would need to be coordinated with cover system. Metals are not affected by process. Heterogeneity of subsurface would interfere with air sparging distribution. |
| | | Dynamic Underground Stripping | Steam injection at the periphery of the contaminated area resulting in the vaporization of volatile compounds bound to soil and the movement of contaminants to a centrally located extraction well. | Eliminate. The heterogeneous subsurface would make effective implementation of this method difficult. Metals are not affected by process. |

**Table 3-1**

**Preliminary Screening of Remedial Technologies and Process Options for Groundwater**
**DRA Site Groundwater Feasibility Study**
**Lockheed Martin, Martin State Airport**
**Middle River, Maryland**


| General Response Action | Technology | Process Options | Description | Screening Comment |
|---|---|---|---|---|
| In-Situ Treatment (continued) | Chemical | Chemical Oxidation | Chemical destruction of organic COCs through oxidation with hydrogen peroxide and ferrous iron (Fenton's Reagent), catalyzed percarbonate (RegenOx™), or potassium permanganate. | Eliminate. Extensive area and subsurface heterogeneity would affect distribution. Metals are not affected by process. |
| | | Permeable Reactive Barrier (PRB) | Use of a PRB with zero-valent iron, which allows the passage of groundwater and reacts with the VOCs. | Retain. Size and depth of contaminant plume would make construction of PRB difficult. Would not be effective for metals and 1,4-dioxane. |
| | Thermal | Electrical Resistance Heating | Volatilization of organic COCs through groundwater and soil heating with electrodes in combination with vacuum extraction of volatilized material. | Eliminate. Large volume would be costly to treat with this process. |
| Ex-Situ Treatment | Biological | Aerobic/ Anaerobic | Natural degradation of organic COCs via microorganisms in an aerobic (oxygen-rich) or anaerobic (oxygen-deficient) environment. | Eliminate. VOCs are more readily treated by air stripping and/or GAC. Would not be effective for metals. Effectiveness on 1,4-dioxane is uncertain. |

**Table 3-1**

**Preliminary Screening of Remedial Technologies and Process Options for Groundwater**
**DRA Site Groundwater Feasibility Study**
**Lockheed Martin, Martin State Airport**
**Middle River, Maryland**


| General Response Action | Technology | Process Options | Description | Screening Comment |
|---|---|---|---|---|
| Ex-Situ Treatment (Continued) | Physical | Filtration | Separation of suspended solids from water via entrapment in a bed of granular media or membrane. | Retain. May be useful in combination with other ex-situ treatment options. |
| | | Air Stripping | Contact of water with an air stream to remove VOCs. | Retain. Proven treatment method for VOC removal. Would not be effective on metals and 1,4-dioxane. |
| | | GAC Adsorption | Separation of dissolved contaminants from water or air streams via adsorption onto GAC. | Retain. Proven treatment method for VOC removal from contaminated groundwater and air stripper off-gas. Would not be effective on metals. Effective for 1,4-dioxane in uncertain. |
| | | Potassium Permanganate Impregnated Zeolite | Removal of vinyl chloride from vapor streams by sorption and subsequent reaction onto zeolite. | Retain. This process is needed because vinyl chloride is poorly removed by vapor-phase GAC. |
| | | Solvent Extraction | Separation of contaminants from a solution by contact with an immiscible liquid with a higher affinity for the COCs. | Eliminate. Not proven to be cost-effective for VOC removal. |

**Table 3-1**

**Preliminary Screening of Remedial Technologies and Process Options for Groundwater**
**DRA Site Groundwater Feasibility Study**
**Lockheed Martin, Martin State Airport**
**Middle River, Maryland**


| General Response Action | Technology | Process Options | Description | Screening Comment |
|---|---|---|---|---|
| Ex-Situ Treatment (Continued) | Physical (Continued) | Sedimentation | Separation of solids from water via gravity settling. | Retain. May be needed for incidental removal of iron and manganese. |
| | Chemical | Coagulation/ Flocculation | Use of chemicals to neutralize surface charges and promote attraction of colloidal particles to facilitate settling. | Retain. May be needed for metals removal and incidental removal of iron and manganese. |
| | | Neutralization/ pH Adjustment | Use of acid or base to counteract high or low pH conditions. | Retain. May be needed for final pH adjustment prior to discharge. May be needed for metals removal. May be needed for incidental removal of iron and manganese. |
| | | Chemical Precipitation | Use of reagents to convert soluble compounds into insoluble compounds. | Eliminate. Metals in groundwater are commonly removed by pH adjustment. |
| | | Ion Exchange | Removal of dissolved ions through exchange with similarly charged ions held on the active sites of a synthetic resin that is contacted with the liquid to be treated. | Retain. May be needed as final polishing step prior to discharge. |

**Table 3-1**

**Preliminary Screening of Remedial Technologies and Process Options for Groundwater**
**DRA Site Groundwater Feasibility Study**
**Lockheed Martin, Martin State Airport**
**Middle River, Maryland**


| General Response Action | Technology | Process Options | Description | Screening Comment |
|---|---|---|---|---|
| Ex-Situ Treatment (Continued) | Chemical (Continued) | Advanced Oxidation | Use of oxidizers such as ozone, hydrogen peroxide, or potassium permanganate to break down certain organic compounds. | Retain. This technology is demonstrated for removal of 1,4-dioxane and other VOCs. Metals would not be affected. |
| Discharge/ Disposal | Surface Discharge | Direct Discharge | Discharge of treated water to surface water. | Retain. Treatment of other constituents, such as other metals, may be required to meet effluent limitation requirements. |
| | | Indirect Discharge | Discharge of collected/treated water to local POTWs. | Retain. Treatment of other constituents, such as metals, may be required to meet effluent limitation requirements. POTW may have flow rate and influent limitations. |
| | | Off-Site Treatment Facility | Treatment and disposal of water at an off-site treatment works. | Eliminate. Separate facility not available. Large volume of water would be too costly to transport by tanker. |
| | Subsurface Discharge | Reinjection | Use of injection wells, spray irrigation, or infiltration for discharge of treated groundwater underground. | Retain. Water reinjected upgradient of source can be amended to promote bioremediation. |

**Table 3-1**

**Preliminary Screening of Remedial Technologies and Process Options for Groundwater**
**DRA Site Groundwater Feasibility Study**
**Lockheed Martin, Martin State Airport**
**Middle River, Maryland**


AS - Air sparge.
COC - Chemical of concern.
GAC - Granular activated carbon.
HDPE - High-density polyethylene.
POTW - Publicly owned treatment works.
LUC - Land use control.
PRB - Permeable reactive barrier.
STP - Sewage treatment plant.
SVE - Soil vapor extraction.
TCE - Trichloroethene.
VOC - Volatile organic compound.

# Section 4
# Assembly and Detailed Analysis of Remedial Alternatives

## 4.1 INTRODUCTION

Each remedial alternative for the interim remedial action was evaluated with respect to the following evaluation criteria set forth in EPA's *National Oil and Hazardous Substances Pollution Contingency Plan* (NCP) [40 *Code of Federal Regulations* (CFR), Part 300]. These criteria and their relative importance are described in the following subsections:

- Overall protection of human health and the environment
- Compliance with applicable or relevant and appropriate requirement (ARARs)
- Long-term effectiveness and permanence
- Reduction of contaminant toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost
- Regulatory agency acceptance
- Community acceptance

An additional non-Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) criterion, sustainability, will also be evaluated. Sustainability is an important consideration for Lockheed Martin Corporation and is evaluated here to minimize the environmental footprint of the remedial action, while still protecting human health and the environment. These criteria were applied to the alternatives being evaluated with the view that this will be an interim remedial action, focusing primarily on containment. Maintaining flexibility to expand the system as part of a future final remedy is also an important factor.

### 4.1.1 Overall Protection of Human Health and the Environment

Remedial alternatives must be assessed for adequate protection of human health and the environment, in both the short and long term, from unacceptable risks posed by hazardous substances or contaminants at the site. This is accomplished by eliminating, reducing, or controlling exposure to contaminant levels exceeding preliminary remediation goals (PRGs). Overall protection draws on the assessments pursuant toother evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs.

### 4.1.2 Compliance with Applicable or Relevant and Appropriate Requirements

For sites in the CERCLA program, alternatives must be assessed to determine whether they attain ARARs under federal environmental laws and state environmental or facility siting laws (see Section 2.3.2). However, because remediation of the Dump Road Area (DRA) Site is not being conducted under CERCLA authority, only applicable regulations need to be considered. The relevant and appropriate evaluation process does not apply to this site. In addition, all federal, state, and local permits must be obtained, whereas sites under CERCLA authority do not need to obtain permits.

### 4.1.3 Long-Term Effectiveness and Permanence

Alternatives must be assessed for the long-term effectiveness and permanence they offer, along with the degree of certainty that the alternative would prove successful. Factors to be considered, as appropriate, include:

- ***Magnitude of residual risk —*** Risk posed by untreated waste or treatment residuals at the conclusion of remedial activities
- ***Adequacy and Reliability of Controls —*** Controls such as containment systems and land use controls (LUCs) that are necessary to manage treatment residuals and untreated waste must be shown to be reliable

### 4.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

The degree to which an alternative uses recycling or treatment to reduce the toxicity, mobility, or volume of contaminants must be assessed, including how treatment addresses principal threats posed by the site. Factors to be considered, as appropriate, include:

- Treatment or recycling processes the alternative uses, and the materials these processes will treat

- The amount of hazardous substances, pollutants, or contaminants that will be destroyed, treated, or recycled

- The degree of expected reduction in toxicity, mobility, or volume of waste due to treatment or recycling and the specification of which reduction(s) is/are occurring

- The degree to which the treatment is irreversible

- Type and quantity of residuals that will remain following treatment, considering the persistence, toxicity, mobility, and tendency to bioaccumulate of such hazardous substances and their constituents

- The degree to which treatment reduces the inherent hazards posed by principal threats at the site

### 4.1.5 Short-Term Effectiveness

The short-term effects of the alternative are to be assessed considering the following:

- Short-term risks that might be posed to the community during implementation

- Potential effects on workers during remedial action and the effectiveness and reliability of protective measures

- Potential environmental effects of the remedial action and the effectiveness and reliability of mitigation measures during implementation

- Time until protection of human health and the environment is achieved

### 4.1.6 Implementability

The ease or difficulty of implementing the alternatives is assessed by considering the following types of factors, as appropriate:

- Technical feasibility, including technical difficulties and unknowns associated with the construction and operation of a technology, its reliability, the ease of undertaking additional remedial actions, and the ability to monitor the effectiveness of the remedy

- Administrative feasibility, including activities necessary to coordinate with regulatory agencies and other offices, and the ability and time required to obtain any necessary approvals and permits from relevant agencies (for off-site actions)

- Availability of services and materials, including the availability of adequate off-site treatment, storage, and disposal capacity and services, availability of necessary

equipment and specialists and provisions to ensure necessary additional resources, availability of services and materials, and the availability of prospective technologies

The selected containment alternative must be designed and implemented so that it does not interfere with the soil and landfill waste remediation projects planned for the site. The design of the containment system must include the flexibility to treat additional groundwater if conditions at the site should change, or the final groundwater FS incorporates additional treatment needs.

### 4.1.7 Sustainability

The sustainability of each alternative will be evaluated. Factors to be considered, as appropriate, include:

- *Environmental factors*, such as energy use and greenhouse gas emissions
- *Resource consumption*
- *Waste generation* as compared to recycling and reuse of materials. The percentage of contaminants destroyed rather than removed is also considered under this category. This component is evaluated as part of the CERCLA criteria, under the "Reduction of Toxicity, Mobility, or Volume through Treatment" criterion
- *Economic factors*, such as life cycle costs, and the development potential of the site after remediation. Costs are considered as part of the CERCLA criteria, under the "Cost" criterion
- *Social factors*, such as traffic and noise. These factors are also considered as part of the CERCLA criteria, under the "Short-Term Effectiveness" criterion

Evaluation of sustainability is consistent with Lockheed Martin's corporate "Go Green" program. Under this program, Lockheed Martin seeks to reduce adverse environmental effects through activities such as improved energy efficiency and reduced waste generation and water usage.

### 4.1.8 Cost

Capital costs, including both direct and indirect costs, and annual operation and maintenance (O&M) costs will be evaluated for each alternative. A net present worth (NPW) value of the capital and O&M costs, based on a 30-year operating period, is provided for an economic comparison of the alternatives. A current value equal to the sum of the capital costs and annual O&M costs adjusted by an annual inflation rate of 2 percent is also provided. Typically, the cost estimate accuracy range for a feasibility study (FS) is +50 percent to -30 percent.

### 4.1.9 Regulatory Agency Acceptance

This Groundwater FS was prepared for review and approval by the MDE and is subject to the regulatory requirements of Maryland's Hazardous Substance Response Plan. Maryland's Hazardous Substance Response Plan grants MDE the authority to choose how the cleanup will be performed.. In addition, the property owner, Maryland Aviation Administration (MAA), and property leaser, the Maryland Air National Guard (MDANG), will also be given the opportunity to comment on the Groundwater FS. Regulators' concerns that must be assessed include:

- The position and key concerns of the MDE relative to the preferred and other alternatives
- MDE's comments on ARARs or the proposed use of waivers

These concerns cannot be completely evaluated until the agencies have reviewed and commented on this Groundwater FS and the Proposed Plan to be prepared subsequent to this document.

### 4.1.10 Community Acceptance

The Groundwater FS, which includes a recommendation for one of the alternatives, and the subsequent Proposed Plan will be made available to the public for review and comment. This criterion consists of community responses to the selected remedy. Comments from the public on the selected remedy will be assessed once they have been received at the conclusion of the public comment period.

### 4.1.11 Relative Importance of Criteria

The following are considered threshold criteria:

- Overall protection of human health and the environment
- Compliance with ARARs (excluding those that may be waived)

The threshold criteria must be satisfied for an alternative to be eligible for selection. Among the remaining criteria, the following six are the primary balancing criteria:

- Long-term effectiveness and permanence
- Implementability

- Reduction of contaminant toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Sustainability
- Cost

The balancing criteria are used to weigh the relative merits of the alternatives being evaluated. The remaining two criteria, "Regulatory Agency Acceptance" and "Community Acceptance," are modifying criteria that must be considered during remedy selection. These last two criteria will be evaluated after this Groundwater FS has been reviewed by EPA and MDE, and after an alternative has been selected. This document therefore addresses only 8 of the 10 criteria.

### 4.1.12 Remedy Selection

Remedy selection is expected to follow a two-step process. The first step identifies a preferred alternative (see Section 5.3) which must meet the following criteria:

- Protection of human health and the environment
- Compliance with ARARs

The second step reviews public comments and determines whether the preferred alternative remains the most appropriate remedial action for the site, with EPA and MDE concurrence.

## 4.2 ASSEMBLY AND DETAILED ANALYSIS OF GROUNDWATER ALTERNATIVES

Based on the detailed screening of technologies and process options presented in Section 3.2, alternatives were developed for the interim remedial action at the DRA Site. These alternatives primarily consider containment of contaminated groundwater at the DRA Site, although some alternatives include limited source area treatment. The design of the containment system must include flexibility for treatment of additional groundwater if conditions at the site change or the final groundwater FS incorporates additional treatment. The following six interim remedial action alternatives were developed:

- ***Alternative G-1 —*** No action

- ***Alternative G-2 —*** Hydraulic control by extraction, *ex situ* treatment of groundwater, discharge to publicly owned treatment works (POTW)/surface water, monitoring, and LUCs

- ***Alternative G-3 —*** Hydraulic control by extraction, *ex situ* treatment of groundwater, reinjection of groundwater, discharge to POTW/surface water, monitoring, and LUCs

- ***Alternative G-4 —*** Hydraulic control by extraction, extraction in high concentration areas (HCAs), *ex situ* treatment of groundwater, reinjection of groundwater, discharge to POTW/surface water, monitoring, and LUCs

- ***Alternative G-5 —*** Hydraulic control by extraction, *ex situ* treatment of groundwater, *in situ* bioremediation of HCAs, discharge to POTW/surface water, monitoring, and LUCs

- ***Alternative G-6 —*** Zero-valent iron (ZVI) permeable reactive barrier (PRB), monitoring, and LUCs

Alternative G-1 was developed and analyzed as a baseline against which the other alternatives can be compared, as required by the NCP. Alternative G-2 was developed as a base case with hydraulic control of the plume only. Groundwater contaminants upgradient of the extraction wells will eventually flow to the extraction wells, but the design does not incorporate acceleration of groundwater cleanup.

Alternative G-3 is an enhanced version of Alternative G-2, in that some of the treated groundwater will be amended with an electron-donor compound and then reinjected upgradient of the HCAs to promote biological remediation. The treatment system in this alternative is sized for a larger flow rate to address the potential for flexibility in future operations, including the final site groundwater remedy. Alternative G-4 is a more aggressive extraction and treatment approach that includes extraction, treatment of highly contaminated groundwater from the HCAs, and reinjection of treated groundwater (with amendments to promote biological activity). Treating additional groundwater may reduce the time required to restore groundwater quality.

Alternative G-5 is similar to Alternative G-4 in that highly contaminated groundwater in the HCAs is treated. In Alternative G-5, highly contaminated groundwater in the HCAs is treated *in situ* by enhanced bioremediation to reduce the time to restore groundwater quality, but extracted groundwater is not reinjected. The treatment system in this alternative is also sized for a larger flow rate to permit flexibility in future operations. Alternative G-6 uses a PRB for passive treatment instead of a groundwater extraction and treatment system. A description and detailed

analysis of these alternatives are presented in the following sections. The key features of each alternative are summarized in Table 4-1.

Groundwater modeling was performed to determine recovery well locations and pumping rates in order to obtain hydraulic control of the plumes (Alternative G-2). An additional modeling simulation (Alternative G-4) was performed to examine the effect of mass removal from extraction wells located in high concentration areas of the plume and reinjection of treated groundwater amended with an electron-donor to promote biological degradation into points upgradient of the high concentration areas. Although the effects of the electron-donor were not simulated in this scenario, additional model simulations may be performed to examine these effects in the enhanced remedial alternatives once the reaction rates are better understood during pilot testing. The extraction rates and extraction well locations that were determined from the hydraulic containment for Alternative G-2 were assumed to be sufficient for Alternatives G-3 and G-5. Similarly, the effects of reinjection modeled for Alternative G-4 were assumed to be sufficient for Alternative G-3. Therefore, specific modeling scenarios for Alternatives G-2 and G-4 were prepared. No modeling was performed for Alternative G-6 because that scenario does not have any groundwater extraction.

### 4.2.1 Alternative G-1: No Action

#### 4.2.1.1 Description

The no action alternative maintains the site as is. This alternative does not address groundwater contamination and is retained as a baseline for comparison to other alternatives. It would achieve no reduction in toxicity, mobility, or volume of the contaminants other than what would result from natural dispersion, dilution, biodegradation, and other attenuating factors.

#### 4.2.1.2 Detailed Analysis

***Overall protection of human health and the environment —*** Alternative G-1 would provide no protection of human health and the environment. Under the current industrial land use, the potential for human and ecological exposure to contaminated groundwater would remain. In addition, under a future residential land use scenario, unacceptable risks to human and ecological receptors from exposure to contaminated groundwater would not be reduced. Potential off-site migration of chemicals of concern (COCs) would not be detected because no

groundwater monitoring would be conducted. The potential for vapor intrusion into future buildings would not be considered under this alternative. Thus, potential migration of COCs would not be detected.

***Compliance with ARARs and other guidance —*** Alternative G-1 would not comply with chemical-specific ARARs or other guidance because no action would be taken to reduce contaminant concentrations. Chemical-specific ARARs may eventually be met by natural attenuation, but no monitoring would be conducted to verify the changes. Compliance with location-specific ARARs or other guidance would be purely incidental. Action-specific ARARs or other guidance are not applicable.

***Long-term effectiveness and permanence —*** Alternative G-1 would have little long-term effectiveness and permanence because contaminated groundwater would remain on-site. In the absence of LUCs to restrict building construction methods, unacceptable risks could potentially be posed to human receptors via vapor intrusion. Potential off-site migration of COCs would not be detected because groundwater monitoring would not be conducted under this alternative. Although COC concentrations might eventually decrease to cleanup goals through natural attenuation, no monitoring would verify this.

***Reduction of toxicity, mobility, or volume through treatment —*** Alternative G-1 would not reduce the toxicity, mobility, or volume of contaminants through treatment because no treatment would occur. Some reduction of the toxicity and volume of COCs might occur through natural dispersion, dilution, or other attenuation processes, but no monitoring would be performed to verify this.

***Short-term effectiveness —*** Implementation of Alternative G-1 would produce no short-term adverse effects to the local community or the environment due to cleanup activities, because no action would be undertaken. Alternative G-1 would never achieve the remedial action objectives (RAOs) and, though the cleanup goals might eventually be achieved through natural attenuation, this would not be verified through monitoring.

***Implementability —*** Alternative G-1 would be readily implementable because no action would occur. The technical feasibility criteria, including constructability, operability, and reliability,

are not applicable. Implementability of additional administrative measures is not applicable because no such measures would be taken.

***Sustainability —*** Alternative G-1 is highly sustainable, since no action would occur. No energy or resources would be consumed, no greenhouse gases would be generated, and no waste would be generated. No costs or increases in negative social factors, such as traffic and noise, are associated with this alternative. An economic factor to consider is that site development would be limited because of the potential for exposure to contaminated groundwater or to contaminants volatilizing from the groundwater and into buildings, but with no controls in place under this alternative.

***Cost —*** The No Action alternative would incur no costs beyond the existing monitoring program.

### 4.2.2 Alternative G-2: Hydraulic Control by Extraction, *ex situ* Treatment of Groundwater, Discharge to Publicly Owned Treatment Works/Surface Water, Monitoring, and Land Use Controls

#### 4.2.2.1 Description

Alternative G-2 would consist of five major components: (1) hydraulic control of the plume by extraction, (2) *ex situ* treatment of groundwater, (3) discharge of treated groundwater to the POTW or surface water, (4) monitoring, and (5) LUCs. Components 1 through 3 are summarized below. See Appendix E for detailed descriptions of these components.

***Component 1 (Alternative G-2): Hydraulic control —*** This component would consist of installing an array of groundwater extraction wells and operating them until the groundwater contamination is remediated. Pumping rates and well locations were selected using the groundwater model to optimize the extraction required for hydraulic containment of the plume. Modeling results for this component are provided in Appendix B. Design calculations for this component are provided in Appendix E.

The results of groundwater modeling suggest that 16 extraction wells at various depths would be sufficient to intercept contaminated groundwater before it reaches Frog Mortar Creek. One result of the groundwater modeling analysis is that most of the extracted groundwater would be from the site and very little water would be drawn in from Frog Mortar Creek. Contaminant

concentrations from locations upgradient of the containment wells would also be reduced as groundwater flows toward the extraction wells.

Under Alternative G-2, seven wells would be screened in the upper zone (at approximately 35 feet deep), five wells would be screened in the intermediate zone (at approximately 65 feet deep), and four would be screened in the lower zone (at approximately 90 feet deep). Each well screen would be at least 10 feet long. The total groundwater extraction rate is estimated to be 40 gallons per minute (gpm). Extraction well locations are shown in Figure 4-1.

A submersible centrifugal pump would be installed in each groundwater extraction well. Each of these pumps would be connected to a piping network that would convey the extracted groundwater to an on-site pumping station (see Figure 4-1). From there, groundwater would be pumped to an off-site treatment system near Eastern Boulevard. Extracted groundwater will be conveyed through double-walled pipes because the contaminated groundwater will pass through areas of uncontaminated groundwater.

Surface water levels in the two ponds and adjacent wetlands will be monitored during extraction. The ponds do not appear to be hydraulically connected to the groundwater. The existence of a hydraulic connection with wetlands is unknown at this time.

***Component 2 (Alternative G-2):*** **Ex situ** ***treatment of groundwater*** **—** Recent groundwater modeling estimates that the total groundwater extraction rate would be approximately 40 gpm. The treatment system conceptual design is sized for a maximum instantaneous flow of 50 gpm. This component would include the installation of a treatment system and operation of it as long as groundwater is being extracted.

As shown in the process flow diagram (PFD) (see Figure 4-2), the extracted groundwater would enter the system at a feed tank, flow through a metals removal system, filter unit, air stripper, advanced oxidation system, the liquid-phase granular activated carbon (GAC) unit, an ion exchange unit, and then exit the system via the GAC unit. Sludge generated by the metals removal step would be thickened, dewatered, and disposed of off-site. The treatment system is described further below.

A conceptual layout of the treatment building is shown in Figure 4-3. Design calculations for this component and a more detailed process description are provided in Appendix E. The following description is typical; the description of the final system will depend on the vendor-specific equipment selected.

The feed tank controls water flow through the treatment system. The tank would also blend groundwater from the various extraction wells to buffer variations in the quality of the treatment system influent. Side streams from the wastewater treatment system will also be sent to the feed tank.

The feed pump would move groundwater through the treatment system to the metals removal system. Groundwater would enter a primary pH adjustment tank, where pH would be adjusted to 10 with caustic soda, followed by addition of hydrogen peroxide to oxidize and precipitate iron and manganese. The groundwater would then enter a secondary pH adjustment tank where pH would be adjusted to 11 with caustic soda to precipitate other metals (such as cadmium) out of the groundwater being treated.

Following pH adjustment, groundwater would flow into the flocculation tank where it would be mixed with a polymer to coagulate and flocculate the suspended solids. The groundwater then would flow into the clarifier, where solids settle out. Clarified effluent would then flow into a final pH adjustment tank where hydrochloric acid would be added to return pH to the range of 6–9 for discharge after final treatment.

Chemicals would be stored in drums or tote tanks, depending on chemical usage rates. Alternative, less aggressive chemicals may be considered. For example, lime or magnesium hydroxide may be used instead of caustic soda. Citric acid or carbon dioxide may be used in place of hydrochloric acid. Mechanical aeration with a blower may be considered for oxidizing iron and manganese instead of using hydrogen peroxide.

Neutralized groundwater would flow by gravity into the clarified water feed tank and pumped through a sand filter. The sand filter will remove the balance of suspended solids (including precipitated iron and manganese). By removing suspended solids, the sand filter will also remove metals so that discharge limitations are met. Three sand filter tanks would be arrayed in parallel: two on-line and one off-line. As solids accumulate, the pressure drop across the sand

filter will increase. When a pre-set pressure drop is reached, the off-line sand filter will automatically be brought on-line while the original sand filter is taken off-line. The off-line sand filter would then be backwashed, as described below.

Following filtration, groundwater flows to the top of an air stripper where the groundwater would then cascade down through multiple trays of a low-profile air stripper where a countercurrent of air would volatilize the volatile organic compounds (VOCs). Treated groundwater would then be collected in a sump at the bottom of the air stripper unit. Treated water would then be pumped to the advanced oxidation process (AOP) and GAC units.

For the purposes of this Groundwater FS, the treatment process described here includes use of HiPOx®, a commercially available system, although other processes can be used. Water from the air stripper would enter the HiPOx® unit, where ozone and hydrogen peroxide would be added to the groundwater undergoing treatment to oxidize organic compounds, particularly 1,4-dioxane. Treated groundwater would then flow through the GAC system.

A GAC system is included to polish the groundwater, that is, to remove remaining diesel range organics (DRO) and gasoline range organics (GRO) and to provide contingency treatment in the event the AOP unit malfunctions. Two GAC tanks would be arrayed in series in a lead-lag configuration. When the GAC in the lead tank reaches capacity (based on analytical testing of the influent and effluent), the flow will be switched to the lag tank while the first tank is taken off-line, so that the GAC can be replaced with fresh GAC. After the GAC is replaced, the GAC tank is put back on-line in the lag position. Following GAC treatment, the treated water flows via the discharge piping to an existing sewer connected to the sanitary sewer system.

Gas exhausted from the top of the air stripper unit would pass through an off-gas treatment unit to remove volatilized contaminants before venting to the atmosphere. The off-gas treatment unit would consist of an electric heater, followed by two vapor-phase GAC adsorption units, followed by two potassium permanganate impregnated zeolite (PPZ) adsorption units. The exhaust gas heater would reduce the relative humidity of the air stripper unit off-gas from nearly 100 percent to approximately 50 percent, to allow efficient operation of the vapor-phase GAC adsorption units.

VOCs in the extracted vapors would be removed by the vapor-phase GAC adsorption units. Upon exhaustion of the carbon in the lead vapor-phase GAC unit, it would be taken out for disposal or regeneration. The lag vapor-phase GAC adsorption unit would then be placed in the lead position and a fresh unit would be placed in the lag position. Potassium permanganate impregnated zeolite is used because vinyl chloride is poorly sorbed by GAC. Vinyl chloride is oxidized by potassium permanganate. Upon exhaustion of the PPZ unit, it would be taken out for disposal.

For discharge to surface water, the contaminant concentrations must also conform to EPA and MDE water quality criteria. For cadmium, the preliminary remediation goal (PRG) is 5 µg/L, and conventional treatment by pH adjustment, clarification, and filtration cannot meet this level. To meet the cadmium requirement, an ion exchange (IE) unit would be provided following the GAC unit. Cartridge filters would be required upstream of the IE system to prevent clogging of the IE resin and to further remove metals sorbed onto fine suspended solids passing through the sand filters. Two tanks would be used: one on-line and the second on standby. The effluent would be routinely monitored for cadmium, and as the concentration approached the PRG, the tank would be taken off-line and the standby tank would be brought into service. The resin would be regenerated off-site by a resin regeneration service.

Part of the treated water will be diverted to a backwash supply tank. The backwash supply tank is sized to provide sufficient water for one backwash cycle each for a sand filter and GAC tank. When a sand filter requires backwashing, the backwash pump is activated and water flows up through the sand filter, suspending the sand and carrying the solids out of the sand filter to the waste backwash tank.

After backwashing, the backwash pump is stopped and the sand filter is ready to be used when the next on-line sand filter reaches capacity. Similarly, when the GAC in a GAC tank is replaced, fines are generated during transfer of the GAC and then removed by backwashing. Water in the waste backwash tank is then slowly metered back to the feed tank.

Settled sludge in the clarifier would be periodically transferred to the sludge thickener tank. In the sludge thickener, the solids content of the sludge is increased by gravity sedimentation from approximately 0.5 percent (by weight) to approximately 4 percent (by weight). Thickened

sludge would be periodically pumped from the bottom of the thickener to a recessed plate filter press. In the filter press, the solids content of the thickened sludge is increased to 25–35 percent (by weight) to form a solid cake that is stored in a roll-off container and later hauled away for appropriate disposal. Supernatant water from the thickener and filtrate water from the filter press is then pumped to the feed tank.

The DRA Site is bordered by taxiways and runways, the MDANG property, and Frog Mortar Creek, making access for routine maintenance difficult, so the location of the treatment building is planned to be off of the Martin State Airport (MSA) property. The property for the treatment building would need to be purchased or leased. Figure 4-4 shows the pipeline routing across the MSA property between the DRA Site and the general area of the treatment building. The planned building has an estimated size of 130 feet by 60 feet. An area of approximately 180 feet by 120 feet would be needed to accommodate construction, parking, and deliveries.

The Groundwater Treatment Plant Building will be designed to contain spills within the building. Spills will flow or be directed into the building sump and transferred to the feed tank. Controls in the sump would activate an alarm and would shut down the extraction wells in the event of a spill. A spare sump pump would be provided. Influent, effluent, and intermediate locations in this process will be sampled routinely to monitor treatment effectiveness and progress. These results will also be used to determine if the GAC needs to be replaced.

***Component 3 (Alternative G-2): Discharge to POTW and surface water —*** Treated groundwater would initially be discharged to the Baltimore County sanitary sewer system and treated at the City of Baltimore Back River Wastewater Treatment Plant. Discharge from the groundwater treatment system would be pumped and tied into an existing sanitary sewer near the proposed treatment building. Discharge to the sanitary sewer would be metered and routinely sampled to comply with Baltimore County Industrial Wastewater Discharge Standards. The design discharge rate of 50 gpm is greater than the 25,000 gallons per day (gpd) threshold for a significant industrial user, so reporting would be required twice per year and annual user fees, in addition to sewage service charges, are also required.

After the extraction and treatment system has operated for two to three years, extraction flow rates, groundwater concentrations, and treated water concentrations will be well established.

Plant operation data will be used to apply for a National Pollutant Discharge Elimination System (NPDES) permit to discharge to surface water (either Frog Mortar Creek or Stansbury Creek). The application will include developing an MDE-approved estuary model to calculate effluent limitations and to field calibrate the model, to obtain effluent limitations from MDE. Treated water would then be discharged to surface water through a submerged multiple diffuser outfall. Discharge would be metered and routinely sampled to comply with the NPDES permit.

***Component 4 (Alternative G-2): Monitoring —*** Monitoring would consist of regularly measuring groundwater levels and collecting and analyzing groundwater samples to evaluate changes in contaminant concentrations (in the plume downgradient of the extraction wells) due to extraction. Tracking water levels will measure the capture zone to confirm hydraulic capture of the plume. Samples would be collected from existing as well as new monitoring wells installed specifically to evaluate system performance. Wells in the monitoring program would include the extraction wells, five three-well clusters in the plume (between the Taxiway Tango and Frog Mortar Creek), two three-well clusters between the runway and Taxiway Tango, and a newly installed pair of two-well clusters (extending into the intermediate and lower zones), with each pair installed downgradient of the extraction wells. Final selection of monitoring wells will be made in the design phase of the project, with the concurrence of relevant regulatory agencies.

Samples will be analyzed for VOCs, 1,4-dioxane, DRO, GRO, and metals. The extraction wells would be sampled semiannually for the first three years because concentrations in these wells are expected to change quickly, then sampled annually thereafter. All other wells would be sampled annually. Groundwater sampling and analysis reports would be submitted annually to the relevant regulatory agencies. The groundwater monitoring program would be reviewed at least every five years to determine if changes are needed in sampling frequency, analyses, or the wells that are sampled. Pumping rates of the extraction wells would also be evaluated for optimization.

***Component 5 (Alternative G-2): LUCs —*** Land use controls for groundwater would include limiting land use to industrial purposes, prohibiting residential use, and prohibiting surficial aquifer use for drinking and industrial purposes. Deed restrictions would be required to implement the LUCs. Land use controls would be maintained as long as groundwater

contaminant concentrations are greater than PRGs. An additional LUC would also be required to restrict construction methods for new buildings on the site.

Vapor intrusion is a potential problem because TCE and other VOCs are present in shallow groundwater. Thus, an additional LUC would be applied to areas overlying shallow groundwater where VOC concentrations are greater than the vapor intrusion PRGs (see Table 2-4). For example, for TCE, the vapor intrusion PRG is 290 µg/L, and for vinyl chloride it is 15 µg/L. The additional LUC would require special construction methods, such as installation of vapor barriers and foundation venting, to prevent unacceptable exposure to VOCs via vapor intrusion.

#### 4.2.2.2 Detailed Analysis

***Overall protection of human health and the environment —*** Alternative G-2 would protect human health and the environment. The extraction wells would prevent contaminated groundwater from entering Frog Mortar Creek. Extraction of groundwater from the leading edge of the plume would also gradually remediate groundwater contamination as the plume flows toward the extraction wells. This would eventually reduce risk from exposure to contaminated groundwater and protect future human receptors that may be exposed during intrusive activities.

Monitoring would protect human health and the environment by evaluating extraction effectiveness and remediation progress and detecting potential migration of contaminants through groundwater. Land use controls would likewise protect human health and the environment during the remediation period until PRGs are achieved. Restricting groundwater use would also protect human health and the environment by avoiding unacceptable risks of exposure to contaminated groundwater. Exposure to VOCs via vapor intrusion would be controlled by requirements placed on building construction methods.

***Compliance with ARARs and other guidance —*** Alternative G-2 would eventually comply with chemical-specific ARARs and other guidance through a combination of extraction, treatment, and plume migration toward the extraction system. Alternative G-2 would also comply with location- and action-specific ARARs and guidance. The chemical-, location-, and action-specific ARARs and other guidance are described in Section 2.

***Long-term effectiveness and permanence —*** Alternative G-2 would provide long-term effectiveness and permanence. Extraction would effectively and permanently remove contaminants from groundwater. Extraction is a well-established method of groundwater treatment. Many extraction systems reach a long-term steady-state groundwater concentration that is greater than the target treatment goal, which is usually a maximum contaminant level (MCL).

Monitoring treatment progress would effectively evaluate remediation progress and verify that COCs are not migrating. Groundwater use restrictions would effectively prevent groundwater use until PRGs are met. Requirements for specific construction methods would effectively prevent exposure to VOCs via vapor intrusion. The controls proposed in this alternative are considered reliable. This alternative contains little flexibility for expansion or use in the final remedial action at the DRA Site.

***Reduction of toxicity, mobility, or volume through treatment —*** Alternative G-2 would reduce the toxicity, mobility, and volume of groundwater COCs. Over a 30-year period, extraction and treatment would permanently and irreversibly remove an estimated 3,600 pounds (lb) of TCE, 1,900 lb of cis-1,2-dichloroethene (DCE), 3,300 lb of vinyl chloride, and 160 lb of 1,4-dioxane from groundwater. Most of these COCs would be sorbed onto GAC and spent GAC would be taken off-site for regeneration. The 1,4-dioxane and some other COCs would be destroyed by AOP. Vinyl chloride captured by the PPZ would be oxidized and destroyed. In addition, metals would be settled out into a sludge that would be disposed of off-site. Spent GAC would require off-site regeneration, and spent PPZ would require off-site disposal.

***Short-term effectiveness —*** Alternative G-2 would reduce human health risks in the short term through groundwater use restrictions. Exposure of workers to contamination during installation of extraction wells and groundwater sampling would be minimized by compliance with federal Occupational Safety and Health Administration (OSHA) requirements, including wearing appropriate personal protective equipment (PPE) and adhering to site-specific health and safety procedures. Implementation of LUCs and monitoring would not adversely affect the surrounding community or the environment.

Slight risk would be posed to the surrounding community from transporting treatment chemicals to the treatment building or from transporting sludge, spent GAC, spent PPZ, and spent IE resin to off-site disposal. Transportation risks would be limited through adherence to U.S. Department of Transportation regulations. The effect of groundwater extraction on site-related wetlands is unknown; water levels in these wetlands will be monitored during groundwater extraction.

Groundwater RAO No. 1 would be attained as soon as the extraction wells and treatment system are activated. Groundwater RAO Nos. 2 and 3 would be achieved immediately upon implementation of LUCs and monitoring. The extraction and treatment system would be completed in approximately 18 months.

***Implementability*** **—** Alternative G-2 is readily implementable. Several qualified contractors are available to install extraction wells and provide groundwater treatment equipment, such as metals removal systems and AOP units. Sampling and maintenance of monitoring wells could be readily accomplished. The resources, equipment, and materials these activities require are readily available. Design and implementation of this alternative's components must also consider the effects of soil remediation activities.

Administrative aspects of Alternative G-2, such as implementation of LUCs, would be relatively simple to implement. However, applying for and receiving the necessary permits may take time.

A permit to discharge treated effluent to the POTW must be obtained. The sanitary sewer authority is under a Consent Order, and the authority's acceptance of the relatively uncontaminated discharge would have to be confirmed. An off-site treatment system location is preferred, for ease of operation, because site access is limited by MDANG, airport operations, and Frog Mortar Creek. A suitable off-site location would have to be identified and either purchased or leased. Alternatively, a portion of the MDANG property along the property line could be designated as the treatment system location, eliminating the need to cross the MDANG property.

***Sustainability*** **—** Alternative G-2 poses significant consequences affecting the sustainability factors listed above. The extraction and treatment system would use approximately 563,000 kilowatt-hour (kW-hr) of electrical power annually during its operational life, although

this rate would decrease over time as groundwater quality improves. Treatment, and thus energy use, can be expected to continue for several decades. The system's electrical energy usage may indirectly lead to greenhouse gas generation if that power is generated from fossil fuels. Renewable energy sources can be investigated during the system design phase. Production of chemicals used in treatment and in regenerating GAC would also contribute to energy use and greenhouse gas production.

Treatment consumes various chemicals, such as hydrogen peroxide, sodium hydroxide, and hydrochloric acid. Several waste streams would also be generated, including sludge from metals removal, spent GAC, spent IE resin, and spent PPZ. Of these streams, the GAC would be regenerated and reused. Regeneration would also destroy contaminants sorbed to the GAC. As noted above, costs would be incurred during construction, followed by annual expenditures for the duration of the remediation.

After remediation is complete, LUCs that would constrain or limit development could be lifted. Traffic from delivery trucks and waste transport trucks would increase under this alternative, but this does not appear to be a significant factor, nor would it be unusual, given the industrial/commercial nature of the general vicinity of the site. Noise may also increase, particularly during construction, but this too would be similar to current activities in the general vicinity of the site.

***Cost —*** Estimated costs for Alternative G-2 are as follows:

- Capital cost: $12,000,000
- 30-year NPW of annual costs: $8,200,000
- 30-year NPW: $20,200,000
- 30-year current value: $37,000,000

Operating costs are based on a treatment system flow rate of 50 gpm. Operating costs directly related to contaminant concentrations, such as chemical use and GAC, were reduced in the NPW analysis by 25 percent in years six through 10 and by 50 percent thereafter, because contaminant concentrations will decrease over time. A detailed breakdown of estimated costs for this alternative is provided in Appendix F.

### 4.2.3 Alternative G-3: Hydraulic Control by Extraction, *ex situ* Treatment of Groundwater, Reinjection of Groundwater, Discharge to Publicly Owned Treatment Works/Surface Water, Monitoring, and Land Use Controls

#### 4.2.3.1 Description

Alternative G-3 would consist of six major components: (1) hydraulic control of the plume by extraction, (2) *ex situ* treatment of groundwater, (3) reinjection of some of the treated groundwater to the aquifer, (4) discharge of treated groundwater to the POTW or surface water, (5) monitoring, and (6) LUCs. Components 1 through 4 are summarized below. See Appendix E for detailed descriptions of these components.

***Component 1 (Alternative G-3): Hydraulic control —*** This component would install an array of groundwater extraction wells and piping as described above for Component 1 of Alternative G-2. As in Alternative G-2, the system would operate until groundwater contamination has been remediated. Extraction well locations are shown in Figure 4-5.

***Component 2 (Alternative G-3):* Ex situ *treatment of groundwater —*** As in Alternative G-2, the total groundwater extraction rate would be approximately 40 gpm. The treatment system conceptual design is sized for 100 gpm because of uncertainties in groundwater extraction rates and to provide flexibility for future operations, but the system is assumed to operate at 50 gpm for costing purposes. The additional flow capacity would allow significant recirculation to facilitate *in situ* treatment of the HCAs as part of a future site remedy. This component would consist of installing a treatment system and operating it until groundwater remediation goals are met. The process is essentially the same as the treatment system in Alternative G-2, and is described below.

As shown in the PFD (see Figure 4-6), the extracted groundwater would enter the system at a feed tank, then flow through a metals removal system, filter unit, air stripper, advanced oxidation system, the liquid-phase GAC and IE units, and then exit the system. Sludge generated by the metals removal step would be thickened, dewatered, and disposed of off-site. This treatment system is the same as was described in Alternative G-2. A conceptual layout of the treatment building is shown in Figure 4-7. Design calculations for this component and a more detailed process description are provided in Appendix E.

In Alternative G-3, some of the treated groundwater would be injected through approximately six injection wells upgradient of the HCAs, as shown in Figure 4-5. Four wells would be screened in the upper zone and two wells in the intermediate zone. The total injection rate would be approximately 13 gpm. Before injection, sodium lactate (an electron-donor compound) would be added to promote bioremediation through reductive dechlorination. This will reduce concentrations of TCE, cis-1,2-DCE, and vinyl chloride, reduce the total loading of contaminants to the groundwater treatment system, and may shorten overall remediation time.

The sodium lactate feed system is described in Component 3 below. This portion of the alternative may be installed following initial installation of the extraction wells and the groundwater treatment system, potentially in conjunction with the soil/landfill waste remedy. Groundwater that is not reinjected would be discharged to the POTW or surface water, as described in Alternative G-2.

Considerations for locating the treatment system building are similar to those described in Component 2 of Alternative G-2. The treatment building under Alternative G-3 (estimated at 155 feet by 65 feet) would have a larger footprint than the one envisioned under Alternative G-2, and an area of approximately 200 feet by 130 feet would be needed to accommodate construction, parking, and deliveries. The tentative location is assumed to be off the Martin State Airport property. Influent, effluent, and intermediate points in the process will be routinely sampled to monitor treatment effectiveness and progress. These results will also be used to determine if the GAC needs to be replaced.

***Component 3 (Alternative G-3): Reinjection of treated groundwater —*** Some groundwater would be reinjected near the HCAs under this alternative. The effects of reinjection are simulated in the groundwater model (see Appendix B). Reinjection would enhance the flushing rate of contaminants from these areas, and an electron-donor compound would be mixed with the reinjected treated groundwater to promote anaerobic reductive dechlorination of chlorinated VOCs (cVOCs).

Six injection wells would be placed in areas contaminated with cVOCs, as shown in Figure 4-5. Treated groundwater would not be reinjected in areas contaminated only with 1,4-dioxane, because the electron-donor compound is not effective in degrading 1,4-dioxane. Four wells

would be screened in the upper zone and two in the intermediate zone. The total flow rate to upper zone wells would be approximately 10 gpm; the total flow rate to the intermediate zone wells would be 3 gpm. The total injection rate would be approximately 13 gpm.

As noted, sodium lactate would be added to the reinjected treated groundwater as an electron-donor compound. Treated groundwater augmented with the electron-donor compound would be intermittently reinjected to the aquifer to allow the electron-donor compound to be flushed away from the wells, to minimize clogging. Absent reinjection, all treated groundwater would be discharged to the POTW. Reinjection facilities may be installed following initial installation of the extraction wells and the groundwater treatment system, potentially in conjunction with the soil/landfill waste remedy. No excess electron-donor compound is expected to reach Frog Mortar Creek because the containment wells would capture the electron-donor compound before it can reach the creek.

***Component 4 (Alternative G-3): Discharge to POTW and surface water —*** This component is the same as Component 3 in Alternative G-2. Reporting would be required twice annually because the potential discharge rate of 100 gpm is greater than the 25,000 gpd threshold for a significant industrial user. Annual user fees are also required, in addition to sewage service charges. As with Alternative G-2, a surface water discharge permit would be obtained after two or three years of operation, once treatment system operating parameters have been established.

***Component 5 (Alternative G-3): Monitoring —*** This component is essentially the same as Component 4 of Alternative G-2. Additional monitoring wells may need to be installed to monitor the effect of adding the electron-donor to the injection wells.

***Component 6 (Alternative G-3): LUCs —*** This component is the same as Component 5 of Alternative G-2.

#### 4.2.3.2 Detailed Analysis

***Overall protection of human health and the environment —*** Alternative G-3 would protect human health and the environment. The extraction wells would prevent contaminated groundwater from entering Frog Mortar Creek. Extraction of groundwater from the leading edge of the plume and bioremediation of the HCAs would also gradually remediate the groundwater contamination. This would eventually reduce risk from exposure to contaminated

groundwater and protect future human receptors that may be exposed to contaminants during intrusive activities.

Monitoring protects human health and the environment by evaluating extraction effectiveness, remediation progress, and by detecting potential migration of contaminants in groundwater. Land use controls would likewise protect human health and the environment during the remediation period until PRGs are met. Restricting groundwater use would protect human health and the environment by avoiding unacceptable risks of exposure to contaminated groundwater. Exposure to VOCs via vapor intrusion would be controlled by requirements on building construction methods.

***Compliance with ARARs and other guidance —*** Alternative G-3 would eventually comply with chemical-specific ARARs and other guidance through a combination of extraction, *in situ* and *ex situ* treatment, and plume migration toward the extraction system. Alternative G-3 would also comply with location- and action-specific ARARs and other guidance. The chemical-, location-, and action-specific ARARs and other guidance are described in Section 2.

***Long-Term effectiveness and permanence —*** Alternative G-3 would provide long-term effectiveness and permanence. Extraction and bioremediation would effectively and permanently remove contaminants from groundwater. Extraction and *in situ* bioremediation are well-established methods of groundwater treatment. Many extraction systems reach a long-term steady-state groundwater concentration that is greater than the target treatment goal, which is usually an MCL.

Monitoring treatment progress would be an effective means of evaluating remediation progress and verifying that no groundwater COCs are migrating. Groundwater use restrictions would effectively prevent groundwater use until PRGs are met. Requirements for specific construction methods would effectively prevent exposure to VOCs via vapor intrusion. The controls proposed under this alternative are considered reliable. The treatment system design envisioned under this alternative provides significant flexibility for future expansion as part of the final remedial action.

***Reduction of toxicity, mobility, or volume through treatment —*** Alternative G-3 would reduce the toxicity, mobility, and volume of groundwater COCs. Over a 30-year period, extraction, treatment, and bioremediation would permanently and irreversibly remove an estimated 3,700

lb of TCE, 1,900 lb of cis-1,2-DCE, 3,400 lb of vinyl chloride, and 160 lb of 1,4-dioxane from groundwater. Most of these COCs would be sorbed onto GAC or destroyed *in situ* via reductive dechlorination. Spent GAC would be taken off-site for regeneration. The 1,4-dioxane and some of the COCs would be destroyed by AOP. Vinyl chloride captured by the PPZ would be oxidized. In addition, metals will be settled out into a sludge that will be disposed off-site. Spent GAC would require off-site regeneration, and spent PPZ would require off-site disposal.

***Short-term effectiveness —*** Alternative G-3 would reduce human health risks in the short term through implementation of groundwater use restrictions. Exposure of workers to contamination during installation of extraction wells, injection wells, and groundwater sampling would be minimized by compliance with OSHA requirements, including wearing appropriate PPE and adhering to site-specific health and safety procedures. Implementation of LUCs and monitoring would not adversely affect the surrounding community or the environment. Slight risk would be posed to the surrounding community from transporting treatment chemicals to the treatment building and transporting sludge, spent IE resin, spent GAC, and spent PPZ to an off-site regeneration or disposal site. Transportation-related risks would be limited by adherence to U.S. Department of Transportation regulations.

The effect of groundwater extraction on nearby wetlands is unknown. Water levels in the wetlands will be monitored during groundwater extraction. Groundwater RAO No. 1 would be attained as soon as the extraction wells and treatment system are activated. Groundwater RAO Nos. 2 and 3 would be achieved immediately upon implementation of LUCs and monitoring. The extraction and treatment system would be completed in approximately 18 months.

***Implementability —*** Alternative G-3 would be readily implementable. Several qualified contractors are available to install extraction and injection wells and provide groundwater treatment equipment such as metals removal systems and AOP units. Sampling and maintenance of monitoring wells could also be readily accomplished. The resources, equipment, and materials required for these activities are all readily available. The design and implementation of this alternative's components must also consider the effects of soil remediation activities at the site.

Implementing administrative aspects of Alternative G-3, such as LUCs, would be relatively simple. A groundwater discharge permit from MDE would be required. However, applying for and receiving permits may take time. A permit to discharge treated effluent to the POTW would also be required. The sanitary sewer authority is under a Consent Order and would have to confirm their acceptance of the relatively uncontaminated treatment system discharge.

An off-site treatment system location is preferred, for ease of operation, because site access is limited by MDANG, airport operations, and Frog Mortar Creek. A suitable off-site location would have to be identified and either purchased or leased. Alternatively, a portion of the MDANG property along the property line could be designated as the treatment system location, eliminating the need to cross the MDANG property.

***Sustainability —*** Alternative G-3 would pose several significant consequences affecting the sustainability factors listed above. The extraction and treatment system would use approximately 563,000 kW-hr of electrical power annually over its operational life, although this rate would decrease over time as groundwater quality improves. Treatment, and thus energy use, can be expected to continue for several decades. The system's electrical energy usage may indirectly lead to greenhouse gas generation if that power is generated from fossil fuels. Renewable energy sources can be investigated during the system design phase. The entire system would have the capacity to use approximately 778,000 kW-hr of power annually, if it operates at its maximum flow rate. Production of chemicals used in treatment and in regenerating GAC would also contribute to energy use and greenhouse gas production.

Treatment consumes chemicals, such as hydrogen peroxide, sodium hydroxide, and hydrochloric acid. Several waste streams would also be generated, including sludge from metals removal, spent GAC, spent IE resin, and spent PPZ. Of these streams, the GAC would be regenerated and reused. Regeneration would also destroy contaminants sorbed to the GAC. As noted above, costs would be incurred during construction, followed by annual expenditures for the duration of the remediation.

After remediation, LUCs that would constrain or limit development could be lifted. Traffic from delivery trucks and waste transport trucks would increase under this alternative, but this does not appear to be a significant factor, nor would it be unusual, given the

industrial/commercial nature of the vicinity of the site. Noise may also increase, particularly during construction, but this too would be similar to current activities in the vicinity of the site.

***Cost —*** Estimated costs for Alternative G-3 are as follows:

- Capital cost: $12,900,000
- 30-year NPW of annual costs: $8,600,000
- 30-year NPW: $21,500,000
- 30-year current value: $38,700,000

Operating costs are based on a treatment system flow rate of 50 gpm. Operating costs directly related to contaminant concentrations, such as chemical use and GAC, were reduced in the NPW analysis by 25 percent in years six through 10 and by 50 percent thereafter, because contaminant concentrations will decrease over time. A detailed breakdown of estimated costs for this alternative is provided in Appendix F.

### 4.2.4 Alternative G-4: Hydraulic Control by Extraction, Extraction in High Concentration Areas, *ex situ* Treatment of Groundwater, Reinjection of Groundwater, Discharge to Publicly Owned Treatment Works/Surface Water, Monitoring, and Land Use Controls

#### 4.2.4.1 Description

Alternative G-4 would consist of seven major components: (1) hydraulic control of the plume by extraction, (2) extraction of contaminated groundwater from the HCAs, (3) *ex situ* treatment of groundwater, (4) reinjection of some of the treated groundwater, (5) discharge of treated groundwater to the POTW or surface water, (6) monitoring, and (7) LUCs. Components 1 through 5 are summarized below. See Appendix E for detailed descriptions of these components.

***Component 1 (Alternative G-4): Hydraulic control —*** This component would install an array of groundwater extraction wells and piping, as described for Component 1 in Alternative G-2. As in Alternative G-2, the system would operate until groundwater contamination has been remediated. Extraction well locations are shown in Figure 4-8.

***Component 2 (Alternative G-4): Extraction of groundwater from the HCAs —*** This component would install groundwater extraction wells downgradient from the HCAs.

Extraction effects are simulated in the groundwater model (see Appendix B). Design calculations for this component are provided in Appendix E. Ten extraction wells would be sufficient to extract contaminated groundwater from the HCAs. Five wells would be screened in the upper zone (approximately 35 feet deep), two in the intermediate zone (approximately 65 feet deep), and three in the lower zone (approximately 90 feet deep). Each well screen would be at least 10 feet long.

The rate of groundwater extraction from the HCAs is estimated at 28 gpm. Six wells would extract groundwater contaminated with cVOCs, and 1,4-dioxane, and one well would extract groundwater contaminated only with 1,4-dioxane. These wells would be installed later because their locations could potentially interfere with soil remediation activities at the site. Extraction well locations are shown in Figure 4-8.

A submersible centrifugal pump equipped with level controls (to turn the pump on and off) would be installed in each groundwater extraction well under this alternative. The discharge line from each pump would have a flow meter, manual flow control valve, shut-off valve, and pressure gauges. Valves and instrumentation would be housed at each wellhead in a subsurface concrete vault with a hinged hatchway. Piping in the vault would be protected from freezing.

Each of these pumps would be connected to a piping network that would convey extracted groundwater to the pumping station. Extracted groundwater will be conveyed through double-walled pipes because the contaminated groundwater will pass through areas of uncontaminated groundwater. As with the hydraulic barrier extraction wells, the system would operate until the groundwater contamination has been remediated.

***Component 3 (Alternative G-4):* Ex situ *treatment of groundwater* —** The total groundwater flow-rate requiring treatment would be higher because of groundwater extracted from the HCAs. The process envisioned under this alternative would be essentially as was described in Alternative G-3 above. The total groundwater extraction rate would be approximately 70 gpm, based on the model, but the treatment system conceptual design is sized for 100 gpm because of uncertainties in groundwater extraction rates. This component would include the installation of a treatment system and operation of it as long as groundwater is being extracted.

As shown in the PFD (see Figure 4-9), extracted groundwater would enter the system at a feed tank, then flow through a metals removal system, filter unit, air stripper, advanced oxidation system, the liquid-phase GAC and IE units, and then exit the system. Sludge generated by the metals removal step would be thickened, dewatered, and disposed of off-site. The treatment system is as was described in Alternative G-3 above. Design calculations for this component are provided in Appendix E.

***Component 4 (Alternative G-4): Reinjection of treated groundwater —*** This component is the same as Component 3 in Alternative G-3.

***Component 5 (Alternative G-4): Discharge to POTW and surface water —*** This component is the same as Component 3 in Alternative G-2. Reporting would be required twice annually because the potential discharge rate of 100 gpm is greater than the 25,000 gpd threshold for a significant industrial user. Annual user fees are required in addition to sewage service charges.

***Component 6 (Alternative G-4): Monitoring —*** This component is the same as Component 5 in Alternative G-3.

***Component 7 (Alternative G-4): LUCs —*** This component is the same as Component 5 in Alternative G-2.

#### 4.2.4.2 Detailed Analysis

***Overall protection of human health and the environment —*** Alternative G-4 would protect human health and the environment. The extraction wells would prevent contaminated groundwater from entering Frog Mortar Creek. Extraction of groundwater at the leading edge of the plume and from the HCAs, and bioremediation at the HCAs would also gradually remediate the groundwater. This would eventually reduce risk from exposure to contaminated groundwater and protect future human receptors that may be exposed to contaminants during intrusive activities.

Monitoring protects human health and the environment by evaluating extraction effectiveness, remediation progress, and by detecting potential migration of contaminants in groundwater. Land use controls would likewise protect human health and the environment during the remediation period until PRGs are met. Restricting groundwater use would protect human

health and the environment by avoiding unacceptable risks of exposure to contaminated groundwater. Exposure to VOCs via vapor intrusion would be controlled by requirements placed on building construction methods.

***Compliance with ARARs and other guidance —*** Alternative G-4 would eventually comply with chemical-specific ARARs and other guidance through a combination of extraction and treatment and plume migration toward the hydraulic containment extraction system. Alternative G-4 would also comply with location- and action-specific ARARs and other guidance. The chemical-, location-, and action-specific ARARs and other guidance are described in Section 2.

***Long-term effectiveness and permanence —*** Alternative G-4 would provide long-term effectiveness and permanence. Extraction would effectively and permanently remove groundwater contaminants. Extraction is a well-established method of groundwater treatment. Many extraction systems reach a long-term steady-state groundwater concentration that is greater than the target treatment goal, which is usually an MCL.

Monitoring treatment progress would be an effective means of evaluating remediation progress and verifying that no groundwater COCs are migrating. Groundwater use restrictions would effectively prevent groundwater use until PRGs are met. Requirements for specific construction methods would effectively prevent exposure to VOCs via vapor intrusion. The controls proposed under this alternative are considered reliable. Since the HCA treatment would be defined before selection of the soil/landfill waste remedy (or the final groundwater remedy), this option is somewhat less flexible with respect to incorporation into a final groundwater remedy.

***Reduction of toxicity, mobility, or volume through treatment —*** Alternative G-4 would reduce the toxicity, mobility, and volume of groundwater COCs. Over a 30-year period, extraction and treatment would permanently and irreversibly remove an estimated 3,900 lb of TCE, 2,000 lb of cis-1,2-DCE, 3,600 lb of vinyl chloride, and 170 lb of 1,4-dioxane from groundwater. Most of the COCs would be sorbed onto GAC or destroyed *in situ* via reductive dechlorination. Spent GAC would be taken off-site for regeneration. The 1,4-dioxane and some of the other COCs would be destroyed by AOP. Vinyl chloride captured by the PPZ would be oxidized.

Metals would be settled out into a sludge that would be disposed of off-site. Spent GAC would require off-site regeneration, and spent PPZ would require off-site disposal.

***Short-term effectiveness —*** Alternative G-4 would reduce human health risks in the short term through implementation of groundwater use restrictions. Exposure of workers to contamination during installation of extraction wells, injection wells, and groundwater sampling would be minimized by compliance with OSHA requirements, including wearing appropriate PPE and adhering to site-specific health and safety procedures. Implementation of LUCs and monitoring would not adversely affect the surrounding community or the environment. Slight risk would be posed to the surrounding community from transporting treatment chemicals to the treatment building and transporting sludge, spent IE resin, spent GAC, and spent PPZ to an off-site regeneration or disposal site. Transportation-related risks would be limited by adherence to U.S. Department of Transportation regulations.

The effect of groundwater extraction on nearby wetlands is unknown. Water levels in the wetlands will be monitored during groundwater extraction. Groundwater RAO No. 1 would be attained as soon as the extraction wells and treatment system are activated. Groundwater RAO Nos. 2 and 3 would be achieved immediately upon implementation of LUCs and monitoring. The extraction and treatment system would be completed in approximately 18 months.

***Implementability —*** Alternative G-4 would be readily implementable. Several qualified contractors are available to install extraction and injection wells and provide groundwater treatment equipment, such as metals removal systems and AOP units. Monitoring well sampling and maintenance could also be readily accomplished. The resources, equipment, and materials required for these activities are all readily available.

Implementing administrative aspects of Alternative G-4, such as LUCs, would be relatively simple. However, applying for and receiving permits may take time. A permit to discharge treated effluent to the POTW would also be required. The sanitary sewer authority is under a Consent Order and the permitting authority must confirm that the relatively uncontaminated discharge will be acceptable.

An off-site treatment system location is preferred, for ease of operation, because site access is limited by MDANG, airport operations, and Frog Mortar Creek. A suitable off-site location

would have to be identified and either purchased or leased. Alternatively, a portion of the MDANG property along the property line could be designated as the treatment system location, eliminating the need to cross the MDANG property.

***Sustainability —*** Alternative G-4 would pose several significant consequences affecting the sustainability factors listed above. The extraction and treatment system would use approximately 778,000 kW-hr of electrical power annually over its operational life, although this rate would decrease over time as groundwater quality improves. Treatment, and thus energy use, can be expected to continue for several decades. The system's electrical energy usage may indirectly lead to greenhouse gas generation if that power is generated from fossil fuels. Renewable energy sources can be investigated during the system design phase. The production of the chemicals used for treatment and regeneration of GAC would also contribute to energy use and greenhouse gas production.

Treatment consumes chemicals, such as hydrogen peroxide, sodium hydroxide, and hydrochloric acid. Several waste streams would also be generated, including sludge from metals removal, spent GAC, spent IE resin, and spent PPZ. Of these streams, the GAC would be regenerated and reused. Regeneration would also destroy contaminants sorbed to the GAC. As noted above, costs would be incurred during construction, followed by annual expenditures for the duration of the remediation.

After remediation, LUCs that would constrain or limit development could be lifted. Traffic from delivery trucks and waste transport trucks would increase under this alternative, but this does not appear to be a significant factor, nor would it be unusual, given the industrial/commercial nature of the vicinity of the site. Noise may also increase, particularly during construction, but this too would be similar to current activities in the vicinity of the site.

***Cost —*** Estimated costs for Alternative G-4 are as follows:

- Capital cost: $13,100,000
- 30-year NPW of annual costs: $11,700,000
- 30-year NPW: $24,800,000
- 30-year current value: $46,900,000

Operating costs are based on a treatment system flow rate of 100 gpm. Operating costs directly related to contaminant concentrations, such as chemical use and GAC, were reduced in the NPW analysis by 25 percent in years six through 10 and by 50 percent thereafter, because contaminant concentrations will decrease over time. A detailed breakdown of estimated costs for this alternative appears in Appendix F.

### 4.2.5 Alternative G-5: Hydraulic Control by Extraction, *ex situ* Treatment of Groundwater, *in situ* Bioremediation of High Concentration Areas, Discharge to Publicly Owned Treatment Works/Surface Water, Monitoring, and Land Use Controls

#### 4.2.5.1 Description

Alternative G-5 would consist of six major components: (1) hydraulic control of the plume by extraction, (2) *ex situ* treatment of groundwater, (3) *in situ* bioremediation of groundwater in the HCAs, (4) discharge of treated groundwater to the POTW/surface water, (5) monitoring, and (6) LUCs. Components 1 through 4 are summarized below. See Appendix E for detailed descriptions of these components.

***Component 1 (Alternative G-5): Hydraulic control —*** This component would include the installation of an array of groundwater extraction wells and piping, as described for Component 1 in Alternative G-2. As in Alternative G-2, the system would operate until the groundwater contamination has been remediated. Extraction well locations are shown in Figure 4-10.

***Component 2 (Alternative G-5):* Ex situ *treatment of groundwater —*** This component is the same as Component 2 in Alternative G-3. Injection wells would not be required because reinjection is not part of this alternative. An IE unit would be required for future discharge to surface water. Figure 4-11 shows a PFD of the process.

***Component 3 (Alternative G-5):* In situ *bioremediation of HCAs —*** This component would include the injection of an oil-based electron-donor compound, such as emulsified oil substrate (EOS) (provided by EOS Remediation, LLC), into groundwater through dedicated injection wells in the HCAs to promote biological reductive dechlorination of the cVOCs. Design calculations for this component appear in Appendix E. Modeling results for this component are provided in Appendix B.

Emulsified oil substrate would be injected into the subsurface along lines (barriers) perpendicular to the groundwater flow direction (see Figure 4-10). Spacing between the lines across the HCAs is based on the groundwater travel time of five years, the typical period of EOS effectiveness. Injection wells would be spaced 10 feet apart.

The estimated number of injection wells in each barrier and the quantity of EOS that would be injected are summarized below. A buffered EOS product would likely be required because of the groundwater's low alkalinity. A pilot study will confirm optimal well spacing and EOS application rate.

Under this alternative, EOS would be injected into the subsurface via permanent wells so that a subsequent injection can be made, if needed. A pump capable of pumping five to 10 gpm would be needed to ensure proper application of the EOS and to minimize application time. A subcontractor would provide the mixing and injection equipment. Injections would be completed in a relatively short period. The number of barriers and wells and the quantity of EOS required are summarized below.

| Plume location (COC and zone) | Nearby well | Number of barriers | Number of wells per barrier | Total EOS added (lb) | Total water added (gallons) |
|---|---|---|---|---|---|
| TCE and DCE (Upper) | DMW11 | 4 | 10 | 8,100 | 10,000 |
| TCE, (Intermediate) | DMW9 | 1 | 70 | 46,000 | 55,000 |
| DCE (Intermediate) | DMW1 | 1 | 20 | 13,000 | 16,000 |
| DCE and vinyl chloride (Upper) | MW20 | 10 | 40 | 80,000 | 95,000 |

As a conservative cost assumption, a second injection of EOS would be applied to half of the injection wells after five years. Appendix E includes cost information provided by EOS Remediation, LLC. Monitoring wells on both sides of each HCA would track EOS progress and effectiveness.

***Component 4 (Alternative G-5): Discharge to POTW and surface water —*** This component is the same as Component 4 in Alternative G-2.

***Component 5 (Alternative G-5): Monitoring —*** For the hydraulic control system and groundwater plume, this component is the same as Component 4 in Alternative G-2. An additional monitoring well would be installed on the downgradient side of each set of HCA barriers. Three new shallow wells and two new intermediate wells would also be installed (see Figure 4-10). In the first year, groundwater samples would be collected quarterly and analyzed for VOCs, oxidation-reduction potential (ORP), and iron. After the first year, samples would be collected and analyzed annually.

***Component 6 (Alternative G-5): LUCs —*** This component is the same as Component 5 in Alternative G-2.

#### 4.2.5.2 Detailed Analysis

***Overall protection of human health and the environment —*** Alternative G-5 would protect human health and the environment. The extraction wells would prevent contaminated groundwater from entering Frog Mortar Creek. Extracting groundwater from the leading edge of the plume and *in situ* bioremediation of the HCAs would also gradually remediate the groundwater. This would eventually reduce risk from exposure to contaminated groundwater and protect future human receptors that may be exposed to contaminants during intrusive activities.

Monitoring would protect human health and the environment by evaluating extraction effectiveness and remediation progress, and by detecting potential contaminant migration through groundwater. Land use controls would likewise protect human health and the environment during the remediation period until PRGs are met. Restricting groundwater use would protect human health and the environment by avoiding unacceptable risks of exposure to contaminated groundwater. Exposure to VOCs via vapor intrusion would be controlled by requirements placed on building construction methods.

***Compliance with ARARs and other guidance —*** Alternative G-5 would eventually comply with chemical-specific ARARs and other guidance through a combination of extraction and treatment, plume migration toward the extraction system, and *in situ* bioremediation. Alternative G-5 would also comply with location- and action-specific ARARs and other

guidance. The chemical-, location-, and action-specific ARARs and other guidance are described in Section 2.

***Long-term effectiveness and permanence —*** Alternative G-5 would provide long-term effectiveness and permanence. Extraction and *in situ* bioremediation would effectively and permanently remove contaminants from groundwater. Both extraction and *in situ* bioremediation are well-established methods of groundwater treatment. Many extraction systems reach a long-term steady-state groundwater concentration that is greater than the target treatment goal, which is usually an MCL.

Monitoring treatment progress would be an effective means of evaluating remediation progress and verifying that no groundwater COCs are migrating. Groundwater use restrictions would effectively prevent groundwater use until PRGs are met. Requirements for specific construction methods would effectively prevent exposure to VOCs via vapor intrusion. The controls proposed under this alternative are considered reliable. Since the HCA treatment would be defined before selection of the soil/landfill waste remedy (or the final groundwater remedy), this option is somewhat less flexible with respect to incorporation into a final groundwater remedy.

***Reduction of toxicity, mobility, or volume through treatment —*** Alternative G-5 would reduce the toxicity, mobility, and volume of COCs in groundwater. Over a 30-year period, extraction and treatment and *in situ* bioremediation would permanently and irreversibly remove an estimated 3,900 lb of TCE, 2,000 lb of cis-1,2-DCE, 3,600 lb of vinyl chloride, and 160 lb of 1,4-dioxane from groundwater. Most of the COCs would be sorbed onto GAC or destroyed *in situ* via reductive dechlorination. Spent GAC would be taken off-site for regeneration. The 1,4-dioxane and some of the other COCs would be destroyed by AOP. Vinyl chloride captured by the PPZ would be oxidized. Spent GAC would require off-site regeneration, and spent PPZ would require off-site disposal.

***Short-term effectiveness —*** Alternative G-5 would reduce human health risks in the short term through implementation of groundwater use restrictions. Exposure of workers to contamination during installation of extraction wells and groundwater sampling would be minimized by compliance with OSHA requirements, including wearing appropriate PPE and adhering to site-specific health and safety procedures. Implementation of LUCs and monitoring would not

adversely affect the surrounding community or the environment. Slight risk would be posed to the surrounding community from transporting treatment chemicals to the treatment building and transporting sludge, spent IE resin, spent GAC, and spent PPZ to an off-site regeneration or disposal site. Transportation-related risks would be limited by adherence to U.S. Department of Transportation regulations.

The effect of groundwater extraction on nearby wetlands is unknown. Water levels in the wetlands will be monitored during groundwater extraction. Groundwater RAO No. 1 would be attained as soon as the extraction wells and treatment system are activated. Groundwater RAO Nos. 2 and 3 would be achieved immediately upon implementation of LUCs and monitoring. The extraction and treatment system would be completed in approximately 18 months.

***Implementability —*** Alternative G-5 would be readily implementable, but installation of the injection wells must be coordinated with the soil remediation remedy. The proposed locations of the 140 injection wells will probably interfere with soil remediation activities, such as excavation or capping. Several qualified contractors are available to install injection and extraction wells, provide oil-based electron-donors, and provide groundwater treatment equipment such as metals removal systems and AOP units. Monitoring well sampling and maintenance could be readily accomplished. The resources, equipment, and materials for these activities are all readily available. Design and implementation of the components envisioned under this alternative must also consider the effects of soil remediation activities.

Implementing administrative aspects of Alternative G-5, such as LUCs, would be relatively simple. However, applying for and receiving permits may take time. A permit to discharge treated effluent to the POTW will have to be obtained. The sanitary sewer authority is under a Consent Order, and the permitting authority must confirm that the relatively uncontaminated discharge will be acceptable.

An off-site treatment system location is preferred, for ease of operation, because site access is limited by MDANG, airport operations, and Frog Mortar Creek. A suitable off-site location would have to be identified and either purchased or leased. Alternatively, a portion of the MDANG property along the property line could be designated as the treatment system location, eliminating the need to cross the MDANG property.

***Sustainability —*** Alternative G-5 would pose several significant consequences that would influence the sustainability factors listed above. The extraction and treatment system would use approximately 563,000 kW-hr of electrical power annually over its operational life, although this usage rate would decrease with time as groundwater quality improves. Treatment will likely continue for several decades, with concomitant ongoing energy use. Electrical energy use will indirectly lead to greenhouse gas generation if that power is generated from fossil fuels. Renewable energy sources can be investigated during system design. The entire system would be capable of using approximately 778,000 kW-hr of power annually. Production and delivery of chemicals used for treatment, GAC regeneration, and *in situ* bioremediation would also contribute to energy use and greenhouse gas production.

Treatment consumes chemicals, such as hydrogen peroxide, sodium hydroxide, and hydrochloric acid. Several waste streams would be generated, including sludge from metals removal, spent GAC, spent IE resin, and spent PPZ. Of these streams, the GAC would be regenerated and reused. Regeneration would also destroy contaminants sorbed to the GAC.

As noted above, costs would be incurred during construction, followed by annual expenditures for the duration of the remediation. Land use controls that would constrain or limit development could be lifted after remediation. Traffic from delivery trucks and waste transport trucks would increase under this alternative, but this does not appear to be a significant factor, nor would it be unusual, given the industrial/commercial nature of the vicinity of the site. Noise may also increase, particularly during construction, but this too would be similar to current activities in the vicinity of the site.

***Cost —*** Estimated costs for Alternative G-5 are as follows:

- Capital cost: $14,000,000
- 30-year NPW of annual costs: $8,800,000
- 30-year NPW: $22,800,000
- 30-year current value: $40,000,000

Operating costs are based on a treatment system flow rate of 50 gpm. The NPW analysis reduces operating costs directly related to contaminant concentrations, such as chemical use and GAC, by 25 percent in years six through 10 and by 50 percent thereafter, since contaminant

concentrations will decrease over time. A detailed breakdown of estimated costs for this alternative is provided in Appendix F.

### 4.2.6 Alternative G-6: Zero-Valent Iron Permeable Reactive Barrier, Monitoring, and Land Use Controls

#### 4.2.6.1 Description

Alternative G-6 would consist of three major components: (1) installation of a ZVI PRB, (2) monitoring, and (3) LUCs.

***Component 1 (Alternative G-6): Installation of a PRB —*** A ZVI PRB would be installed to mitigate migration of the cVOC plume toward Frog Mortar Creek (see Figure 4-12). The PRB would be installed along the downgradient edge of the plume, close to the shore of Frog Mortar Creek. The useful life of a ZVI PRB is 10 to 15 years. This estimate assumes a 15-year life before maintenance would be required to restore groundwater flow through the PRB. Groundwater velocity varies with depth. The velocity of organic compounds is slower than the surrounding groundwater because of sorption and desorption. The reduction in contaminant velocities can be estimated by calculating a retardation factor.

Of the primary contaminants (TCE, cis-1,2-DCE, and vinyl chloride), TCE will have the slowest velocity and so will be used to estimate the time for the plume to flow through the PRB. In the upper zone, TCE velocity is estimated at 0.006 feet per day, so the travel distance in 10 years would be 22 feet. In the intermediate zone, TCE velocity is estimated at 0.013 feet per day, so the travel distance in 10 years would be 47 feet. In the lower zone, TCE velocity is estimated at 0.05 feet per day, so the travel distance in 10 years would be 180 feet.

Comparing these distances to the length of the plume upgradient of the PRB (650–1,000 feet), the total treatment time would be 300 to 460 years in the upper zone, 140 to 210 years in the intermediate zone, and 36 to 55 years in the lower zone. The PRB in the upper zone would need to be replenished 30 to 46 times. The PRB in the intermediate and lower zones would only need to be replenished 14 to 21 and four to five times, respectively.

The PRB would be constructed using biopolymer supported trench excavations. The PRB would not need to be extended to the deep low permeability layer over the entire width of the plume because plume width decreases with depth. In the upper zone, the PRB would be approximately

1,100 feet long. In the intermediate zone, the PRB would be approximately 800 feet long, and in the lower zone, the PRB would be approximately 600 feet long. The ZVI and support matrix would then be pumped into the trench up to the depth of the water table. The balance of the trench would be filled with a non-reactive clean fill. The estimated width of each PRB is 2.5 feet, and the vertical thickness of ZVI through all three zones would be 65 to 70 feet.

***Component 2 (Alternative G-6): Monitoring —*** This component includes sampling and analysis of groundwater from wells in the plume upgradient of the PRB and from wells on either side of the PRB, as described in Component 1. Monitoring wells in the plume that would be included in the monitoring program would include five existing three-well clusters between Taxiway Tango and Frog Mortar Creek, and two existing three-well clusters between the runway and Taxiway Tango. Five new three-well clusters (each downgradient of the PRB) and five existing three-well clusters (upgradient of the PRB) will monitor PRB performance. Samples will be collected and analyzed annually. Final selection of monitoring wells will be made in the design phase of the project, with the concurrence of relevant regulatory agencies.

Samples will be analyzed for VOCs, 1,4-dioxane, DRO, GRO, and metals. Monitoring wells would be sampled annually because contaminant concentrations are not expected to change quickly. Annual groundwater sampling and analysis reports will be submitted to the appropriate regulatory agencies. The groundwater monitoring program would be reviewed at least every five years to determine if changes in sampling frequency, analyses, or the wells that are sampled are needed.

***Component 3 (Alternative G-6): LUCs —*** This component is the same as Component 5 in Alternative G-2.

#### 4.2.6.2 Detailed Analysis

***Overall protection of human health and the environment —*** Alternative G-6 would protect human health and the environment. As the plume passes through the PRB, *in situ* chemical reduction would significantly reduce concentrations of cVOCs, but concentrations of 1,4-dioxane, DRO, and GRO would be unaffected. The degree of metals removed, particularly cadmium, is uncertain. Cadmium, 1,4-dioxane, DRO, and GRO will eventually attenuate through natural physical processes. Diesel range organics and GRO may also attenuate through

biological processes. This would significantly reduce risk from exposure to contaminated groundwater and protect future human receptors that could be exposed to contaminants during intrusive activities. Contaminant concentrations downgradient of the PRB would be reduced by natural attenuation.

Monitoring would protect human health and the environment by evaluating the effectiveness of the *in situ* treatment and detecting changes in COC concentrations in the plume upgradient of the PRB. Land use controls would also protect human health and the environment during the remedial period until PRGs are met. Restricting the use of groundwater would protect human health and the environment by avoiding unacceptable risks of exposure to contaminated groundwater. Exposure to VOCs via vapor intrusion would be controlled by requirements on building construction methods.

***Compliance with ARARs and other guidance —*** Alternative G-6 would eventually comply with chemical-specific ARARs and other guidance for cVOCs through a combination of *in situ* treatment and natural attenuation. The effect of the PRB on cadmium is uncertain, although cadmium concentrations on-site would eventually attenuate through dilution and dispersion. Concentrations of 1,4-dioxane, DRO, and GRO would be unaffected by the PRB and would eventually attenuate through dilution and dispersion, but the off-site consequences of low concentrations of these contaminants are uncertain. Alternative G-6 would also comply with location- and action-specific ARARs and other guidance. The chemical-, location-, and action-specific ARARs and other guidance are described in Section 2.

***Long-term effectiveness and permanence —*** Alternative G-6 would provide long-term effectiveness and permanence. *In situ* treatment by the PRB would effectively and permanently remove cVOCs from groundwater as the plume flows through the PRB. However, as noted, the PRB would not affect concentrations of 1,4-dioxane, DRO, and GRO. A pilot-scale treatability study would be needed before designing the PRB. Further groundwater modeling would also be required to design the PRB.

Monitoring treatment progress would effectively evaluate remediation progress and verify that no COCs are migrating beyond the PRB. Administrative restrictions would effectively prevent groundwater use until PRGs are met. Requirements for specific construction methods would

effectively prevent exposure to VOCs via vapor intrusion. The controls proposed in this alternative are considered reliable.

This alternative provides expansion flexibility as part of the final groundwater remedial action because the HCAs and other parts of the plume can be treated without interfering with the PRB. However, the PRB would have to be installed before the soil/landfill waste remedy is implemented because of the disturbance at the ground surface that will be caused by PRB construction.

***Reduction of toxicity, mobility, or volume through treatment —*** Alternative G-6 would reduce the toxicity, mobility, and volume of groundwater COCs. Over 30 years, *in situ* reduction would permanently and irreversibly remove an estimated 1,600 lb of TCE, 800 lb of cis-1,2-DCE, and 1,500 lb of vinyl chloride from groundwater. No 1,4-dioxane, DRO, or GRO would be removed. The PRB's effectiveness in removing metals such as cadmium is uncertain. No treatment residues would be generated by this alternative, although a large volume of excavated soil generated during installation will require disposal.

***Short-term effectiveness —*** Alternative G-6 would reduce human health risks in the short term through groundwater use restrictions. Workers' exposure to contamination during installation of the PRB and groundwater sampling would be minimized by compliance with OSHA requirements, including wearing appropriate PPE and adhering to site-specific health and safety procedures. Implementation of LUCs and monitoring would not adversely affect the surrounding community or the environment.

Groundwater RAO No. 1 would be attained for cVOCs after the PRB is installed. Groundwater RAO Nos. 2 and 3 would be achieved immediately upon implementation of LUCs and monitoring. The PRB would be completed in approximately 12 months.

***Implementability —*** Alternative G-6 would be difficult to implement. A limited number of qualified contractors are available for ZVI PRB installation. Installation of a PRB to this depth would be difficult and require specialized equipment.

A large area adjacent to the PRB would be needed to handle excavated and contaminated soil, which would need to be properly disposed of. Sampling and maintenance of monitoring wells

could be readily accomplished. Only a few contractors can perform this type of construction, and only a few sources of ZVI are available. Design and implementation of the components of this alternative must also consider the effect of soil remediation activities.

A bench-scale treatability study would be needed to confirm the effectiveness of these technologies at this site. Groundwater modeling would also be required to design the PRB. The administrative aspects of Alternative G-6, such as imposing LUCs, would be relatively simple to implement. However, applying for and obtaining permits may take time.

***Sustainability —*** Alternative G-6 would pose several significant consequences affecting the sustainability factors listed above. Heavy construction equipment would generate greenhouse gases during initial installation and each subsequent PRB replacement. The PRB would have to be replaced numerous times until the plume has been remediated. However, long-term greenhouse gas generation would be minimal, and long-term electricity demand would be avoided. Production of the ZVI used in the PRB would contribute to energy use, as well as greenhouse gas production. A large volume of soil requiring off-site disposal would be generated during initial installation and each subsequent replacement of the PRB, but no waste streams would be generated during long-term operations.

The cVOCs would be destroyed as they pass through the PRB by reaction with the ZVI. As noted above, costs would be incurred during construction and replacement, followed by annual expenditures for the duration of the remediation. Although the site could be developed within the constraints of the LUCs, the types of development on top of the PRB and near construction equipment staging areas (for PRB replacement) would be limited by the presence of the PRB. Traffic from construction and waste transport would increase, but this would be a short-term effect during construction periods and would not create conditions significantly different from the normal industrial/commercial nature of the vicinity of the site. Noise may increase, particularly during construction, but this too would be similar to current activities near the site.

***Cost —*** Estimated costs for Alternative G-6 are as follows:

- Capital cost: $13,300,000
- 30-year NPW of annual costs: $5,700,000

- 30-year NPW: $19,000,000
- 30-year current value: $33,500,000

A detailed breakdown of estimated costs for this alternative is provided in Appendix F.

**Table 4-1**

**Summary of Key Features of the Alternatives - DRA Site Groundwater Feasibility Study**
**Lockheed Martin, Martin State Airport**
**Middle River, Maryland**

| FS Alt No. | Name | GW Treatment System Size, gpm | Operating GW flow rate basis, gpm | Re-injection of Treated GW | HCA Extraction Wells | ISB of HCA |
|---|---|---|---|---|---|---|
| G-1 | No Action | NA | NA | NA | NA | NA |
| G-2 | Hydraulic Control by Extraction, Ex-Situ Treatment of Groundwater, Discharge to POTW/Surface Water, Monitoring, and LUCs | 50 | 50 | No | No | No |
| G-3 | Hydraulic Control by Extraction, Ex-Situ Treatment of Groundwater, Re-injection of Groundwater, Discharge to POTW/Surface Water, Monitoring, and LUCs | 100 | 50 | Yes | No | No |
| G-4 | Hydraulic Control by Extraction, Extraction of HCA, Ex-Situ Treatment of Groundwater, Re-injection of Groundwater, Discharge to POTW/Surface Water, Monitoring, and LUCs | 100 | 100 | Yes | Yes | No |
| G-5 | Hydraulic Control by Extraction, Ex-Situ Treatment of Groundwater, In-Situ Bioremediation of HCA, Discharge to POTW/Surface Water, Monitoring, and LUCs | 100 | 50 | No | No | Yes |
| G-6 | ZVI PRB, Monitoring, and LUCs [No groundwater treatment] | NA | NA | NA | NA | NA |

gpm - gallons per minute
GW - Groundwater.
HCA - High Concentration Areas
ISB - In-Situ Bioremediation (using dedicated injection system)
LUC - Land use control.
NA - Not Applicable.
POTW - Publicly Owned Treatment Works.
PRB - Permeable reactive barrier.
ZVI - Zero-valent iron.

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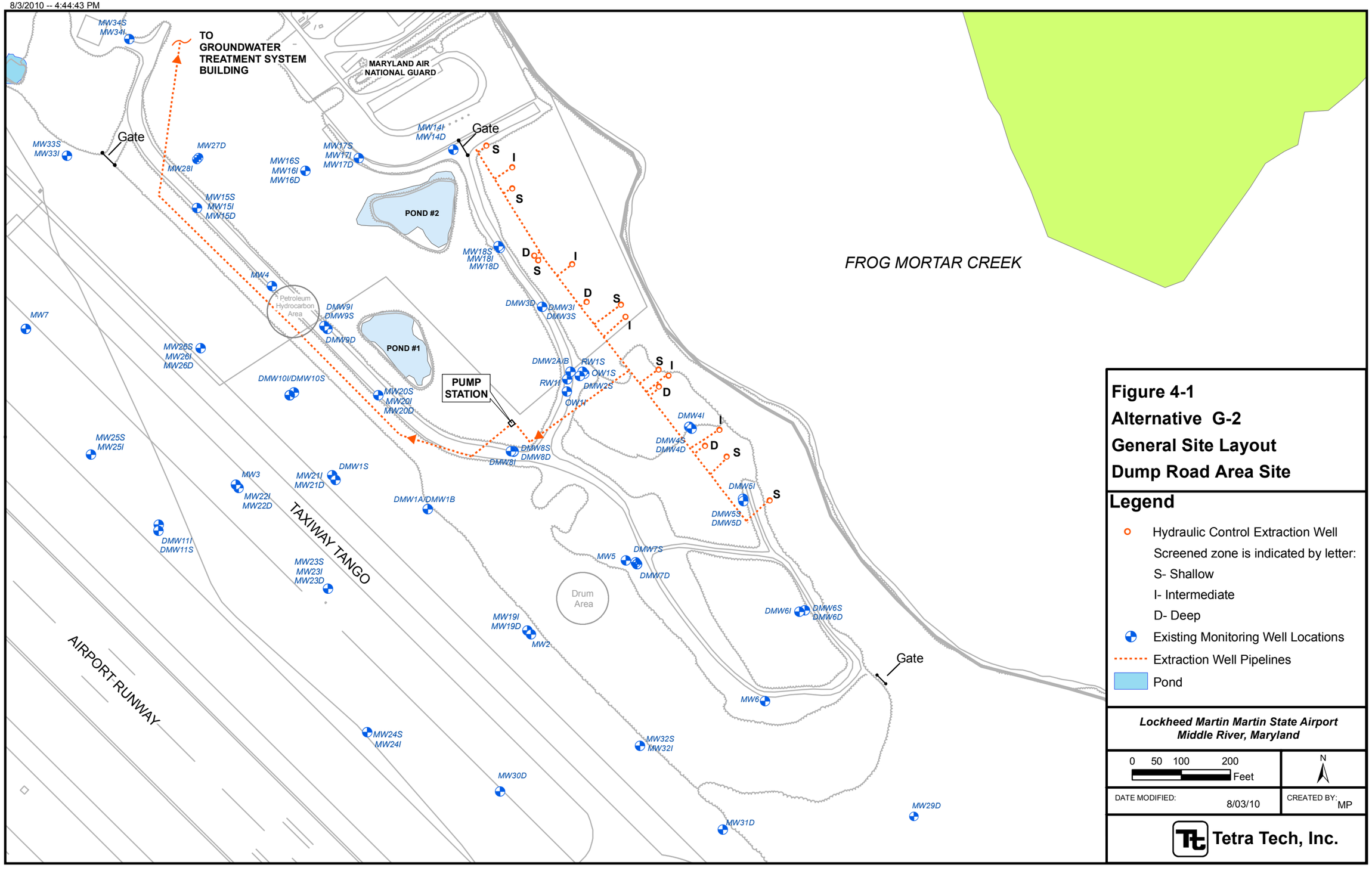


**Figure 4-1**
**Alternative G-2**
**General Site Layout**
**Dump Road Area Site**

## Legend

- Hydraulic Control Extraction Well
  Screened zone is indicated by letter:
  S- Shallow
  I- Intermediate
  D- Deep
- Existing Monitoring Well Locations
- Extraction Well Pipelines
- Pond

***Lockheed Martin Martin State Airport***
***Middle River, Maryland***

0 50 100 200 Feet

N

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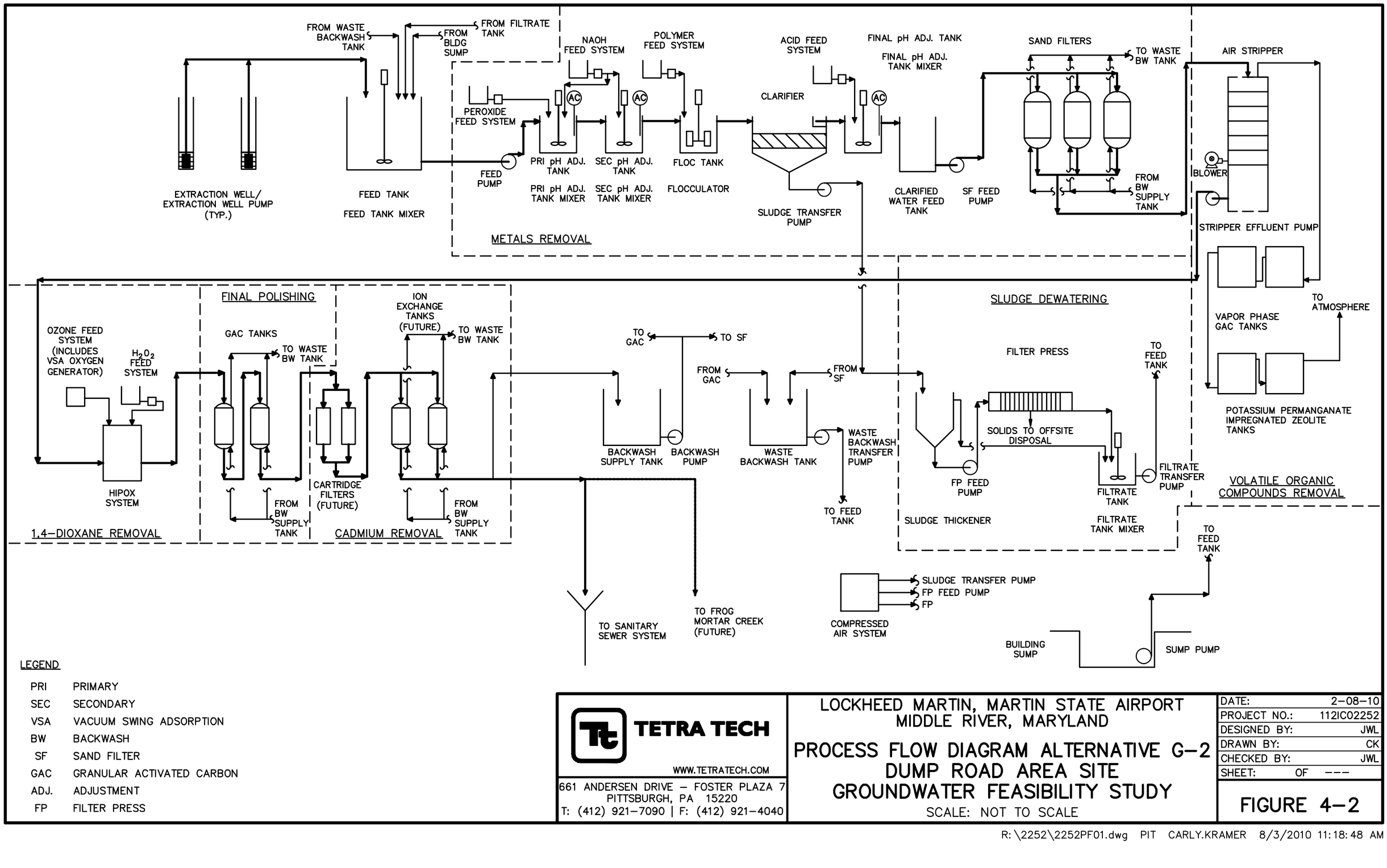


LEGEND

| | |
|---|---|
| PRI | PRIMARY |
| SEC | SECONDARY |
| VSA | VACUUM SWING ADSORPTION |
| BW | BACKWASH |
| SF | SAND FILTER |
| GAC | GRANULAR ACTIVATED CARBON |
| ADJ. | ADJUSTMENT |
| FP | FILTER PRESS |

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MIDDLE RIVER, MARYLAND

# PROCESS FLOW DIAGRAM ALTERNATIVE G–2
# DUMP ROAD AREA SITE
# GROUNDWATER FEASIBILITY STUDY

SCALE: NOT TO SCALE

| | |
|---|---|
| DATE: | 2–08–10 |
| PROJECT NO.: | 112IC02252 |
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| CHECKED BY: | JWL |
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FIGURE 4–2

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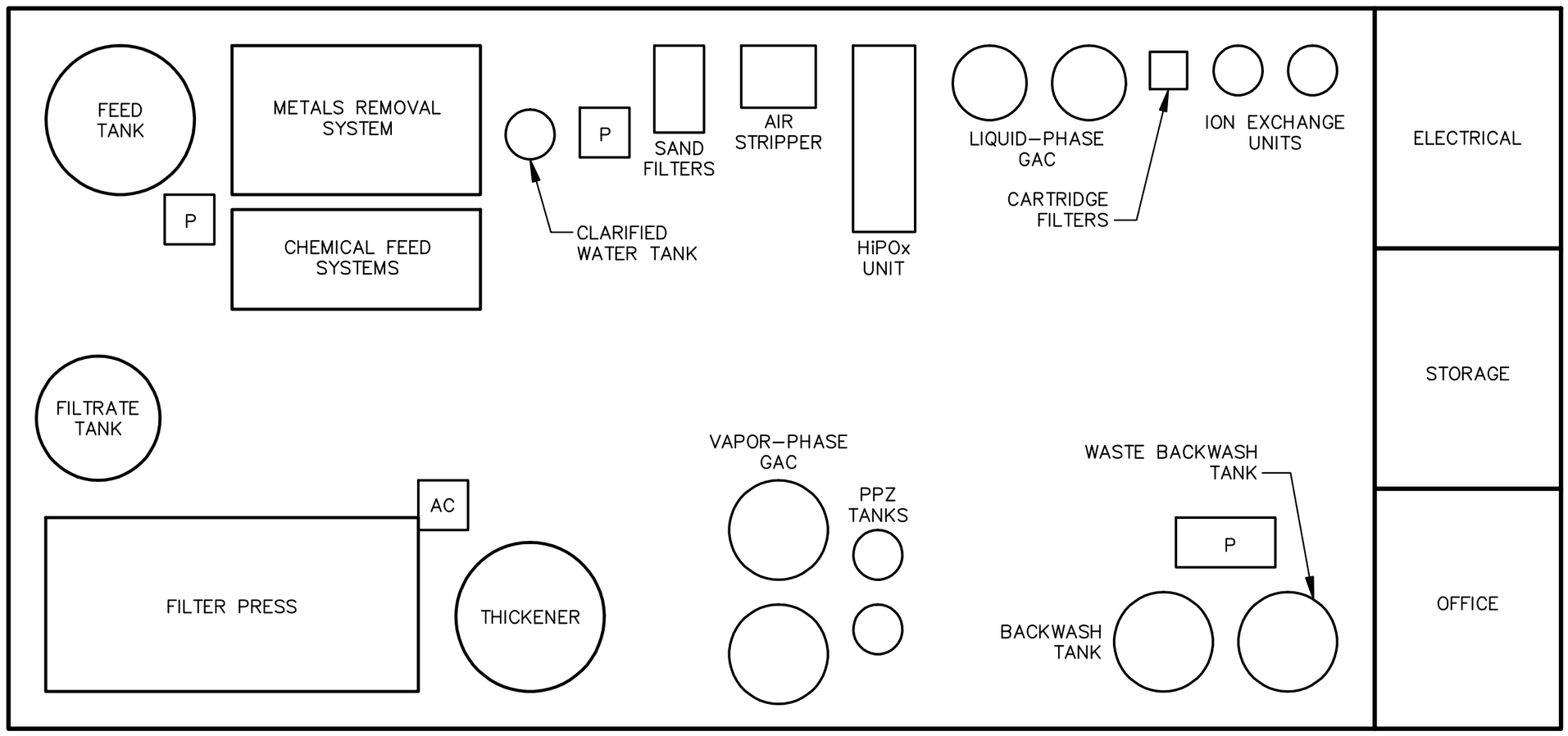


0 10 20

SCALE: 1" = 10'

LEGEND

P = PUMPS
AC = AIR COMPRESSOR
PPZ = POTASSIUM PERMANGANATE IMPREGNATED ZEOLITE

NOTE:

BUILDING DIMENSIONS ARE 60 FEET x 130 FEET

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# CONCEPTUAL BUILDING LAYOUT ALTERNATIVE G–2 DUMP ROAD AREA SITE GROUNDWATER FEASIBILITY STUDY

SCALE: 1"=10'

| | |
|---|---|
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FIGURE 4–3

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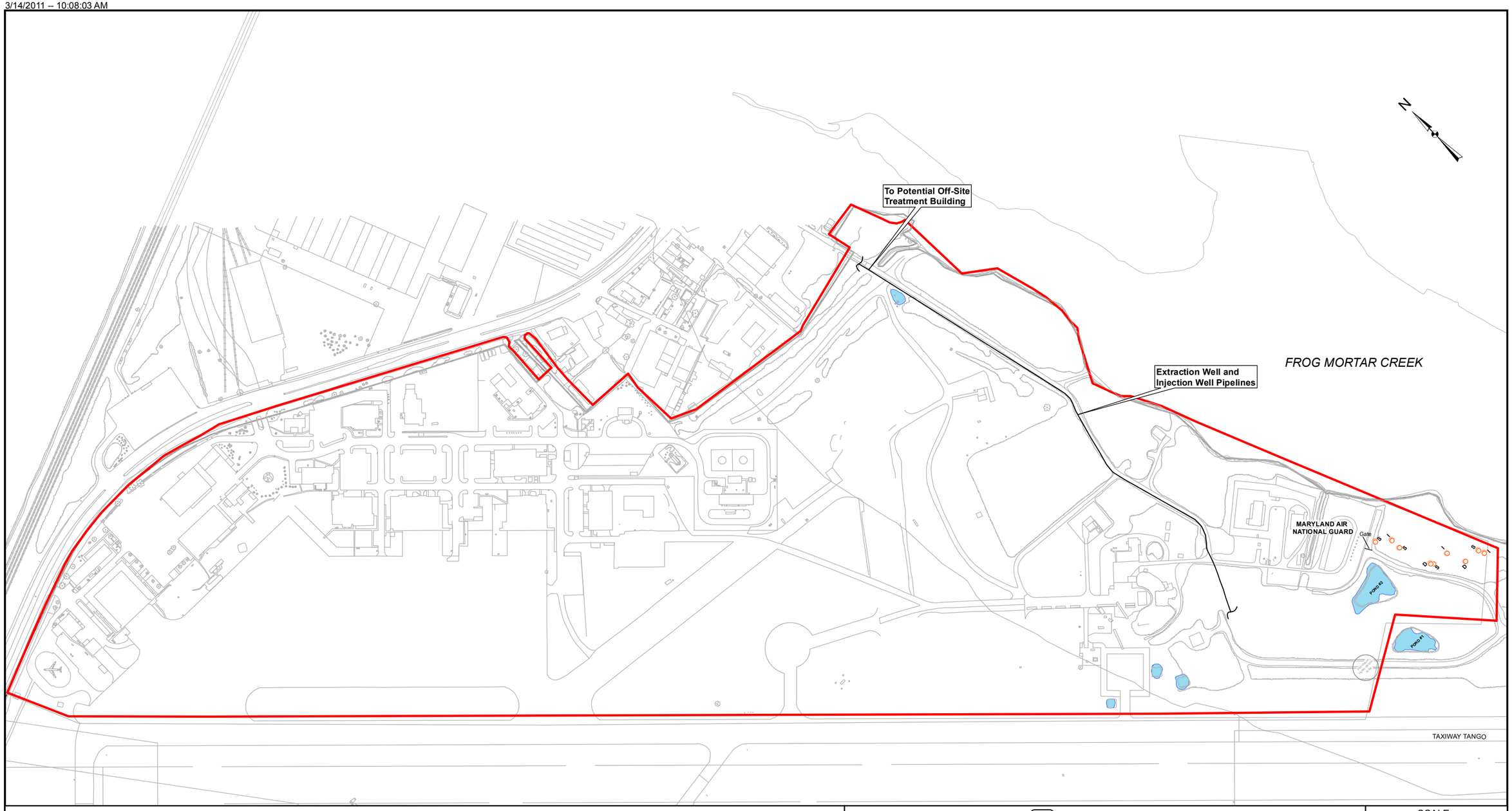


**Legend**

- Pond
- Maryland Air National Guard
- Hydraulic Control Extraction Well
  Screened zone is indicated by letter:
  S- Shallow D- Deep
  I- Intermediate

0 200 400 800 Feet

**Tetra Tech, Inc.**

PROPOSED GROUNDWATER TREATMENT
SYSTEM PIPELINE ROUTING
DUMP ROAD AREA SITE
LOCKHEED MARTIN, MARTIN STATE AIRPORT
MIDDLE RIVER, MARYLAND

| | |
|---|---|
| SCALE | as shown |
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| FIGURE NUMBER | 4-4 |

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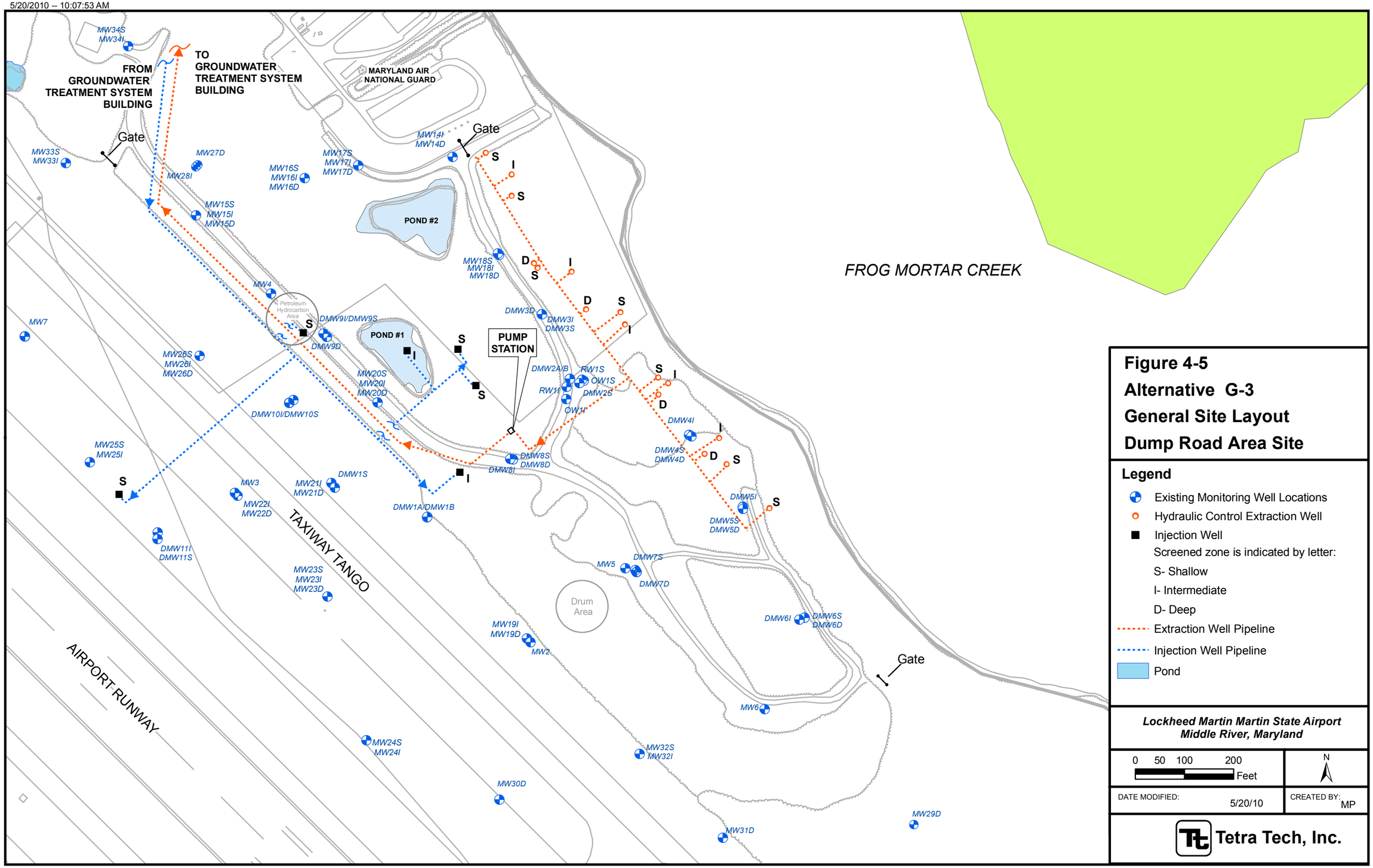


**Figure 4-5**
**Alternative G-3**
**General Site Layout**
**Dump Road Area Site**

**Legend**

- Existing Monitoring Well Locations
- Hydraulic Control Extraction Well
- Injection Well
- Screened zone is indicated by letter:
- S- Shallow
- I- Intermediate
- D- Deep
- Extraction Well Pipeline
- Injection Well Pipeline
- Pond

***Lockheed Martin Martin State Airport***
***Middle River, Maryland***

0 50 100 200 Feet

N

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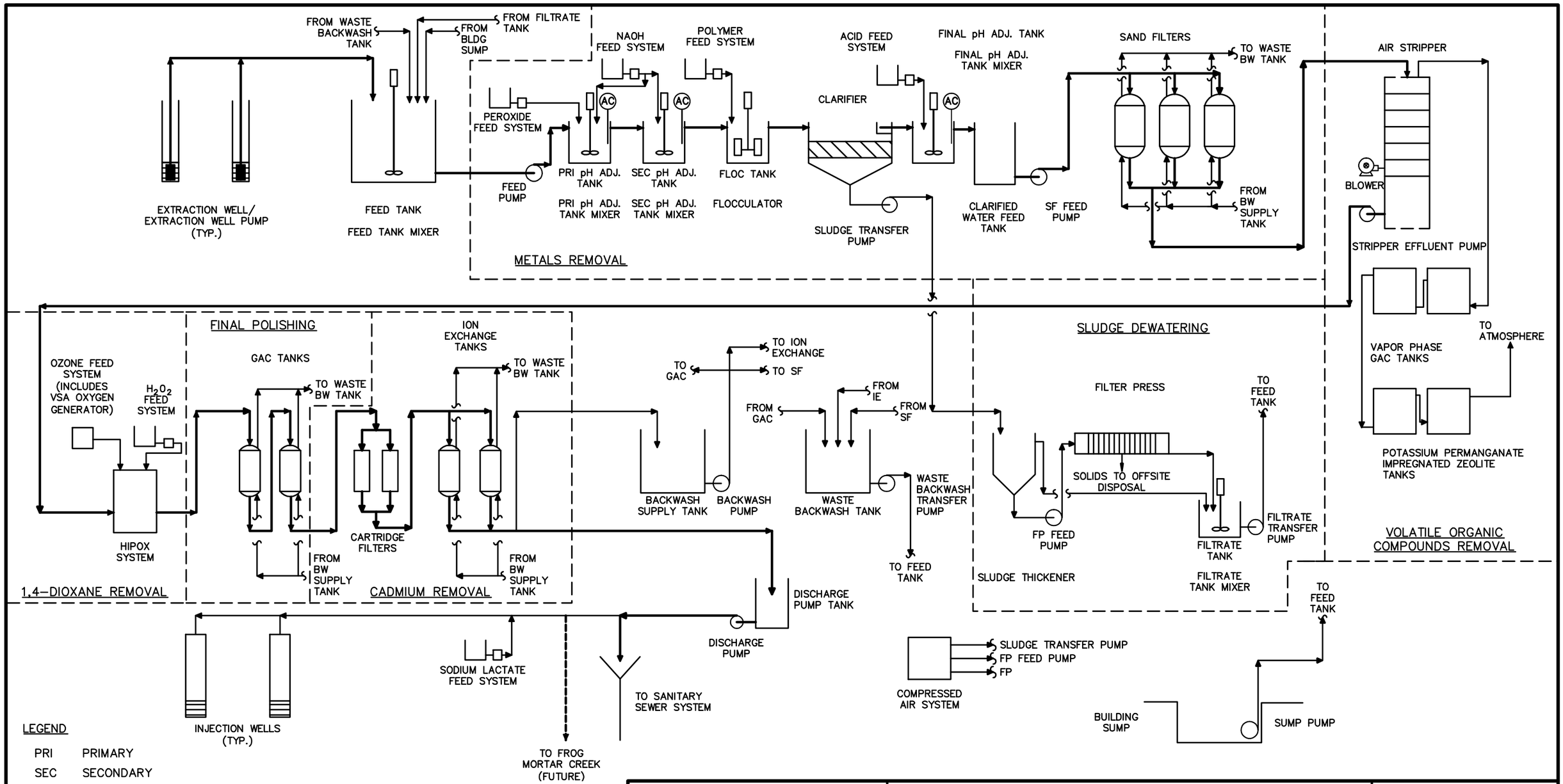


LEGEND

| | |
|---|---|
| PRI | PRIMARY |
| SEC | SECONDARY |
| VSA | VACUUM SWING ADSORPTION |
| BW | BACKWASH |
| SF | SAND FILTER |
| IE | ION EXCHANGE |
| GAC | GRANULAR ACTIVATED CARBON |
| ADJ. | ADJUSTMENT |
| FP | FILTER PRESS |

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# PROCESS FLOW DIAGRAM ALTERNATIVE G–3 DUMP ROAD AREA SITE GROUNDWATER FEASIBILITY STUDY

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FIGURE 4–6

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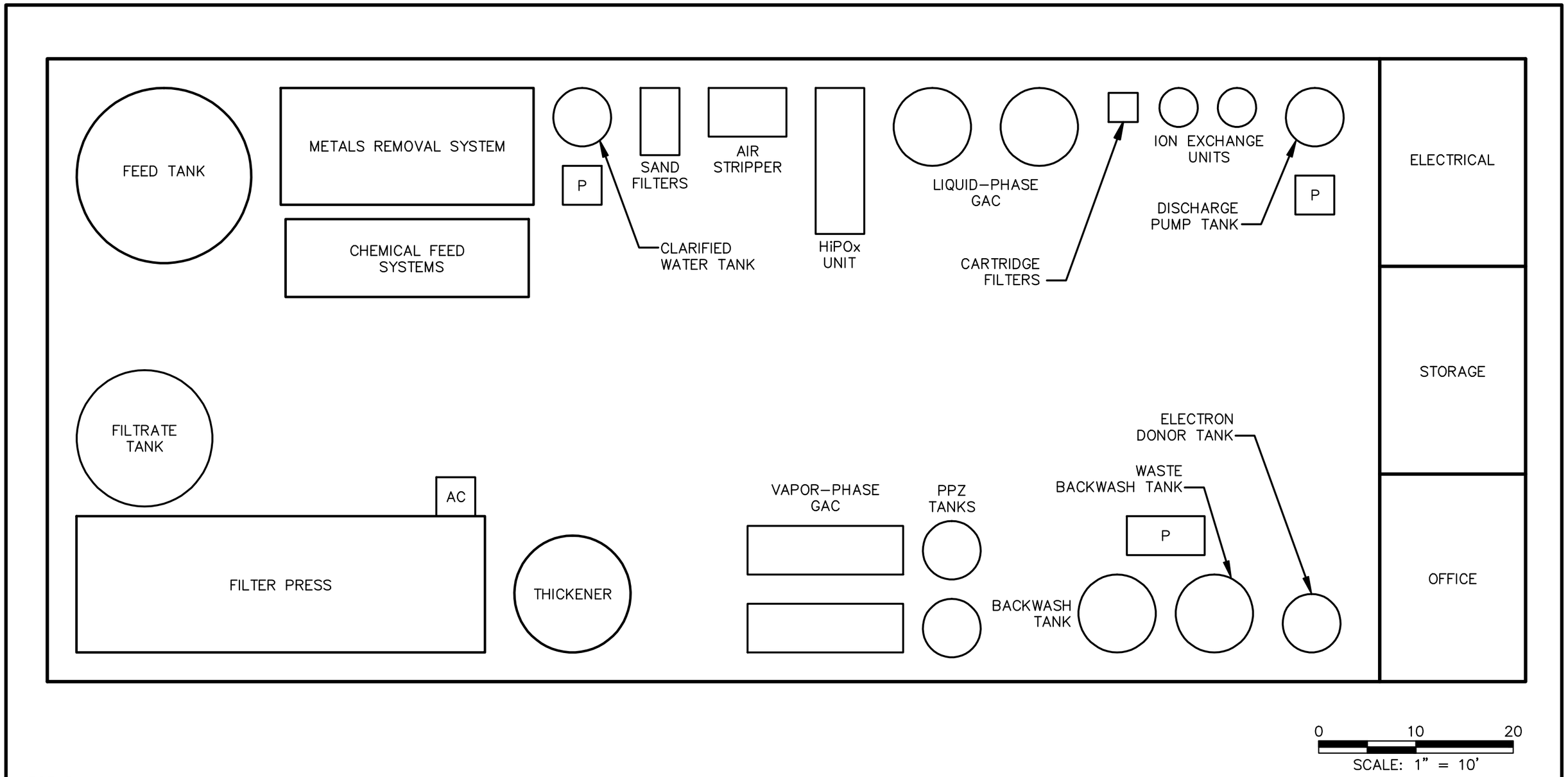


LEGEND

P = PUMPS
AC = AIR COMPRESSOR
PPZ = POTASSIUM PERMANGANATE IMPREGNATED ZEOLITE

NOTE:

BUILDING DIMENSIONS ARE 65 FEET x 155 FEET

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# CONCEPTUAL BUILDING LAYOUT ALTERNATIVES G–3, G–4, AND G–5 DUMP ROAD AREA SITE GROUNDWATER FEASIBILITY STUDY

SCALE: 1"=10'

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FIGURE 4–7

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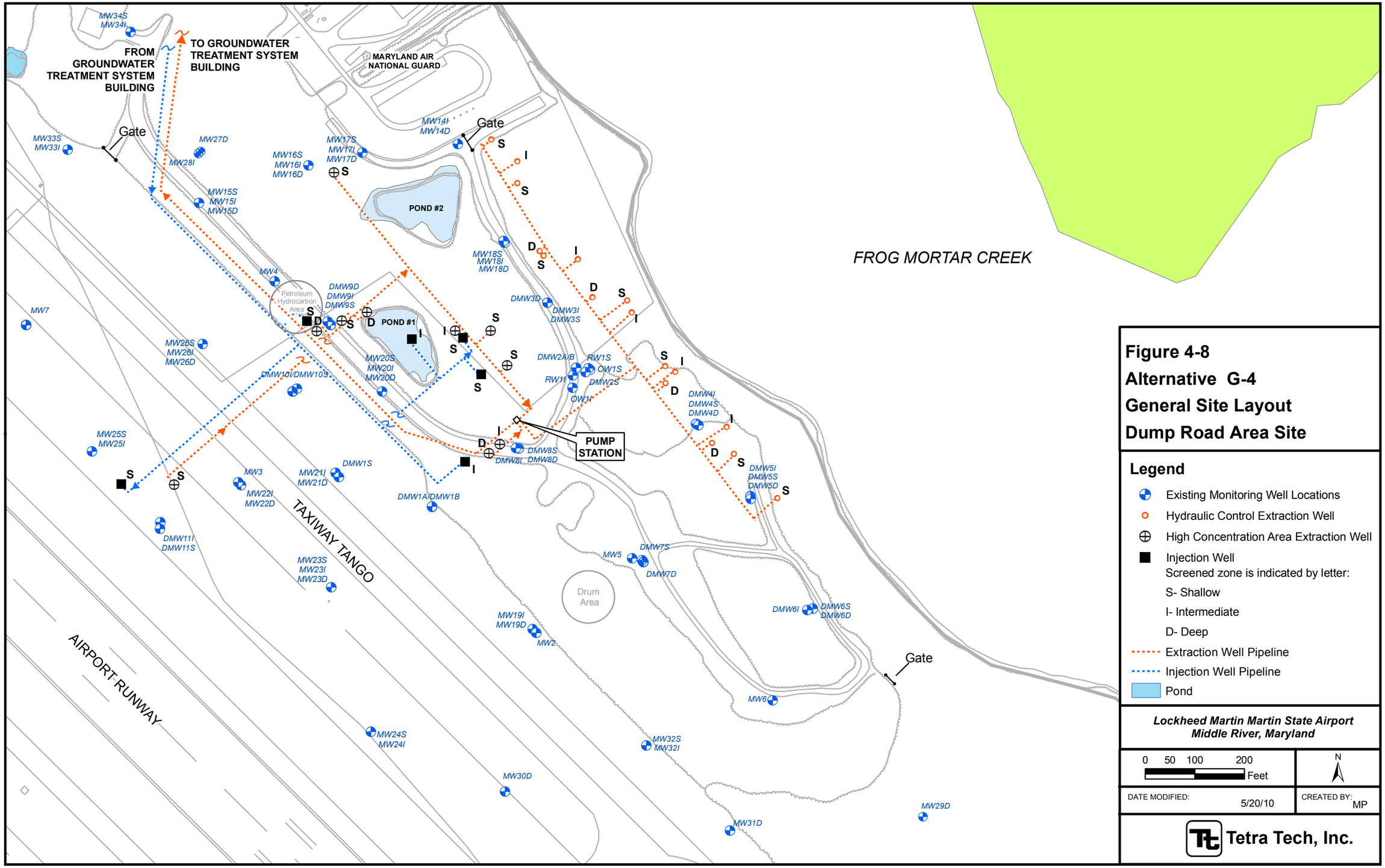


**Figure 4-8**
**Alternative G-4**
**General Site Layout**
**Dump Road Area Site**

## Legend

- Existing Monitoring Well Locations
- Hydraulic Control Extraction Well
- High Concentration Area Extraction Well
- Injection Well
  Screened zone is indicated by letter:
  - S- Shallow
  - I- Intermediate
  - D- Deep
- Extraction Well Pipeline
- Injection Well Pipeline
- Pond

***Lockheed Martin Martin State Airport***
***Middle River, Maryland***

0 50 100 200 Feet

N

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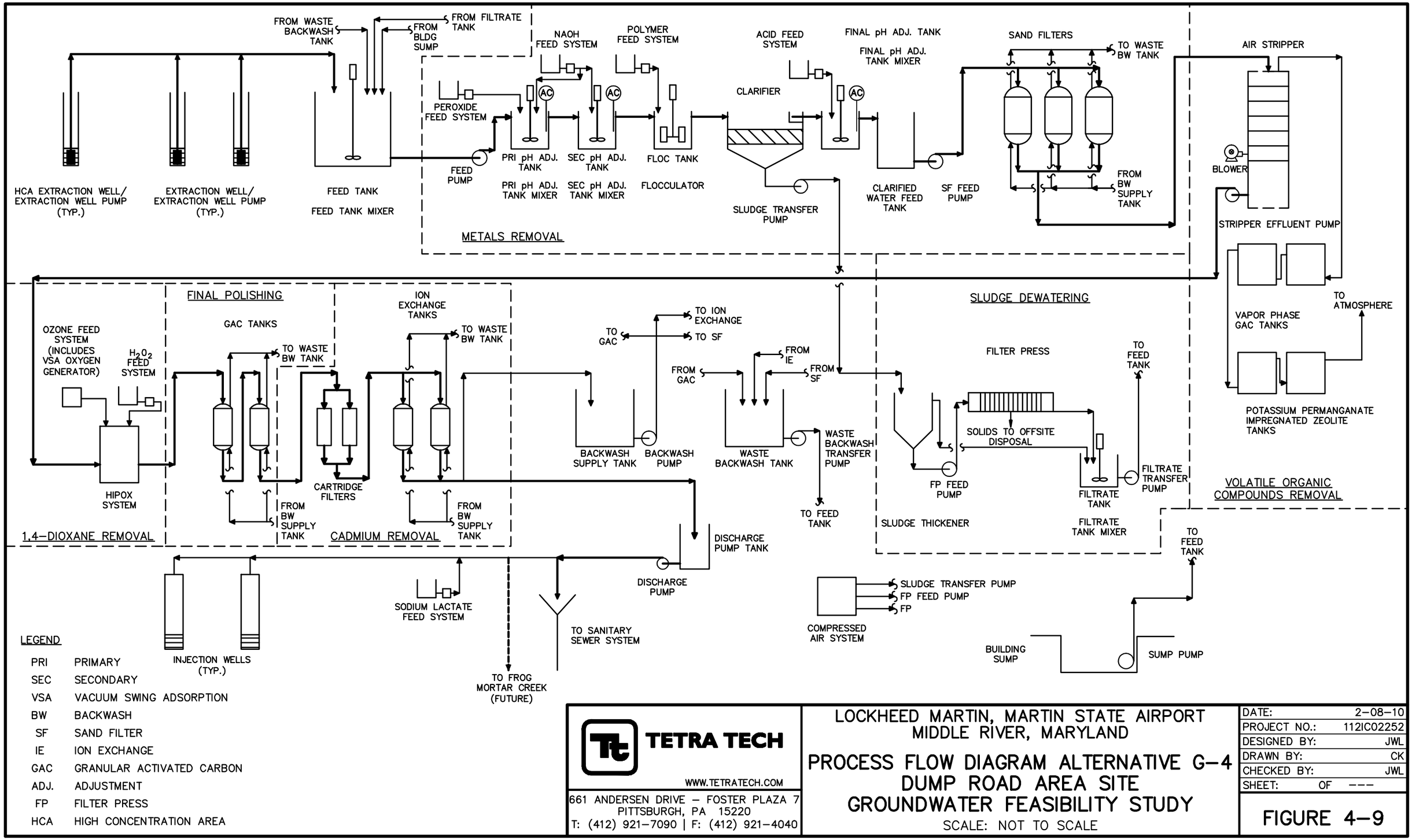


LEGEND

| | |
|---|---|
| PRI | PRIMARY |
| SEC | SECONDARY |
| VSA | VACUUM SWING ADSORPTION |
| BW | BACKWASH |
| SF | SAND FILTER |
| IE | ION EXCHANGE |
| GAC | GRANULAR ACTIVATED CARBON |
| ADJ. | ADJUSTMENT |
| FP | FILTER PRESS |
| HCA | HIGH CONCENTRATION AREA |

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# PROCESS FLOW DIAGRAM ALTERNATIVE G–4 DUMP ROAD AREA SITE GROUNDWATER FEASIBILITY STUDY

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FIGURE 4–9

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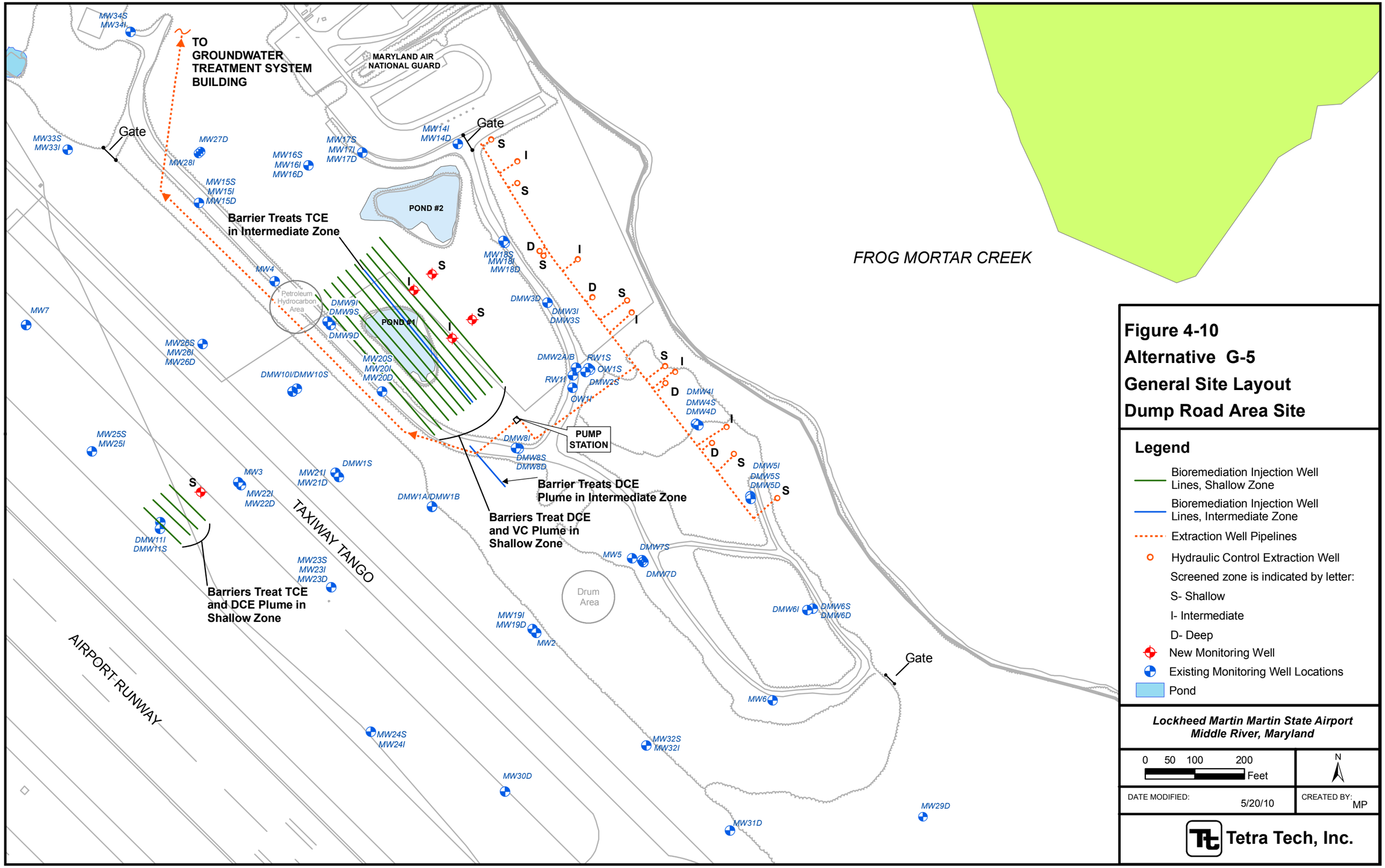


**Figure 4-10**
**Alternative G-5**
**General Site Layout**
**Dump Road Area Site**

## Legend

- Bioremediation Injection Well Lines, Shallow Zone
- Bioremediation Injection Well Lines, Intermediate Zone
- Extraction Well Pipelines
- Hydraulic Control Extraction Well
- Screened zone is indicated by letter:
  - S- Shallow
  - I- Intermediate
  - D- Deep
- New Monitoring Well
- Existing Monitoring Well Locations
- Pond

***Lockheed Martin Martin State Airport***
***Middle River, Maryland***

0 50 100 200 Feet

N

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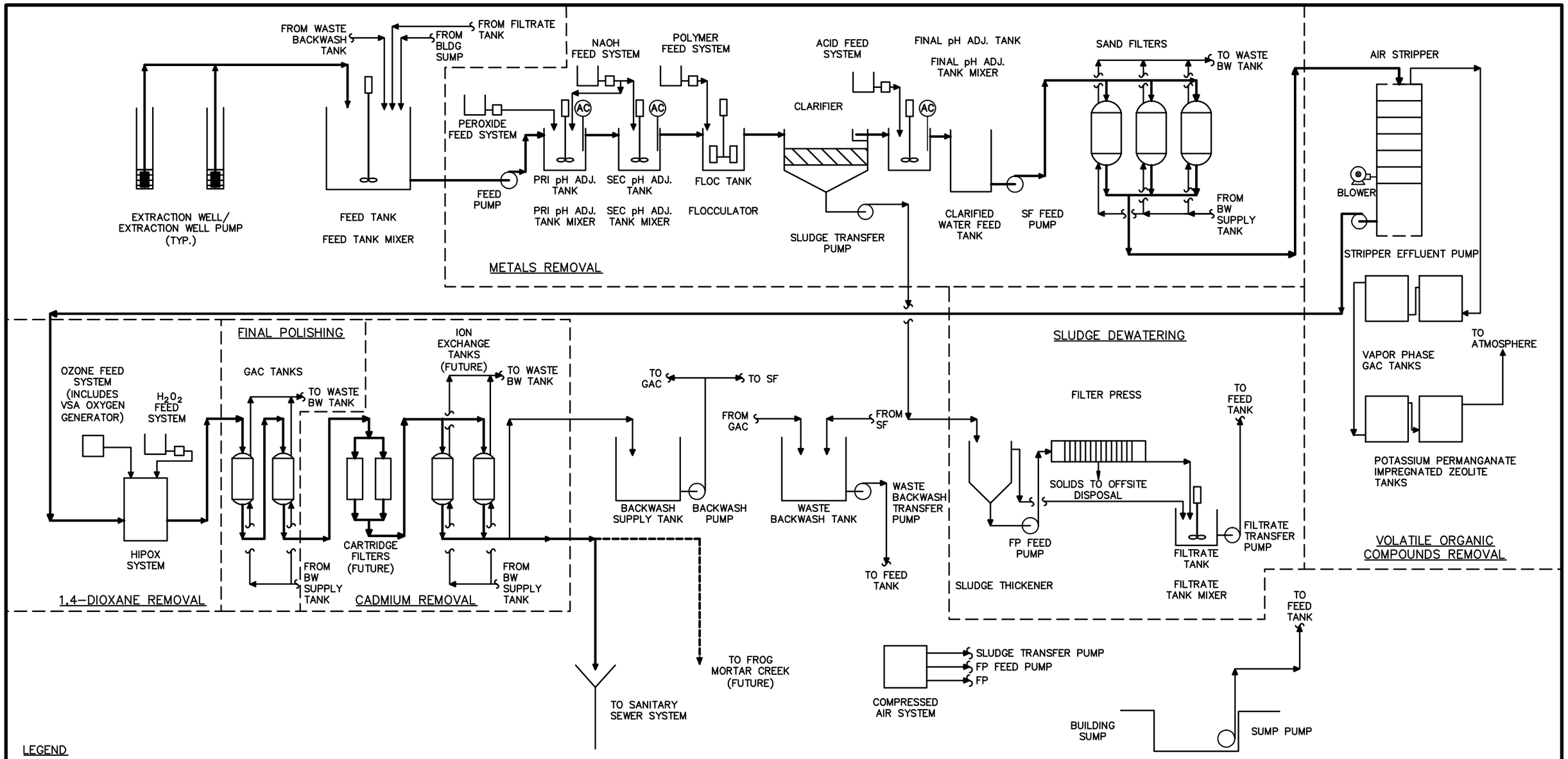


LEGEND

| | |
|---|---|
| PRI | PRIMARY |
| SEC | SECONDARY |
| VSA | VACUUM SWING ADSORPTION |
| BW | BACKWASH |
| SF | SAND FILTER |
| GAC | GRANULAR ACTIVATED CARBON |
| ADJ. | ADJUSTMENT |
| FP | FILTER PRESS |

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# PROCESS FLOW DIAGRAM ALTERNATIVE G–5 DUMP ROAD AREA SITE GROUNDWATER FEASIBILITY STUDY

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FIGURE 4–11

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MW34S
MW34I
MARYLAND AIR NATIONAL GUARD
Gate
MW14I
MW14D
Gate
MW33S
MW33I
MW27D
MW28I
MW16S
MW16I
MW16D
MW17S
MW17I
MW17D
MW15S
MW15I
MW15D
POND #2
MW18S
MW18I
MW18D
FROG MORTAR CREEK
MW4
Petroleum Hydrocarbon Area
DMW9I/DMW9S
DMW9D
POND #1
DMW3I
DMW3S
DMW3D
MW7
MW26S
MW26I
MW26D
DMW2A/B
RW1S
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RW1I
DMW2S
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DMW4D
MW25S
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DMW8I
DMW8S
DMW8D
MW3
MW21I
MW21D
DMW1S
(TCE U)
& DCE UW
MW22I
MW22D
DMW1A/DMW1B
DMW5I
DMW5S
DMW5D
ZVI PRB
TAXIWAY TANGO
DMW11I
DMW11S
MW23S
MW23I
MW23D
MW5
DMW7S
DMW7D
Drum Area
DMW6I
DMW6S
DMW6D
MW19I
MW19D
MW2
Gate
AIRPORT RUNWAY
MW6
MW24S
MW24I
MW32S
MW32I
MW30D
MW29D
MW31D

**Figure 4-12**
**Alternative G-6**
**General Site Layout**
**Dump Road Area Site**

**Legend**

- Existing Monitoring Well Locations
- New Monitoring Well Cluster
- ZVI PRB
- Pond

***Lockheed Martin Martin State Airport***
***Middle River, Maryland***

0 50 100 200 Feet

N

DATE MODIFIED: 2/8/10

CREATED BY: MP

Tetra Tech, Inc.

# Section 5
# Comparative Analysis of Alternatives

The analyses for each of the groundwater alternatives presented in Section 4.0 of this Groundwater Feasibility Study (FS) are compared in this section. The comparison criteria are identical to those used for the detailed analysis of individual alternatives.

## 5.1 COMPARISON OF GROUNDWATER ALTERNATIVES BY CRITERIA

The following alternatives for groundwater are compared in this section:

- ***Alternative G-1***: No action
- ***Alternative G-2***: Hydraulic control by extraction, *ex situ* treatment of groundwater, discharge to publicly owned treatment works (POTW), monitoring, and land use controls (LUCs)
- ***Alternative G-3***: Hydraulic control by extraction, *ex situ* treatment of groundwater, reinjection of groundwater, discharge to POTW, monitoring, and LUCs
- ***Alternative G-4***: Hydraulic control by extraction, extraction in high concentration areas (HCAs), *ex situ* treatment of groundwater, reinjection of groundwater, discharge to POTW, monitoring, and LUCs
- ***Alternative G-5***: Hydraulic control by extraction, *ex situ* treatment of groundwater, *in situ* bioremediation of HCAs, discharge to POTW, monitoring, and LUCs
- ***Alternative G-6***: Zero-valent iron (ZVI) permeable reactive barrier (PRB), monitoring, and LUCs

### 5.1.1 Overall Protection of Human Health and the Environment

Alternatives G-2, G-3, G-4, and G-5 would all protect human health and the environment. Alternative G-2 offers site containment but does not address contaminant source areas. Alternatives G-4 and G-5 would provide the best protection because they also treat the HCAs.

Alternative G-3 provides the next best protection through reinjection of groundwater with an electron-donor compound to promote biological degradation of the HCAs. Alternative G-3 also offers the greatest flexibility to provide additional protection as part of a final groundwater remedy. In Alternative G-6, contaminants would continue to migrate off-site under this alternative because 1,4-dioxane, diesel range organics (DRO), and gasoline range organics (GRO) are not affected by the PRB. This could potentially affect downgradient users and allow contaminants to enter surface water.

Alternatives G-2, G-3, G-4, G-5, and G-6 would further reduce contaminant concentrations. Monitoring would be effective in detecting potential plume migration and in tracking remediation progress. Land use controls would protect human health until preliminary remediation goals (PRGs) are met by restricting groundwater use and mandating construction methods that will mitigate potential vapor intrusion into future buildings. Land use controls would significantly reduce risks from exposure to contaminated groundwater.

Alternative G-1 would provide no protection of human health and the environment. Groundwater contamination might migrate off-site under this alternative, and the potential for vapor intrusion into any future buildings is not considered. Potential migration of chemicals of concern (COCs) would not be detected under this alternative because no monitoring would be performed.

### 5.1.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternatives G-2, G-3, G-4, G-5, and G-6 would comply with location- and action-specific applicable or relevant and appropriate requirements (ARARs) and other guidance. Alternatives G-2, G-3, G-4, and G-5 would not immediately comply with chemical-specific ARARs and other guidance, but these alternatives would eventually achieve compliance as they attain PRGs through a combination of extraction and *ex situ* treatment and/or *in situ* treatment. Alternative G-6 would eventually comply with chemical-specific ARARs and other guidance for chlorinated volatile organic compounds (cVOCs) through a combination of *in situ* treatment and natural attenuation. The effect of the PRB on cadmium is uncertain, although cadmium concentrations on-site would eventually attenuate through dilution and dispersion. Concentrations of 1,4-dioxane, DRO, and GRO would be unaffected by the PRB and would eventually attenuate through dilution and dispersion.

Alternative G-1 would not comply with chemical-specific ARARs, and compliance with location-specific ARARs would be incidental. Although this alternative might eventually meet chemical-specific ARARs though natural attenuation, no monitoring would be conducted to confirm this. Action-specific ARARs or other guidance would not apply.

### 5.1.3 Long-Term Effectiveness and Permanence

Alternatives G-2, G-3, G-4, and G-5 would provide long-term effectiveness and permanence. Alternatives G-2, G-3, G-4, and G-5 provide essentially equal levels of long-term effectiveness and permanence through a combination of *ex situ* and *in situ* treatment and LUCs. As noted above, Alternative G-3 offers the greatest flexibility to provide additional effectiveness as part of a final groundwater remedy. Alternative G-6 would be less effective because 1,4-dioxane, DRO, and GRO would not be treated through the PRB. For all five alternatives, LUCs could be maintained until PRGs are met. All five alternatives require an extended period to reach PRGs. Operation and maintenance (O&M) would be required for an extended period to meet the PRGs.

Alternative G-1 would have no long-term effectiveness and permanence because contaminated groundwater would remain on-site. In the absence of LUCs, groundwater could be used and buildings could be built over the plume, potentially posing unacceptable risks to human receptors via vapor intrusion. Potential off-site migration of COCs would not be detected under this alternative because no groundwater monitoring would be conducted. Although COC concentrations might eventually decrease to PRGs through natural attenuation, no monitoring would verify this.

### 5.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternatives G-2, G-3, G-4, G-5, and G-6 would achieve reductions in COC toxicity and volume through treatment. Under Alternatives G-2, G-3, G-4, and G-5, COCs would be sorbed onto GAC, and spent GAC would be regenerated off-site. The 1,4-dioxane and some of the other COCs would be destroyed by the advanced oxidation process (AOP). Vinyl chloride captured by the potassium permanganate impregnated zeolite (PPZ) would be oxidized.

Additional reductions of contaminant toxicity and volume would also occur under Alternatives G-3, G-4, and G-5 through *in situ* biological degradation. Alternative G-6 eliminates cVOCs through reductive dechlorination, although 1,4-dioxane, DRO, and GRO are not affected and

the level of cadmium removal is uncertain. Metals removed in the treatment system under Alternatives G-2, G-3, G-4, and G-5 would be disposed of off-site. Each alternative would permanently and irreversibly remove contaminants as summarized below:

| Alternative | TCE (lb) | cis-1,2-DCE (lb) | Vinyl chloride (lb) | 1,4-Dioxane (lb) |
|---|---|---|---|---|
| Alternative G-2 | 3,600 | 1,900 | 3,300 | 160 |
| Alternative G-3 | 3,700 | 1,900 | 3,400 | 160 |
| Alternative G-4 | 3,900 | 2,000 | 3,600 | 170 |
| Alternative G-5 | 3,900 | 2,000 | 3,600 | 170 |
| Alternative G-6 | 1,600 | 800 | 1,500 | 0 |

Alternative G-6 would not generate treatment residues, but a large volume of excavated soil generated during installation would require disposal. Alternatives G-2, G-3, G-4, and G-5 would generate spent GAC, spent PPZ, spent ion exchange resin, and sludge that would require off-site management. Alternative G-1 would not achieve any reduction of toxicity, mobility, or volume of COCs through treatment. Reduction of contaminant toxicity and volume through natural attenuation might be achieved; however, under Alternative G-1, this reduction would neither be verified nor quantified.

### 5.1.5 Short-Term Effectiveness

Implementation of Alternatives G-2, G-3, G-4, and G-5 would result in a slight possibility of exposing site workers to contaminated groundwater during installation and maintenance of the groundwater collection and treatment system, as well as during sampling of new and existing monitoring wells. Alternatives G-2 and G-3 would result in the lowest short-term risk with the potential for exposure only during well installation, plant operation, and monitoring. As with Alternatives G-2 and G-3, Alternatives G-4 and G-5 would result in approximately the same level of short-term exposure during installation of additional wells (under Alternative G-4) and injection points (under Alternative G-5).

Alternative G-6 would pose the greatest potential for short-term exposure during groundwater sampling and excavation of contaminated saturated soil during PRB construction. However, these exposure risks could be effectively controlled by wearing appropriate PPE and compliance with appropriate site-specific health and safety procedures. Implementation of

Alternative G-6 could also pose a slightly higher risk to the surrounding community than would the other alternatives during the transport of contaminated soil excavated from the site and of clean sand and ZVI brought to the site. Implementation of Alternatives G-2, G-3, G-4, and G-5 could also pose a slight risk to the surrounding community as a result of transporting treatment chemicals to the treatment building and spent GAC, sludge, and/or IE resin from the site.

Alternatives G-2, G-3, G-4, G-5, and G-6 would achieve groundwater remedial action objective (RAO) Nos. 2 and 3 immediately upon implementation of LUCs and monitoring. Construction associated with Alternatives G-2, G-3, G-4, G-5, and G-6 would be completed in approximately 18 months. Groundwater RAO No. 1 would be attained upon startup of the hydraulic barrier entailed in Alternatives G-2, G-3, G-4, and G-5. For Alternative G-6, groundwater RAO No. 1 would be attained for cVOCs upon completion of the PRB. Whether RAO No. 1 would be attained for 1,4-dioxane, DRO, GRO, and cadmium is uncertain.

All alternatives can be expected to require operation for more than 50 years. Alternative G-6 would take the longest because of the long travel times for the plume to reach the PRB under natural groundwater gradients, and the expected need to rely on natural processes for some contaminants to achieve PRGs. The increased gradients due to groundwater extraction and treatment of HCAs under Alternatives G-2, G-3, G-4, and G-5 decrease the treatment duration as compared to Alternative G-6. Implementation of Alternative G-1 would not result in risks to site workers or adversely affect the surrounding community or environment because no activities would be performed. Alternative G-1 would not achieve RAOs, and though cleanup goals might eventually be attained through natural processes, this would not be verified because no sampling would be conducted.

### 5.1.6 Implementability

Alternative G-1 would be easiest to implement because it undertakes no action to address groundwater contamination at the site. Technical implementation of the various components of Alternatives G-2 and G-3 would be the next easiest to implement. Alternatives G-4 and G-5 would be slightly more difficult to implement because of the additional flow of groundwater to the treatment system and additional extraction wells envisioned under Alternative G-4 and the addition of EOS through injection wells envisioned under Alternative G-5. The large number of

injection wells envisioned under Alternative G-5 would also have to be coordinated with the soil/landfill waste remedy. Contractors and equipment are readily available for all four of these alternatives. All four would require long-term O&M.

Alternative G-6 would be the most difficult to implement because it would require specialized construction methods for the PRB trenches and specialized media (ZVI) to fill the trench. Only a few contractors do this type of construction, and only a few sources of ZVI are available. Alternatives G-2, G-3, G-4, G-4, and G-6 all require similar LUCs that would have to be implemented and maintained for the duration of treatment.

Several alternatives, if implemented, might affect use of the property. Alternative G-2 poses the fewest consequences because it involves only the installation of the hydraulic control extraction wells. Alternatives G-3, G-4, and G-5 would further affect site use because of the injection wells, the HCA extraction wells, and the EOS injection wells (respectively). Piping to and from the wells, and electrical supply to the wells, might also affect site use. Alternative G-6 would primarily affect site use during construction, but only the area of the PRB and the area immediately adjacent would be restricted. High concentrations of VOCs in the shallow groundwater will limit the type of building construction that can be allowed over the plume because of the potential for vapor intrusion.

A permit to discharge to the POTW will have to be obtained for Alternatives G-2, G-3, G-4, and G-5. This could prove difficult because of the sanitary authority's program to minimize the introduction of relatively clean water (such as groundwater infiltration) into the system. A permit for direct discharge to surface water could be more difficult to obtain because of the modeling, field testing, and calibration that would be required to estimate effluent limitations into the Frog Mortar Creek estuary or Stansbury Creek estuary. Discharge limitations to the POTW are much less restrictive compared to the limitations anticipated for a direct discharge. For Alternative G-6, a large volume of waste material would need to be managed and properly disposed of.

### 5.1.7 Sustainability

Alternative G-1 is the most sustainable of the alternatives evaluated, based on the factors considered for this criterion in this FS. No energy or resources would be consumed, no

greenhouse gases or waste would be generated, nor would costs or increases in negative social factors (such as traffic and noise) occur. However, an economic factor to consider is that site development would be limited because, with no controls in place under this alternative, potential exposure to contaminated groundwater or to contaminants volatilizing from groundwater into buildings could occur.

Alternative G-6 offers high to moderate sustainability. The passive process described in Alternative G-6 would use little electrical power in the long-term, but would entail significant energy use from construction vehicles during initial PRB installation and each subsequent PRB replacement. A large waste stream would also be generated during each PRB installation. The PRB would need to be replaced numerous times until the plume is remediated. Local effects, such as noise and traffic, would be limited to the construction period. The space occupied by the PRB could not be developed until remediation goals were met.

Alternatives G-2, G-3, G-4, and G-5 would have similar consequences for sustainability. All four alternatives use electrical power that contributes to greenhouse gas generation, but alternatives G-2 and G-5 would use the least. Electricity use under Alternative G-3 would initially be similar to that of Alternatives G-2 and G-5, but could increase to the same level as Alternative G-4. Alternative G-4 has the highest electrical energy use and highest contribution to greenhouse gas generation. Manufacture of the carbon substrate used for the *in situ* bioremediation component under Alternative G-5 would contribute additional greenhouse gases as compared to the other alternatives.

All four of these alternatives consume chemicals (such as hydrogen peroxide, sodium hydroxide, and hydrochloric acid) in the groundwater treatment system. Production of chemicals used to treat and regenerate GAC would also contribute to energy use and greenhouse gas production. Alternatives G-2 and G-5 would use the least amount of chemicals.

Chemical consumption under Alternative G-3 would initially be similar to that of Alternatives G-2 and G-5, but could increase to the same level as Alternative G-4, which uses the most. Alternatives G-3 and G-5 use similar quantities of electron-donor compound in the groundwater reinjection system. Production of the electron-donor compound would also contribute to energy use and greenhouse gas production. An electron-donor compound would

also be injected as part of Alternative G-4. The quantity of electron-donor compound under Alternative G-4 would be greater than what would be used under Alternatives G-3 and G-5, and production of the electron-donor compound would likewise contribute to energy use and greenhouse gas production.

All four groundwater treatment alternatives would generate similar quantities of waste and would destroy similar quantities of COCs in proportion to the amount of groundwater treated. All four would likewise pose similar noise and traffic impacts near the site. These alternatives would have the greatest effect on waste generation, COC destruction, traffic, and noise factors because of the higher groundwater treatment rates associated with Alternative G-4 and potentially with Alternatives G-3 and G-5,

### 5.1.8 Cost

Capital and O&M costs and the net present worth (NPW) of the alternatives evaluated above in this Groundwater FS are as follows:

| Alternative | Capital | NPW of annual costs | NPW | Current value |
|---|---|---|---|---|
| G-1 | $0 | $0 | $0 (30 years) | $0 |
| G-2 | $12,000,000 | $8,200,000 | $20,200,000 (30 years) | $37,000,000 |
| G-3 | $12,900,000 | $8,600,000 | $21,500,000 (30 years) | $38,700,000 |
| G-4 | $13,100,000 | $11,700,000 | $24,800,000 (30 years) | $46,900,000 |
| G-5 | $14,000,000 | $8,800,000 | $22,800,000 (30 years) | $40,000,000 |
| G-6 | $13,300,000 | $5,700,000 | $19,000,000 (30 years) | $33,500,000 |

Detailed cost estimates are provided in Appendix F.

## 5.2 SUMMARY OF COMPARATIVE ANALYSIS OF GROUNDWATER ALTERNATIVES

The comparative analysis of the groundwater remedial alternatives is summarized in Table 5-1.

## 5.3 SELECTION OF GROUNDWATER ALTERNATIVE

Alternative G-3 (hydraulic control by extraction, *ex situ* treatment of groundwater, reinjection of groundwater, discharge to POTW/surface water, monitoring, and LUCs) was selected as the interim remedial action to address groundwater contamination at the DRA Site. This alternative

meets the interim remedial action requirement in that it provides hydraulic containment to prevent migration of TCE, 1,4-dioxane, and cadmium to the surface water. It also provides additional groundwater treatment capacity so that the groundwater extraction system can be expanded in the future, particularly after the soil and landfill waste have been remediated.

Future expansion of this alternative could include groundwater recirculation and *in situ* bioremediation in the HCAs to provide some destruction of cVOCs, and such expansion could be designed for implementation in conjunction with the soil/landfill waste remedy. This alternative is economical and provides both effective treatment of all COCs and operational flexibility. Alternative G-3 is moderately sustainable, but this sustainability is comparable to the levels of Alternatives G-2, G-4, and G-5.

Additional investigations are being conducted in several of the HCAs. The purpose of these investigations is to better characterize and delineate the areas of the site with the highest contaminant concentrations in order to focus potential future remedial actions. The results of these investigations will be submitted in future documents and will be used to plan potential remedial actions conducted subsequent to this IRA. The HCAs to be investigated further include the vicinity of DMW-11S, the area in and around Pond 1, the Drum Area, and the vicinity of boring TA-1. Additionally, the surface water hydrology in the areas of Ponds 1 and 2 is being further studied to confirm that groundwater extraction would have a limited effect on water levels in these ponds and cause limited additional contaminant infiltration from pond sediments. Alternative G-3 contains sufficient flexibility to address these HCAs, including additional contaminant flux to the recovery wells, and the results of the investigations will be used to refine the design of the IRA.

Alternative G-2 was not selected primarily because it offers too little flexibility for future operations if higher flow rates or extraction of groundwater from other areas is required. In addition, the overall time to meet PRGs under Alternative G-2 is the second-longest. Alternative G-6 was not selected because 1,4-dioxane, DRO, and GRO would not be affected and the level of treatment of metals is uncertain. Alternative G-6 has the highest capital cost, and installation of the PRB to the required depth would be very difficult. Alternatives G-4 and G-5 were not selected because they require a commitment to a greater capital expenditure before the effects of the hydraulic barrier can be fully evaluated.

Alternatives G-4 and G-5 also include features such as additional extraction wells and injection wells that may need to be abandoned and re-installed as part of the soil and landfill waste remediation. Finally, after several years of Alternative G-3 system operation, components of Alternatives G-4 and/or G-5 could be optimally phased in using data and observations from the Alternative G-3 system operation and knowledge of the details of the final soil/landfill waste remedy. Therefore, Alternative G-3 was selected to provide hydraulic containment and to allow for a phased approach to remediation of other parts of the plume, such as the HCAs.

## 5.4 SUSTAINABILITY PRACTICES

Sustainability considerations were factored into determining the preferred remedial alternative. These considerations, in conjunction with Lockheed Martin's "Go Green" program, will also be applied in implementing that alternative. Sustainable practices in general are those that consider economic and natural resources, ecology, human health and safety, and quality of life. For remediation projects, sustainability means implementing projects in a manner that not only meets traditional remediation requirements (e.g., protection of human health and the environment and compliance with ARARs), but that also considers sustainable practices with a goal of minimizing the overall environmental "footprint."

Environmental footprint relates to the effects on environmental media and society that are the direct or indirect consequence of performing the remedial action. Minimizing the environmental footprint of a specific project might involve reducing toxic air and greenhouse gas emissions (e.g., carbon dioxide, methane, and nitrous oxide), reducing unnecessary or inefficient use of energy, promoting renewable energy over conventional sources, reducing soil erosion and nutrient depletion, reducing adverse effects to ecological receptors and ecosystems, and reducing water consumption or waste generation.

To improve the overall net environmental benefit of a remedial action, implementation of the selected remedial alternative will follow best management practices (BMPs) for sustainability. This includes resource management practices to minimize material demands, water consumption, energy usage, toxicity, and emissions of greenhouse gases and criteria pollutants. Considerations to encourage the sustainability of the remedial action may include items such as:

- Considering equipment material or construction during equipment specification. Selecting compatible materials that are recycled or have manufacturing processes that emit lower greenhouse gas and criteria pollutants, and require less energy and water demand.

- Using locally available resources to reduce transportation impacts.

- Installing variable frequency drives (as applicable) and high-efficiency motors on all major rotating equipment.

- If recovery of high concentration areas is conducted, pulsing of the wells may be conducted to reduce overall energy consumption.

- Optimizing the treatment system building's high-efficiency heating, ventilation, and air conditioning system and using high R-value rated insulation on building walls and roofing.

- Purchasing electricity from a renewable energy provider.

- Installing renewable energy sources (e.g., wind, solar, etc.) on-site and connecting directly to the treatment system's electrical source, and supplying surplus electricity to the power grid.

- Reducing process waste generation and landfilling by using reusable or recycled media (e.g., sand filter media and reactivated GAC).

- Continual optimization of the remedial system and groundwater monitoring program to ensure that equipment operates efficiently and treatment processes do not become redundant over time (e.g., GAC adsorption and AOP in series).

- Reducing overall effects on site water resources by discharging treated water to on-site surface water once adequate water quality information is confirmed and the discharge has been permitted.

**Table 5-1**

**Summary of Comparative Analysis of Groundwater Remedial Alternatives - DRA Site Groundwater Feasibility Study**
**Lockheed Martin, Martin State Airport**
**Middle River, Maryland**


| Evaluation Criterion | Alternative G-1: No Action | Alternative G-2: Hydraulic Control by Extraction, Ex-Situ Treatment of Groundwater, Discharge to Publicly Owned Treatment Works / Surface Water, Monitoring, and Land Use Controls | Alternative G-3: Hydraulic Control by Extraction, Ex-Situ Treatment of Groundwater, Re-injection of Groundwater, Discharge to Publicly Owned Treatment Works / Surface Water, Monitoring, and Land Use Controls | Alternative G-4: Hydraulic Control by Extraction, Extraction of High Concentration Areas, Ex-Situ Treatment of Groundwater, Re-injection of Groundwater, Discharge to Publicly Owned Treatment Works / Surface Water, Monitoring, and Land Use Controls | Alternative G-5: Hydraulic Control by Extraction, Ex-Situ Treatment of Groundwater, In-Situ Bioremediation of High Concentration Areas, Discharge to Publicly Owned Treatment Works / Surface Water, Monitoring, and Land Use Controls | Alternative G-6: Zero-Valent Iron Permeable Reactive Barrier, Monitoring, and Land Use Controls |
|---|---|---|---|---|---|---|
| Overall Protection of Human Health and Environment | Would not be protective of human health or the environment because no action would occur. Migration of COCs would continue and remain undetected. | Would be protective of human health and the environment. Would be less protective than Alternatives G-3 through G-5 because there would be no early reduction of the HCAs. Same level of protection as Alternative G-6. LUCs would prevent exposure to the rest of the plume. | Would be protective of human health and the environment. Would be more protective than Alternatives G-2 and G-6 less protective than Alternatives G-4 and G-5 because there would be no early reduction of the HCAs. LUCs would prevent exposure to the rest of the plume. | Would be protective of human health and the environment. Would be more protective than Alternatives G-2, G-3, and G-6, because there would be early reduction of the HCAs. As protective as Alternative G-5 LUCs would prevent exposure to the rest of the plume. | Would be protective of human health and the environment. Would be more protective than Alternatives G-2, G-3, and G-6, because there would be early reduction of the HCAs. As protective as Alternative G-4 LUCs would prevent exposure to the rest of the plume. | Would be protective of human health and the environment. Would be slightly less protective than Alternatives G-3, G-4, and G-5 because there is no HCA treatment, no 1,4-dioxane, DRO, or GRO removal, and cadmium removal is uncertain. Also, less protective than Alternative G-2 because no 1,4-dioxane, DRO, or GRO are removed. High COC concentrations would persist until plume moves through the barrier. LUCs would prevent exposure to the rest of the plume. |
| Compliance with ARARs: | | | | | | |
| Chemical-Specific | Would not comply | Would eventually comply | Would eventually comply | Would eventually comply | Would eventually comply | Would eventually comply for cVOCs, although compliance for 1,4-dioxane, DRO, GRO, and cadmium is uncertain. |
| Location-Specific | Would not comply | Would comply | Would comply | Would comply | Would comply | Would comply |
| Action-Specific | Not applicable | Would comply | Would comply | Would comply | Would comply | Would comply |
| Long-Term Effectiveness and Permanence | No long-term effectiveness and permanence because no action would occur. Contaminant reduction or migration would remain undetected. | Would be as permanent and effective as the other alternatives, although the remediation time will be longer because there is no HCA treatment. LUCs would prevent exposure. Long-term O&M is required. | Would be as permanent and effective as the other alternatives, although the remediation time will be longer because there is no HCA treatment. LUCs would prevent exposure. Long-term O&M is required. | Would be as permanent and effective as the other alternatives, although the remediation time will be shorter because there is HCA treatment. LUCs would prevent exposure. Long-term O&M is required. | Would be as permanent and effective as the other alternatives, although the remediation time will be shorter because there is HCA treatment. LUCs would prevent exposure. Long-term O&M is required. | Would be as permanent and effective for cVOCs as the other alternatives, although the remediation time will be longest because groundwater velocity under natural gradient is slow. The PRB would not affect DRO, GRO, or 1.4-dioxane. The PRB would reduce cVOCs, and LUCs would prevent exposure. |

**Table 5-1**

**Summary of Comparative Analysis of Groundwater Remedial Alternatives - DRA Site Groundwater Feasibility Study**
**Lockheed Martin, Martin State Airport**
**Middle River, Maryland**


| Evaluation Criterion | Alternative G-1: No Action | Alternative G-2: Hydraulic Control by Extraction, Ex-Situ Treatment of Groundwater, Discharge to Publicly Owned Treatment Works / Surface Water, Monitoring, and Land Use Controls | Alternative G-3: Hydraulic Control by Extraction, Ex-Situ Treatment of Groundwater, Re-injection of Groundwater, Discharge to Publicly Owned Treatment Works / Surface Water, Monitoring, and Land Use Controls | Alternative G-4: Hydraulic Control by Extraction, Extraction of High Concentration Areas, Ex-Situ Treatment of Groundwater, Re-injection of Groundwater, Discharge to Publicly Owned Treatment Works / Surface Water, Monitoring, and Land Use Controls | Alternative G-5: Hydraulic Control by Extraction, Ex-Situ Treatment of Groundwater, In-Situ Bioremediation of High Concentration Areas, Discharge to Publicly Owned Treatment Works / Surface Water, Monitoring, and Land Use Controls | Alternative G-6: Zero-Valent Iron Permeable Reactive Barrier, Monitoring, and Land Use Controls |
|---|---|---|---|---|---|---|
| Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment | Would not reduce contaminant toxicity, mobility or volume through treatment because no treatment would occur. Although some reductions would occur through natural attenuation, this would not be measured. | Would irreversibly and permanently reduce approximately 8,960 lb of COCs through advanced oxidation process. | Would irreversibly and permanently reduce approximately 9,160 lb of COCs through advanced oxidation process and in-situ biodegradation from electron donor addition to the injection wells. | Would irreversibly and permanently reduce approximately 9,670 lb of COCs through AOP and in-situ biodegradation from electron donor addition to the injection wells. | Would irreversibly and permanently reduce approximately 9,670 lb of COCs through advanced oxidation process and in-situ biodegradation. | Would irreversibly and permanently reduce approximately 3,900 lb of cVOCs through the PRB. |
| Short-Term Effectiveness | Would not result in any short-term risk to site workers or adversely impact the surrounding community or environment because no action would occur. The RAOs would never be achieved with the implementation of this alternative. | Would result in a possibility of exposing site workers to contaminated groundwater as a result of groundwater extraction, treatment, and monitoring activities. This risk would be reduced through compliance with appropriate site-specific health and safety procedures. Because of the long period of active treatment, this alternative has potential for short-term exposure. There would be a slight risk to the surrounding community or the environment. Groundwater RAO Nos. 1 and 3 would be achieved immediately upon implementation of LUCs and monitoring. RAO No. 2 would be met as soon as system was started up. Remediation time would up to 50 years and potentially longer. Construction activities would be completed in 12 months. | Would result in a possibility of exposing site workers to contaminated groundwater as a result of groundwater extraction, treatment, and monitoring activities. This risk would be reduced through compliance with appropriate site-specific health and safety procedures. Because of the long period of active treatment, this alternative has potential for short-term exposure. There would be a slight risk to the surrounding community or the environment. Groundwater RAO Nos. 1 and 3 would be achieved immediately upon implementation of LUCs and monitoring. RAO No. 2 would be met as soon as system was started up. Remediation time would up to 50 years and potentially longer. Construction activities would be completed in 12 months. | Would result in a possibility of exposing site workers to contaminated groundwater as a result of groundwater extraction, treatment, and monitoring activities. This risk would be reduced through compliance with appropriate site-specific health and safety procedures. Because of the long period of active treatment, this alternative has potential for short-term exposure. There would be a slight risk to the surrounding community or the environment. Groundwater RAO Nos. 1 and 3 would be achieved immediately upon implementation of LUCs and monitoring. RAO No. 2 would be met as soon as system was started up. Remediation time would up to 50 years and potentially longer. Construction activities would be completed in 12 months. | Would result in a possibility of exposing site workers to contaminated groundwater as a result of groundwater extraction, treatment, in-situ bioremediation chemical injection, and monitoring activities. This risk would be reduced through compliance with appropriate site-specific health and safety procedures. Because of the long period of active treatment, this alternative has potential for short-term exposure. There would be a slight risk to the surrounding community or the environment. Groundwater RAO Nos. 1 and 3 would be achieved immediately upon implementation of LUCs and monitoring. RAO No. 2 would be met as soon as system was started up. Remediation time would up to 50 years and potentially longer. Construction activities would be completed in 12 months. | Would result in a possibility of exposing site workers to contaminated groundwater as a result PRB installation and monitoring activities. This risk would be reduced through compliance with appropriate site-specific health and safety procedures. There would be a slight risk to the surrounding community and the environment during PRB construction. Groundwater RAO Nos. 1 and 3 would be achieved immediately upon implementation of LUCs and monitoring. RAO No. 2 would be met for cVOCs as soon as PRB is installed. Remediation time would up to 50 years and potentially longer. Construction activities would be completed within 12 months. |

**Table 5-1**

**Summary of Comparative Analysis of Groundwater Remedial Alternatives - DRA Site Groundwater Feasibility Study**
**Lockheed Martin, Martin State Airport**
**Middle River, Maryland**


| Evaluation Criterion | Alternative G-1: No Action | Alternative G-2: Hydraulic Control by Extraction, Ex-Situ Treatment of Groundwater, Discharge to Publicly Owned Treatment Works / Surface Water, Monitoring, and Land Use Controls | Alternative G-3: Hydraulic Control by Extraction, Ex-Situ Treatment of Groundwater, Re-injection of Groundwater, Discharge to Publicly Owned Treatment Works / Surface Water, Monitoring, and Land Use Controls | Alternative G-4: Hydraulic Control by Extraction, Extraction of High Concentration Areas, Ex-Situ Treatment of Groundwater, Re-injection of Groundwater, Discharge to Publicly Owned Treatment Works / Surface Water, Monitoring, and Land Use Controls | Alternative G-5: Hydraulic Control by Extraction, Ex-Situ Treatment of Groundwater, In-Situ Bioremediation of High Concentration Areas, Discharge to Publicly Owned Treatment Works / Surface Water, Monitoring, and Land Use Controls | Alternative G-6: Zero-Valent Iron Permeable Reactive Barrier, Monitoring, and Land Use Controls |
|---|---|---|---|---|---|---|
| Implementability | Technical and administrative implementation would be extremely simple because there would be no action to implement. | Easy to implement extraction, treatment, and monitoring. Less difficult to implement than Alternatives G-3 through G-6.<br><br>LUCs would be relatively easy to develop and implement.<br><br>Permit for discharge to POTW still needs to be negotiated.<br><br>Use of property may be affected by extraction wells. | Easy to implement extraction, treatment, injection, and monitoring. More difficult to implement than Alternative G-2. Less difficult to implement than Alternatives G-4 through G-6.<br><br>LUCs would be relatively easy to develop and implement.<br><br>Permit for discharge to POTW still needs to be negotiated.<br><br>Use of property may be affected by extraction and injection wells. | Easy to implement extraction, treatment, injection, and monitoring. More difficult to implement than Alternatives G-2 and G-3. Less difficult to implement than Alternatives G-5 and G-6.<br><br>LUCs would be relatively easy to develop and implement.<br><br>Permit for discharge to POTW still needs to be negotiated.<br><br>Use of property may be affected by extraction, HCA, and injection wells. | Easy to implement extraction, treatment, injection, in-situ bioremediation, and monitoring. More difficult to implement than Alternatives G-2, G-3, and G-4. Less difficult to implement than Alternative G-6.<br><br>LUCs would be relatively easy to develop and implement.<br><br>Permit for discharge to POTW still needs to be negotiated.<br><br>Use of property may be affected by extraction, in-situ bioremediation of HCA, and injection wells. | Difficult to install deep PRBs, but monitoring is easy to implement. Most difficult alternative. Bench-scale treatability testing would be required.<br><br>LUCs would be relatively easy to develop and implement.<br><br>Use of property may be affected by PRB.<br><br>Management of excavated soil as hazardous waste requires RCRA TSDF permit. Corrective action may be triggered. |
| Sustainability | Would be highly sustainable. No energy or resources consumed. No GHG or wastes generated. No traffic or noise. Site development would be limited by the contaminated groundwater. | Would be moderately sustainable. Consumes energy and resources, and generates GHG and wastes. Slight increase in traffic and noise. More sustainable than G-3, G-4, and G-5. | Would be moderately sustainable. Consumes energy and resources, and generates GHG and wastes. Slight increase in traffic and noise. Less sustainable than G-2 and G-5. More sustainable than G-4. | Would be moderately sustainable. Consumes energy and resources, and generates GHG and wastes. Slight increase in traffic and noise. Less sustainable than G-2, G-3, and G-5. | Would be moderately sustainable. Consumes energy and resources, and generates GHG and wastes. Slight increase in traffic and noise. Less sustainable than G-2. More sustainable than G-3 and G-4. | Would be moderately to highly sustainable. Consumes energy and resources, and generates GHG and wastes during PRB installation. Slight increase in traffic and noise during construction periods. |
| Costs: | | | | | | |
| Capital | $0 | $12,000,000 | $12,900,000 | $13,100,000 | $14,000,000 | $13,300,000 |
| NPW of Annual Costs | $0 | $8,200,000 (30-Year) | $8,600,000 (30-Year) | $11,700,000 (30-Year) | $8,800,000 (30-Year) | $5,700,000 (30-Year) |
| NPW | $0 | $20,200,000 (30-Year) | $21,500,000 (30-Year) | $24,800,000 (30-Year) | $22,800,000 (30-Year) | $19,000,000 (30-Year) |
| Current Value | $0 | $37,000,000 | $38,700,000 | $46,900,000 | $40,000,000 | $33,500,000 |

ARAR - Applicable or Relevant and Appropriate Requirement.
COC - Chemical of concern.
DRO - Diesel range organics
GHG - Greenhouse gas.
GRO - gasoline range organics.
HCA - High concentration Area.
LUCs - Land use control.
NPW - Net present worth.
O&M - Operation and maintenance.
POTW - Publicly owned treatment works.
PRB - Permeable reactive barrier.
RAO - Remedial Action Objective.
RCRA - Resource Conservation and Recovery Act.
TSDF - Treatment, storage, and disposal facility.
VOC - Volatile organic compound.

# Section 6
# Future Actions

Implementation of the selected groundwater interim remedial action and subsequent final remedies for groundwater and soil/landfill waste at the DRA Site at Martin State Airport will require the following steps:

- The final version of the FS and a subsequent Proposed Plan for the groundwater interim remedial action will be submitted to the MDE for their review and approval. Requirements for subsequent document submittal will be described in a Consent Order for the site, once it has been completed. A Proposed Plan summarizing this feasibility study and identifying the selected alternative will then be prepared and distributed for public review.

- Design of the containment portion of Alternative G-3.

- Conduct additional investigations in the high concentration areas, including the vicinity of DMW-11S, Pond 1, the Drum Area, and the vicinity of boring PA-7.

- The containment portion of the interim remedial action for groundwater will be installed and operated and will initially discharge to the publicly owned treatment works. After that discharge has been fully characterized, a permit to discharge treated water to surface water will be obtained. The reinjection portion of the remedy will be installed in coordination with the final soil/landfill waste and groundwater remedies.

- The soil/landfill waste FS and final Groundwater FS will be completed in consultation with Maryland Aviation Administration (MAA) and Maryland Air National Guard (MDANG) and will be submitted for approval by MDE. What, if any, additional groundwater remedy is required will be determined at that time.

- Final remedies for site groundwater and soil/landfill waste will be designed and coordinated to eliminate potential interferences.

- The final groundwater and soil/landfill waste remedies will be implemented once the designs are complete.

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# Section 7
# References


1. Andreasen, D. C., 2007. "Optimization of Ground-Water Withdrawals in Anne Arundel County, Maryland, from the Upper Patapsco, Lower Patapsco, and Patuxent Aquifers Projected through 2044." *Maryland Geologic Survey Report of Investigations No. 77*.

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5. Glaser, J. D., 1969. "Petrology and Origin of Potomac and Magothy (Cretaceous) Sediments, Middle Atlantic Coastal Plain." *Maryland Geological Survey Reports of Investigations No. 11*. Maryland Geological Survey.

6. Hansen, H. J., 1969. "A Geometric Method to Subdivide the Patapsco Formation of Southern Maryland into Informal Mapping Units for Hydrogeologic Use." *Geological Society of America Bulletin.* Vol. 80, No. 2.

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8. Tetra Tech, 2010a. *Groundwater Monitoring Report August–September 2009, Martin State Airport, Middle River, Maryland*. January.

9. Tetra Tech, 2010b. *Remedial Investigation Report, Martin State Airport, Middle River, Maryland*. May.

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# APPENDIX A
# SELECTED RI FIGURES AND TABLES

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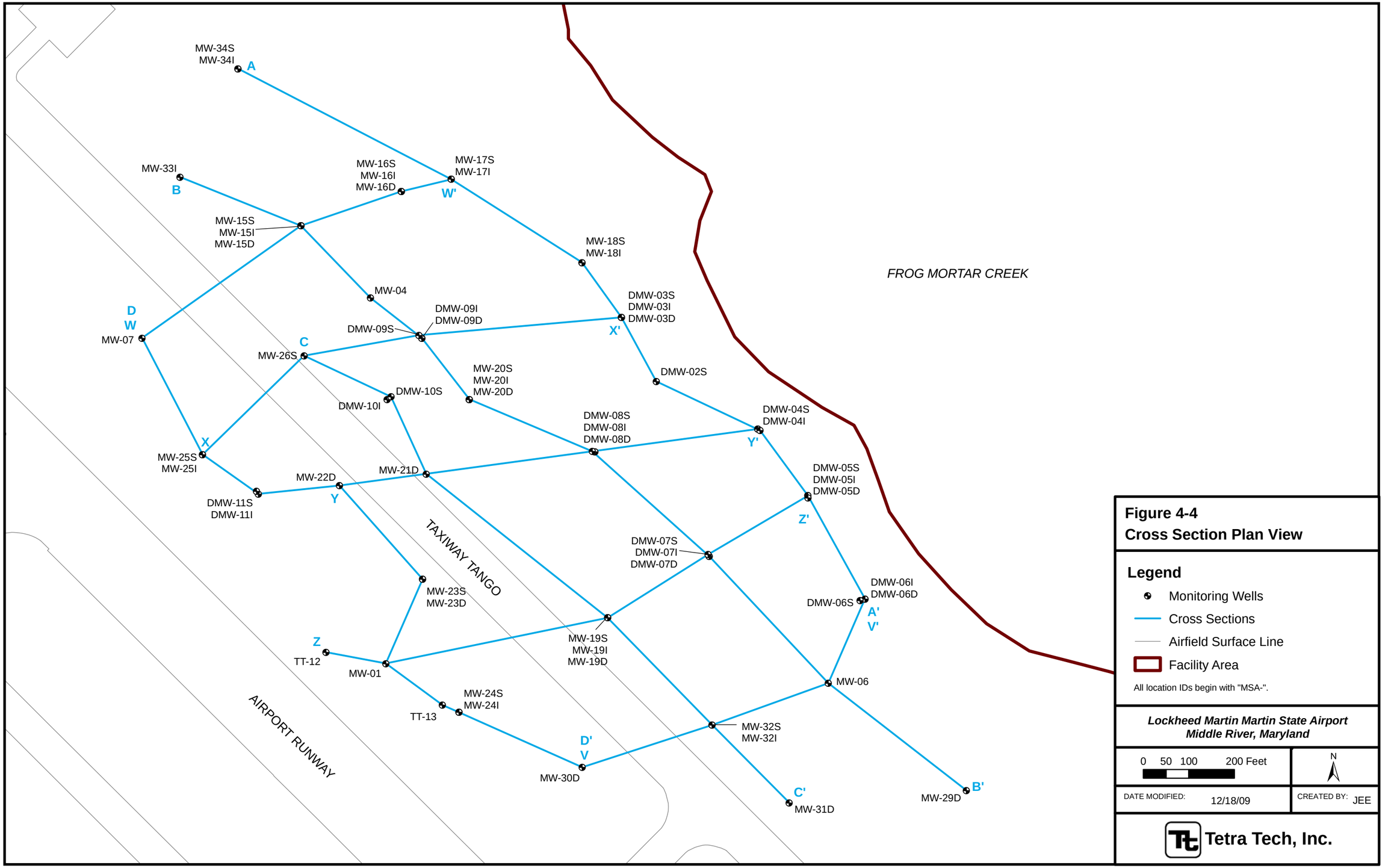


**Figure 4-4**
**Cross Section Plan View**

**Legend**

- Monitoring Wells
- Cross Sections
- Airfield Surface Line
- Facility Area

All location IDs begin with "MSA-".

***Lockheed Martin Martin State Airport***
***Middle River, Maryland***

0 50 100 200 Feet

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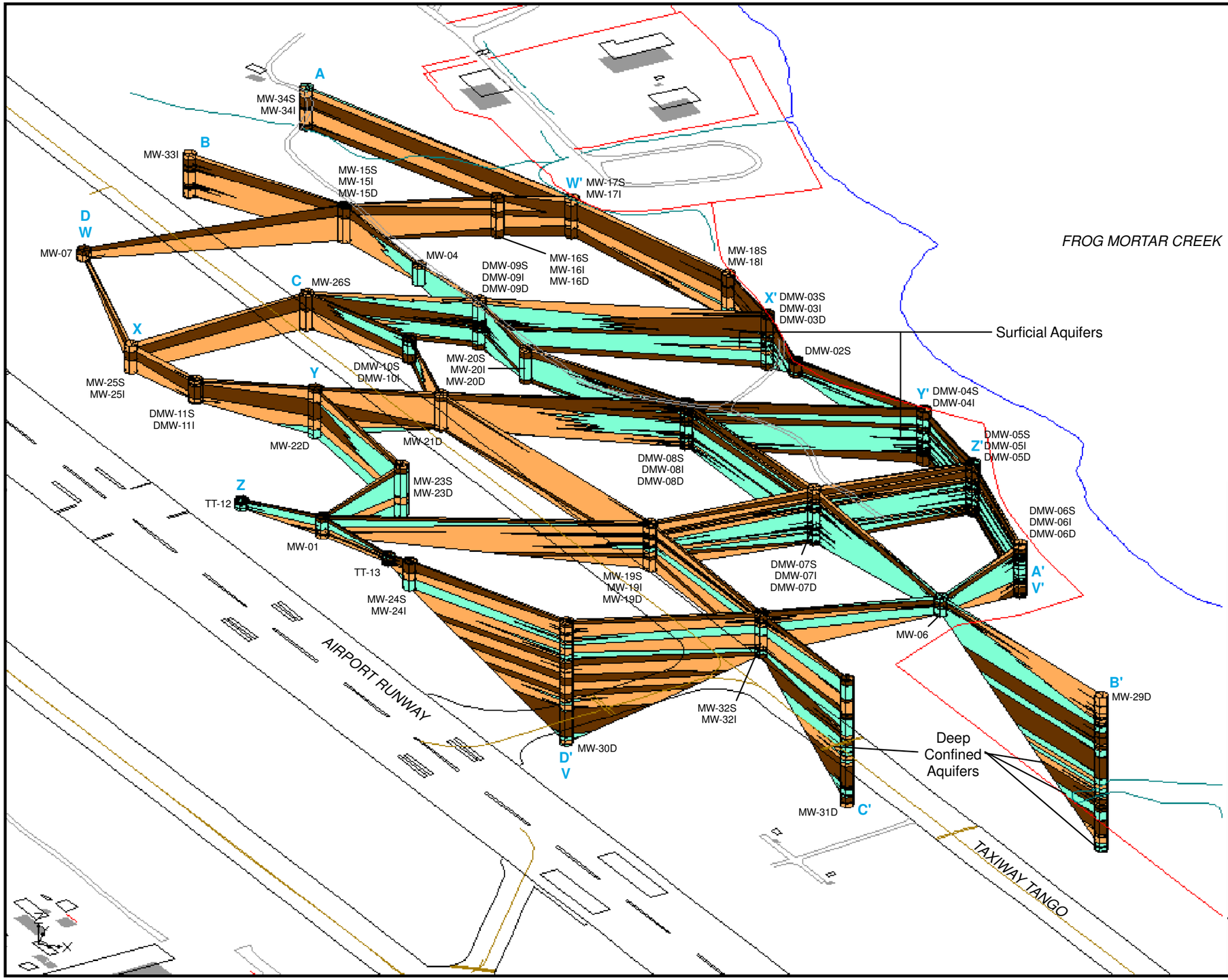


**Figure 4-5**
**Fence Diagram**

## Legend

### Materials

- Higher Permeability (typically >10 ft/day): Sand and sand & gravel
- Medium Permeability (typically 1-10 ft/day): Mixture of sand, silt, and/or some clay
- Lower Permeability (typically <1 ft/day): Clay and silt & clay

Hydrostratigraphic units were interpreted from lithology information of boring logs and slug test results.

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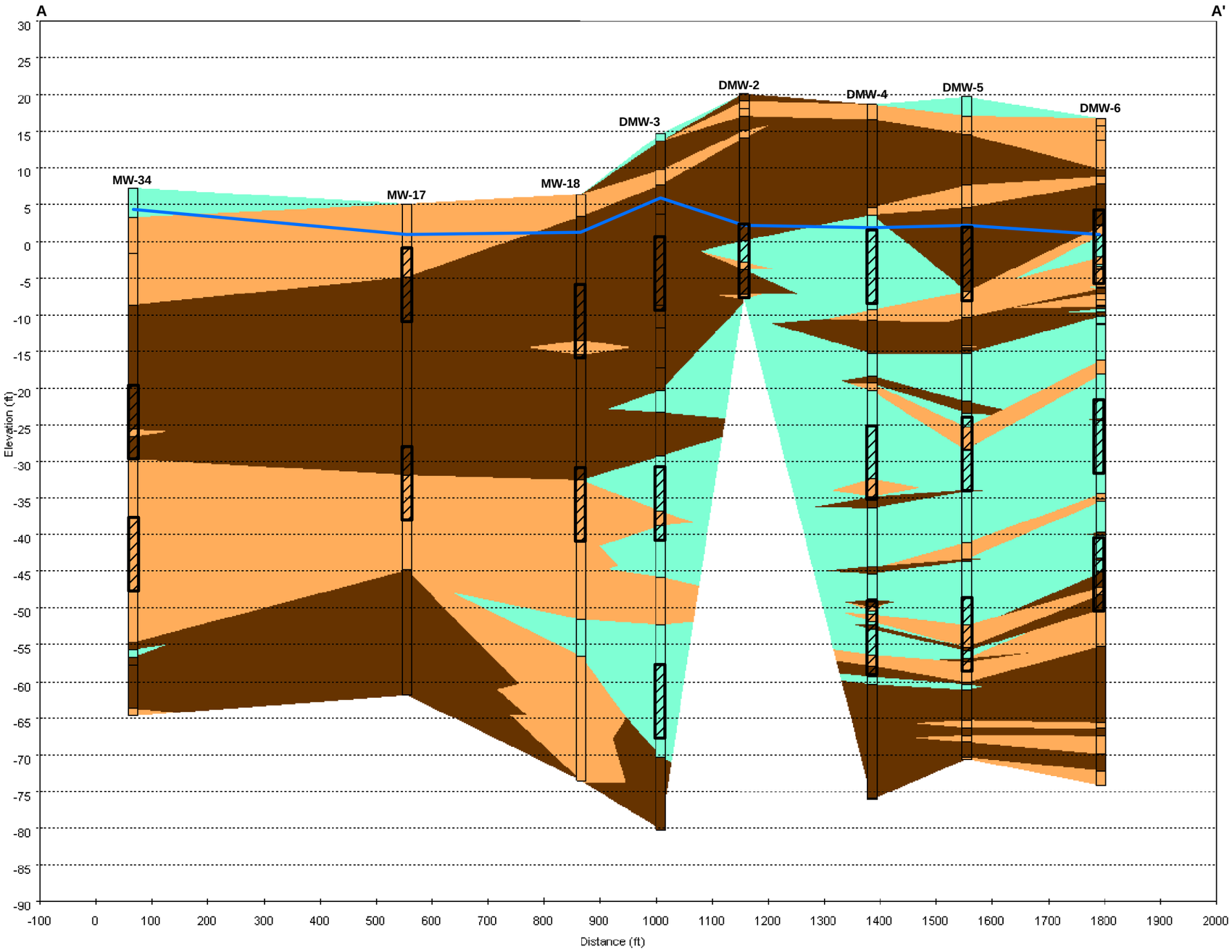


**Figure 4-6**
**Hydrostratigraphic Cross Section**
**Transect A-A'**

**Legend**

- Well Screen
- Soil / Well Boring
- Groundwater Surface

**Materials**

- Higher Permeability (typically >10 ft/day): Sand and sand & gravel
- Medium Permeability (typically 1-10 ft/day): Mixture of sand, silt, and/or some clay
- Lower Permeability (typically <1 ft/day): Clay and silt & clay

Hydrostratigraphic units were interpreted from lithology information of boring logs and slug test results.

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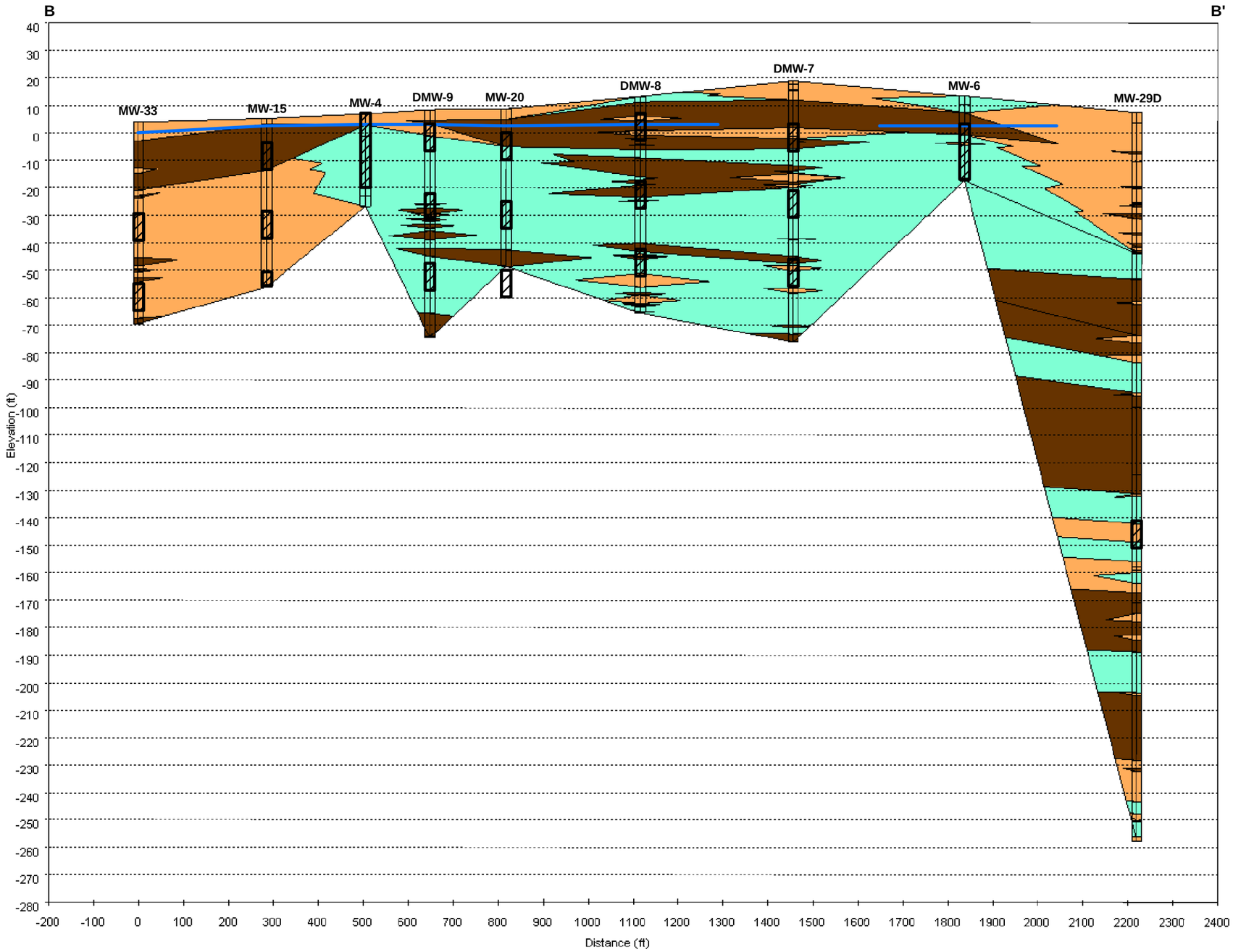


**Figure 4-7**
**Hydrostratigraphic Cross Section**
**Transect B-B'**

**Legend**

- Well Screen
- Soil / Well Boring
- Groundwater Surface

**Materials**

- Higher Permeability (typically >10 ft/day): Sand and sand & gravel
- Medium Permeability (typically 1-10 ft/day): Mixture of sand, silt, and/or some clay
- Lower Permeability (typically <1 ft/day): Clay and silt & clay

Hydrostratigraphic units were interpreted from lithology information of boring logs and slug test results.

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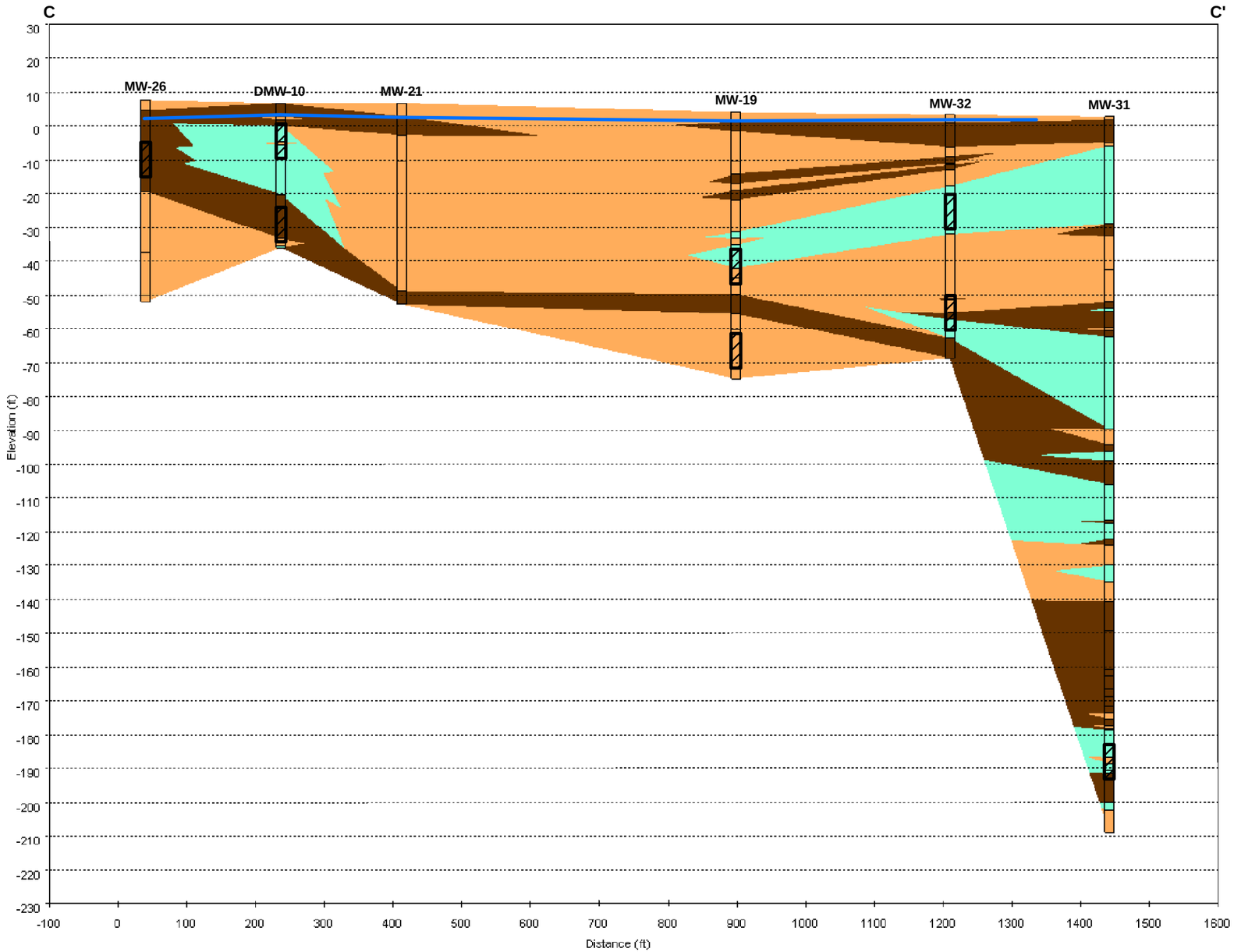


**Figure 4-8**
**Hydrostratigraphic Cross Section**
**Transect C-C'**

**Legend**

- Well Screen
- Soil / Well Boring
- Groundwater Surface

**Materials**

- Higher Permeability (typically >10 ft/day): Sand and sand & gravel
- Medium Permeability (typically 1-10 ft/day): Mixture of sand, silt, and/or some clay
- Lower Permeability (typically <1 ft/day): Clay and silt & clay

Hydrostratigraphic units were interpreted from lithology information of boring logs and slug test results.

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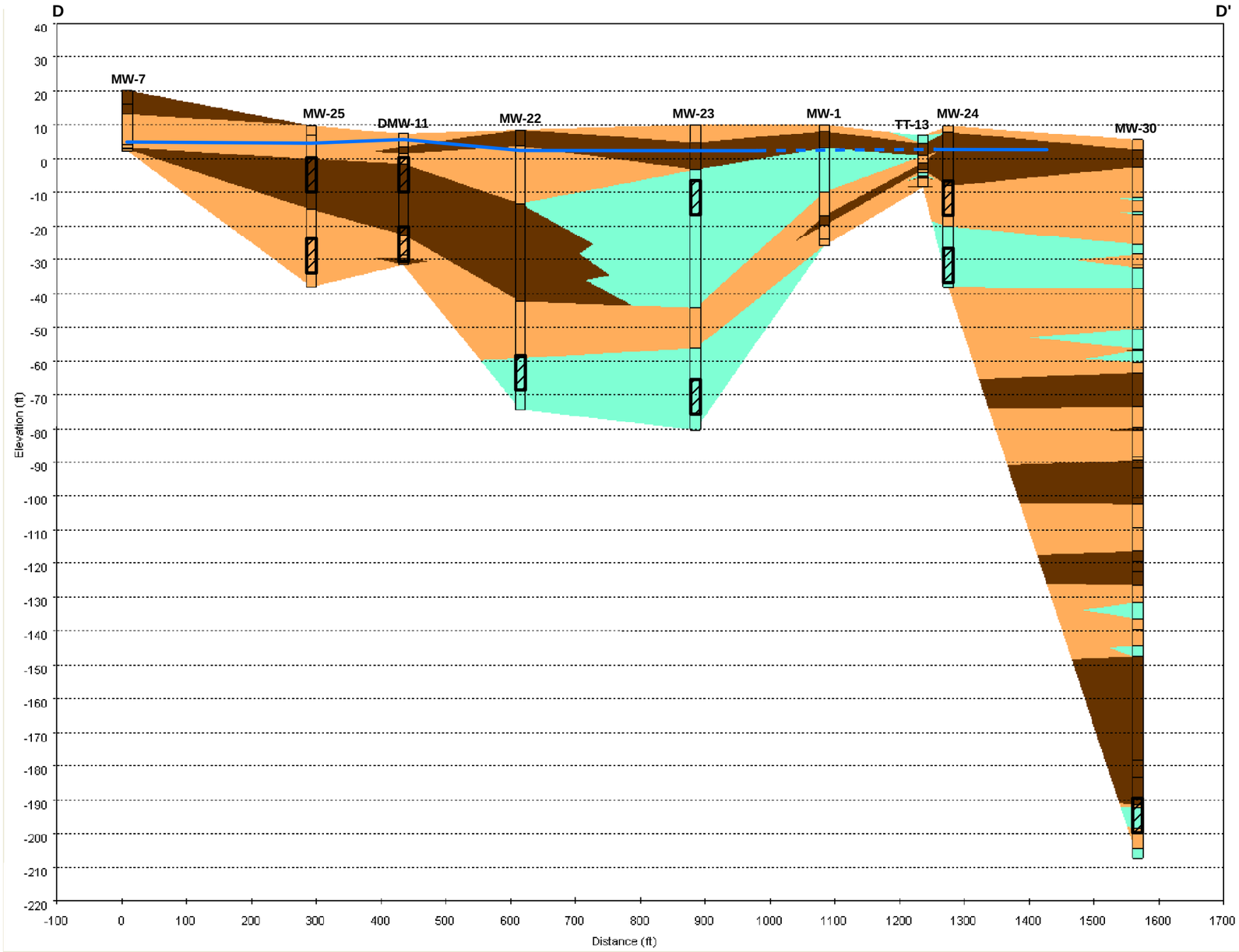


**Figure 4-9**
**Hydrostratigraphic Cross Section**
**Transect D-D'**

**Legend**

- Well Screen
- Soil / Well Boring
- Groundwater Surface (Dashed Where Inferred)

**Materials**

- Higher Permeability (typically >10 ft/day): Sand and sand & gravel
- Medium Permeability (typically 1-10 ft/day): Mixture of sand, silt, and/or some clay
- Lower Permeability (typically <1 ft/day): Clay and silt & clay

Hydrostratigraphic units were interpreted from lithology information of boring logs and slug test results.

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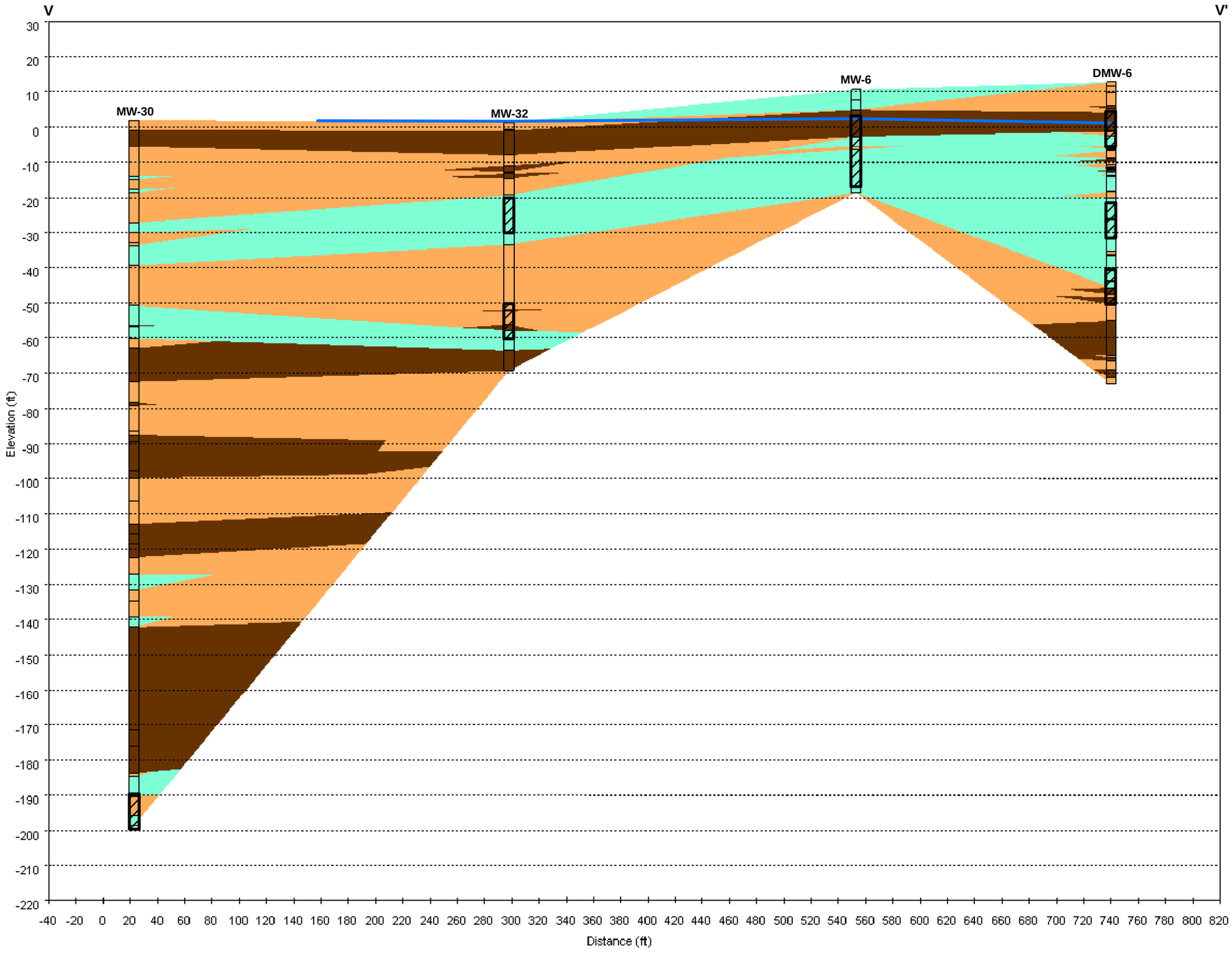


**Figure 4-10**
**Hydrostratigraphic Cross Section**
**Transect V-V'**

**Legend**

- Well Screen
- Soil / Well Boring
- Groundwater Surface

**Materials**

- Higher Permeability (typically >10 ft/day): Sand and sand & gravel
- Medium Permeability (typically 1-10 ft/day): Mixture of sand, silt, and/or some clay
- Lower Permeability (typically <1 ft/day): Clay and silt & clay

Hydrostratigraphic units were interpreted from lithology information of boring logs and slug test results.

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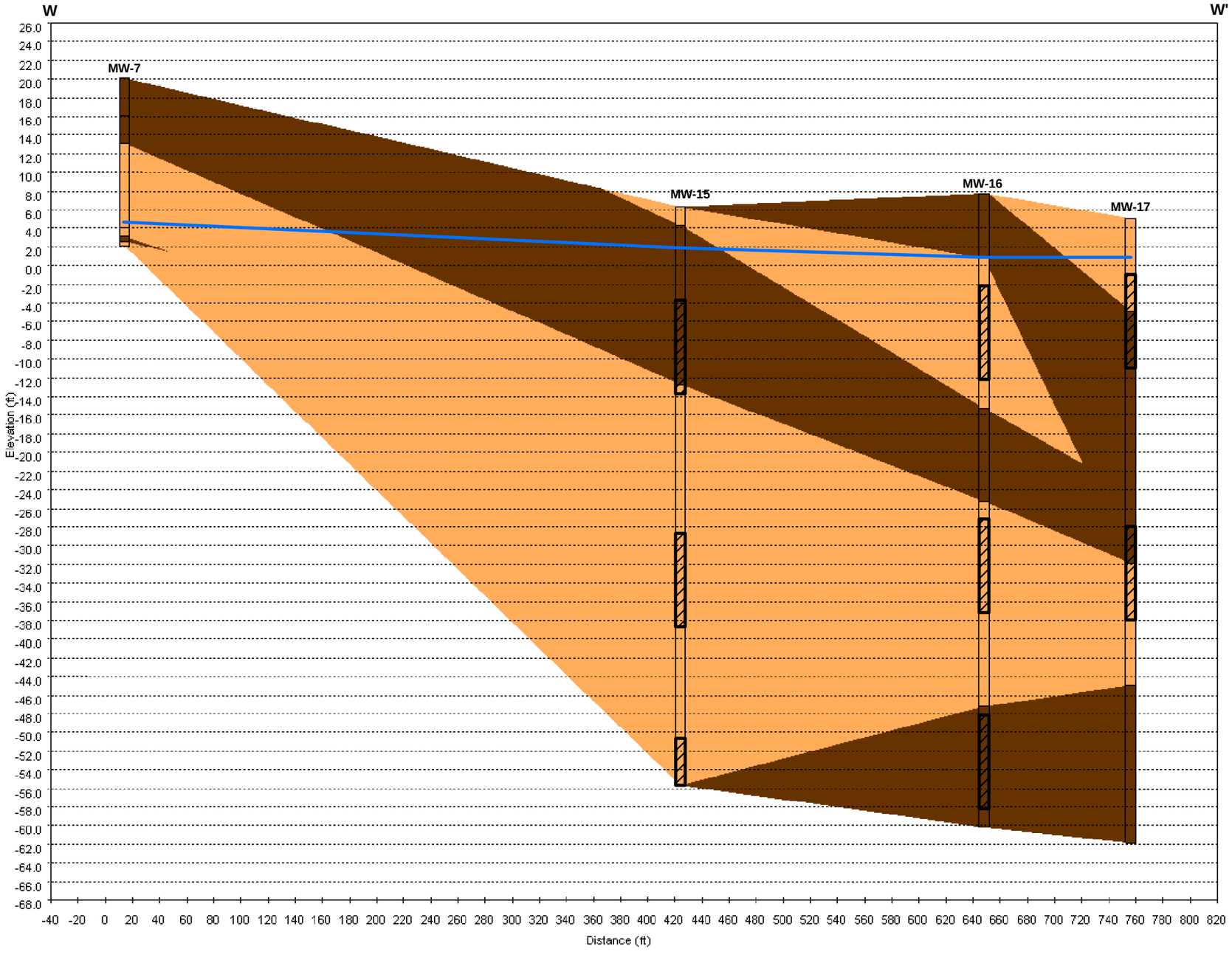


**Figure 4-11**
**Hydrostratigraphic Cross Section**
**Transect W-W'**

## Legend

- Well Screen
- Soil / Well Boring
- Groundwater Surface

**Materials**

- Higher Permeability (typically >10 ft/day): Sand and sand & gravel
- Medium Permeability (typically 1-10 ft/day): Mixture of sand, silt, and/or some clay
- Lower Permeability (typically <1 ft/day): Clay and silt & clay

Hydrostratigraphic units were interpreted from lithology information of boring logs and slug test results.

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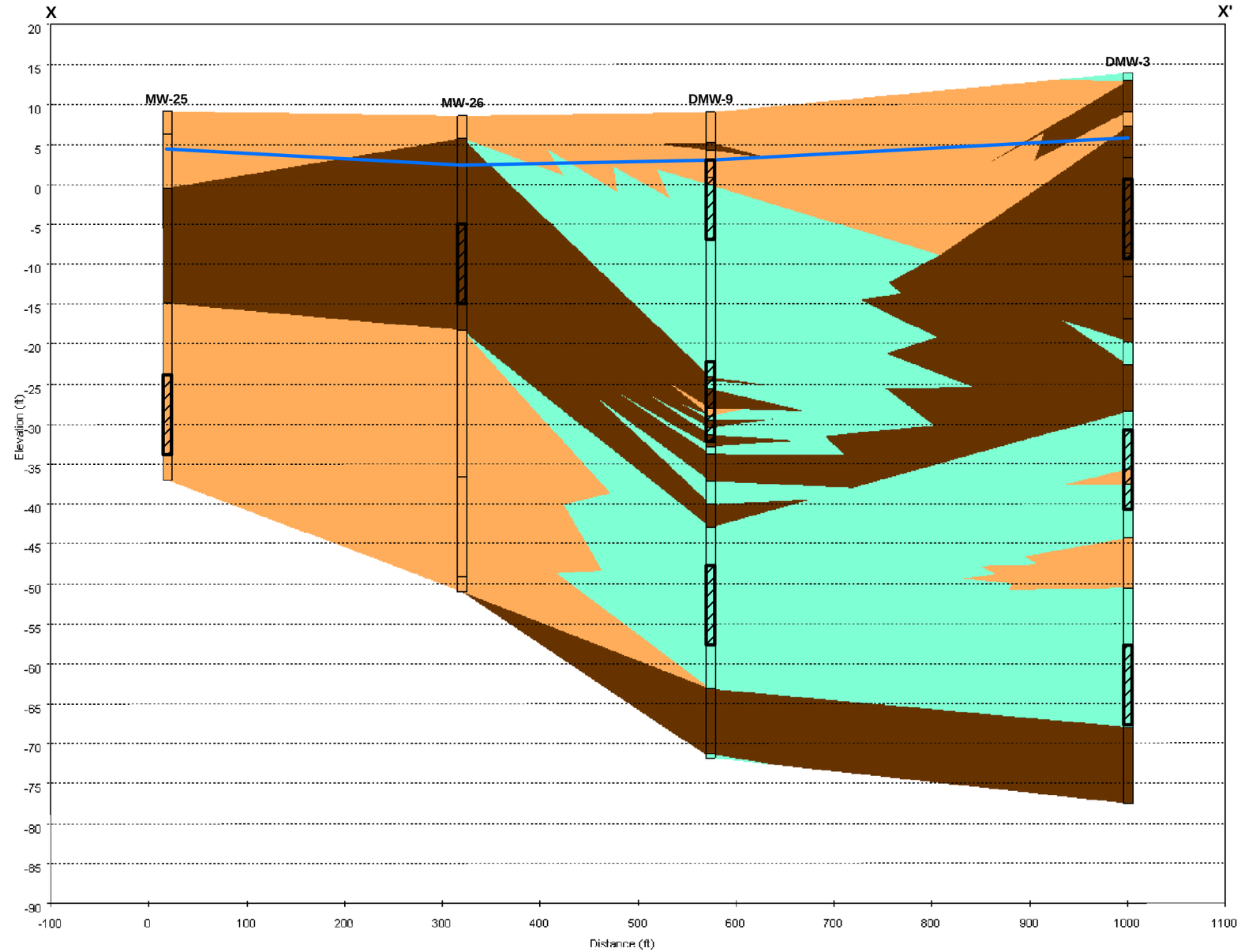


**Figure 4-12**
**Hydrostratigraphic Cross Section**
**Transect X-X'**

**Legend**

- Well Screen
- Soil / Well Boring
- Groundwater Surface

**Materials**

- Higher Permeability (typically >10 ft/day): Sand and sand & gravel
- Medium Permeability (typically 1-10 ft/day): Mixture of sand, silt, and/or some clay
- Lower Permeability (typically <1 ft/day): Clay and silt & clay

Hydrostratigraphic units were interpreted from lithology information of boring logs and slug test results.

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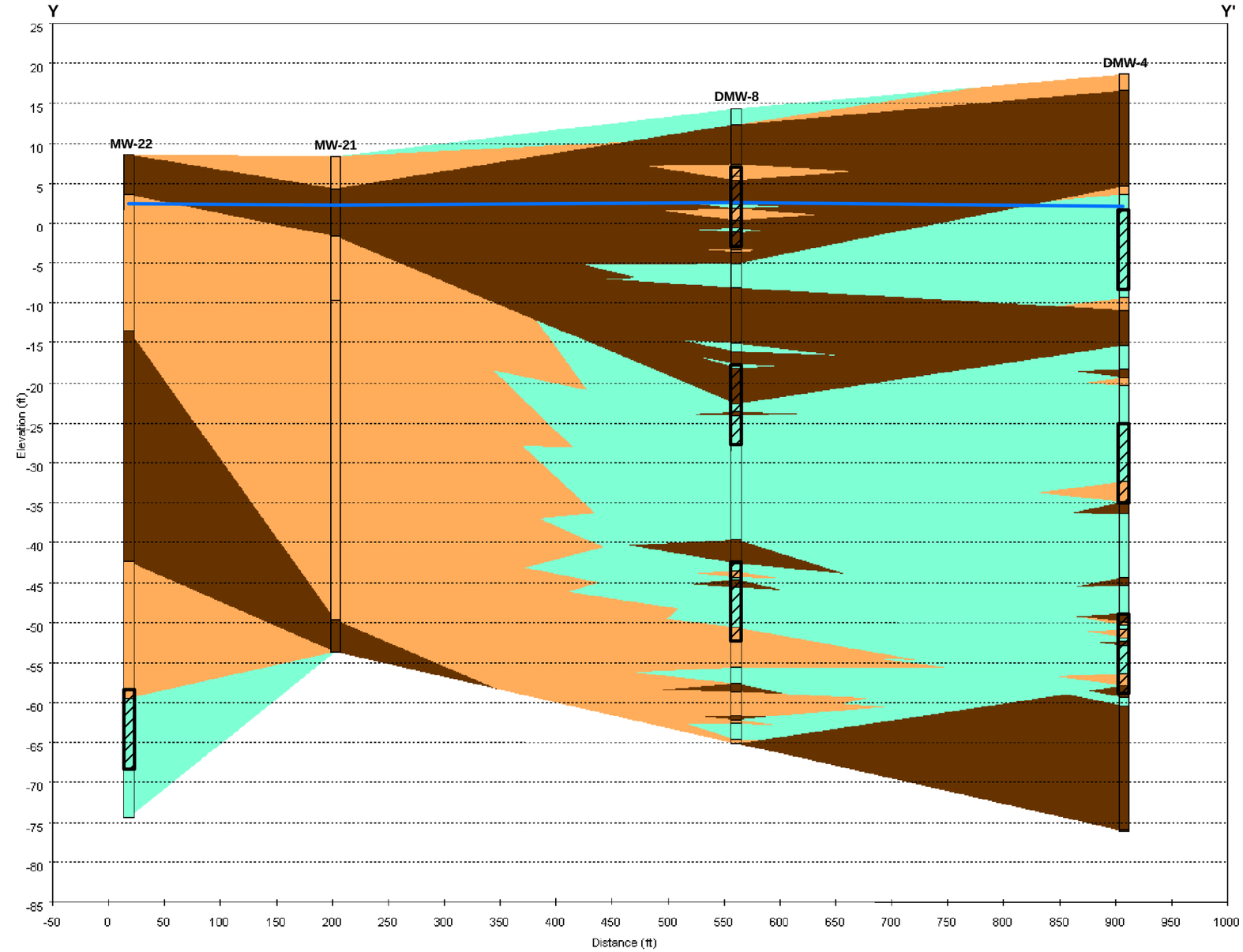


**Figure 4-13**
**Hydrostratigraphic Cross Section**
**Transect Y-Y'**

**Legend**

- Well Screen
- Soil / Well Boring
- Groundwater Surface

**Materials**

- Higher Permeability (typically >10 ft/day): Sand and sand & gravel
- Medium Permeability (typically 1-10 ft/day): Mixture of sand, silt, and/or some clay
- Lower Permeability (typically <1 ft/day): Clay and silt & clay

Hydrostratigraphic units were interpreted from lithology information of boring logs and slug test results.

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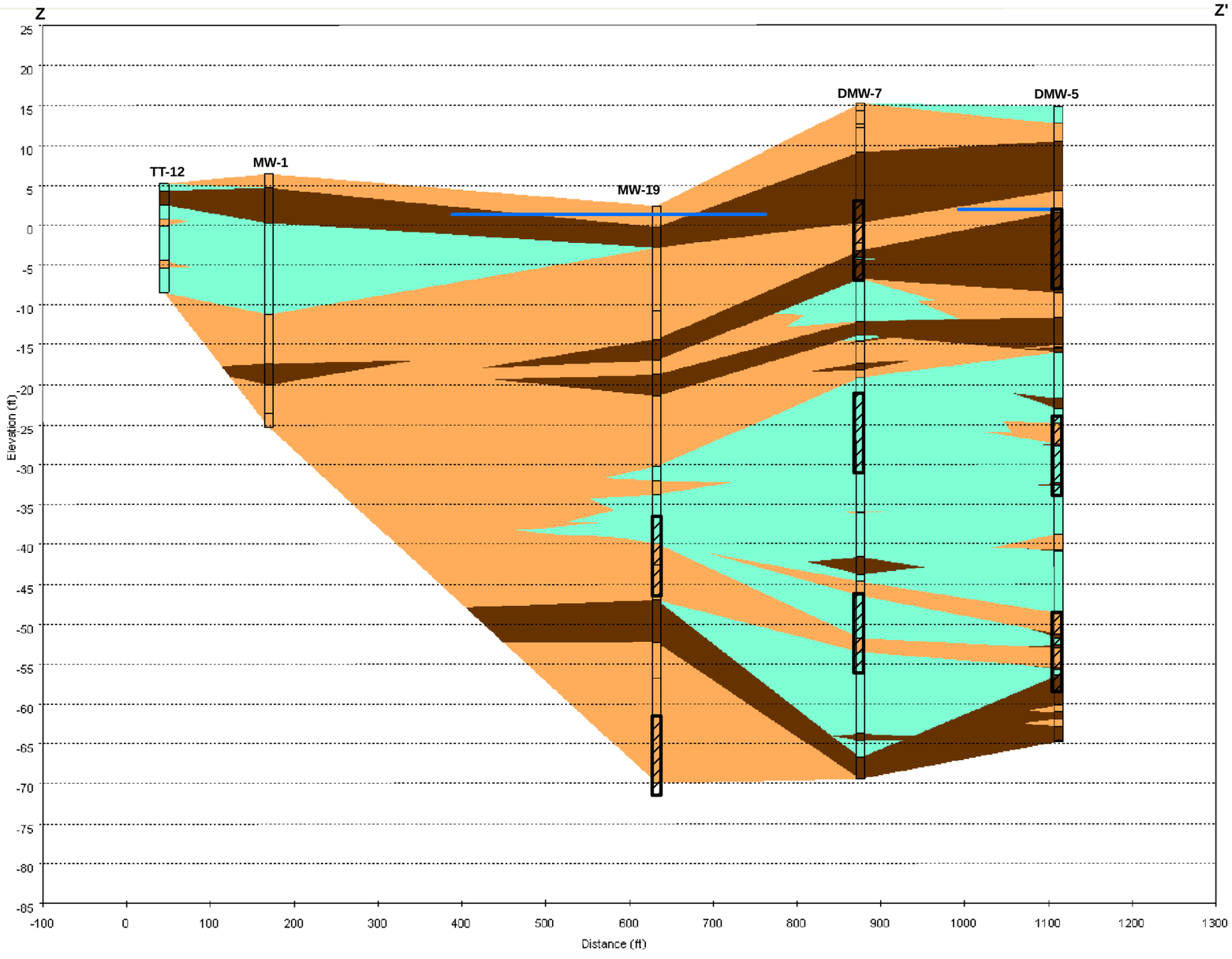


**Figure 4-14**
**Hydrostratigraphic Cross Section**
**Transect Z-Z'**

## Legend

- Well Screen
- Soil / Well Boring
- Groundwater Surface

**Materials**

- Higher Permeability (typically >10 ft/day): Sand and sand & gravel
- Medium Permeability (typically 1-10 ft/day): Mixture of sand, silt, and/or some clay
- Lower Permeability (typically <1 ft/day): Clay and silt & clay

Hydrostratigraphic units were interpreted from lithology information of boring logs and slug test results.

***Lockheed Martin Martin State Airport***
***Middle River, Maryland***

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MW34S
MW34I
MARYLAND AIR NATIONAL GUARD
Conrad's Ruth Villa
MW33S
MW33I
Gate
MW28I
MW27D
MW16S
MW16I
MW16D
MW17S
MW17I
MW17D
Gate
MW14I
MW14D
POND #2
MW15S
MW15I
MW15D
MW18S
MW18I
MW18D
FROG MORTAR CREEK
MW4
PETROLEUM HYDRO-CARBON AREA
MW7
MW26S
MW26I
MW26D
DMW9S
DMW9I
DMW9D
POND #1
DMW3S
DMW3I
DMW3D
DMW2A
DMW2B
RW1I
OW1I
RW1I
OW1I
DMW2S
DMW10S
DMW10I
MW20S
MW20I
MW20D
DMW8S
DMW8I
DMW8D
DMW4S
DMW4I
DMW4D
MW25S
MW25I
MW3
MW21I
MW21D
MW22I
MW22D
DMW1S
DMW5S
DMW5I
DMW5D
DMW11S
DMW11I
DMW1A
DMW1B
MW23S
MW23I
MW23D
MW5
DMW7S
DMW7I
DMW7D
DRUM AREA
DMW6S
DMW6I
DMW6D
MW19I
MW19D
MW2
MW1
AIRPORT RUNWAY
TAXIWAY TANGO
Gate
MW6
MW24S
MW24I
MW32S
MW32I
MW30D
MW29D
MW31D

**Figure 5-14**
**CVOC Concentrations in Groundwater**
**(2007-2009 Maximum Concentration)**

## Legend

- Groundwater Well Location
- Ponds
- 0 - 5
- >=5 - 50
- >=50 - 500
- >=500 - 5000
- >= 5000

Ranges are based on Micrograms Per Liter (ug/l)

***Lockheed Martin Martin State Airport***
***Middle River, Maryland***

0 50 100 200 Feet

N

DATE MODIFIED: 12/12/09

CREATED BY: BJ

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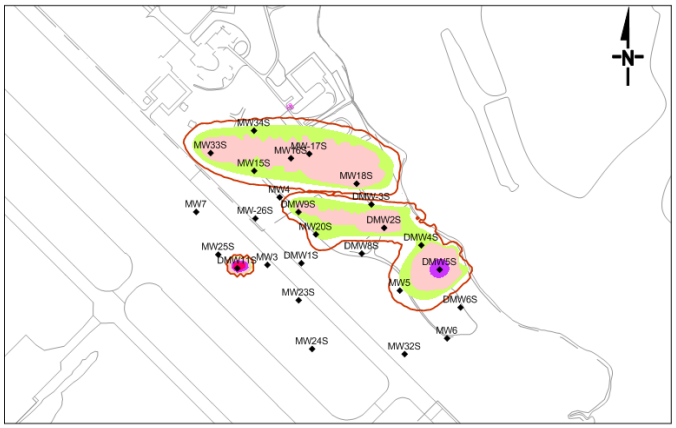
# Figure 5-15
# Contour Plots of TCE for the Upper, Intermediate, and Lower Surficial Aquifers - August - September 2009
# Lockheed Martin, Martin State Airport, Middle River Maryland

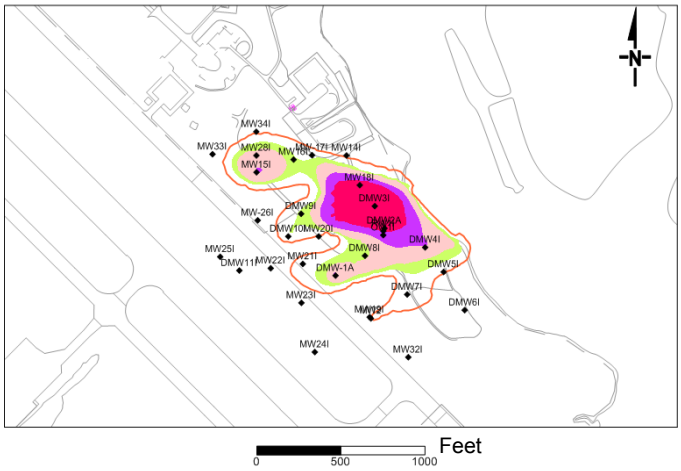
TCE - Upper Surficial Aquifer



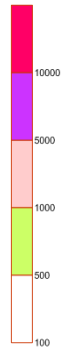

TCE Concentration ug/L



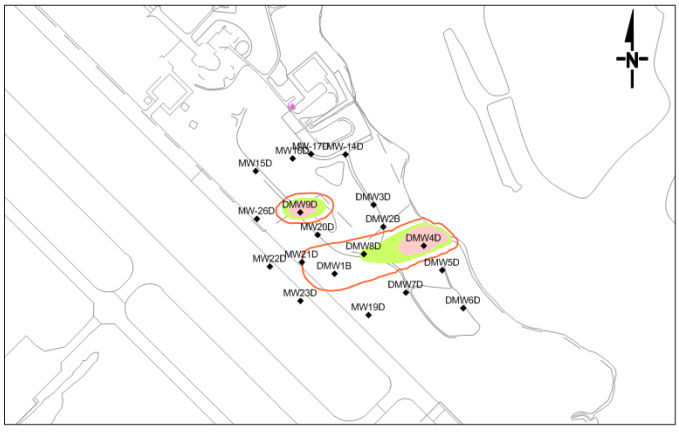

TCE - Intermediate Surficial Aquifer



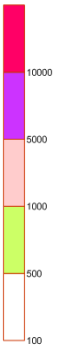

TCE Concentration ug/L




TCE - Lower Surficial Aquifer

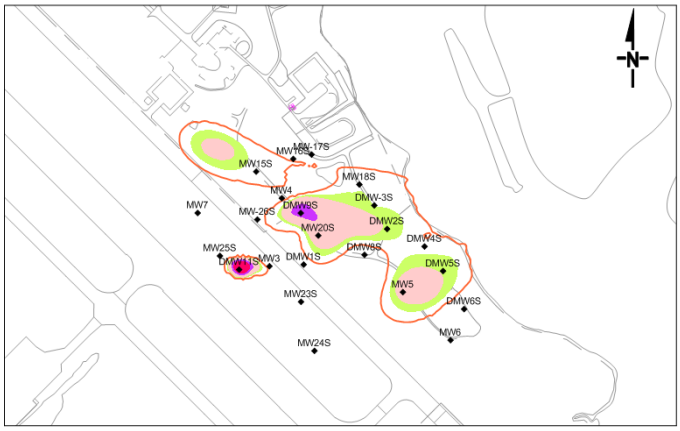



TCE Concentration ug/L



# Figure 5-16
# Contour Plots of cDCE for the Upper, Intermediate, and Lower Surficial Aquifers - August - September 2009
# Lockheed Martin, Martin State Airport, Middle River Maryland

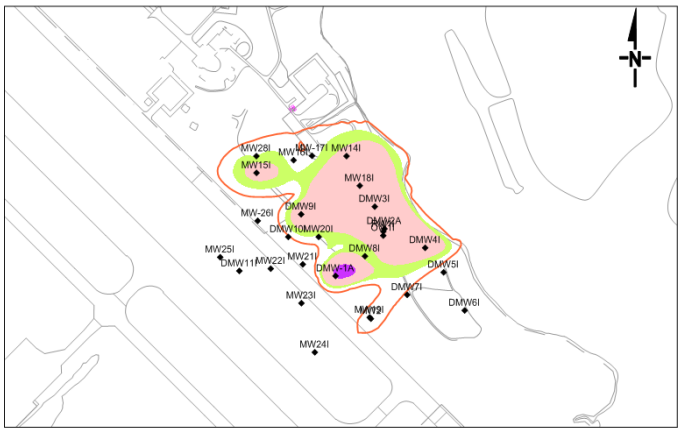
CIS-1,2-DCE - Upper Surficial Aquifer




cDCE Concentration ug/L

10000
5000
1000
500
100

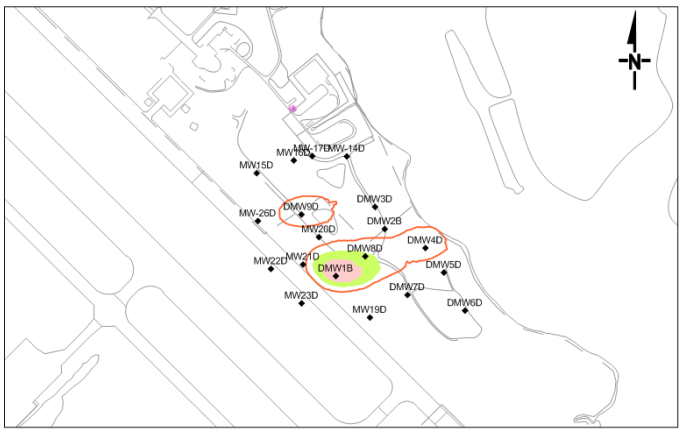
CIS-1,2-DCE - Intermediate Surficial Aquifer




cDCE Concentration ug/L

10000
5000
1000
500
100

CIS-1,2-DCE - Lower Surficial Aquifer

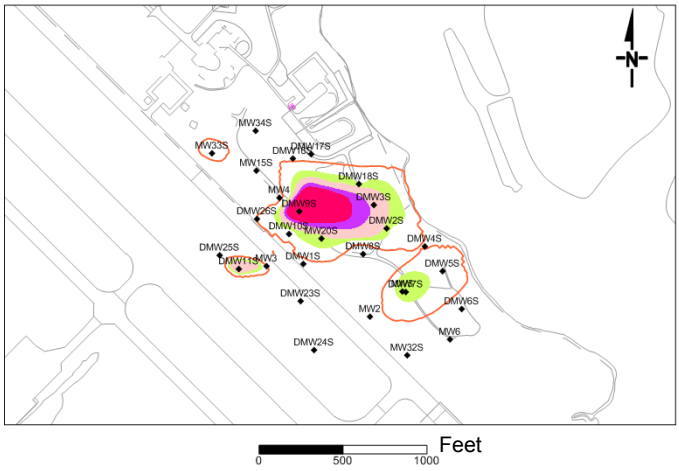



cDCE Concentration ug/L

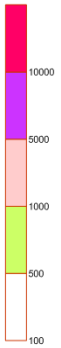
10000
5000
1000
500
100

# Figure 5-17
# Contour Plots of Vinyl Chloride for the Upper, Intermediate, and Lower Surficial Aquifers - August - September 2009
# Lockheed Martin, Martin State Airport, Middle River Maryland

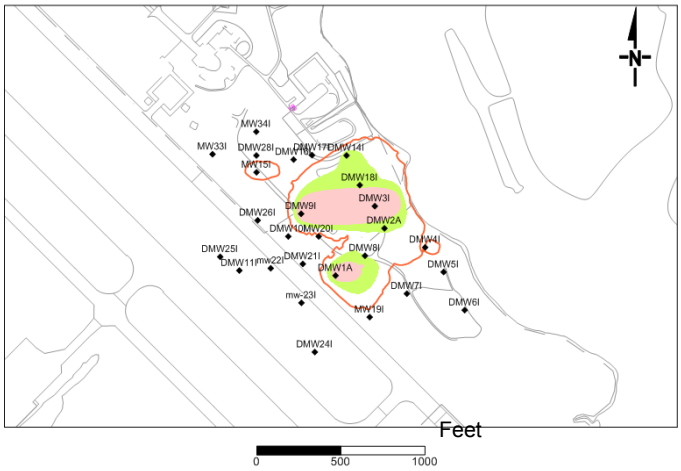
VINYL CHLORIDE - Upper Surficial Aquifer



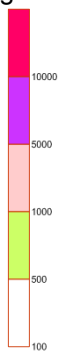

Vinyl Chloride Concentration ug/L



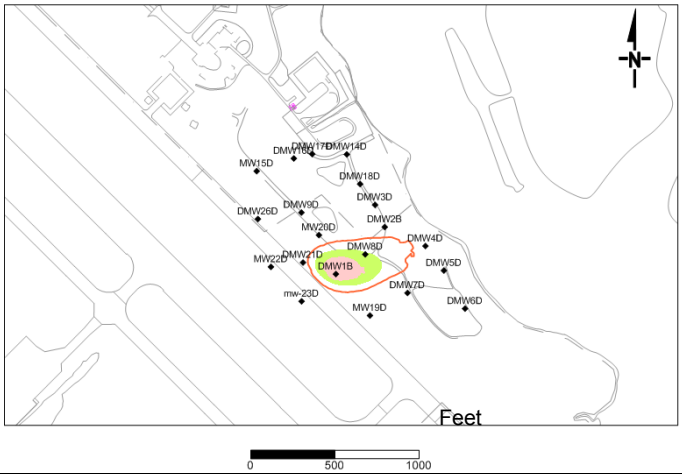

VINYL CHLORIDE - Intermediate Surficial Aquifer



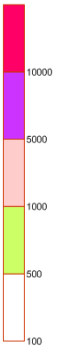

Vinyl Chloride Concentration ug/L




VINYL CHLORIDE - Lower Surficial Aquifer




Vinyl Chloride Concentration ug/L



Map Document: (K:\GProject\MartinStateAirport-LMC\MapDocs\MXD\Maps\BTEX Max 2007-2009.mxd)
12/23/2009 -- 10:08:20 AM

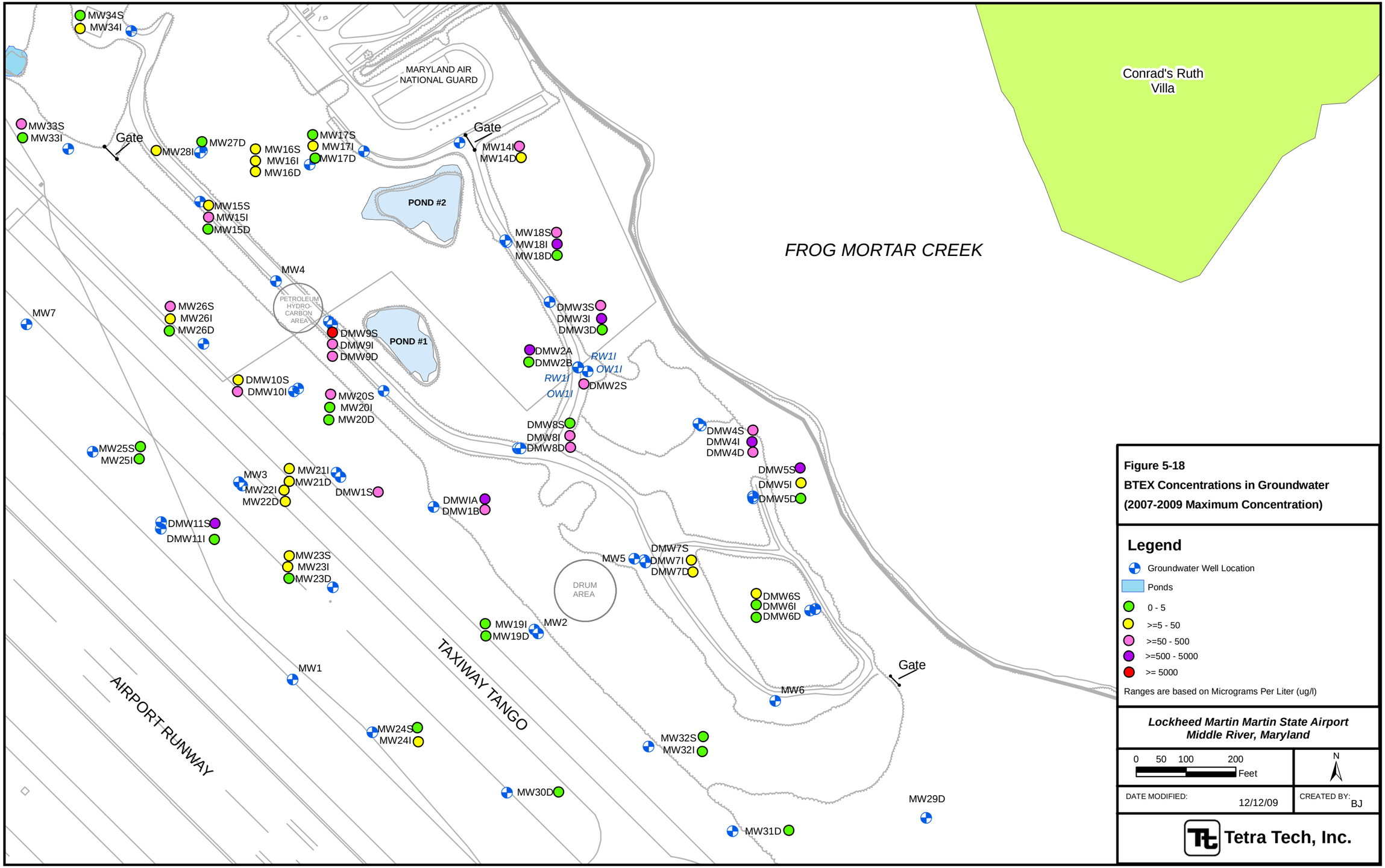



**Figure 5-18**
**BTEX Concentrations in Groundwater**
**(2007-2009 Maximum Concentration)**

## Legend

- Groundwater Well Location
- Ponds
- 0 - 5
- >=5 - 50
- >=50 - 500
- >=500 - 5000
- >= 5000

Ranges are based on Micrograms Per Liter (ug/l)

***Lockheed Martin Martin State Airport***
***Middle River, Maryland***

0 50 100 200 Feet

N

DATE MODIFIED: 12/12/09

CREATED BY: BJ

Tetra Tech, Inc.

Map Document: (K:\GProject\MartinStateAirport-LMC\MapDocs\MXD\Maps\DIOXANE1, 4 Max 2007-2009.mxd)
3/9/2012 -- 4:05:46 PM

MW34S
MW34I
MW33S
MW33I
Gate
MW28I
MW27D
MW16S
MW16I
MW16D
MW17S
MW17I
MW17D
MARYLAND AIR NATIONAL GUARD
MW14I
MW14D
Gate
Conrad's Ruth Villa
POND #2
MW15S
MW15I
MW15D
MW18S
MW18I
MW18D
FROG MORTAR CREEK
MW4
PETROLEUM HYDRO-CARBON AREA
MW7
MW26S
MW26I
MW26D
DMW9S
DMW9I
DMW9D
POND #1
DMW3S
DMW3I
DMW3D
DMW2A
DMW2B
RW1S
OW1I
RW1I
OW1I
DMW2S
DMW10S
DMW10I
MW20S
MW20I
MW20D
DMW8S
DMW8I
DMW8D
DMW4S
DMW4I
DMW4D
DMW5S
DMW5I
DMW5D
MW25S
MW25I
MW21I
MW21D
MW3
MW22I
MW22D
DMW1S
DMW1A
DMW1B
DMW11S
DMW11I
MW23S
MW23I
MW23D
MW5
DMW7S
DMW7I
DMW7D
DRUM AREA
DMW6S
DMW6I
DMW6D
MW19I
MW19D
MW2
TAXIWAY TANGO
AIRPORT RUNWAY
MW1
Gate
MW6
MW24S
MW24I
MW32S
MW32I
MW30D
MW29D
MW31D

**Figure 5-23**
**1,4-Dioxane Concentrations in Groundwater**
**(2007-2009 Maximum Concentration)**

**Legend**

- Non Detect (DL <= 0.67 ug/l)
- Non Detect (DL > 0.67 ug/l; 1 or 1.3 ug/l))
- 0-0.67 (EPA RSL Tapwater; Risk= 1 E-06)
- >0.67-6.7 (1 E-05)
- >6.7-67 (1 E-04)
- >67 (>1 E-04)
- Groundwater Well Locations

Ranges are in Micrograms Per Liter (ug/l)
Risk levels (e.g., 1E-04) are in parentheses

DL= Detection Limit

***Lockheed Martin Martin State Airport***
***Middle River, Maryland***

0 50 100 200 Feet

N

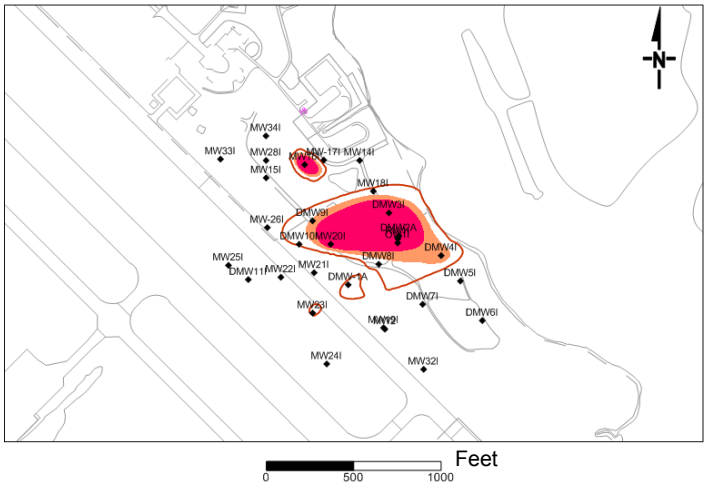
DATE MODIFIED: 3/9/12

CREATED BY: LR

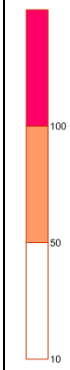
Tetra Tech, Inc.

# Figure 5-24
# Contour Plots of 1,4-Dioxane for the Upper, Intermediate, and Lower Surficial Aquifers – August - September 2009
# Lockheed Martin, Martin State Airport, Middle River Maryland

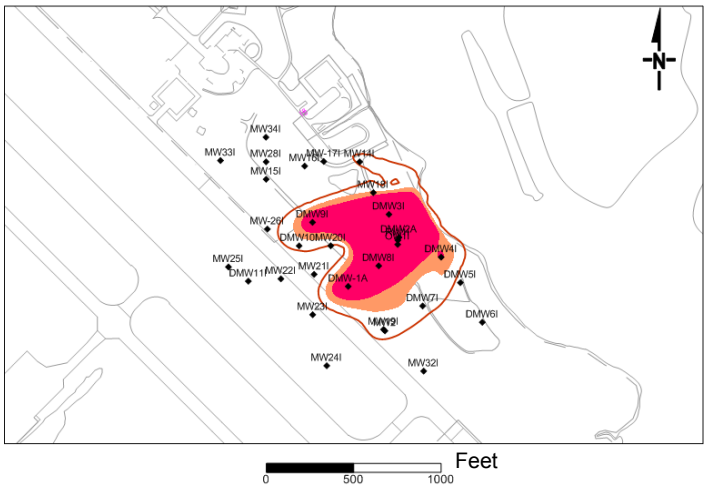
1,4 dioxane - Upper Surficial Aquifer



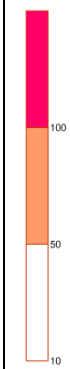

1,4 dioxane Concentration ug/L



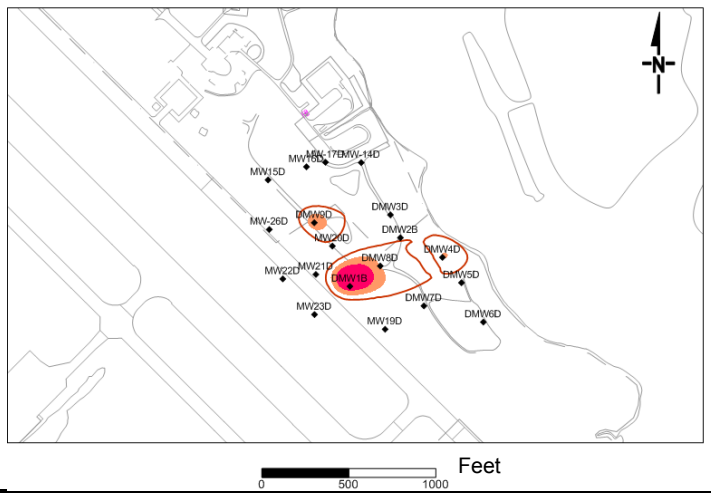

1,4 dioxane - Intermediate Surficial Aquifer




1,4 dioxane Concentration ug/L




1,4 dioxane - Lower Surficial Aquifer




1,4 dioxane Concentration ug/L

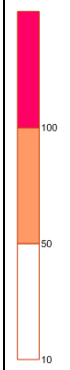


**Table 4-3**

**Groundwater Levels and Elevations, Dump Road Area**
**Lockheed Martin Martin State Airport, Middle River, Maryland**


| Well ID | Aquifer Level | Elevation[1] Top of Well Casing NAVD88 Feet | Depth to Groundwater Top of Well Casing 10/14/2003 Feet | Groundwater Elevation[1] NAVD88 10/14/2003 Feet | Depth to Groundwater Top of Well Casing 12/1/2003 Feet | Groundwater Elevation[1] NAVD88 12/1/2003 Feet | Depth to Groundwater Top of Well Casing 9/30/2004 Feet | Groundwater Elevation[1] NAVD88 9/30/2004 Feet | Depth to Groundwater Top of Well Casing 12/10/2004 Feet | Groundwater Elevation[1] NAVD88 12/10/2004 Feet | Depth to Groundwater Top of Well Casing 6/25/2004 Feet | Groundwater Elevation[1] NAVD88 6/25/2004 Feet |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DMW-1A | I | 12.05 | 8.43 | 3.62 | 8.91 | 3.14 | 9.50 | 2.55 | 8.75 | 3.30 | 9.35 | 2.70 |
| DMW-1B | D | 12.04 | 8.81 | 3.23 | 9.54 | 2.50 | 9.65 | 2.39 | 9.11 | 2.93 | 9.57 | 2.47 |
| DMW-1S | S | 11.08 | 7.34 | 3.74 | 7.74 | 3.34 | 8.50 | 2.58 | 7.60 | 3.48 | 8.15 | 2.93 |
| DMW-2A | I | 21.65 | 19.37 | 2.28 | 20.92 | 0.73 | 20.13 | 1.52 | 20.20 | 1.45 | 2.75 | 18.90 |
| DMW-2B | D | 21.66 | 19.14 | 2.52 | 20.55 | 1.11 | 19.90 | 1.76 | 19.95 | 1.71 | 20.35 | 1.31 |
| DMW-2S | S | 21.75 | 19.31 | 2.44 | 20.53 | 1.22 | 20.60 | 1.15 | 20.43 | 1.32 | 20.49 | 1.26 |
| DMW-3D | D | 16.46 | 14.02 | 2.44 | 15.61 | 0.85 | 14.82 | 1.64 | 15.25 | 1.21 | 14.95 | 1.51 |
| DMW-3I | I | 16.45 | 14.03 | 2.42 | 15.53 | 0.92 | 14.85 | 1.60 | 15.23 | 1.22 | 14.90 | 1.55 |
| DMW-3S | S | 16.52 | 14.41 | 2.11 | 10.06 | 6.46 | 10.51 | 6.01 | 10.34 | 6.18 | 9.63 | 6.89 |
| DMW-4D | D | 20.44 | 18.32 | 2.12 | 20.11 | 0.33 | 19.00 | 1.44 | 19.45 | 0.99 | 19.50 | 0.94 |
| DMW-4I | I | 20.48 | 18.23 | 2.25 | 19.70 | 0.78 | 18.95 | 1.53 | 19.20 | 1.28 | 19.12 | 1.36 |
| DMW-4S | S | 20.52 | 18.55 | 1.97 | 20.15 | 0.37 | 19.25 | 1.27 | 19.70 | 0.82 | 19.60 | 0.92 |
| DMW-5D | D | 21.38 | 19.18 | 2.20 | 20.81 | 0.57 | 20.02 | 1.36 | 19.80 | 1.58 | 20.20 | 1.18 |
| DMW-5I | I | 21.39 | 19.13 | 2.26 | 20.68 | 0.71 | 19.95 | 1.44 | 19.75 | 1.64 | 20.15 | 1.24 |
| DMW-5S | S | 21.34 | 19.09 | 2.25 | 20.48 | 0.86 | 20.12 | 1.22 | 20.00 | 1.34 | 20.02 | 1.32 |
| DMW-6D | D | 18.51 | 16.29 | 2.22 | 17.76 | 0.75 | 17.25 | 1.26 | 17.15 | 1.36 | 17.70 | 0.81 |
| DMW-6I | I | 18.64 | 16.41 | 2.23 | 17.71 | 0.93 | 17.15 | 1.49 | 17.42 | 1.22 | 17.98 | 0.66 |
| DMW-6S | S | 18.62 | 16.20 | 2.42 | 17.72 | 0.90 | 17.09 | 1.53 | 17.35 | 1.27 | 17.75 | 0.87 |
| DMW-7D | D | 21.94 | 19.31 | 2.63 | 20.41 | 1.53 | 20.11 | 1.83 | 20.24 | 1.70 | 20.35 | 1.59 |
| DMW-7I | I | 21.90 | 19.28 | 2.62 | 20.49 | 1.41 | 20.20 | 1.70 | 20.42 | 1.48 | 20.47 | 1.43 |
| DMW-7S | S | 21.84 | 19.18 | 2.66 | 20.14 | 1.70 | 19.98 | 1.86 | 20.12 | 1.72 | 20.20 | 1.64 |
| DMW-8D | D | 16.35 | 13.64 | 2.71 | 14.65 | 1.70 | 14.31 | 2.04 | 14.60 | 1.75 | 14.36 | 1.99 |
| DMW-8I | I | 16.30 | 13.64 | 2.66 | 14.60 | 1.70 | 14.37 | 1.93 | 14.15 | 2.15 | 14.45 | 1.85 |
| DMW-8S | S | 15.80 | 12.38 | 3.42 | 11.86 | 3.94 | 14.20 | 1.60 | 12.50 | 3.30 | 13.05 | 2.75 |
| DMW-9D | D | 11.41 | 8.22 | 3.19 | 9.21 | 2.20 | 9.20 | 2.21 | 9.00 | 2.41 | 9.37 | 2.04 |
| DMW-9I | I | 11.40 | 7.95 | 3.45 | 9.18 | 2.22 | 9.16 | 2.24 | 8.82 | 2.58 | 9.11 | 2.29 |
| DMW-9S | S | 11.45 | 7.91 | 3.54 | 8.44 | 3.01 | 9.22 | 2.23 | 8.79 | 2.66 | 9.10 | 2.35 |
| MW-1[2] | I | 11.08 | 7.31 | 3.77 | 6.35 | 4.73 | NA | NA | NA | NA | NA | NA |
| MW-10I | I | 10.27 | 6.78 | 3.49 | 7.25 | 3.02 | 7.70 | 2.57 | 6.81 | 3.46 | 7.60 | 2.67 |
| MW-10S | S | 10.29 | 6.60 | 3.69 | 6.94 | 3.35 | 7.80 | 2.49 | 6.82 | 3.47 | 7.58 | 2.71 |
| MW-11I | I | 9.15 | 5.20 | 3.95 | 5.60 | 3.55 | 6.30 | 2.85 | 5.20 | 3.95 | 6.20 | 2.95 |
| MW-11S | S | 9.20 | 3.43 | 5.77 | 3.20 | 6.00 | 3.30 | 5.90 | 3.40 | 5.80 | 4.32 | 4.88 |
| MW-14D | DD | 11.56 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MW-14I | I | 11.72 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MW-15D | D | 8.77 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MW-15I | I | 8.79 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MW-15S | S | 8.60 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MW-16D | D | 10.22 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MW-16I | I | 10.06 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MW-16S | S | 10.20 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MW-17D | D | 7.56 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MW-17I | I | 7.68 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MW-17S | S | 7.61 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MW-18D | D | 8.88 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MW-18I | I | 8.91 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MW-18S | S | 8.89 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MW-19D | D | 7.94 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

**Table 4-3**

**Groundwater Levels and Elevations, Dump Road Area**
**Lockheed Martin Martin State Airport, Middle River, Maryland**


| Well ID | Aquifer Level | Elevation[1] Top of Well Casing NAVD88 Feet | Depth to Groundwater Top of Well Casing 10/14/2003 Feet | Groundwater Elevation[1] NAVD88 10/14/2003 Feet | Depth to Groundwater Top of Well Casing 12/1/2003 Feet | Groundwater Elevation[1] NAVD88 12/1/2003 Feet | Depth to Groundwater Top of Well Casing 9/30/2004 Feet | Groundwater Elevation[1] NAVD88 9/30/2004 Feet | Depth to Groundwater Top of Well Casing 12/10/2004 Feet | Groundwater Elevation[1] NAVD88 12/10/2004 Feet | Depth to Groundwater Top of Well Casing 6/25/2004 Feet | Groundwater Elevation[1] NAVD88 6/25/2004 Feet |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MW-19I | I | 7.90 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MW-2 | I | 8.40 | 5.35 | 3.05 | 6.06 | 2.34 | 6.20 | 2.20 | 5.83 | 2.57 | 6.50 | 1.90 |
| MW-20D | D | 12.40 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MW-20I | I | 12.39 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MW-20S | S | 12.44 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MW-21D | D | 10.78 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MW-21I | I | 10.83 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MW-22D | D | 11.02 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MW-22I | I | 11.01 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MW-23D | D | 10.03 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MW-23I | I | 10.07 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MW-23S | S | 10.01 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MW-24I | I | 7.68 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MW-24S | S | 7.72 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MW-25I | I | 9.72 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MW-25S | S | 9.69 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MW-26D | D | 11.66 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MW-26I | I | 11.67 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MW-26S | S | 11.72 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MW-27D | DD | 8.39 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MW-28I | I | 8.65 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MW-29D | DD | 11.43 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MW-3 | S | 11.19 | 7.23 | 3.96 | 7.25 | 3.94 | 8.65 | 2.54 | 7.40 | 3.79 | 8.27 | 2.92 |
| MW-30D | DD | 8.26 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MW-31D | DD | 6.95 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MW-32I | I | 7.28 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MW-32S | S | 7.27 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MW-33I | I | 10.02 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MW-33S | S | 9.97 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MW-34I | I | 7.37 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MW-34S | S | 7.44 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MW-4 | S | 10.34 | 6.62 | 3.72 | 6.10 | 4.24 | 7.85 | 2.49 | 7.00 | 3.34 | 7.25 | 3.09 |
| MW-5 | S | 22.65 | 19.99 | 2.66 | 21.10 | 1.55 | 20.96 | 1.69 | 21.00 | 1.65 | 21.05 | 1.60 |
| MW-6 | S | 15.72 | 12.92 | 2.80 | 13.46 | 2.26 | 13.70 | 2.02 | 13.75 | 1.97 | 13.97 | 1.75 |
| MW-7 | S | 10.90 | 5.78 | 5.12 | 6.86 | 4.04 | 7.36 | 3.54 | 5.73 | 5.17 | 6.70 | 4.20 |
| OW1-I | I | 18.05 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| OW1-S | S | 19.17 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| RW1-I | I | 18.44 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| RW1-S | S | 19.09 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| TT-11[2] | S | 11.16 | 6.45 | 4.71 | 5.60 | 5.56 | NA | NA | NA | NA | NA | NA |
| TT-12[2] | S | 11.51 | 6.39 | 5.12 | 5.79 | 5.72 | NA | NA | NA | NA | NA | NA |
| TT-13[2] | S | 9.55 | 4.31 | 5.24 | 4.23 | 5.32 | NA | NA | NA | NA | NA | NA |
| TT-14[2] | S | 10.31 | 4.81 | 5.50 | 3.96 | 6.35 | NA | NA | NA | NA | NA | NA |

**Table 4-3**

**Groundwater Levels and Elevations, Dump Road Area**
**Lockheed Martin Martin State Airport, Middle River, Maryland**


| Well ID | Aquifer Level | Elevation[1] Top of Well Casing NAVD88 Feet | Depth to Groundwater Top of Well Casing 1/14/2008 Feet | Groundwater Elevation[1] NAVD88 1/14/2008 Feet | Depth to Groundwater Top of Well Casing 10/30/2008 Feet | Groundwater Elevation[1] NAVD88 10/30/2008 Feet | Depth to Groundwater Top of Well Casing 9/10/2009 Feet | Groundwater Elevation[1] NAVD88 9/10/2009 Feet | Depth to Groundwater Top of Well Casing 9/18/2009 Feet | Groundwater Elevation[1] NAVD88 9/18/2009 Feet | Depth to Groundwater Top of Well Casing 1/19/2010 Feet | r Elevation[1] NAVD88 1/19/2010 Feet |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DMW-1A | I | 12.05 | 9.70 | 2.35 | 10.30 | 1.75 | 9.92 | 2.13 | NA | NA | 8.70 | 3.35 |
| DMW-1B | D | 12.04 | 9.90 | 2.14 | 10.50 | 1.54 | 10.11 | 1.93 | NA | NA | 9.00 | 3.04 |
| DMW-1S | S | 11.08 | 8.60 | 2.48 | 8.10 | 2.98 | 8.81 | 2.27 | NA | NA | 7.65 | 3.43 |
| DMW-2A | I | 21.65 | 20.50 | 1.15 | 21.15 | 0.50 | 20.54 | 1.11 | NA | NA | 19.95 | 1.70 |
| DMW-2B | D | 21.66 | 20.30 | 1.36 | 21.00 | 0.66 | 20.35 | 1.31 | NA | NA | 19.60 | 2.06 |
| DMW-2S | S | 21.75 | 21.00 | 0.75 | 21.30 | 0.45 | 20.85 | 0.90 | NA | NA | 20.35 | 1.40 |
| DMW-3D | D | 16.46 | 15.15 | 1.31 | 15.90 | 0.56 | 15.26 | 1.20 | NA | NA | 14.65 | 1.81 |
| DMW-3I | I | 16.45 | 15.20 | 1.25 | 15.85 | 0.60 | 15.31 | 1.14 | NA | NA | 14.65 | 1.80 |
| DMW-3S | S | 16.52 | NA | NA | 12.40 | 4.12 | 11.79 | 4.73 | NA | NA | 8.45 | 8.07 |
| DMW-4D | D | 20.44 | 19.40 | 1.04 | 20.20 | 0.24 | 19.32 | 1.12 | NA | NA | 18.80 | 1.64 |
| DMW-4I | I | 20.48 | 19.50 | 0.98 | 20.05 | 0.43 | 19.36 | 1.12 | NA | NA | 18.70 | 1.78 |
| DMW-4S | S | 20.52 | 19.95 | 0.57 | 20.50 | 0.02 | 19.69 | 0.83 | NA | NA | 19.20 | 1.32 |
| DMW-5D | D | 21.38 | 20.40 | 0.98 | 21.10 | 0.28 | 20.38 | 1.00 | NA | NA | 19.70 | 1.68 |
| DMW-5I | I | 21.39 | 20.40 | 0.99 | 21.10 | 0.29 | 20.36 | 1.03 | NA | NA | 19.70 | 1.69 |
| DMW-5S | S | 21.34 | 20.50 | 0.84 | 20.95 | 0.39 | 20.39 | 0.95 | NA | NA | 19.80 | 1.54 |
| DMW-6D | D | 18.51 | 17.60 | 0.91 | 18.30 | 0.21 | 17.52 | 0.99 | NA | NA | 16.80 | 1.71 |
| DMW-6I | I | 18.64 | 17.60 | 1.04 | 18.30 | 0.34 | 17.56 | 1.08 | NA | NA | 16.80 | 1.84 |
| DMW-6S | S | 18.62 | 17.45 | 1.17 | 18.30 | 0.32 | 18.78 | -0.16 | NA | NA | 16.85 | 1.77 |
| DMW-7D | D | 21.94 | 20.60 | 1.34 | 21.20 | 0.74 | 20.57 | 1.37 | NA | NA | 19.70 | 2.24 |
| DMW-7I | I | 21.90 | 20.70 | 1.20 | 21.25 | 0.65 | 20.61 | 1.29 | NA | NA | 19.80 | 2.10 |
| DMW-7S | S | 21.84 | dry | dry | NA | NA | NA | NA | NA | NA | NA | NA |
| DMW-8D | D | 16.35 | 14.80 | 1.55 | 15.35 | 1.00 | 14.79 | 1.56 | NA | NA | 14.00 | 2.35 |
| DMW-8I | I | 16.30 | 14.90 | 1.40 | 15.40 | 0.90 | 14.84 | 1.46 | NA | NA | 14.02 | 2.28 |
| DMW-8S | S | 15.80 | 13.90 | 1.90 | 14.30 | 1.50 | 14.44 | 1.36 | NA | NA | 12.23 | 3.57 |
| DMW-9D | D | 11.41 | 9.51 | 1.90 | 10.15 | 1.26 | 9.68 | 1.73 | NA | NA | 8.65 | 2.76 |
| DMW-9I | I | 11.40 | 9.35 | 2.05 | 9.80 | 1.60 | 9.59 | 1.81 | NA | NA | 8.25 | 3.15 |
| DMW-9S | S | 11.45 | 9.35 | 2.10 | 9.75 | 1.70 | 9.49 | 1.96 | NA | NA | 8.16 | 3.29 |
| MW-1[2] | I | 11.08 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| MW-10I | I | 10.27 | 7.80 | 2.47 | 8.45 | 1.82 | 8.87 | 1.40 | NA | NA | 6.95 | 3.32 |
| MW-10S | S | 10.29 | 7.90 | 2.39 | 8.30 | 1.99 | 8.06 | 2.23 | NA | NA | 6.90 | 3.39 |
| MW-11I | I | 9.15 | 33.20 | -24.05 | 7.15 | 2.00 | 6.78 | 2.37 | NA | NA | 5.40 | 3.75 |
| MW-11S | S | 9.20 | 4.00 | 5.20 | 5.00 | 4.20 | 4.45 | 4.75 | NA | NA | 3.25 | 5.95 |
| MW-14D | DD | 11.56 | 7.60 | 3.96 | 8.25 | 3.31 | 7.71 | 3.85 | NA | NA | 7.00 | 4.56 |
| MW-14I | I | 11.72 | 10.60 | 1.12 | 11.20 | 0.52 | 10.72 | 1.00 | 10.32 | 1.40 | 10.15 | 1.57 |
| MW-15D | D | 8.77 | 6.26 | 2.51 | 7.00 | 1.77 | 6.61 | 2.16 | 5.5 | 3.27 | 5.43 | 3.34 |
| MW-15I | I | 8.79 | 6.30 | 2.49 | 7.02 | 1.77 | 6.63 | 2.16 | 5.55 | 3.24 | 5.43 | 3.36 |
| MW-15S | S | 8.60 | 5.80 | 2.80 | 6.83 | 1.77 | 6.66 | 1.94 | 4.95 | 3.65 | 4.65 | 3.95 |
| MW-16D | D | 10.22 | 7.90 | 2.32 | 8.70 | 1.52 | 8.26 | 1.96 | 7.3 | 2.92 | 7.19 | 3.03 |
| MW-16I | I | 10.06 | 7.80 | 2.26 | 8.50 | 1.56 | 8.11 | 1.95 | 7.1 | 2.96 | 7.01 | 3.05 |
| MW-16S | S | 10.20 | 8.40 | 1.80 | 9.10 | 1.10 | 9.26 | 0.94 | 8.49 | 1.71 | 8.35 | 1.85 |
| MW-17D | D | 7.56 | 18.00 | -10.44 | 10.90 | -3.34 | 5.88 | 1.68 | 4.9 | 2.66 | 4.40 | 3.16 |
| MW-17I | I | 7.68 | 5.60 | 2.08 | 6.30 | 1.38 | 6.12 | 1.56 | 5.65 | 2.03 | 5.22 | 2.46 |
| MW-17S | S | 7.61 | 6.00 | 1.61 | 9.35 | -1.74 | 6.69 | 0.92 | 5.92 | 1.69 | 5.83 | 1.78 |
| MW-18D | D | 8.88 | 7.85 | 1.03 | 8.30 | 0.58 | NA | NA | NA | NA | 7.21 | 1.67 |
| MW-18I | I | 8.91 | 7.80 | 1.11 | 8.50 | 0.41 | 7.86 | 1.05 | NA | NA | 7.21 | 1.70 |
| MW-18S | S | 8.89 | 7.80 | 1.09 | 7.70 | 1.19 | 7.72 | 1.17 | NA | NA | 7.10 | 1.79 |
| MW-19D | D | 7.94 | 6.35 | 1.59 | 7.00 | 0.94 | 6.48 | 1.46 | NA | NA | 5.49 | 2.45 |

**Table 4-3**

**Groundwater Levels and Elevations, Dump Road Area**
**Lockheed Martin Martin State Airport, Middle River, Maryland**


| Well ID | Aquifer Level | Elevation[1] Top of Well Casing NAVD88 Feet | Depth to Groundwater Top of Well Casing 1/14/2008 Feet | Groundwater Elevation[1] NAVD88 1/14/2008 Feet | Depth to Groundwater Top of Well Casing 10/30/2008 Feet | Groundwater Elevation[1] NAVD88 10/30/2008 Feet | Depth to Groundwater Top of Well Casing 9/10/2009 Feet | Groundwater Elevation[1] NAVD88 9/10/2009 Feet | Depth to Groundwater Top of Well Casing 9/18/2009 Feet | Groundwater Elevation[1] NAVD88 9/18/2009 Feet | Depth to Groundwater Top of Well Casing 1/19/2010 Feet | r Elevation[1] NAVD88 1/19/2010 Feet |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MW-19I | I | 7.90 | 6.80 | 1.10 | 7.05 | 0.85 | 6.48 | 1.42 | NA | NA | 5.50 | 2.40 |
| MW-2 | I | 8.40 | 6.60 | 1.80 | 7.25 | 1.15 | 7.74 | 0.66 | NA | NA | 5.65 | 2.75 |
| MW-20D | D | 12.40 | 10.60 | 1.80 | 11.30 | 1.10 | 10.74 | 1.66 | NA | NA | 9.80 | 2.60 |
| MW-20I | I | 12.39 | 10.40 | 1.99 | 10.75 | 1.64 | 10.42 | 1.97 | NA | NA | 9.20 | 3.19 |
| MW-20S | S | 12.44 | 10.40 | 2.04 | 10.80 | 1.64 | 10.51 | 1.93 | NA | NA | 9.23 | 3.21 |
| MW-21D | D | 10.78 | 8.85 | 1.93 | 9.20 | 1.58 | 9.10 | 1.68 | NA | NA | 8.00 | 2.78 |
| MW-21I | I | 10.83 | 8.60 | 2.23 | 8.90 | 1.93 | 8.75 | 2.08 | NA | NA | 7.60 | 3.23 |
| MW-22D | D | 11.02 | 8.70 | 2.32 | 9.30 | 1.72 | 9.02 | 2.00 | NA | NA | 7.85 | 3.17 |
| MW-22I | I | 11.01 | 9.22 | 1.79 | 9.45 | 1.56 | 8.61 | 2.40 | NA | NA | 7.90 | 3.11 |
| MW-23D | D | 10.03 | 8.70 | 1.33 | 8.62 | 1.41 | 8.16 | 1.87 | NA | NA | 7.10 | 2.93 |
| MW-23I | I | 10.07 | 7.65 | 2.42 | 7.95 | 2.12 | 7.84 | 2.23 | NA | NA | 6.70 | 3.37 |
| MW-23S | S | 10.01 | 7.55 | 2.46 | 7.95 | 2.06 | 7.76 | 2.25 | NA | NA | 6.65 | 3.36 |
| MW-24I | I | 7.68 | 5.20 | 2.48 | 5.80 | 1.88 | 5.42 | 2.26 | NA | NA | 4.30 | 3.38 |
| MW-24S | S | 7.72 | 4.10 | 3.62 | 4.50 | 3.22 | 4.32 | 3.40 | NA | NA | 3.65 | 4.07 |
| MW-25I | I | 9.72 | 6.90 | 2.82 | 7.30 | 2.42 | 7.31 | 2.41 | NA | NA | 5.95 | 3.77 |
| MW-25S | S | 9.69 | 5.03 | 4.66 | 5.66 | 4.03 | 5.32 | 4.37 | NA | NA | 4.80 | 4.89 |
| MW-26D | D | 11.66 | 9.80 | 1.86 | 9.10 | 2.56 | 9.42 | 2.24 | NA | NA | 6.65 | 5.01 |
| MW-26I | I | 11.67 | 9.25 | 2.42 | 9.60 | 2.07 | 9.44 | 2.23 | NA | NA | 8.39 | 3.28 |
| MW-26S | S | 11.72 | 10.05 | 1.67 | 9.55 | 2.17 | 9.41 | 2.31 | NA | NA | 7.75 | 3.97 |
| MW-27D | DD | 8.39 | NA | NA | 6.02 | NA | 5.65 | 2.74 | NA | NA | 4.00 | 4.39 |
| MW-28I | I | 8.65 | NA | NA | 6.81 | NA | 6.57 | 2.08 | 5.45 | 3.20 | 5.40 | 3.25 |
| MW-29D | DD | 11.43 | NA | NA | 12.25 | NA | 11.89 | -0.46 | NA | NA | 10.00 | 1.43 |
| MW-3 | S | 11.19 | 8.65 | 2.54 | 9.00 | 2.19 | 8.79 | 2.40 | NA | NA | 7.70 | 3.49 |
| MW-30D | DD | 8.26 | NA | NA | NA | NA | 8.00 | 0.26 | NA | NA | 6.20 | 2.06 |
| MW-31D | DD | 6.95 | NA | NA | NA | NA | 7.47 | -0.52 | NA | NA | 5.75 | 1.20 |
| MW-32I | I | 7.28 | NA | NA | NA | NA | 5.71 | 1.57 | 4.65 | 2.63 | 4.62 | 2.66 |
| MW-32S | S | 7.27 | NA | NA | NA | NA | 5.62 | 1.65 | 4.52 | 2.75 | 4.50 | 2.77 |
| MW-33I | I | 10.02 | NA | NA | NA | NA | 7.38 | 2.64 | 6.25 | 3.77 | 6.25 | 3.77 |
| MW-33S | S | 9.97 | NA | NA | NA | NA | 7.34 | 2.63 | 6.05 | 3.92 | 6.23 | 3.74 |
| MW-34I | I | 7.37 | NA | NA | NA | NA | 5.15 | 2.22 | NA | NA | 4.00 | 3.37 |
| MW-34S | S | 7.44 | NA | NA | NA | NA | 5.20 | 2.24 | NA | NA | 3.90 | 3.54 |
| MW-4 | S | 10.34 | 7.50 | 2.84 | 8.25 | 2.09 | 8.15 | 2.19 | NA | NA | 5.45 | 4.89 |
| MW-5 | S | 22.65 | 21.15 | 1.50 | 21.55 | 1.10 | 21.35 | 1.30 | NA | NA | 20.30 | 2.35 |
| MW-6 | S | 15.72 | 14.30 | 1.42 | 15.00 | 0.72 | 14.46 | 1.26 | NA | NA | 13.15 | 2.57 |
| MW-7 | S | 10.90 | NA | NA | NA | NA | 7.27 | 3.63 | NA | NA | NA | NA |
| OW1-I | I | 18.05 | 17.00 | 1.05 | NA | NA | 17.02 | 1.03 | NA | NA | NA | NA |
| OW1-S | S | 19.17 | 18.50 | 0.67 | NA | NA | NA | NA | NA | NA | NA | NA |
| RW1-I | I | 18.44 | 17.50 | 0.94 | NA | NA | 17.40 | 1.04 | NA | NA | NA | NA |
| RW1-S | S | 19.09 | 18.20 | 0.89 | NA | NA | NA | NA | NA | NA | NA | NA |
| TT-11[2] | S | 11.16 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| TT-12[2] | S | 11.51 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| TT-13[2] | S | 9.55 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| TT-14[2] | S | 10.31 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

1 Based on an October 2010 survey of all Dump Road Area wells
2 Well has been sealed and abandoned in accordance with state regulations and is no longer in use
NA - Not available or not measured
S - Upper surficial aquifer
I - Intermediate surficial aquifer
D - Lower surficial aquifer
DD - Deep confined aquifer or below the lower surficial aquifer
NAVD88 = North American Vertical Datum of 1988

**Table 5-7**

**Distribution and Occurrence - Groundwater - 2007**
**Dump Road**
**Lockheed Martin Martin State Airport, Middle River, Maryland**


| Chemical | Frequency of Detection | | Mininum Non Detected | Maximum Non Detected | Mininum Detected | Maximum Detected | Mean of All Samples | Mean of Positive Detects | Standard Deviation |
|---|---|---|---|---|---|---|---|---|---|
| | Number | Percent | | | | | | | |
| **SVOCs** | | | | | | | | | |
| **1,4-DIOXANE** | **49/70** | **70%** | **0.19** | **0.96** | **0.35 J** | **1800** | **115** | **164** | **306** |
| **MNA VOLATILES (mg/l)** | | | | | | | | | |
| CARBON DIOXIDE | 2/2 | 100% | - | - | 220 | 630 | 425 | 425 | NA(1) |
| ETHANE | 12/12 | 100% | - | - | 0.016 J | 61 | 6.49 | 6.49 | 17.5 |
| ETHENE | 12/12 | 100% | - | - | 0.02 J | 2100 | 191 | 191 | 602 |
| CARBON DIOXIDE | 10/10 | 100% | - | - | 34 | 600 | 208 | 208 | 166 |
| METHANE | 12/12 | 100% | - | - | 0.23 | 1700 | 256 | 256 | 479 |
| **VOLATILES (ug/l)** | | | | | | | | | |
| **1,1,1-TRICHLOROETHANE** | **9/65** | **14%** | **1** | **50** | **2.9** | **240** | **7.89** | **41.1** | **30.8** |
| **1,1,2,2-TETRACHLOROETHANE** | **1/65** | **2%** | **1** | **100** | **20** | **20** | **3.63** | **20.0** | **8.63** |
| 1,1,2-TRICHLOROTRIFLUOROETHANE | 1/65 | 2% | 1 | 100 | 2.2 J | 2.2 J | 3.33 | 2.20 | 8.38 |
| **1,1-DICHLOROETHANE** | **6/65** | **9%** | **1** | **50** | **0.62 J** | **83.3 J** | **4.18** | **19.4** | **11.9** |
| **1,1-DICHLOROETHENE** | **31/65** | **48%** | **1** | **50** | **0.47 J** | **222** | **13.0** | **25.1** | **36.0** |
| 1,2,3-TRICHLOROBENZENE | 5/65 | 8% | 2 | 200 | 3 | 115 | 8.72 | 48.2 | 22.7 |
| **1,2,4-TRICHLOROBENZENE** | **6/65** | **9%** | **2** | **200** | **1.8 J** | **689** | **28.3** | **253** | **118** |
| **1,2,4-TRIMETHYLBENZENE** | **12/65** | **18%** | **1** | **100** | **0.8 J** | **375** | **10.5** | **42.1** | **47.1** |
| 1,2-DICHLOROBENZENE | 8/65 | 12% | 1 | 100 | 0.24 J | 4.4 J | 3.39 | 1.24 | 8.38 |
| **1,2-DICHLOROETHANE** | **21/65** | **32%** | **1** | **100** | **0.63 J** | **129** | **11.3** | **27.6** | **27.0** |
| **1,3,5-TRIMETHYLBENZENE** | **16/62** | **26%** | **1** | **100** | **0.3 J** | **190** | **5.48** | **15.5** | **24.7** |
| 1,3-DICHLOROBENZENE | 4/65 | 6% | 1 | 100 | 0.21 J | 1.2 | 3.33 | 0.470 | 8.38 |
| **1,4-DICHLOROBENZENE** | **4/65** | **6%** | **1** | **100** | **0.23 J** | **5** | **3.43** | **2.61** | **8.38** |
| 2-BUTANONE | 1/9 | 11% | 10 | 250 | 18.9 J | 18.9 J | 56.0 | 18.9 | 53.4 |
| 2-HEXANONE | 1/65 | 2% | 5 | 500 | 1.4 J | 1.4 J | 16.6 | 1.40 | 41.9 |
| 4-ISOPROPYLTOLUENE | 5/65 | 8% | 1 | 100 | 0.43 J | 9.9 | 3.53 | 3.06 | 8.40 |
| 4-METHYL-2-PENTANONE | 1/65 | 2% | 5 | 500 | 7.8 | 7.8 | 16.7 | 7.80 | 41.9 |
| ACETONE | 12/60 | 20% | 10 | 1000 | 6.1 J | 52 | 31.6 | 17.8 | 74.3 |
| ACETYLENE | 1/2 | 50% | 0.5 | 0.5 | 1.2 | 1.2 | 0.725 | 1.20 | NA(1) |
| **BENZENE** | **29/65** | **45%** | **1** | **100** | **0.42 J** | **491** | **13.6** | **25.3** | **61.0** |
| **BROMODICHLOROMETHANE** | **5/65** | **8%** | **1** | **100** | **0.21 J** | **0.78 J** | **3.32** | **0.424** | **8.38** |
| BUTANE | 2/2 | 100% | - | - | 0.15 | 0.28 | 0.215 | 0.215 | NA(1) |
| CARBON DISULFIDE | 13/65 | 20% | 1 | 100 | 0.15 J | 1.7 | 3.36 | 0.656 | 8.37 |
| **CARBON TETRACHLORIDE** | **4/65** | **6%** | **1** | **100** | **5.2** | **333** | **10.3** | **114** | **43.1** |
| **CHLOROBENZENE** | **22/65** | **34%** | **1** | **100** | **0.25 J** | **283** | **10.6** | **26.3** | **38.6** |
| CHLOROETHANE | 2/65 | 3% | 1 | 100 | 0.32 J | 0.61 J | 3.33 | 0.465 | 8.38 |
| **CHLOROFORM** | **33/65** | **51%** | **0.72** | **100** | **0.3 J** | **1870** | **49.4** | **92.6** | **239** |

**Table 5-7**

**Distribution and Occurrence - Groundwater - 2007**
**Dump Road**
**Lockheed Martin Martin State Airport, Middle River, Maryland**


| Chemical | Frequency of Detection | | Mininum Non Detected | Maximum Non Detected | Mininum Detected | Maximum Detected | Mean of All Samples | Mean of Positive Detects | Standard Deviation |
|---|---|---|---|---|---|---|---|---|---|
| | Number | Percent | | | | | | | |
| CHLOROMETHANE | 1/65 | 2% | 1 | 100 | 0.56 J | 0.56 J | 3.33 | 0.560 | 8.38 |
| **CIS-1,2-DICHLOROETHENE** | **55/65** | **85%** | **1** | **1** | **0.25 J** | **38000** | **1981** | **2341** | **6586** |
| DICHLORODIFLUOROMETHANE | 4/65 | 6% | 1 | 100 | 0.78 J | 5.5 | 3.50 | 3.67 | 8.37 |
| DIISOPROPYL ETHER | 6/65 | 9% | 1 | 250 | 0.25 J | 3.4 | 8.02 | 1.33 | 26.8 |
| ETHYL TERT-BUTYL ETHER | 1/65 | 2% | 1 | 250 | 0.16 J | 0.16 J | 7.94 | 0.160 | 26.8 |
| **ETHYLBENZENE** | **11/65** | **17%** | **1** | **100** | **0.48 J** | **2610** | **44.2** | **245** | **323** |
| ISOBUTANE | 2/2 | 100% | - | - | 0.065 | 0.082 | 0.074 | 0.074 | NA(1) |
| ISOPROPYLBENZENE | 14/65 | 22% | 1 | 100 | 0.18 J | 28.9 J | 3.43 | 3.13 | 8.54 |
| **M+P-XYLENES** | **18/65** | **28%** | **2** | **100** | **0.41 J** | **26000** | **409** | **1464** | **3224** |
| **METHYLENE CHLORIDE** | **30/65** | **46%** | **1** | **50** | **0.19 J** | **135** | **8.71** | **14.5** | **20.4** |
| **NAPHTHALENE** | **7/65** | **11%** | **2** | **200** | **2.4** | **63.3 J** | **6.46** | **17.4** | **15.2** |
| N-PROPYLBENZENE | 7/65 | 11% | 1 | 100 | 0.27 J | 28.5 J | 3.46 | 5.51 | 8.52 |
| **O-XYLENE** | **25/65** | **38%** | **1** | **100** | **0.21 J** | **2500** | **43.5** | **107** | **310** |
| PROPANE | 2/2 | 100% | - | - | 0.05 J | 0.43 | 0.240 | 0.240 | NA(1) |
| PROPYLENE | 2/2 | 100% | - | - | 0.075 | 0.36 | 0.218 | 0.218 | NA(1) |
| SEC-BUTYLBENZENE | 1/65 | 2% | 2 | 200 | 1.1 J | 1.1 J | 5.51 | 1.10 | 14.4 |
| TERTIARY-BUTYL ALCOHOL | 9/27 | 33% | 10 | 10 | 4 J | 53 | 11.7 | 25.1 | 13.2 |
| **TETRACHLOROETHENE** | **30/65** | **46%** | **1** | **100** | **0.42 J** | **40.9** | **6.30** | **7.51** | **11.0** |
| **TOLUENE** | **28/65** | **43%** | **0.59** | **50** | **0.21 J** | **5900** | **139** | **318** | **787** |
| **TOTAL XYLENES** | **20/65** | **31%** | **3** | **300** | **0.63 J** | **28500** | **452** | **1449** | **3533** |
| **TRANS-1,2-DICHLOROETHENE** | **36/65** | **55%** | **1** | **50** | **0.25 J** | **376** | **22.1** | **37.4** | **66.5** |
| **TRICHLOROETHENE** | **54/65** | **83%** | **1** | **1** | **0.23 J** | **41100** | **2160** | **2600** | **5948** |
| TRICHLOROFLUOROMETHANE | 1/65 | 2% | 1 | 100 | 0.88 J | 0.88 J | 3.34 | 0.880 | 8.38 |
| **VINYL CHLORIDE** | **44/65** | **68%** | **1** | **1** | **0.28 J** | **26200** | **735** | **1085** | **3325** |
| **MISCELLANEOUS (mg/l)** | | | | | | | | | |
| ALKALINITY | 7/12 | 58% | 4 | 4 | 8.1 | 440 | 77.7 | 132 | 147 |
| CHLORIDE | 12/12 | 100% | - | - | 8.1 | 190 | 80.5 | 80.5 | 59.0 |
| NITRATE | 11/12 | 92% | 0.5 | 0.5 | 1 | 15 | 2.85 | 3.09 | 3.94 |
| **NITRITE** | **5/12** | **42%** | **0.5** | **0.5** | **1.4** | **2.1** | **0.838** | **1.66** | **0.747** |
| SULFATE | 12/12 | 100% | - | - | 3.1 | 1300 | 472 | 472 | 482 |
| **MISCELLANEOUS (S.U.)** | | | | | | | | | |
| PH | 3/3 | 100% | - | - | 6.3 | 6.4 | 6.33 | 6.33 | NA(1) |
| **MISCELLANEOUS (ug/l)** | | | | | | | | | |
| ACETYLENE | 3/10 | 30% | 0.5 | 0.5 | 0.18 J | 2.1 | 0.423 | 0.827 | 0.590 |
| BUTANE | 7/10 | 70% | 0.05 | 0.05 | 0.046 J | 0.55 | 0.157 | 0.213 | 0.166 |
| ISOBUTANE | 5/10 | 50% | 0.05 | 0.05 | 0.013 J | 0.56 | 0.088 | 0.150 | 0.170 |

**Table 5-7**

**Distribution and Occurrence - Groundwater - 2007**
**Dump Road**
**Lockheed Martin Martin State Airport, Middle River, Maryland**


| Chemical | Frequency of Detection | | Mininum Non Detected | Maximum Non Detected | Mininum Detected | Maximum Detected | Mean of All Samples | Mean of Positive Detects | Standard Deviation |
|---|---|---|---|---|---|---|---|---|---|
| | Number | Percent | | | | | | | |
| **PERCHLORATE** | **5/31** | **16%** | **0.8** | **8** | **2** | **8** | **1.99** | **3.80** | **1.45** |
| PROPANE | 9/10 | 90% | 0.05 | 0.05 | 0.03 J | 0.36 | 0.109 | 0.118 | 0.103 |
| PROPYLENE | 7/10 | 70% | 0.05 | 0.05 | 0.032 J | 0.79 | 0.155 | 0.210 | 0.235 |
| **TOTAL METALS (mg/l)** | | | | | | | | | |
| **ANTIMONY** | **35/62** | **56%** | **0.00005** | **0.002** | **0.0001** | **0.0017** | **0.0003** | **0.0004** | **0.0003** |
| **ARSENIC** | **59/62** | **95%** | **0.0005** | **0.006** | **0.001** | **0.028** | **0.006** | **0.006** | **0.006** |
| **BARIUM** | **62/62** | **100%** | **-** | **-** | **0.0039** | **44100** | **711** | **711** | **5601** |
| **BERYLLIUM** | **33/62** | **53%** | **0.0001** | **0.001** | **0.0001** | **0.0094** | **0.0010** | **0.002** | **0.002** |
| **CADMIUM** | **29/62** | **47%** | **0.0004** | **0.001** | **0.0003** | **0.997** | **0.047** | **0.100** | **0.157** |
| **CHROMIUM** | **58/62** | **94%** | **0.0002** | **0.0002** | **0.0003** | **0.889** | **0.027** | **0.028** | **0.114** |
| **COBALT** | **54/62** | **87%** | **0.0005** | **0.0005** | **0.0006** | **39200** | **632** | **726** | **4978** |
| **COPPER** | **61/62** | **98%** | **0.0003** | **0.0003** | **0.0003** | **0.297** | **0.022** | **0.022** | **0.046** |
| **LEAD** | **52/62** | **84%** | **0.00004** | **0.002** | **5E-05** | **0.228** | **0.007** | **0.008** | **0.029** |
| **MERCURY** | **17/62** | **27%** | **0.00003** | **0.0005** | **3E-05** | **0.0026** | **0.0002** | **0.0005** | **0.0004** |
| **MOLYBDENUM** | **40/62** | **65%** | **0.0005** | **0.002** | **0.0005** | **0.0265** | **0.004** | **0.006** | **0.005** |
| **NICKEL** | **62/62** | **100%** | **-** | **-** | **0.0004** | **0.226** | **0.037** | **0.037** | **0.049** |
| **SELENIUM** | **54/62** | **87%** | **0.001** | **0.006** | **0.0003** | **0.055** | **0.007** | **0.008** | **0.010** |
| SILVER | 56/62 | 90% | 0.001 | 0.001 | 0.0002 | 0.0012 L | 0.0006 | 0.0006 | 0.0002 |
| **THALLIUM** | **35/62** | **56%** | **0.00002** | **0.001** | **2E-05** | **0.0005** | **0.0002** | **0.0002** | **0.0002** |
| **VANADIUM** | **47/62** | **76%** | **0.00003** | **0.001** | **0.0001** | **0.0892** | **0.006** | **0.008** | **0.014** |
| **ZINC** | **60/62** | **97%** | **0.002** | **0.002** | **0.0014** | **1.78** | **0.137** | **0.141** | **0.273** |
| **FILTERED METALS (mg/l)** | | | | | | | | | |
| ANTIMONY | 19/62 | 31% | 0.0002 | 0.002 | 0.0003 | 0.0013 | 0.0007 | 0.0007 | 0.0004 |
| **ARSENIC** | **58/62** | **94%** | **0.003** | **0.003** | **8E-05** | **0.0198** | **0.004** | **0.005** | **0.005** |
| **BARIUM** | **62/62** | **100%** | **-** | **-** | **0.003** | **0.313** | **0.048** | **0.048** | **0.051** |
| **BERYLLIUM** | **41/62** | **66%** | **0.0002** | **0.001** | **9E-05** | **0.0094** | **0.001** | **0.002** | **0.002** |
| **CADMIUM** | **28/62** | **45%** | **0.00001** | **0.001** | **7E-05** | **0.956** | **0.039** | **0.085** | **0.146** |
| **CHROMIUM** | **62/62** | **100%** | **-** | **-** | **0.0003** | **0.229** | **0.010** | **0.010** | **0.029** |
| **COBALT** | **60/62** | **97%** | **0.00002** | **0.005** | **0.0002** | **0.567** | **0.059** | **0.061** | **0.103** |
| **COPPER** | **55/62** | **89%** | **0.005** | **0.005** | **0.0004** | **0.136** | **0.011** | **0.012** | **0.021** |
| **IRON** | **12/12** | **100%** | **-** | **-** | **0.023 L** | **240** | **34.9** | **34.9** | **65.5** |
| LEAD | 34/62 | 55% | 0.0001 | 0.002 | 0.0001 | 0.0112 | 0.002 | 0.002 | 0.002 |
| MERCURY | 3/62 | 5% | 0.00003 | 0.0005 | 4E-05 | 0.0001 L | 0.0002 | 0.00008 | 0.0001 |
| **MOLYBDENUM** | **44/62** | **71%** | **0.0001** | **0.002** | **0.0001** | **0.0223** | **0.003** | **0.004** | **0.005** |
| **NICKEL** | **61/62** | **98%** | **0.005** | **0.005** | **0.0004** | **0.235** | **0.035** | **0.036** | **0.048** |
| **SELENIUM** | **39/62** | **63%** | **0.005** | **0.005** | **0.0003** | **0.037 K** | **0.004** | **0.006** | **0.005** |

**Table 5-7**

**Distribution and Occurrence - Groundwater - 2007**
**Dump Road**
**Lockheed Martin Martin State Airport, Middle River, Maryland**


| Chemical | Frequency of Detection | | Mininum Non Detected | Maximum Non Detected | Mininum Detected | Maximum Detected | Mean of All Samples | Mean of Positive Detects | Standard Deviation |
|---|---|---|---|---|---|---|---|---|---|
| | Number | Percent | | | | | | | |
| SILVER | 14/62 | 23% | 0.00001 | 0.001 | 0.0003 | 0.0014 L | 0.0004 | 0.0009 | 0.0004 |
| **THALLIUM** | **15/62** | **24%** | **0.00001** | **0.001** | **0.0001** | **0.0004** | **0.0003** | **0.0002** | **0.0002** |
| **VANADIUM** | **59/62** | **95%** | **0.001** | **0.001** | **0.0001** | **0.0206** | **0.003** | **0.003** | **0.004** |
| **ZINC** | **57/62** | **92%** | **0.005** | **0.005** | **0.0003** | **0.822** | **0.098** | **0.106** | **0.159** |

**Footnotes:**
For non-detects, 1/2 sample quantitation limit was used as a proxy concentration.
1/2 the detection limit was used for B qualified data.
Data Validation Qualifiers:
J = Estimated concentration
L = Result biased low
K = Result biased high
U = Analyte not detected at the analytical reporting limit
mg/kg = Milligrams per kilogram (i.e., parts per million)
ug/kg = Micrograms per kilogram (i.e., parts per billion)
Shaded line indicate analyte is a COPC.

**Table 5-8**

**Distribution and Occurrence - Groundwater - 2008**
**Dump Road**
**Lockheed Martin Martin State Airport, Middle River, Maryland**


| Chemical | Frequency of Detection | | Mininum Non Detected | Maximum Non Detected | Mininum Detected | Maximum Detected | Location of Maximum Detected | Mean of All Samples | Mean of Positive Detects | Standard Deviation |
|---|---|---|---|---|---|---|---|---|---|---|
| | Number | Percent | | | | | | | | |
| **SEMIVOLATILES (ug/l)** | | | | | | | | | | |
| **1,4-DIOXANE** | **39/70** | **56%** | **0.49** | **4** | **0.54 J** | **590** | **DMW-16S-082108** | **41.3** | **73.8** | **103** |
| **VOLATILES (ug/l)** | | | | | | | | | | |
| **CIS-1,2-DICHLOROETHENE** | **52/71** | **73%** | **0.17** | **2.5** | **0.34 J** | **36000** | **DMW-11S-081108** | **1283** | **1751** | **4725** |
| **VINYL CHLORIDE** | **43/71** | **61%** | **0.22** | **250** | **0.23 J** | **35000** | **DMW-9S-082208** | **880** | **1448** | **4224** |
| **TRICHLOROETHENE** | **39/71** | **55%** | **0.17** | **1200** | **0.36 J** | **29000** | **DMW-11S-081108** | **1741** | **3151** | **4883** |
| **CHLOROFORM** | **19/71** | **27%** | **0.16** | **1200** | **0.17 J** | **1000 J** | **DMW-11S-081108** | **43.7** | **80.8** | **142** |
| **TOLUENE** | **12/71** | **17%** | **0.13** | **500** | **0.32 J** | **4400** | **DMW-9S-082208** | **102** | **498** | **538** |
| **TRANS-1,2-DICHLOROETHENE** | **10/71** | **14%** | **0.19** | **1700** | **0.31 J** | **200** | **DMW-3S-082708** | **45.4** | **29.6** | **131** |
| **1,1-DICHLOROETHENE** | **9/71** | **13%** | **0.19** | **1700** | **0.31 J** | **76 J** | **DMW-4I-082508** | **42.2** | **20.5** | **129** |
| **1,2-DICHLOROETHANE** | **8/71** | **11%** | **0.22** | **1700** | **0.93 J** | **150 J** | **DMW-2A-082908 DMW-3I-082708** | **38.7** | **53.1** | **125** |
| CARBON DISULFIDE | 7/71 | 10% | 0.13 | 1700 | 0.29 J | 0.95 J | DMW-17D-090508 | 43.0 | 0.599 | 129 |
| **CHLOROBENZENE** | **7/71** | **10%** | **0.15** | **1700** | **0.22 J** | **720** | **DMW-1S-081808** | **62.8** | **210** | **161** |
| 2-BUTANONE | 6/71 | 8% | 0.57 | 8300 | 0.66 J | 1.4 J | DMW-23S-081108 | 214 | 0.917 | 645 |
| **BENZENE** | **5/71** | **7%** | **0.13** | **1700** | **4.2** | **570 J** | **DMW-9S-082208** | **43.0** | **122** | **127** |
| **METHYLENE CHLORIDE** | **5/71** | **7%** | **0.33** | **1700** | **8.2 J** | **140 J** | **DMW-18I-090208** | **42.6** | **48.4** | **129** |
| **1,2,4-TRIMETHYLBENZENE** | **3/71** | **4%** | **0.12** | **1700** | **0.6 J** | **240 J** | **DMW-9S-082208** | **37.8** | **80.7** | **113** |
| **CARBON TETRACHLORIDE** | **3/71** | **4%** | **0.13** | **1700** | **0.7 J** | **430 J** | **DMW-10I-081508** | **48.5** | **150** | **137** |
| **ETHYLBENZENE** | **3/71** | **4%** | **0.17** | **1700** | **1.5 J** | **2100** | **DMW-9S-082208** | **64.7** | **714** | **269** |
| **1,1,1-TRICHLOROETHANE** | **2/71** | **3%** | **0.22** | **1700** | **4.5 J** | **78 J** | **DMW-4I-082508** | **42.6** | **41.3** | **129** |
| 1,2,3-TRIMETHYLBENZENE | 2/71 | 3% | 0.0059 | 8300 | 0.11 J | 1.1 J | MW26S-080708 | 147 | 0.605 | 617 |
| **1,2,4-TRICHLOROBENZENE** | **2/71** | **3%** | **0.15** | **1700** | **650** | **730** | **DMW-3I-082708** | **53.8** | **690** | **165** |
| 1,2-DICHLOROBENZENE | 2/71 | 3% | 0.13 | 1700 | 0.42 J | 1.9 J | DMW-16S-082108 | 42.9 | 1.16 | 129 |
| ISOPROPYLBENZENE | 2/71 | 3% | 0.13 | 1700 | 0.24 J | 0.32 J | DMW-23S-081108 | 42.9 | 0.280 | 129 |
| **M+P-XYLENES** | **2/71** | **3%** | **0.24** | **3300** | **0.33 J** | **15000** | **DMW-9S-082208** | **280** | **7500** | **1785** |
| **NAPHTHALENE** | **2/71** | **3%** | **0.24** | **1700** | **0.31 J** | **0.32 J** | **DMW-6D-082008** | **43.3** | **0.315** | **129** |
| **O-XYLENE** | **2/71** | **3%** | **0.14** | **1700** | **1.4 J** | **830 J** | **DMW-9S-082208** | **46.2** | **416** | **145** |
| **TOTAL XYLENES** | **2/71** | **3%** | **0.28** | **3300** | **0.33 J** | **16000** | **DMW-9S-082208** | **294** | **8000** | **1903** |
| 1,3-DICHLOROBENZENE | 1/71 | 1% | 0.14 | 1700 | 0.63 J | 0.63 J | DMW-16S-082108 | 43.0 | 0.630 | 129 |
| **1,4-DICHLOROBENZENE** | **1/71** | **1%** | **0.13** | **1700** | **0.83 J** | **0.83 J** | **DMW-16S-082108** | **42.9** | **0.830** | **129** |
| 4-ISOPROPYLTOLUENE | 1/71 | 1% | 0.12 | 1700 | 11 | 11 | MW26S-080708 | 43.0 | 11.0 | 129 |
| ACETONE | 1/71 | 1% | 1.1 | 8300 | 12 | 12 | DMW-17D-090508 | 209 | 12.0 | 644 |
| CHLOROETHANE | 1/71 | 1% | 0.29 | 1700 | 1.1 J | 1.1 J | MW-23I-081808 | 43.5 | 1.10 | 129 |
| N-PROPYLBENZENE | 1/71 | 1% | 0.14 | 1700 | 0.3 J | 0.3 J | MW-23I-081808 | 43.0 | 0.300 | 129 |
| SEC-BUTYLBENZENE | 1/71 | 1% | 0.13 | 1700 | 0.39 J | 0.39 J | DMW-23S-081108 | 42.9 | 0.390 | 129 |

**Table 5-8**

**Distribution and Occurrence - Groundwater - 2008**
**Dump Road**
**Lockheed Martin Martin State Airport, Middle River, Maryland**


| Chemical | Frequency of Detection | | Mininum Non Detected | Maximum Non Detected | Mininum Detected | Maximum Detected | Location of Maximum Detected | Mean of All Samples | Mean of Positive Detects | Standard Deviation |
|---|---|---|---|---|---|---|---|---|---|---|
| | Number | Percent | | | | | | | | |
| TERT-BUTYLBENZENE | 1/71 | 1% | 0.13 | 1700 | 0.42 J | 0.42 J | DMW-23S-081108 | 42.9 | 0.420 | 129 |
| **TETRACHLOROETHENE** | **1/71** | **1%** | **0.29** | **1700** | **0.73 J** | **0.73 J** | **MW26D-080708** | **43.5** | **0.730** | **129** |
| **TOTAL METALS (ug/l)** | | | | | | | | | | |
| **BARIUM** | **71/71** | **100%** | **-** | **-** | **5.5** | **1610** | **MW26S-080708** | **71.5** | **71.5** | **191** |
| MAGNESIUM | 17/17 | 100% | - | - | 592 | 199000 | DMW-18S-090208 | 47265 | 47265 | 45865 |
| **MANGANESE** | **71/71** | **100%** | **-** | **-** | **21** | **12000** | **MW-6-082608** | **2096** | **2096** | **2273** |
| **COBALT** | **70/71** | **99%** | **0.37** | **0.37** | **0.25** | **467** | **DMW-2A-082908** | **60.8** | **61.7** | **99.4** |
| **ARSENIC** | **69/71** | **97%** | **0.13** | **0.13** | **0.62** | **41.7** | **DMW-4I-082508** | **8.44** | **8.68** | **8.99** |
| **IRON** | **69/71** | **97%** | **30.5** | **118** | **66.6 K** | **275000** | **DMW-6S-082108** | **31790** | **32710** | **41080** |
| **NICKEL** | **69/71** | **97%** | **0.28** | **0.36** | **0.48** | **530** | **DMW-24S-081108** | **41.3** | **42.5** | **72.2** |
| CALCIUM | 16/17 | 94% | 1660 | 1660 | 1990 | 199000 | DMW-18S-090208 | 70144 | 74476 | 57805 |
| **CHROMIUM** | **62/71** | **87%** | **0.27** | **3.8** | **0.5 K** | **349 K** | **DMW-1A-081508** | **18.2** | **20.7** | **50.7** |
| **VANADIUM** | **54/71** | **76%** | **0.46** | **20** | **0.6** | **139 J** | **DMW-17D-090508** | **11.6** | **14.3** | **22.3** |
| **SELENIUM** | **50/71** | **70%** | **0.14** | **5** | **0.16 L** | **47.2** | **DMW-24S-081108** | **5.14** | **7.02** | **10.1** |
| **LEAD** | **49/71** | **69%** | **0.026** | **0.85** | **0.33** | **30** | **DMW-9I-082208** | **4.10** | **5.89** | **6.66** |
| **COPPER** | **45/71** | **63%** | **0.051** | **2.2** | **0.096 K** | **262** | **DMW-2A-082908** | **29.3** | **46.0** | **57.1** |
| **ZINC** | **44/71** | **62%** | **2.1** | **44.5** | **13.3** | **1780** | **DMW-24S-081108** | **133** | **211** | **248** |
| **BERYLLIUM** | **42/71** | **59%** | **0.012** | **1** | **0.016** | **9.3** | **DMW-4I-082508** | **1.30** | **2.16** | **2.11** |
| **CADMIUM** | **31/71** | **44%** | **0.0061** | **0.33** | **0.077 L** | **768** | **DMW-2A-082908** | **42.9** | **98.3** | **137** |
| **MOLYBDENUM** | **29/71** | **41%** | **0.12** | **2.7** | **0.17 K** | **9.2 K** | **DMW-27DEEP-080808** | **1.06** | **2.02** | **1.60** |
| **CHROMIUM (HEXAVALENT)** | **24/61** | **39%** | **0.002** | **0.04** | **0.002 L** | **0.25** | **DMW-17D-090508** | **0.016** | **0.028** | **0.037** |
| **MERCURY** | **16/71** | **23%** | **0.1** | **0.22** | **0.1** | **3.9** | **DMW-1B-081508** | **0.237** | **0.833** | **0.560** |
| ANTIMONY | 15/71 | 21% | 0.035 | 2 | 0.038 K | 2.9 | MW-4-081808 | 0.240 | 0.596 | 0.442 |
| SILVER | 5/71 | 7% | 0.0026 | 1 | 0.058 | 0.35 K | DMW-4I-082508 | 0.105 | 0.188 | 0.188 |
| **THALLIUM** | **1/71** | **1%** | **0.11** | **1** | **0.24 K** | **0.24 K** | **DMW-6I-082008** | **0.162** | **0.240** | **0.166** |
| **FILTERED METALS (ug/l)** | | | | | | | | | | |
| MAGNESIUM | 17/17 | 100% | - | - | 418 | 183000 | DMW-18S-090208 | 48406 | 48406 | 43806 |
| **MANGANESE** | **71/71** | **100%** | **-** | **-** | **9.5** | **11900** | **MW-6-082608** | **2226** | **2226** | **2489** |
| **BARIUM** | **70/71** | **99%** | **2.9** | **2.9** | **6.4** | **1720** | **MW26S-080708** | **65.7** | **66.6** | **203** |
| **COBALT** | **69/71** | **97%** | **0.15** | **0.38** | **0.23** | **544** | **DMW-2A-082908** | **63.6** | **65.4** | **105** |
| **ARSENIC** | **68/71** | **96%** | **0.13** | **5** | **0.25** | **36** | **DMW-24S-081108** | **6.84** | **7.11** | **7.40** |
| **NICKEL** | **67/71** | **94%** | **0.22** | **0.38** | **0.65** | **542** | **DMW-24S-081108** | **42.0** | **44.5** | **75.1** |
| **CALCIUM** | **16/17** | **94%** | **1630** | **1630** | **2220** | **184000** | **DMW-18S-090208** | **70826** | **75201** | **55329** |
| **IRON** | **64/71** | **90%** | **5.2** | **79.3** | **156** | **284000** | **DMW-6S-082108** | **29930** | **33202** | **41784** |
| **CHROMIUM** | **45/71** | **63%** | **0.1** | **2.7** | **0.32 K** | **260 K** | **DMW-1A-081508** | **6.01** | **9.27** | **30.7** |
| **SELENIUM** | **44/71** | **62%** | **0.14** | **5** | **0.14** | **48.3** | **DMW-24S-081108** | **4.95** | **7.56** | **10.2** |

**Table 5-8**

**Distribution and Occurrence - Groundwater - 2008**
**Dump Road**
**Lockheed Martin Martin State Airport, Middle River, Maryland**


| Chemical | Frequency of Detection | | Mininum Non Detected | Maximum Non Detected | Mininum Detected | Maximum Detected | Location of Maximum Detected | Mean of All Samples | Mean of Positive Detects | Standard Deviation |
|---|---|---|---|---|---|---|---|---|---|---|
| | Number | Percent | | | | | | | | |
| **VANADIUM** | **36/71** | **51%** | **0.46** | **20** | **0.47** | **82.4** | **DMW-24S-081108** | **4.74** | **6.03** | **10.6** |
| **ZINC** | **36/71** | **51%** | **1.5** | **42.8** | **10.8** | **1810** | **DMW-24S-081108** | **113** | **219** | **243** |
| **BERYLLIUM** | **35/71** | **49%** | **0.012** | **1** | **0.1** | **10.2** | **DMW-4I-082508** | **1.17** | **2.29** | **2.10** |
| **COPPER** | **25/71** | **35%** | **0.051** | **2.7** | **0.38 K** | **156** | **DMW-24S-081108** | **10.1** | **28.4** | **25.7** |
| **CADMIUM** | **23/71** | **32%** | **0.0061** | **1** | **0.076 L** | **787** | **DMW-1A-081508** | **33.2** | **102** | **126** |
| LEAD | 23/71 | 32% | 0.018 | 1 | 0.043 | 10.9 | DMW-7I-082808 | 0.979 | 2.86 | 2.09 |
| **MOLYBDENUM** | **17/71** | **24%** | **0.12** | **2** | **0.19 K** | **10.2** | **DMW-3S-082708** | **0.799** | **2.20** | **1.63** |
| MERCURY | 7/71 | 10% | 0.1 | 0.2 | 0.1 K | 0.19 | MW-5-082808 | 0.075 | 0.143 | 0.033 |
| ANTIMONY | 3/71 | 4% | 0.035 | 2 | 0.089 K | 0.18 | DMW-6I-082008 | 0.135 | 0.121 | 0.291 |
| **THALLIUM** | **1/71** | **1%** | **0.11** | **1** | **0.22 K** | **0.22 K** | **DMW-6I-082008** | **0.167** | **0.220** | **0.174** |
| **MISCELLANEOUS (mg/l)** | | | | | | | | | | |
| ALKALINITY | 11/17 | 65% | 5 | 9.8 | 2.4 | 482 | DMW-9S-082208 | 95.9 | 147 | 164 |
| CHEMICAL OXYGEN DEMAND | 15/17 | 88% | 20 | 20 | 17.3 | 245 | DMW-9S-082208 | 59.4 | 65.9 | 61.0 |
| TOTAL ORGANIC CARBON | 17/17 | 100% | - | - | 0.5 | 43 | DMW-18S-090208 | 11.5 | 11.5 | 12.4 |
| **MISCELLANEOUS (S.U.)** | | | | | | | | | | |
| PH | 17/17 | 100% | - | - | 4.1 | 6.6 | DMW-16S-082108<br>DMW-18S-090208 | 5.40 | 5.40 | 0.919 |

**Footnotes:**
Bolded shaded indicates direct contact COPC.
For non-detects, 1/2 sample quantitation limit was used as a proxy concentration.
1/2 the detection limit was used for B qualified data.
Data Validation Qualifiers:
J = Estimated concentration
L = Result biased low
K = Result biased high
U = Analyte not detected at the analytical reporting limit
mg/kg = Milligrams per kilogram (i.e., parts per million)
ug/kg = Micrograms per kilogram (i.e., parts per billion)
Shaded line indicate analyte is a COPC.

**Table 5-9**

**Distribution and Occurrence - Groundwater - 2009**
**Dump Road**
**Lockheed Martin Martin State Airport, Middle River, Maryland**


| Chemical | Frequency of Detection | | Mininum Non Detected | Maximum Non Detected | Mininum Detected | Maximum Detected | Sample of Maximum Detected | Mean of All Samples | Mean of Positive Detects | Standard Deviation |
|---|---|---|---|---|---|---|---|---|---|---|
| | Number | Percent | | | | | | | | |
| VOLATILES (ug/l) | | | | | | | | | | |
| CIS-1,2-DICHLOROETHENE | 46/65 | 71% | 0.17 | 0.85 | 0.51 J | 41000 | MSA-DMW11S | 1515 | 2141 | 5542 |
| TRICHLOROETHENE | 41/65 | 63% | 0.17 | 280 | 0.3 J | 36000 | MSA-DMW11S | 2115 | 3349 | 5693 |
| 1,4-DIOXANE | 34/54 | 63% | 1 | 1 | 0.75 L | 1100 | MSA-DMW3I | 114 | 181 | 231 |
| VINYL CHLORIDE | 39/65 | 60% | 0.22 | 55 | 0.32 J | 56000 | MSA-DMW9S | 1222 | 2035 | 6954 |
| 1,2-DICHLOROETHANE | 18/65 | 28% | 0.22 | 370 | 0.26 J | 160 J | MSA-DMW3I | 13.7 | 22.2 | 35.3 |
| TRANS-1,2-DICHLOROETHENE | 17/65 | 26% | 0.19 | 320 | 0.19 J | 180 J | MSA-DMW11S | 14.1 | 29.4 | 34.2 |
| CHLOROFORM | 15/65 | 23% | 0.16 | 270 | 0.49 J | 950 | MSA-DMW11S | 26.1 | 89.9 | 123 |
| BENZENE | 13/65 | 20% | 0.13 | 93 | 0.35 J | 570 J | MSA-DMW9S | 14.6 | 54.0 | 70.8 |
| 1,1-DICHLOROETHENE | 11/65 | 17% | 0.19 | 320 | 0.24 J | 160 J | MSA-DMW11S | 11.7 | 28.8 | 30.1 |
| CARBON DISULFIDE | 8/65 | 12% | 0.13 | 220 | 0.2 J | 1.1 | MSA-MW32I | 5.89 | 0.690 | 15.7 |
| CHLOROBENZENE | 6/65 | 9% | 0.15 | 250 | 0.33 J | 560 | MSA-MW20S | 20.0 | 146 | 77.6 |
| TOLUENE | 6/65 | 9% | 0.13 | 150 | 0.3 J | 6500 | MSA-DMW9S | 132 | 1390 | 827 |
| 1,2,4-TRICHLOROBENZENE | 5/65 | 8% | 0.15 | 250 | 0.73 J | 560 | MSA-DMW3I | 23.5 | 240 | 95.0 |
| CARBON TETRACHLORIDE | 3/65 | 5% | 0.13 | 220 | 0.37 J | 23 J | MSA-DMW9I | 6.13 | 8.86 | 15.9 |
| 1,2-DICHLOROBENZENE | 2/65 | 3% | 0.13 | 220 | 0.36 J | 1.2 J | MSA-MW16S | 5.82 | 0.780 | 15.8 |
| 1,3-DICHLOROBENZENE | 2/65 | 3% | 0.14 | 230 | 0.4 J | 0.75 J | MSA-MW23S | 6.23 | 0.575 | 16.6 |
| 1,4-DICHLOROBENZENE | 2/65 | 3% | 0.13 | 220 | 0.37 J | 0.45 J | MSA-MW16S | 5.81 | 0.410 | 15.8 |
| BROMODICHLOROMETHANE | 2/65 | 3% | 0.15 | 250 | 0.17 J | 0.94 J | MSA-MW32I | 6.71 | 0.555 | 18.1 |
| ETHYLBENZENE | 2/65 | 3% | 0.17 | 120 | 27 J | 2100 | MSA-DMW9S | 38.0 | 1064 | 260 |
| M+P-XYLENES | 2/65 | 3% | 0.24 | 170 | 19 | 19000 | MSA-DMW9S | 300 | 9510 | 2356 |
| O-XYLENE | 2/65 | 3% | 0.14 | 100 | 2.5 | 1400 J | MSA-DMW9S | 26.0 | 701 | 173 |
| TOTAL XYLENES | 2/65 | 3% | 0.28 | 200 | 21 | 21000 | MSA-DMW9S | 332 | 10511 | 2604 |
| 1,1,1-TRICHLOROETHANE | 1/65 | 2% | 0.22 | 370 | 68 J | 68 J | MSA-DMW4I | 10.6 | 68.0 | 27.6 |
| 1,2,3-TRIMETHYLBENZENE | 1/65 | 2% | 0.0059 | 9.8 | 0.056 J | 0.056 J | MSA-MW32I | 0.264 | 0.056 | 0.707 |
| 1,2,4-TRIMETHYLBENZENE | 1/65 | 2% | 0.12 | 86 | 210 J | 210 J | MSA-DMW9S | 7.03 | 210 | 26.8 |
| 2-BUTANONE | 1/65 | 2% | 0.57 | 950 | 0.94 J | 0.94 J | MSA-MW32I | 25.2 | 0.940 | 68.3 |
| CHLORODIBROMOMETHANE | 1/65 | 2% | 0.18 | 300 | 0.57 J | 0.57 J | MSA-MW32I | 8.01 | 0.570 | 21.6 |
| CHLOROMETHANE | 1/65 | 2% | 0.3 | 500 | 0.31 J | 0.31 J | MSA-MW34S | 13.3 | 0.310 | 35.9 |
| ISOPROPYLBENZENE | 1/65 | 2% | 0.13 | 220 | 0.19 J | 0.19 J | MSA-DMW1S | 5.80 | 0.190 | 15.8 |
| SEC-BUTYLBENZENE | 1/65 | 2% | 0.13 | 220 | 0.26 J | 0.26 J | MSA-MW23S | 5.80 | 0.260 | 15.8 |
| TERT-BUTYLBENZENE | 1/65 | 2% | 0.13 | 220 | 0.36 J | 0.36 J | MSA-MW23S | 5.81 | 0.360 | 15.8 |
| ETHENE | 6/6 | 100% | - | - | 1.6 | 36 J | MSA-MW14I | 13.1 | 13.1 | 14.4 |
| ETHANE | 4/6 | 67% | 0.27 | 0.27 | 0.95 | 31 J | MSA-MW14I | 6.37 | 9.49 | 12.1 |
| METHANE | 6/6 | 100% | - | - | 21 | 1000 J | MSA-MW14I | 317 | 317 | 360 |

**Table 5-9**

**Distribution and Occurrence - Groundwater - 2009**
**Dump Road**
**Lockheed Martin Martin State Airport, Middle River, Maryland**


| Chemical | Frequency of Detection | | Mininum Non Detected | Maximum Non Detected | Mininum Detected | Maximum Detected | Sample of Maximum Detected | Mean of All Samples | Mean of Positive Detects | Standard Deviation |
|---|---|---|---|---|---|---|---|---|---|---|
| | Number | Percent | | | | | | | | |
| **SEMIVOLATILES (ug/l)** | | | | | | | | | | |
| DIETHYL PHTHALATE | 1/6 | 17% | 0.6 | 0.6 | 1.6 | 1.6 | MSA-MW34S | 0.517 | 1.60 | 0.531 |
| **TOTAL METALS (ug/l)** | | | | | | | | | | |
| **BARIUM** | **65/65** | **100%** | **-** | **-** | **3.1** | **539** | **MSA-MW26S** | **53.6** | **53.6** | **70.4** |
| CALCIUM | 6/6 | 100% | - | - | 43200 | 189000 | MSA-MW14I | 117750 | 117750 | 60092 |
| MAGNESIUM | 6/6 | 100% | - | - | 31200 | 202000 | MSA-MW18S | 80267 | 80267 | 62176 |
| **MANGANESE** | **65/65** | **100%** | **-** | **-** | **12.3** | **13400 J** | **MSA-MW6** | **2448** | **2448** | **2769** |
| POTASSIUM | 6/6 | 100% | - | - | 5050 | 42500 J | MSA-MW18S | 15905 | 15905 | 14175 |
| SILICA | 6/6 | 100% | - | - | 4270 | 30200 | MSA-MW18S | 17512 | 17512 | 10296 |
| SODIUM | 6/6 | 100% | - | - | 44600 | 560000 | MSA-MW18S | 196600 | 196600 | 183500 |
| **COBALT** | **61/65** | **94%** | **0.12** | **0.37** | **0.12** | **724** | **MSA-MW24S** | **81.6** | **87.0** | **135** |
| **IRON** | **61/65** | **94%** | **58.6** | **97.4** | **239** | **238000** | **MSA-MW24S** | **31142** | **33181** | **46327** |
| **NICKEL** | **61/65** | **94%** | **0.2** | **1** | **1.4 K** | **991** | **MSA-MW24S** | **57.9** | **61.6** | **128** |
| **ARSENIC** | **54/65** | **83%** | **0.12** | **0.93** | **0.28** | **82.2 J** | **MSA-DMW1B** | **8.34** | **10.00** | **15.4** |
| **VANADIUM** | **50/65** | **77%** | **0.29** | **0.6** | **0.62** | **116** | **MSA-MW24S** | **7.35** | **9.49** | **17.2** |
| **CHROMIUM** | **49/65** | **75%** | **0.36** | **1.7** | **0.84** | **303** | **MSA-DMW1A** | **14.0** | **18.5** | **42.7** |
| **SELENIUM** | **43/65** | **66%** | **0.14** | **1.1** | **0.16** | **149** | **MSA-MW24S** | **5.96** | **8.94** | **19.7** |
| **ZINC** | **43/65** | **66%** | **2.2** | **51.6** | **18.3 J** | **3150** | **MSA-MW24S** | **196** | **291** | **423** |
| **COPPER** | **41/65** | **63%** | **0.079** | **3.7** | **0.47** | **534** | **MSA-DMW6I** | **26.4** | **41.6** | **72.4** |
| **LEAD** | **39/65** | **60%** | **0.028** | **1.2** | **0.12 K** | **38** | **MSA-DMW9I** | **2.79** | **4.54** | **6.00** |
| **BERYLLIUM** | **36/65** | **55%** | **0.025** | **0.48** | **0.055** | **9.9** | **MSA-MW24S** | **1.10** | **1.95** | **2.05** |
| **CADMIUM** | **29/65** | **45%** | **0.014** | **0.43** | **0.073** | **1130** | **MSA-DMW1A** | **47.9** | **107** | **174** |
| **MOLYBDENUM** | **14/65** | **22%** | **0.2** | **1.8** | **0.97** | **4.3** | **MSA-DMW11I** | **0.794** | **2.43** | **1.00** |
| **MERCURY** | **10/65** | **15%** | **0.1** | **0.2** | **0.11 K** | **13.2** | **MSA-DMW4D** | **0.341** | **1.93** | **1.66** |
| **ANTIMONY** | **4/65** | **6%** | **0.043** | **0.82** | **0.51** | **1.7** | **MSA-DMW3S, MSA-DMW9I** | **0.160** | **1.12** | **0.297** |
| SILVER | 2/65 | 3% | 0.02 | 0.2 | 0.08 K | 0.15 K | MSA-DMW4I | 0.022 | 0.115 | 0.025 |
| **THALLIUM** | **1/65** | **2%** | **0.072** | **0.78** | **0.2** | **0.2** | **MSA-MW14I** | **0.085** | **0.200** | **0.059** |

**Table 5-9**

**Distribution and Occurrence - Groundwater - 2009**
**Dump Road**
**Lockheed Martin Martin State Airport, Middle River, Maryland**


| Chemical | Frequency of Detection | | Mininum Non Detected | Maximum Non Detected | Mininum Detected | Maximum Detected | Sample of Maximum Detected | Mean of All Samples | Mean of Positive Detects | Standard Deviation |
|---|---|---|---|---|---|---|---|---|---|---|
| | Number | Percent | | | | | | | | |
| **FILTERED METALS (ug/l)** | | | | | | | | | | |
| **BARIUM** | **65/65** | **100%** | **-** | **-** | **2.3** | **582** | **MSA-MW26S** | **49.6** | **49.6** | **75.9** |
| **MANGANESE** | **65/65** | **100%** | **-** | **-** | **11.8** | **12600** | **MSA-MW6** | **2474** | **2474** | **2808** |
| **COBALT** | **60/65** | **92%** | **0.11** | **0.39** | **0.078** | **692** | **MSA-MW24S** | **80.9** | **87.6** | **134** |
| **NICKEL** | **59/65** | **91%** | **0.3** | **1.3** | **1** | **942** | **MSA-MW24S** | **55.2** | **60.8** | **122** |
| **IRON** | **58/65** | **89%** | **4.7** | **73.9** | **175** | **222000** | **MSA-MW24S** | **29045** | **32548** | **45387** |
| **ARSENIC** | **51/65** | **78%** | **0.12** | **1.1** | **0.22 J** | **77.3** | **MSA-MW24S** | **6.38** | **8.10** | **11.5** |
| **SELENIUM** | **38/65** | **58%** | **0.14** | **1.2** | **0.15** | **139** | **MSA-MW24S** | **5.65** | **9.57** | **18.7** |
| **ZINC** | **37/65** | **57%** | **1.5** | **54.2** | **16.8 J** | **2860** | **MSA-MW24S** | **138** | **239** | **368** |
| **CHROMIUM** | **32/65** | **49%** | **0.19** | **1.3** | **0.83** | **171** | **MSA-DMW1A** | **4.99** | **9.82** | **21.3** |
| **BERYLLIUM** | **31/65** | **48%** | **0.025** | **0.6** | **0.073** | **10.4** | **MSA-DMW4I** | **1.00** | **2.05** | **2.03** |
| **VANADIUM** | **30/65** | **46%** | **0.29** | **0.6** | **0.6** | **141** | **MSA-MW24S** | **3.91** | **8.21** | **17.5** |
| **COPPER** | **27/65** | **42%** | **0.064** | **2.1** | **0.47** | **157** | **MSA-MW24S** | **12.2** | **29.0** | **27.6** |
| LEAD | 24/65 | 37% | 0.028 | 0.79 | 0.1 K | 6.8 | MSA-DMW4I | 0.708 | 1.80 | 1.41 |
| **CADMIUM** | **23/65** | **35%** | **0.014** | **0.41** | **0.041** | **1070** | **MSA-DMW1A** | **43.4** | **123** | **166** |
| **MOLYBDENUM** | **7/65** | **11%** | **0.2** | **2.2** | **0.48** | **2.6** | **MSA-DMW11I** | **0.426** | **1.97** | **0.623** |
| **MERCURY** | **4/65** | **6%** | **0.1** | **0.24** | **0.11 K** | **0.34** | **MSA-DMW4D** | **0.059** | **0.178** | **0.040** |
| **MISCELLANEOUS (mg/l)** | | | | | | | | | | |
| ALKALINITY | 4/6 | 67% | 1.1 | 1.1 | 26 | 270 | MSA-MW18S | 80.0 | 120 | 103 |
| CHLORIDE | 6/6 | 100% | - | - | 23.3 J | 594 | MSA-MW18S | 207 | 207 | 211 |
| DISSOLVED ORGANIC CARBON | 6/6 | 100% | - | - | 4 | 33 | MSA-MW18S | 11.3 | 11.3 | 10.8 |
| HEXAVALENT CHROMIUM | 14/42 | 33% | 0.002 | 0.02 | 0.002 L | 0.01 | MSA-DMW11S | 0.002 | 0.005 | 0.002 |
| NITRATE-N | 2/6 | 33% | 0.023 | 0.023 | 0.1 | 2.8 | MSA-DMW4D | 0.491 | 1.45 | 1.13 |
| SULFATE | 6/6 | 100% | - | - | 439 | 1600 | MSA-MW18S | 895 | 895 | 405 |
| TOTAL DISSOLVED SOLIDS | 6/6 | 100% | - | - | 1100 | 3500 | MSA-MW18S | 1667 | 1667 | 922 |
| **MISCELLANEOUS (ug/l)** | | | | | | | | | | |
| **PERCHLORATE** | **14/59** | **24%** | **0.082** | **0.082** | **0.086 J** | **5.8** | **MSA-DMW4D** | **0.252** | **0.929** | **0.947** |
| **PETROLEUM HYDROCARBONS (ug/l)** | | | | | | | | | | |
| DIESEL RANGE ORGANICS | 13/23 | 57% | 46 | 840 | 150 | 1300 | MSA-MW20S | 340 | 508 | 308 |
| GASOLINE RANGE ORGANICS | 22/23 | 96% | 28 | 28 | 30 J | 70000 | MSA-DMW9S | 4233 | 4425 | 14768 |

Footnotes:
For non-detects, 1/2 sample quantitation limit was used as a proxy concentration.
1/2 the detection limit was used for B qualified data.
Data Validation Qualifiers:
J = Estimated concentration
L = Result biased low
K = Result biased high
U = Analyte not detected at the analytical reporting limit
mg/kg = Milligrams per kilogram (i.e., parts per million)
ug/kg = Micrograms per kilogram (i.e., parts per billion)
Shaded line indicate analyte is a COPC.

**Table 5-14**

**Summary of Metals Exceeding Maryland Groundwater Standards, 2007 Through 2009**
**Dump Road**
**Lockheed Martin Martin State Airport, Middle River, Maryland**

| Analyte | MDE Groundwater Standard[1] (ug/L) | Total Metals Samples | | | Filtered Metals Samples | | |
|---|---|---|---|---|---|---|---|
| | | Detections Exceeding Standards | | Maximum Concentration (ug/L) | Detections Exceeding Standards | | Maximum Concentration (ug/L) |
| | | (Quantity) | (Percent)[2,3] | | (Quantity) | (Percent)[2,3] | |
| Arsenic | 10 | 42 | 21% | 82.2 J | 34 | 17% | 77.3 |
| Barium | 2000 | 1 | 1% | 44,100,000 | 0 | 0% | 582 |
| Beryllium | 4 | 22 | 11% | 9.9 | 23 | 12% | 10.4 |
| Cadmium | 5 | 41 | 21% | 1,130 | 34 | 17% | 1,070 |
| Chromium | 100 | 8 | 4% | 889 | 3 | 2% | 260 K |
| Chromium (hexavalent) | 100 | NS | -- | -- | 2 | 1% | 250 |
| Iron | 2600 | 119 | 88% | 275,000 | 120 | 81% | 284,000 |
| Lead | 15 | 12 | 6% | 228 | 0 | 0% | 11.2 |
| Manganese | 73 | 122 | 90% | 13,400 J | 121 | 89% | 12,600 |
| Mercury | 2 | 4 | 2% | 13.2 | 0 | 0% | 0.34 |
| Nickel | 73 | 39 | 20% | 991 | 38 | 19% | 942 |
| Selenium | 50 | 2 | 1% | 149 | 1 | 1% | 139 |
| Vanadium | 3.7 | 71 | 36% | 139 J | 33 | 17% | 141 |
| Zinc | 1100 | 2 | 1% | 3,150 | 1 | 1% | 2,860 |

1 MDE Soil and Groundwater Standards, Interim Final, June 2008.
2 Total number of samples is 198 for listed analytes except filtered iron, total/filtered manganese and hexavalent chromium.
3 Total number of samples is 146 for hexavalent chromium, 148 for filterd iron and 136 for total iron and total/filtered manganese.
J = Estimated concentration below the contract required reporting limit.
K = Concentration is biased high
NS = Not sampled
ug/L = Micrograms per liter (i.e., parts per billion)

## Table 5-15

## Analytical Results for Groundwater Natural Attenuation Parameters
## Dump Road
## Lockheed Martin Martin State Airport, Middle River, Maryland

| SAMPLE ID: | MSA-DMW4D-090309 | MSA-DMW4I-090109 | MSA-DMW4S-090309 | MSA-MW14I-090809 | MSA-MW18I-090109 | MSA-MW18S-090109 |
|---|---|---|---|---|---|---|
| LABORATORY ID: | A9I040243011 | A9I020192010 | A9I040243010 | A9I090172002 | A9I020192007 | A9I020192006 |
| SAMPLE DATE: | 9/3/2009 | 9/1/2009 | 9/3/2009 | 9/8/2009 | 9/1/2009 | 9/1/2009 |
| LOCATION: | MSA-DMW4D | MSA-DMW4I | MSA-DMW4S | MSA-MW14I | MSA-MW18I | MSA-MW18S |
| **NATURAL ATTENUATION PARAMETERS (mg/l)** | | | | | | |
| ALKALINITY | 1.1 U | 1.1 U | 73 | 110 J | 26 | 270 |
| CHLORIDE | 123 | 94 | 105 | 23.3 J | 305 | 594 |
| DISSOLVED ORGANIC CARBON | 4 | 7 | 8 | 10 | 6 | 33 |
| ETHANE | 0.27 U | 0.27 U | 3.3 | 31 J | 2.7 | 0.95 |
| ETHENE | 1.6 | 4.3 | 2.5 | 36 J | 26 | 8 |
| METHANE | 21 | 53 | 210 | 1000 J | 390 | 230 |
| NITRATE-N | 2.8 | 0.1 | 0.023 U | 0.023 U | 0.023 U | 0.023 UJ |
| NITRITE-N | 0.012 U | 0.012 U | 0.012 U | 0.012 U | 0.012 U | 0.012 UJ |
| ORTHOPHOSPHATE-P | 0.044 UL | 0.044 U | 0.044 UL | 0.044 U | 0.044 U | 0.044 U |
| SULFATE | 723 L | 1050 | 908 L | 649 J | 439 | 1600 |
| TOTAL DISSOLVED SOLIDS | 1200 | 1600 | 1500 | 1100 | 1100 | 3500 |

B - Analyte was detected but is considered to be a laboratory contaminant.

J - Positive value is considered estimated as a result of technical noncompliance.

L - Positive value is considered biased low as a result of technical noncompliance.

U - Not detected

mg/l - milligrams per liter

# APPENDIX B
# GROUNDWATER MODELING REPORT

***DRAFT***

# MSA GROUNDWATER FEASIBILITY STUDY
# APPENDIX B —
# REFINEMENT AND CALIBRATION OF A GROUNDWATER FLOW MODEL AT THE "DUMP ROAD AREA SITE" AT MARTIN STATE AIRPORT

**MIDDLE RIVER, MARYLAND**

*Prepared for:*

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*Prepared by:*

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*GEOTRANS, INC. PROJECT NO. 117-0512042*

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# ACRONYMS

| | |
|---|---|
| bgs | below ground surface |
| C | Conductance |
| *d* | elevation of water level in drain |
| DCE | cis-1,2-dichloroethene |
| foc | fraction of organic carbon |
| FS | feasibility study |
| ft | Feet |
| gpm | gallons per minute |
| *h* | water level in grid cell (feet) |
| in. | inch(es) |
| IRA | interim remedial action |
| $K_e$ | hydraulic conductivity |
| $K_{oc}$ | partitioning coefficient |
| MRC | Middle River Complex |
| MSA | Martin State Airport |
| msl | mean sea level |
| NAD83 | North American Datum of 1983 |
| NAVD88 | North American Vertical Datum of 1988 |
| *Q* | extraction rate |
| RAO | remedial action objective |
| RAP | remedial action plan |
| $r_w$ | well radius (in feet) |
| TCE | Trichloroethene |
| USGS | United States Geological Survey |
| VC | vinyl chloride |
| VOC | volatile organic compound |

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# GLOSSARY

**aquifer—**Subsurface formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield usable quantities of water to wells and springs.

**drawdown—**A lowering of the water table of an unconfined aquifer or the potentiometric surface of a confined aquifer caused by pumping groundwater from wells. The drawdown is the vertical distance between the original water level and the new water level in the well.

**effective porosity—**The interconnected pore space through which fluids can pass, expressed as a percent of bulk volume. Part of the total porosity will be occupied by static fluid being held to mineral surfaces by surface tension; therefore, the effective porosity will be less than total porosity.

**hydraulic conductivity—**An aquifer characteristic related to its permeability. Hydraulic conductivity is a coefficient of proportionality describing the volumetric flow rate per unit area of water through a permeable medium, when the hydraulic gradient is unity.

**hydraulic gradient—**Slope of a water table or potentiometric surface. More specifically, change in the hydraulic head per unit of distance in the direction of the maximum rate of decrease.

**model domain—**The modeling area of interest bounded by model boundary conditions.

**residual—**The difference between the model-computed and field-measured values of a variable, such as hydraulic head or groundwater flow rate, at a specific time and location.

**pumping test—**A test to determine aquifer or well characteristics by pumping a well for a period of time and observing the change in hydraulic head in the aquifer. The results can be used to determine the capacity of the well and the hydraulic characteristics of the aquifer.

**slug test—**A test to determine aquifer or well characteristics by inducing a sudden pressure change in a well and observing the change in hydraulic head in the well as it returns to its original level. The results can be used to estimate the horizontal hydraulic conductivity of the screened portion of the aquifer.

**storativity—**The amount of water a given aquifer volume will absorb or expel per unit area when a unit change in hydraulic head is applied.

**specific yield—**A ratio representing the volumetric fraction of total bulk volume an aquifer will yield when all water is allowed to drain out under force of gravity. The specific yield is a property of unconfined aquifers.

**steady-state model—**A model of an aquifer system in equilibrium (or in balance) with respect to groundwater inflow and outflow. In a steady-state model simulation, the groundwater head and flux conditions do not change over time.

**stratigraphy—**Classifying rock and geologic materials into separate formations based on their physical, geochemical, geologic age, and other characteristics.

**transient model** (time-dependent)**—**A model of an aquifer system not in equilibrium with respect to groundwater inflow and outflow. In a steady-state model simulation, the groundwater head and flux conditions change over time.

# 1 INTRODUCTION AND MODELING OBJECTIVES

As part of the interim remedial action (IRA) feasibility study (FS) for the groundwater operable unit at the "Dump Road Area Site" at Martin State Airport (MSA) in Middle River, Maryland, this report summarizes the calibration and application of a groundwater flow model of the southeast portion of the airport (see **Figure 1**). This updated model refines previous groundwater flow modeling performed for the site (Tetra Tech, 2004). The primary focus of this refined model is to help develop an effective FS preliminary groundwater remedial system design to hydraulically capture high concentration zones of contaminants in groundwater at MSA.

In this updated model, the model domain was extended to be consistent with natural hydrogeologic boundaries and to assess the potential for contaminated groundwater to migrate beneath Frog Mortar Creek. In addition, the model was extended downward to include a deeper, confined, water-bearing zone. New hydrogeologic data collected after the earlier modeling effort— including groundwater elevation, groundwater sampling, stratigraphic boring, and pumping test data— were also incorporated into the updated flow and advective transport model.

The groundwater modeling efforts are defined based on the knowledge gained from prior modeling efforts and the availability of data collected during current site remedial investigation efforts. In summary, the modeling study includes the following primary tasks:

- refine the existing flow model using new site-specific data collected since 2004
- calibrate the flow model to both steady-state and transient-flow conditions
- apply the flow model to develop a conceptual remedial design for contaminated groundwater

The engineering team uses the model iteratively to develop technically sound remediation alternatives. Remedial approaches under consideration include plume control, plume capture, and ex-situ treatment of the extracted groundwater in order to meet remedial action objectives (RAOs) that include preventing migration of contaminated groundwater toward Frog Mortar Creek.

The primary contaminants driving the remedial action plan (RAP) approach include three volatile organic compounds (VOCs)— trichloroethene (TCE), cis-1,2-dichloroethene (DCE), and vinyl chloride (VC)— as well as 1,4-dioxane. The primary area of concern is shown by mapping

the groundwater concentrations of these VOCs and 1,4-dioxane (see **Figures 2 through 5**), based on groundwater sampling in September 2009. The likely sources of contamination include the following areas of concern:

- Taxiway Tango Median Anomaly Area
- Drum Area
- Two ponds on-site
- Petroleum Hydrocarbon Area (Handex, 1992; MES 1994; Tetra Tech, 2004)

These features guided the development of groundwater remediation scenarios, which were tested through groundwater model-based predictive simulations.

This report discusses refinements to the existing model and calibration of the flow model based on July 2010 water level data and a pumping test conducted in the intermediate zone of the surficial aquifer. After model calibration, the groundwater flow model was applied to determine appropriate locations for recovery wells and adequate pumping rates to prevent migration of upgradient contaminated groundwater toward Frog Mortar Creek. The model was also applied to examine the effects of additional pumping in high concentration zones of the contaminant plumes. Given its ability to simulate various extraction well configurations, this groundwater flow model is a useful and appropriate decision-analysis tool for this stage of the overall remediation project.

# 2 CONCEPTUAL MODEL

Groundwater modeling begins with defining goals and objectives, as listed in section 1, followed by the development of a conceptual model that forms the basis for the analytical techniques used to evaluate groundwater remediation alternatives. The conceptual model of a hydrogeologic system is a working description of the system's characteristics and dynamics. It consolidates site and regional hydrologic data into a set of assumptions and concepts that can be quantitatively evaluated (ASTM, 1996). The conceptual model is subsequently translated into a numerical representation to simulate groundwater, including modeling-based development, testing, and comparative evaluation of FS remediation options. This section describes the conceptual model developed for this project, with subsequent sections presenting the implementation and application of numerical groundwater-flow modeling for the analysis of remediation scenarios.

## 2.1 GEOLOGY

Martin State Airport is in the western shore of the Coastal Plain Physiographic Province. Geologic mapping of Baltimore County shows that MSA is underlain by the Potomac Group, a lower Cretaceous age interbedded gravel, sand, silt, and clay unit ranging in thickness from zero to 800 feet. The Potomac Group at MSA consists of three units (from the top down): the Patapsco Formation, the Arundel clay, and the Patuxent Formation. Sediments of the Potomac Group were deposited in a river delta environment (Hansen, 1969). Patapsco Formation deposits constitute fine to medium sand and silt beds characteristic of back swamps and flood-plain deposits. The Patapsco Formation, the primary formation of interest in this investigation, is composed primarily of silty sands, fine-grained to medium-grained sands, silty clays, clayey silts, and plastic clay. The Arundel clay is composed of dark gray and maroon lignitic clays ranging between 25–200 feet thick in the study area.

Previous (MES, 1994; Tetra Tech, 1999; 2002; 2004) and recent investigations at MSA indicate that the subsurface is characterized by interbedded zones of heterogeneous sand, silt, and clay deposits from the Patapsco Formation. Boring logs and cross-sections across MSA indicate relatively continuous layers of sand and gravel locally separated by silts and clays. These shallow permeable zones form the surficial aquifer. Both regional information (Andreasen, 2007; Fleck and Vroblesky, 1996; Chapelle, 1985) and recent deep borings at MSA indicate the

presence of a thick clay unit approximately 120 feet (ft) below MSA, which may be the top of the Arundel Formation. Interbedded sand zones in this clay unit form local, confined, water-bearing zones.

## 2.2 HYDROGEOLOGY

The hydrogeologic system beneath MSA consists of relatively continuous zones of sand and gravel that provide the primary pathways for groundwater flow and contaminant transport. These zones are interlayered with zones of lower permeability sediments, resulting in a relatively complex stratigraphic sequence. MSA data indicate that the surficial aquifer consists of three hydraulically connected monitoring zones: upper, intermediate, and lower. All zones contain lower conductivity lenses that result in horizontal and vertical anisotropy. In addition, the lower surficial unit is separated from the intermediate unit by a semi-confining layer. The surficial aquifer (part of the Patapsco Formation) is underlain at approximately 75 ft below mean sea level (msl) by a relatively thick clay unit that acts as a basal confining unit. Hydrostratigraphic cross-sections are presented along various transects in Addendum A. Deep borings at MSA indicate the presence of deeper sand zones, which are confined above and below by clay units most likely from the Arundel formation, which is a regionally extensive, thick, dense clay confining unit.

Water enters these units primarily via natural infiltration of precipitation (i.e., recharge) through the shallow fill materials before reaching the water table. From there, groundwater migrates along various pathways depending on location, with some groundwater flowing vertically downward to recharge units below the water table. Eventually almost all groundwater flows laterally through permeable zones before discharging to estuaries surrounding the peninsula on which MSA is located. In the Dump Road Area, the estuary of relevance is Frog Mortar Creek. Recharge of the deeper zones in the surficial aquifer occurs via low rates of downward leakage from the upper zone. In addition, the potential exists for groundwater in the lower surficial-aquifer zone, as well as in deeper flow zones, to flow eastward beneath and beyond Frog Mortar Creek.

Water level fluctuations have been measured through the use of recorders placed in selected monitoring wells and the tidal water bodies near the site. Water level fluctuations in the surficial aquifer result from surface water tidal fluctuations, with the greatest tidal influence generally occurring in the intermediate and deep surficial-aquifer zones. Frog Mortar Creek is

affected by tidal fluctuations with average amplitudes of approximately 1.2 ft (and thus a tidal range of about 2.4 ft). In the upper zone of the surficial aquifer, transducer data indicate that tidal fluctuation amplitudes decrease to less than 0.1 foot within a few hundred feet of Frog Mortar Creek. This damping effect is most likely due to the relatively high storage coefficient (i.e., "specific yield") of this unconfined zone. In other words, this layer zone is a water table aquifer in which its storage capacity is strongly correlated to the primary porosity of the formation. In the intermediate and deep zones, tidal fluctuations diminish less rapidly with distance from Frog Mortar Creek because of the semi-confined or confined conditions in these zones. Much less damping of the tidal signal occurs under these conditions because the aquifer units are fully saturated and under artesian pressure, with confined storage coefficient (i.e., "storativity") values significantly lower than in the shallow, water table zone.

Groundwater flow patterns at the site have been identified through the network of monitoring wells in which several rounds of water level measurements have been conducted, in addition to the continuously-recorded data from a select set of wells. Groundwater in the area generally flows eastward toward Frog Mortar Creek. **Figure 6** presents a water table map of the upper zone of the surficial aquifer based on water level data collected in July 2010, with elevations surveyed using the North American Vertical Datum of 1988 (NAVD88) and horizontal coordinates surveyed using North American Datum of 1983 (NAD83). **Figures 7** and **8** both indicate a similar flow direction in the intermediate and deep zones based on water level data collected in July 2010. At monitoring well clusters, the concurrently measured hydraulic heads indicate that groundwater vertical head differences in the surficial aquifer are generally downward in the upland areas and upward near Frog Mortar Creek.

## 2.3 AQUIFER HYDRAULIC CHARACTERISTICS

Slug testing at MSA yielded hydraulic conductivity estimates ranging from 1–68 ft/day in sand zones to 0.01–0.2 ft/day in clay zones (Tetra Tech, 2004; Tetra Tech 2010). Pumping tests were performed in both the shallow and intermediate zones of the surficial aquifer. For the shallow zone, only low pumping rates [less than one gallon per minute (gpm)] could be sustained, indicating a relatively lower hydraulic conductivity in the shallow zone. This is consistent with the greater amounts of clay in the shallow zone noted in boring logs.

For the intermediate zone, the pumping test was performed for three days at a rate of 10 gpm. Analyses of drawdown vs. time and drawdown vs. distance data from the intermediate zone-pumping test indicate an average horizontal hydraulic conductivity ranging from 42–140 ft/day, with a mean of 68 ft/day (Tetra Tech, 2010). Although no pumping tests have been performed in the deep zone, analyses of tidal data indicate a relatively higher hydraulic conductivity of 100 ft/day in this zone (GeoTrans, 2010), which is consistent with the observed presence of coarse-grained sediments in the lower zone of the surficial aquifer. Tidal fluctuations could not be used to estimate hydraulic conductivity in the upper and intermediate zones. The responses in the upper zone were diminished because of the higher storage coefficient in this unconfined zone. The responses were also diminished in the intermediate zone because of both the local presence of clay zones and the distance of the wells from Frog Mortar Creek.

## 2.4 SURFACE WATERS

The primary surface water drainages in the model vicinity are estuarine. Martin State Airport is bounded by Frog Mortar Creek to the east and Stansbury Creek to the west (see **Figure 1**). Dark Head Cove lies west and northwest of Stansbury Creek. Each of these creeks joins Middle River south of the airport. Middle River discharges into Chesapeake Bay to the east. South of Frog Mortar Creek is Seneca Creek, which also joins Middle River southeast of the airport.

Freshwater surface water features relevant to the model include two ponds, approximately 0.25 and 0.33 of an acre in size, respectively. The ponds are an area of concern in the RAP. The significantly higher elevation of water measured in these ponds in comparison to the water table elevation below them indicates that they are not well connected to shallow groundwater.

## 2.5 WATER BUDGET

Groundwater flow at the site is generated almost exclusively by the infiltration of precipitation and redirected storm runoff and snowmelt, leading to the recharge of the groundwater system. For this reason, development of the conceptual model focused on the identification and characterization of the processes affecting recharge. In addition, the conceptual

and numerical models assume that a single parameter called “net effective recharge” could be defined to incorporate all of the processes involved.

MSA topography is relatively flat, with a steeper slope near Frog Mortar Creek. The nature of the ground surface (much of which is paved or covered by buildings) creates a significant potential for precipitation runoff. Runoff from buildings and some or all of the paved areas is captured and conveyed through a storm-sewer system. In the area of interest, additional overland flow drains into locally perched ponds or Frog Mortar Creek. Therefore, the net effective recharge will be lower at MSA than in open areas that do not have runoff controls.

Areal variations in recharge rates are influenced by topography and surficial geology, including the presence or absence of paved surfaces. Precipitation in this area is approximately 44 inches (in.) per year (Tenbus and Fleck, 2001). Recharge is expected primarily in late winter and early spring, when evapotranspiration is minimal. Tenbus and Fleck (2001) estimated recharge rates between zero and nine inches per year at the nearby Graces Quarters site. Recharge rates applied in the associated groundwater model vary, based on whether the area is paved or unpaved. Recharge to the groundwater system where the ground surface at MSA is not covered by buildings or pavement is expected to be at the higher end of the 0–9 inches per year range referred to by Tenbus and Fleck (2001).

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# 3 NUMERICAL FLOW MODEL

Developing a numerical groundwater flow model entails transforming the conceptual model into a mathematical form. Fundamental components of the numerical groundwater flow modeling process conducted before model calibration include selection of an appropriate mathematical-solution basis, or code, development of a three-dimensional model grid, assignment of representative initial and boundary conditions for calibration and predictive-simulation purposes, and characterization of hydraulic properties (ASTM, 1996).

## 3.1 CODE SELECTION

The groundwater flow model was developed using *MODFLOW 200*0, a well documented, widely used and accepted code developed by the U.S. Geological Survey (USGS) (McDonald and Harbaugh, 1988; Harbaugh *et al.*, 2000).

## 3.2 MODEL GRID AND LAYERING

The site-specific model uses 15 layers to represent the groundwater system beneath MSA. The base of the model is approximately 120 ft below ground surface (bgs), which is where deep borings at MSA have encountered thick clays. These clays are likely the top of the Arundel clay confining-unit, which is represented in the model as an impermeable bottom edge, called a no-flow boundary. Table 1 summarizes model layering information.

The top and bottom elevations of each model layer are defined based both on regional trends of the geologic units and site-specific boring logs. The model grid shown in **Figure 9** is oriented at a rotation of approximately 45 degrees off true north, so that the columns are aligned parallel to northeast (NE) to southwest (SW), and the rows parallel to northwest (NW) to southeast (SE). The model domain includes the Middle River Complex (MRC), which is approximately a mile northwest of MSA. Given the distance between the MRC and MSA, different models are used to simulate local plume fate and transport characteristics at each site. At MSA, the model grid spacing varies from 25 ft in the area of interest to 100 ft at the outer regions of the model domain.

## 3.3 BOUNDARY CONDITIONS

Model boundaries are mathematical statements specifying the groundwater level (head), groundwater flux, or head-dependent flux at the boundaries of the model domain. Beginning with the top layer, this section discusses the boundary conditions specified for each of the layers in the numerical groundwater-flow model. Boundary conditions simulated in Layer 1 include net recharge, river leakage, and zero flux (no flow), as shown in **Figure 9**. The primary source of water to the model is from precipitation-derived recharge. As shown in **Figure 10**, uniform recharge rates equal to 8.4 inches per year for unpaved areas and 0.36 inch per year for paved areas are simulated in the model. The principal surface water drainages (including Frog Mortar Creek, Stansbury Creek, Dark Head Cove, Galloway Creek, and Seneca Creek) are simulated using river-boundary-conditions cells.

The lateral edges of the model grid were placed sufficiently far from the remediation site so that any groundwater pumping or injection would not affect groundwater conditions at the edges of the grid. In addition, the lateral sides of the grid were located either at a watershed divide, or along regional scale groundwater flow line – in both cases, groundwater can be assumed to flow neither in nor out of the model on these edges and thus they are termed no-flow boundaries. A no-flow boundary corresponding to the prevailing respective groundwater flow paths was placed along the northeastern and southeastern edges of the model. And, a no-flow boundary corresponding to the approximate position of a groundwater divide was assigned along the northwestern edge of the model.

Except for recharge, the boundary conditions for Layers 2 and 3 are similar to Layer 1 in that they include river leakage and zero flux conditions. Recharge is applied only to Layer 1. Head conditions and areal extent of the river cells in Layers 2 and 3 are identical to the Layer 1 specifications. Similarly, the no-flow boundary specifications in model Layers 2 and 3 are the same as for model Layer 1. The same types of boundary-condition settings are specified for Layers 4–15. In each of these layers, the entire perimeter of the model is designated as a no-flow boundary. Also, the bottom of Layer 15 is a no-flow boundary.

## 3.4 HYDRAULIC PROPERTIES

For groundwater flow modeling, the hydraulic properties to be specified include horizontal and vertical hydraulic conductivity, and storage coefficients [including specific yield for simulation of water table (unconfined) conditions and specific storativity for simulating confined situations]. In steady-state simulations, changes in storage are not simulated and thus the storage coefficients are needed only in transient simulations. Various sources of information guided the characterization of hydraulic properties. These include hydraulic tests conducted in a limited number of wells at the site, analyses of tidally-influenced water levels from selected monitoring wells instrumented with recorders, calibration results from prior site-specific modeling for Lockheed Martin and from regional scale modeling efforts by others, and site-specific geologic information from boring logs.

Initial values of hydraulic conductivity in the model were assigned using calibrated values from the previous groundwater flow model (Tetra Tech, 2004). These initial values are consistent with observed hydraulic conductivity values from slug testing (Tetra Tech, 2004; 2010). In addition, site boring-log data in combination with published, grain-size based hydraulic conductivity ranges were used to help assign hydraulic conductivity in the model.

Hydraulic testing results that were used to help improve modeling accuracy include data from multi-day pumping tests and short-term slug testing. Two recent pumping tests in the upper and intermediate zones (as described in section 2.3) provide the basis for estimating local values of horizontal and vertical hydraulic conductivities and confined and unconfined storage coefficients. The initial values in the model were modified as appropriate during model calibration to match the data from both of the new tests, as described in the next section.

In addition, supplemental slug testing and collection of tidally influenced water level data helped confirm horizontal hydraulic conductivity estimates from initial calibration testing, which is described in the next section. An analysis of the supplemental slug test data provided estimates ranging from 0.03–25 ft/day in the lower zone of the surficial aquifer. However, hydraulic conductivity estimates from slug tests tend to underestimate actual values, and the boring logs indicate relatively high permeability sediments in the lower zone of the surficial aquifer.

The analysis of the supplemental data on water level responses to surface water tidal fluctuations indicates a value of 100 ft/day for the horizontal hydraulic conductivity of the lower

zone of the surficial aquifer. This field-scale value in the lower zone prompted supplemental numerical model simulations to confirm the higher value. Last, the model's hydraulic conductivity distribution was compared to other relevant modeling efforts, including the USGS "Regional Aquifer System Analysis" (RASA) modeling of the Maryland Coastal Plain. The initial and calibrated hydraulic conductivities are consistent with the range of values reported by the USGS modelers for the geologic formations of interest.

# 4 FLOW MODEL CALIBRATION

## 4.1 INTRODUCTION

Calibration of a groundwater flow model entails adjusting hydraulic parameters, initial conditions, and boundary conditions within reasonable ranges to match measured and simulated hydraulic heads, flow rates, or other calibration targets (ASTM, 1996). For MSA, the flow model calibration consisted of simulating the following measured conditions:

- transient responses during two constant-rate pumping tests, one each in the intermediate and shallow zones of the surficial aquifer
- transient responses to tidal water level changes in the lower zone of the surficial aquifer
- approximate, steady-state conditions throughout all three vertical zones of the surficial aquifer, based on water level measurements collected on July 2, 2010

The quality of the steady-state calibration was assessed and quantified through statistical analysis of residuals (ASTM Standard D5981; Anderson and Woessner, 1992), which are the differences between the measured and simulated water levels on a well-by-well basis. Flow calibration criteria are based on the following statistical measures:

- a mean residual value near zero
- an absolute mean residual less than or equal to 10% of the observed range in water level elevations
- a standard deviation less than or equal to 20% of the observed range in water level elevations
- a random spatial distribution of the positive and negative residuals

To assist the assessment of calibration criteria, a plot of observed versus predicted water levels was used to examine the spread of points around the ideal line of a perfect calibration. In addition, horizontal and vertical flow directions in the model were examined for consistency with directions inferred from contour maps drawn using field data and from clustered monitoring wells where vertical-head differences were measured.

Calibration of a groundwater flow model to a single set of field measurements (assumed to represent steady-state conditions) does not provide the foundation for obtaining a unique solution. To reduce the problem of "non-uniqueness," the model should be tested against a different set of boundary conditions or stresses, labeled "verification" (ASTM, 1996). In

particular, non-uniqueness can be reduced through calibration to transient responses caused by measured groundwater flows (typically, extraction well pumping). Therefore, the groundwater flow model calibration focused on simulation of groundwater flow during constant-rate pumping tests in the shallow and intermediate zones of the surficial aquifer.

The objective of the transient calibration was to examine the model's ability to match both observed responses over time and final drawdowns at the test's end. Responses observed in well clusters help estimate both vertical and horizontal hydraulic conductivity values in the surficial aquifer. This simulation has the dual advantage of verification through matching to a second hydrologic condition, while also testing the model's ability to simulate the aquifer system's transient hydraulic response to carefully measured pumping stresses, thereby helping to reduce non-uniqueness. A second important calibration verification step involves transient simulation of tidal responses to estimate the hydraulic properties of the lower surficial zone. Because a pumping test had not yet been conducted in this unit, the tidal response data provided the foundation for testing and adjusting the model using what could be labeled a "naturally conducted" pumping test—i.e., the "pumping" action of the tidal waters in the estuaries surrounding the Martin State peninsula.

Calibration was conducted in sequence from initial steady-state calibration testing and adjustments for an improved match, followed by transient simulations for local area adjustments and model-domain-wide adjustments, and then re-simulation of steady-state conditions for final fine-tuning and consistency checking. In some cases, the transient and steady-state sequence of simulations was re-run to ensure full consistency and sufficient accuracy. Although the steady-state simulations are described before the reporting of the transient calibration efforts, calibration was iterative between the different types of runs. The final values of calibrated hydraulic properties are presented as part of the steady-state results because that simulation condition includes the largest number of observation wells; thus, a more thorough assessment of calibration matching can be provided than for the transient simulations.

## 4.2 STEADY-STATE FLOW

The July 2, 2010 water level data set was chosen for use as model calibration targets because of both the large number of wells measured in that round and the new elevation survey, which has provided a consistent set of measuring point elevations for calculating water level

elevations. In calibrating the model, hydraulic conductivities of the different materials were modified within reasonable ranges. In addition, the recharge rate was adjusted slightly during model calibration. The final distribution of hydraulic conductivity by model layer is presented in **Table 1**. Calibrated values for horizontal hydraulic conductivity in the upper, intermediate, and lower zones are consistent with available field data from slug tests, pumping tests, and tidal data. In general, the vertical hydraulic conductivity is estimated at one tenth of the horizontal hydraulic conductivity. Calibrated recharge rates were estimated at 8.4 inches per year (in/yr.) in the unpaved areas and 0.36 in/yr. in paved areas, as shown in **Figure 10**.

Simulated and observed July 2010 groundwater levels in all 80 wells monitored, and vertical gradients at well clusters, are presented in **Table 2**. **Table 3** presents a statistical summary of the model residuals (i.e., simulated minus observed head) for the 80 water level targets. The mean residual (-0.08 ft) is near zero, indicating that positive and negative residuals cancel out. In addition, the absolute mean residual is 0.34 ft, which is about one tenth of the difference between the minimum and maximum water level targets, and thus the calibration criterion is achieved.

Measured and simulated water levels are plotted relative to one another in **Figure 11**. The linear trend in this plot, the limited spread around the best-fit line, and the favorable residual statistics indicate that the model adequately represents MSA water levels. Simulated steady-state potentiometric surfaces and residuals in the upper zone (model Layers 1 and 6), intermediate zone (Layer 8), and lower zone (Layer 11) are presented in **Figure 12**. These plots indicate that simulated groundwater flow at MSA is predominantly to the east toward Frog Mortar Creek, which is consistent with the July 2010 observed data (**Figures 6-8**) and historical potentiometric surface maps for each zone (Tetra Tech, 2002; 2004).

In general, the residuals are relatively low in each layer, and their statistical measures are below the calibration criteria. The higher residuals in the runway area may be caused by local areas of preferential recharge or heterogeneities not represented in the model. In addition, simulated vertical head differences, including generally downward gradients in the upland areas and upward gradients near Frog Mortar Creek, are consistent with the field data overall (see **Table 2**). Further, the calibrated hydraulic conductivity values and recharge rates are within estimated field values for MSA. The agreement of the flow model with the observed prevailing

groundwater flow directions, based on field data, provides additional evidence of an adequately accurate calibration.

## 4.3 SIMULATION OF PUMPING TESTS

Tetra Tech conducted two constant-rate pumping tests, one each in the shallow and intermediate zones of the surficial aquifer. Although model simulations agree with observed drawdown for the low rate of pumping (less than 1 gpm) in the shallow zone, the transient model-calibration efforts focused on the higher pumping rate (10 gpm) during the 72-hour pumping test in the intermediate zone of the surficial aquifer. To verify the calibrated, steady-state groundwater flow model, the test was simulated using the groundwater flow model. Additional adjustments to the hydraulic conductivity values for the intermediate zone were made to improve the match to the drawdown data from this pumping test.

Measured and simulated drawdowns at wells monitored during the 72-hour pumping test are compared in **Table 4.** The comparison indicates that the model adequately simulates the effects of pumping according to the objectives established for this transient calibration exercise. This indicates that the flow model is a useful predictive tool for simulating new hydraulic stresses in the surficial aquifer within the area tested.

## 4.4 TIDAL INFLUENCE SIMULATION

A transient simulation of tidal responses in site monitoring wells was conducted to verify the calibrated, steady-state groundwater flow model. **Figure 13** shows the simulated versus observed hydraulic head changes at DMW4S, DMW4I, and DMW4D during tidal fluctuation from July 2–4, 2010. An examination of these plots indicates an excellent match between the model and the field data. The simulation period was divided into 12 stress periods, each representing a 6-hour period. The transient river-stage values were averaged over the same 6-hour intervals based on measured data in the Frog Mortar Creek Gage at Parkside Marina. The hydraulic conductivity values and storage coefficient of the lower zone were adjusted slightly to improve the match to the water level fluctuations. The calibrated values are presented in **Table 1** and were also used for the final calibrated steady-state model and pump test verification simulation. The ability of the model to match transient tidal variations in this important zone

where elevated contaminants are present in the surficial aquifer provides additional confidence in the application of the groundwater flow model for remedial design.

## 4.5 FLOW MODEL SENSITIVITY ANALYSIS

A sensitivity analysis was performed to evaluate the effects of changes in selected model parameters. One parameter at a time was varied while all other parameters were held constant. The tested model parameters were varied by 50% of the calibrated values. Results of the sensitivity analysis are shown in **Table 5**. These results were analyzed to identify the parameters that cause the greatest sensitivity when changed, and to confirm that their final calibrated values fall within the range of expected values according to the ranges set during conceptual model formulation, while also ensuring that calibration statistics would not be significantly improved.

Model results are most sensitive to the unpaved-area recharge rate, horizontal hydraulic conductivity values in the surficial aquifer, and especially the lower zone of the surficial aquifer. This is because the unpaved-area recharge is the source of all groundwater flow in the model, and most of the local site area's groundwater flow is occurring in the surficial aquifer, with horizontal hydraulic conductivity the primary property with regard to accurate simulation of the flow field. Hydraulic conductivity, when conducting steady-state simulations, can be adjusted in direct linear proportion to the prevailing recharge rate while still simulating the same flow field pattern of groundwater levels (this is the "non-uniqueness" concern cited above with regard to the need for conducting transient calibrations); thus, changes in hydraulic conductivity produce identical model-sensitivity results to the same, proportional changes in prevailing recharge rates.

Calibrated values for these parameters are consistent with values in the study area, as identified during the conceptual model formulation stage. In addition, no significant enough improvement would be achieved in the model calibration by adjusting these parameters to warrant making such changes. Thus, the model was accepted for use in performing predictive simulations, according to the objectives set forth at the beginning of the modeling process, and the model-calibration criteria established at the outset of numerical model development.

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# 5 REMEDIAL SCENARIO ANALYSES

The primary objective of these preliminary remedial-design-scenario analyses is to help identify and develop a remediation approach that will prevent migration of elevated concentrations of contaminants in groundwater toward Frog Mortar Creek. In addition, enhanced contaminant-mass removal was a secondary objective explored through predictive simulation modeling.

## 5.1 PREDICTIVE SIMULATION METHODOLOGY

Advective-particle tracking helped develop and evaluate the effectiveness of the hydraulic containment and contaminated-groundwater-capture scenarios described in the remedial alternatives analysis section of the FS. The overall predictive modeling process consisted of conducting groundwater flow simulations using the numerical groundwater-flow model described in section 4, followed by a companion particle-tracking simulation for determining whether sufficient capture is achieved. Iterative simulations were conducted, primarily to ensure adequate capture, and then to achieve efficiency in terms of limiting the induced inflow of brackish water from Frog Mortar Creek. The predictive simulations also included a scenario in which enhanced flushing of high-concentration groundwater was tested, involving the use of injection wells and additional extraction wells and higher extraction rates to compensate for the injected water. Using an initial starting point, particle tracking simulates the movement of a particle of groundwater through a groundwater flow field over time. Thus, particle tracking techniques are useful tools for evaluating groundwater flow directions, dissolved contaminant migration pathways, and evaluating hydraulic capture of groundwater recovery well systems.

Particle tracking is a simple form of contaminant transport analysis that does not include the effects of dispersion, retardation, and chemical reactions. Although plume dispersion could cause lateral spreading and thus lead to concern whether the lateral edges of the plume would be captured effectively, the final recommended scenarios include sufficient recovery well placement and pumping rates to account for this factor. In addition, the convergent flow produced by recovery well pumping would help offset the effect of lateral spreading.

The USGS particle-tracking code *MODPATH* (Pollock, 1989) was used to perform particle tracking in this modeling analysis. Using a groundwater flow field simulated with *MODFLOW*, *MODPATH* computes groundwater velocities in the three principal coordinate directions throughout the model domain, in each of the model-grid cells. Then, *MODPATH* uses the cell-by-cell 3D velocities as the basis for moving each simulated particle from one cell to the next. It does this by resolving the three velocities in each cell to a single velocity vector, and then uses these vectors to move the particles in the appropriate direction.

To compute these velocities, *MODPATH* requires study-area-specific values of effective porosity for converting *MODFLOW*-simulated specific discharge-values into groundwater velocities. The effective porosity represents a correction factor that accounts for the reduced flow area, as defined by the open pore space in which flow effectively occurs. Effective porosity can range as high as the porous medium's total porosity, but is typically a significant amount less than that. The results of the previously calibrated solute-transport model (Tetra Tech, 2004) led to the use of a value of 0.28 for effective porosity in these particle tracking analyses, whereas the geologic sediments' total porosity could range as high as 40 or 45%. Although the selected value of effective porosity directly influences the simulated velocities of particles, its value does not affect the size of the simulated capture zone.

For MSA, particle tracking was performed to help identify and simulate groundwater remediation options designed to achieve the objectives of plume control and capture. The particle tracking modeling was applied to simulate two categories of FS options:

- a hydraulic-barrier recovery well system at the downgradient extent of the contaminated groundwater area, along Frog Mortar Creek
- "focused," or "enhanced," extraction pumping in high concentration zones, in addition to the hydraulic-barrier recovery well system, as in the preceding option.

In the particle tracking analyses, particles were first initialized in grid cells throughout the extent of the VOC and 1,4-dioxane plumes. A containment scenario was then simulated under steady-state flow conditions using forward tracking to determine whether all particles in the upgradient plumes were captured by the recovery wells. Recovery well locations and their individual pumping rates were adjusted as necessary to achieve sufficient drawdowns to capture all of the particles within the target capture zone.

## 5.2 REPRESENTATION OF RECOVERY WELLS

The calibrated groundwater-flow model and its companion particle-tracking code were used to identify potential groundwater remediation scenarios that would successfully contain and capture contaminated groundwater. The target capture zones for contaminant plumes were the extent of TCE contamination in excess of 5 µg/L, vinyl chloride in excess of 2 µg/L, and 1,4-dioxane in excess of 6 µg/L. For hydraulic containment, extraction wells were placed near the downgradient end of the plumes, adjacent and parallel to the shoreline of Frog Mortar Creek.

Potential extraction wells were represented using the *MODFLOW* drain package. Water levels at the extraction wells were modeled as a fixed two-foot drawdown. Wells were assumed to have an effective diameter of one foot. Conductance and well efficiency were estimated as follows:

*Conductance term*—The conductance term (C) for each drain cell representing a fixed head well was calculated using the following equation [based on Prickett (1967) and Anderson and Woessner (1992)]:

$$C = 2K_e \pi b/\ln (\text{delta} \times/4.81 r_w) \quad (1)$$

where $K_e$ is the effective hydraulic conductivity at the cell (ft/d), $b$ is the saturated thickness of the cell (ft), *delta x* is the representative grid spacing (ft), and $r_w$ is the well radius (ft).

*Efficiency*—Because the wells are represented in the model as drains, the extraction rate ($Q$) achieved is effectively calculated by the model and controlled by the aquifer properties, as described in the equation:

$$Q = C (h - d) * \text{efficiency} \quad (2)$$

where $h$ is the water level in the grid cell (ft) and $d$ is the elevation of the water level in the drain. An efficiency value of 50% was applied to the wells.

## 5.3 HYDRAULIC-BARRIER WELLS ANALYSES

Numerous steady-state groundwater flow model simulations were performed to define effective and efficient recovery well locations and pumping rates for capturing the upgradient VOC and 1,4-dioxane plumes before their migration toward Frog Mortar Creek. Model simulations indicate that placing recovery wells only in the upper and intermediate zones of the

surficial aquifer would fail to capture contaminated groundwater in the lower zone of the surficial aquifer. Therefore, recovery wells were also included in the lower zone of the surficial aquifer in the hydraulic barrier wells analyses.

These model simulations indicate that upgradient plume capture can be achieved by placing seven wells in the upper zone, five in the intermediate zone, and four in the lower zone of the surficial aquifer. **Table 6** summarizes the injection and pumping rates by layer for this remedial scenario. The simulated total pumping rates were 12.2 gpm, 13.6 gpm, and 22.2 gpm, respectively, in the upper, intermediate, and lower zones of the surficial aquifer. Simulated steady-state hydraulic heads and recovery well locations are shown in **Figure 14** for the upper (Layer 1), intermediate (Layer 8), and lower (Layer 11) zones of the surficial aquifer. Forward particle tracking was conducted by placing particles in each cell and delineating the zone from which the particles would eventually be captured by the recovery wells. Examination of these simulated capture zones (**Figure 14**) and the extent of contaminated groundwater at MSA (**Figures 2 to 5**) indicates that these recovery wells establish a capture zone encompassing the mapped areas of MSA with VOC and 1,4-dioxane contamination, and thus the simulated scenario is sufficiently effective.

The model simulations also indicate that low rates (less than 1.6 gpm) of induced inflow from Frog Mortar Creek result from pumping, so capture of saline water is unlikely to be a problem for this hydraulic barrier pumping scenario. In essence, the simulations indicate that induced infiltration would be diluted by the pumped freshwater at a ratio of about 30:1. Also, Frog Mortar Creek is brackish (it ranges from about 25–50% of full seawater salinity), due to its position relatively far from the open ocean mouth of Chesapeake Bay, as well as its proximity to incoming freshwater flow from Middle River, the other local tributary streams and swales, and groundwater base-flow. Thus, the induced inflow already has much lower saline concentrations than ocean water, and therefore the recovery wells are predicted to produce groundwater that includes approximately 60:1 to 120:1 dilution of seawater salinity.

## 5.4 HIGH CONCENTRATION ZONE REMEDIATION ANALYSES

To increase mass-removal rates, a second overall scenario was developed in which additional recovery wells were placed in high concentration zones, along with injection wells placed upgradient of some of these pumping wells. Simulated steady-state hydraulic heads and

injection/recovery well locations are shown in **Figure 15**. **Table 6** summarizes injection and pumping rates by layer under this remedial scenario. Total simulated injection rates per layer are 10 gpm and 3 gpm in the upper and intermediate zones of the surficial aquifer, respectively. Total simulated pumping rates are 12.3 gpm, 21.3 gpm, and 34.3 gpm, respectively, in the upper, intermediate, and lower zones of the surficial aquifer.

Examination of the capture zones created by the simulated pattern of pumping and injection wells (**Figure 15**), in comparison to the initial extent of contaminated groundwater at MSA (**Figures 2 to 5**), indicates that this scenario would establish a capture zone that limits the upgradient VOCs and 1,4-dioxane from migrating toward Frog Mortar Creek. In comparison to the previous hydraulic barrier scenario (**Figure 14**), a higher amount of pumping under this scenario is needed to ensure adequate capture because of the effect of the injection wells on the groundwater-flow field. The higher net total pumping rate results in somewhat increased drawdowns near the recovery wells and an increase in the size of the capture zone (**Figure 15**). Model simulations also indicate that very limited amounts (less than 1.8 gpm) of induced inflow from Frog Mortar Creek would occur, so capture of saline water is very unlikely to be a problem for this pumping scenario, as was the case for the first scenario.

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# 6 SUMMARY AND DISCUSSION

This section summarizes the development, calibration, and application of a groundwater flow model to support the feasibility study and to help develop remediation alternatives to address volatile organic compounds (VOCs) and 1,4-dioxane contamination in groundwater at MSA in Middle River, Maryland. The remediation alternatives are based on the primary objectives of controlling and capturing contaminated groundwater at MSA to prevent its migration into off-site areas and toward Frog Mortar Creek. The primary results of this groundwater flow modeling analysis are summarized below, including recommendations.

The groundwater flow model was constructed and calibrated to both steady state and transient groundwater conditions at MSA. The simulated steady-state conditions are based on water level data collected on July 2, 2010. The simulated transient conditions are based on measured water level changes over time during two pumping tests and from various periods in which tidally induced fluctuations were measured in the surficial aquifer. Results of the groundwater-flow model calibration indicate that adequate calibration was achieved and that the groundwater flow model could be used to help design a remedial system to capture contaminated groundwater at MSA.

Viable FS-stage groundwater remedial scenarios for capturing MSA groundwater contaminated by VOCs and 1,4-dioxane were developed and tested through simulation modeling. The lateral and vertical extent of contaminated groundwater was established based on recent groundwater sampling. Two scenarios were analyzed using groundwater flow and advective-particle-tracking predictive modeling: (1) a stand-alone hydraulic barrier recovery well system, and (2) high concentration zone mass-removal, along with limited reinjection of treated groundwater, in conjunction with the first scenario. Results from modeling both scenarios indicate that the contaminated groundwater at MSA would be effectively controlled and captured; faster contaminant mass-removal could be achieved under the second scenario, although a net increase of recovery pumping would be needed to maintain sufficient capture, including a higher rate of recovery pumping from the lower aquifer layer.

For the hydraulic barrier scenario, numerous modeling simulations were performed to select sufficiently effective recovery well locations while also limiting the groundwater pumping rate and the induced infiltration of saline water from Frog Mortar Creek. This scenario includes

16 recovery wells arranged roughly perpendicular to the plume, adjacent and parallel to the shoreline of Frog Mortar Creek, with seven recovery wells in the upper zone, five in the intermediate zone, and four in the lower zone, and a total system-wide pumping rate of 48 gpm.

The second scenario combines the hydraulic barrier from the first scenario with focused injection and extraction for faster contaminant-mass reduction. This second scenario is designed to increase flushing rates while maintaining downgradient capture, so it includes the 16 hydraulic barrier recovery wells of the first scenario along with six injection wells and nine additional recovery wells located in high concentration zones: four injection/extraction well pairs in the upper zone, two pairs in the intermediate zone, and two individual recovery wells in the lower zone. The total injection rate under this scenario is 13 gpm, and the total pumping rate is 67.9 gpm, resulting in a net extraction rate of 54.9 gpm. The modeling analyses indicate that increased groundwater capture rates are needed, especially in the intermediate and lower surficial aquifer units, to offset the tendency for increased spreading due to the injection wells and to achieve the design objective for increasing the groundwater flushing rate.

The model results indicate that the hydraulic barrier wells, in both scenarios, form an effective hydraulic containment system without inducing significant brackish water inflow from Frog Mortar Creek. In the remedial scenario simulations, the model predicts that a very small percentage (approximately 3–5%) of the extracted groundwater would be from Frog Mortar Creek, and thus its salinity would be significantly diluted by fresh groundwater.

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# FIGURES

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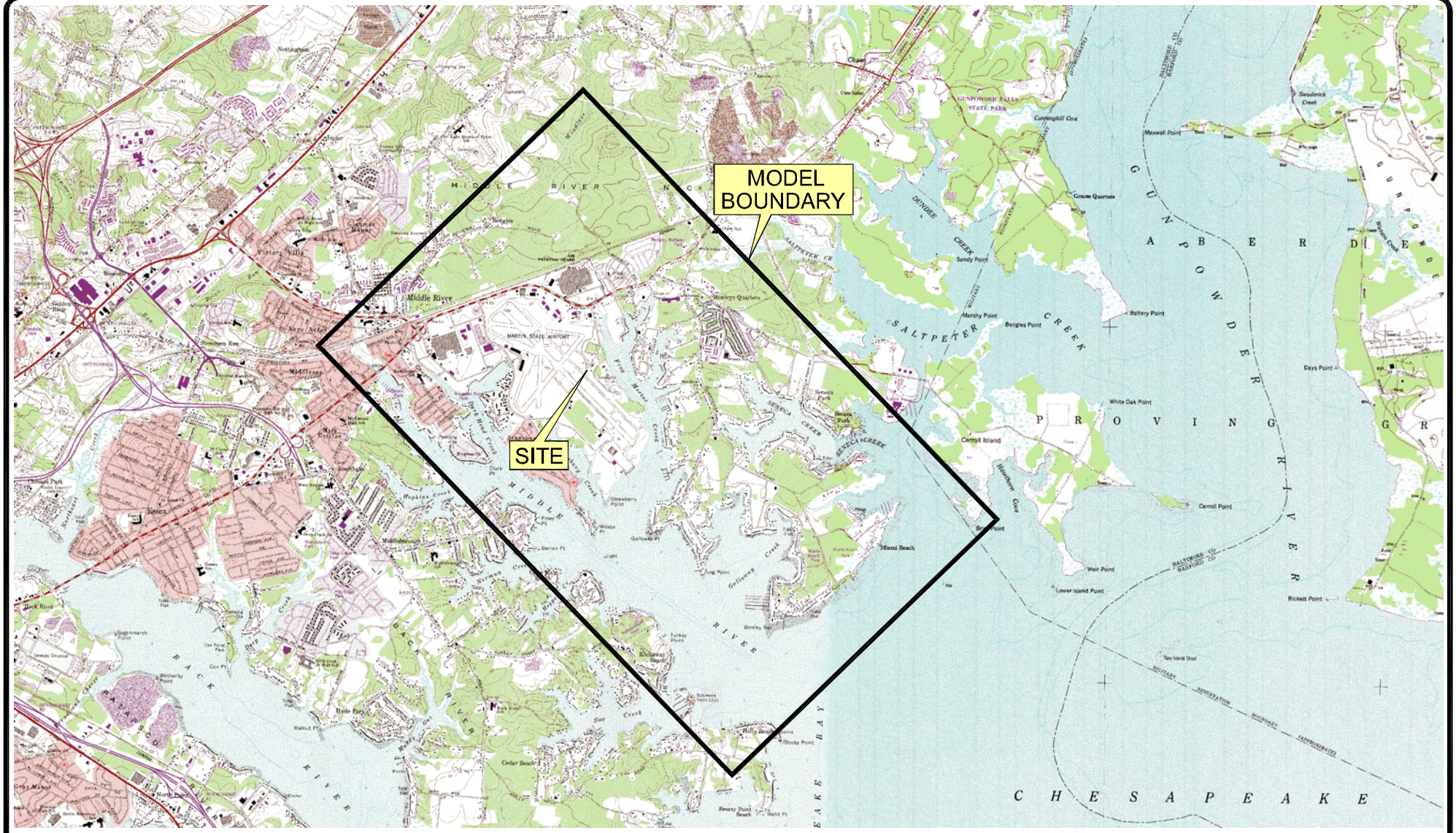


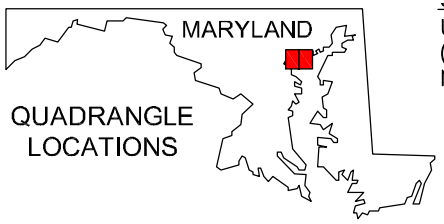


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SCALE IN FEET

N

TITLE:

**SITE LOCATION MAP**

LOCATION:

**Martin State Airport, Maryland**

GeoTrans, Inc. A TETRA TECH COMPANY

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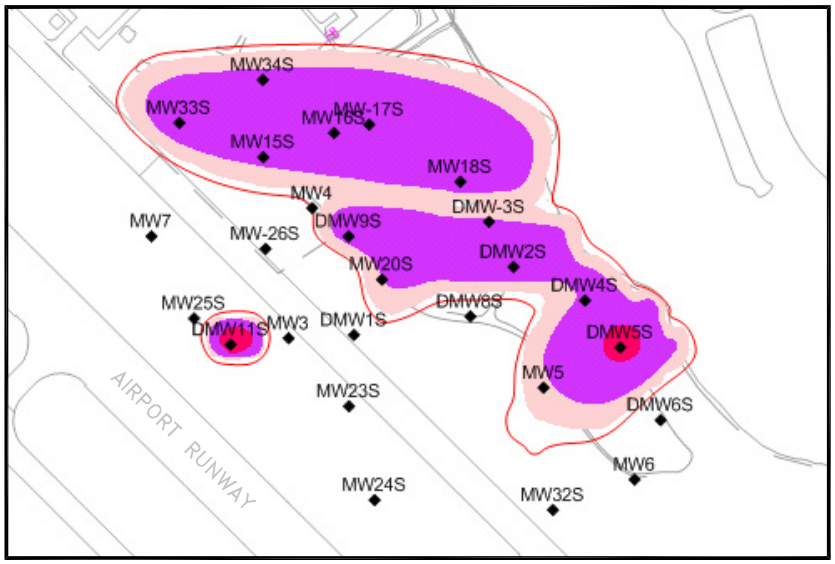
| APPROVED | DB |
| DRAFTED | CP |
| PROJECT# | 117-0512055 |
| DATE | 12-15-10 |

FIGURE 1

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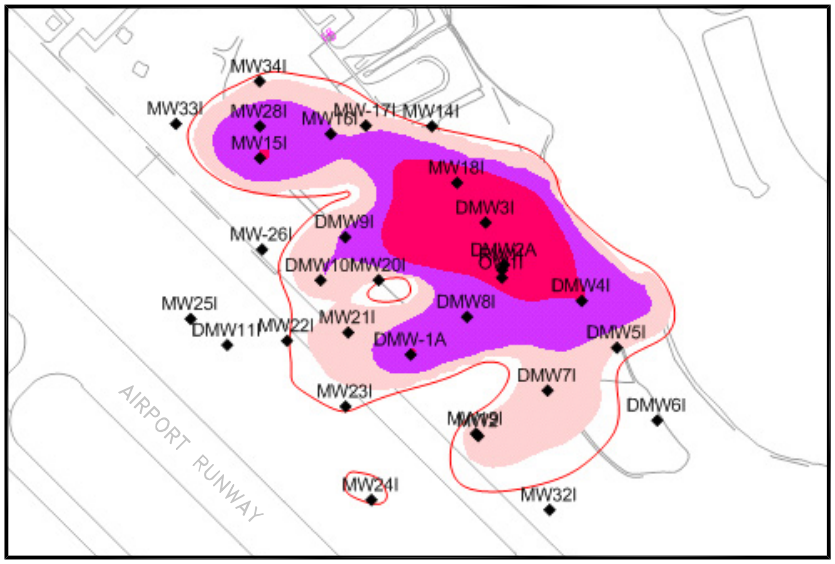


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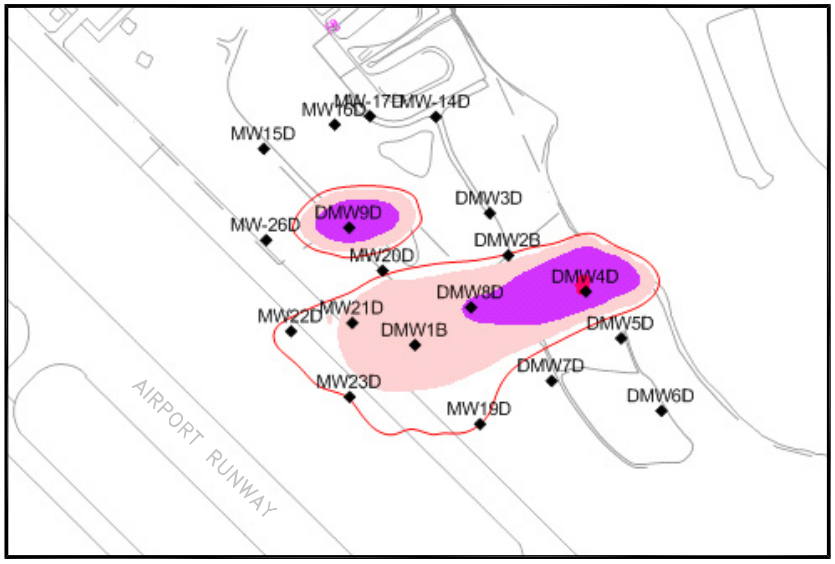


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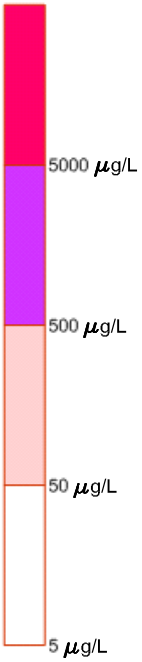


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SCALE IN FEET

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LOCATION: **Martin State Airport, Maryland**

GeoTrans, Inc. A TETRA TECH COMPANY

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| DRAFTED | CP |
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| DATE | 12-15-10 |

FIGURE 2

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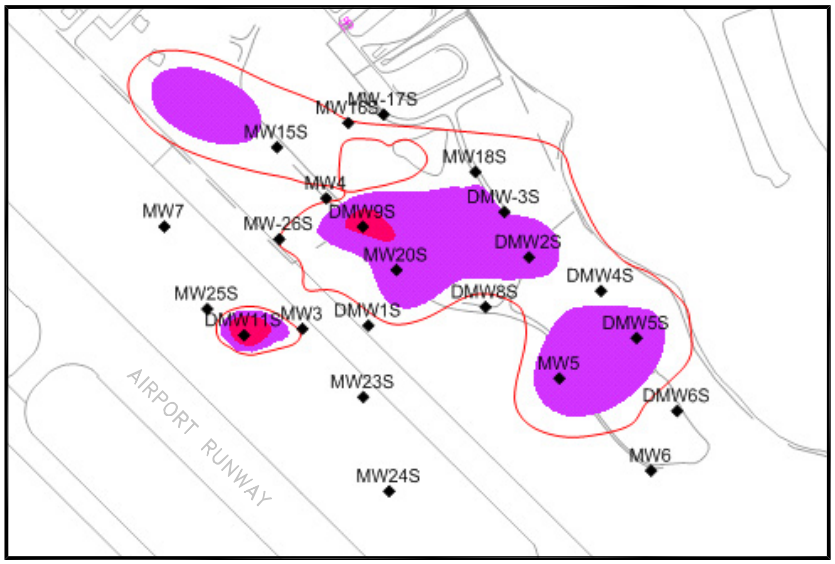
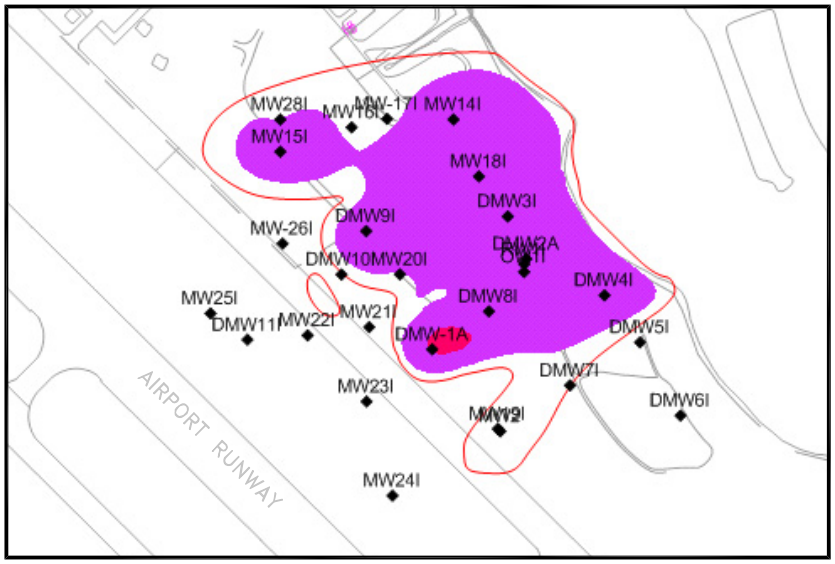
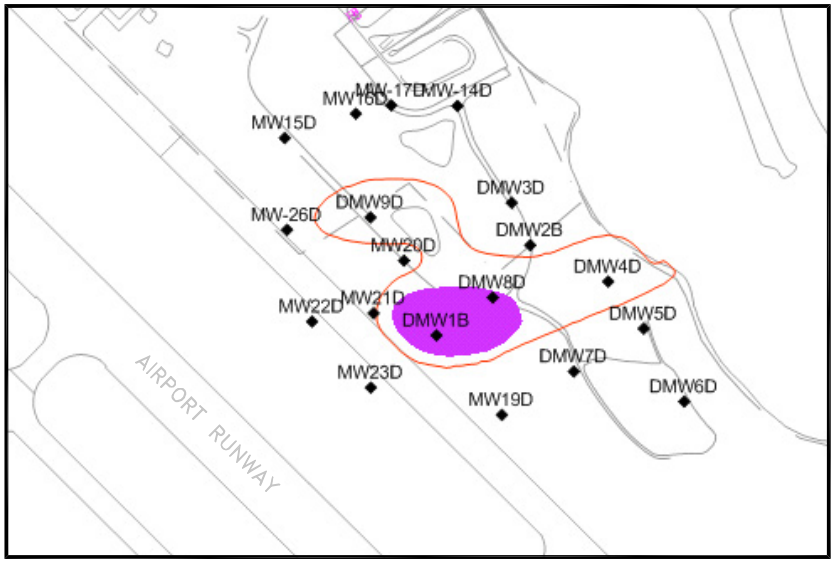



UPPER ZONE




INTERMEDIATE ZONE




LOWER ZONE







0 600 1200

SCALE IN FEET

TITLE: **DISTRIBUTION OF CIS 1,2-DCE IN UPPER, INTERMEDIATE, AND LOWER ZONES OF SURFICIAL AQUIFER, SEPTEMBER 2009**

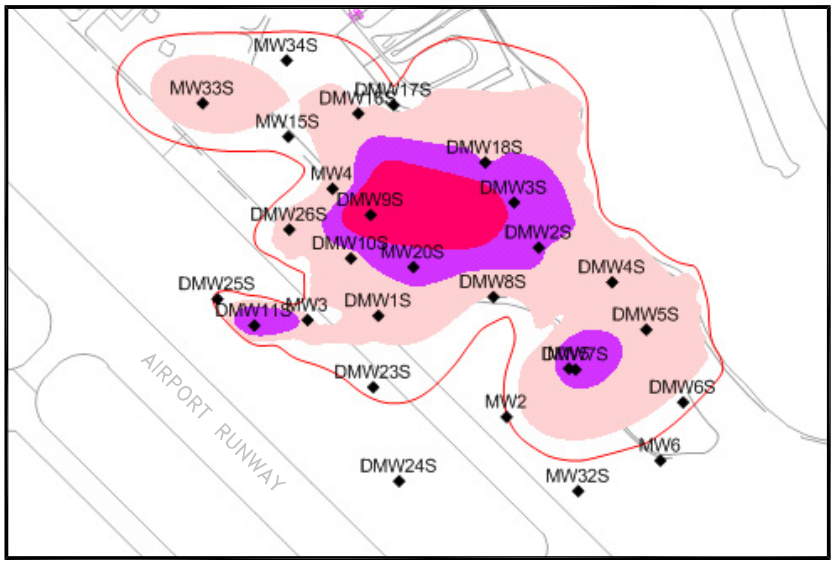
LOCATION: **Martin State Airport, Maryland**

GeoTrans, Inc. A TETRA TECH COMPANY

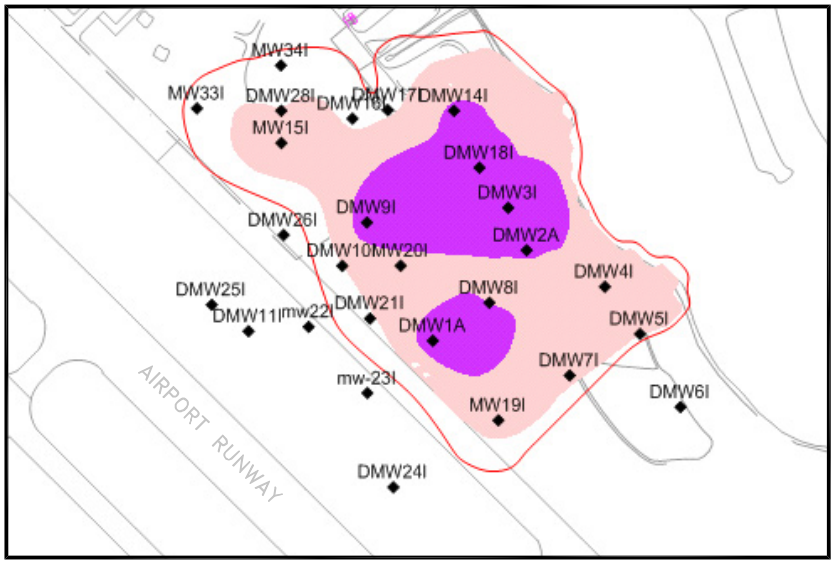
| | |
|---|---|
| APPROVED | DB |
| DRAFTED | CP |
| PROJECT# | 117-0512055 |
| DATE | 12-15-10 |

FIGURE 3

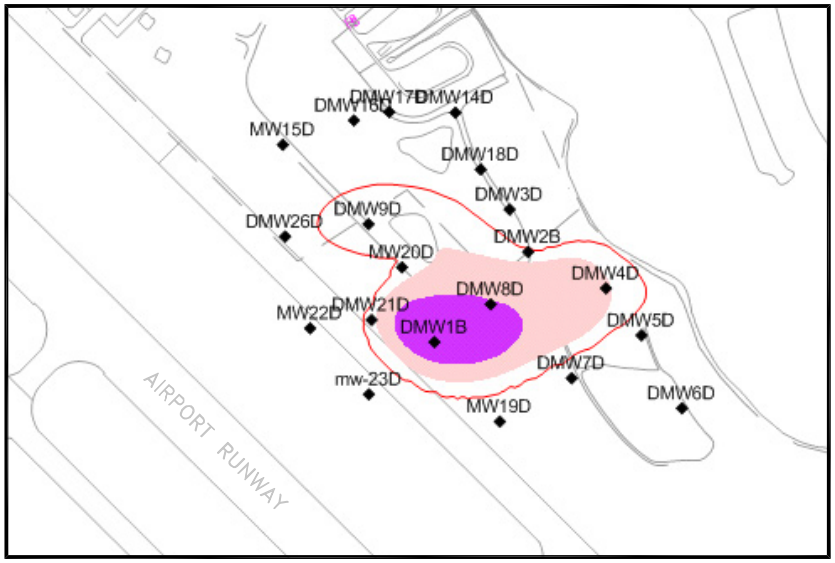
P:\ACAD\0512-055-MSA\0512055003A.DWG



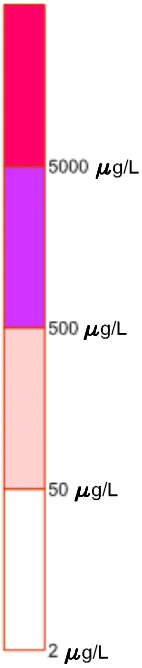

UPPER ZONE

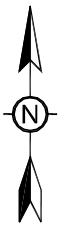



INTERMEDIATE ZONE




LOWER ZONE




0 600 1200

SCALE IN FEET

TITLE: **DISTRIBUTION OF VC IN UPPER, INTERMEDIATE, AND LOWER ZONES OF SURFICIAL AQUIFER, SEPTEMBER 2009**

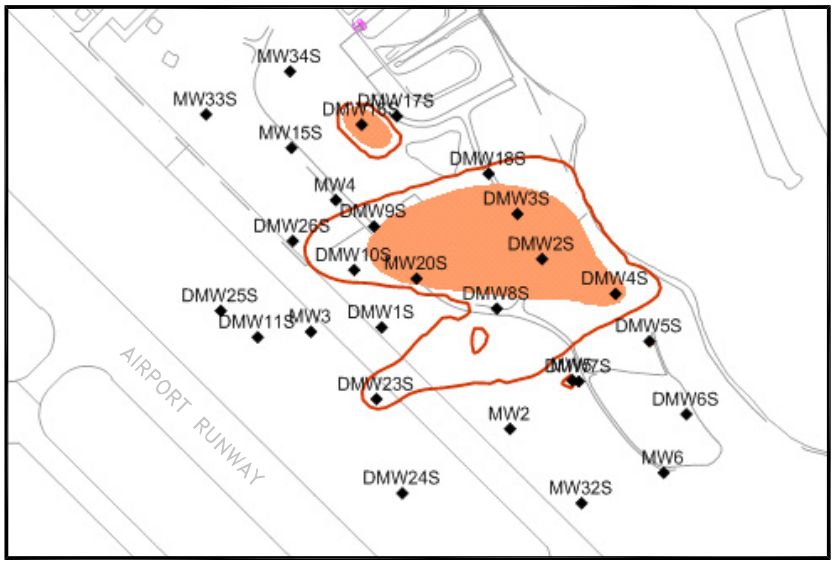
LOCATION: **Martin State Airport, Maryland**

GeoTrans, Inc. A TETRA TECH COMPANY

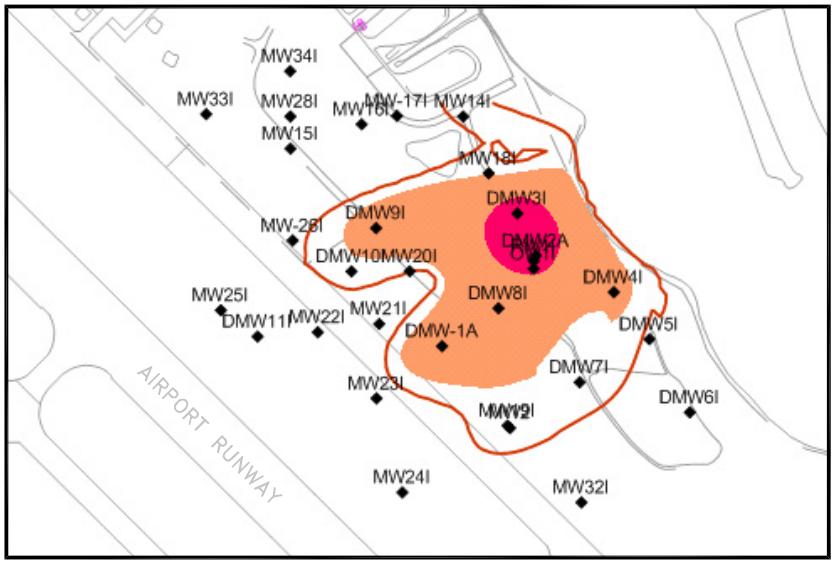
| | |
|---|---|
| APPROVED | DB |
| DRAFTED | CP |
| PROJECT# | 117-0512055 |
| DATE | 12-15-10 |

FIGURE 4

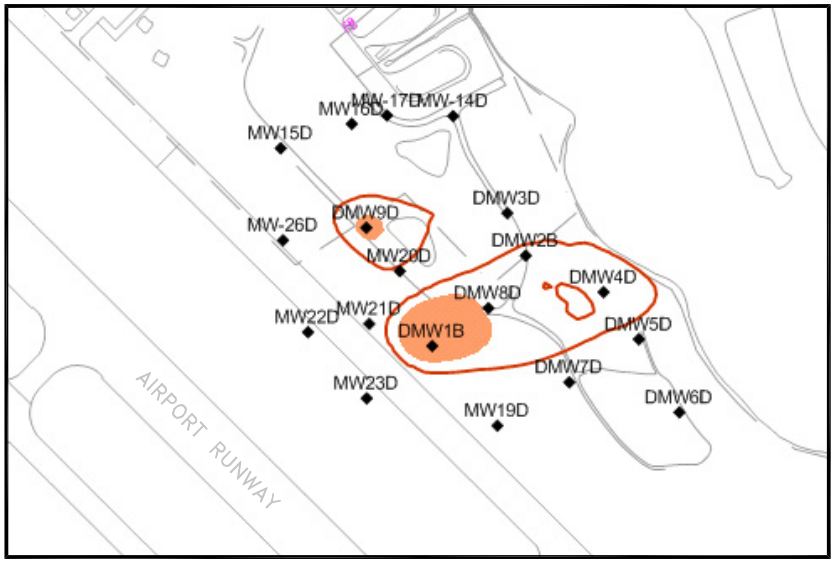
P:\ACAD\0512-055-MSA\0512055004A.DWG




UPPER ZONE




INTERMEDIATE ZONE




LOWER ZONE




0 600 1200

SCALE IN FEET

TITLE: **DISTRIBUTION OF 1,4-DIOXANE IN UPPER, INTERMEDIATE, AND LOWER ZONES OF SURFICIAL AQUIFER, SEPTEMBER 2009**

LOCATION: **Martin State Airport, Maryland**

GeoTrans, Inc. A TETRA TECH COMPANY

| | |
|---|---|
| APPROVED | DB |
| DRAFTED | CP |
| PROJECT# | 117-0512055 |
| DATE | 12-15-10 |

FIGURE 5

P:\ACAD\0512-055-MSA\0512055005A.DWG

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LEGEND

- GROUNDWATER MONITORING WELL OR PIEZOMETER LOCATION
- ABANDONED WELL
- GROUNDWATER ELEVATION CONTOUR CONTOUR INTERVAL = 0.5 OR 1 FOOT
- 1.79 GROUNDWATER ELEVATION FEET, MEAN SEA LEVEL
- MARYLAND AIR NATIONAL GUARD BOUNDARY
- POND

* Not used for contouring: well installed in clay and may represent perched groundwater.

0 250 500

SCALE IN FEET

TITLE:

# WATER TABLE MAP BASED ON GROUNDWATER LEVELS IN THE UPPER ZONE OF THE SURFICIAL AQUIFER, JULY 2010

LOCATION:

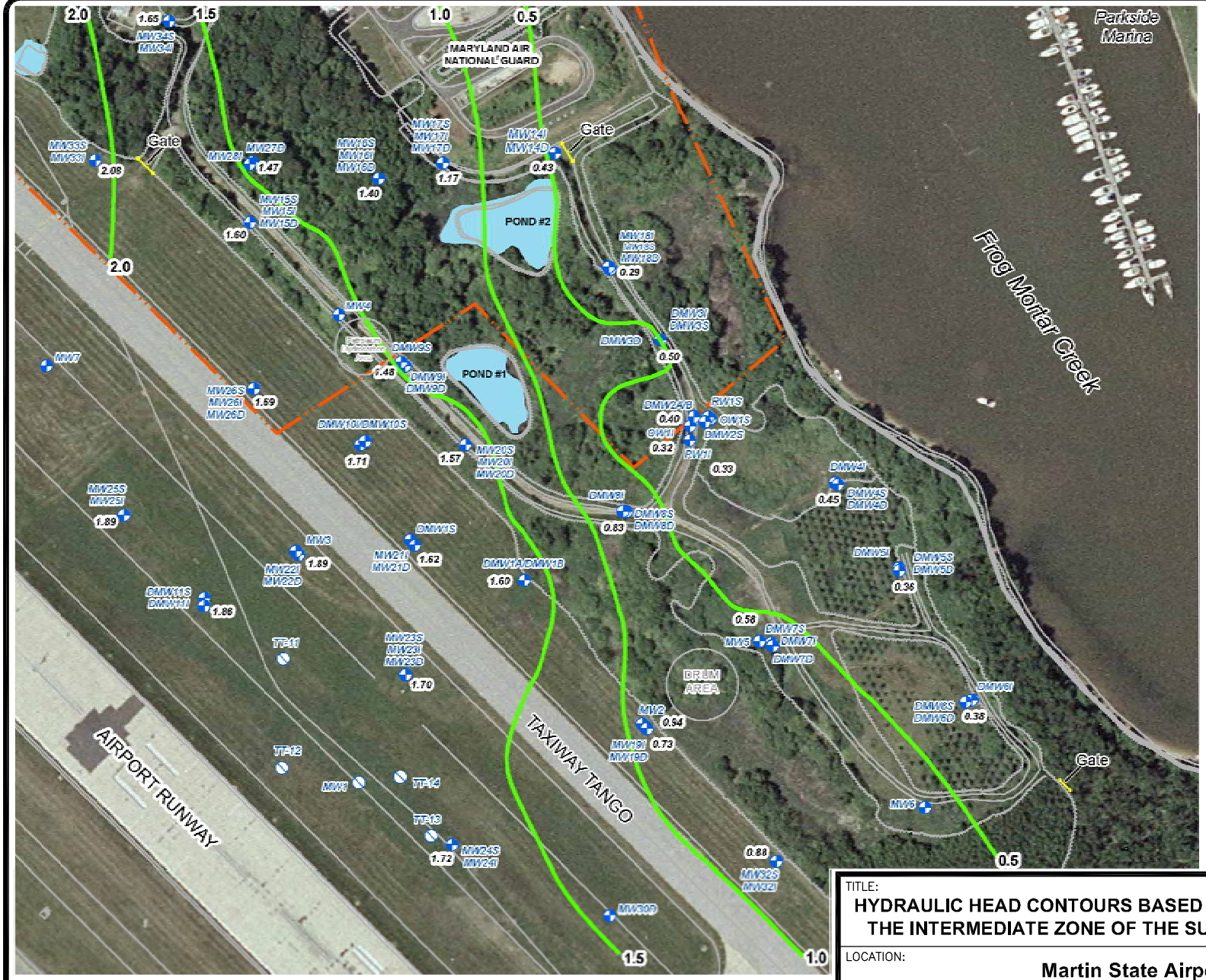
**Martin State Airport, Maryland**

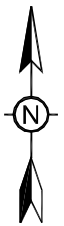
GeoTrans, Inc. A TETRA TECH COMPANY

| | |
|---|---|
| APPROVED | DB |
| DRAFTED | CP |
| PROJECT# | 117-0512055 |
| DATE | 12-15-10 |

FIGURE 6

P:\ACAD\0512-055-MSA\0512055013A.DWG



LEGEND

- GROUNDWATER MONITORING WELL OR PIEZOMETER LOCATION
- ABANDONED WELL
- GROUNDWATER ELEVATION CONTOUR CONTOUR INTERVAL = 0.5 FOOT
- 1.79 GROUNDWATER ELEVATION FEET, MEAN SEA LEVEL
- MARYLAND AIR NATIONAL GUARD BOUNDARY
- POND

0 250 500

SCALE IN FEET

TITLE:

**HYDRAULIC HEAD CONTOURS BASED ON GROUNDWATER LEVELS IN THE INTERMEDIATE ZONE OF THE SURFICIAL AQUIFER, JULY 2010**

LOCATION:

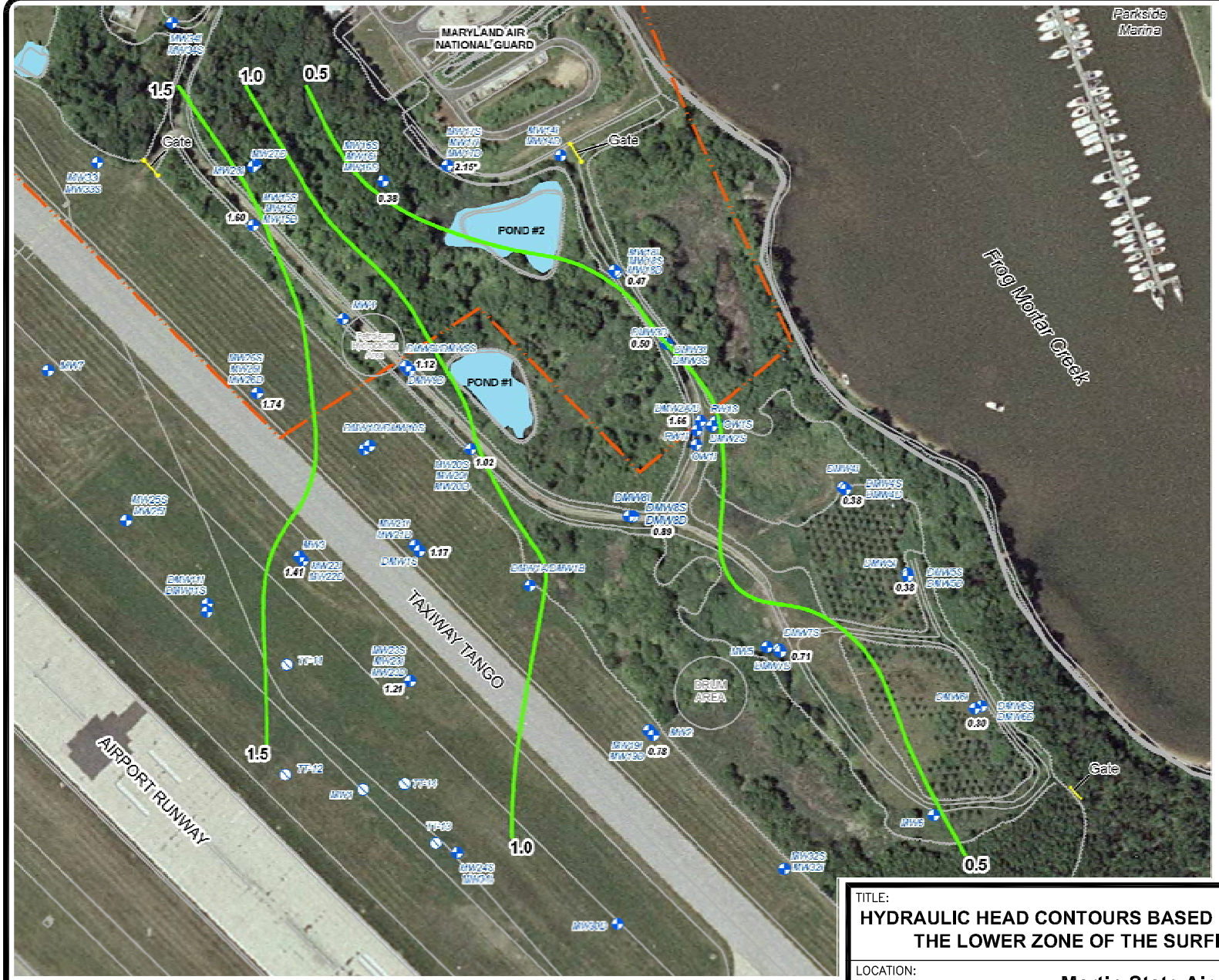
**Martin State Airport, Maryland**

GeoTrans, Inc. A TETRA TECH COMPANY

| | |
|---|---|
| APPROVED | DB |
| DRAFTED | CP |
| PROJECT# | 117-0512055 |
| DATE | 12-15-10 |

FIGURE 7

P:\ACAD\0512-055-MSA\0512055014A.DWG




N

**LEGEND**

- GROUNDWATER MONITORING WELL OR PIEZOMETER LOCATION
- ABANDONED WELL
- GROUNDWATER ELEVATION CONTOUR CONTOUR INTERVAL = 0.5 FOOT
- 1.79 GROUNDWATER ELEVATION FEET, MEAN SEA LEVEL
- MARYLAND AIR NATIONAL GUARD BOUNDARY
- POND

* Not used for contouring: well installed in clay and level may not represent sands of the lower surficial aquifer

TITLE:

# HYDRAULIC HEAD CONTOURS BASED ON GROUNDWATER LEVELS IN THE LOWER ZONE OF THE SURFICIAL AQUIFER, JULY 2010

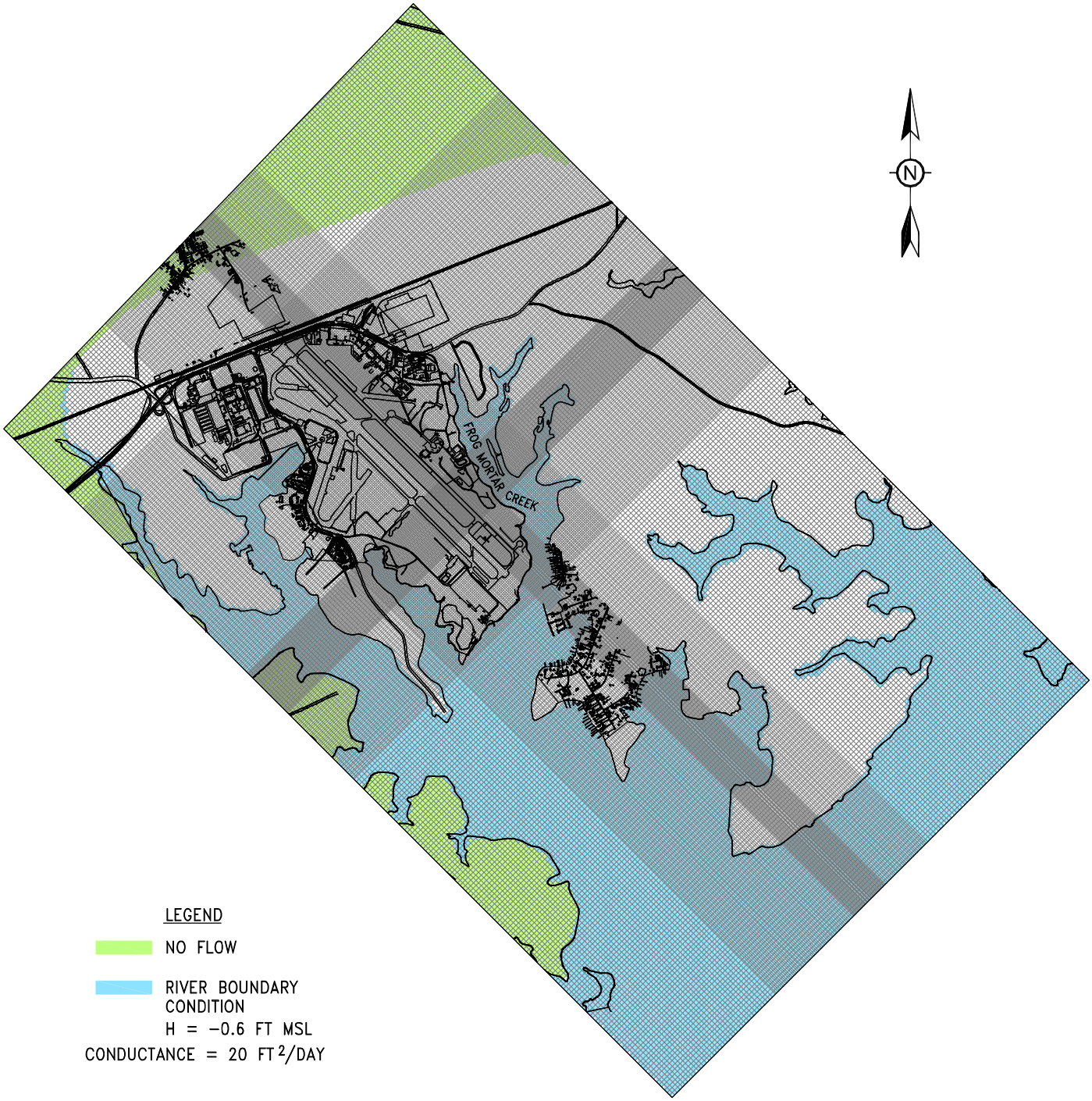
LOCATION:

**Martin State Airport, Maryland**

GeoTrans, Inc. A TETRA TECH COMPANY

| | |
|---|---|
| APPROVED | DB |
| DRAFTED | CP |
| PROJECT# | 117-0512055 |
| DATE | 12-15-10 |

FIGURE 8




LEGEND

NO FLOW

RIVER BOUNDARY CONDITION
H = −0.6 FT MSL
CONDUCTANCE = 20 FT²/DAY

NOTE:
RIVER BOUNDARY CONDITION IS ONLY IN LAYERS 1, 2, AND 3.

0 4000 8000
SCALE IN FEET

TITLE:
**MODEL GRID AND BOUNDARY CONDITIONS**

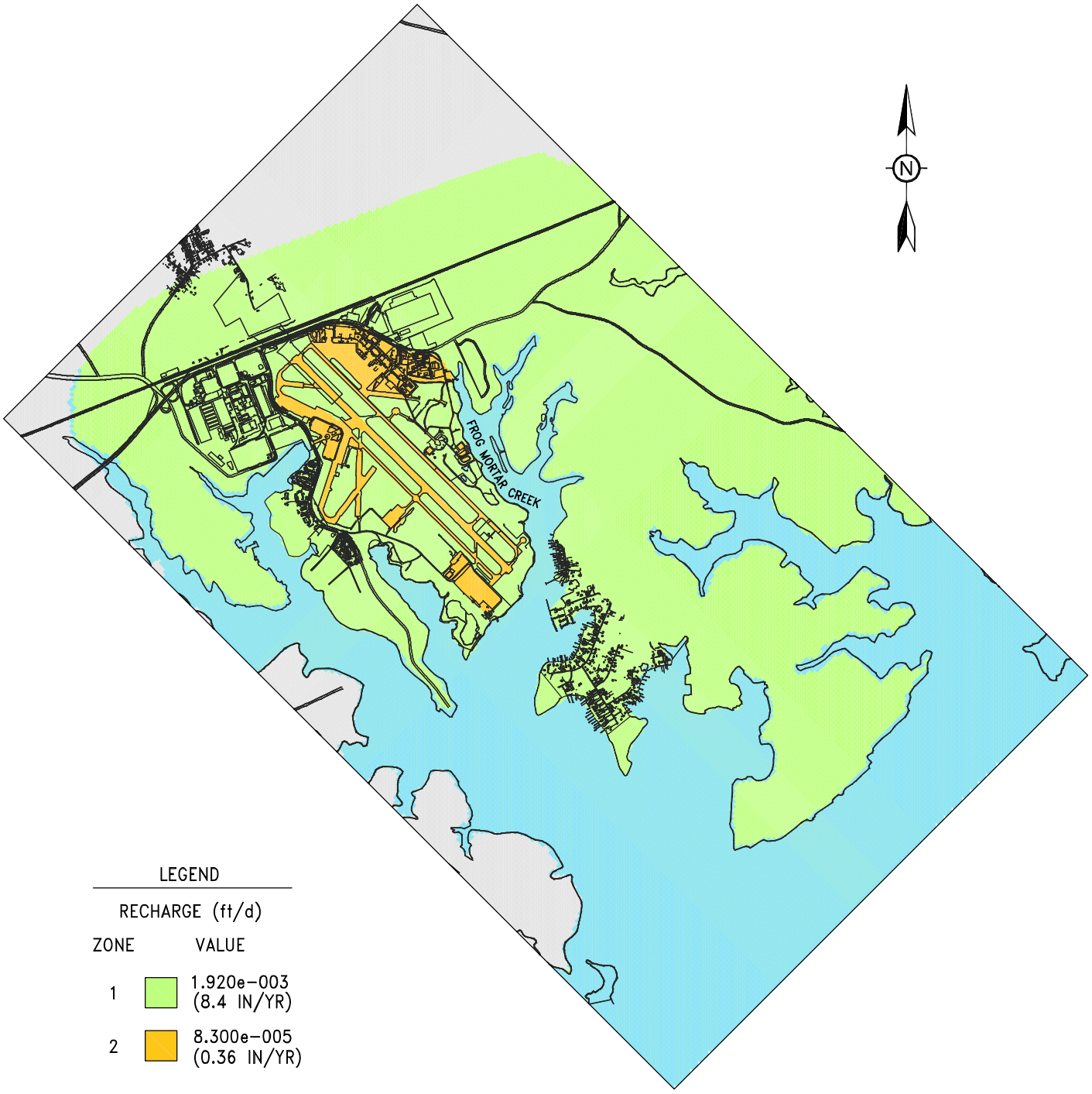
LOCATION:
**Martin State Airport, Maryland**

GeoTrans, Inc. A TETRA TECH COMPANY

| | |
|---|---|
| APPROVED | DB |
| DRAFTED | CP |
| PROJECT# | 117-0512055 |
| DATE | 12-15-10 |

FIGURE 9

P:\ACAD\0512-055-MSA\0512055007A.DWG




LEGEND

RECHARGE (ft/d)

| ZONE | VALUE |
|---|---|
| 1 | 1.920e-003 (8.4 IN/YR) |
| 2 | 8.300e-005 (0.36 IN/YR) |
| | RIVER |
| | NO FLOW |

0 4000 8000

SCALE IN FEET

TITLE: **SIMULATED DISTRIBUTION OF GROUNDWATER RECHARGE IN THE CALIBRATED MODEL**

LOCATION: **Martin State Airport, Maryland**

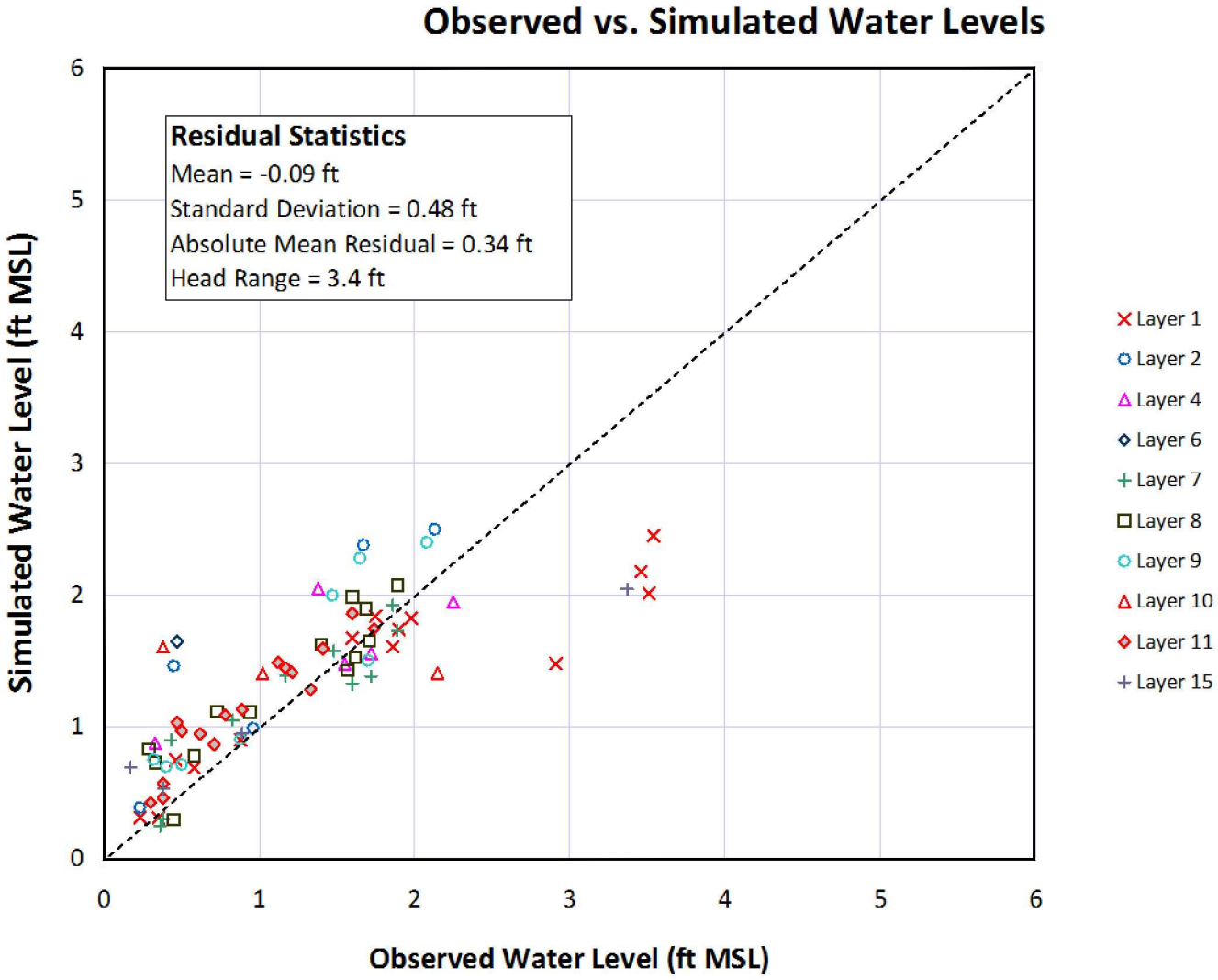
GeoTrans, Inc. A TETRA TECH COMPANY

| | |
|---|---|
| APPROVED | DB |
| DRAFTED | CP |
| PROJECT# | 117-0512055 |
| DATE | 12-15-10 |

FIGURE 10

P:\ACAD\0512-055-MSA\0512055008A.DWG

0512055009A.DWG



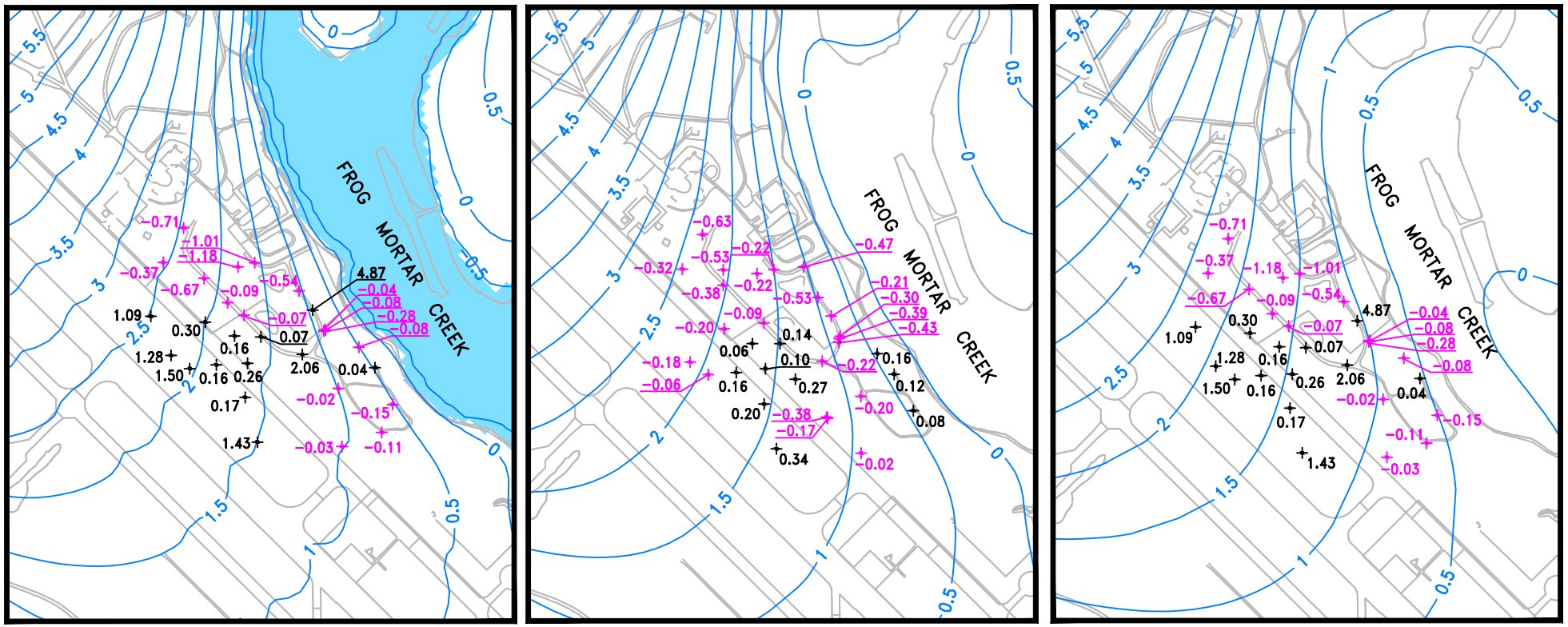

| | |
|---|---|
| TITLE: | PLOT OF MEASURED VERSUS SIMULATED GROUNDWATER LEVELS, JULY 2010 |
| LOCATION: | Martin State Airport, Maryland |

GeoTrans, Inc. A TETRA TECH COMPANY

| | |
|---|---|
| APPROVED | DB |
| DRAFTED | CP |
| PROJECT# | 117-0512055 |
| DATE | 2-1-11 |

FIGURE 11

0512055016A.DWG




NOTES:

1. RESIDUALS ARE FOR ALL MODEL LAYERS IN THE UPPER, INTERMEDIATE, AND LOWER ZONE.
2. SIMULATED HEADS ARE FOR MODEL LAYERS 1, 8, AND 11, RESPECTIVELY.
3. UPPER ZONE (LAYERS 1–6), INTERMEDIATE ZONE (LAYERS 7–9), AND LOWER ZONE (LAYERS 10,11).

N

0 1000 2000

SCALE IN FEET

LEGEND

—4— POTENTIOMETRIC CONTOUR (ft MSL)

0.76+ SIMULATED < OBSERVED RESIDUAL (FT)

−0.74+ SIMULATED > OBSERVED RESIDUAL (FT)

TITLE:

**SIMULATED POTENTIOMETRIC SURFACE AND RESIDUALS IN UPPER SURFICIAL (LAYER 1), INTERMEDIATE SURFICIAL (LAYER 8), AND LOWER SURFICIAL (LAYER 11) AQUIFER**

LOCATION:

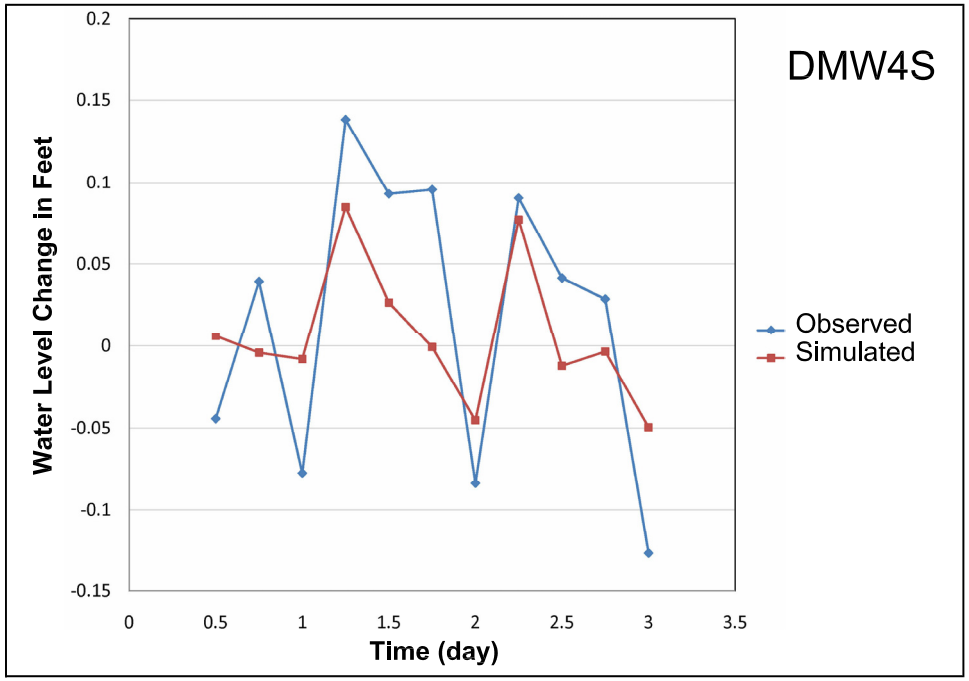
**Martin State Airport, Maryland**

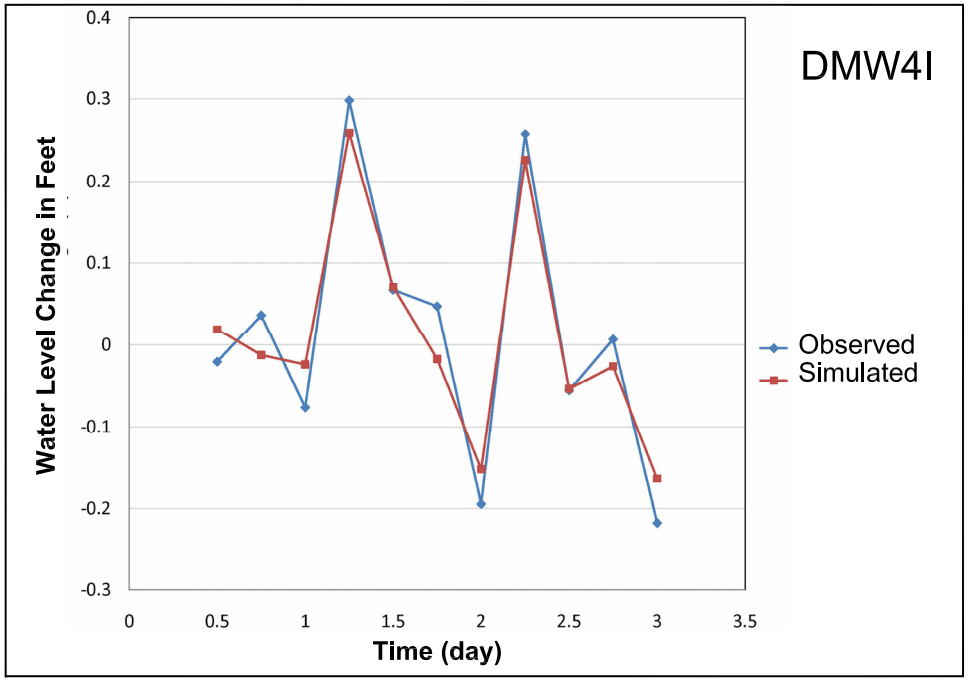
GeoTrans, Inc. A TETRA TECH COMPANY

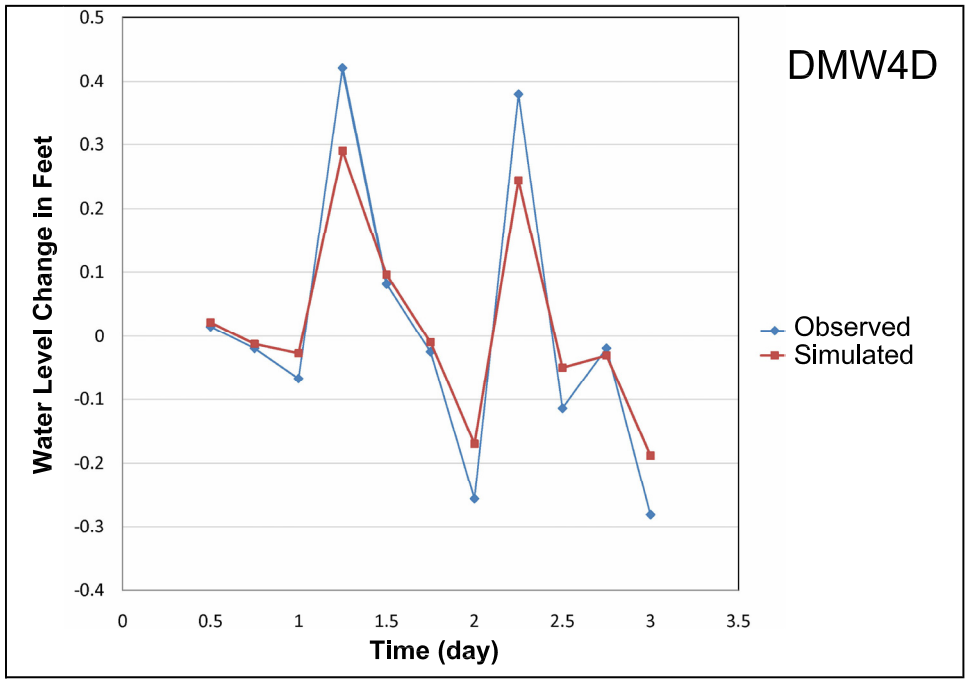
| | |
|---|---|
| APPROVED | DB |
| DRAFTED | CP |
| PROJECT# | 117-0512055 |
| DATE | 2-1-11 |

FIGURE 12

P:\ACAD\0512-055-MSA\0512055017A.DWG



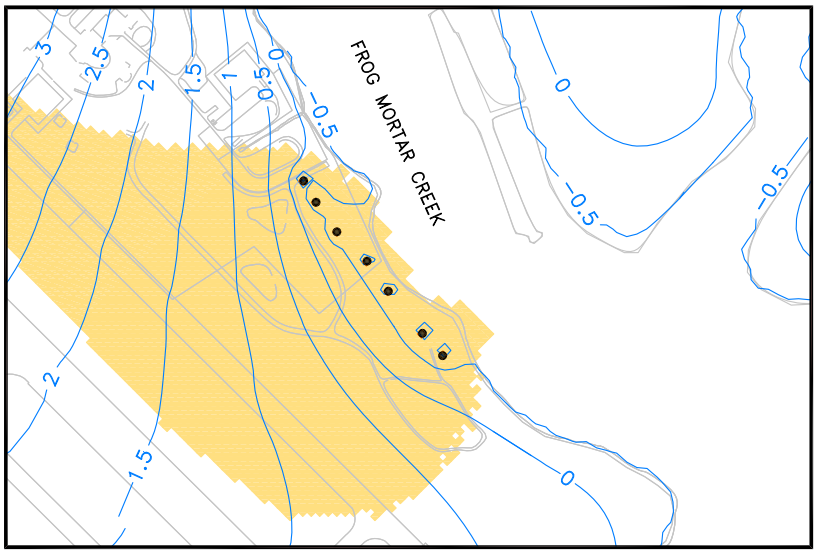

TITLE: **SIMULATED AND OBSERVED HYDRAULIC HEAD CHANGES AT DMW4S, DMW4I, AND DMW4D DURING TIDAL FLUCTUATION FROM JULY 2, 2010 TO JULY 4, 2010**

LOCATION: **Martin State Airport, Maryland**

GeoTrans, Inc. A TETRA TECH COMPANY

| | |
|---|---|
| APPROVED | DB |
| DRAFTED | CP |
| PROJECT# | 117-0512055 |
| DATE | 1-14-11 |

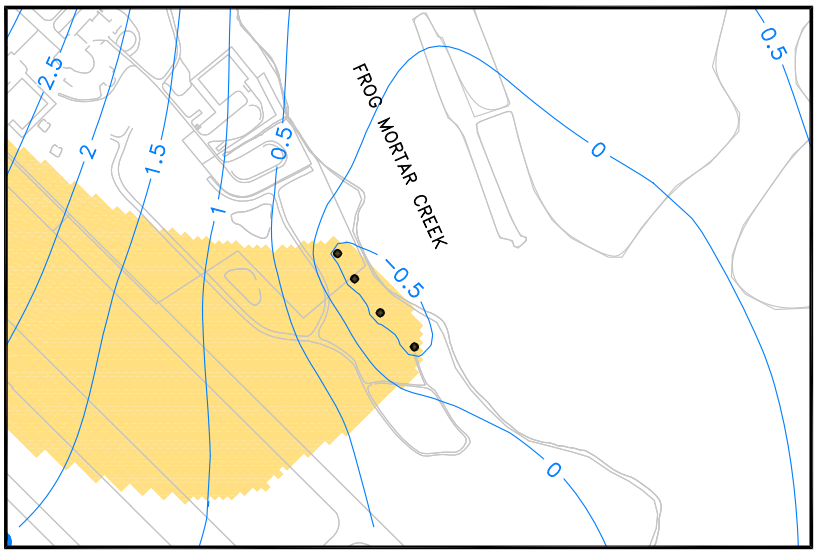
FIGURE **13**




UPPER ZONE




INTERMEDIATE ZONE




LOWER ZONE

LEGEND

- EXTRACTION WELL
- INJECTION WELL
- EXTENT OF CAPTURE ZONE
- RIVER
- — 3 — SIMULATED HEAD (FT MSL)

0 800 1600

SCALE IN FEET

TITLE: **PREDICTED CAPTURE ZONE IN HYDRAULIC BARRIER SCENARIO IN UPPER SURFICIAL (LAYERS 1 AND 6), INTERMEDIATE SURFICIAL (LAYER 8), AND LOWER SURFICIAL (LAYER 11) AQUIFER**

LOCATION: **Martin State Airport, Maryland**

GeoTrans, Inc. A TETRA TECH COMPANY

| | |
|---|---|
| APPROVED | DB |
| DRAFTED | CP |
| PROJECT# | 117-0512055 |
| DATE | 12-15-10 |

FIGURE 14

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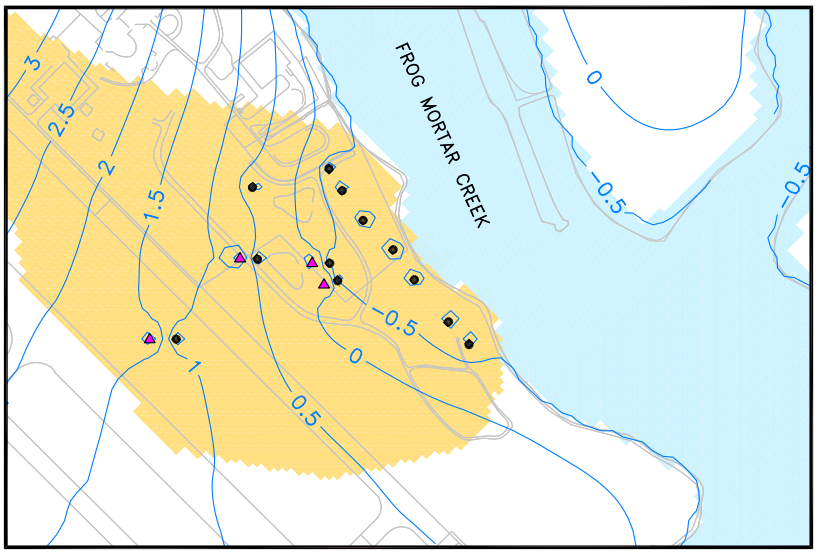
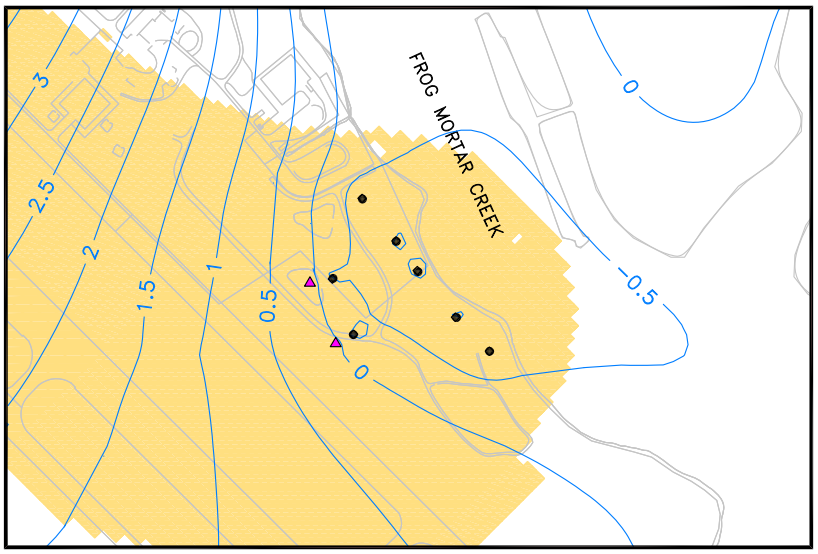
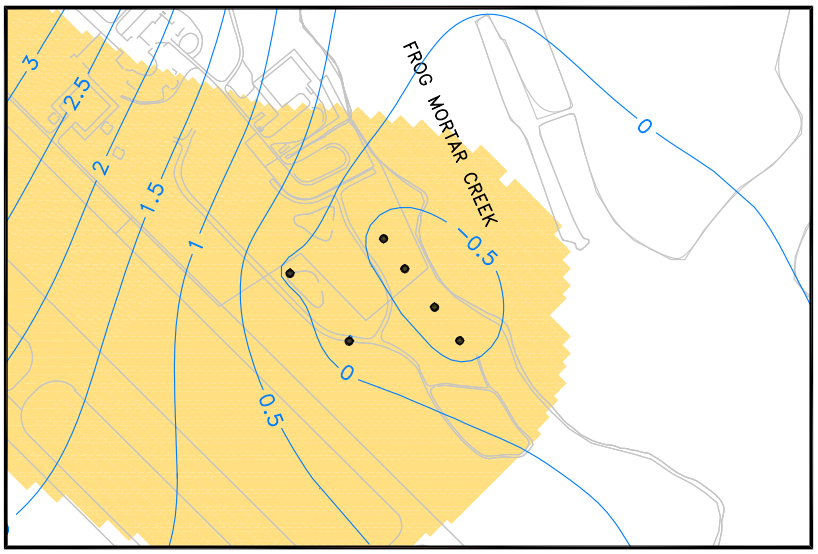



UPPER ZONE




INTERMEDIATE ZONE




LOWER ZONE

N

LEGEND

- EXTRACTION WELL
- INJECTION WELL
- EXTENT OF CAPTURE ZONE
- RIVER
- —3— SIMULATED HEAD (FT MSL)

0 800 1600

SCALE IN FEET

TITLE: **PREDICTED CAPTURE ZONE IN HYDRAULIC BARRIER AND HIGH CONCENTRATION ZONE REMEDIATION SCENARIO IN UPPER SURFICIAL (LAYERS 1 AND 6), INTERMEDIATE SURFICIAL (LAYER 8), AND LOWER SURFICIAL (LAYER 11) AQUIFER**

LOCATION: **Martin State Airport, Maryland**

GeoTrans, Inc. A TETRA TECH COMPANY

| | |
|---|---|
| APPROVED | DB |
| DRAFTED | CP |
| PROJECT# | 117-0512055 |
| DATE | 1-14-11 |

FIGURE 15

P:\ACAD\0512-055-MSA\0512055018A.DWG

# TABLES

Table 1. Summary of Groundwater Flow Model Parameter Values

| Unit | Layer | Horizontal Hydraulic Conductivity $K_h$ (ft/day) | Vertical Hydraulic Conductivity $K_z$ (ft/day) | Specific Yield $S_y$ | Specific Storage $S_s$ ($ft^{-1}$) |
|---|---|---|---|---|---|
| Upper | 1 | 4 | 0.4 | 0.25 | 0.0001 |
| | 2 | 4.5 | 0.45 | | |
| | 3 | 4.5 | 0.45 | | |
| | 4 | 9 | 0.9 | | |
| | 5 | 4.5 | 0.45 | | |
| | 6 | 4.5 | 0.45 | | |
| Intermediate | 7 | 20 | 2 | | 0.0001 |
| | 8 | 20 | 2 | | |
| | 9 | 20 | 2 | | |
| Lower | 10 | 1.4 | 0.14 | | 0.00001 |
| | 11 | 100 | 10 | | |
| Intermediate Aquitard | 12 | 0.5 | 0.05 | | 0.0001 |
| | 13 | 0.5 | 0.05 | | |
| | 14 | 0.5 | 0.05 | | |
| Deep confined | 15 | 40 | 4 | | 0.0001 |

Note: The recharge rate for unpaved area is 0.00192 ft/day (8.4 in/yr); for the paved area is 0.000083 ft/day (0.36 in/yr).

Table 2. July 2, 2010 Measured Groundwater Elevations and Vertical Hydraulic Gradients Versus Simulated Values in the Calibrated Groundwater Flow Model

| Well Name | X | Y | Layer | Observed WL | Computed WL | Residual | Observed Vertical Head Difference | Computed Vertical Head Difference |
|---|---|---|---|---|---|---|---|---|
| DMW-1S | 1479310.5 | 604458.6 | 1 | 1.86 | 1.60 | 0.26 | | |
| DMW-1A | 1479498.3 | 604398.6 | 7 | 1.6 | 1.33 | 0.27 | 0.2600 | 0.2798 |
| DMW1B | 1479498.3 | 604398.6 | 11 | 1.33 | 1.28 | 0.05 | 0.2700 | 0.0436 |
| DMW-2S | 1479807.5 | 604670.4 | 1 | 0.46 | 0.74 | -0.28 | | |
| OW1-S | 1479817.3 | 604674.9 | 4 | 0.6 | 0.68 | -0.08 | -0.1400 | 0.0647 |
| RW1-S | 1479813.4 | 604677.6 | 4 | 0.64 | 0.68 | -0.04 | -0.0400 | -0.0065 |
| DMW2A | 1479789.4 | 604678.8 | 9 | 0.4 | 0.70 | -0.30 | 0.2400 | -0.0109 |
| OW1-I | 1479781.4 | 604638.0 | 9 | 0.32 | 0.75 | -0.43 | 0.0800 | -0.0543 |
| OW1-S | 1479817.3 | 604674.9 | 8 | 0.6 | 0.68 | -0.08 | -0.2800 | 0.0717 |
| DMW-2B | 1479789.4 | 604678.8 | 11 | 0.62 | 0.95 | -0.33 | -0.0200 | -0.2678 |
| DMW-3S | 1479733.9 | 604804.9 | 1 | 5.66 | 0.79 | 4.87 | | |
| DMW-3I | 1479731.1 | 604810.5 | 9 | 0.5 | 0.71 | -0.21 | 5.1600 | 0.0759 |
| DMW-3D | 1479731.1 | 604810.5 | 11 | 0.5 | 0.97 | -0.47 | 0.0000 | -0.2529 |
| DMW-4S | 1480036.3 | 604563.0 | 1 | 0.23 | 0.31 | -0.08 | | |
| DMW-4I | 1480031.5 | 604566.0 | 8 | 0.45 | 0.29 | 0.16 | -0.2200 | 0.0177 |
| DMW-4D | 1480031.5 | 604566.0 | 11 | 0.38 | 0.57 | -0.19 | 0.0700 | -0.2762 |
| MW-4 | 1479180.8 | 604852.9 | 1 | 1.75 | 1.84 | -0.09 | | |
| DMW-5S | 1480141.1 | 604430.0 | 1 | 0.35 | 0.31 | 0.04 | | |
| DMW-5I | 1480140.5 | 604431.1 | 7 | 0.36 | 0.24 | 0.12 | -0.0100 | 0.0614 |
| DMW-5D | 1480140.6 | 604431.1 | 11 | 0.38 | 0.46 | -0.08 | -0.0200 | -0.2134 |
| DMW-6S | 1480255.0 | 604190.5 | 2 | 0.23 | 0.38 | -0.15 | | |
| DMW-6I | 1480266.2 | 604193.6 | 7 | 0.38 | 0.30 | 0.08 | -0.1500 | 0.0881 |
| DMW-6D | 1480266.2 | 604193.6 | 11 | 0.3 | 0.42 | -0.12 | 0.0800 | -0.1260 |
| MW-6 | 1480184.7 | 604009.3 | 1 | 0.58 | 0.69 | -0.11 | | |
| MW-7 | 1478680.4 | 604765.2 | 1 | 3.54 | 2.45 | 1.09 | | |
| MW-5 | 1479901.9 | 604294.7 | 1 | 0.88 | 0.90 | -0.02 | | |
| DMW-7I | 1479924.2 | 604287.2 | 8 | 0.58 | 0.78 | -0.20 | 0.3000 | 0.1195 |
| DMW-7D | 1479924.2 | 604287.2 | 11 | 0.71 | 0.87 | -0.16 | -0.1300 | -0.0884 |
| DMW-8S | 1479667.8 | 604516.6 | 1 | 3.2 | 1.14 | 2.06 | | |
| DMW-8I | 1479673.6 | 604516.0 | 7 | 0.83 | 1.05 | -0.22 | 2.3700 | 0.0924 |
| DMW-8D | 1479673.6 | 604516.0 | 11 | 0.89 | 1.13 | -0.24 | -0.0600 | -0.0805 |
| DMW-9S | 1479286.9 | 604771.6 | 1 | 1.6 | 1.67 | -0.07 | | |
| DMW-9I | 1479293.4 | 604764.9 | 7 | 1.48 | 1.57 | -0.09 | 0.1200 | 0.0964 |
| DMW-9D | 1479293.4 | 604764.9 | 11 | 1.12 | 1.49 | -0.37 | 0.3600 | 0.0880 |
| DMW-10S | 1479225.8 | 604636.8 | 1 | 1.9 | 1.74 | 0.16 | | |
| DMW-10I | 1479217.3 | 604630.7 | 8 | 1.71 | 1.65 | 0.06 | 0.1900 | 0.0868 |
| DMW-11S | 1478934.9 | 604424.2 | 1 | 3.51 | 2.01 | 1.50 | | |
| DMW-11I | 1478930.8 | 604429.3 | 7 | 1.86 | 1.92 | -0.06 | 1.6500 | 0.0899 |
| MW-14I | 1479550.7 | 605129.9 | 7 | 0.43 | 0.90 | -0.47 | | |

| Well Name | X | Y | Layer | Observed WL | Computed WL | Residual | Vertical Head Difference | Vertical Head Difference |
|---|---|---|---|---|---|---|---|---|
| MW-15S | 1479028.3 | 605011.0 | 4 | 1.38 | 2.05 | -0.67 | | |
| MW-15I | 1479028.3 | 605011.0 | 8 | 1.6 | 1.98 | -0.38 | -0.2200 | 0.0676 |
| MW-15D | 1479028.3 | 605011.0 | 11 | 1.6 | 1.86 | -0.26 | 0.0000 | 0.1252 |
| MW-16S | 1479248.8 | 605086.4 | 6 | 0.47 | 1.65 | -1.18 | | |
| MW-16I | 1479248.8 | 605086.4 | 8 | 1.4 | 1.62 | -0.22 | -0.9300 | 0.0220 |
| MW-16D | 1479248.8 | 605086.4 | 10 | 0.38 | 1.60 | -1.22 | 1.0200 | 0.0205 |
| MW-17S | 1479358.3 | 605112.7 | 2 | 0.45 | 1.46 | -1.01 | | |
| MW-17I | 1479358.3 | 605112.7 | 7 | 1.17 | 1.39 | -0.22 | -0.7200 | 0.0733 |
| MW-17D | 1479358.3 | 605112.7 | 10 | 2.15 | 1.41 | 0.74 | -0.9800 | -0.0178 |
| MW-18S | 1479645.1 | 604930.8 | 4 | 0.33 | 0.87 | -0.54 | | |
| MW-18I | 1479645.1 | 604930.8 | 8 | 0.29 | 0.82 | -0.53 | 0.0400 | 0.0493 |
| MW-2 | 1479708.3 | 604144.3 | 8 | 0.94 | 1.11 | -0.17 | | |
| MW-19I | 1479701.2 | 604152.7 | 8 | 0.73 | 1.11 | -0.38 | 0.2100 | -0.0067 |
| MW-19D | 1479701.2 | 604152.7 | 11 | 0.78 | 1.09 | -0.31 | -0.0500 | 0.0266 |
| DMW-1S | 1479310.5 | 604458.6 | 1 | 1.86 | 1.60 | 0.26 | | |
| MW-20S | 1479397.9 | 604631.0 | 4 | 1.55 | 1.48 | 0.07 | 0.3100 | 0.1273 |
| MW-20I | 1479397.9 | 604631.0 | 8 | 1.57 | 1.43 | 0.14 | -0.0200 | 0.0514 |
| MW-20D | 1479397.9 | 604631.0 | 10 | 1.02 | 1.40 | -0.38 | 0.5500 | 0.0257 |
| MW-21I | 1479303.2 | 604467.8 | 8 | 1.62 | 1.52 | 0.10 | | |
| MW-21D | 1479303.2 | 604467.8 | 11 | 1.17 | 1.44 | -0.27 | 0.4500 | 0.0804 |
| MW-3 | 1479107.2 | 604448.8 | 1 | 1.98 | 1.82 | 0.16 | | |
| MW-22I | 1479112.8 | 604442.1 | 7 | 1.89 | 1.73 | 0.16 | 0.0900 | 0.0927 |
| MW-22D | 1479112.8 | 604442.1 | 11 | 1.41 | 1.59 | -0.18 | 0.4800 | 0.1371 |
| MW-23S | 1479295.1 | 604237.1 | 4 | 1.72 | 1.55 | 0.17 | | |
| MW-23I | 1479295.1 | 604237.1 | 9 | 1.7 | 1.50 | 0.20 | 0.0200 | 0.0525 |
| MW-23D | 1479295.1 | 604237.1 | 11 | 1.21 | 1.41 | -0.20 | 0.4900 | 0.0908 |
| MW-24S | 1479375.2 | 603945.7 | 2 | 2.91 | 1.48 | 1.43 | | |
| MW-24I | 1479375.2 | 603945.7 | 7 | 1.72 | 1.38 | 0.34 | 1.1900 | 0.0985 |
| MW-25S | 1478812.4 | 604510.1 | 1 | 3.46 | 2.18 | 1.28 | | |
| MW-25I | 1478812.4 | 604510.1 | 8 | 1.89 | 2.07 | -0.18 | 1.5700 | 0.1041 |
| MW-26S | 1479035.4 | 604726.4 | 4 | 2.25 | 1.95 | 0.30 | | |
| MW-26I | 1479035.4 | 604726.4 | 8 | 1.69 | 1.89 | -0.20 | 0.5600 | 0.0522 |
| MW-26D | 1479035.4 | 604726.4 | 11 | 1.74 | 1.74 | 0.00 | -0.0500 | 0.1510 |
| MW-29D | 1480488.4 | 603774.8 | 15 | 0.38 | 0.53 | -0.15 | | |
| MW-30D | 1479645.7 | 603825.5 | 15 | 0.89 | 0.95 | -0.06 | | |
| MW-31D | 1480099.6 | 603747.8 | 15 | 0.17 | 0.69 | -0.52 | | |
| MW-28I | 1479027.9 | 605110.6 | 9 | 1.47 | 2.00 | -0.53 | | |
| MW-27D | 1479032.0 | 605114.3 | 15 | 3.37 | 2.04 | 1.33 | -1.9000 | -0.0467 |
| MW-32S | 1479926.5 | 603917.7 | 2 | 0.96 | 0.99 | -0.03 | | |
| MW-32I | 1479926.5 | 603917.7 | 9 | 0.88 | 0.90 | -0.02 | 0.0800 | 0.0831 |
| MW-33S | 1478762.0 | 605115.6 | 2 | 2.13 | 2.50 | -0.37 | | |
| MW-33I | 1478762.0 | 605115.6 | 9 | 2.08 | 2.40 | -0.32 | 0.0500 | 0.1000 |
| MW-34S | 1478893.8 | 605340.1 | 2 | 1.67 | 2.38 | -0.71 | | |
| MW-34I | 1478893.8 | 605340.1 | 9 | 1.65 | 2.28 | -0.63 | 0.0200 | 0.0982 |

Table 3. Summary Statistics for Steady-State Flow Model Simulation for July 2010 Conditions

| Model Layer | Unit | # Targets | Range of Water Levels (ft) | Residual Mean (ft) | Absolute Residual Mean (ft) | Residual Standard Deviation (ft) | Standard Deviation / Range |
|---|---|---|---|---|---|---|---|
| | **Entire Model** | **81** | **3.37** | **-0.09** | **0.34** | **0.48** | **0.14** |
| 1 | Upper Zone | 14 | 3.31 | 0.38 | 0.41 | 0.64 | 0.19 |
| 2 | Upper Zone | 5 | 1.90 | -0.45 | 0.45 | 0.40 | 0.21 |
| 3 | Upper Zone | 0 | - | - | - | - | - |
| 4 | Upper Zone | 7 | 1.92 | -0.11 | 0.27 | 0.36 | 0.19 |
| 5 | Upper Zone | 0 | - | - | - | - | - |
| 6 | Upper Zone | 1 | - | -1.18 | 1.18 | - | - |
| 7 | Intermediate Zone | 10 | 1.53 | -0.01 | 0.20 | 0.25 | 0.16 |
| 8 | Intermediate Zone | 13 | 1.60 | -0.17 | 0.24 | 0.23 | 0.14 |
| 9 | Intermediate Zone | 8 | 1.76 | -0.28 | 0.33 | 0.27 | 0.15 |
| 10 | Lower Zone | 3 | 1.77 | -0.29 | 0.78 | 0.99 | 0.56 |
| 11 | Lower Zone | 16 | 1.44 | -0.23 | 0.24 | 0.16 | 0.11 |
| 12 | Basal Confing Unit | 0 | - | - | - | - | - |
| 13 | Basal Confing Unit | 0 | - | - | - | - | - |
| 14 | Basal Confing Unit | 0 | - | - | - | - | - |
| 15 | Deep Confined Zone | 4 | 3.20 | 0.15 | 0.41 | 0.81 | 0.25 |

Table 4. Comparison of Simulated and Measured Drawdown at the End of 72 Hour Pumping Test in the Intermediate Zone of the Surficial Aquifer.

| Well ID | Actual Drawdown (Feet) | Simulated Drawdown (Feet) |
|---|---|---|
| OW-01I | 1.18 | 1.28 |
| DMW-2A | 1.16 | 1.34 |
| DMW-2B | 0.54 | 0.55 |
| DMW-3I | 0.46 | 0.4 |
| DMW-4I | 0.39 | 0.17 |
| DMW-8I | 0.28 | 0.30 |

Table 5. Summary of Flow Model Sensitivity Analysis

| Model Parameter | Multiplier | Normalized RSS |
|---|---|---|
| | | |
| Recharge Rate (unpaved area) | 0.5 | 1.99 |
| Recharge Rate (unpaved area) | 1.5 | 2.58 |
| Recharge Rate (paved area) | 0.5 | 1.00 |
| Recharge Rate (paved area) | 1.5 | 1.00 |
| Horizontal Hydraulic Conductivity of Upper Zone | 0.5 | 1.06 |
| Horizontal Hydraulic Conductivity of Upper Zone | 1.5 | 0.98 |
| Horizontal Hydraulic Conductivity of Intermediate Zone | 0.5 | 1.11 |
| Horizontal Hydraulic Conductivity of Intermediate Zone | 1.5 | 0.98 |
| Horizontal Hydraulic Conductivity of Lower Zone | 0.5 | 1.18 |
| Horizontal Hydraulic Conductivity of Lower Zone | 1.5 | 0.98 |
| Vertical Hydraulic Conductivity of Upper Zone | 0.5 | 1.11 |
| Vertical Hydraulic Conductivity of Upper Zone | 1.5 | 0.99 |
| Vertical Hydraulic Conductivity of Intermediate Zone | 0.5 | 1.04 |
| Vertical Hydraulic Conductivity of Intermediate Zone | 1.5 | 0.99 |
| Vertical Hydraulic Conductivity of Lower Zone | 0.5 | 1.10 |
| Vertical Hydraulic Conductivity of Lower Zone | 1.5 | 0.99 |
| Vertical Hydraulic Conductivity Intermediate Aquitard (Layer 12, 13, and 14) | 0.5 | 1.01 |
| Vertical Hydraulic Conductivity Intermediate Aquitard (Layer 12, 13, and 14) | 1.5 | 1.00 |
| Horizontal Hydraulic Conductivity of Deep Confined Zone (Layer 15) | 0.5 | 1.00 |
| Horizontal Hydraulic Conductivity of Deep Confined Zone (Layer 15) | 1.5 | 1.00 |
| Vertical Hydraulic Conductivity of Deep Confined Zone (Layer 15) | 0.5 | 1.00 |
| Vertical Hydraulic Conductivity of Deep Confined Zone (Layer 15) | 1.5 | 1.00 |

Note: Normalized RSS (residual sum of squares) is the new RSS divided by calibrated model RSS

Table 6. Summary of Injection and Pumping Rates by Model Layer for Each Remedial Scenario.

| Scenario Description | Layer | Zone | Pumping Rate (gpm) | Pumping Rate by Zone (gpm) | Injection Rate (gpm) |
|---|---|---|---|---|---|
| Hydraulic Barrier Wells Along Frog Mortar Creek | Layer 2 | Upper | 1.5 | 12.2 | |
| | Layer 3 | Upper | 1.6 | | |
| | Layer 4 | Upper | 3.2 | | |
| | Layer 5 | Upper | 1.6 | | |
| | Layer 6 | Upper | 4.3 | | |
| | Layer 7 | Intermediate | 1.8 | 13.6 | |
| | Layer 8 | Intermediate | 6.0 | | |
| | Layer 9 | Intermediate | 5.8 | | |
| | Layer 11 | Lower | 22.2 | 22.2 | |
| | **Total** | | | 48.1 | |
| Hydraulic Barrier Wells With High Concentration Zone Injection and Pumping | Layer 2 | Upper | 2.3 | 12.3 | 2.0 |
| | Layer 3 | Upper | 2.3 | | 2.0 |
| | Layer 4 | Upper | 2.5 | | 2.0 |
| | Layer 5 | Upper | 2.4 | | 2.0 |
| | Layer 6 | Upper | 2.7 | | 2.0 |
| | Layer 7 | Intermediate | 7.2 | 21.3 | 1.0 |
| | Layer 8 | Intermediate | 7.0 | | 1.0 |
| | Layer 9 | Intermediate | 7.0 | | 1.0 |
| | Layer 11 | Lower | 34.3 | 34.3 | |
| | **Total** | | | 67.9 | |

*Addendum A —*

*Hydrostratigraphic Cross-Sections at MSA*

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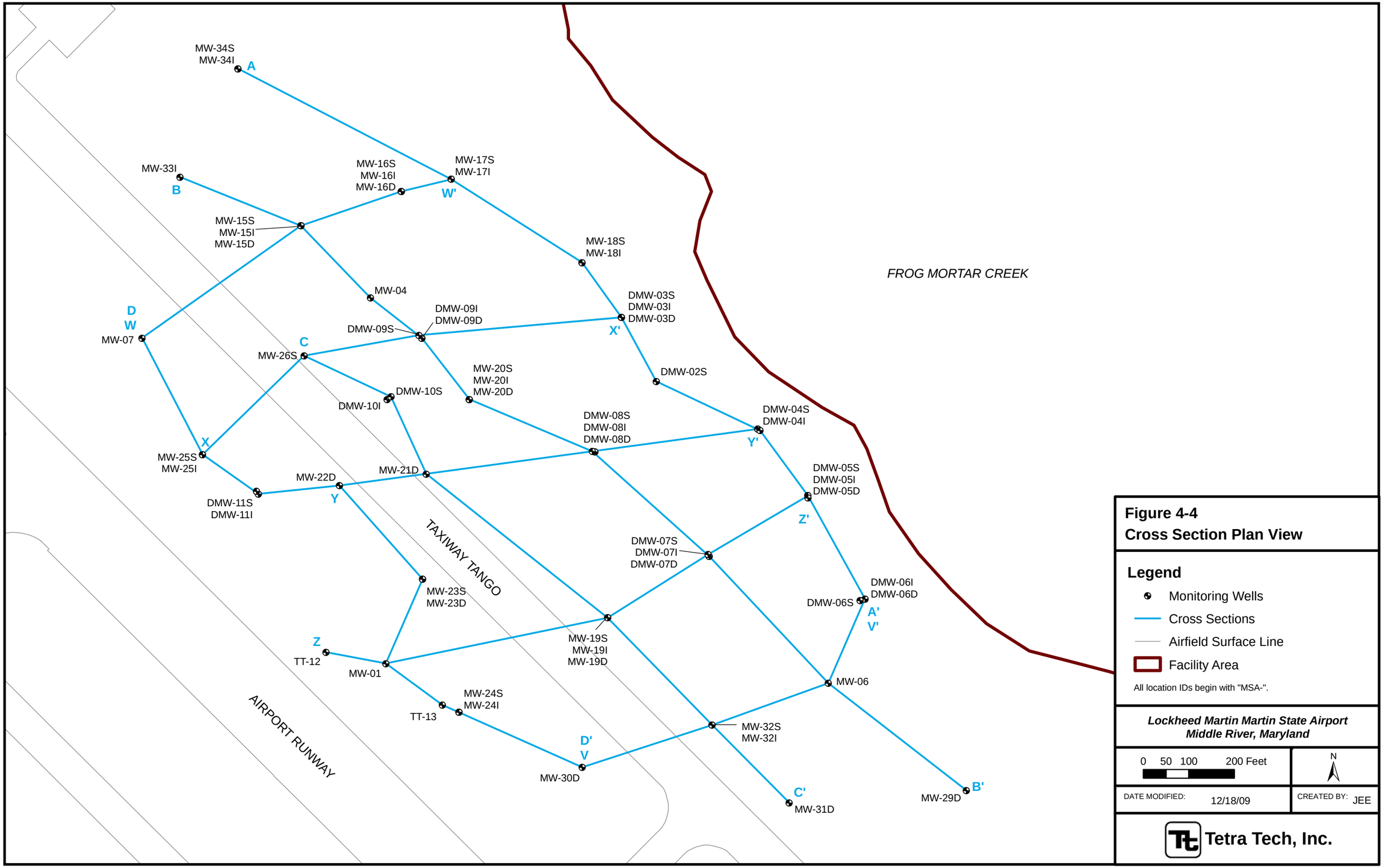


**Figure 4-4**
**Cross Section Plan View**

**Legend**

- Monitoring Wells
- Cross Sections
- Airfield Surface Line
- Facility Area

All location IDs begin with "MSA-".

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0 50 100 200 Feet

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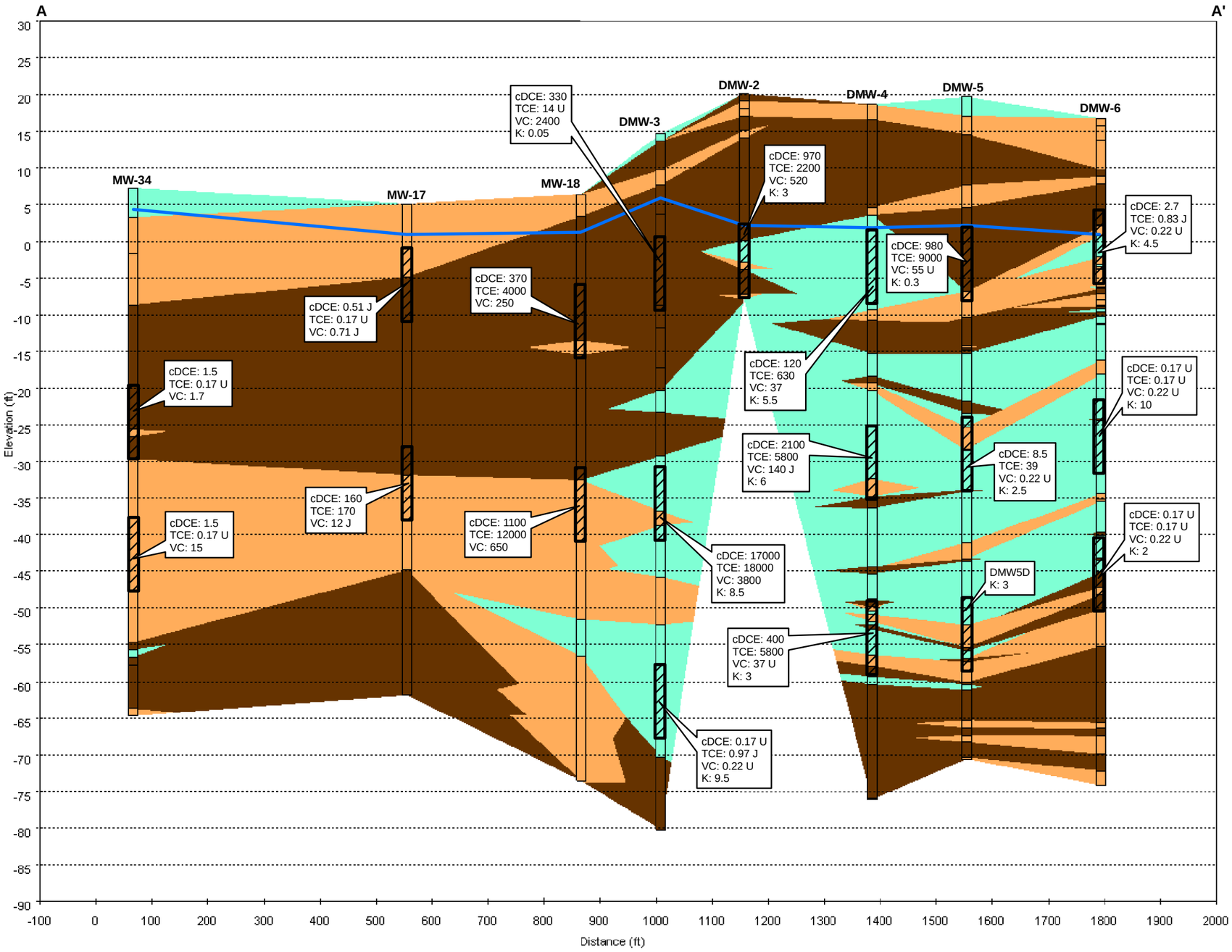


**Figure 4-6**
**Hydrostratigraphic Cross Section**
**Transect A-A'**

## Legend

- Well Screen
- Soil / Well Boring
- Groundwater Surface
- **K** Hydraulic Conductivity (ft/day)

**September 2009 Sampling Results**

- **cDCE** cis-1,2-Dichloroethene Concentration (ug/L)
- **TCE** Trichloroethene Concentration (ug/L)
- **VC** Vinyl Chloride Concentration (ug/L)
- **J** Estimated Result
- **U** Result Below Detection Limit

**Materials**

- Higher Permeability (typically >10 ft/day): Sand and sand & gravel
- Medium Permeability (typically 1-10 ft/day): Mixture of sand, silt, and/or some clay
- Lower Permeability (typically <1 ft/day): Clay and silt & clay

Hydrostratigraphic units were interpreted from lithology information of boring logs and slug test results.

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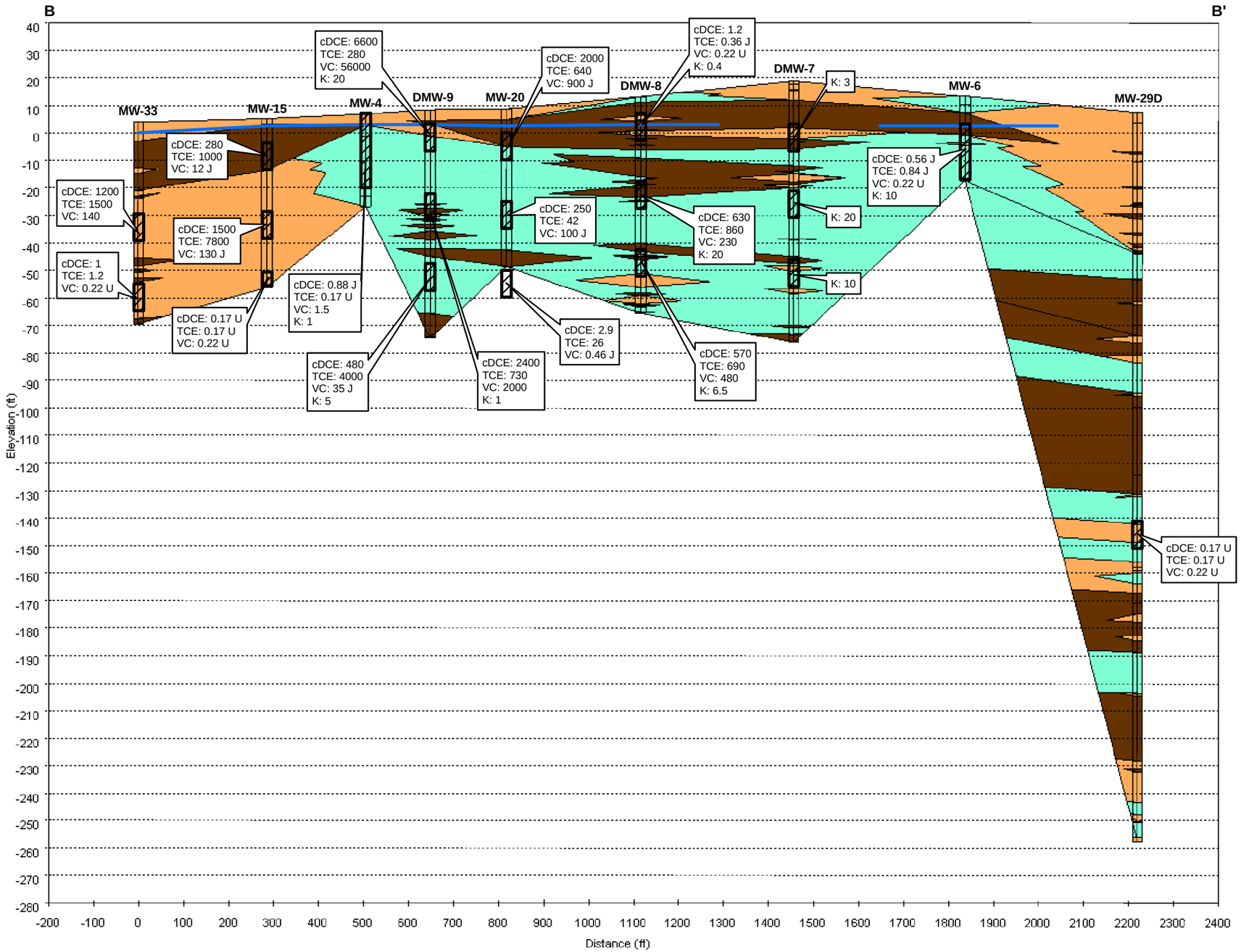


**Figure 4-7**
**Hydrostratigraphic Cross Section**
**Transect B-B'**

## Legend

- Well Screen
- Soil / Well Boring
- Groundwater Surface
- **K** Hydraulic Conductivity (ft/day)

**September 2009 Sampling Results**

- **cDCE** cis-1,2-Dichloroethene Concentration (ug/L)
- **TCE** Trichloroethene Concentration (ug/L)
- **VC** Vinyl Chloride Concentration (ug/L)

- **J** Estimated Result
- **U** Result Below Detection Limit

**Materials**

- Higher Permeability (typically >10 ft/day): Sand and sand & gravel
- Medium Permeability (typically 1-10 ft/day): Mixture of sand, silt, and/or some clay
- Lower Permeability (typically <1 ft/day): Clay and silt & clay

Hydrostratigraphic units were interpreted from lithology information of boring logs and slug test results.

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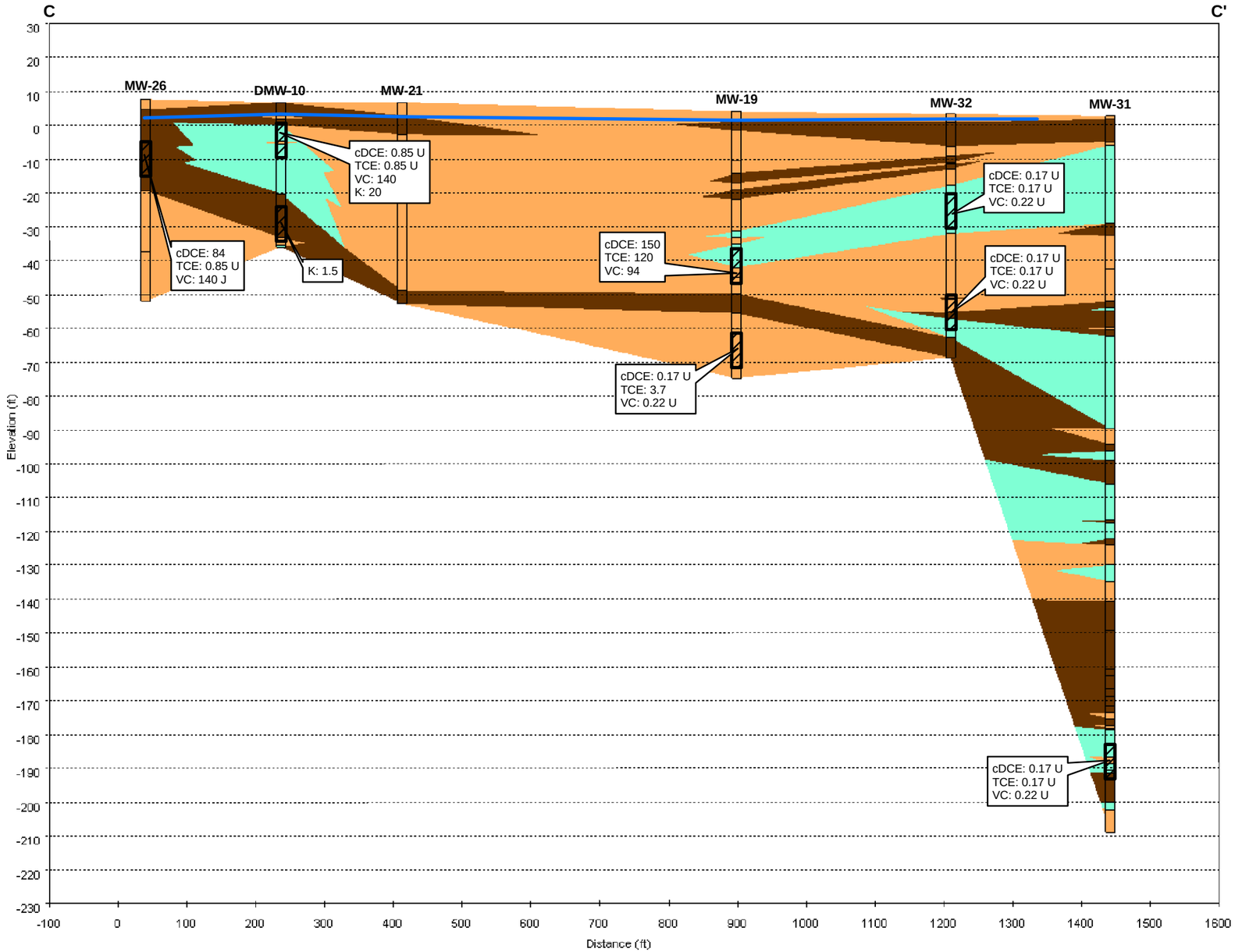


**Figure 4-8**
**Hydrostratigraphic Cross Section**
**Transect C-C'**

## Legend

- Well Screen
- Soil / Well Boring
- Groundwater Surface
- **K** Hydraulic Conductivity (ft/day)

**September 2009 Sampling Results**

- **cDCE** cis-1,2-Dichloroethene Concentration (ug/L)
- **TCE** Trichloroethene Concentration (ug/L)
- **VC** Vinyl Chloride Concentration (ug/L)

- **J** Estimated Result
- **U** Result Below Detection Limit

**Materials**

- Higher Permeability (typically >10 ft/day): Sand and sand & gravel
- Medium Permeability (typically 1-10 ft/day): Mixture of sand, silt, and/or some clay
- Lower Permeability (typically <1 ft/day): Clay and silt & clay

Hydrostratigraphic units were interpreted from lithology information of boring logs and slug test results.

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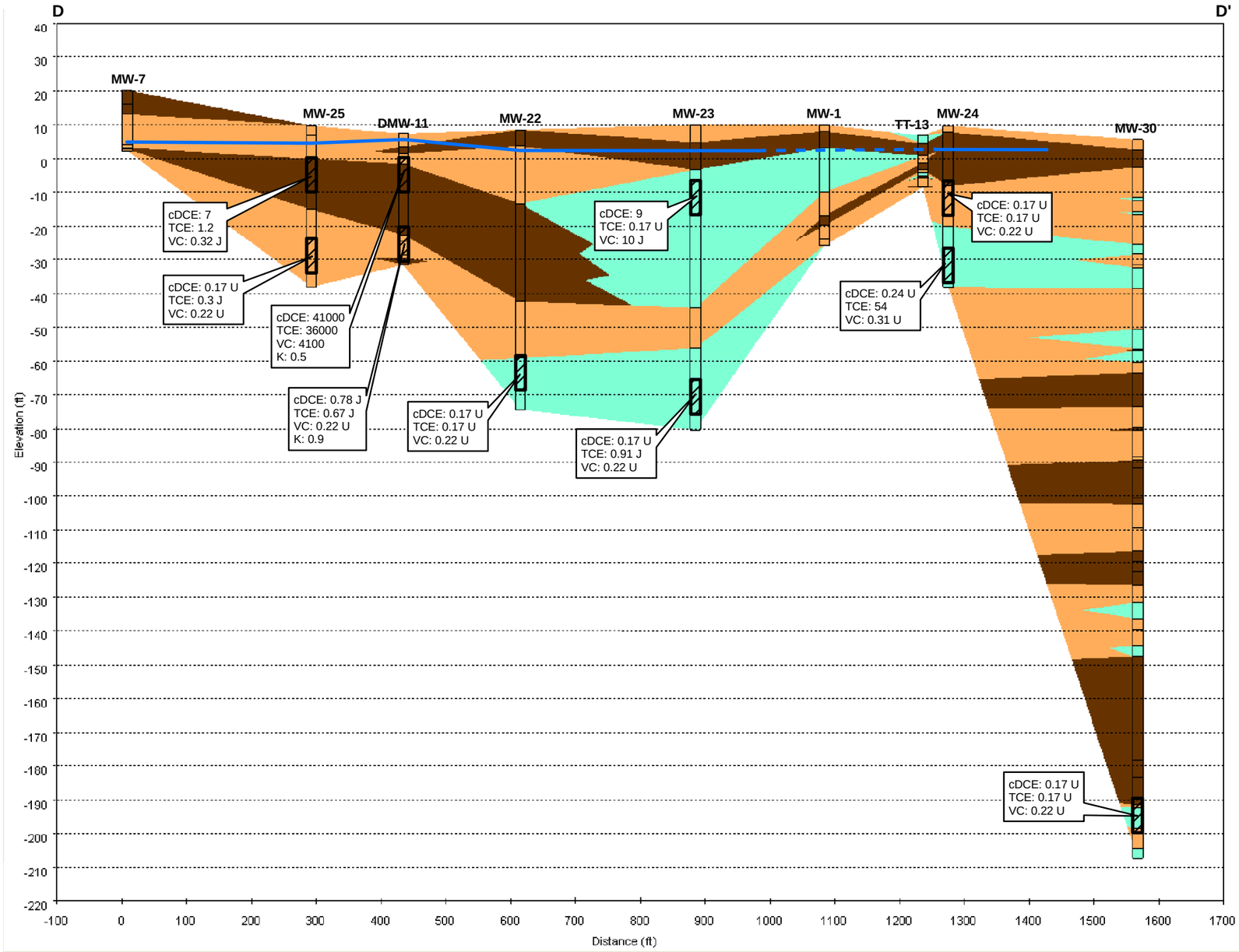


**Figure 4-9**
**Hydrostratigraphic Cross Section**
**Transect D-D'**

## Legend

- Well Screen
- Soil / Well Boring
- Groundwater Surface (Dashed Where Inferred)
- **K** Hydraulic Conductivity (ft/day)

**September 2009 Sampling Results**

- **cDCE** cis-1,2-Dichloroethene Concentration (ug/L)
- **TCE** Trichloroethene Concentration (ug/L)
- **VC** Vinyl Chloride Concentration (ug/L)
- **J** Estimated Result
- **U** Result Below Detection Limit

**Materials**

- Higher Permeability (typically >10 ft/day): Sand and sand & gravel
- Medium Permeability (typically 1-10 ft/day): Mixture of sand, silt, and/or some clay
- Lower Permeability (typically <1 ft/day): Clay and silt & clay

Hydrostratigraphic units were interpreted from lithology information of boring logs and slug test results.

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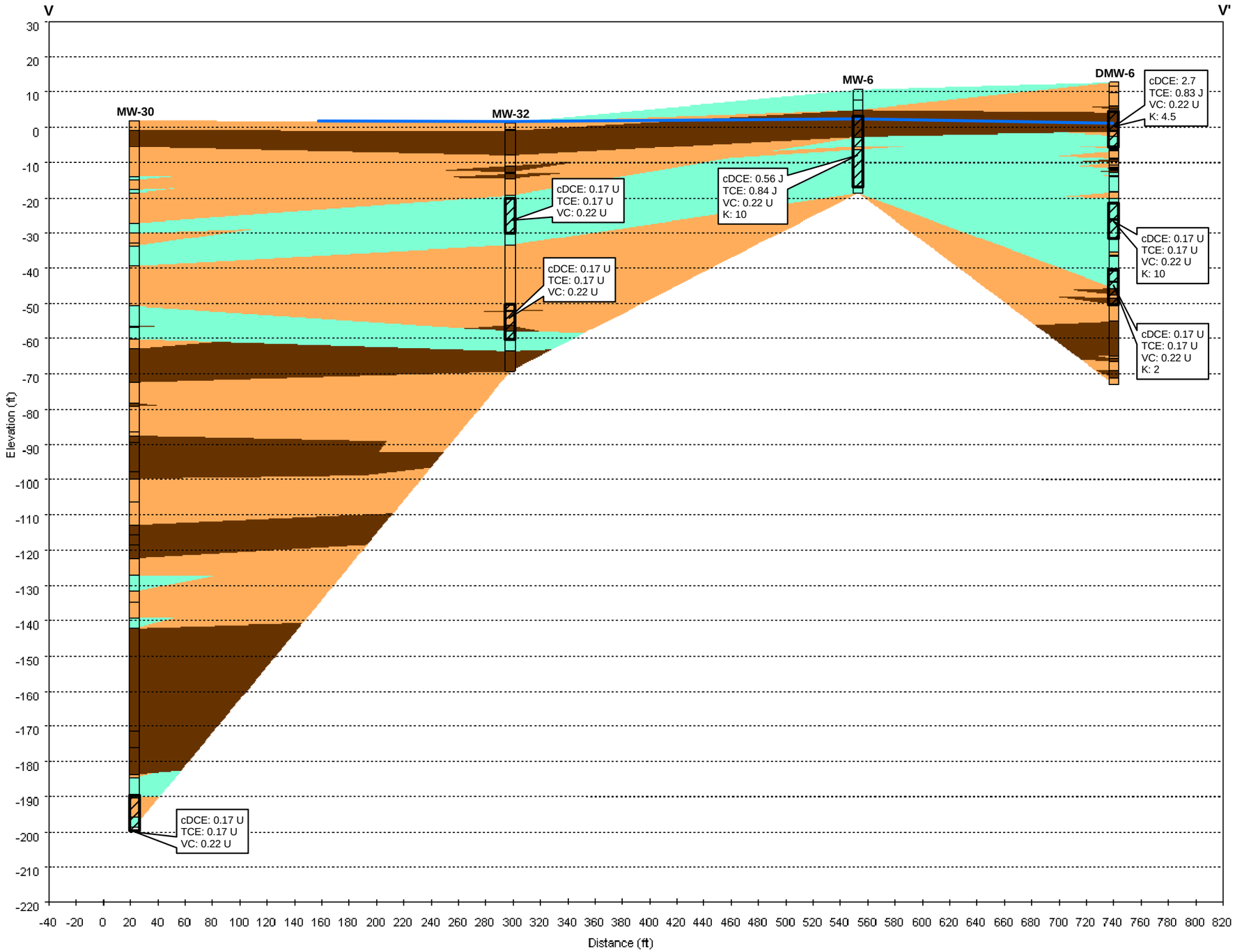


**Figure 4-10**
**Hydrostratigraphic Cross Section**
**Transect V-V'**

## Legend

- Well Screen
- Soil / Well Boring
- Groundwater Surface
- **K** Hydraulic Conductivity (ft/day)

**September 2009 Sampling Results**

- **cDCE** cis-1,2-Dichloroethene Concentration (ug/L)
- **TCE** Trichloroethene Concentration (ug/L)
- **VC** Vinyl Chloride Concentration (ug/L)
- **J** Estimated Result
- **U** Result Below Detection Limit

**Materials**

- Higher Permeability (typically >10 ft/day): Sand and sand & gravel
- Medium Permeability (typically 1-10 ft/day): Mixture of sand, silt, and/or some clay
- Lower Permeability (typically <1 ft/day): Clay and silt & clay

Hydrostratigraphic units were interpreted from lithology information of boring logs and slug test results.

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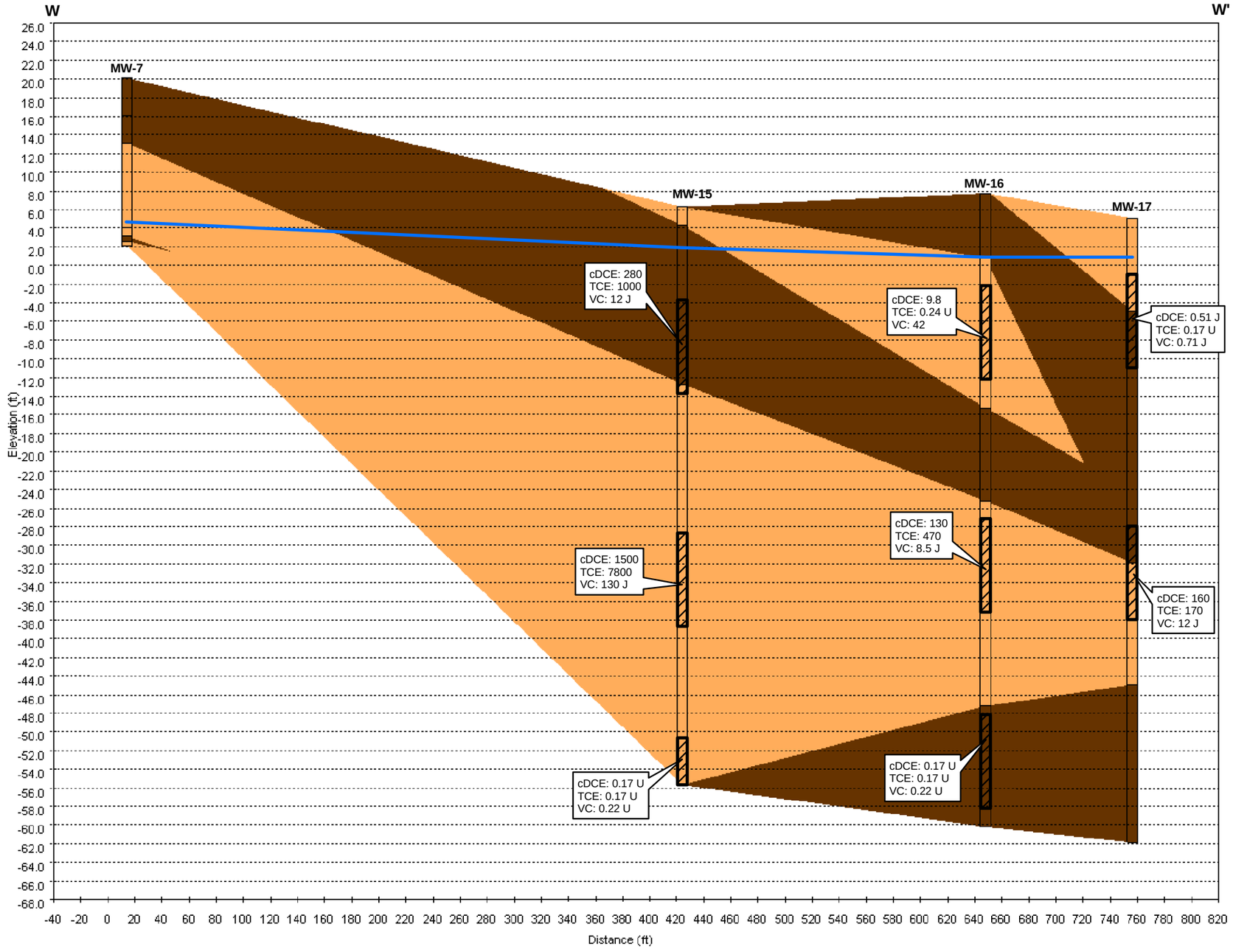


**Figure 4-11**
**Hydrostratigraphic Cross Section**
**Transect W-W'**

## Legend

- Well Screen
- Soil / Well Boring
- Groundwater Surface
- **K** Hydraulic Conductivity (ft/day)

**September 2009 Sampling Results**

- **cDCE** cis-1,2-Dichloroethene Concentration (ug/L)
- **TCE** Trichloroethene Concentration (ug/L)
- **VC** Vinyl Chloride Concentration (ug/L)
- **J** Estimated Result
- **U** Result Below Detection Limit

**Materials**

- Higher Permeability (typically >10 ft/day): Sand and sand & gravel
- Medium Permeability (typically 1-10 ft/day): Mixture of sand, silt, and/or some clay
- Lower Permeability (typically <1 ft/day): Clay and silt & clay

Hydrostratigraphic units were interpreted from lithology information of boring logs and slug test results.

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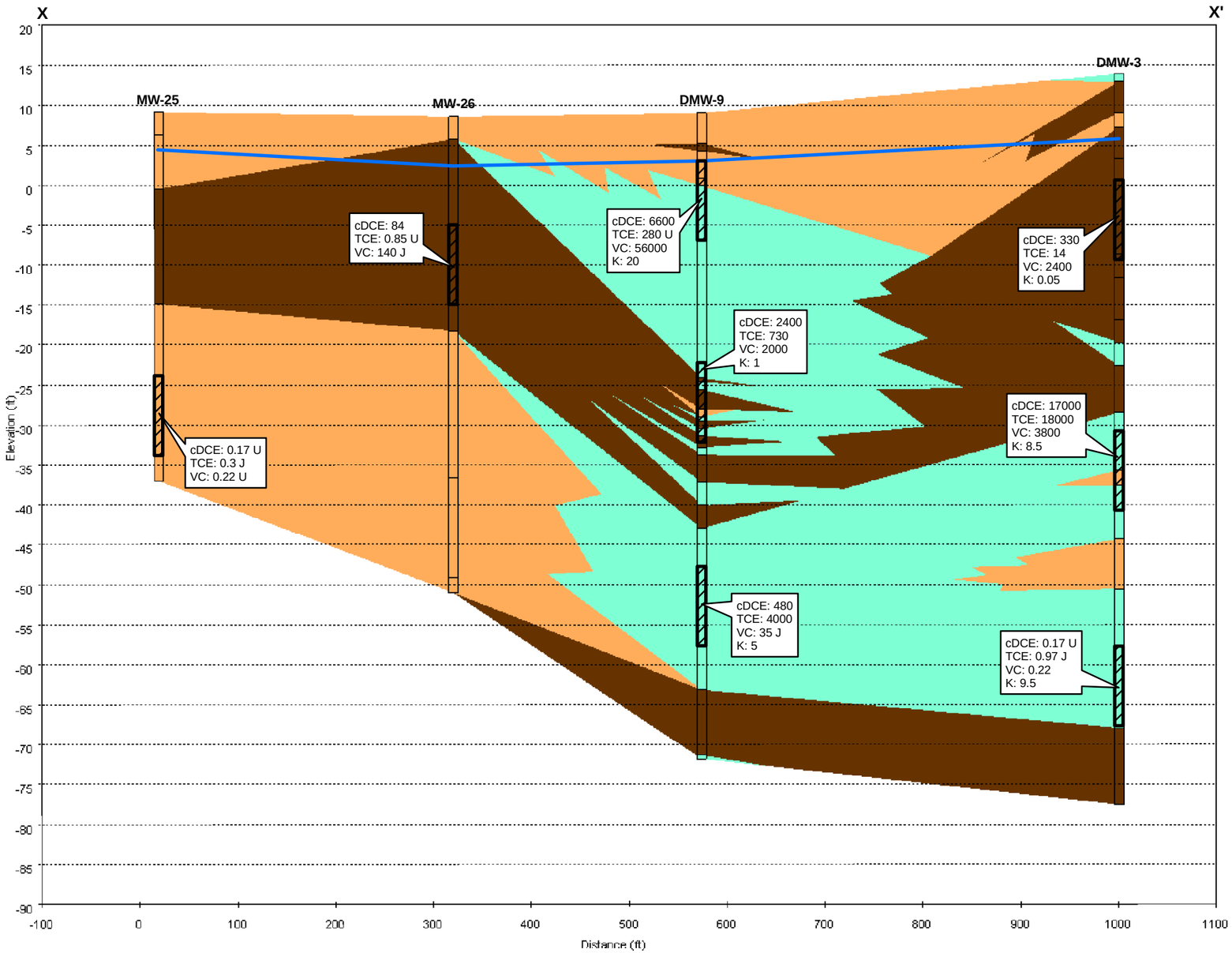


**Figure 4-12**
**Hydrostratigraphic Cross Section**
**Transect X-X'**

## Legend

- Well Screen
- Soil / Well Boring
- Groundwater Surface
- **K** Hydraulic Conductivity (ft/day)

**September 2009 Sampling Results**

- **cDCE** cis-1,2-Dichloroethene Concentration (ug/L)
- **TCE** Trichloroethene Concentration (ug/L)
- **VC** Vinyl Chloride Concentration (ug/L)
- **J** Estimated Result
- **U** Result Below Detection Limit

**Materials**

- Higher Permeability (typically >10 ft/day): Sand and sand & gravel
- Medium Permeability (typically 1-10 ft/day): Mixture of sand, silt, and/or some clay
- Lower Permeability (typically <1 ft/day): Clay and silt & clay

Hydrostratigraphic units were interpreted from lithology information of boring logs and slug test results.

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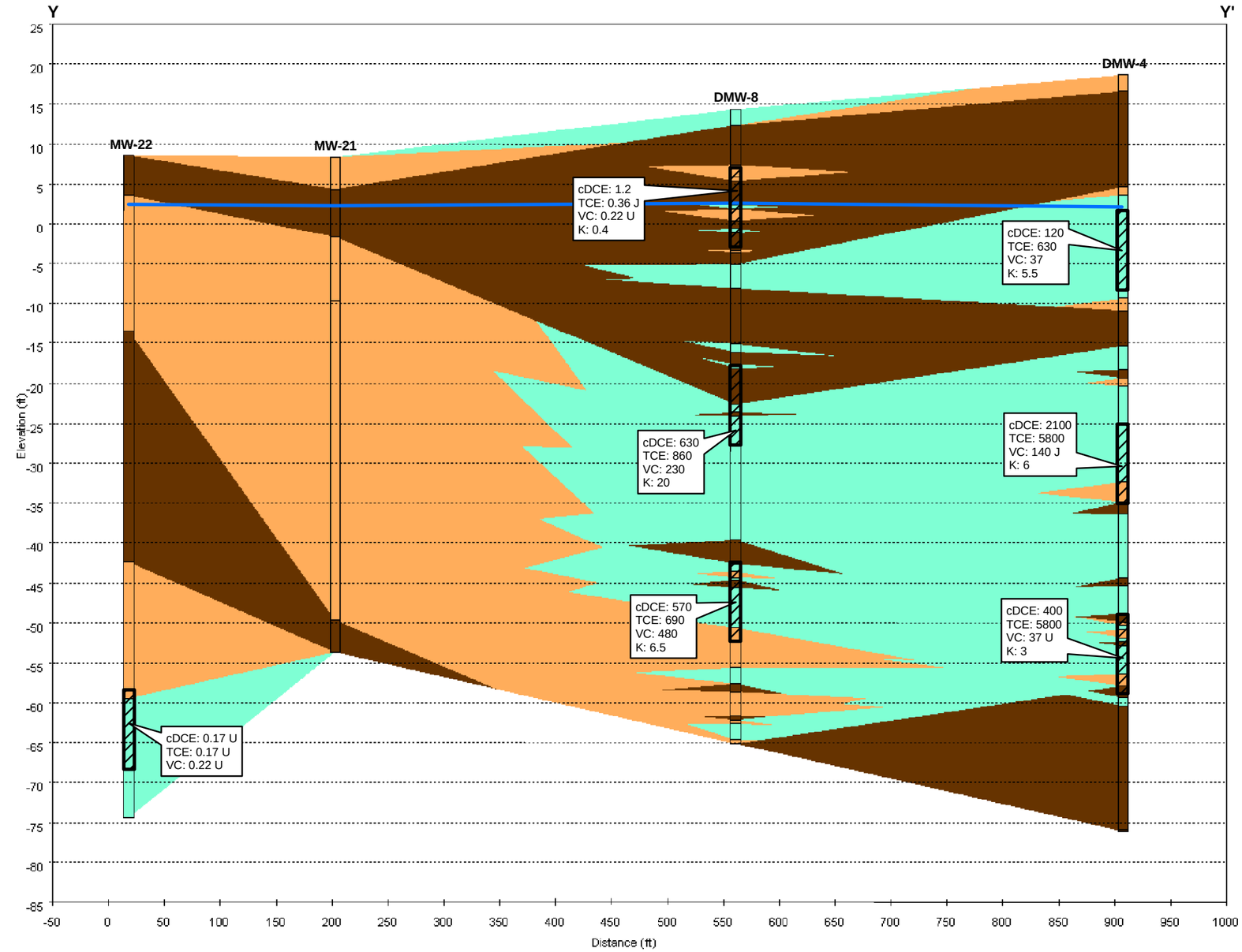


**Figure 4-13**
**Hydrostratigraphic Cross Section**
**Transect Y-Y'**

## Legend

- Well Screen
- Soil / Well Boring
- Groundwater Surface
- **K** Hydraulic Conductivity (ft/day)

**September 2009 Sampling Results**

- **cDCE** cis-1,2-Dichloroethene Concentration (ug/L)
- **TCE** Trichloroethene Concentration (ug/L)
- **VC** Vinyl Chloride Concentration (ug/L)

- **J** Estimated Result
- **U** Result Below Detection Limit

**Materials**

- Higher Permeability (typically >10 ft/day): Sand and sand & gravel
- Medium Permeability (typically 1-10 ft/day): Mixture of sand, silt, and/or some clay
- Lower Permeability (typically <1 ft/day): Clay and silt & clay

Hydrostratigraphic units were interpreted from lithology information of boring logs and slug test results.

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***Middle River, Maryland***

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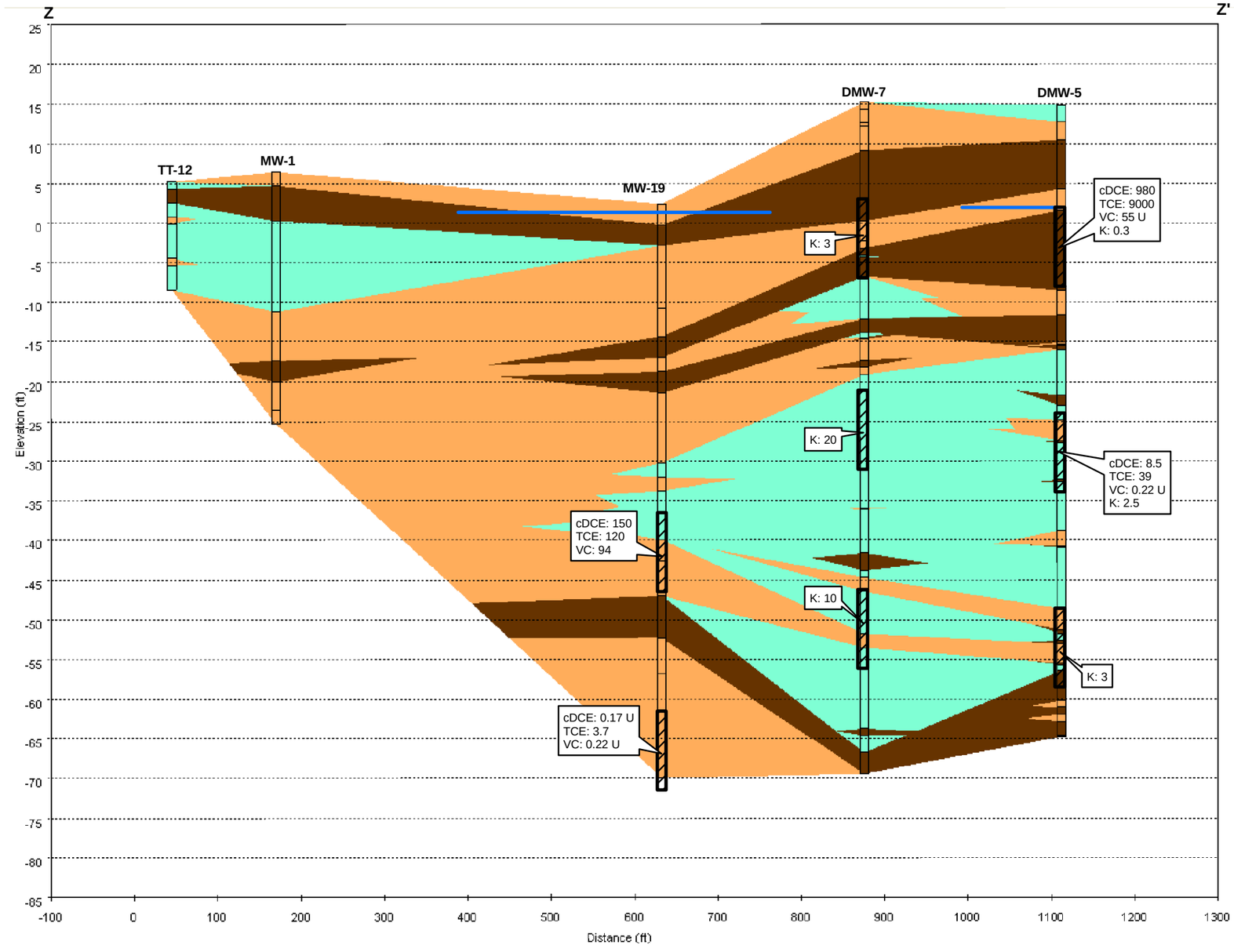


**Figure 4-14**
**Hydrostratigraphic Cross Section**
**Transect Z-Z'**

## Legend

- Well Screen
- Soil / Well Boring
- Groundwater Surface
- **K** Hydraulic Conductivity (ft/day)

**September 2009 Sampling Results**

- **cDCE** cis-1,2-Dichloroethene Concentration (ug/L)
- **TCE** Trichloroethene Concentration (ug/L)
- **VC** Vinyl Chloride Concentration (ug/L)
- **J** Estimated Result
- **U** Result Below Detection Limit

**Materials**

- Higher Permeability (typically >10 ft/day): Sand and sand & gravel
- Medium Permeability (typically 1-10 ft/day): Mixture of sand, silt, and/or some clay
- Lower Permeability (typically <1 ft/day): Clay and silt & clay

Hydrostratigraphic units were interpreted from lithology information of boring logs and slug test results.

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# APPENDIX C
# CALCULATIONS OF CONTAMINATED MEDIA QUANTITIES

# GROUNDWATER

LOCKHEED MARTIN
MARTIN STATE AIRPORT
DRA SITE FS
CONTAMINATED GROUNDWATER VOLUME AND CONTAMINANT MASS (FROM GW MODEL)
2/10/10

Volume of contaminated groundwater contaminated by each COC. The largest value was used in the text. These volumes over lap and are not additive.

Based on 5 ppb contour.

| Compound | Initial Volume (ft3) |
|---|---|
| TCE | 2.8E+07 |
| DCE | 2.0E+07 |
| VC | 2.3E+07 |
| 1,4 Dioxane | 1.8E+07 |

Mass of contaminants, based on 5 ppb contour. 2009 data.

| Compound | Initial Mass (lbs) |
|---|---|
| TCE | 6.35E+03 |
| DCE | 3.28E+03 |
| VC | 5.84E+03 |
| 1,4 Dioxane | 2.75E+02 |

| Time (Year) | TCE Total Mass (lbs) | | | | | |
|---|---|---|---|---|---|---|
| | No Further Action | % dec. | Hydraulic Barrier Pumping Wells | % dec. | High Conc. and Hydraulic Barrier Pumping Wells | % dec. |
| 0 | 6352 | | 6352 | | 6352 | |
| 10 | 5938 | 6.5 | 4621 | 27.2 | 4279 | 32.6 |
| 20 | 5598 | 11.9 | 3442 | 45.8 | 3138 | 50.6 |
| 30 | 5249 | 17.4 | 2703 | 57.4 | 2410 | 62.1 |

Notes:

1. TCE Half Life = 5.9 yr
2. TCE Retardation Factor is 6.9

# APPENDIX D
# SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS

# Screening of Technologies and Process Options

Information regarding identification, screening, and evaluation of the potential technologies and process options that may be applicable to the remedial alternatives for impacted groundwater in the Dump Road Area (DRA) Site are provided in this section. The primary objective of this phase of the Groundwater Feasibility Study (FS) is to develop an appropriate range of remedial technologies and process options to be used for developing the remedial alternatives. This includes the completion of the following analytical steps:

- Identification and screening of remedial technologies and process options
- Evaluation and selection of representative process options

A variety of technologies and process options are identified under each general response action (GRA) and screened. The screening is first conducted at a preliminary level to focus on relevant technologies and process options, and then the screening is conducted at a more detailed level based on certain evaluation criteria. Finally, process options are selected to represent the technologies that have passed the detailed evaluation and screening.

The evaluation criteria for detailed screening of technologies and process options that have been retained after the preliminary level screening are effectiveness, implementability, and cost. The following are descriptions of these evaluation criteria:

- Effectiveness
    - Protection of human health and the environment; reduction in toxicity, mobility, or volume; and permanence of the solution.
    - Ability of the technology to address the estimated areas or volumes of the contaminated media.
    - Ability of the technology to attain the preliminary remediation goals (PRGs) required to achieve the remedial action objectives (RAOs).

- Technical reliability (innovative versus well-proven) with respect to contaminants and site conditions.

- Implementability
  - Overall technical feasibility at the site.
  - Availability of vendors, mobile units, storage and disposal services, etc.
  - Administrative feasibility.
  - Special long-term maintenance and operation requirements.
- Cost (Qualitative)
  - Capital cost.
  - Operation and maintenance (O&M) costs.

## D.1 PRELIMINARY SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS

The results of the identification and screening of remediation technologies and process options for groundwater at a preliminary stage based on implementation with respect to site-specific conditions and chemicals of concern (COCs) are provided in this section. The results of this preliminary screening process are summarized in Table 3-1. It presents the GRAs, identifies the technologies and process options, and provides a brief description of each process option followed by comments about the results of the screening process.

The following are the groundwater technologies and process options remaining for detailed screening.

| General Response Action | Technology | Process Options |
|---|---|---|
| No Action | None | Not applicable |
| Limited Action | Land Use Controls (LUCs) | Groundwater use restrictions, construction restrictions |
| | Monitoring | Sampling and analysis |
| | Monitored Natural Attenuation | Sampling and analysis |

| General Response Action | Technology | Process Options |
|---|---|---|
| Containment | Vertical Barrier (Physical) | Cut-Off Walls, Grout Curtain, Sheet Piling |
| | Vertical Barrier (Hydraulic) | Extraction Wells |
| Removal | Groundwater Extraction | Extraction Wells |
| In-Situ Treatment | Biological | Enhanced bioremediation with an electron-donor compound |
| | Chemical | Permeable reactive barrier with zero-valent iron |
| Ex-Situ Treatment | Physical | Filtration |
| | | Air stripping |
| | | Liquid-phase granular activated carbon (GAC) adsorption |
| | | Vapor-phase GAC adsorption |
| | | Vapor-phase potassium permanganate impregnated zeolite adsorption |
| | | Sedimentation |
| | Chemical | Coagulation/Flocculation |
| | | Neutralization/pH adjustment |
| | | Ion Exchange |
| | | Advanced Oxidation |
| Disposal | Surface Discharge | Direct surface water discharge |
| | | Indirect discharge to publicly owned treatment works (POTW) |
| | Subsurface Discharge | Reinjection |

## D.2 DETAILED SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS

### D.2.1 No Action

Because the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process is being used in this evaluation, the No Action alternative is being considered. No Action consists of maintaining the status quo at the site. The No Action

alternative is carried through the Groundwater FS to provide a baseline for comparison with other alternatives and their effectiveness in mitigating risks posed by site contaminants.

Effectiveness

No Action would not be effective in meeting the RAOs. Potential contaminant reduction through natural attenuation could not be evaluated, and off-site migration would not be monitored.

Implementability

There would be no implementability concerns because no action would be implemented.

Cost

There would be no costs associated with the No Action alternative.

Conclusion

No Action is retained because of National Oil and Hazardous Substances Pollution Contingency Plan (NCP) requirements, although it would not be effective.

### D.2.2 Limited Action

The technologies considered under this GRA are LUCs, monitoring, and natural attenuation.

#### D.2.2.1 Land Use Controls

Land use controls (LUCs) would be developed through the implementation of a LUC Remedial Design (RD) to prevent the site and groundwater from being used in the future for purposes that are not consistent with the residual risk after implementation of the final remedy. Deed restrictions would be required to prevent the land from being developed and the groundwater from being used for potable purposes. Signage would be required to indicate the restrictions identified in the LUCs and to show the boundaries of the contamination. Environmental LUCs would be developed to meet the groundwater RAOs. Because the site is an airport, access is severely restricted.

Note that because of the presence of elevated concentrations of volatile organic compounds (VOCs) in groundwater, LUCs that place restrictions on construction of buildings over the plume would also be required. The restrictions would require special construction methods such as vented foundations for buildings to control vapor intrusion.

Effectiveness

Groundwater use restrictions would be effective in combination with source control activities. These controls would minimize potential human health risks associated with exposure to contaminated groundwater. Routine site inspections would be required to confirm that LUCs are being followed. Because of the long time required for natural attenuation and the potential for off-site migration, a LUCs-only alternative would not be feasible.

Implementability

Land use controls would be readily implementable. Resources are readily available for the preparation of deed restrictions.

Cost

Costs of LUCs would be low.

Conclusion

Land use controls are retained in combination with other process options for the development of groundwater remedial alternatives.

#### D.2.2.2 Monitoring

Sampling and analysis of groundwater would be used to evaluate migration of COCs. Monitoring would also be used to monitor potential natural attenuation or the progress of active groundwater remediation.

Effectiveness

Monitoring would not of itself reduce the toxicity, mobility, or volume of COCs in groundwater, but it would allow the observation and evaluation of potential migration of COCs and the reductions in their concentrations through natural attenuation or active remediation.

Implementability

A groundwater monitoring program could be readily implemented and is routinely performed at other sites. Monitoring well installation would need to comply with state and local regulations.

Cost

Capital and O&M costs of monitoring would be low.

Conclusion

Monitoring is retained in combination with other process options for the development of groundwater remedial alternatives.

### D.2.2.3 Monitored Natural Attenuation

Monitored natural attenuation (MNA) would consist of monitoring groundwater quality to determine the extent to which naturally occurring processes such as biodegradation, abiotic transformation, dispersion, and dilution would reduce concentrations of COCs over time. For this purpose, new monitoring wells would be installed. In the chlorinated volatile organic compound (cVOC) plume, samples from new and existing wells would be regularly collected and analyzed for natural attenuation parameters such as oxidation-reduction potential (ORP), dissolved oxygen (DO), pH, alkalinity, temperature, conductivity, total organic carbon (TOC), ferrous and total iron, sulfur compounds (sulfide and sulfate), nitrogen compounds (nitrite and nitrate), orthophosphate, chloride, and metabolic gases (methane, ethane, ethene, and carbon dioxide), as well as for the cVOCs themselves.

Natural attenuation processes may also affect concentrations of inorganic contaminants. Dispersion and dilution would reduce concentrations over time. As metals migrate to zones with different geochemistry, metals may precipitate or sorb onto soil particles.

In the 2009 annual sampling event (Tetra Tech, 2010a), groundwater samples were collected from six wells and analyzed to evaluate whether anaerobic reductive dechlorination of cVOCs was occurring at the site and whether site conditions could be enhanced by adding electron-donor and/or pH adjustment to stimulate anaerobic reductive dechlorination. Evidence indicated that slow or incomplete reductive dechlorination of lower order cVOCs may be occurring in the lower surficial aquifer zone.

Effectiveness

Naturally occurring processes could reduce low concentrations of trichloroethene (TCE) and other organic contaminants in groundwater over the long term. Based on the results of samples collected during previous investigations, natural anaerobic reductive dechlorination is occurring at the site but not to a significant degree. Monitored natural attenuation may be applied at the fringe area of a plume where concentrations are low and suspected source areas are controlled or no longer migrating toward this area. More typically, MNA is applied after suspected source areas have been removed and residual cVOC groundwater concentrations are less than 100 µg/l.

Groundwater monitoring would provide an effective means of evaluating the concentrations of COCs in groundwater and of assessing the rate of decrease of these concentrations. Monitoring of indicator parameters would be used to evaluate the potential effectiveness of the reductive dechlorination process.

Implementability

Monitored natural attenuation would be easy to implement. Monitoring groundwater quality and periodically reviewing site conditions could readily be performed, and the necessary resources are available to provide these services.

Cost

Capital and O&M costs for MNA would be low.

Conclusion

Because of the relatively high concentrations of COCs, MNA is not anticipated to be effective and will not be a significant component for any of the alternatives. Changes in contaminant concentrations and the effects of natural attenuation will be observed coincidentally as part of the long-term monitoring program for the site. Monitored natural attenuation is eliminated as a specific process option for the development of groundwater remedial alternatives.

### D.2.3 Containment

The only technologies retained for this GRA are physical vertical barriers and hydraulic barriers.

#### D.2.3.1 Physical Barriers

Low permeability vertical barriers include cut-off walls, grout curtains, and sheet piles that are used to minimize the horizontal migration of contaminants, especially in the saturated zone. These barriers are placed around wastes or contaminated areas. Low permeability vertical barriers extend from the ground surface to at least the bottom depth of the contamination or to the confining layer of the aquifer. The type of barrier selected depends on site-specific conditions. To be most effective, a barrier generally needs to be "keyed" 2 to 3 feet into a low permeability layer, such as clay or bedrock.

Conventional cut-off walls are most often constructed using the slurry trenching method. This is a two-step process. First, a hydraulic excavator or clamshell excavates soil, forming a trench with sidewalls supported by the weight of a bentonite slurry. Excavated or imported soil with low permeability is then mixed with bentonite slurry outside of the trench to form a low permeability soil/bentonite mixture to be used in the trench as backfill material. The soil/bentonite backfill is typically pushed into the bentonite slurry filled trench to displace the bentonite slurry thus forming the soil/bentonite vertical cut-off wall. Alternatively, Portland cement may be mixed with the bentonite slurry if a higher strength is required and greater permeability is acceptable. Walls are generally 2 to 4 feet thick and installed to depths of 50 feet or less with a hydraulic excavator and to depths greater than 50 feet with a clamshell.

Grout curtains are installed by pressure injection of grout composed of Portland cement and bentonite. The injection creates a column of grout and columns are injected side by side and overlapped or are spaced closely to create a continuous wall. Grout curtains can readily be installed to depths of 100 feet and depths of 200 feet have even been installed. Grout curtains may be installed by methods such as deep soil mixing using augers and pressure grouting.

Sheet piling of steel or plastic can be installed by driving or vibrating methods, depending on the soil conditions. Individual sheets have interlocking joints on each side that fit into the adjoining sheet. The joints are sealed with hydrophilic rubber, grout, or polymer, but are subject to leakage. Steel sheet pile is subject to corrosion. The maximum sheet piling installation depth is 70 to 80 feet.

Effectiveness

The use of low permeability vertical barriers is effective in controlling the horizontal migration of contaminants. Cut-off walls are more commonly used than grout curtains and sheet piling. The geotechnical properties of the backfill material must be considered in the design of a physical barrier. Barriers are most effective when keyed into a confining layer. The required service life of the barrier must be considered during design. Long service lives will require a thicker or lower permeability barrier.

Although the barrier prevents migration of contaminants, additional technologies are usually required to treat the groundwater behind the barrier and maintain the groundwater level to minimize the gradient across the barrier.

Implementability

The use of low permeability vertical barriers could cause an increase in groundwater elevations upgradient of the barrier. Maintenance of the integrity of low permeability vertical barriers is difficult over the long term, and groundwater monitoring may be required to ensure that the barrier remains effective. An excessive depth to the confining layer may cause problems with constructability. The depth to the Arundel clay varies from 80 to 100 feet. This depth is greater than the typical maximum depth for cut-off walls constructed using hydraulic excavators and

may exceed the limit for driven sheet piles. Specialty equipment such as a clamshell may be required for construction of a low permeability barrier installed to this depth.

Because of high concentrations of COCs in the groundwater in the vicinity of a proposed barrier, some of the excavated soil and groundwater could be classified as Toxicity Characteristic Leaching Procedure (TCLP) hazardous waste, which would require managing the waste according to hazardous waste regulations.

Cost

A physical barrier was modeled to evaluate the level of groundwater extraction that would be required compared to the level of groundwater extraction needed for a hydraulic barrier (see Section D.2.3.2). The model results show that the pumping rate would be similar to the rate needed for a hydraulic barrier, and a groundwater treatment system would be essentially the same size for both cases. Thus, the cost of a physical barrier alternative would be much higher than the cost of a similar hydraulic barrier alternative because of the additional cost of the physical barrier. The groundwater model results are included in Appendix B.

The costs are high for cut-off walls, sheet piling, and grout curtains. Long-term O&M costs are low.

Conclusion

Cut-off walls, grout curtains, and sheet piles will be eliminated primarily because they would not be effective as there is no cost benefit for a physical barrier compared to a hydraulic barrier. In addition, sheet piles may not be implementable to the presumed installation depth due to subsurface obstructions, such as buried debris.

### D.2.3.2 Hydraulic Barrier

Hydraulic barriers use groundwater extraction composed of a series of wells that are used to intercept and extract contaminated groundwater at the leading edge of the plume. The wells used in the hydraulic capture system are designed and located to provide optimum efficiency in attaining hydraulic containment of the contaminant plume. Extraction wells are further described below in Section D.2.4.1.

Effectiveness

Groundwater extraction is a well-established and well-proven technology for the containment of groundwater contaminant plumes. This technology is reliable and minimal effects on human health and the environment would be expected during implementation. The extraction system and related components must be operated and maintained until the site groundwater contaminant concentrations have met PRGs. Modeling was conducted to determine the number, depth, and placement of monitoring wells (see Appendix B).

Although the hydraulic barrier prevents migration of contaminants, additional technologies are required to treat the extracted groundwater.

Implementability

This technology uses readily available equipment and techniques and has been widely used in remedial actions. Implementation of this technology would require long term operation and maintenance. Maintenance would require periodic replacement of mechanical components and well inspections. Local and state permits might be required for installation of additional extraction wells.

Concentrations of TCE and vinyl chloride are greater than the TCLP leachate criteria, so untreated groundwater must be managed as a hazardous waste. Treatment of groundwater in a system that conforms to the requirements of a Resource Conservation and Recovery Act (RCRA) wastewater treatment unit can also be performed to exclude the system from RCRA permitting requirements.

Cost

Capital and O&M costs for groundwater extraction would be moderate, depending on the extent of the contaminant plume and aquifer characteristics.

Conclusion

Plume containment through groundwater extraction is retained in combination with other process options for the development of remedial alternatives.

### D.2.4 Removal

The only technology and process option for groundwater removal considered under this GRA is groundwater extraction with wells.

#### D.2.4.1 Extraction Wells

Wells would be installed in the surficial aquifer and screened below the water table to access the groundwater. Pumping would be used to extract the water as it collects in the wells and bring it to the surface. The process of extraction would create a hydraulic gradient that would induce flow of groundwater into the well. For hydraulic containment, extraction wells would be placed in the path of migration of a contaminant plume to intercept and contain the plume. Extraction wells placed within the contaminated plume could be used to clean the aquifer by removing the contaminated groundwater and flushing the saturated zone. The flushing action would occur when water from upgradient (clean) areas (or from reinjection) replaces the extracted contaminated groundwater and causes more contaminants to desorb from saturated zone soil. Thus, theoretically, the saturated zone soil would progressively lose contaminants until the concentrations in groundwater are at acceptable levels. The selection of the appropriate well system depends on the depth of contamination and the hydrologic and geologic characteristics of the aquifer.

Vertical extraction wells are commonly used. Wells are screened within the contaminated zone, and multiple wells are installed to capture or intercept the plume. The number of wells needed to capture or intercept a plume is a function of the characteristics of the aquifer, such as hydraulic conductivity, aquifer thickness, and the width of the plume.

Horizontal wells can also be installed through the contaminated zone to capture or intercept the plume. A single, long horizontal well can often be used to capture or intercept a plume. Horizontal wells are often used where surface structures, such as buildings or roads prevent the installation of vertical wells. As with vertical wells, the effectiveness of a horizontal well depends on the characteristics of the aquifer.

Extraction pumps are typically submersible, electrically operated, centrifugal pumps or pneumatically operated ejector pumps. For shallow groundwater extraction (depths up to 10

feet), surface pumps may be used. Centrifugal pumps are not practical for use at low extraction rates, less than 1 gallon per minute (gpm), and in such cases, pneumatic ejector pumps are preferred.

Effectiveness

Extraction wells could be effective for intercepting and containing the migration of contaminant plumes and extracting the groundwater from the high concentration areas such as the plumes at the DRA Site. The locations and screening depths of the wells are important criteria that must be taken into consideration in achieving adequate capture of the contaminant plume. Extraction wells are a well-established and well-proven technology for the removal of contaminated groundwater and the containment of groundwater contaminant plumes. Although the initial effectiveness of this technology for contaminant mass capture is high, it has often been shown to decrease over time. This decrease is generally due to one or more factors, including the presence of preferential flow pathways due to aquifer heterogeneity, contaminant adsorption to aquifer materials, diffusion of contaminants into the pore spaces of low permeability materials, and creation of stagnation zones due to pumping operations. This technology is reliable, and minimal effects on human health and the environment would be expected during implementation.

The concentrations of contaminants in groundwater in plumes being treated with extraction systems often reach a steady-state concentration greater than the target goal, typically a Maximum Contaminant Level (MCL).

Because horizontal wells consist of one long continuous screen, variations in permeability of the aquifer cannot be easily accommodated. Because horizontal wells are generally parallel to bedding planes, they are less effective in heterogeneous formations. Conversely, with a line of vertical wells, the extraction rate from each well can be adjusted as needed to account for different contaminant concentrations and/or well yield.

Implementability

Vertical extraction wells are relatively easy to install, while horizontal wells are more difficult to install and require specialized equipment. Pumps are widely available for a variety of flow rates and aquifer conditions. Implementation of this technology would require long-term O&M. Well

screens would require regular inspection and well flushing to remove fine-grained material that may clog the wells. Pumps would also require regular preventive maintenance. Installation of extraction wells would need to comply with state and location regulations. Extracted groundwater would require treatment prior to disposal/discharge. Placement of vertical wells and piping may interfere with current or future site operations. Horizontal wells are less likely to interfere with future site use.

Concentrations of TCE and vinyl chloride are greater than the TCLP leachate criteria, so untreated groundwater must be handled as a hazardous waste.

Cost

The capital and O&M costs of extraction wells are low although the costs of the treatment plant are high, especially considering the variety of COCs and their differing treatment processes. The costs of horizontal wells are typically higher than the costs of vertical wells.

Conclusion

Because the groundwater plume will be contained, extraction wells are retained for the development of groundwater remedial alternatives. Due to the heterogeneity of the site, only vertical wells will be considered to accommodate potential differences in hydraulic conductivity and allow for changes in extraction rates. Multiple vertical extraction wells will also allow for variation in pumping, improving capture of groundwater with the highest levels of contamination.

### D.2.5 In-Situ Treatment

The technologies considered under this GRA are enhanced bioremediation of the high concentration areas (HCAs) and permeable reactive barriers (PRBs).

#### D.2.5.1 In-Situ Enhanced Bioremediation

In-situ enhanced bioremediation involves the use of microorganisms, primarily bacteria, actinomycetes, and fungi, to breakdown hazardous organic compounds into nontoxic or less toxic forms. In-situ enhanced bioremediation includes biostimulation and bioaugmentation.

Biostimulation consists of using an electron-donor compound to cause anaerobic reductive dechlorination or an oxygen-release compound (ORC®) to enhance aerobic processes and the growth of indigenous microorganisms and natural biodegradation processes. Anaerobic and aerobic processes can be applied in sequence, such as applying an anaerobic process in the source area and then promoting aerobic conditions downgradient. Bioaugmentation consists of using a bacterial culture to increase the naturally occurring microorganism population and to provide organisms specifically targeted to the degradation of COCs.

For the DRA Site, in-situ biostimulation would consist of an electron-donor compound such as a lactate or emulsified oil substrate (EOS) to enhance the anaerobic dechlorination of TCE and other cVOCs. The TCE can be transformed to ethene, carbon dioxide, chloride, and water through anaerobic biological process.

In-situ bioaugmentation could consist of injecting a specialized bacterial culture, such as *Dehalococcoides* (DHC), to enhance the dechlorination of TCE if indigenous microorganisms are not sufficient.

The electron-donor compound and/or bacterial culture would be injected into the VOC plumes using multiple direct push technology (DPT) injection points or permanent injection wells. Injection via DPT is simple to implement and can be used over large areas.

Effectiveness

Biostimulation with an electron-donor compound and bioaugmentation with the use of DHC are fairly well-proven technologies for the complete dechlorination of non-degraded chlorinated solvents (e.g., TCE) from groundwater. The effectiveness of these technologies, particularly in cases of very high contaminant concentrations, still typically needs to be demonstrated through site-specific treatability testing.

Implementability

In-situ enhanced bioremediation could be implemented at the DRA Site. Many qualified contractors would be available for the implementation of this technology. Because of the relatively large surface area and considerable plume depth, application of an electron-donor

compound and bacterial culture would best be accomplished through DPT injection. Placement of future injection points may interfere with future site uses.

Cost

Capital and O&M costs for in-situ enhanced bioremediation would be moderate to high.

Conclusion

In-situ enhanced bioremediation is retained in combination with other processes options for the development of groundwater remedial alternatives.

### D.2.5.2 Permeable Reactive Barriers

Permeable reactive barriers involve emplacement of reactive materials in the subsurface to intercept a contaminant plume, provide a flow path through the reactive media, and transform the contaminant(s) into environmentally acceptable forms in order to attain PRGs downgradient of the barrier. Barriers can be constructed with materials that remove contaminants through chemical reactions or with materials that promote degradation of organics through biological activity.

Permeable reactive barriers have been used to treat a wide range of groundwater contaminants, including cVOCs and non-cVOCs such as benzene, toluene, ethybenzene and xylenes (BTEX), and inorganics such as hexavalent chromium. Iron metal [zero valent-iron (ZVI)] is the most common reactive medium used in PRBs for the treatment of cVOCs such as TCE. For barriers that promote biological degradation, organic materials that provide electron donors for an extended period of time, such as mulch or emulsified oil, are used.

Permeable reactive barriers using ZVI are generally built in two basic configurations: funnel-and-gate and continuous. The funnel-and-gate PRB uses impermeable walls (sheet pilings, slurry walls, etc.) as a “funnel” to direct the contaminant plume into a “gate” containing the reactive media, whereas the continuous PRB completely intercepts the plume flow path with reactive media. Because PRBs are not designed to contain groundwater movement, but to intercept groundwater contaminants, the permeability of the reactive medium must be at least equal to or greater than the permeability of the surrounding aquifer to avoid diversion of the groundwater

flow path. This is particularly necessary with the funnel-and-gate design where the cross-section of the permeable zones is restricted. Because the emplacement of reactive material generally requires excavation, both types of PRBs have typically been limited to relatively shallow depths of approximately 50 feet bgs. However, the use of alternative technologies, such as slurry injection and hydrofracturing, may help to overcome some of these emplacement limitations.

For deep barrier emplacements, such as necessary at the DRA Site, PRBs using emulsified oil electron donor substrate would be installed using injection techniques. Emulsified oil substrate material must typically be replaced at intervals of 5 years, so if multiple injections are anticipated, then permanent injection wells must be installed. To provide good distribution of the substrate, injection well screen lengths are usually limited to 10 feet.

Placement of PRBs must consider both groundwater and contaminant velocity and lifespan of the reactive material in the PRB. For this site, a single PRB located near the banks of Frog Mortar Creek would be used. A ZVI PRB would need to be replaced at 15 year intervals, and the electron donor substrate barriers would need to be replaced at 5 year intervals. Because of the relatively slow plume velocity, approximately 55 to 460 years would be required for the contaminants to flow through the barriers (see Section 4.2.6 of the FS for additional details).

Effectiveness

A ZVI PRB would be effective for the in-situ treatment of TCE and other chlorinated organic compounds. Some metal removal may also occur. Petroleum hydrocarbons and 1,4-dioxane would not be affected by the ZVI. The barrier may plug over time; therefore, the duration of the effectiveness of the ZVI is difficult to predict.

An electron donor (ED) substrate PRB would be effective for the in-situ treatment of TCE and other chlorinated organic compounds, although the degradation of TCE to ethene may not be complete. Some metal removal is likely, primarily because of reducing conditions. Petroleum hydrocarbons and 1,4-dioxane would probably not be affected by the ED. Because of the slow groundwater velocity, multiple injections will be needed.

Implementability

Installation of a ZVI PRB would be difficult because of the depth of the aquifer to be treated. Installation methods would be similar to those for a physical barrier except that a biodegradable polymer would be used to stabilize the trench. A large quantity of waste material will be generated. Alternative methods of installations, such as high-pressure jetting or deep soil mixing may need to be considered. The number of competent contractors available to implement these specialized techniques would also be relatively limited.

Installation of an ED barrier would be simpler using conventional well installation techniques and slurry injection equipment. Multiple well clusters would be required to provide full depth coverage and ED distribution.

Once installed, the O&M requirements of PRBs would be minimal and would be essentially limited to the monitoring of groundwater quality to verify performance with routine inspections to verify continued integrity of the structure. However, periodic replacement of the ZVI and ED would be required.

Because of the high concentrations of COCs in the groundwater in the vicinity of a proposed barrier, some of the excavated soil and groundwater would be classified as TCLP hazardous waste and would have to be managed as a hazardous waste.

Cost

Capital cost of installation of deep PRBs would be high. O&M costs would be low.

Conclusion

Zero-valent iron PRBs are retained for the development of groundwater remedial alternatives. Because the TCE may not be completely degraded and there may be multiple injections required, ED PRBs are eliminated from further consideration.

### D.2.6 Ex-Situ Treatment

The technologies and process options considered under this GRA include filtration, air stripping, liquid-phase granular activated carbon (GAC) adsorption, vapor-phase GAC adsorption,

vapor phase potassium permanganate impregnated zeolite (PPZ), sedimentation, coagulation/flocculation, neutralization/pH adjustment, ion exchange, and advanced oxidation.

### D.2.6.1 Filtration

Filtration uses a porous medium to remove solid particles from a liquid or gas. This technology is generally used as a groundwater pretreatment to remove suspended material before other treatment processes and/or for the final cleaning or polishing of treated effluent to remove metals that are sorbed to suspended solids.

Liquid filtration may be accomplished by numerous methods including screens, fibrous fabrics (paper or cloth), or beds of granular material such as sand. Flow through a filter can be enhanced by pressure on the inlet side or by drawing a vacuum on the filter outlet.

Most types of liquid filters, except those utilizing disposable filter elements (such as cartridge filters), require periodic cleaning to remove suspended solids accumulated in the filter medium and to restore filtration efficiency. This cleaning is typically performed with a countercurrent of water or backwash, which carries away the solids retained on the filter medium. Disposable filters would be disposed at an off-site landfill.

Effectiveness

Filtration is a very well-proven technology for the removal of fines from groundwater that might otherwise undermine the efficiency of downstream treatment technologies such as liquid-phase GAC adsorption and for meeting low cleanup goals that could be affected by metals concentrations associated with suspended solids.

Implementability

Filtration would be readily implementable. Treatment systems are commercially available from a wide variety of manufacturers and can be readily ordered to almost any specification. Liquid or solid residues resulting from periodic cleaning or replacement of the filter medium would have to be properly disposed.

Cost

The capital and O&M costs for filtration would be low.

Conclusion

Filtration is retained for the development of groundwater remedial alternatives in combination with other process options for the development of groundwater remedial alternatives.

### D.2.6.2 Air Stripping

Air stripping is an aeration process that promotes the transfer of VOCs from the aqueous phase to the gas phase. Air stripping is typically most effective for the removal of VOCs with a Henry's Law constant greater than or equal to 3.0 atmosphere-liter per mole (atm-L/mole), such as TCE. Removal efficiencies of VOCs typically exceed 99 percent depending on the operating parameters and the physical properties of the organic contaminants. However, air stripping is not very effective for the removal of 1,4-dioxane.

A countercurrent packed tower or tray tower is the most commonly used air stripping configuration. Water is distributed over the top of the unit while air is forced upward through the bottom. In packed towers, loosely fitted packing material serves to increase the air/water interface area to provide maximum mass transfer. In tray towers, water flows down through a tower equipped with perforated trays that allow air to pass upward through the water. Key factors that influence process performance include air-to-water ratio, height of packing and type of packing material, number of trays, operating temperature, surface hydraulic loading, and contact time.

Effectiveness

Air stripping is a well-proven and reliable technology that would be effective for removing TCE and other VOCs from the DRA Site groundwater, but 1,4-dioxane and metals cannot be removed by this process. Removal efficiencies greater than 99 percent could theoretically be achieved for the cVOCs. Because air stripping only removes the contaminants from the water and concentrates them in an exhaust gas, this gas would have to be further treated to meet air

discharge regulations prior to release to the atmosphere by such means as vapor-phase GAC adsorption, catalytic oxidation, or thermal destruction.

Implementability

Air stripping would be readily implementable. There are a significant number of vendors that provide air stripping equipment.

A maintenance problem commonly associated with air stripping is the channeling of flow resulting from clogging in the packing material. Typical causes of clogging include suspended solids, and iron concentrations, and slightly soluble salts such as calcium carbonate.

Cost

Capital cost for air stripping would be low. O&M costs would be low to moderate depending on influent contaminant concentrations and the degree of removal required.

Conclusion

Air stripping is retained for the development of groundwater remedial alternatives in combination with other process options for the development of groundwater remedial alternatives. Because 1,4-dioxane is not removed by air stripping, an additional process would be needed.

### D.2.6.3 Liquid-Phase Granular Activated Carbon Adsorption

Granular activated carbon is a frequently applied technology for the removal of contaminants from water. Liquid-phase GAC adsorption is principally used for removal of organic compounds and is more effective for less polar and less soluble compounds. Liquid-phase GAC adsorption involves the physical attraction of organic solute molecules to exchange sites on the internal pore surface areas of specially treated (activated) carbon grains. As the contaminated groundwater passes through one or more vessels containing GAC, contaminants are captured on the active sites of the carbon grains and eventually occupy all of these sites. The spent GAC must then either be regenerated or disposed.

Typical GAC adsorption treatment systems include atmospheric or pressurized columns operating in series and/or parallel configuration. Liquid-phase GAC columns are typically designed with backwashing capability to minimize solids fouling that would increase GAC replacement frequency. Factors such as pH and temperature of the influent, empty bed contact time (EBCT), surface area to volume ratio of the activated carbon, and solubility of the organic compound will affect the carbon adsorption process.

Effectiveness

Liquid-phase GAC adsorption is a well-proven reliable technology that would be effective for removing of many organic compounds, including TCE. However, GAC does not effectively remove 1,4-dioxane. Treatability testing might be required to confirm GAC adsorption efficiency. Because of the relatively high costs of GAC replacement, a preceding process, such as air stripping or advanced oxidation, is typically used to remove cVOCs to a very low level, so GAC would be used as a polishing step.

Implementability

Liquid-phase GAC adsorption would be readily implementable. Treatment systems are commercially available from a wide variety of manufacturers and can be readily ordered to almost any specification. There are a sufficient number of qualified vendors that provide GAC adsorption units. As previously mentioned, it is anticipated that pretreatment with filtration would be required. As it becomes saturated, GAC would have to be periodically replaced, and the spent GAC would have to be disposed. Treatability testing might be required to determine the anticipated frequency of GAC replacement.

Cost

The capital cost for liquid-phase GAC adsorption would be low, and O&M costs would be moderate to high based on expected GAC consumption.

Conclusion

Liquid-phase GAC adsorption is retained for the development of groundwater remedial alternatives, in combination with other process options.

### D.2.6.4 Vapor-Phase Granular Activated Carbon Adsorption

Granular activated carbon adsorption is a frequently applied technology for the removal of contaminants from air. The GAC process adsorbs most organic compounds to some extent but is more effective for the less polar and less soluble compounds. Granular activated carbon adsorption involves the physical attraction of organic solute molecules to exchange sites on the internal pore surface areas of the specially treated (activated) carbon grains. As the contaminated vapor passes through one or more vessels containing GAC, the organic molecules are captured on the active sites of the carbon grains and eventually occupy all of these sites. The exhausted GAC must then either be regenerated or disposed.

Typical GAC adsorption treatment systems include atmospheric columns operating in series and/or parallel configuration. Factors such as temperature and relative humidity of the inlet stream, EBCT, and surface area to volume ratio of the activated carbon will affect the carbon adsorption process.

Effectiveness

Vapor-phase GAC adsorption is a well-proven reliable technology that would be effective for removing most of the COCs from the off-gas from the air stripper to meet the requirements of air discharge regulations. Removal efficiency exceeding 99 percent is possible depending on the compound and system operating parameters such as retention time. However, vinyl chloride is poorly sorbed by GAC.

Implementability

Granular activated carbon adsorption would be readily implementable. There are a sufficient number of qualified vendors that provide vapor-phase GAC adsorption units.

Spent GAC containing concentrated organic contaminants would have to be regenerated, incinerated, or disposed in a hazardous waste landfill. Thermal, steam, and solvent treatments are the most common types of GAC regeneration technologies, and these are typically conducted off-site.

Cost

Capital cost for GAC adsorption would be low and O&M costs would range from moderate to high, depending on the carbon usage rate, which is a function of influent contaminant concentration.

Conclusion

Because air stripping has been retained as a process option, vapor-phase GAC adsorption is also retained for the development of groundwater remedial alternatives.

### D.2.6.5 Potassium Permanganate Impregnated Zeolite

Because GAC is not very effective in removing vinyl chloride from air, PPZ can be used. Potassium permanganate impregnated zeolite is effective in the removal of vinyl chloride and other chlorinated ethenes.

As the contaminated vapor passes through one or more vessels containing PPZ, the cVOCs are oxidized by the potassium permanganate. After all potassium permanganate is consumed, the zeolite must then be disposed as a hazardous waste and replaced with new PPZ. Typical PPZ adsorption treatment systems operate in series and/or parallel configurations.

Effectiveness

Treatment of vapor streams contaminated with VOCs with PPZ is a relatively recent technology, although it is well established for other industries. Potassium permanganate impregnated zeolite would be effective for removing most of the vinyl chloride from the off-gas from the air stripper to meet the requirements of air discharge regulations. Removal efficiency exceeding 95 percent is possible.

Implementability

Potassium permanganate impregnated zeolite adsorption would be readily implementable. There are a sufficient number of qualified vendors that provide vapor-phase PPZ adsorption units.

Spent PPZ would have to be disposed in a non-hazardous waste landfill. Unlike GAC, PPZ cannot be regenerated.

Cost

Capital cost for PPZ adsorption would be moderate and O&M costs would range from moderate to high, depending on the PPZ rate, which is a function of influent contaminant concentration.

Conclusion

Because air stripping has been retained as a process option, PPZ adsorption is also retained for the development of groundwater remedial alternatives.

### D.2.6.6 Neutralization/pH Adjustment

Neutralization/pH adjustment is a process for achieving appropriate pH levels for removal of contaminants, primarily metals. This is generally accomplished by adding acidic compounds to balance alkaline solutions or vice versa.

Effectiveness

Neutralization/pH adjustment is generally effective for the removal of certain contaminants, mostly inorganics, by bringing them out of solution. For the DRA Site, neutralization/pH adjustment would not of itself be effective for the removal of all COCs in groundwater. However, this technology might be required prior to discharge of treated groundwater, or in advance of certain other treatment technologies, to prevent fouling or to improve treatment effectiveness.

Implementability

Neutralization/pH adjustment would be readily implementable. This technology is widely used, and numerous qualified equipment vendors and contractors offer these types of equipment and services. There can be safety issues associated with storing and handling pH adjustment compounds.

Cost

Capital and O&M costs for neutralization/pH adjustment would be low.

Conclusion

Neutralization/pH adjustment is retained because of high metals concentrations in the groundwater that must be removed prior to further treatment and discharge. This process would be used in combination with other treatment process options.

### D.2.6.7 Coagulation/Flocculation and Sedimentation

Coagulation/flocculation is a process that consists of adding certain chemical reagents that result in the agglomeration of small suspended solids particles into larger ones, thus increasing significantly the effectiveness of sedimentation. This step is typically applied after chemical precipitation.

Sedimentation is a process that removes the suspended solids from a liquid by producing quiescent hydraulic conditions. This allows gravity to settle out the unstable solids from suspension. This technology may be used in conjunction with precipitation. Two slightly different sedimentation options are used including clarification (to typically produce a sludge that is 2 to 8 percent solids) and thickening (to typically further concentrate clarification sludges to 8 to 15 percent solids). Sludge would be further processed in a dewatering unit, such as a plate and frame filter press, so that the solids could be disposed off-site.

Effectiveness

Coagulation/flocculation and sedimentation would not of themselves be effective for the removal of COCs from groundwater at the DRA Site. However, these technologies would be effective for the removal of excessive concentrations of suspended solids (such as iron and manganese compounds) that would otherwise undermine the efficiency of COC removal technologies such as air stripping and GAC adsorption. Therefore, coagulation/flocculation is often required following a neutralization/pH adjustment step. Based on characterization of the groundwater, pretreatment would be required not only for iron and manganese removal, but also for the removal of other metals, such as cadmium.

Implementability

Coagulation/flocculation and sedimentation would be readily implementable. Numerous qualified equipment vendors and contractors offer this type of equipment and services.

Cost

Capital and O&M costs for coagulation/flocculation and sedimentation would be low.

Conclusion

Coagulation/flocculation and sedimentation are retained because of the high suspended solids concentrations from iron and manganese compounds (and other metals) that will be precipitated from the groundwater.

### D.2.6.8 Ion Exchange

Ion exchange would consist of pumping the groundwater to be treated through a bed of a special resin medium capable of capturing ions from the groundwater and exchanging these with the ions populating the active sites of the resin medium. There are two main categories of ion exchange resins, including cationic resins, with active sites populated with positive ions (cations), and anionic resins, with active sites populated with negative ions (anions). Ion exchange is capable of reducing metals concentrations to very low levels that may be required for a discharge to Frog Mortar Creek and meeting MCLs of certain metals, such as cadmium, prior to reinjection.

Cationic resins are most often used with either sodium ($Na^+$) or hydrogen ($H^+$) ions populating their active sites. Anionic resins are most often used with either chloride ($Cl^-$) or hydroxyl ($OH^-$) ions populating their active sites. Once most of the original ions on the active sites have been replaced with those captured from the groundwater being treated, the ion exchange resin is said to be saturated and is temporarily taken out of service for regeneration. This regeneration consists of flushing the resin with a concentrated solution of the original ion to reverse the exchange process and repopulate the active sites with this original ion. Typically, cationic resins are regenerated with either sodium chloride, if operating in the sodium cycle, or sulfuric or hydrochloric acid, if operating in the hydrogen cycle. Anionic resins are regenerated with sodium chloride, if operating in the chloride cycle, or with caustic soda (sodium hydroxide), if operating

in the hydroxyl cycle. The regeneration process generates a waste brine residue that contains the ions removed from the treated groundwater and a surplus of the regenerating ions. This waste brine must be neutralized and undergo some form of treatment, such as evaporation, prior to disposal. Ion exchange resins can be regenerated on-site or off-site.

Effectiveness

Ion exchange is a well-proven process for the removal of inorganic compounds down to extremely low concentrations that may be required for surface water discharge or re-injection to the groundwater.

Implementability

Ion exchange would be simple to implement. Treatability testing would be required to verify that metals can be removed down to surface discharge limits and MCLs. The resources, equipment, and materials necessary for such an implementation are readily available. Typical ion exchange systems are fully automatic and require minimum operating supervision. Maintenance requirements would consist of routine inspection of the resin bed and periodic replacement of damaged or lost resin. Since suspended solids interfere with the performance of most ion exchange resins, pretreatment would most likely be required.

As previously mentioned, the ion exchange units would have to be regularly regenerated with sodium chloride brine or an acid solution that would generate a waste fluid requiring off-site disposal. Alternatively, resins can be regenerated off-site.

Cost

Capital and O&M costs for ion exchange would be high.

Conclusion

Ion exchange is retained in combination with other process options for the development of remedial alternatives.

### D.2.6.9 Advanced Oxidation

Advanced oxidation processes (AOPs) use a controlled combination of either ozone or hydrogen peroxide with ultraviolet (UV) light or UV light in the presence of a catalyst to induce photochemical oxidation of organic compounds. Ultraviolet radiation is electromagnetic (EM) energy with wavelengths that fall between those of visible light and X-ray radiation on the EM spectrum. Ultraviolet energy is capable of breaking down or rearranging a molecular structure, depending on the dissociation energies of the chemical bonds within the structure. The combination of ultraviolet radiation with ozone or hydrogen peroxide or in the presence of a catalyst results in the oxidation of organic contaminants at a rate many times faster than that obtained from applying UV light alone. An alternative process uses ozone and hydrogen peroxide without UV light to accomplish the destruction of organic chemicals.

A typical, continuous flow hydrogen peroxide/ozone and UV system consists of an oxygen or air source, an ozone generator or hydrogen peroxide feed system, a UV/oxidation reactor, and an ozone decomposer. Flow patterns and configurations are designed to maximize exposure of the wastewater to the UV radiation, which is supplied by an arrangement of UV lamps. Typical reactor designs range from mechanically agitated reactors to spray, packed, and tray type towers. If ozone is utilized, reactor gases are passed through a catalytic ozone decomposer that converts remaining ozone to oxygen and destroys any residual VOCs.

A catalytic process (Photo-Cat by Purifics, Inc.) consists of multiple UV lights in reactor tubes, through which the wastewater flows. The catalyzed process generates radicals that react with and oxidize contaminants. No chemicals are added in this process.

Similarly, an ozone-hydrogen peroxide system (such as HiPOx® by APTwater, Inc.) consists of an oxygen source, an ozone generator, a hydrogen peroxide feed system, a reactor, and an ozone decomposer. Flow patterns and configurations are designed to maximize exposure of the wastewater to the oxidizing chemicals. Reactor gases are passed through a catalytic ozone decomposer that converts remaining ozone to oxygen and destroys any residual VOCs.

Effectiveness

Advanced oxidation with hydrogen peroxide/ozone and/or UV technology has been proven effective for the destruction of halogenated organic compounds, benzene derivatives, various aliphatic hydrocarbons, and specifically, 1,4-dioxane. Removal effectiveness varies greatly depending on the contaminant of concern. For the DRA Site groundwater, chlorinated alkenes such as TCE, cis-1,2-DCE, and 1,4-dioxane, along with petroleum-related compounds would be readily destroyed.

Implementability

Advanced oxidation processes would be readily implementable. However, only a few vendors currently offer this technology. Recent improvements have been made by vendors of this technology to minimize energy usage and reduce UV lamp fouling problems. However, because of the high iron and manganese concentrations, systems using UV lights may have high maintenance requirements and costs. With this treatment, no toxics are emitted to the atmosphere or adsorbed onto media that require further treatment or disposal.

Cost

Capital costs of AOPs would be moderate to high. O&M costs vary significantly depending on flow rate, and contaminant type and concentration.

Conclusion

The advanced oxidation process with ozone and hydrogen peroxide is retained in combination with other process options for the development of remedial alternatives, primarily for the removal of 1,4-dioxane. Ultraviolet light systems have the propensity to foul, and require pretreatment for solids removal. For the purposes of this Groundwater FS, the HiPOx® system is described in the process descriptions, although other processes can be used.

### D.2.7 Disposal

The technologies and process options considered under this GRA includes surface water discharge, indirect discharge, and reinjection.

### D.2.7.1 Direct Surface Discharge

Direct surface discharge would consist of disposing of treated groundwater by discharging it directly to a surface water body such as Frog Mortar Creek. Because of distance, a discharge to another surface water body is not feasible. In addition, for the groundwater treatment system to qualify for the RCRA wastewater treatment unit exemption, a permitted direct (or indirect) discharge is necessary.

Because of the poor mixing in the tidal portion of Frog Mortar Creek, effluent limitations are expected to be very low, close to surface Water Quality Criteria (WQC), without significant dilution. Frog Mortar Creek is considered to be fresh water by Maryland Department of the Environment (MDE), so fresh water quality criteria would be considered. This portion of Frog Mortar Creek is tidal and not considered to be usable as a drinking water source, so human health WQC based on consumption of organisms only is applicable. Effluent limitations would need to be developed using a model acceptable to MDE and then model assumptions would need to be calibrated by field tests. Note that WQC for a few parameters (for example, cadmium) are less than MCLs, so additional treatment, such as ion exchange may be needed to meet the surface water effluent limitations compared to the groundwater cleanup goals. Table D-1 lists the contaminants and the corresponding WQC. To maximize mixing the discharge with the surface water, the discharge would likely be through a submerged diffuser along the bottom of Frog Mortar Creek.

Effectiveness

Direct surface discharge of treated groundwater would be an effective means of disposal. However, appropriate on-site treatment would be required prior to discharge to satisfy applicable water quality criteria and the requirements of a National Pollutant Discharge Elimination System (NPDES) permit.

Implementability

Direct surface discharge to Frog Mortar Creek would be easy to implement; however, achieving the stringent WQC will be more difficult. Because the DRA Site is in close proximity to the creek, transfer distances would be relatively short and it is likely that existing storm sewers

might be used for this purpose. In addition, the discharge would have to meet the requirements of an NPDES permit. Because of the relatively small drainage area of Frog Mortar Creek and the poor mixing typical of tidal portions of the creek, effluent limitations will probably be very stringent. A submerged, multiport diffuser would likely be needed for the discharge to meet effluent limitations. As noted above, effluent limitations would need to be calculated using a state-approved model, and the model would need to be field calibrated and verified.

Cost

The capital and O&M costs of direct surface discharge would be low.

Conclusion

Direct surface discharge is retained as a contingency for the development of groundwater remedial alternatives.

#### D.2.7.2 Indirect Discharge

This technology would consist of discharging the treated groundwater to a local publicly owned treatment works (POTW) where it would undergo either the full or incremental treatment required for discharge. In addition, for the groundwater treatment system to qualify for the RCRA wastewater treatment unit exemption, a permitted indirect (or direct) discharge is necessary. Local limits for the discharge to the POTW system are much less stringent than MCLs or surface water effluent limitations. The limitations for industrial discharges to the City of Baltimore POTW are summarized in Table D-2.

Effectiveness

Indirect discharge to a POTW would be an effective method of disposal of the treated groundwater. The POTW would provide the necessary polishing treatment for ultimate discharge to surface water.

Implementability

Although the POTW appears to have the capacity to handle the flow, the county sanitary sewer system may be unwilling to accept the flow. The sewer system is under a Consent Order with the United States Environmental Protection Agency (EPA)/Department of Justice (DOJ)/MDE regarding overflows from the sanitary system, and elimination of excess inflows and infiltration from the system. The sewer authority is trying to eliminate groundwater and rainwater from entering the sewers, and the addition of a relatively clean groundwater stream may be counterproductive to their goal. Thus, acceptance of the discharge by the sanitary sewer authority may need to be negotiated.

Cost

Capital and O&M costs for indirect discharge to a POTW would be moderate to high, depending on the distance to the sewer tie-in and the service and annual fees charged by the sewer authority to accept the treated water.

Conclusion

Indirect discharge is retained for further consideration although there may be significant administrative implementability issues. Because of uncertainties in estimating surface water discharge effluent limitations at this time, treated groundwater could be discharged to the POTW for the first few years of operation until flow rates, influent, and effluent quality are better characterized. Then, a surface water discharge permit can be obtained based on actual site operating data.

#### D.2.7.3 Reinjection

Reinjection consists of disposing treated groundwater back into the original aquifer from which it was removed through infiltration galleries or reinjection wells. Based on the relatively shallow groundwater table at the DRA Site, infiltration galleries may be an acceptable option. Reinjection may be used to improve contaminant remediation by creating artificial hydraulic gradients that direct groundwater toward extraction wells. Reinjection can be coupled with extraction wells to create a closed system in which pumping and injection rates balance one another. The groundwater would need to be treated to meet groundwater MCLs prior to injection. Other groundwater quality parameters, such as total dissolved solids concentration, must also be

considered. In addition, the groundwater can be amended with an electron donor prior to reinjection to promote in-situ reductive dechlorination.

Effectiveness

Reinjection via infiltration galleries or injection wells is an effective means of disposing of the volumes of water generated by a groundwater pumping/treatment system. Infiltration galleries offer the advantage of decreasing groundwater remediation time by increasing groundwater flow through the aquifer. The vertical infiltration of treated groundwater through the vadose zone will create elevated groundwater conditions (i.e., groundwater mounding) in the vicinity of the infiltration gallery, requiring detailed flow modeling to ensure that the design of the infiltration gallery can accommodate these changes to water levels within the aquifer. Injection well systems must be designed to minimize potential for clogging the wells and galleries with suspended solids. The effectiveness of reinjection depends on hydraulic conductivity, aquifer thickness, and hydraulic gradient/aquifer recharge rate. This method of disposal would require treatment of the water to meet groundwater MCLs for all contaminants.

Implementability

Installation of an infiltration gallery system or injection well system for underground injection is implementable using established procedures. Vendors and equipment for installation are commercially available. Reinjected water could potentially force contaminated groundwater into less-contaminated areas. Periodic groundwater monitoring would be needed to assess the impacts of reinjection. Infiltration galleries will require a larger area than injection wells. The placement of infiltration galleries, injection wells, and associated piping could restrict development and use of the site and complicate the soil FS yet to come.

Using reinjection as the sole method of groundwater disposal would eliminate exemption from permitting under RCRA as a wastewater treatment unit.

Cost

Costs for construction and O&M of a reinjection system would be low to moderate.

Conclusion

Reinjection (infiltration gallery or wells) is retained for the development of groundwater remedial alternatives, but only in conjunction with a permitted direct and/or indirect discharge. This process will be used in combination with other technologies such as extraction and ex-situ treatment.

## D.3 SELECTION OF REPRESENTATIVE TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER

The following technologies and process options, under the GRAs as noted, were retained for the development of groundwater containment remedial alternatives:

- No Action
- Limited Action: LUCs, Monitoring
- Containment: Hydraulic Barrier
- Removal: Extraction
- In-Situ Treatment: Enhanced Bioremediation, ZVI PRB
- Ex-Situ Treatment: Filtration, Air Stripping, Liquid-Phase GAC Adsorption, Vapor-Phase GAC Adsorption, Vapor-Phase PPZ Adsorption, Neutralization/pH Adjustment, Coagulation/Flocculation and Sedimentation, Ion Exchange, Advanced Oxidation
- Disposal: Indirect Discharge to POTW, Reinjection, Direct Discharge

The purpose of this FS is to evaluate containment of contaminated groundwater, which must consider the overall depth of the contaminated groundwater (approximately 90 feet) and wide variety of contaminants (for example, cVOCs, metals, and 1,4-dioxane). Therefore, the number of processes and technologies that can be applied is limited. The primary objective of containment is particularly limiting, and contaminant removal technologies that might be applied throughout the plume were not considered. All remediation technologies and processes will be revisited when the FS for the site-wide groundwater remedy is prepared.

**Table D-1**

**Water Quality Criteria**
**DRA Site Groundwater Feasibility Study**
**Lockheed Martin, Martin State Airport**
**Middle River, Maryland**


| Parameter | WQC Aquatic Life (ug/L) | WQC HH (ug/L) | MCL (ug/L) |
|---|---|---|---|
| **Organic Compounds** | | | |
| 1,1- Dichloroethene | - | 32 | 7 |
| 1,2-Dichloroethane | - | 370 | 5 |
| 1,2,4-Trichlorobenzene | - | 940 | 70 |
| 1,3,5-Trimethylbenzene | - | - | - |
| 1,4-Dioxane | - | - | - |
| Benzene | - | 510 | 5 |
| Chloroform | - | 4,700 | 80 (as TTHMs) |
| cis-1,2-Dichloroethene | - | - | 70 |
| Ethylbenzene | - | 29,000 | 700 |
| Naphthalene | - | - | - |
| Tetrachloroethene | - | 33 | 5 |
| Toluene | - | 200,000 | 1,000 |
| Trichloroethene | - | 300 | 5 |
| Vinyl chloride | - | 5,300 | 2 |
| Xylenes | - | - | 10,000 |
| **Inorganics** | | | |
| Arsenic | 150 | 41 | 10 |
| Barium | - | 2,000 (DW+O) | 2,000 |
| Beryllium | - | 4 (DW+O) | 4 |
| Cadmium | 0.25 | 5 (DW+O) | 5 |
| Chromium | -/ 74 / 11 | 100 (DW+O) | 100 |
| Copper | 9 | 1,300 (DW+O) | 1,300 (AL) |
| Iron | - | - | - |
| Mercury | 0.77 | - | 2 |

**Table D-1**

**Water Quality Criteria**
**DRA Site Groundwater Feasibility Study**
**Lockheed Martin, Martin State Airport**
**Middle River, Maryland**


| Parameter | WQC Aquatic Life (ug/L) | WQC HH (ug/L) | MCL (ug/L) |
|---|---|---|---|
| Manganese | - | - | - |
| Nickel | 52 | 4,600 | - |
| Lead | 2.5 | - | 15 (AL) |
| Selenium | 5 | 4,200 | 50 |
| Silver | 3.2 | - | - |
| Vanadium | - | - | - |
| Zinc | 120 | 26,000 | - |

WOC - Water Quality Criteria
WQC Aquatic life - fresh water, lowest of chronic and acute.
WQC HH - Human health, consumption of organisms only (unless noted).
DW+O - Human health, based on drinking water and consumption of organisms. No WQC for consumption of organisms only.
MCL - Maximum Contaminant Level
AL - Action Level
TTHMs - Total Trihalomethanes
For metals, dissolved metals are shown.
Max concentrations from June 2008 (Tetra Tech, 2008) and May 2009 (Tetra Tech, 2009) reports.
Mean Concentrations are from June 2008 (Tetra Tech, 2008).
For chromium, the WQC AL values are for total/III/VI
"-" indicates not criteria.

**Table D-2**

**Baltimore County Industrial Wastewater Discharge Standards**
**DRA Site Groundwater Feasibility Study**
**Lockheed Martin, Martin State Airport**
**Middle River, Maryland**

| Parameter | Limit (mg/L) |
|---|---|
| Cadmium | 0.21 |
| Chromium | 6.89 |
| Copper | 6.59 |
| Lead | 6.81 |
| Mercury | 0.01 |
| Nickel | 2.82 |
| Silver | 1.20 |
| Zinc | 17.85 |
| Fats, Oils, and Grease (FOG) | 100.0 |
| Total Petroleum Hydrocarbons | 100.0 |
| Total Toxic Organics | 2.13 |
| pH | 6.0 to 10.0 SU |

mg/L – milligram(s) per liter.
SU – Standard units.

# APPENDIX E
# PRELIMINARY DESIGN CALCULATIONS AND PROCESS DESCRIPTIONS

# APPENDIX E

# PRELIMINARY DESIGN CALCULATIONS AND PROCESS DESCRIPTIONS

# GROUNDWATER COMPOSITION DESIGN BASIS

| **Tetra Tech NUS** | | | *STANDARD CALCULATION SHEET* |
|---|---|---|---|
| CLIENT: Lockheed Martin – Martin State Airport – DRA Site FS | FILE No: | BY: JWL | PAGE: 1 of 1 |
| SUBJECT: Groundwater Treatment system – Design basis for untreated groundwater to treatment system | | CHECKED BY: | DATE: 2/1/10 |

The composition of the untreated groundwater to the treatment system was based on the locations of the extraction wells from the model. The composition was estimated based on the monitoring wells close to the proposed extraction wells. If an extraction well is near two monitoring wells, then the results of the two well will be averaged. See attached sketch.

| Extraction Well – Shallow | Monitoring wells |
|---|---|
| S1 | MW14S |
| S2 | MW14S + DMW18S |
| S3 | DMW18S + DMW3S |
| S4 | DMW2S + DMW3S |
| S5 | DMW2S + DMW4S |
| S6 | DWM4S + DMW5S |
| S7 | DWM5S |

| Extraction Well – intermediate | Monitoring wells |
|---|---|
| I1 | MW14I + DMW18I |
| I2 | DMW3I |
| I3 | DMW3I + DMW2A |
| I4 | DMW2A + DMW4I |
| I5 | DWM4I |

| Extraction Well – Deep | Monitoring wells |
|---|---|
| D1 | DMW18D + DMW3D |
| D2 | DMW3D + DMW2B |
| D3 | DMW2B + DMW4D |
| D4 | DMW4D |

**GROUNDWATER DESIGN BASIS - SECOND PUMPING SCHEME**
**DUMP ROAD SITE**
**LOCKHEED MARTIN - MARTIN STATE AIRPORT**
**MIDDLE RIVER, MARYLAND**


| **Extraction well No.** | S1 | | | | | | | I2 | | S3 | | D1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **LOCATION** | **14S** | **14I** | **14D** | **18S** | **18I** | **18D** | **3S** | **3I** | **3D** | **AVE 18S 3S** | **AVE** | **AVE 18D 3D** |
| **SAMPLE DATE** | | | | | | | | | | | | |
| SAMPLE ID | | | | | | | | | | | | |
| MATRIX | | | | | | | | | | | | |
| SAMPLE CODE | | | | | | | | | | | | |
| **Volatile Organics (ug/L)** | | | | | | | | | | | | |
| 1,1,1-TRICHLOROETHANE | 1 | 11 | 1 | 20 | 73 | 1 | 18 | 110 | 1 | 19 | 91.5 | 1 |
| 1,1-DICHLOROETHENE | 1 | 28 | 1 | 20 | 63 | 1 | 16 | 95 | 1 | 18 | 79 | 1 |
| 1,2,4-TRICHLOROBENZENE | 2 | 7.5 | 1 | 29 | 92 | 0.25 | 12 | 730 | 1 | 21 | 411 | 0.63 |
| 1,2-DICHLOROETHANE | 1 | 11 | 1 | 30 | 78 | 1 | 18 | 160 | 1 | 24 | 119 | 1 |
| BENZENE | 1 | 11 | 1 | 16 | 43 | 1 | 11 | 65 | 1 | 14 | 54 | 1 |
| BTEX | 0 | 11 | | | | | | 210 | 0.4 | | 210 | 0.4 |
| CHLOROBENZENE | 0.21 | 270 | 1 | 19 | 50 | 1 | 12 | 75 | 1 | 16 | 63 | 1 |
| CHLOROFORM | 1 | 8 | 1 | 3.7 | 53 | 0.58 | 13 | 100 | 0.49 | 8 | 77 | 0.5 |
| CIS-1,2-DICHLOROETHENE | 1 | 1700 | 1 | 370 | 1100 | 0.43 | 550 | 17000 | 1 | 460 | 9050 | 0.7 |
| METHYLENE CHLORIDE | 1 | 16 | 1 | 8.2 | 140 | 1 | 90 | 500 | 1 | 49 | 320 | 1 |
| NAPHTHALENE | 2 | 12 | 1 | 20 | 80 | 0.3 | 20 | 120 | 1 | 20 | 100 | 0.7 |
| TOLUENE | 0.42 | 6.5 | 1 | 16 | 43 | 1 | 11 | 210 | 0.4 | 14 | 127 | 0.7 |
| TOTAL CHLORINATED VOCS | 0 | 2750 | 0 | 4620 | 13750 | 7.33 | 4950 | 38800 | 0.97 | 4785 | 26275 | 4.2 |
| TRANS-1,2-DICHLOROETHENE | 1 | 12 | 1 | 20 | 63 | 1 | 200 | 95 | 1 | 110 | 79 | 1 |
| TRICHLOROETHENE | 1 | 50 | 1 | 4000 | 12000 | 6.9 | 14 | 18000 | 0.97 | 2007 | 15000 | 3.9 |
| VINYL CHLORIDE | 1 | 1000 | 1 | 250 | 650 | 1 | 4400 | 4300 | 1 | 2325 | 2475 | 1 |
| **Volatile Organics - SIM (ug/L)** | | | | | | | | | | | | |
| 1,4-DIOXANE | 0.59 | 130 | 0.33 | 150 | 350 | 1 | 480 | 1100 | 0.33 | 315 | 725 | 0.7 |
| **Petroleum Hydrocarbons (ug/L)** | | | | | | | | | | | | |
| DIESEL RANGE ORGANICS | 100 | 100 | 100 | 320 | 100 | 100 | 440 | 100 | 100 | 380 | 100 | 100 |
| GASOLINE RANGE ORGANICS | 100 | 100 | 100 | 1700 | 100 | 100 | 120 | 100 | 100 | 910 | 100 | 100 |
| **Inorganics (ug/L)** | | | | | | | | | | | | |
| ANTIMONY | 30 | 0.035 | 0.33 | 2 | 0.07 | 2 | 1.7 | 0.33 | 0.5 | 1.9 | 0.2 | 1.3 |
| ARSENIC | 16 | 24.4 | 19.6 | 3.1 | 19.4 | 0.83 | 15.4 | 4 | 1.2 | 9.3 | 12 | 1.0 |
| BARIUM | | 16 | 25.6 | 52.3 | 70.1 | 11.1 | 92.9 | 12.9 | 107 | 72.6 | 41.5 | 59.1 |
| BERYLLIUM | 3 | 0.037 | 0.71 | 0.2 | 7.3 | 0.02 | 0.23 | 0.19 | 1.1 | 0.2 | 3.7 | 0.6 |
| CADMIUM | 2 | 0.027 | 0.25 | 0.077 | 129 | 0.1 | 0.88 | 478 | 0.51 | 0.5 | 303.5 | 0.3 |
| CALCIUM | | 189000 | 1660 | 199000 | 66000 | 1990 | 0 | 0 | 0 | 99500 | 33000 | 995 |
| CHROMIUM | 59 | 1.3 | 22.9 | 3.2 | 9.3 | 0.27 | 17.1 | 6.5 | 3.6 | 10.2 | 7.9 | 1.9 |
| COBALT | 0.00 | 14.3 | 13.9 | 88.7 | 330 | 6.6 | 2.3 | 203 | 74.4 | 45.5 | 266.5 | 40.5 |
| COPPER | 73 | 0.22 | 37.2 | 1.1 | 245 | 0.62 | 40.6 | 68.4 | 20.5 | 20.9 | 156.7 | 10.6 |
| IRON | | 73500 | 11100 | 163000 | 64300 | 888 | 21600 | 60500 | 1620 | 92300 | 62400 | 1254 |
| LEAD | 6 | 0.064 | 2.6 | 0.48 | 2.5 | 0.07 | 25.1 | 3.9 | 4.3 | 12.8 | 3.2 | 2.2 |
| MAGNESIUM | | 31200 | 592 | 202000 | 61500 | 763 | | 0 | 0 | 2E+05 | 30750 | 381.5 |
| MANGANESE | | 2230 | 47.3 | 4420 | 5490 | 50.6 | 440 | 5720 | 559 | 2430 | 5605 | 304.8 |
| MERCURY | 2.9 | 0.1 | 0.83 | 0.2 | 0.11 | 0.2 | 0.2 | 0.74 | 0.42 | 0.2 | 0.4 | 0.3 |
| MOLYBDENUM | | 0.91 | 3 | 0.51 | 0.82 | 2 | 7.2 | 0.38 | 1.3 | 3.9 | 0.6 | 1.7 |
| NICKEL | 10 | 8.6 | 21.3 | 58.2 | 200 | 10 | 9.4 | 52.4 | 86.7 | 33.8 | 126.2 | 48.4 |
| POTASSIUM | | 11300 | | 42500 | 5880 | | | | | 42500 | 5880 | |
| SELENIUM | 10 | 0.43 | 1.1 | 0.76 | 20.6 | 5 | 0.32 | 3.4 | 0.67 | 0.5 | 12 | 2.8 |
| SILICA | | 4270 | | 30200 | 11600 | | | | | 30200 | 11600 | |
| SILVER | 4 | 0.033 | 0.044 | 1 | 0.02 | 1 | 0.15 | 0.025 | 0.033 | 0.6 | 0.02 | 0.5 |
| SODIUM | | 44600 | | 560000 | 2E+05 | | | | | 6E+05 | 2E+05 | |
| THALLIUM | 20 | 0.2 | 0.18 | 1 | 1 | 1 | 0.12 | 0.46 | 0.45 | 0.56 | 0.73 | 0.7 |
| VANADIUM | | 0.72 | 31.6 | 3 | 12.8 | 20 | 13.6 | 11.8 | 2 | 8.3 | 12.3 | 11 |
| ZINC | 20 | 2.9 | 31.1 | 65 | 363 | 16.3 | 165 | 282 | 132 | 115 | 322.5 | 74.2 |
| **Filtered Inorganics (ug/L)** | | | | | | | | | | | | |
| ANTIMONY | 20 | 0.25 | 0.081 | 2 | 2 | 2 | 0.36 | 0.12 | 0.4 | 1.2 | 1.1 | 1.2 |
| ARSENIC | 10 | 23.6 | 7.9 | 2.8 | 8 | 0.85 | 18.7 | 4.1 | 0.84 | 10.8 | 6.1 | 0.8 |
| BARIUM | 0 | 14.5 | 8.1 | 49.7 | 67.2 | 11.5 | 99.5 | 10.2 | 103 | 74.6 | 38.7 | 57.3 |
| BERYLLIUM | 4 | 0.047 | 0.26 | 0.24 | 2.8 | 0.02 | 0.025 | 0.18 | 0.99 | 0.1 | 1.5 | 0.5 |
| CADMIUM | 2 | 0.027 | 0.24 | 1 | 81.1 | 0.08 | 0.023 | 76.9 | 0.32 | 0.5 | 79 | 0.2 |
| CALCIUM | | 181000 | 1630 | 184000 | 68400 | 2220 | | 0 | | 2E+05 | 34200 | 2220 |
| CHROMIUM | 5 | 0.92 | 1.8 | 2 | 1.9 | 0.2 | 1.4 | 2.1 | 1.3 | 1.7 | 2 | 0.8 |
| COBALT | | 13.7 | 14.3 | 107 | 333 | 6.9 | 0.68 | 208 | 72.6 | 53.8 | 270.5 | 39.8 |
| COPPER | 10 | 0.082 | 4.6 | 0.49 | 22.2 | 0.11 | 0.63 | 25.1 | 2.6 | 0.6 | 23.7 | 1.4 |
| IRON | | 70900 | 4020 | 138000 | 43600 | 800 | 1240 | 60300 | 1120 | 69620 | 51950 | 960 |
| LEAD | 6 | 0.072 | 0.18 | 1 | 0.33 | 0.04 | 1 | 2 | 0.24 | 1 | 1.2 | 0.1 |
| MAGNESIUM | | 27700 | 418 | 183000 | 63400 | 839 | | 0 | | 2E+05 | 31700 | 839 |
| MANGANESE | | 2200 | 50.3 | 4180 | 5560 | 50.9 | 330 | 5690 | 556 | 2255 | 5625 | 303.5 |
| MERCURY | 0.06 | 0.1 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.14 | 0.2 | 0.2 | 0.2 | 0.2 |
| MOLYBDENUM | | 0.89 | 0.4 | 2 | 2 | 2 | 10.2 | 0.23 | 1.2 | 6.1 | 1.1 | 1.6 |
| NICKEL | 5 | 6.7 | 21.8 | 72.2 | 200 | 10.1 | 0.65 | 51.8 | 84.6 | 36.4 | 125.9 | 47.4 |
| SELENIUM | 20 | 0.48 | 5 | 0.77 | 14 | 5 | 0.22 | 3.6 | 0.44 | 0.5 | 8.8 | 2.7 |
| THALLIUM | 6 | 0.22 | 1 | 1 | 0.27 | 1 | 0.2 | 0.36 | 0.19 | 0.6 | 0.3 | 0.6 |
| VANADIUM | | 0.64 | 2.9 | 1.9 | 2.7 | 20 | 1.9 | 7 | 0.62 | 1.9 | 4.9 | 10.3 |
| ZINC | 6 | 3.5 | 54.2 | 85.6 | 356 | 16.7 | 8.5 | 267 | 119 | 47.1 | 311.5 | 67.9 |
| **Miscellaneous Parameters** | | | | | | | | | | | | |
| ALKALINITY MG/L | | 110 | 4.9 | 355 | 55.1 | 8.8 | | | | 355 | 55 | 9 |
| CHEMICAL OXYGEN DEMAND MG/L | | 42 | 20 | 168 | 56.9 | 20 | | | | 168 | 57 | 20 |
| CHLORIDE MG/L | | 23.3 | | 594 | 305 | | | | | 594 | 305 | |
| HEXAVALENT CHROMIUM MG/L | | 0.02 | 0.04 | 0.002 | 0.02 | 0.02 | 0.02 | 0.02 | 0.004 | 0.011 | 0.020 | 0.012 |
| NITRATE-N MG/L | | 0.023 | | 0.023 | 0.023 | | | | | 0.023 | 0.023 | |
| PERCHLORATE UG/L | | 0.082 | 0.082 | 0.082 | 0.13 | | 0.082 | 0.082 | 0.082 | 0.082 | 0.106 | 0.082 |
| PH S.U. | | 6.1 | 5.7 | 6.6 | 5.9 | 5.5 | | | | 6.6 | 5.9 | 5.5 |
| SULFATE MG/L | | 649 | | 1600 | 439 | | | | | 1600 | 439 | |
| TOTAL DISSOLVED SOLIDS MG/L | | 1100 | | 3500 | 1100 | | | | | 3500 | 1100 | |

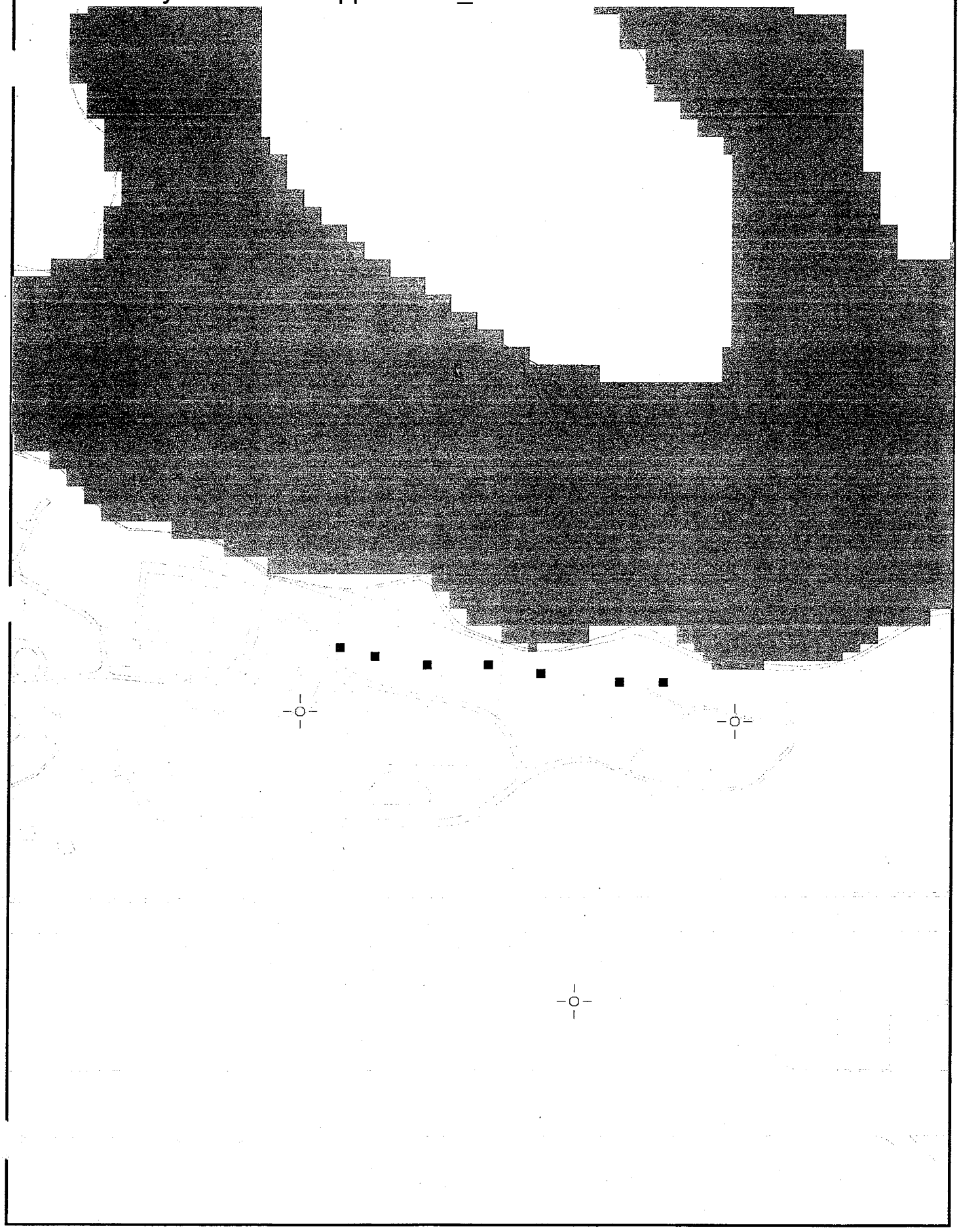
**GROUNDWATER DESIGN BASIS - SECOND PUMPING SCHEME**
**DUMP ROAD SITE**
**LOCKHEED MARTIN - MARTIN STATE AIRPORT**
**MIDDLE RIVER, MARYLAND**


01/18/10

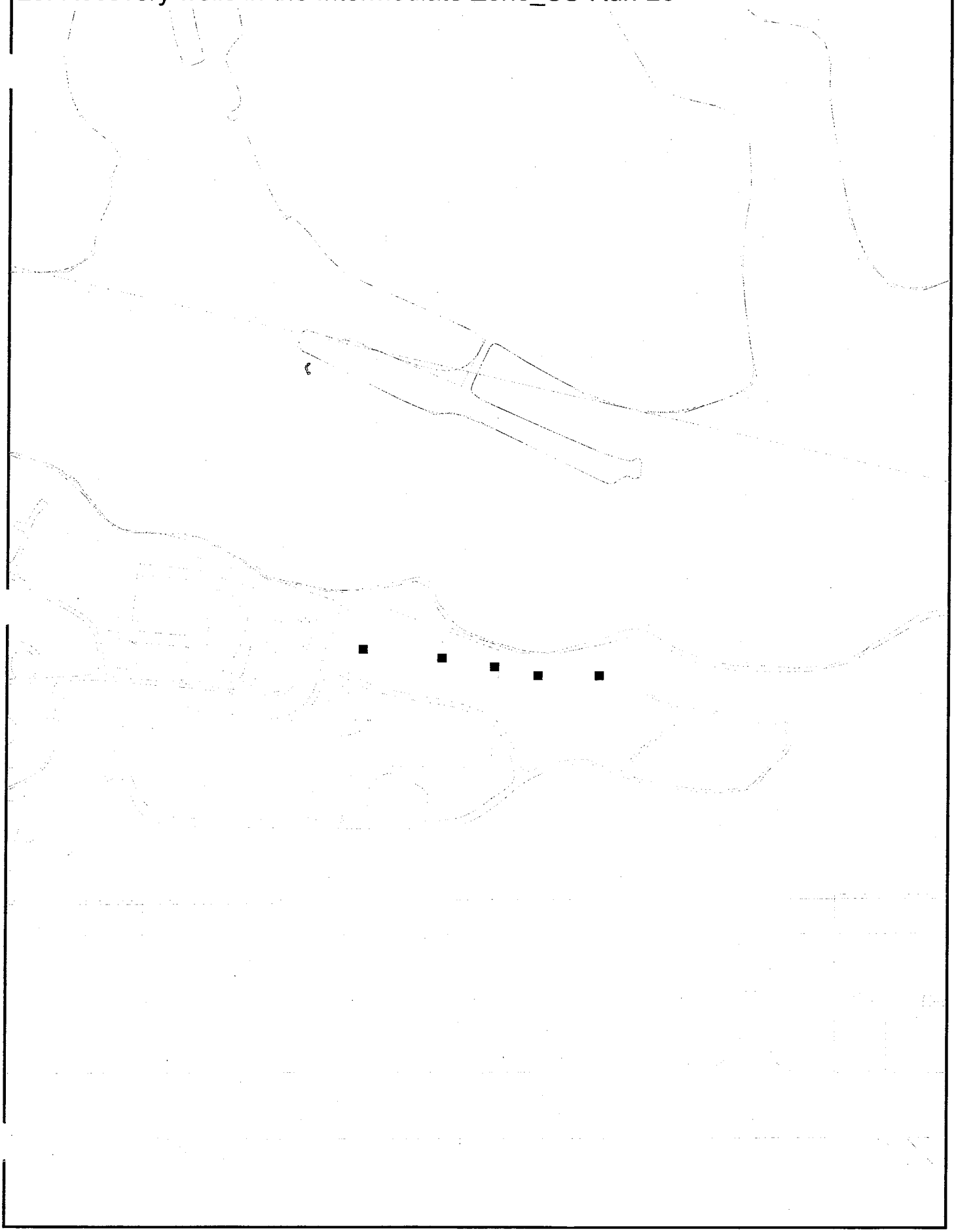
| **Extraction well No.** | | | | | I5 | D4 | S5 | I4 | D3 | S7 | | | | | | S2 | S4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **LOCATION** | **2S** | **2A** | **2B** | **4S** | **4I** | **4D** | **AVE** | **AVE** | **AVE** | **5S** | **5I** | **5D** | **6S** | **6I** | **6D** | **4S** | **2S** |
| **SAMPLE DATE** | | | | | | | **2S** | **2A** | **2B** | | | | | | | **18S** | **3S** |
| SAMPLE ID | | | | | | | **4S** | **4I** | **4D** | | | | | | | **AVE** | **AVE** |
| MATRIX | | | | | | | | | | | | | | | | | |
| SAMPLE CODE | | | | | | | | | | | | | | | | | |
| **Volatile Organics (ug/L)** | | | | | | | | | | | | | | | | | |
| 1,1,1-TRICHLOROETHANE | 18 | 110 | 1 | 4.4 | 78 | 37 | 11.2 | 94 | 19 | 55 | 0.22 | 1 | 0.22 | 0.22 | 0.22 | 12.2 | 18 |
| 1,1-DICHLOROETHENE | 16 | 95 | 1 | 27 | 83 | 32 | 21.5 | 89 | 16.5 | 48 | 0.19 | 1 | 0.19 | 0.19 | 0.19 | 23.5 | 16 |
| 1,2,4-TRICHLOROBENZENE | 12 | 650 | 1 | 3 | 25 | 25 | 7.5 | 337.5 | 13 | 38 | 0.15 | 1 | 0.15 | 0.15 | 0.15 | 16 | 12 |
| 1,2-DICHLOROETHANE | 18 | 150 | 1 | 16 | 37 | 37 | 17 | 93.5 | 19 | 55 | 0.93 | 1 | 0.22 | 0.22 | 0.22 | 23 | 18 |
| BENZENE | 11 | 65 | 1 | 2.6 | 22 | 22 | 6.8 | 43.5 | 11.5 | 32 | 0.35 | 1 | 0.13 | 0.13 | 0.13 | 9.3 | 11 |
| BTEX | | | 0 | | | | | | | | 0.35 | | | | | | |
| CHLOROBENZENE | 12 | 75 | 1 | 3 | 25 | 25 | 7.5 | 50 | 13 | 38 | 0.15 | 1 | 0.33 | 0.15 | 0.15 | 11 | 12 |
| CHLOROFORM | 11 | 89 | 1 | 3.2 | 27 | 27 | 7.1 | 58 | 14 | 40 | 1.3 | 1 | 0.16 | 0.16 | 0.16 | 3.45 | 12 |
| CIS-1,2-DICHLOROETHENE | 1000 | 5000 | 4.5 | 170 | 2100 | 400 | 585 | 3550 | 202.3 | 980 | 53 | 1 | 3.6 | 0.17 | 0.17 | 270 | 775 |
| METHYLENE CHLORIDE | 27 | 500 | 1 | 21 | 55 | 140 | 24 | 277.5 | 70.5 | 250 | 0.33 | 1 | 0.33 | 0.33 | 0.33 | 14.6 | 58.5 |
| NAPHTHALENE | 20 | 120 | 1 | 4.8 | 40 | 40 | 12.4 | 80 | 20.5 | 60 | 0.24 | 1 | 0.24 | 0.24 | 0.32 | 12.4 | 20 |
| TOLUENE | 11 | 65 | 1 | 2.6 | 22 | 22 | 6.8 | 43.5 | 11.5 | 32 | 0.13 | 1 | 0.13 | 0.13 | 0.13 | 9.3 | 11 |
| TOTAL CHLORINATED VOCS | 3730 | 25840 | 6.6 | 1518 | 8674 | 6200 | 2624 | 17257 | 3103 | 9980 | 176.6 | 1.1 | 3.6 | | | | |
| TRANS-1,2-DICHLOROETHENE | 16 | 95 | 0.36 | 3.8 | 32 | 32 | 9.9 | 63.5 | 16.18 | 48 | 2.5 | 1 | 0.19 | 0.19 | 0.19 | 11.9 | 108 |
| TRICHLOROETHENE | 2200 | 20000 | 2.1 | 1300 | 7300 | 5800 | 1750 | 13650 | 2901 | 9000 | 120 | 1.1 | 0.83 | 0.17 | 0.17 | 2650 | 1107 |
| VINYL CHLORIDE | 530 | 840 | 1 | 48 | 140 | 37 | 289 | 490 | 19 | 55 | 3.6 | 1 | 0.22 | 0.22 | 0.22 | 149 | 2465 |
| **Volatile Organics - SIM (ug/L)** | | | | | | | | | | | | | | | | | |
| 1,4-DIOXANE | 250 | 890 | 1 | 120 | 120 | 75 | 185 | 505 | 38 | 41 | 2.9 | 1 | 1 | 1 | 1 | 135 | 365 |
| **Petroleum Hydrocarbons (ug/L)** | | | | | | | | | | | | | | | | | |
| DIESEL RANGE ORGANICS | 310 | 100 | 100 | 270 | 100 | 100 | 290 | 100 | 100 | 290 | 100 | 100 | 420 | 100 | 100 | 295 | 375 |
| GASOLINE RANGE ORGANICS | 980 | 100 | 100 | 310 | 100 | 100 | 645 | 100 | 100 | 3500 | 100 | 100 | 39 | 100 | 100 | 1005 | 550 |
| **Inorganics (ug/L)** | | | | | | | | | | | | | | | | | |
| ANTIMONY | 0.04 | 0.71 | 0.45 | 0.2 | 0.53 | 0.2 | 0.122 | 0.62 | 0.325 | 0.038 | 0.49 | 0.07 | 0.9 | 0.45 | 0.16 | 1.1 | 0.8715 |
| ARSENIC | 12.6 | 7.7 | 3.1 | 4.4 | 41.7 | 24 | 8.5 | 24.7 | 13.55 | 17.1 | 14 | 0.13 | 6.8 | 4.5 | 3.3 | 3.75 | 14 |
| BARIUM | 15.1 | 37.9 | 32.1 | 13.8 | 21.5 | 29.3 | 14.45 | 29.7 | 30.7 | 13.7 | 34.2 | 10.1 | 52.9 | 15.4 | 56.4 | 33.05 | 54 |
| BERYLLIUM | 4.7 | 1.2 | 0.32 | 1.2 | 9.5 | 3.8 | 2.95 | 5.35 | 2.06 | 4.7 | 2.4 | 0.12 | 0.051 | 5.8 | 0.75 | 0.7 | 2.465 |
| CADMIUM | 242 | 777 | 1 | 49.9 | 56.6 | 24.4 | 146 | 416.8 | 12.7 | 4.9 | 23.3 | 0.04 | 0.061 | 37.8 | 0.81 | 24.989 | 121.44 |
| CALCIUM | | 27600 | | 118000 | 115000 | 67300 | ### | 71300 | 67300 | 77900 | 76700 | | | | | 158500 | 0 |
| CHROMIUM | 4 | 45.1 | 42.1 | 6.7 | 70.3 | 15 | 5.35 | 57.7 | 28.55 | 158 | 11.9 | 0.52 | 1.2 | 15.7 | 11.4 | 4.95 | 10.55 |
| COBALT | 247 | 573 | 3.6 | 72.4 | 150 | 162 | 159.7 | 361.5 | 82.8 | 88.5 | 74.5 | 4.1 | 6.4 | 70.4 | 27.6 | 80.55 | 124.65 |
| COPPER | 55.3 | 262 | 20.5 | 21.7 | 142 | 80.3 | 38.5 | 202 | 50.4 | 59.7 | 214 | 1.2 | 2 | 534 | 18.8 | 11.4 | 47.95 |
| IRON | 66.6 | 48200 | 5240 | 49400 | 15300 | 3930 | 24733 | 31750 | 4585 | 25900 | 32600 | 30.5 | 275000 | ### | 2800 | 106200 | 10833 |
| LEAD | 1 | 13.9 | 11 | 4.9 | 13.5 | 7.1 | 2.95 | 13.7 | 9.05 | 4.3 | 19.6 | 0.03 | 0.63 | 16 | 3.1 | 2.69 | 13.05 |
| MAGNESIUM | | 27800 | | 76500 | 72900 | 57900 | 76500 | 50350 | 57900 | 53700 | 43800 | | | | | 139250 | |
| MANGANESE | 6500 | 9940 | 45.8 | 6210 | 8010 | 6300 | 6355 | 8975 | 3173 | 4560 | 2580 | 24.2 | 2240 | 4430 | 774 | 5315 | 3470 |
| MERCURY | 0.1 | 0.56 | 0.29 | 0.1 | 0.12 | 13.2 | 0.1 | 0.34 | 6.745 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 2.6 | 0.15 | 0.15 |
| MOLYBDENUM | 0.23 | 1.6 | 0.97 | 0.72 | 2.2 | 1.2 | 0.475 | 1.9 | 1.085 | 3.4 | 0.82 | 0.12 | 1 | 3.7 | 1.3 | 0.615 | 3.715 |
| NICKEL | 112 | 143 | 13.2 | 33.4 | 113 | 117 | 72.7 | 128 | 65.1 | 78.6 | 65.2 | 5.7 | 5.7 | 82.3 | 37.3 | 45.8 | 60.7 |
| POTASSIUM | | | | 20700 | 10000 | 5050 | 20700 | 10000 | 5050 | | | | | | | 31600 | |
| SELENIUM | 33.8 | 9.4 | 0.48 | 4.4 | 41.7 | 36.2 | 19.1 | 25.55 | 18.34 | 39.2 | 30.5 | 0.2 | 0.43 | 3.6 | 2 | 2.58 | 17.06 |
| SILICA | | | | 11800 | 28700 | 18500 | 11800 | 28700 | 18500 | | | | | | | 21000 | |
| SILVER | 0.02 | 0.27 | 0.11 | 0.02 | 0.35 | 0.096 | 0.02 | 0.3 | 0.1 | 0.02 | 0.033 | 0 | 0.025 | 0.04 | 0.02 | 0.51 | 0.085 |
| SODIUM | | 0 | | 170000 | 124000 | ### | ### | 62000 | ### | | | | | | | 365000 | |
| THALLIUM | 0.34 | 0.39 | 0.13 | 0.11 | 0.5 | 0.23 | 0.2 | 0.4 | 0.2 | 0.25 | 0.24 | 0.11 | 0.17 | 0.24 | 0.13 | 0.555 | 0.23 |
| VANADIUM | 0.46 | 44.8 | 15.2 | 4.6 | 66.9 | 10.6 | 2.5 | 55.9 | 12.9 | 11.7 | 4.9 | 0.46 | 1.1 | 2.9 | 7.1 | 3.8 | 7.03 |
| ZINC | 303 | 534 | 38.8 | 153 | 512 | 498 | 228 | 523 | 268.4 | 211 | 328 | 16.3 | 7.6 | 835 | 111 | 109 | 234 |
| **Filtered Inorganics (ug/L)** | | | | | | | | | | | | | | | | | |
| ANTIMONY | 0.04 | 0.12 | 0.08 | 0.074 | 0.095 | 0.043 | 0.06 | 0.1 | 0.06 | 0.067 | 0.055 | 0.04 | 0.29 | 0.18 | 0.04 | 1.037 | 0.2015 |
| ARSENIC | 12.3 | 5.1 | 5 | 4.4 | 27.1 | 20.8 | 8.4 | 16.1 | 12.9 | 17.1 | 13.1 | 0.13 | 6.8 | 3.8 | 0.77 | 3.6 | 15.5 |
| BARIUM | 14.3 | 13.2 | 8.3 | 10.5 | 14.6 | 20.7 | 12.4 | 13.9 | 14.5 | 13.4 | 34 | 10.2 | 53.6 | 11.9 | 54.3 | 30.1 | 56.9 |
| BERYLLIUM | 4.3 | 1.3 | 0.07 | 1.3 | 10.4 | 4.2 | 2.8 | 5.9 | 2.1 | 4.9 | 2.6 | 0.11 | 0.025 | 6.8 | 0.72 | 0.77 | 2.1625 |
| CADMIUM | 238 | 762 | 0.8 | 6.6 | 59.6 | 26.5 | 122.3 | 410.8 | 13.7 | 4.6 | 3.4 | 0.06 | 0.014 | 9.9 | 0.73 | 3.8 | 119.01 |
| CALCIUM | | 33900 | | 95000 | 119000 | 72100 | 95000 | 76450 | 72100 | 77400 | 81500 | | | | | 139500 | |
| CHROMIUM | 3.5 | 7.7 | 0.39 | 0.97 | 11.7 | 2.8 | 2.2 | 9.7 | 1.6 | 9.3 | 10 | 0.18 | 0.66 | 4.5 | 1.4 | 1.485 | 2.45 |
| COBALT | 248 | 589 | 1.2 | 83.3 | 171 | 174 | 165.7 | 380 | 87.6 | 90.9 | 79.2 | 3.9 | 6.5 | 76.4 | 29 | 95.15 | 124.34 |
| COPPER | 55.2 | 56 | 5.1 | 3 | 111 | 67.8 | 29.1 | 83.5 | 36.5 | 10.2 | 4.6 | 1.3 | 0.49 | 66 | 20.7 | 1.745 | 27.915 |
| IRON | 59.6 | 44900 | 6 | 47900 | 15000 | 224 | 23980 | 29950 | 115 | 26000 | 34500 | 5.6 | 284000 | ### | 156 | 92950 | 649.8 |
| LEAD | 0.91 | 4.2 | 0.41 | 1.2 | 10.1 | 1.9 | 1.1 | 7.2 | 1.2 | 3.1 | 4.6 | 0.02 | 0.13 | 6.4 | 2 | 1.1 | 0.955 |
| MAGNESIUM | | 31800 | | 74100 | 90900 | 62500 | 74100 | 61350 | 62500 | 53500 | 47300 | | | | | 128550 | |
| MANGANESE | 6510 | 10700 | 9.5 | 7150 | 8760 | 6960 | 6830 | 9730 | 3485 | 4690 | 2800 | 22.7 | 2340 | 4850 | 838 | 5665 | 3420 |
| MERCURY | 0.1 | 0.2 | 0.2 | 0.1 | 0.1 | 0.34 | 0.1 | 0.2 | 0.3 | 0.1 | 0.1 | 0.14 | 0.1 | 0.1 | 0.17 | 0.15 | 0.15 |
| MOLYBDENUM | 0.23 | 2 | 0.13 | 0.23 | 0.23 | 0.23 | 0.2 | 1.1 | 0.2 | 0.23 | 0.2 | 0.12 | 0.23 | 0.19 | 0.36 | 1.115 | 5.215 |
| NICKEL | 111 | 142 | 4.1 | 37.8 | 134 | 125 | 74 | 138 | 65 | 80 | 70 | 5.5 | 2.5 | 85.8 | 39.2 | 55 | 55.825 |
| SELENIUM | 33 | 9.2 | 5 | 4 | 44 | 37.4 | 18.5 | 26.6 | 21.2 | 38.6 | 32.7 | 0.22 | 1.3 | 4.1 | 2.3 | 2.385 | 16.61 |
| THALLIUM | 0.32 | 0.27 | 0.17 | 0.11 | 0.32 | 0.21 | 0.2 | 0.3 | 0.2 | 0.22 | 0.17 | 0.11 | 0.12 | 0.22 | 0.11 | 0.555 | 0.26 |
| VANADIUM | 0.46 | 13.3 | 20 | 0.46 | 4.6 | 0.46 | 0.5 | 9.0 | 10.2 | 12.2 | 3.8 | 0.46 | 0.7 | 1.6 | 0.46 | 1.18 | 1.18 |
| ZINC | 301 | 533 | 21 | 134 | 517 | 374 | 217.5 | 525 | 197.5 | 212 | 236 | 16 | 7.1 | 398 | 127 | 109.8 | 154.75 |
| **Miscellaneous Parameters** | | | | | | | | | | | | | | | | | |
| ALKALINITY MG/L | | 2.4 | | 73 | 5 | 5 | 73 | 3.7 | 5 | 5 | 5 | | | | | 214 | |
| CHEMICAL OXYGEN DEMAND MG/L | | 54.4 | | 42 | 59.3 | 27.2 | 42 | 56.9 | 27.2 | 34.6 | 27.2 | | | | | 105 | |
| CHLORIDE MG/L | | | | 105 | 94 | 123 | 105 | 94 | 123 | | | | | | | 349.5 | |
| HEXAVALENT CHROMIUM MG/L | 0.02 | 0.004 | 0.007 | 0.003 | 0.02 | 0.005 | 0.01 | 0.01 | 0.006 | 0.002 | 0.02 | 0.02 | 0.13 | 0.02 | 0.02 | 0.0025 | 0.02 |
| NITRATE-N MG/L | | | | 0.023 | 0.1 | 2.8 | 0.02 | 0.1 | 2.8 | | | | | | | 0.023 | |
| PERCHLORATE UG/L | 0.12 | 0.11 | | 0.082 | 4.6 | 5.8 | 0.1 | 2.4 | 5.8 | 0.63 | 0.082 | | 0.082 | 0.08 | 0.1 | 0.082 | 0.101 |
| PH S.U. | | 4.6 | | 5.4 | 4.2 | 4.2 | 5.4 | 4.4 | 4.2 | 4.3 | 4.4 | | | | | 6 | |
| SULFATE MG/L | | | | 908 | 1050 | 723 | 908 | 1050 | 723 | | | | | | | 1254 | |
| TOTAL DISSOLVED SOLIDS MG/L | | | | 1500 | 1600 | 1200 | 1500 | 1600 | 1200 | | | | | | | 2500 | |

| Extraction well No. | S6 | I1 | I3 | D2 | ALL | GW CRIT | WQC | WQC x 5 | Design Basis 1.5 x All well Ave | max all wells | max Ave wells | max/DB |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **LOCATION** | **4S** | **14I** | **3I** | **3D** | **ALL** | | | | | | | |
| **SAMPLE DATE** | **5S** | **18I** | **2A** | **2B** | **WELL** | | | | | | | |
| SAMPLE ID | **AVE** | **AVE** | **AVE** | **AVE** | **AVE** | | | | | | | |
| MATRIX | | | | | | | | | | | | |
| SAMPLE CODE | | | | | | | | | | | | |
| **Volatile Organics (ug/L)** | | | | | | | | | | | | |
| 1,1,1-TRICHLOROETHANE | 29.7 | 42 | 110 | 1 | 40 | 200 | 200 HH | 1000 | 60 | 500 | 110 | 1.8 |
| 1,1-DICHLOROETHENE | 37.5 | 45.5 | 95 | 1 | 39 | 7 | 0.57 | 2.85 | **58** | 500 | 95 | 1.6 |
| 1,2,4-TRICHLOROBENZENE | 20.5 | 49.75 | 690 | 1 | 124 | 70 | 260 | 1300 | 186 | 730 | 730 | 3.9 |
| 1,2-DICHLOROETHANE | 35.5 | 44.5 | 155 | 1 | 45 | 5 | 3.8 | 19 | **68** | 160 | 160 | 2.4 |
| BENZENE | 17.3 | 27 | 65 | 1 | 22 | 5 | 22 | 110 | **5** | 500 | **5** | 1.0 |
| BTEX | | | | | | | | | | | | |
| CHLOROBENZENE | 20.5 | 160 | 75 | 1 | 33 | 100 | 680 HH | 3400 | 50 | 270 | 160 | 3.2 |
| CHLOROFORM | 21.6 | 30.5 | 94.5 | 0.745 | 28 | 80 | 80 | 400 | 42 | 100 | 100 | 2.4 |
| CIS-1,2-DICHLOROETHENE | 575 | 1400 | 11000 | 2.75 | 2456 | 70 | - | - | **3685** | 17000 | 17000 | 4.6 |
| METHYLENE CHLORIDE | 135.5 | 78 | 500 | 1 | 135 | 5 | 46 HH | 230 | **10** | 540 | **10** | 1.0 |
| NAPHTHALENE | 32.4 | 46 | 120 | 1 | 39 | 0.65 | - | - | **21** | 500 | **21** | 1.0 |
| TOLUENE | 17.3 | 24.75 | 137.5 | 0.7 | 35 | 1000 | 6500 | 32500 | 53 | 500 | 210 | 4.0 |
| TOTAL CHLORINATED VOCS | | | | | | | | | | | | |
| TRANS-1,2-DICHLOROETHENE | 25.9 | 37.5 | 95 | 0.68 | 43 | 100 | 700 HH | 3500 | 64 | 200 | 110 | 1.7 |
| TRICHLOROETHENE | 5150 | 6025 | 19000 | 1.535 | 5897 | 5 | 2.5 | 12.5 | **8845** | 20000 | 19000 | 2.1 |
| VINYL CHLORIDE | 51.5 | 825 | 2570 | 1 | 857 | 2 | 20 | 100 | **1286** | 4400 | 4300 | 3.3 |
| **Volatile Organics - SIM (ug/L)** | | | | | | | | | | | | |
| 1,4-DIOXANE | 80.5 | 240 | 995 | 0.665 | 262 | 6.1 | - | - | **393** | 1100 | 1100 | 2.8 |
| **Petroleum Hydrocarbons (ug/L)** | | | | | | | | | | | | |
| DIESEL RANGE ORGANICS | 280 | 100 | 100 | 100 | 182 | 47 | - | - | **273** | 440 | 380 | 1.4 |
| GASOLINE RANGE ORGANICS | 1905 | 100 | 100 | 100 | 595 | 47 | - | - | **892** | 3500 | 3500 | 3.9 |
| **Inorganics (ug/L)** | | | | | | | | | | | | |
| ANTIMONY | 0.119 | 0.0525 | 0.52 | 0.475 | 2 | 6 | 5.6 | 28 | 2 | 1.9 | 30 | 12.5 |
| ARSENIC | 10.75 | 21.9 | 5.85 | 2.15 | 14 | 10 | 10 | 50 | **20** | 41.7 | 41.7 | 2.0 |
| BARIUM | 13.75 | 43.05 | 25.4 | 69.55 | 35 | 2000 | 2000 | 10000 | 52 | 107 | 72.6 | 1.4 |
| BERYLLIUM | 2.95 | 3.6685 | 0.695 | 0.71 | 3 | 4 | 4 | 20 | 4 | 9.5 | 9.5 | 2.3 |
| CADMIUM | 27.4 | 64.514 | 627.5 | 0.755 | 126 | 5 | 0.25 | 1.25 | **188** | 777 | 627.5 | 3.3 |
| CALCIUM | 97950 | 127500 | 13800 | 0 | 67670 | - | - | - | 67670 | 199000 | 158500 | 2.3 |
| CHROMIUM | 82.35 | 5.3 | 25.8 | 22.85 | 35 | 100 | 11 | 55 | **53** | 158 | 158 | 3.0 |
| COBALT | 80.45 | 172.15 | 388 | 39 | 136 | 11 RSL | - | - | **204** | 573 | 388 | 1.9 |
| COPPER | 40.7 | 122.61 | 165.2 | 20.5 | 72 | 1300 | 9 | 45 | **108** | 534 | 202 | 1.9 |
| IRON | 37650 | 68900 | 54350 | 3430 | 36108 | 300 | - | - | **54162** | 275000 | 106200 | 2.0 |
| LEAD | 4.6 | 1.282 | 8.9 | 7.65 | 7 | 15 | 2.5 | 12.5 | **11** | 25.1 | 13.7 | 1.3 |
| MAGNESIUM | 65100 | 46350 | 13900 | 0 | 59731 | - | - | - | 89596 | 202000 | 202000 | 2.3 |
| MANGANESE | 5385 | 3860 | 7830 | 302.4 | 4799 | 50 | - | - | **7199** | 9940 | 8975 | 1.2 |
| MERCURY | 0.1 | 0.105 | 0.65 | 0.355 | 2 | 2 | 0.77 | 3.85 | **2** | 13.2 | 13.2 | 8.0 |
| MOLYBDENUM | 2.06 | 0.865 | 0.99 | 1.135 | 2 | 180 RSL | - | - | 2 | 7.2 | 3.855 | 2.3 |
| NICKEL | 56 | 104.3 | 97.7 | 49.95 | 71 | 73 | 52 | 260 | 106 | 200 | 128 | 1.2 |
| POTASSIUM | 20700 | 8590 | | | 17132 | - | - | - | 25698 | 42500 | 42500 | 1.7 |
| SELENIUM | 21.8 | 10.515 | 6.4 | 0.575 | 16 | 50 | 5 | 25 | **24** | 41.7 | 41.7 | 1.7 |
| SILICA | 11800 | 7935 | | | 19682 | - | - | - | 19682 | 30200 | 30200 | 1.5 |
| SILVER | 0.02 | 0.0265 | 0.1475 | 0.0715 | 0 | 100 | 3.5 | 17.5 | 0.4 | 4 | 4 | 9.3 |
| SODIUM | 170000 | 103300 | 0 | | 179230 | - | - | - | 268845 | 560000 | 560000 | 2.1 |
| THALLIUM | 0.18 | 0.6 | 0.425 | 0.29 | 2 | - | 1.7 | 8.5 | 1.6 | 20 | 1.6 | 1.0 |
| VANADIUM | 8.15 | 6.76 | 28.3 | 8.6 | 17 | 3.7 | - | - | **17** | 66.9 | 66.9 | 3.9 |
| ZINC | 182 | 182.95 | 408 | 85.4 | 246 | 5000 | 120 | 600 | **369** | 835 | 523 | 1.4 |
| **Filtered Inorganics (ug/L)** | | | | | | | | | | | | |
| ANTIMONY | 0.0705 | 1.125 | 0.12 | 0.2405 | 2 | 6 | 5.6 | 28 | 1.6 | 20 | 1.6 | 1.0 |
| ARSENIC | 10.75 | 15.8 | 4.6 | 2.92 | 11 | 10 | 10 | 50 | 11 | 27.1 | 27.1 | 2.4 |
| BARIUM | 11.95 | 40.85 | 11.7 | 55.65 | 27 | 2000 | 2000 | 10000 | 41 | 103 | 74.6 | 1.8 |
| BERYLLIUM | 3.1 | 1.4235 | 0.74 | 0.5315 | 3 | 4 | 4 | 20 | 3 | 10.4 | 10.4 | 3.8 |
| CADMIUM | 5.6 | 40.564 | 419.45 | 0.56 | 82 | 5 | 0.25 | 1.25 | **122** | 762 | 419.45 | 3.4 |
| CALCIUM | 86200 | 124700 | 16950 | | 81971 | - | - | - | 81971 | 184000 | 184000 | 2.2 |
| CHROMIUM | 5.135 | 1.41 | 4.9 | 0.845 | 4 | 100 | 11 | 55 | 6 | 11.7 | 11.7 | 2.0 |
| COBALT | 87.1 | 173.35 | 398.5 | 36.9 | 152 | 11 RSL | - | - | **229** | 589 | 398.5 | 1.7 |
| COPPER | 6.6 | 11.141 | 40.55 | 3.85 | 29 | 1300 | 9 | 45 | **44** | 111 | 111 | 2.5 |
| IRON | 36950 | 57250 | 52600 | 563 | 31141 | 300 | - | - | 46711 | 284000 | 92950 | 2.0 |
| LEAD | 2.15 | 0.201 | 3.1 | 0.325 | 3 | 15 | 2.5 | 12.5 | 4 | 10.1 | 10.1 | 2.6 |
| MAGNESIUM | 63800 | 45550 | 15900 | | 64807 | - | - | - | 97210 | 183000 | 183000 | 1.9 |
| MANGANESE | 5920 | 3880 | 8195 | 282.75 | 5071 | 50 | - | - | **7607** | 10700 | 9730 | 1.3 |
| MERCURY | 0.1 | 0.15 | 0.17 | 0.2 | 0 | 2 | 0.77 | 3.85 | 0.2 | 0.34 | 0.1 | 0.6 |
| MOLYBDENUM | 0.23 | 1.445 | 1.115 | 0.665 | 1 | 180 RSL | - | - | 1.3 | 10.2 | 6.1 | 4.6 |
| NICKEL | 58.9 | 103.35 | 96.9 | 44.35 | 73 | 73 | 52 | 260 | **110** | 200 | 138 | 1.3 |
| SELENIUM | 21.3 | 7.24 | 6.4 | 2.72 | 17 | 50 | 5 | 25 | **25** | 44 | 44 | 1.7 |
| THALLIUM | 0.165 | 0.245 | 0.315 | 0.18 | 1 | - | 1.7 | 8.5 | 0.7 | 6 | 6 | 9.0 |
| VANADIUM | 6.33 | 1.67 | 10.15 | 10.31 | 6 | 3.7 | - | - | **6** | 20 | 12.2 | 2.1 |
| ZINC | 173 | 179.75 | 400 | 70 | 220 | 5000 | 120 | 600 | **330** | 533 | 525 | 1.6 |
| **Miscellaneous Parameters** | | | | | | | | | | | | |
| ALKALINITY MG/L | 39 | 82.55 | 2.4 | | 67 | | | | 67 | 355 | 355 | 5.3 |
| CHEMICAL OXYGEN DEMAND MG/L | 38.3 | 49.45 | 54.4 | | 57 | | | | 57 | 168 | 168 | 3.0 |
| CHLORIDE MG/L | 105 | 164.15 | | | 195 | | | | 195 | 594 | 594 | 3.1 |
| HEXAVALENT CHROMIUM MG/L | 0.0025 | 0.02 | 0.012 | 0.0055 | 0 | | 0.011 | 0.055 | **0.01** | 0.13 | 0.02 | 1.9 |
| NITRATE-N MG/L | 0.023 | 0.023 | | | 1 | | | | 0.7 | 2.8 | 2.8 | 4.3 |
| PERCHLORATE UG/L | 0.356 | 0.106 | 0.096 | 0.082 | 1 | | | | 1.4 | 5.8 | 5.8 | 4.3 |
| PH S.U. | 4.85 | 6 | 4.6 | | 5 | | | | 5 | 6.6 | 6.6 | 1.3 |
| SULFATE MG/L | 908 | 544 | | | 973 | | | | 973 | 1600 | 1600 | 1.6 |
| TOTAL DISSOLVED SOLIDS MG/L | 1500 | 1100 | | | 1744 | | | | 1744 | 3500 | 3500 | 2.0 |

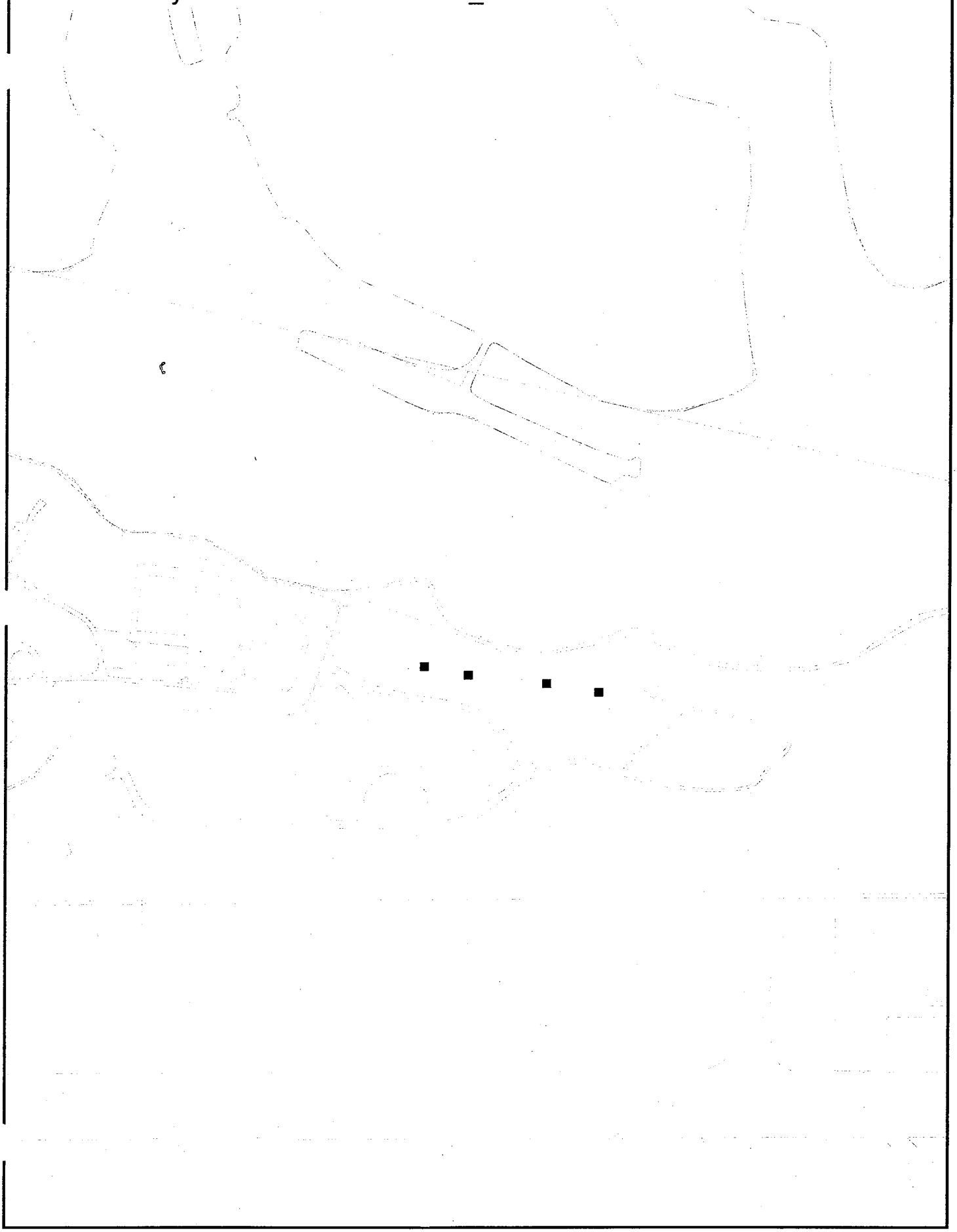
L2: Recovery wells in the Upper Zone_SS-Run-26



L8: Recovery wells in the Intermediate Zone_SS-Run-26



L11: Recovery wells in the Lower Zone_SS-Run-26



Map Document: (K:\GProject\MartinStateAirport-LMC\MapDocs\MXD\Maps\Groundwater monitoring well locs Nov2008 1 30 09.mxd)
11/12/2009 -- 1:59:35 PM

1/4/09

MARYLAND AIR NATIONAL GUARD

Gate

Gate

Gate

POND #2

POND #1

Petroleum Hydrocarbon Area

Drum Area

FROG MORTAR CREEK

MSA- Gage 01

TAXIWAY TANGO

AIRPORT-RUNWAY

MW34S MW34I
MW33S MW33I
MW27D
MW28I
MW16S MW16I MW16D
MW17S MW17I MW17D
MW14I MW14D
MW15S MW15I MW15D
MW18S MW18I MW18D
MW4
MW7
DMW9I/DMW9S
DMW9D
MW26S MW26I MW26D
DMW10I/DMW10S
MW20S MW20I MW20D
DMW3I DMW3S
DMW3D
DMW2A/B
RW1S OW1S
RW1I
OW1I
DMW2S
DMW4I
DMW8I
DMW8S DMW8D
MW25S MW25I
MW3
MW21I MW21D
DMW1S
MW22I MW22D
DMW1A/DMW1B
DMW5I
DMW5S DMW5D
DMW11I DMW11S
TT-11
MW23S MW23I MW23D
MW5
DMW7S
DMW7D
DMW6I
DMW6S DMW6D
MW19I MW19D
MW2
TT-12
TT-14
MW1
TT-13
MW24S MW24I
MW6
MW32S MW32I
MW30D
MW29D
MW31D

**Figure 3-1**
**Groundwater Monitoring Well and Staff Gage Locations**

**Legend**

- Sampled Groundwater Monitoring Well Location
- Installed Well Locations Aug - Sept 09
- Staff Gage Location
- Well Not Sampled
- Ponds

***Lockheed Martin Martin State Airport***
***Middle River, Maryland***

0 50 100 200 Feet

N

DATE MODIFIED: 11/12/09

CREATED BY: MP

Tetra Tech, Inc.

20 scale:
2.1 = 200'

# GROUNDWATER TREATMENT SYSTEM AND VENDOR QUOTES

| **Tetra Tech NUS** | | | *STANDARD CALCULATION SHEET* |
|---|---|---|---|
| CLIENT: Lockheed Martin – Martin State Airport – DRA Site FS | FILE No: | BY: JWL | PAGE: 1 of 3 |
| SUBJECT: Groundwater treatment – Estimate sludge generation | | CHECKED BY: CAM | DATE: 4/9/10 |

Alternative G-2 (aka N-2)

Solids generation

Solids will be generated during the pH adjustment and oxidation step. The majority of the solids will be from the precipitation of iron, manganese, and magnesium. Additional solids may result from sulfate compounds. Although other metals are present (such as cadmium), their concentrations are so low compared to iron, manganese, magnesium, and calcium, they don't need to be calculated individually. Flow rate is 50 gpm. Fe and Mg will precipitate by hydroxide reactions. Ca will react with available alkalinity (about 60 mg/L as CaCO3 is available). Mn will precipitate as an oxide after oxidation.

Assume:

$Fe\ (III) + 3\ OH^- \rightarrow Fe\ (OH)_3$ (MW = 107)

$Mn(II) \rightarrow MnO_2$ (MW = 87)

$Mg + 2\ OH^- \rightarrow Mg\ (OH)_2$ (MW = 58)

$Ca^{2+} + CO_3^{2-} \rightarrow CaCO_3$ (MW = 100)

Base inorganic concentrations of filtered results because over time, no suspended solids will be generated by the wells. Use average concentrations times a factor of 1.5 rather than maximums. These cations will generally be consistent in concentrations.

Fe – 47,000 ug/L MW = 56

Mn – 7,600 ug/L MW = 55

Mg – 97,000 ug/L MW = 24

Ca – 82,000 ug/L MW = 40

Flow rate = Q = 50 gpm

Estimate $Fe\ (OH)_3$ rate:

50 gal/min x 1,440 min/day x 3.785 L/gal x 47,000 ug Fe/L x 107 ug $Fe\ (OH)_3$ /56 ug Fe x 1 g/$10^6$ ug x 1 lb/454 g = 54 lb $Fe\ (OH)_3$ /day

Estimate MnO2 rate:

50 gal/min x 1,440 min/day x 3.785 L/gal x 7,600 ug Mn/L x 87 ug MnO2 /55 ug Mn x 1 g/$10^6$ ug x 1 lb/454 g = 7 lb MnO2 /day

Estimate $Mg\ (OH)_2$ rate:

From literature, typical endpoint Mg concentration from cold lime softening is 60 mg/l Mg as CaCO3. But the conditions will not be ideal for softening (shorter residence time), so assume 120 mg/L as CaCO3.

To convert Mg concentration of ion to equivalent as CaCO3, multiply Mg concentration by 4.12. (from Permutit Data Book)

Similarly, to convert Mg as CaCO3 to Mg, divide the equivalent by 4.12.

So, final concentration of Mg assumed to be 120 mg/L as CaCO3/4.12 = ~30 mg/L Mg.

Amount of Mg precipitated (volume basis) = 97 mg/L – 30 Mg/L = 67 Mg/L.

Estimate Mg $(OH)_2$ rate:

50 gal/min x 1,440 min/day x 3.785 L/gal x 67 Mg mg/L x 58 mg MgOH2 /24 mg Mg x 1 g/$10^3$ mg x 1 lb/454 g = 97 lb Mg(OH)2 /day

Estimate CaCO3 rate

Assume that the alkalinity at 60 mg/L as CaCO3 precipitates the same equivalent of calcium.

Equivalent weight of Ca is 2.5.

60 mg/L Ca x 1/2.5 = 24 mg/L Ca

MW CaCO3 – 100

24 mg/L Ca x 100 mg CaCO2/40 mg Ca = 60 mg/L CaCO3 precipitates

50 gal/min x 1,440 min/day x 3.785 L/gal x 60 CaCO3 mg/L x 1 g/$10^3$ mg x 1 lb/454 g = 36 lb CaCO3 /day

Total = 54 + 7 + 36 + 97 = 194 lb/day

To account for other solids, use 200 lb/day solids

Sludge flow rates
Assume sludge from clarifier is 0.5% solids.
Assume sludge from thickener is 4% solids.
Assume sludge from filter press is 30% solids.

Estimate volumetric sludge rate from clarifier:

200 lb solids/day x 1 lb sludge/0.005 lb solid x 1 gal/8.34 lb = 4,800 gal/day

Estimate volumetric sludge rate from thickener underflow:

200 lb solids/day x 1 lb sludge/0.04 lb solid x 1 gal/8.34 lb = 600 gal/day

Estimate sludge rate from filter press:

(Assume typical concentration of 25 lb solids per cubic feet of dewatered sludge)

200 lb solids/day x 1 ft3 dewatered sludge/25 lb solids = 8 ft3/day

[Use 8 ft3/day for filter press sizing]

These rates apply to Alternatives G-2, G-3, and G-5. For Alternative G-4, the rates will be scaled directly to the flow rate (100 gpm).

## pH ADJUSTMENT/WASTEWATER NEUTRALIZATION

| $H_2SO_4$ (100%) | HCl (100%) | pH | NaOH (100%) | $Ca(OH)_2$ (100%) |
|---|---|---|---|---|
| 49 g/L | 36.5 g/L | 0 | 40 g/L | 37 g/L |
| 4.9 g/L | 3.65 g/L | 1 | 4.0 g/L | 3.7 g/L |
| 0.49 g/L | 0.365 g/L | 2 | 0.4 g/L | 0.37 g/L |
| 49 mg/L | 36.5 mg/L | 3 | 40 mg/L | 37 mg/L |
| 4.9 mg/L | 3.65 mg/L | 4 | 4.0 mg/L | 3.7 mg/L |
| 0.49 mg/L | 0.365 mg/L | 5 | 0.4 mg/L | 0.37 mg/L |
| 0.049 mg/L | 0.0365 mg/L | 6 | 0.04 mg/L | 0.037 mg/L |
| | | 7 | | |
| 0.049 mg/L | 0.0365 mg/L | 8 | 0.04 mg/L | 0.037 mg/L |
| 0.49 mg/L | 0.365 mg/L | 9 | 0.4 mg/L | 0.37 mg/L |
| 4.9 mg/L | 3.65 mg/L | 10 | 4.0 mg/L | 3.7 mg/L |
| 49 mg/L | 36.5 mg/L | 11 | 40.0 mg/L | 37 mg/L |
| 0.49 g/L | 0.365 g/L | 12 | 0.4 g/L | 0.37 g/L |
| 4.9 g/L | 3.65 g/L | 13 | 4.0 g/L | 3.7 g/L |
| 49 g/L | 36.5 g/L | 14 | 40 g/L | 37 g/L |

Note: $pH_o$ and $pH_f$ mean initial and final pH, respectively. Units used in table must be corrected in calculations.

Calculation of:

Acid Requirement:

- If $pH_o > 7.0$ and $7.0 \leq pH_f < pH_o$, subtract the acid requirement for $pH_f$ from that for $pH_o$.
- If $pH_o > 7.0$ and $pH_f \leq 7.0$, add the acid requirement for $pH_f$ to that for $pH_o$.
- If $pH_o < 7.0$ and $pH_f < pH_o$, subtract the acid requirement for $pH_o$ from that for $pH_f$.

Base Requirement:

- If $pH_o \geq 7.0$ and $pH_f > pH_o$, subtract the base requirement for $pH_o$ from that for $pH_f$.
- If $pH_o \leq 7.0$ and $pH_f > 7.0$, add the base requirements.
- If $pH_o < 7.0$ and $pH_o < pH_f < 7.0$, subtract the base requirement for $pH_f$ from that for $pH_o$.

| **Tetra Tech NUS** | | | *STANDARD CALCULATION SHEET* |
|---|---|---|---|
| CLIENT: Lockheed Martin – Martin State Airport – DRA Site FS | FILE No: | BY: JWL | PAGE: 1 of 1 |
| SUBJECT: Sand Filter – Back wash rate | | CHECKED BY: CAH | DATE: 4/9/10 |

Estimate the backwash flow rates to be used for preliminary sizing of backwash tanks. Base calculation on 50 gpm. (Alternatives G-2, G-3, and G-5)

Assume typical sand filter feed rate of 5 gpm/ft2 (per Siemens quote )

Three sand filters, each 2.5 feet in diameter. (Same filters for 50 and 100 gpm case)

Per Siemens quote, use backwash rate per filter of 40 gpm for 16 minutes.

Estimated backwash volume is 633 gallons, use 800 gallon per backwash, per filter.

Volume of BW:

Although not typical, assume that all three sand filters were backwashed in succession, so volume is 3 x 800 = 2,400 gallons

Backwash of GAC and IE will be needed occasionally when fresh material is added, but will be of shorter duration and lower flow rate, so assume an additional 2,000 gallons volume.

V = 2,400 + 2,000 = 4,400 gal

V = 4,400 gal x 1 ft3/7.481 gal = 588 ft3

Assume a tank diameter (D) of 8 feet.

$V = \pi D^2 H/4$, where H is tank height

$588\ ft3 = \pi 8^2 H/4 \rightarrow H = 12$ feet

$\pi\ 8^2 12/4 \times 7.481\ gal/ft3 = 4{,}500\ gal$ (OK)

These dimensions will be used for Backwash Storage Tank and Waste Backwash Storage Tank.

Estimate return rate of waste backwash (800 gallons) to Feed Tank for different durations:

20 hour – rate = 800 gallons/(20 hr x 60 min/hr) = 0.7 gpm
12 hour – rate = 800 gallons/(12 hr x 60 min/hr) = 0.1 gpm

Use flow rate of 1 gpm.

Same size BW tanks and pumps for 100 gpm and 50 gpm case.

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| SUBJECT: Groundwater treatment – Feed Tank | | CHECKED BY: CAH | DATE: 4/9/10 |

**Estimate size of Feed Tank for 50 gpm case.**

Purpose of Feed Tank is to provide some nominal equalization, mixing of internal streams (such as waste backwash), and level control for the feed pump.

For tank height assume:

- 1 foot to maintain flooded pump suction
- 1 foot of freeboard above LAH
- Place low level switch (pump off) 1 foot above flooded suction level
- Place high level switch (pump on) 1 foot below LAH
- Start with 4 to 6 feet for pump control and to minimize cycling of feed pump.
- Allow 3,000 gallons surge capacity for miscellaneous backwash and water from dewatering.

Try tank 12 feet D and 12 feet H (4 feet for first 4 items above, and 8 feet for working volume and surge).

Check minimum pump operating volume (on-off) per Flygt article. Minimum condition, where 1/2 Qo equals Q in has been substituted in the Flygt article equation:

Min Volume (gal) = $60/(N\Phi) \times (Qo/4)$

Where:
N = number of pumps in automatic alternation system = 1
$\Phi$ = allowable motor starts per hour = 8 (assumed, typical is 10)
Qo = flow out of pump = 50 gpm

Min Volume (gal) = $60/(1 \times 8) \times (50/4) = 94$ gal

94 gal x 1 ft3/7.481 gal = 12.6 ft3

At 12 ft D, the change in height is:

12.6 Ft3/$12^2\pi/4$ ft2 = 0.1 ft, so there is enough change in height in the initial assumption above.

Check for surge volume change in height:

3,000 gal x 1 ft3/7.481 gal x $1/12^2\pi/4$ ft2 = 3.5 feet, so here is sufficient height and volume for tank operation.

Total height (excluding height between pump start and pump stop): 1 + 1 + 1 + 1 + 3.5 = 7.5

For uncertainties at this stage, allow 4 more feet = 7.5 + 4 = 11/5 feet, use 12 feet.

Feed Tank – 12 feet D x 12 feet H, 10,200 gal

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| SUBJECT: Groundwater treatment – Feed Tank | | CHECKED BY: CAH | DATE: 4/9/10 |

Size for 100 gpm case:

Target volume for approximately 100 gpm/50 gpm x 10,200 gal = 20,400 gal.

Maintain same height

Try 18 feet D

$V = 18^2\pi/4 \times 12 \times 7.481$ gal/ft3 = 22,800 gallons (Okay)

$V_1 = \frac{60}{N\phi}\left[0.25\,Q_2\right]$ // AT $N=1$ and $\phi=5$, $V_1 = 3Q_2$ or 3 minutes.

**Pump Starts Per Hour**

Now we have gotten to the point where the permissible number of starts per hour of the pump selected becomes an important factor. One of the advantages of submersible pumps is their substantially greater start capability than dry pit pumps. Flygt pumps, for example, normally operate with 10 starts per hour, and it is permissible to utilize up to 15 starts per hour for specific applications where sump volumes must be maintained at a minimum. In addition to adhering to the manufacturer's recommendations for maximum pump starts per hour, it is also imperative to consider the recommendations of the starting equipment manufacturer to assure that the number of starts permitted by the latter does not exceed the number of starts capability of the contactors. The electrical control equipment must be compatible with the pump motors. Specifying a single source for pumps, motors, and controls assures such compatibility.

The number of starts per hour, together with the number of pumps used in the station, will determine the minimum sump capacity, and this will be our next consideration. To determine the required volume, we begin by calculating the minimum pumping volume per cycle, which is determined by the turn-on and shut-off points in the pit.

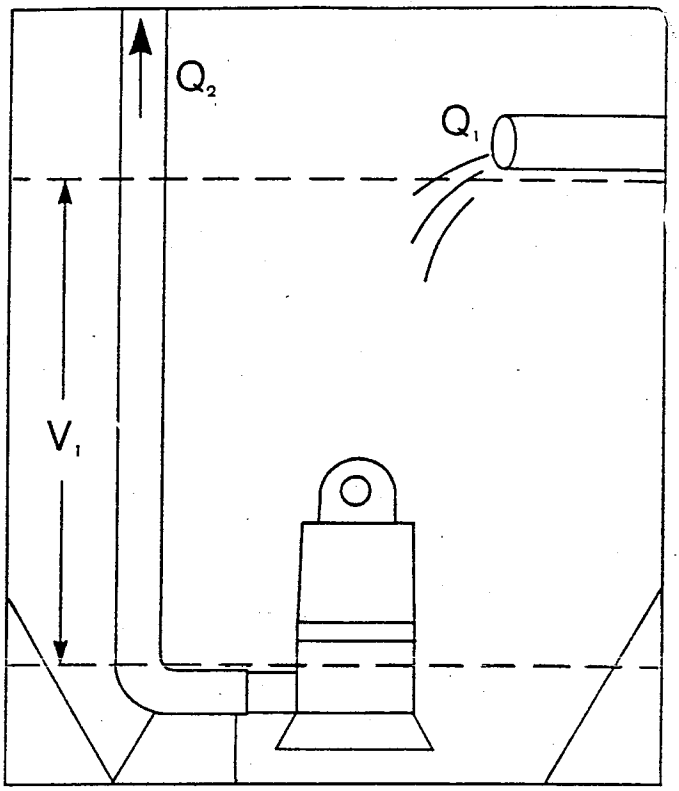
The formula for determining the minimum pumping volume per cycle is $V_1 = \frac{60}{N\phi}\left[\frac{Q_1}{Q_2}(Q_2-Q_1)\right]$. $V_1$ stands for the required minimum pumping volume per cycle, N is the number of pumps alternating in the system, $\phi$ is the permissible number of starts per hour per pump, $Q_1$ is the rate of influent flow in gallons per minute, and $Q_2$ is the rate of pump discharge in gallons per minute.

Now this formula can be reduced in terms of time (T), which is a determinant of volume $V_1$. By taking the first differential of the equation containing both $V_1$ and T and equating it to zero, we determine that minimum pumping volume per cycle occurs when $Q_1$ is ½ of $Q_2$ (or when the inflow to the station is ½ the pump capacity). To repeat, these calculations will provide us with the requirements for the minimum volume permitted by the number of starts per hour. Any volume below the minimum will necessitate more starts per hour and possibly exceed the capacity of the pump. If we apply the formula to a duplex pump station with one pump operating as an alternating active standby, and calculate on the basis of 10 starts per hour, then $V_1$ becomes .75 of $Q_2$ or the required operating minimum volume between pump turn-on and shut-off is ¾ of the pump capacity.

A final refinement of the preliminary selection of pumps, pumping station depth, and its diameter or area is now in order. Utilizing the preliminary sump depth assumption, the shutoff point for the pump selected, the diameter or area assigned for the pump station, and having calculated the required minimum volume, it is now possible to determine if the assumed pump station depth selected agrees with requirements. If the assumed sump volume is excessive or inadequate, the pump station depth can be altered to suit the requirements. It then becomes necessary to make corrections to the head curve as well as the other considerations to end up with a properly designed pumping station. If the sump volume has been determined as excessive, diminution of wet well depth can provide significant savings in station construction.

**Final Design**

With all the pump and pumping station details established, we are now at the final design stage. The final design includes the layout of the pumps, controls, and valves, as well as the miscellaneous accessories. It also includes final setting of the turn-on and shut-off of the pumps and the alarm system.




Minutes "on" $= t_1 = \frac{V_1}{Q_2-Q_1}$ Minutes "off" $= t_2 = \frac{V_1}{Q_1}$

Complete cycle $= t_1 + t_2 = t_3$

Single pump (of "N" pumps) cycles/hr. $= \phi$

$$\phi = \frac{60}{t_3 \cdot N} = \frac{60}{NV_1}\left[\frac{Q_1}{Q_2}(Q_2-Q_1)\right]$$

Required pumping vol./cycle $= V_1$

$$V_1 = \frac{60}{N\phi}\left[\frac{Q_1}{Q_2}(Q_2-Q_1)\right]$$

For 2 pumps and 10 cy./hr./pump $V_1 = 0.75\,Q_2$

Important factors to be considered in the layout are the location of the pumps and the pump discharge relative to the inflow sewer. The liquid level controls should be placed in a quiescent area away from the incoming flow or protected in one of several ways from direct impingement.

Another item is the location of the check valves in the system. Certain states require an external chamber for the valves so that maintenance department personnel need not enter the wet well to service the valves.

Final design will also include considerations for future needs such as possible increased capacity. In the latter instance, the control panel should be large enough to accommodate future larger breakers and starting equipment if necessary.

The type of alarm system must also be selected and designed into the control system. Options include a local or a remote alarm system. Local systems generally make use of bells, horns, and lights. A remote system will require a means of transmitting the signal from the local station to a location such as the treatment plant or a police or fire station.

I have attempted in this relatively short paper to outline certain of the basic considerations to be followed in the design of small and medium size submersible pump stations. A refinement in detail would require a much longer paper. However, I believe that the major factors for consideration have been touched on sufficiently to alert pump station designers to possible major items where care should be exercised to assure a safe, dependable and economical submersible pump station.

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| CLIENT: Lockheed Martin – Martin State Airport – DRA Site FS | FILE No: | BY: JWL | PAGE: 1 of 1 |
| SUBJECT: Groundwater treatment system. Clarified Water Feed Tank and Discharge Pump Tank size. | | CHECKED BY: CAH | DATE: 4/9/10 |

Estimate the size of the Clarified Water Feed Tank for 50 gpm case. This will also be the size of the Discharge Pump Feed Tank.

Purpose of tank is to provide working volume for pump. Assume on-off operation of pump.

For tank height assume:

- 1 foot to maintain flooded pump suction
- 1 foot of freeboard above LAH
- Place low level switch (pump off) 1 foot above flooded suction level
- Place high level switch (pump on) 1 foot below LAH
- Use 2 to 4 feet for pump control and working volume.

Small diameter tank.

Check pump operating volume (on-off) per Flygt article

Min Volume (gal) = $60/(N\Phi) \times (Qo/4)$

Where:
N = number of pumps in automatic alternation system = 1
$\Phi$ = allowable motor starts per hour = 8 (assumed, typical is 10)
Qo = flow out of pump = 50 gpm

Min Volume (gal) = 60/(1 x8) x (50/4) = 94 gal

94 gal x 1 ft3/7.481 gal = 12.6 ft3

Try 4 ft D, and check a working height of 4 feet:

$V = 4^2\pi/4 \times 4 \times 7.481$ gal/ft3 = 376 gallons (Okay)

Tank will be 4 feet D x 8 feet high

Tank $V = 4^2\pi/4 \times 8 \times 7.481$ gal/ft3 = 750 gallons

This is for both the Clarified Water Feed Tank and Discharge Pump Feed Tank.

Calculate 100 gpm case

Scale volume to flow rate

Target volume is 100 gpm/50 gpm x 750 gal = 1,500 gal

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| SUBJECT: Groundwater treatment system. Clarified Water Feed Tank and Discharge Pump Tank size. | | CHECKED BY: CAH | DATE: 4/9/10 |

Use same H to maintain hydraulics

Try 6 feet D x 8 feet H:

Tank V = $6^2\pi/4$ x 8 x 7.481 gal/ft3 = 1,690 gallons.

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| CLIENT: Lockheed Martin – Martin State Airport – DRA Site FS | FILE No: | BY: JWL | PAGE: 1 of 2 |
| SUBJECT: Groundwater treatment system. Air Stripper size and Vapor-Phase GAC | | CHECKED BY: CAM | DATE: 4/9/10 |

**Air Stripper**
Estimate the size of the air stripper for the 50 gpm and 100 gpm cases.

Air stripper sizes were estimated using QED Environmental model at their website. The stripper was sized so that the effluent VOC concentrations would be less than MCLs so that the AOP system would only be treating the 1,4-dioxane.

Based on the model output and information from the QED website (attached) the characteristics of the air strippers are as follows:

50 gpm case

EZ-Tray 8.6 with 6 trays, 75 gpm maximum flow rate, 420 cfm blower with 5 hp motor.

100 gpm case

EZ-Tray 16.6 with 6 trays, 150 gpm maximum flow rate, 850 cfm blower with 7.5 hp motor.

**Vapor-Phase GAC**

The QED stripper model output provides a vapor stream composition, and this information was put into a spreadsheet (attached) to estimate the GAC requirement. GAC usage was calculated for a daily, monthly, and annual rates. Based on this, the monthly rate was selected.

The GAC system will have two GAC tanks, each containing sufficient GAC for 1 month operation.

Per the spreadsheet, for 50 gpm, the GAC rate is 4,000 lb/month, so there will be two tanks, each containing 4,000 lb GAC.

For 100 gpm, the GAC rate is 9,000 lb/month, so there will be two tanks, each containing 9,000 lb GAC.

**Electric Heater for Vapor to GAC**

Need electric heater to raise temperature of air stripper discharge to 80% relative humidity (RH).

Assume air temperature equals water temperature, about 50 F.

Using a psychrometric chart:

Enthalpy (BTU/lb dry air) at 50 F, 100 % RH = 20.4
Follow line of constant moisture:
Enthalpy (BTU/lb dry air) at 56.5 F, 80 % RH = 22.0

Δenthalpy (BTU/lb dry air) = 1.6

Specific weight of dry air (from chart) = 13 ft3/lb dry air = 0.077 lb dry air/Ft3

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| CLIENT: Lockheed Martin – Martin State Airport – DRA Site FS | FILE No: | BY: JWL | PAGE: 2 of 2 |
| SUBJECT: Groundwater treatment system. Air Stripper size and Vapor-Phase GAC | | CHECKED BY: CAH | DATE: 4/9/10 |

Q air = 420 scfm (because pressure change is very small, this can be used.)

1 kw = 0.9478 BTU/sec

Power = 420 ft3/min x 1 min/60 sec x 0.077 lb air/ft3 x 1.6 BTU/lb air x 1 kw/(0.9478 BTU/sec) = 0.91 kw

Assume 75% efficiency: 0.91/0.75 = 1.2 kw, round to 2 kw.

For 100 gpm case, use 4 kw.

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| CLIENT: Lockheed Martin – Martin State Airport – DRA Site FS | FILE No: | BY: JWL | PAGE: 1 of 1 |
| SUBJECT: Groundwater treatment system. Potassium permanganate impregnated zeolite | | CHECKED BY: CAH | DATE: 4/9/10 |

Estimate the usage rate of potassium permanganate impregnated zeolite (PPIZ) to remove vinyl chloride from air stripper offgas. Estimate quantity for 50 gpm case and double those values for 100 gpm case.

Per Carbonair, the loading rate of vinyl chloride on PPOZ is 1.4% by weight. The vinyl chloride reacts with and consumes the PP, and the spent zeolite is disposed of as a non-hazardous waste.

From the vapor-phase GAC spreadsheet, the vinyl chloride rates are:

50 gpm – 44.6 lb/mo

100 gpm – 89.2 lb/mo

1.4% loading equals 1.4 lb vinyl chloride (VC)/100 lb PPIZ.

50 gpm

44.6 lb VC/mo x 100 lb PPIZ/1.4 lb VC = 3,186 lb/mo, use 3,000 lb/month.

100 gpm

89.2 lb VC/mo x 100 lb PPIZ/1.4 lb VC = 6,370 lb/mo, use 6,000 lb/month.

At 60 lb/ft3, estimate the tank size.

50 gpm

3,000 lb x ft3/60 lb = 50 ft3

$V = 4^2\pi/4 \times 6 = 75$ ft3 → 4 feet diameter x 6 feet high

100 gpm

6,000 lb x ft3/60 lb = 100 ft3

$V = 6^2\pi/4 \times 6 = 170$ ft3 → 6 feet diameter x 6 feet high

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| CLIENT: Lockheed Martin – Martin State Airport – DRA Site FS | FILE No: | BY: JWL | PAGE: 1 of 1 |
| SUBJECT: Groundwater treatment system – Liquid-phase GAC estimate | | CHECKED BY: CAH | DATE: 4/9/10 |

Estimate liquid-phase GAC requirement based on design flows and concentrations. Note that concentrations will significantly decrease with time and that air stripper and AOP system will destroy/remove most of the organic compounds.

Size for 50 gpm.

Post-AOP concentrations will be MCLs, although GRO and DRO may be high.

Use average DRO and GRO for design basis. Assume 25% removal by the air stripper and AOP.

Untreated water:

DRO – 300 µg/L
GRO – 900 µg/L

Post AOP (based on 25% removal)

DRO – 0.75 x 300 µg/L = 225 µg/L
GRO – 0.75 x 900 µg/L = 675 µg/L

Mass Rate

DRO

225 µg DRO/L x 50 gal/min x 1,440 min/day x 3.785 L/gal x 1 g/$10^6$ µg x 1 lb/454 g = 0.14 lb GRO/day

GRO

675 µg DRO/L x 50 gal/min x 1,440 min/day x 3.785 L/gal x 1 g/$10^6$ µg x 1 lb/454 g = 0.4 lb DRO/day

Total = 0.14 + 0.4 = 0.54 lb/day, use 0.6 lb/day

GAC Volume
Check volume based on empty bed contact time (EBCT)

Base on 20 minute EBCT

50 gal/min x 20 min = 1,000 gallons (assume 2 tanks)

Mass of GAC per tank

1,000 gal x 1 ft3/7.481 gal x 30 lb GAC/ft3 = 4,000 lb GAC

Estimate replacement rate at 10 lb GAC per lb DRO/GRO

4,000 lb GAC x 1 lb DRO-GRO/10 lb GAC x 1 day/0.6 lb DRO-GRO = 660 days

This is more than sufficient. Actual change out will occur more frequently, and as a safety factor, the change-out rate is assumed to be semi-annual.

For the 100 gpm case, the tanks will be larger for a higher EBCT (Two tanks at 2,000 gallons each with 8,000 lb GAC per tank.)

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| SUBJECT: Groundwater Treatment – Thickener size | | CHECKED BY: CAH | DATE: 4/9/10 |

Estimate the size of the thickener. Assume that this will be a small diameter unit for inorganic solids, and a plain tank without a rake will be sufficient.

The thickener thickens sludge from 0.5% to 4% by gravity.

Thickener will be able to hold 10 days of 4% sludge (for weekly filter press runs)

(See Sludge generation calculations for quantity estimation.)

Volume 0.5% sludge = 4,800 gal/day

Volume 4% sludge = 600 gal/day

Mass solids rate = 200 lb/day

Typical sizing factor for iron sludge is 2 to 10 lb per ft2-day. Use the low end of the range: 2 lb/ft2-day

200 lb/day x ft2-day/2 lb = 100 ft2

$A = \pi D^2/4 = 100$ ft2 → D = 11.3 ft, use 12 feet.

Assume 12 feet high (1 foot freeboard)

Assume pumping to thickener would be intermittent. Use 1 pumping cycle per hour for 15 minutes per cycle:

Q = 4,800 gal/24 cycles x 1 cycle/15 minutes = 13.3 gpm (use 15 gpm) as the flow rate for the sludge transfer pump

Check sludge inventory:

Volume per foot:

$V = \pi D^2 H/4 \times 7.481 = \pi 12^2 1/4 \times 7.481$ gal/ft3 = 846 gal/foot

Ten days of 4% sludge = 10 x 600 gal/day = 6,000 gal

Assume 9 feet of height is available:

Sludge storage volume = $\pi D^2 H/4 \times 7.481 = \pi 12^2 9/4 \times 7.481$ gal/ft3 = 7,600 gal (this is sufficient)

Overall: 12 feet Dia x 12 feet high, 10,000 gal

<u>For 100 gpm case</u>

Use the same height for hydraulics. Scale area to flow rate.

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| SUBJECT: Groundwater Treatment – Thickener size | | CHECKED BY: CAH | DATE: 4/9/10 |

Area = 100 gpm/50 gpm x 100 ft 2 = 200 ft2

$A = \pi D^2/4 = 200$ ft2 → D = 15.9 ft, use 16 feet.

Overall: 16 feet Dia x 12 feet high, 18,000 gal

(These sizes are similar to Siemens quoted equipment.)

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| CLIENT: Lockheed Martin – Martin State Airport – DRA Site FS | FILE No: | BY: JWL | PAGE: 1 of 1 |
| SUBJECT: Groundwater treatment system – Filtrate Tank | | CHECKED BY: CAH | DATE: 4/9/10 |

Estimate size of Filtrate Tank for 50 gpm case. This receives overflow from thickener and filtrate from filter press. The tank also provides pump control (on and off) for Filtrate Transfer Pump.

Size based on 7 days of 4% sludge. This water volume will be conservatively estimated to be the thickened sludge flow rate. Assume entire flow as water.

Sludge rate is 600 gal/day

600 gal/day x 7 day = 4,200 gallons. Use 4,400 gallons.

Tank needs to be low in height to receive water by gravity from thickener overflow and from the filter press. Thickener is 12 feet high, and filter press will be mounted on an elevated platform, 8 to 10 feet above the flow.

10 feet D x 8 feet H

$V = 10^2\pi/4 \times 8 \times 7.481$ gal/ft3 = 4,700 gallons (Okay)

Filtrate Transfer Pump will be sized to match Sludge Transfer Pump = 15 gpm.

<u>100 gpm case</u>

Scale according to flow rates. Use 8 feet height.

V = 100 gpm/50 gpm x 4,700 gal = 9,400 gal

14 feet D x 8 feet H

$V = 14^2\pi/4 \times 8 \times 7.481$ gal/ft3 = 9,200 gallons (Okay)

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| CLIENT: Lockheed Martin – Martin State Airport – DRA Site FS | FILE No: | BY: JWL | PAGE: 1 of 1 |
| SUBJECT: Groundwater treatment system – Filter Press Pump and Filter press | | CHECKED BY: CAH | DATE: 4/9/10 |

Estimate size of filter press:

Assume 8 ft3 day of dewatered sludge (see separate calculation).

Assume press is operated weekly, so 7 days of sludge is processed.

V = 7 day x 8 ft3/day = 56 ft3

Provide capability for 10 days:

V = 10 day x 8 ft3/day = 80 ft3

Estimate size of Filter Press Feed Pump

Size for pumping 7 days of 4% sludge in 4 hours

7 days x 600 gal / (4 x 60 minutes) = 17.5 gpm use 20 gpm

Use an air-operated double diaphragm pump.

For 100 gpm case, scale to flow rate:

100 gpm/50 gpm x 80 ft3 = 160 Ft3

(Siemens quote had a 25 Ft3 unit, so cost estimate will be increased for a larger filter press.)

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| CLIENT: Lockheed Martin – Martin State Airport – DRA Site FS | FILE No: | BY: JWL | PAGE: 1 of 1 |
| SUBJECT: Groundwater treatment system – Building Sump | | CHECKED BY: CAH | DATE: 4/9/10 |

Estimate size of Building sump.

Sump is intended to capture small spills and miscellaneous small drains. Contents would be pumped to Feed Tank. A major spill would be contained entirely within the building.

Assume 8 feet x 8 feet and 6 feet deep. Opening would be covered by a steel grating.

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| CLIENT: Lockheed Martin – Martin State Airport – DRA Site FS | FILE No: | BY: JWL | PAGE: 1 of 5 |
| SUBJECT: Groundwater treatment system – Pump sizes | | CHECKED BY: CAH | DATE: 4/9/10 |

Estimate pump sizes for wastewater pumps in the groundwater treatment system for 50 gpm case.

1. Feed Pump

Transfers water from the Feed Tank to the Metals Removal Step

Pressure losses and static head:

| Item | Δh, feet |
|---|---|
| Static head – based on estimated height of clarifier | 20 feet |
| Piping losses: 4" Sch 80 PVC (0.21ft/100feet). Assume 150 equivalent feet of piping. Δh = 150 feet x 0.21 ft/100 ft = | 0.3 |
| Meters (flow meter) assume 5 psi = 12 feet | 12 |
| | |
| Total | 32.3 |

Use ΔH = 40 feet

Estimate motor horsepower (assume 70% efficiency)
Pump hp = (50 gpm x 40 feet)/(3,960 x 0.7) = 0.72 → use 1 hp

100 gpm case:

Pump hp = (100 gpm x 40 feet)/(3,960 x 0.7) = 1.4 → use 1.5 hp

2. Clarified Water Pump

Transfers water from Clarified water Tank through Sand Filters, to Air Stripper.

Pressure losses:

| Item | Δh, feet |
|---|---|
| Static head – based on estimated height of Air Stripper | 10 |
| Sand Filter: Use 10 psi. 10 psi x 2.3 feet/psi = 23 feet | 23 |
| | |
| | |
| | |
| | |
| | |
| Total | 33 |

Use ΔH = 40 feet

Estimate motor horsepower (assume 70% efficiency)
Pump hp = (50 gpm x 40 feet)/(3,960 x 0.7) = 0.7 → use 1 hp

100 gpm case:

Pump hp = (100 gpm x 40 feet)/(3,960 x 0.7) = 1.5 → use 2 hp

3. Stripper Effluent Pump

Transfers water from Stripper Effluent sump through HiPOx, GAC, IE, and into BW supply tank and Discharge Pump Tank.

Pressure losses:

| Item | Δh, feet |
|---|---|
| Static head – based on estimated height of backwash supply tank | 10 |
| HiPOx: Use 15 psi. 15 psi x 2.3 feet/psi = 35 feet | 35 |
| GAC: Use 10 psi. 10 psi x 2.3 feet/psi = 23 feet | 23 |
| IE tank: Use 5 psi. 5 psi x 2.3 feet/psi = 12 feet | 12 |
| | |
| | |
| Total | 80 |

Use ΔH = 90 feet

Estimate motor horsepower (assume 70% efficiency)
Pump hp = (50 gpm x 90 feet)/(3,960 x 0.7) = 1.6 → use 3 hp

100 gpm case:

Pump hp = (100 gpm x 90 feet)/(3,960 x 0.7) = 3.2 → use 5 hp

4. Backwash Pump

Backwashes sand filter.

Per vendor, flow rate is 40 gpm

Pressure losses:

| Item | Δh, feet |
|---|---|
| Static head – estimated | 12 |
| Tank – assume 10 psi: 10 psi x 2.3 feet/psi = 23 feet | 23 |
| Miscellaneous piping losses. Assume 5 feet | 5 |
| | |
| | |
| | |
| | |
| Total | 40 |

Use ΔH = 40 feet

Estimate motor horsepower (assume 70% efficiency)
Pump hp = (40 gpm x 40 feet)/(3,960 x 0.7) = 0.6 → use 1 hp

100 gpm case:

Same filters are used, so pump is the same.
Pump hp = (40 gpm x 40 feet)/(3,960 x 0.7) = 0.6 → use 1 hp

5. Waste Backwash Pump

Transfers waste backwash from Waste Backwash Tank to the Feed Tank.

Assume 1 gpm.

Pressure losses:

| Item | Δh, feet |
|---|---|
| Static head | 12 |
| Miscellaneous piping losses. Assume 5 feet | 5 |
| | |
| | |
| Total | 17 |

Use ΔH = 20 feet

Estimate motor horsepower (assume 70% efficiency)
Pump hp = (1 gpm x 20 feet)/(3,960 x 0.7) = 0.07 → use 0.5 hp

100 gpm case:

Use the same size. 0.5 hp.

6. Sump Pump

Transfers water Building Sump to Feed Tank.

Assume 10 gpm.

Pressure losses:

| Item | Δh, feet |
|---|---|
| Static head – bottom of sump to floor | 10 |
| Static head – Floor to top of Feed Tank | 12 |
| Miscellaneous piping losses. Assume 5 feet | 5 |
| | |
| Total | 27 |

Use ΔH = 30 feet

Estimate motor horsepower (assume 70% efficiency)
Pump hp = (10 gpm x 30 feet)/(3,960 x 0.7) = 0.1 → use 0.5 hp

100 gpm case:

Use the same size. 0.5 hp.

7. Filtrate Transfer Pump

Transfers water from Filtrate Tank to Feed Tank.

Assume 15 gpm.

Pressure losses:

| Item | Δh, feet |
|---|---|
| Static head | 12 |
| Miscellaneous piping losses. Assume 5 feet | 5 |
| | |
| | |
| Total | 17 |

Use ΔH = 20 feet

Estimate motor horsepower (assume 70% efficiency)
Pump hp = (15 gpm x 20 feet)/(3,960 x 0.7) = 0.1 → use 0.5 hp

100 gpm case:

Pump hp = (15 x (100/50) gpm x 20 feet)/(3,960 x 0.7) = 0.2 → use 0.5 hp

7. Discharge Water Pump

Transfers water Discharge Tank to Sanitary sewer tie-in near road and injects water into injection wells. Size for injection.

Length of pipe is 3,900 feet
Assume 200 equivalent feet for fittings
Total; equivalent length is 4,100 feet

Assume 4" dia Sch 80 PVC, Δh = 0.21ft/100 feet

Assume 10 psi for injection = 10 psi x 2.3feet/psi = 23 feet

Pressure losses:

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|---|---|---|---|
| CLIENT: Lockheed Martin – Martin State Airport – DRA Site FS | FILE No: | BY: JWL | PAGE: 5 of 5 |
| SUBJECT: Groundwater treatment system – Pump sizes | | CHECKED BY: CAH | DATE: 4/9/10 |

| Item | Δh, feet |
|---|---|
| Static head | 0 feet |
| Piping losses: Δh = 4,100 feet x 0.21 ft/100 ft = 8.6, use 10 foot | 10 |
| Meter (flow meter) assume 5 psi = 12 feet | 12 |
| Injection losses | 23 |
| | |
| Total | 45 |

Use ΔH = 50 feet

Estimate motor horsepower (assume 70% efficiency)
Pump hp = (50 gpm x 50 feet)/(3,960 x 0.7) = 0.9 → use 1.5 hp

100 gpm case:

Pump hp = (100 gpm x 50 feet)/(3,960 x 0.7) = 1.8 → use 2 hp

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|---|---|---|---|
| CLIENT: Lockheed Martin – Martin State Airport – DRA Site FS | FILE No: | BY: JWL | PAGE: 1 of 1 |
| SUBJECT: Groundwater Treatment system - Mixers | | CHECKED BY: CAH | DATE: 4/9/10 |

Estimate mixer sizing for 50 gpm case, from vendor catalogue and Siemens quote.

| Mixer | Tank Volume, Gal | Mixer HP (50 GPM) | Mixer HP (100 GPM) |
|---|---|---|---|
| Feed Tank | 10,000 | 10 | 10 |
| Primary pH adj. Tank | - | 0.5 | 0.5 |
| Secondary pH adj. Tank | - | 0.5 | 0.5 |
| Flocculator | - | 0.5 | 0.5 |
| Final pH Adj. Tank | 1,000 | 0.5 | 1 |
| Filtrate Tank | 4,700 | 5 | 7.5 |

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|---|---|---|---|
| CLIENT: Lockheed Martin – Martin State Airport – DRA Site FS | FILE No: | BY: JWL | PAGE: 1 of 1 |
| SUBJECT: Groundwater Treatment System – Air Compressor | | CHECKED BY: CAH | DATE: 4/9/10 |

Air Compressor only needs to provide service to the sludge transfer pump, filter press feed pump, and filter press.

Assume a 100 psig unit that provides 50 scfm.

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|---|---|---|---|
| CLIENT: Lockheed Martin – Martin State Airport – DRA Site FS | FILE No: | BY: JWL | PAGE: 1 of 3 |
| SUBJECT: Groundwater treatment system – Chemical feed rates | | CHECKED BY: CAH | DATE: 4/9/10 |

Estimate chemical addition rates for 50 gpm case. For 100 gpm, rates will be increase by factor of 100/50 = 2.

1. Hydrogen peroxide ($H_2O_2$) for iron and manganese oxidation. Iron and manganese are assumed to be reduced. (See sludge calculations for Fe and Mn concentrations.).

For Fe(II) to Fe(III)

$2 Fe^{+2} + H_2O_2 + 4 OH^- \rightarrow 2 Fe(OH)_3$

From US Peroxide Website, the $H_2O_2$ rate for the iron (50 gpm and 47,000 ug/L) is 8.5 lb/day, use 9 lb/day

For Mn(II) to Mn(VI)

1 mole of $H_2O_2$ oxidizes 2 mole $e^-$

So 1 mole $H_2O_2$ oxidizes 1 mole Mn(II) to Mn(VI)

MW $H_2O_2$ = 34, MW Mn = 55

Concentration Mn = 7,600 µg/L

$H_2O_2$ for Mn:

50 gal/min x 1,440 min/day x 7,600 ug/L x 3.785 L/gal x g/$10^6$ ug x 1 lb/454 g x 34 lb $H_2O_2$/55 lb Mn = 3 lb $H_2O_2$/day

Total = 9 + 3 = 12 $H_2O_2$ lb/day

(100 gpm case is 2 x 12 = 24 $H_2O_2$ lb/day)

2. NaOH

Base this on chart to adjust pH from 6 to 11 for Cd removal, fast Fe oxidation, and precipitation of other metals.

pH from 6 to 7 needs 0.04 mg NaOH/L
pH from 7 to 11 needs 40 mg NaOH/L

Total for pH adjustment – 40.04 mg NaOH/L

50 gal/min x 1,440 min/day x 40.04 mg NaOH /L x 3.785 L/gal x g/$10^3$ mg x 1 lb/454 g = 24 NaOH lb/day

Additional hydroxide for Fe and Mg precipitation. (See Sludge estimate calculation.)

Estimated $Fe(OH)_3$ – 54 lb/day (MW = 107) (from sludge calculation)

Estimated Mg(OH)2 – 97 lb/day (MW = 58) (from sludge calculation)

MW NaOH = 40

NaOH for Fe(OH)3:
54 lb Fe(OH)3/day x (3 x 17 lb OH)/107 lb Fe(OH)3 x 40 lb NaOH/17 lb OH = 60 lb NaOH/day

NaOH for Mg(OH)2:

97 lb Mg(OH)2/day x (2 x 17 lb OH)/58 lb Mg(OH)2 x 40 lb NaOH/17 lb OH = 133 lb NaOH/day

Total NaOH = 24 + 60 + 133 = 220 lb/day

At 50% solution (s.g. = 1.2):

220 lb/day x 1 lb solution/0.5 lb NaOH x 1 gal/(8.34 x 1.2) lb = 44 gal/day NaOH 50% solution

(100 gpm case is 2 x 220 = 440 lb NaOH/day and 2 x 44 = 88 gal/day NaOH 50% solution)

3. HCl

Base this on chart to adjust pH from 11 to 7.

pH from 11 to 7 needs 36.5 mg HCl/L

50 gal/min x 1,440 min/day x 36.5 mg HCl /L x 3.785 L/gal x g/$10^3$ mg x 1 lb/454 g = 22 lb HCl/day

At 35% solution (s.g. = 1.2):

22 lb/day x 1 lb solution/0.35 lb HCl x 1 gal/(8.34 x 1.2) lb = 6.3 gal/day HCl 35% solution

(100 gpm case is 2 x 22 = 44 lb HCl/day and 2 x 6.3 = 12.6 gal/day HCl 35% solution)

4. Polymer (for coagulation and flocculation)

Assume typical concentration of 10 ppm.

50 gal/min x 1,440 min/day x 8.34 lb/gal x 10 lb polymer/$10^6$ lb water = 6 lb polymer/day

(100 gpm case is 6 x 2 = 12 lb/day)

5. H2O2 and ozone for HiPOx

See HiPOx Quote.




*Full-Service Chemical Treatment Programs for Municipal an*

# $H_2O_2$ Calculator

## Determine your hydrogen peroxide requirements for the treatment of 15 different reactants.

| | | |
|---|---|---|
| **Reactant:** | Iron (II) | |
| **Reactant Concentration:** | 47 | (mg/L) |
| **Waste Flow:** | 72000 | (gallons / day) |

Submit

*Notes: Calculations are based on continuous flow. If more than one type of reactive contaminant is present, enter the contaminants separately and add the H2O2 requirements together.*

| | |
|---|---|
| **Calculated lbs per day of Reactant:** | 28.2 lbs / day |
| **Calculated lbs per day of $H_2O_2$ (100%):** | 8.5 lbs / day |
| **Calculated $H_2O_2$ Requirement (50%):** | 1.7 gallons / day |
| **Hourly Dosing Requirement (50% $H_2O_2$):** | 0.07 gallons / hour |
| **Monthly Usage (50% $H_2O_2$):** | 50.8 gallons / month |
| **List Price per gallon (50% $H_2O_2$):** | $3.45 per gallon (full truck load, FOB manufacturer's site) |
| **Cost per day (based on above list price):** | $5.85 per day |
| **Reaction Equation(s):** | $2\ Fe^{2+} + H_2O_2 + 4\ OH^- \rightarrow 2\ Fe(OH)_3$ (ferrous iron + hydrogen peroxide → ferric acid) |

**Theoretical Weight Ratio:** 0.3 lbs $H_2O_2$ (100%) per lb $Fe^{2+}$

**Process Notes:**

Reaction occurs within seconds at neutral to alkaline pH

The ferric hydroxide product may be removed by precipitation or filtration

Manganese (II) may be removed concurrently through a similar conversion to $MnO_2$

**Note:** This information is provided for preliminary evaluation purposes only. The estimates are based upon theoretical requirements of $H_2O_2$ using 100% efficiency of reaction. Actual requirements may vary depending on the specific composition of the waste and the conditions under which the reaction is performed. It is user's responsibility to familiarize himself with the safe handling of $H_2O_2$ and to ensure that no patents or licenses are being infringed upon in practicing this reaction.

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| **Tetra Tech NUS** | | | *STANDARD CALCULATION SHEET* |
|---|---|---|---|
| CLIENT: Lockheed Martin – Martin State Airport – DRA Site FS | FILE No: | BY: JWL | PAGE: 1 of 2 |
| SUBJECT: Estimate Chemical storage containers | | CHECKED BY: CAH | DATE: 5/26/2010 |

Estimate chemical containers, drum or totes.

H2O2

50 gpm – 12 lb/day
100 gpm – 24 lb/day

assume 35% H2O2

1 drum = 55 gal x 8.34 lb/gal x 0.35 = 160 lb H2O2

50 gpm: 160 lb/(12 lb/day) = 13 days per drum
100 gpm: 160 lb/(24 lb/day) = 7 days per drum

Use drum

NaOH

50 gpm – 12 gal/day at 50%
100 gpm – 24 gal/day at 50%

assume tote tank at 300 gal

50 gpm: 300 gal/(44 gal/day) = 7 days per tote
100 gpm: 300 gal/(88 gal/day) = 3.5 days per tote

Need to use a large tote tank, say 500 gal.

50 gpm: 500 gal/(44 gal/day) = 11 days per tote
100 gpm: 500 gal/(88 gal/day) = 6 days per tote

HCl

50 gpm – 6.3 gal/day at 35%
100 gpm – 12.6 gal/day at 35%

assume tote tank at 300 gal

50 gpm: 300 gal/(6.3 gal/day) = 48 days per tote
100 gpm: 300 gal/(12.6 gal/day) = 24 days per tote

| **Tetra Tech NUS** | | | *STANDARD CALCULATION SHEET* |
|---|---|---|---|
| CLIENT: Lockheed Martin – Martin State Airport – DRA Site FS | FILE No: | BY: JWL | PAGE: 2 of 2 |
| SUBJECT: Estimate Chemical storage containers | | CHECKED BY: CAH | DATE: 5/26/2010 |

Polymer

Use a 55 gal drum

6 lb/day ~ 0.8 gal/day

55 gal/(0.8 gal/day) = 68 days

H2O2 for HiPOx

50 gpm – 3 gal/day at 35%
100 gpm – 6 gal/day at 35%

assume tote tank at 300 gal

50 gpm: 300 gal/(3 gal/day) = 100 days per tote
100 gpm: 300 gal/(6 gal/day) = 50 days per tote

| **Tetra Tech NUS** | | | *STANDARD CALCULATION SHEET* |
|---|---|---|---|
| CLIENT: Lockheed Martin – Martin State Airport – DRA Site FS | FILE No: | BY: JWL | PAGE: 1 of 2 |
| SUBJECT: Groundwater Treatment system – Estimate of piping quantity for estimate. | | CHECKED BY: CAH | DATE: 4/9/10 |

Estimate piping quantity based on preliminary layout sketch.

For 50 gpm, the velocity in 2" PVC is 5.5 ft/sec, which is greater than the recommended maximum velocity of 5 ft/sec. Therefore, assume 4" schedule 80 PVC. At 100 gpm, velocity through 4" pipe is 2.87 ft/sec.

The cost of a fitting (for example a T or elbow) is about the same as 10 feet of piping. So a fitting unit cost will be based on 10 feet of PVC.

Price valves as ball valves.

Assume 3 fittings into and out of each piece of equipment (on each line).

Assume 1 valve on each line into and out of each piece of equipment.

Assume 1 fitting between each piece of equipment.

For estimating length, use layout for horizontal and assume 10 feet vertical for each piece of equipment.

Horizontal piping
Main process flow – 300 feet
Backwash – 190 feet
Sludge - 170 feet
Air – 200 feet (steel)

Total = 860 feet, use 1,000 feet

Vertical piping
10 feet x 60 items of equipment = 600 feet

Total = 1,000 + 600 = 1,600 feet

Fittings

(60 +20) x 3 + 25 x 1 = 265, use 300.

Valves

60 x 2 = 120

| **Tetra Tech NUS** | | | *STANDARD CALCULATION SHEET* |
|---|---|---|---|
| CLIENT: Lockheed Martin – Martin State Airport – DRA Site FS | FILE No: | BY: JWL | PAGE: 2 of 2 |
| SUBJECT: Groundwater Treatment system – Estimate of piping quantity for estimate. | | CHECKED BY: CAH | DATE: 4/9/10 |

Assume there will be some 2" piping:

300 feet
50 fittings
20 valves

Assume there will be some 6" piping:

100 feet
10 fittings
5 valves

For air duct work from stripper through GAC and zeolite, assume:

100 feet
20 fittings
10 valves

| **Tetra Tech NUS** | | *STANDARD CALCULATION SHEET* | |
|---|---|---|---|
| CLIENT: Lockheed Martin – Martin State Airport – DRA Site FS | FILE No: | BY: JWL | PAGE: 1 of 2 |
| SUBJECT: Groundwater Treatment system – Extraction well, injection well, and other long pipe lines | | CHECKED BY: CAH | DATE: 4/9/10 |

1. Estimate length of piping for hydraulic control extraction wells.

Assume a common header, then individual take-offs to each well. Assume that common header will run close to the wells.

From figure, the Main Header length is 4,050 feet (as 4"diameter double wall pipe.)

Assume that each well has a 25 foot long 1" diameter double wall line.

For 16 wells, this is 16 x 25 feet = 400 feet.

2. Estimate length of injection well piping from building to injection wells. Single wall pipe.

Assume a main header with individual lines to each well. From sketch, the Main Header length is 3,900 feet.

Total length of 1-inch lines to each well is 950 feet.

3. Estimate additional length of piping for HCA extraction wells (This is added to Item 1, for appropriate Alternatives).

Assume a common header, then individual take-offs to each well. Assume that common header will run close to the wells.

From figure, the Main Header length is 1,600 feet (as 2"diameter double wall pipe.)

Assume that each well has a 25 foot long 1" diameter double wall line.

For 16 wells, this is 16 x 25 feet = 400 feet.

4. Estimate length of piping to sanitary sewer connection. Single wall pipe.

Assume the tie-in point is along side street.

The Header length is assumed to be 400 feet. Assume 4" Polyethylene

5. Estimate length of piping to surface water outfall. Single wall pipe.

The Header length is assumed to be 400 feet. Assume 4" Polyethylene

6. Estimate length of piping to supply potable water to treatment building. Single wall pipe.

Assume the tie-in point is along side street.

The Header length is 300 feet. Assume 2" Polyethylene.

| **Tetra Tech NUS** | | *STANDARD CALCULATION SHEET* | |
|---|---|---|---|
| CLIENT: Lockheed Martin – Martin State Airport – DRA Site FS | FILE No: | BY: JWL | PAGE: 1 of 1 |
| SUBJECT: Groundwater treatment system – extraction well pumps | | CHECKED BY: CAH | DATE: 5/19/10 |

Estimate size of extraction well pumps.

Estimate size by starting with average rate, then providing for 2X flow rate for a typical pump.

Flow rate of 50 gpm total and 16 wells

50 gpm/16 wells x 2 = 6 gpm

For well depths, assume these values (similar to line A-A' of cross-section).

Shallow – 35 feet
Intermediate – 65 feet
Deep – 90 feet

Assume 4" main header to pump station and 1" well line. Assume 1-inch line is 25 feet long.

Length of 4" line is 500 feet (average), and at 50 gpm, line losses are 0.21 feet/100 feet.

For 4", add 10 feet of length for each fitting and assume 10 fittings.

Total equivalent L = 500 + 10 x 10 = 600 feet

$\Delta h$ = 600 x 0.21 feet/100 feet = 1.3 feet, use 2 feet

Size 1-inch line for deepest well. Length = 25 + 90 = 115 feet. At 6 gpm, line loss is 5 feet per 100 feet.

For 1", add 3 feet of length for each fitting and assume 20 fittings.

Total equivalent L = 115 + 20 x 3 = 175 feet

$\Delta h$ = 175 x 5 feet/100 feet = 9 feet

Static h
Assume 4 feet drawdown and 20 feet depth to water

= 4 + 20 = 24 feet

Assume top of pump station is near grade.

H static = 24 feet

Total h = 2 + 9 +24 = 35 feet

Hp = (6 gpm x 35 feet)/(3960 x 0.5) = 0.11, use 0.5 hp.

| **Tetra Tech NUS** | | | *STANDARD CALCULATION SHEET* |
|---|---|---|---|
| CLIENT: Lockheed Martin – Martin State Airport – DRA Site FS | FILE No: | BY: JWL | PAGE: 1 of 2 |
| SUBJECT: Pump Station for Extraction Wells | | CHECKED BY: CAH | DATE: 5/26/2010 |

Based on Flygt paper.

Calculate vault size

Vworking = 60/(NΦ) [Q1/Q2(Q2-Q1)]

Size for 100 gpm

Min working volume is for Q1 = ½ Q2

Although there will be 2 pumps, size for N=1.

Assume Φ = 8 (typical)

V (gal) = 60/(1 x 8)[50/100(100-50)] = 188 gal

= 25.2 ft3, use 26 ft3

Depth:

Allow 2 feet for submergence of pumps.
Allow 3 feet for pipe burial.
Allow 1 foot for LAH.

Assume 6 feet x 6 feet vault

Working Depth = 26 ft3/(6 feet x 6 feet) = 0.7 feet, use 1 foot.

Total depth = 2 + 3 +1 +1 = 7 feet, use 8 feet

Estimate pump

Pipeline is 4-inch PE; length is 4,000 feet

Add 200 additional feet for fittings, etc.

Static h = depth of station + height of Feed Tank = 8 + 12 = 20 feet

For 50 gpm, Δh = 0.21 feet /100 feet
For 100 gpm, Δh = 0.76 feet /100 feet

50 gpm:

hdyn = 4,200 feet x 0.21 feet/100 feet = 9 feet

hstatic = 20 feet

total h = 20 + 9 = 29 feet

hp = (50 x 29)/3,960 x 0.7) = 0.52, use 1 hp

100 gpm:

hdyn = 4,200 feet x 0.76 feet/100 feet = 32 feet

hstatic = 20 feet

total h = 20 + 32 = 52 feet

hp = (100 x 52)/3,960 x 0.7) = 1.9, use 3 hp

| Tetra Tech NUS | | | STANDARD CALCULATION SHEET |
|---|---|---|---|
| CLIENT: Lockheed Martin – Martin State Airport – DRA Site FS | FILE No: | BY: JWL | PAGE: 1 of 1 |
| SUBJECT: Groundwater treatment system – estimate of ED for injection wells | | CHECKED BY: CAH | DATE: 4/9/10 |

Estimate quantity and rate of ED (sodium lactate) to feed into injected water.

The groundwater that will be affected by the injection wells is assumed to be the area affected per the initial groundwater modeling (see attached figures). Assume that the thickness is 20 feet for each injection well.

In Alternative G-3, the distribution of the ED will only be affected by the hydraulic barrier pumping gradient. In Alternative G-4, DE distribution will also be affected by the extraction wells in the HCAs. It is assumed that in Alternative G-4, this will indirectly affect the amount of ED that can be injected to avoid drawing the ED into the extraction well. For Alternative G-4, it may be beneficial to not activate the HCA extraction wells until the ED has substantially degraded.

Injection wells are in the Upper and Intermediate zones only (Designated I-A, I-B, U-A, U-B, U-C, and U-D on the sketches. Because of the slow groundwater velocity in the shallow zone, distribution of the ED may be limited. However, injection will locally increase the gradient and the velocity will increase.

For estimating purposes, assume that the velocity increase in about 2x. From the model and previous calculations, the normal velocities under pumped conditions (from the hydraulic barrier) are 22 feet/year and 91 feet/year for the shallow and intermediate zones, respectively. For the injection case, (Alternative G-4), assume this is 2 x 22 feet/yr, or about 40 feet/yr. For the intermediate case, the velocity is 2 x 91, or about 200 feet/yr.

The contour lines from the model output suggest an affected area of about 140 feet in diameter (see sketches), or a radius of 70 feet.

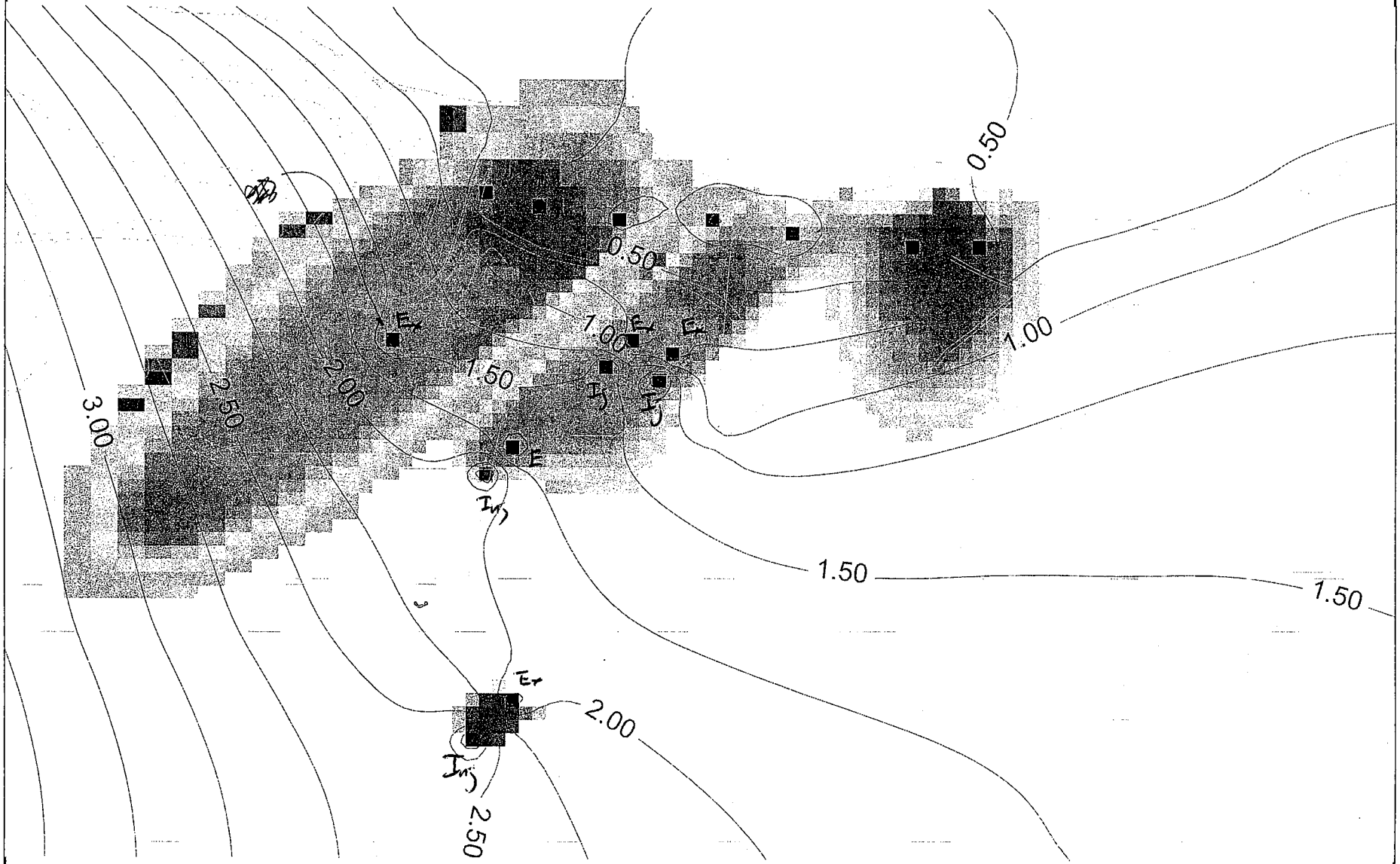
Thus, for the shallow zone, the time for travel across the radius is approximately 70 feet/(40 feet/year) = 1.75 years, or about 2 years. Thus, the duration of injection is will only be about 2 years, at which time, the HCA extraction wells will begin drawing in the sodium lactate.

It is also unlikely that the lactate can remain effect for that long. Thus, for estimating purposes, only 2 years of chemical injection will be assumed.

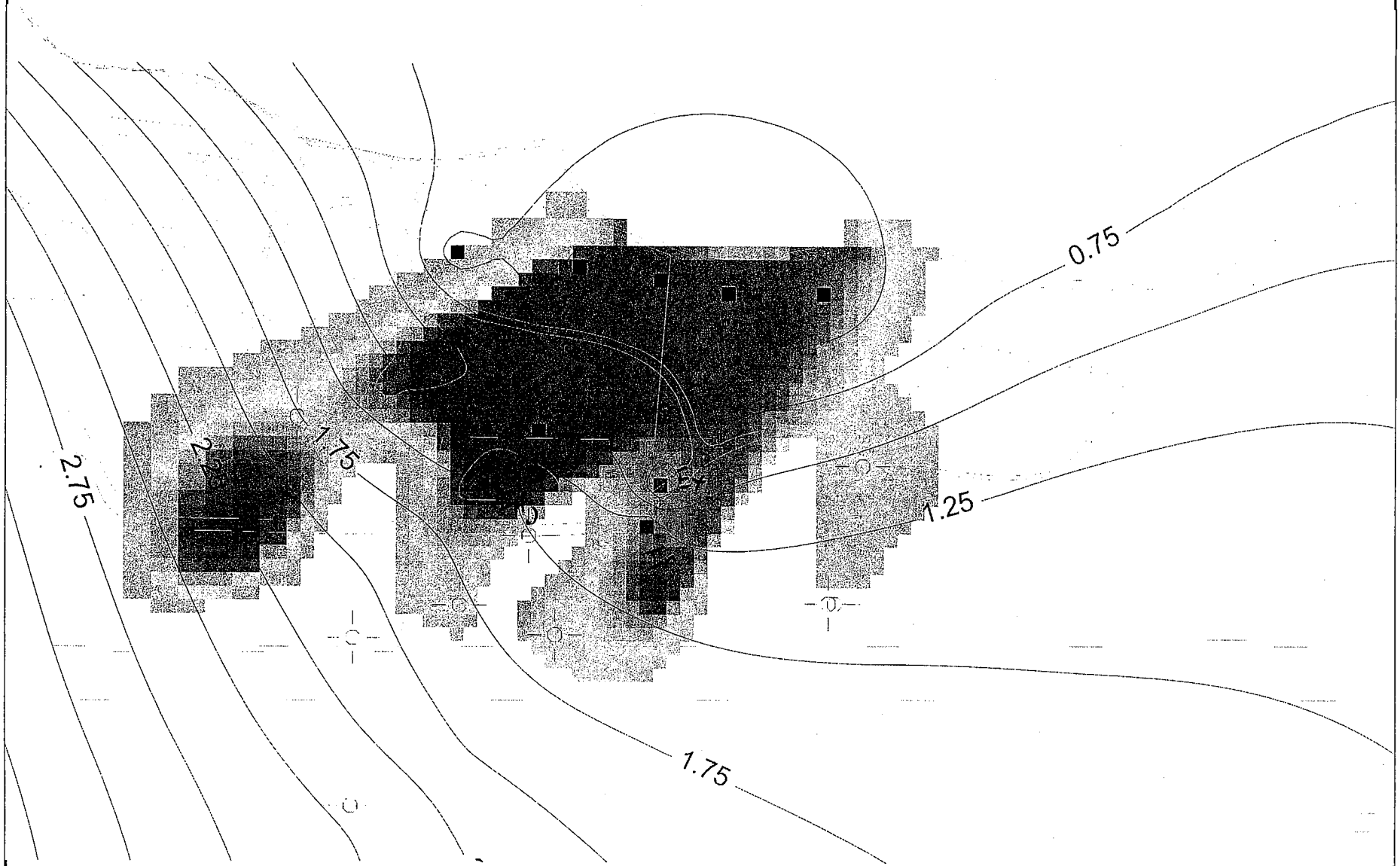
The attached spreadsheet summarizes the estimation of the quantity of sodium lactate to treat the groundwater near each injection well. The sulfate concentration is very high near several of the injection wells and the sulfate controls the amount of ED to be added. The amount of sodium lactate was estimate for each zone and a low sulfate concentration and a high sulfate concentration. The low sulfate concentration is more typical of the intermediate zone, and the sodium lactate loading was estimated based on high sulfate concentrations in the shallow zone and low concentrations in the intermediate zone.

| Run | Unit | groundwater velocity (ft/d) | 1,4d diox velocity (ft/d) | TCE retardation | TCE velocity (ft/d) |
|---|---|---|---|---|---|
| No pumping | Upper | 0.02 - 0.06 | 0.02 - 0.06 | 6.9 | 0.0029 - 0.0086 |
| | Intermediate | 0.06 - 0.12 | 0.06 - 0.12 | 6.9 | 0.0087 - 0.017 |
| | Lower | 0.3 - 0.5 | 0.3 - 0.5 | 6.9 | 0.043 - 0.072 |
| pumping | Upper | 0.05 - 0.08 | 0.05 - 0.08 | 6.9 | 0.0072 - 0.012 |
| | Intermediate | 0.25 | 0.25 | 6.9 | 0.036 |
| | Lower | 0.6 - 0.95 | 0.6 - 0.95 | 6.9 | 0.087 - 0.14 |

Upper Surficial (Layer 6) Heads and TCE for Injection and Pumping Scenario ESA-1



Intermediate Surficial (Layer 8) Heads and TCE for Injection and Pumping Scenario ESA-1



LMC MARTIN STATE AIRPORT
ED ESTIMATE
1/29/2010

Estimate ED requirement based on hydrogen estimates.

4 shallow injection wells
2 Intermediate injection wells

| Hydrogen demand, no SF | lb |
|---|---|
| Shallow - High Sulfate | 504 |
| Shallow - Low Sulfate | 173 |
| Intermediate - High Sulfate | 751 |
| Intermediate - Low Sulfate | 255 |

| Hydrogen in sodium lactate, lb H/lb SL | 0.045 |
|---|---|

| | lb | lb/day |
|---|---|---|
| SL requirement, high sulfate | 78,231 | 214 |
| SL requirement, low sulfate | 26,674 | 73 |

Mix Shallow high sulfate and Intermediate low sulfate

| SL requirement | 56,176 | 154 |
|---|---|---|

SUBSTRATE CALCULATION SHEET - LMC - DRA - ED Addition for Re-injection - Shallow

| 1. Treatment zone dimensions | Units | Value |
|---|---|---|
| Length (perpendicular to GW flow) | feet | 140 |
| Width | feet | 140 |
| Saturated thickness | feet | 20 |
| Treatment zone cross section (vertical) | square feet | 2,800 |
| Treatment zone volume | cubic feet | 392,000 |
| Treatment zone pore volume | gallons | 879,766 |
| Design performance period | years | 1 |

**2. Treatment zone hydrogeologic properties**

| | | | |
|---|---|---|---|
| Total porosity | | 0.3 | |
| Effective porosity | | 0.28 | per GW model |
| Average hydraulic conductivity | ft/day | 4.5 | |
| Average hydraulic gradient | ft/ft | 0.0085 | Adjusted to meet 50 ft/yr, below |
| Average seepage velocity through treatment zone | ft/day | 0.136607 | |
| Average seepage velocity through treatment zone | ft/year | 49.86161 | (Use 50 ft/yr) |
| Average groundwater flux through treatment zone | gal/yr | 292,444 | |
| Soil bulk density | gm/cm3 | 1.8 | per GW model |
| Soil fraction organic carbon (foc) | | 0.005 | default |

**3. Initial treatment cell electron-acceptor demand (one pore volume)**

**A. Aqueous phase native electron acceptors**

| | C, mg/L | mass, lb | Stoic demand, wt/wt H2 | Hydrogen demand, lb | Electron equiv per mole |
|---|---|---|---|---|---|
| Oxygen | 2 | 14.67 | 7.9 | 1.9 | 4 |
| Nitrate | 0 | 0.00 | 10.2 | 0.0 | 5 |
| Sulfate | 400 | 2933.84 | 10.6 | 276.8 | 8 |
| Carbon dioxide | 10 | 73.35 | 5.5 | 13.3 | 8 |
| Subtotal | | | | **292.0** | |

**B. Solid phase native electron acceptors**

| | C, mg/L | mass, lb | Stoic demand, wt/wt H2 | Hydrogen demand, lb | Electron equiv per mole |
|---|---|---|---|---|---|
| Mn(IV) | 9 | 66.01 | 27.5 | 2.4 | 1 |
| Fe(III) | 50 | 366.73 | 55.9 | 6.6 | 1 |
| Subtotal | | | | **9.0** | |

**C. Soluble contaminant electron acceptors**

| | C, mg/L | mass, lb | Stoic demand, wt/wt H2 | Hydrogen demand, lb | Electron equiv per mole |
|---|---|---|---|---|---|
| PCE | 0 | 0.00 | 20.6 | 0.0 | 8 |
| TCE | 36 | 264.05 | 21.7 | 12.2 | 6 |
| cis-1,2-DCE | 41 | 300.72 | 24 | 12.5 | 4 |
| Vinyl chloride | 56 | 410.74 | 31 | 13.2 | 2 |
| Carbon tetrachloride | 0 | 0.00 | 25.4 | 0.0 | 8 |
| Chloroform | 0 | 0.00 | 12.3 | 0.0 | 6 |
| 1,1,1-TCA | 0 | 0.00 | 22 | 0.0 | 6 |
| 1,1-DCA | 0 | 0.00 | 25 | 0.0 | 4 |
| 1,1-DCE | 0 | 0.00 | 24 | 0.0 | 4 |
| Subtotal | | | | **37.9** | |

**D. Sorbed contaminant electron acceptors**

| Cs = Koc x foc x Cw | Koc, ml/g | Cs, mg/kg | mass, lb | Stoic demand, wt/wt H2 | Hydrogen demand, lb | Electron equiv per mole |
|---|---|---|---|---|---|---|
| PCE | 263 | 0 | 0.00 | 20.6 | 0.0 | 8 |
| TCE | 107 | 19.26 | 829.16 | 21.7 | 38.2 | 6 |
| cis-1,2-DCE | 45 | 9.23 | 397.15 | 24 | 16.5 | 4 |
| Vinyl chloride | 3 | 0.84 | 36.16 | 31 | 1.2 | 2 |
| Carbon tetrachloride | 224 | 0.00 | 0.00 | 25.4 | 0.0 | 8 |
| Chloroform | 63 | 0.00 | 0.00 | 12.3 | 0.0 | 6 |
| 1,1,1-TCA | 105 | 0.00 | 0.00 | 22 | 0.0 | 6 |
| 1,1-DCA | 30 | 0.00 | 0.00 | 25 | 0.0 | 4 |
| 1,1-DCE | 65 | 0.00 | 0.00 | 24 | 0.0 | 4 |
| Subtotal | | | | | **55.9** | |

**4. Treatment Cell Electron Acceptor Flux (per year)**

**A. Soluble native electron acceptors**

| | C, mg/L | mass, lb | Stoic demand, wt/wt H2 | Hydrogen demand, lb | Electron equiv per mole |
|---|---|---|---|---|---|
| Oxygen | 2 | 4.88 | 7.9 | 0.6 | 4 |
| Nitrate | 0 | 0.00 | 10.2 | 0.0 | 5 |
| Sulfate | 400 | 975.24 | 10.6 | 92.0 | 8 |
| Carbon dioxide | 10 | 24.38 | 5.5 | 4.4 | 8 |
| Subtotal | | | | **97.1** | |

**B. Soluble contaminant electron acceptors**

| | C, mg/L | mass, lb | Stoic demand, wt/wt H2 | Hydrogen demand, lb | Electron equiv per mole |
|---|---|---|---|---|---|
| PCE | 0 | 0.00 | 20.6 | 0.0 | 8 |
| TCE | 36 | 87.77 | 21.7 | 4.0 | 6 |
| cis-1,2-DCE | 41 | 99.96 | 24 | 4.2 | 4 |
| Vinyl chloride | 56 | 136.53 | 31 | 4.4 | 2 |
| Carbon tetrachloride | 0 | 0.00 | 25.4 | 0.0 | 8 |
| Chloroform | 0 | 0.00 | 12.3 | 0.0 | 6 |
| 1,1,1-TCA | 0 | 0.00 | 22 | 0.0 | 6 |
| 1,1-DCA | 0 | 0.00 | 25 | 0.0 | 4 |
| 1,1-DCE | 0 | 0.00 | 24 | 0.0 | 4 |
| Subtotal | | | | **12.6** | |

| | | |
|---|---|---|
| **Total Demand** | | **504.5** |

**5. Design Factors on total Demand**

| | |
|---|---|
| Factor (2 to 10) | 1 |

| | | |
|---|---|---|
| **Total Demand (Design)** | | **504** |

Shaded is entered for each project.
Blue is given.

SUBSTRATE CALCULATION SHEET - LMC - DRA - ED Addition for Re-injection - Intermediate

| 1. Treatment zone dimensions | Units | Value |
|---|---|---|
| Length (perpendicular to GW flow) | feet | 140 |
| Width | feet | 140 |
| Saturated thickness | feet | 20 |
| Treatment zone cross section (vertical) | square feet | 2,800 |
| Treatment zone volume | cubic feet | 392,000 |
| Treatment zone pore volume | gallons | 879,766 |
| Design performance period | years | 1 |

**2. Treatment zone hydrogeologic properties**

| | | | |
|---|---|---|---|
| Total porosity | | 0.3 | |
| Effective porosity | | 0.28 | per GW model |
| Average hydraulic conductivity | ft/day | 20 | |
| Average hydraulic gradient | ft/ft | 0.008 | Adjusted to meet 200 ft/yr, below |
| Average seepage velocity through treatment zone | ft/day | 0.5714286 | |
| Average seepage velocity through treatment zone | ft/year | 208.57143 | (Use 200 ft/yr) |
| Average groundwater flux through treatment zone | gal/yr | 1,223,293 | |
| Soil bulk density | gm/cm3 | 1.8 | per GW model |
| Soil fraction organic carbon (foc) | | 0.005 | default |

**3. Initial treatment cell electron-acceptor demand (one pore volume)**

**A. Aqueous phase native electron acceptors**

| | C, mg/L | mass, lb | Stoic demand, wt/wt H2 | Hydrogen demand, lb | Electron equiv per mole |
|---|---|---|---|---|---|
| Oxygen | 2 | 14.67 | 7.9 | 1.9 | 4 |
| Nitrate | 0 | 0.00 | 10.2 | 0.0 | 5 |
| Sulfate | 400 | 2933.84 | 10.6 | 276.8 | 8 |
| Carbon dioxide | 10 | 73.35 | 5.5 | 13.3 | 8 |
| Subtotal | | | | **292.0** | |

**B. Solid phase native electron acceptors**

| | C, mg/L | mass, lb | Stoic demand, wt/wt H2 | Hydrogen demand, lb | Electron equiv per mole |
|---|---|---|---|---|---|
| Mn(IV) | 9 | 66.01 | 27.5 | 2.4 | 1 |
| Fe(III) | 50 | 366.73 | 55.9 | 6.6 | 1 |
| Subtotal | | | | **9.0** | |

**C. Soluble contaminant electron acceptors**

| | C, mg/L | mass, lb | Stoic demand, wt/wt H2 | Hydrogen demand, lb | Electron equiv per mole |
|---|---|---|---|---|---|
| PCE | 0 | 0.00 | 20.6 | 0.0 | 8 |
| TCE | 14.4 | 105.62 | 21.7 | 4.9 | 6 |
| cis-1,2-DCE | 13.6 | 99.75 | 24 | 4.2 | 4 |
| Vinyl chloride | 3.4 | 24.94 | 31 | 0.8 | 2 |
| Carbon tetrachloride | 0 | 0.00 | 25.4 | 0.0 | 8 |
| Chloroform | 0 | 0.00 | 12.3 | 0.0 | 6 |
| 1,1,1-TCA | 0 | 0.00 | 22 | 0.0 | 6 |
| 1,1-DCA | 0 | 0.00 | 25 | 0.0 | 4 |
| 1,1-DCE | 0 | 0.00 | 24 | 0.0 | 4 |
| Subtotal | | | | **9.8** | |

**D. Sorbed contaminant electron acceptors**

| Cs = Koc x foc x Cw | Koc, ml/g | Cs, mg/kg | mass, lb | Stoic demand, wt/wt H2 | Hydrogen demand, lb | Electron equiv per mole |
|---|---|---|---|---|---|---|
| PCE | 263 | 0 | 0.00 | 20.6 | 0.0 | 8 |
| TCE | 107 | 7.70 | 331.66 | 21.7 | 15.3 | 6 |
| cis-1,2-DCE | 45 | 3.06 | 131.74 | 24 | 5.5 | 4 |
| Vinyl chloride | 3 | 0.05 | 2.20 | 31 | 0.1 | 2 |
| Carbon tetrachloride | 224 | 0.00 | 0.00 | 25.4 | 0.0 | 8 |
| Chloroform | 63 | 0.00 | 0.00 | 12.3 | 0.0 | 6 |
| 1,1,1-TCA | 105 | 0.00 | 0.00 | 22 | 0.0 | 6 |
| 1,1-DCA | 30 | 0.00 | 0.00 | 25 | 0.0 | 4 |
| 1,1-DCE | 65 | 0.00 | 0.00 | 24 | 0.0 | 4 |
| Subtotal | | | | | **20.8** | |

**4. Treatment Cell Electron Acceptor Flux (per year)**

**A. Soluble native electron acceptors**

| | C, mg/L | mass, lb | Stoic demand, wt/wt H2 | Hydrogen demand, lb | Electron equiv per mole |
|---|---|---|---|---|---|
| Oxygen | 2 | 20.40 | 7.9 | 2.6 | 4 |
| Nitrate | 0 | 0.00 | 10.2 | 0.0 | 5 |
| Sulfate | 400 | 4079.44 | 10.6 | 384.9 | 8 |
| Carbon dioxide | 10 | 101.99 | 5.5 | 18.5 | 8 |
| Subtotal | | | | **406.0** | |

**B. Soluble contaminant electron acceptors**

| | C, mg/L | mass, lb | Stoic demand, wt/wt H2 | Hydrogen demand, lb | Electron equiv per mole |
|---|---|---|---|---|---|
| PCE | 0 | 0.00 | 20.6 | 0.0 | 8 |
| TCE | 14.4 | 146.86 | 21.7 | 6.8 | 6 |
| cis-1,2-DCE | 13.6 | 138.70 | 24 | 5.8 | 4 |
| Vinyl chloride | 3.4 | 34.68 | 31 | 1.1 | 2 |
| Carbon tetrachloride | 0 | 0.00 | 25.4 | 0.0 | 8 |
| Chloroform | 0 | 0.00 | 12.3 | 0.0 | 6 |
| 1,1,1-TCA | 0 | 0.00 | 22 | 0.0 | 6 |
| 1,1-DCA | 0 | 0.00 | 25 | 0.0 | 4 |
| 1,1-DCE | 0 | 0.00 | 24 | 0.0 | 4 |
| Subtotal | | | | **13.7** | |

| | | |
|---|---|---|
| **Total Demand** | | **751.2** |

**5. Design Factors on total Demand**

| | |
|---|---|
| Factor (2 to 10) | 1 |

| | | |
|---|---|---|
| **Total Demand (Design)** | | **751** |

Shaded is entered for each project.
Blue is given.

SUBSTRATE CALCULATION SHEET - LMC - DRA - ED Addition for Re-injection - Shallow - Lower sulfate

| 1. Treatment zone dimensions | Units | Value |
|---|---|---|
| Length (perpendicular to GW flow) | feet | 140 |
| Width | feet | 140 |
| Saturated thickness | feet | 20 |
| Treatment zone cross section (vertical) | square feet | 2,800 |
| Treatment zone volume | cubic feet | 392,000 |
| Treatment zone pore volume | gallons | 879,766 |
| Design performance period | years | 1 |

**2. Treatment zone hydrogeologic properties**

| | | | |
|---|---|---|---|
| Total porosity | | 0.3 | |
| Effective porosity | | 0.28 | per GW model |
| Average hydraulic conductivity | ft/day | 4.5 | |
| Average hydraulic gradient | ft/ft | 0.0085 | Adjusted to meet 50 ft/yr, below |
| Average seepage velocity through treatment zone | ft/day | 0.136607 | |
| Average seepage velocity through treatment zone | ft/year | 49.86161 | (Use 50 ft/yr) |
| Average groundwater flux through treatment zone | gal/yr | 292,444 | |
| Soil bulk density | gm/cm3 | 1.8 | per GW model |
| Soil fraction organic carbon (foc) | | 0.005 | default |

**3. Initial treatment cell electron-acceptor demand (one pore volume)**

**A. Aqueous phase native electron acceptors**

| | C, mg/L | mass, lb | Stoic demand, wt/wt H2 | Hydrogen demand, lb | Electron equiv per mole |
|---|---|---|---|---|---|
| Oxygen | 2 | 14.67 | 7.9 | 1.9 | 4 |
| Nitrate | 0 | 0.00 | 10.2 | 0.0 | 5 |
| Sulfate | 40 | 293.38 | 10.6 | 27.7 | 8 |
| Carbon dioxide | 10 | 73.35 | 5.5 | 13.3 | 8 |
| Subtotal | | | | **42.9** | |

**B. Solid phase native electron acceptors**

| | C, mg/L | mass, lb | Stoic demand, wt/wt H2 | Hydrogen demand, lb | Electron equiv per mole |
|---|---|---|---|---|---|
| Mn(IV) | 9 | 66.01 | 27.5 | 2.4 | 1 |
| Fe(III) | 50 | 366.73 | 55.9 | 6.6 | 1 |
| Subtotal | | | | **9.0** | |

**C. Soluble contaminant electron acceptors**

| | C, mg/L | mass, lb | Stoic demand, wt/wt H2 | Hydrogen demand, lb | Electron equiv per mole |
|---|---|---|---|---|---|
| PCE | 0 | 0.00 | 20.6 | 0.0 | 8 |
| TCE | 36 | 264.05 | 21.7 | 12.2 | 6 |
| cis-1,2-DCE | 41 | 300.72 | 24 | 12.5 | 4 |
| Vinyl chloride | 56 | 410.74 | 31 | 13.2 | 2 |
| Carbon tetrachloride | 0 | 0.00 | 25.4 | 0.0 | 8 |
| Chloroform | 0 | 0.00 | 12.3 | 0.0 | 6 |
| 1,1,1-TCA | 0 | 0.00 | 22 | 0.0 | 6 |
| 1,1-DCA | 0 | 0.00 | 25 | 0.0 | 4 |
| 1,1-DCE | 0 | 0.00 | 24 | 0.0 | 4 |
| Subtotal | | | | **37.9** | |

**D. Sorbed contaminant electron acceptors**

| Cs = Koc x foc x Cw | Koc, ml/g | Cs, mg/kg | mass, lb | Stoic demand, wt/wt H2 | Hydrogen demand, lb | Electron equiv per mole |
|---|---|---|---|---|---|---|
| PCE | 263 | 0 | 0.00 | 20.6 | 0.0 | 8 |
| TCE | 107 | 19.26 | 829.16 | 21.7 | 38.2 | 6 |
| cis-1,2-DCE | 45 | 9.23 | 397.15 | 24 | 16.5 | 4 |
| Vinyl chloride | 3 | 0.84 | 36.16 | 31 | 1.2 | 2 |
| Carbon tetrachloride | 224 | 0.00 | 0.00 | 25.4 | 0.0 | 8 |
| Chloroform | 63 | 0.00 | 0.00 | 12.3 | 0.0 | 6 |
| 1,1,1-TCA | 105 | 0.00 | 0.00 | 22 | 0.0 | 6 |
| 1,1-DCA | 30 | 0.00 | 0.00 | 25 | 0.0 | 4 |
| 1,1-DCE | 65 | 0.00 | 0.00 | 24 | 0.0 | 4 |
| Subtotal | | | | | **55.9** | |

**4. Treatment Cell Electron Acceptor Flux (per year)**

**A. Soluble native electron acceptors**

| | C, mg/L | mass, lb | Stoic demand, wt/wt H2 | Hydrogen demand, lb | Electron equiv per mole |
|---|---|---|---|---|---|
| Oxygen | 2 | 4.88 | 7.9 | 0.6 | 4 |
| Nitrate | 0 | 0.00 | 10.2 | 0.0 | 5 |
| Sulfate | 40 | 97.52 | 10.6 | 9.2 | 8 |
| Carbon dioxide | 10 | 24.38 | 5.5 | 4.4 | 8 |
| Subtotal | | | | **14.3** | |

**B. Soluble contaminant electron acceptors**

| | C, mg/L | mass, lb | Stoic demand, wt/wt H2 | Hydrogen demand, lb | Electron equiv per mole |
|---|---|---|---|---|---|
| PCE | 0 | 0.00 | 20.6 | 0.0 | 8 |
| TCE | 36 | 87.77 | 21.7 | 4.0 | 6 |
| cis-1,2-DCE | 41 | 99.96 | 24 | 4.2 | 4 |
| Vinyl chloride | 56 | 136.53 | 31 | 4.4 | 2 |
| Carbon tetrachloride | 0 | 0.00 | 25.4 | 0.0 | 8 |
| Chloroform | 0 | 0.00 | 12.3 | 0.0 | 6 |
| 1,1,1-TCA | 0 | 0.00 | 22 | 0.0 | 6 |
| 1,1-DCA | 0 | 0.00 | 25 | 0.0 | 4 |
| 1,1-DCE | 0 | 0.00 | 24 | 0.0 | 4 |
| Subtotal | | | | **12.6** | |

| | | |
|---|---|---|
| **Total Demand** | | **172.6** |

**5. Design Factors on total Demand**

| | |
|---|---|
| Factor (2 to 10) | 1 |

| | | |
|---|---|---|
| **Total Demand (Design)** | | **173** |

Shaded is entered for each project.
Blue is given.

SUBSTRATE CALCULATION SHEET - LMC - DRA - ED Addition for Re-injection - Intermediate - Low Sulfate

| 1. Treatment zone dimensions | Units | Value |
|---|---|---|
| Length (perpendicular to GW flow) | feet | 140 |
| Width | feet | 140 |
| Saturated thickness | feet | 20 |
| Treatment zone cross section (vertical) | square feet | 2,800 |
| Treatment zone volume | cubic feet | 392,000 |
| Treatment zone pore volume | gallons | 879,766 |
| Design performance period | years | 1 |

**2. Treatment zone hydrogeologic properties**

| | | | |
|---|---|---|---|
| Total porosity | | 0.3 | |
| Effective porosity | | 0.28 | per GW model |
| Average hydraulic conductivity | ft/day | 20 | |
| Average hydraulic gradient | ft/ft | 0.008 | Adjusted to meet 200 ft/yr, below |
| Average seepage velocity through treatment zone | ft/day | 0.571429 | |
| Average seepage velocity through treatment zone | ft/year | 208.5714 | (Use 200 ft/yr) |
| Average groundwater flux through treatment zone | gal/yr | 1,223,293 | |
| Soil bulk density | gm/cm3 | 1.8 | per GW model |
| Soil fraction organic carbon (foc) | | 0.005 | default |

**3. Initial treatment cell electron-acceptor demand (one pore volume)**

**A. Aqueous phase native electron acceptors**

| | C, mg/L | mass, lb | Stoic demand, wt/wt H2 | Hydrogen demand, lb | Electron equiv per mole |
|---|---|---|---|---|---|
| Oxygen | 2 | 14.67 | 7.9 | 1.9 | 4 |
| Nitrate | 0 | 0.00 | 10.2 | 0.0 | 5 |
| Sulfate | 100 | 733.46 | 10.6 | 69.2 | 8 |
| Carbon dioxide | 10 | 73.35 | 5.5 | 13.3 | 8 |
| Subtotal | | | | **84.4** | |

**B. Solid phase native electron acceptors**

| | C, mg/L | mass, lb | Stoic demand, wt/wt H2 | Hydrogen demand, lb | Electron equiv per mole |
|---|---|---|---|---|---|
| Mn(IV) | 9 | 66.01 | 27.5 | 2.4 | 1 |
| Fe(III) | 50 | 366.73 | 55.9 | 6.6 | 1 |
| Subtotal | | | | **9.0** | |

**C. Soluble contaminant electron acceptors**

| | C, mg/L | mass, lb | Stoic demand, wt/wt H2 | Hydrogen demand, lb | Electron equiv per mole |
|---|---|---|---|---|---|
| PCE | 0 | 0.00 | 20.6 | 0.0 | 8 |
| TCE | 14.4 | 105.62 | 21.7 | 4.9 | 6 |
| cis-1,2-DCE | 13.6 | 99.75 | 24 | 4.2 | 4 |
| Vinyl chloride | 3.4 | 24.94 | 31 | 0.8 | 2 |
| Carbon tetrachloride | 0 | 0.00 | 25.4 | 0.0 | 8 |
| Chloroform | 0 | 0.00 | 12.3 | 0.0 | 6 |
| 1,1,1-TCA | 0 | 0.00 | 22 | 0.0 | 6 |
| 1,1-DCA | 0 | 0.00 | 25 | 0.0 | 4 |
| 1,1-DCE | 0 | 0.00 | 24 | 0.0 | 4 |
| Subtotal | | | | **9.8** | |

**D. Sorbed contaminant electron acceptors**

| Cs = Koc x foc x Cw | Koc, ml/g | Cs, mg/kg | mass, lb | Stoic demand, wt/wt H2 | Hydrogen demand, lb | Electron equiv per mole |
|---|---|---|---|---|---|---|
| PCE | 263 | 0 | 0.00 | 20.6 | 0.0 | 8 |
| TCE | 107 | 7.70 | 331.66 | 21.7 | 15.3 | 6 |
| cis-1,2-DCE | 45 | 3.06 | 131.74 | 24 | 5.5 | 4 |
| Vinyl chloride | 3 | 0.05 | 2.20 | 31 | 0.1 | 2 |
| Carbon tetrachloride | 224 | 0.00 | 0.00 | 25.4 | 0.0 | 8 |
| Chloroform | 63 | 0.00 | 0.00 | 12.3 | 0.0 | 6 |
| 1,1,1-TCA | 105 | 0.00 | 0.00 | 22 | 0.0 | 6 |
| 1,1-DCA | 30 | 0.00 | 0.00 | 25 | 0.0 | 4 |
| 1,1-DCE | 65 | 0.00 | 0.00 | 24 | 0.0 | 4 |
| Subtotal | | | | | **20.8** | |

**4. Treatment Cell Electron Acceptor Flux (per year)**

**A. Soluble native electron acceptors**

| | C, mg/L | mass, lb | Stoic demand, wt/wt H2 | Hydrogen demand, lb | Electron equiv per mole |
|---|---|---|---|---|---|
| Oxygen | 2 | 20.40 | 7.9 | 2.6 | 4 |
| Nitrate | 0 | 0.00 | 10.2 | 0.0 | 5 |
| Sulfate | 100 | 1019.86 | 10.6 | 96.2 | 8 |
| Carbon dioxide | 10 | 101.99 | 5.5 | 18.5 | 8 |
| Subtotal | | | | **117.3** | |

**B. Soluble contaminant electron acceptors**

| | C, mg/L | mass, lb | Stoic demand, wt/wt H2 | Hydrogen demand, lb | Electron equiv per mole |
|---|---|---|---|---|---|
| PCE | 0 | 0.00 | 20.6 | 0.0 | 8 |
| TCE | 14.4 | 146.86 | 21.7 | 6.8 | 6 |
| cis-1,2-DCE | 13.6 | 138.70 | 24 | 5.8 | 4 |
| Vinyl chloride | 3.4 | 34.68 | 31 | 1.1 | 2 |
| Carbon tetrachloride | 0 | 0.00 | 25.4 | 0.0 | 8 |
| Chloroform | 0 | 0.00 | 12.3 | 0.0 | 6 |
| 1,1,1-TCA | 0 | 0.00 | 22 | 0.0 | 6 |
| 1,1-DCA | 0 | 0.00 | 25 | 0.0 | 4 |
| 1,1-DCE | 0 | 0.00 | 24 | 0.0 | 4 |
| Subtotal | | | | **13.7** | |

| | |
|---|---|
| **Total Demand** | **255.0** |

**5. Design Factors on total Demand**

| | |
|---|---|
| Factor (2 to 10) | 1 |

| | |
|---|---|
| **Total Demand (Design)** | **255** |

Shaded is entered for each project.
Blue is given.

SIEMENS

Siemens Water Technologies Corp.

# BUDGETARY PROPOSAL TO SUPPLY A

# METALS PRECIPITATION SYSTEM WITH FILTER PRESS

# FOR

# TETRA TECH NUS, INC


**Submitted To:**
**Joseph W. Logan Jr.**
**Process Engineer**
**Tetra Tech NUS, Inc.**
**661 Andersen Dr.**
**Foster Plaza 7**
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**Prepared By:**
Bob Hall
Siemens Water Technologies


Proposal No. 1002007
February 2, 2010

SIEMENS

# 1. OVERVIEW

This budgetary proposal has been prepared to assist you to develop equipment cost estimates for your wastewater treatment system project. Siemens Water Technologies (herein referred to as Siemens) appreciates the opportunity to offer our services and looks forward to working closely with you as your project moves forward.

We have based our budgetary estimate on the information provided and on comparing this application to similar installations successfully completed by Siemens. At this stage our estimate is for equipment only but can be expanded to include process later as the project develops. A comprehensive system recommendation and proposal can be developed once more complete design parameters have been provided and specific requirements are identified for the metals precipitation portion of the project. A final proposal should be based on bench testing of actual wastewater, comprehensive wastewater source profiling, technology treatability testing and perhaps site pilot testing.

We are providing pricing on the clarifier, neutralizer, filtration and sludge dewatering portion of your request. We have not included the ion exchange service portion or the carbon tank portion of your request. Other Siemens Business units offer those products and services.

# 2. BASIS FOR DESIGN

| Mechanical Specification | Description |
|---|---|
| Maximum Flow Rate | 80 gpm |
| Concentrated Acids | None |
| Concentrated Bases | None |

## 2.1. Clarifications and Exceptions

- The above specifications are preliminary. Listed are design and performance requirements of the wastewater treatment system offered in this quotation. Site specific conditions that exceed these parameters would require this design recommendation to be modified. Prior to developing a full proposal and complete wastewater treatment system recommendation, it will be necessary to develop an accurate and comprehensive site specification.

- Siemens' equipment is built to Seismic Zone 2 unless otherwise stated. Seismic design calculations are not included.

# 3. EQUIPMENT LIST

## 3.1. TotalTreat® Continuous Precipitation System
**Model No. CPS-100-2-SA**

One modular, epoxy painted, carbon steel constructed multi-chamber unit. The prepackaged unit contains the following treatment equipment:

**First Stage Reaction Chamber**

- 1,070-gallon capacity
- Single-speed, gear drive agitator with 316 stainless steel wetted parts (Brawn or equal)
- pH probe (Hach or equal)
- Two chemical metering pumps (LMI or equal)

**Second Stage Reaction Chamber**

- 1,070-gallon capacity
- Single-speed, gear drive agitator with 316 stainless steel wetted parts (Brawn or equal)
- pH probe (Hach or equal)
- Three chemical metering pumps (LMI or equal)

**Flocculation Chamber**

- 770-gallon capacity
- Polypropylene and stainless steel constructed paddlewheel type agitator
- Low speed, gear type agitator drive motor (Bodine or equal)

**Clarifier Chamber**

- 3,690-gallon capacity
- Settling modules with Chevron shaped tube packing
- One air operated diaphragm pump for sludge recycle (ARO or equal)

**Sludge Age Chamber Feed Pump**

- One air operated diaphragm pump (ARO or equal)
- Cast iron construction
- Santoprene elastomers

**Effluent Clearwell**

- 850-gallon capacity

**Sludge Age Chambers**

- Two 1,340-gallon capacity tanks
- Two single point, float type, PVC and polypropylene constructed level switches
- One air operated diaphragm pump to decant clear water (ARO or equal)
- One air operated diaphragm pump to transfer sludge to the sludge surge tank (ARO or equal)

**Operator Access Platforms**

- Two platforms with handrail and toeplate
- Carbon steel construction
- Access ladders

### 3.2. Neutralization System
**Model No. NSP-1500**

- One 1,500-gallon capacity, heavy-duty, HDPE constructed reaction tank
- One heavy-duty mixer (Brawn or equal)
- One pH monitor/transmitter (Hach or equal)
- Two chemical metering pumps (LMI or equal)
- Skid-mounting

### 3.3. Equalization Tank
**Model No. EQ-1500-HDPE**

- One 1,500-gallon capacity, heavy-duty, HDPE constructed, dome top collection tank
- Manway
- Inlet connection
- Pump suction connection

### 3.4. Transfer Pump System (Duplex)
**Model No. PSH-150-D**

- Duplex, horizontal centrifugal pumps, stainless steel constructed
- 150 gpm capacity at 150 ft total discharge head
- 230/460-VAC, 3-Phase, TEFC motors
- Pump discharge flow meter
- Pump discharge pressure gauge
- Level switches for pump on/off control
- Pump skid with Schedule-80 PVC piping and shutoff valves

### 3.5. Hydrus Backwashing Sand Filters
**Model No. HF-330m**

- 150 gpm service flow
- 60 gpm service flow during backwash
- Three Hydrus non-electric control valves
- Three FRP media vessels, 30" Dia x 72" H
- 125 psi non-code vessels
- 9 $ft^3$ of filter media (per vessel)
- Automatic backwash based on pressure drop
- 40 gpm backwash flow
- Piping manifold with bypass valve
- 2" flanged inlet and outlet connections
- 2" threaded drain connections
- Smart Start controller
- Differential pressure switch
- Three cartridge filters for effluent polishing

### 3.6. Sludge Holding Tank
**Model No. 50-71100-3**

- 10,000-gallon capacity, vertical, cylindrical, FRP tank
- Conical bottom
- Internal baffles
- Overflow nozzle
- Flanged bottom nozzle

### 3.7. Air Diaphragm Filter Press Feed Pump System (Simplex)
**Model No. PS2.0C-S-AD**

- Simplex, air operated diaphragm pump, cast iron constructed (ARO or equal)
- 80 gpm capacity at 50 ft total discharge head
- Level switches for pump on/off control
- Pump skid with Schedule-80 PVC piping

### 3.8. Filter Press
**Model No. JP-25-800**

- 25 cu ft filter cake capacity
- 1.26-inch cake thickness
- 100 psi filtration capacity
- Center feed
- Four corner filtrate discharge connection
- Set of gasketed polypropylene plates

- Air blowdown manifold
- Two dumpsters
- Plate shifter
- Painted steel skeleton
- Automatic pump control

## 4. PROCESS CONTROLS

The Siemens Water Technologies standard control system consists of a PLC (Programmable Logic Controller) and HMI (Human Machine Interface) graphical display as the main components providing system automation and operator monitoring of the water treatment system.

The HMI display is provided as the central location for an operator to visually monitor equipment status, alarm messaging, and process pH, flow, and level values. The adjustment of process set-points is performed via the HMI. The HMI will allow Hand/Off/Auto (or On/Off) control of devices and display interlock statuses. The HMI also displays all alarm conditions.

Alarms are also annunciated with an alarm horn that can be silenced.

The control system includes all engineering, programming, instrumentation, and documentation for the system. A main panel contains the PLC, HMI, programming receptacle, and alarming. Power distribution, motor starters, emergency stop pushbuttons, relays, remote I/O, and other control hardware are located remotely at each treatment module being controlled. 10% spare I/O capacity is provided, with spares wired to terminal blocks.

The Siemens Simatic S7-300 series PLC is used as the standard controller with a monochromatic 5.7" Siemens HMI. Communication is over a Profibus network to the Siemens ET200 remote I/O. Transformers, power supplies, disconnects, circuit breakers, and motor starters are Siemens or equivalent. Relays and terminal blocks are Phoenix or equivalent. Fuses and fuse blocks are Bussmann or equivalent. Enclosures are Hoffman Type 4X fiberglass.

## 5. DRAWINGS AND DOCUMENTATION

The following mechanical and electrical drawings are included with the system:

General Arrangement Drawing – Shows the overall general arrangement for the system with dimensions to locate equipment.

Piping and Instrumentation Diagram(s) - Provides a flow schematic illustrating the treatment equipment. Equipment is shown with the instrumentation, valves, pipe sizes and materials of construction.

Equipment Arrangement Drawings for the System Modules - Each equipment arrangement drawing will show overall equipment dimensions, access and maintenance clearance requirements, shipping and operating weights, equipment coatings or lining specifications, anchoring details, piping connections and utility requirements.

Control Panel Enclosure Layout - A dimensioned front elevation of the Electrical Control Panel, which details door-mounted component locations and identification. This document also includes part number references for component identification. Depending on system size and complexity, the Nameplate Schedule or Sub-Panel Layout may also be included on this drawing in lieu of a separate drawing.

Control Panel Sub-Panel Layout - A dimensioned layout drawing detailing each control component's description, part number reference, and location on the sub-panel. This information may be incorporated into the Control Panel Enclosure Layout drawing depending on enclosure size.

Electrical Schematic Diagrams - This drawing provides a schematic representation of all circuitry contained within the Electrical Control Panel including internal and field termination points, PLC I/O wiring, and wire numbering.

Nameplate Schedule - Lists individual nameplates for control panel devices. This includes nameplate text, material type, size and mounting methods. Depending on system size, this information may be incorporated into one of the Control Panel Layout drawings.

Electrical Bill of Materials - A spreadsheet listing of all components contained in the Control Panel design. Each component is assigned a bill of material number allowing its reference to the Control Panel Layout drawings.

Operating and Maintenance Manuals - Include installation instructions for utilities and piping connections to the system. It includes operating procedures, maintenance instructions and vendor manuals for the equipment furnished.

Notes: All copies described above are in triplicate. Additional copies may be obtained at an additional cost. All drawings and documentation will be submitted for information only. All drawings and documentation will be completed in Siemens' standard format. All drawings and documentation will be completed in English.

# 6. SYSTEM INSTALLATION

## 6.1. Overview

The wastewater treatment system presented in this document has been designed as a modular system. It is comprised of individual modular subsystems that are designed to connect to each other. Each module (subsystem) will be piped, wired and assembled at the Siemens manufacturing facility (to the extent possible). At the conclusion of manufacturing, a Functional Operating Test will be performed. Following QC testing, the modules will be partially dismantled and packed for shipping.

A typical installation requires equipment off-loading, placement, reassembly, interconnection of piping and wiring between subsystems, utility hook-ups and process piping/wiring to the treatment system (as required by the layout).

The interconnecting piping and wiring connections between subsystem modules are the responsibility of the customer (or their installing contractor).

## 6.2. System Unloading and Placement

Receiving, unloading and setting the system modules in place at the installation location (including any required leveling/grouting/lagging as required by site conditions), is the responsibility of the customer or the customers contractor. Siemens will provide layout drawings to assist the customer in the correct placement and locating of the system components. During the placement of the system, platforms and access ladders (or stairs) may require reassembly.

## 6.3. Reassembly of Modular Subsystem Components

The Siemens Wastewater Treatment System is assembled at the factory as modular subsystems. This is done to simplify the field installation and minimize the labor required to fully commission the system. When the system arrives at the installation site it will have been partially dismantled from its factory assembled condition. Components such as mixers, instrumentation probes, ladders, stairways and platforms will have been secured for shipment. The customer will be responsible for remounting and reassembly of these items.

### 6.4. Utilities, Interconnecting Piping/Wiring and Process Piping Installation

The customer or the customer's contractor will be responsible for connecting utilities, piping feed lines to the system, providing and installing interconnecting piping and wiring, and connecting discharge lines from the system. The customer is responsible for all process piping lines from the customer's facility to the WTS. The customer is responsible for utility installation including: power drops, water lines and air connections to designated points within the boundaries of the WTS.

The customer is also responsible for supplying and installing the piping connections and control wiring connections between the modular subsystems.

### 6.5. Codes and Fees

The Siemens wastewater treatment system will be designed and assembled to the standards and codes identified in the Basis for Design section of this document. Any codes, regulations or standards that apply to any portion of the project that differ with those standards offered by Siemens, are not included in Siemens' scope of work for this project.

Fees associated with permits, licenses, inspections etc., are the responsibility of the customer and are not included in Siemens' scope of work. They are not included in the price for the system presented in this document.

## 7. START-UP AND OPERATOR TRAINING

Start-up and operator training have not been included in the budgetary price. Start-up and operator training can be provided at our standard per diem rate of $1,250.00 per 8-hour day per person, plus all out of pocket travel and living expenses. Travel and living expenses will be charged at net cost plus a 5% handling fee.

## 8. BUDGETARY PRICE $322,500.00

The price in this proposal is budgetary and intended for estimating and planning purposes only. The design of the system and the price estimate are based on preliminary design information and subject to change and revision. This budgetary proposal is not intended to be used as an offer for purchase or as a binding commercial proposal.

Recent market conditions have resulted in exceptionally volatile prices for both stainless and carbon steels. Supply conditions are such that producers have instituted surcharges, which they apply at the time of actual shipment of the steel. This means that the cost for steel used for developing the prices in this quotation are not firm. As a result of this policy, it has become necessary for Siemens to pass along any escalation in the cost of carbon and stainless steels. The price escalation will be calculated by indexing the cost of the steel based on the London Metals Exchange from the date that this proposal is issued to the date that the steel is actually received.

## 9. SHIPPING SCHEDULE

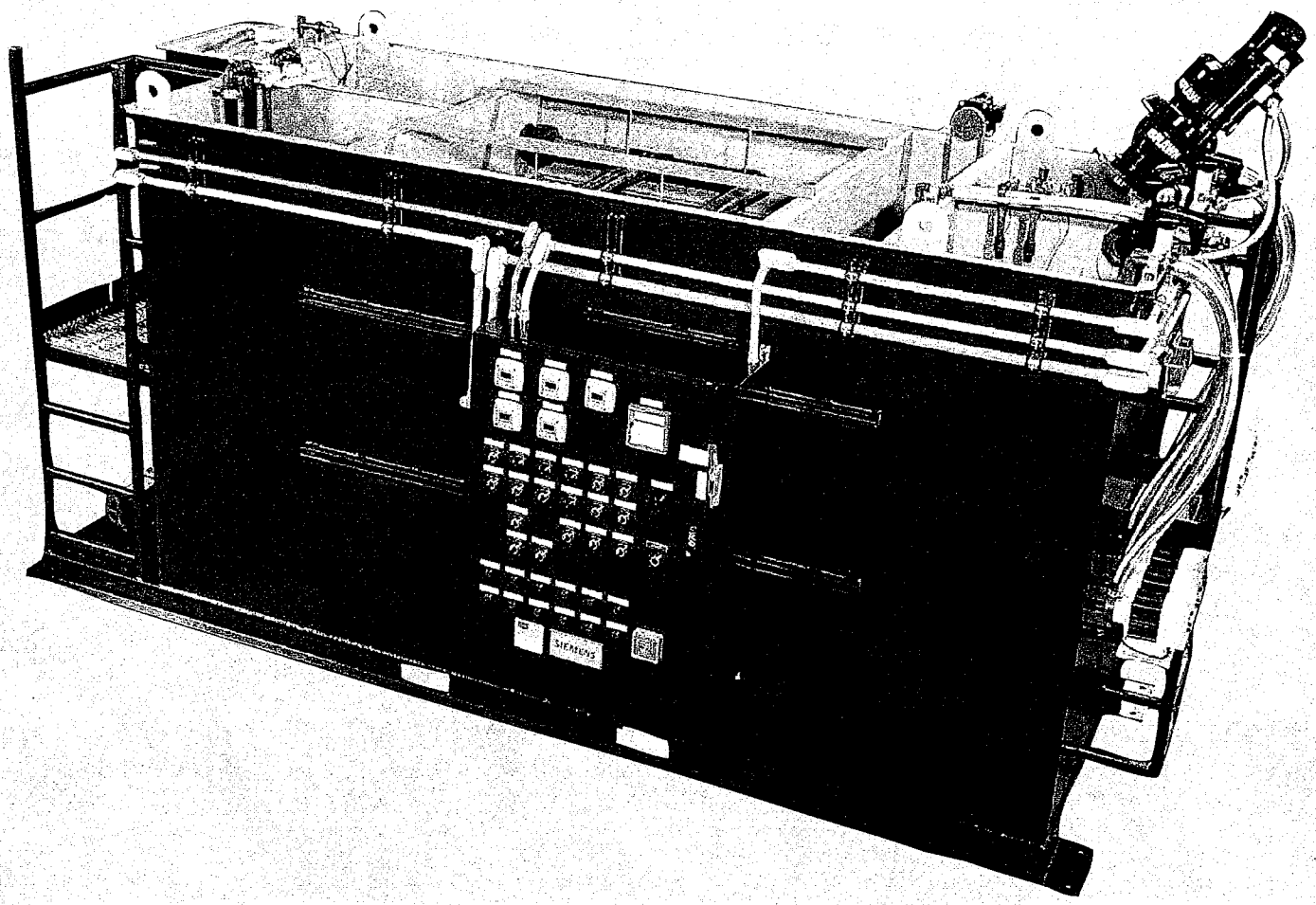
The system would be shipped approximately 14 to 20 weeks from the time of an accepted order. Shipping charges are not included in the estimated price of this budgetary proposal.

## 10. EQUIPMENT WARRANTY

Siemens warrants all equipment for a maximum period of 18 months from date of shipment or 12 months from the date of installation. This warranty would cover all defects in materials and workmanship. Excluded are membranes, ion exchange resins, instrumentation electrodes, pump seals and consumables.

## 11. CONFIDENTIALITY AGREEMENT

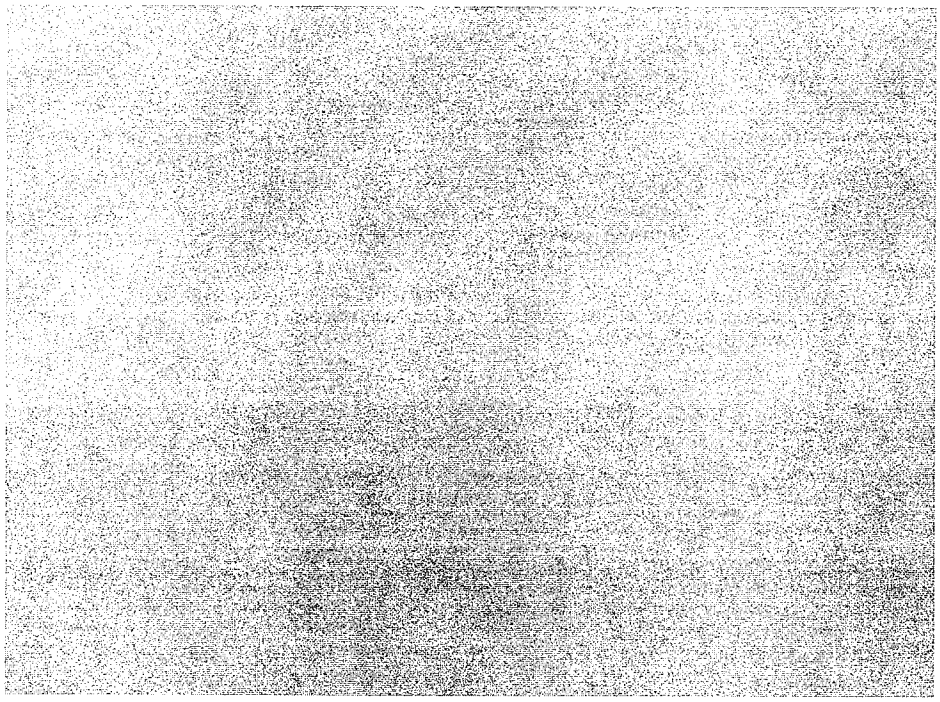
This budgetary proposal is confidential and contains proprietary information. It is not to be disclosed to a third party without the written consent of Siemens.

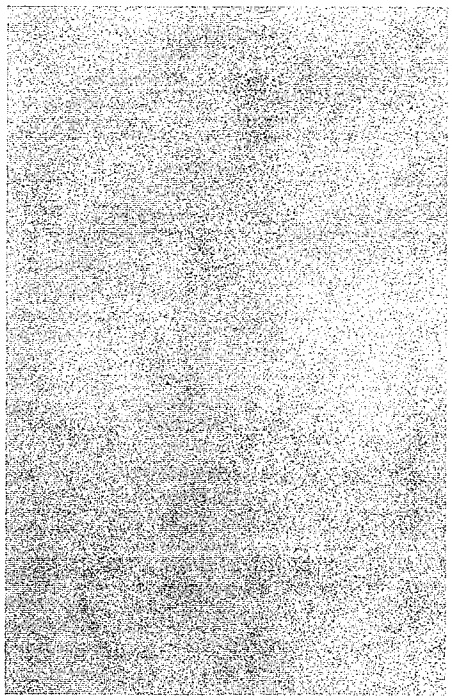


# TotalTreat® Continuous Precipitation System (CPS)

Water Technologies

SIEMENS





# TotalTreat® Continuous Precipitation System (CPS)

## Introduction

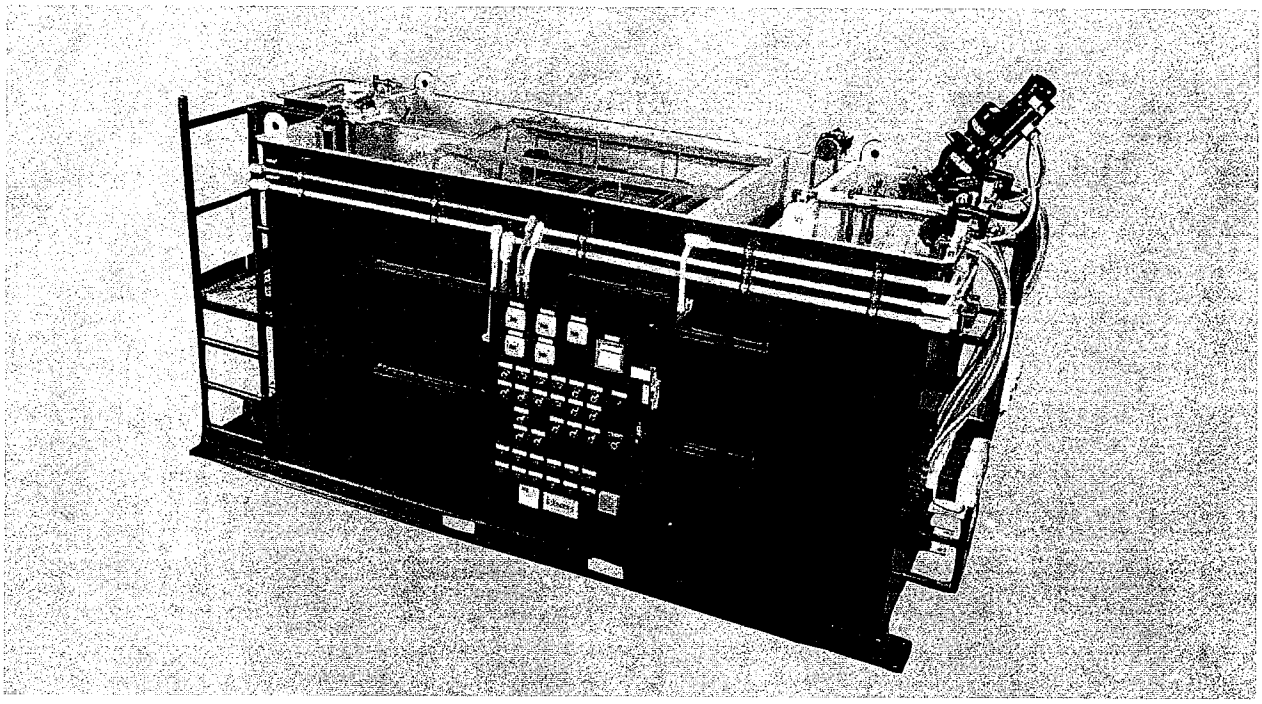
The TotalTreat® Continuous Precipitation System (CPS) has a compact, skid-mounted design that performs a continuous flow chemical precipitation process. The CPS incorporates two chemical process reaction chambers, a flocculation chamber, an inclined tube separator for solids separation, two sludge thickening chambers, and an effluent sampling/pumping chamber, all on one skid. The CPS has been used in a wide range of applications for wastewater treatment. Some markets/industries where the CPS is commonly used are: microelectronics, petrochemical, printed circuit board manufacturing, metal finishing/plating, industrial laundries, and landfill leachate/ground water remediation.

## Features/Benefits

- Process guarantee ensures specified effluent pH/contaminant levels
- Compact design for small footprint requirement
- Skid-mounted, factory assembled and tested to ensure trouble-free installation
- PLC controls for low operating costs and safety interlocks
- Dual sludge thickening chambers for improved filter press operation
- 60° inclined tube settling modules for clarification
- Integral platforms for operator access
- Epoxy coated carbon steel materials of construction for superior corrosion resistance

### Typical CPS Applications

- Hydrofluoric (HF) Acid Wastewater Treatment
- Grinding Slurry
- Chemical Mechanical Polishing (CMP) Slurry
- Arsenic Wastewater
- Heavy Metals (Cu, Ni, Pb, etc.)
- Hexavalent Chrome Wastewater
- Suspended Solids



Process Description

Waste flow from the facility is captured in an influent collection tank (separate equipment). During times of high flow or equipment maintenance, this tank provides flow equalization and normalization. The collected waste is transferred to the first reaction chamber of the CPS via a transfer pump.

The first stage reaction chamber is designed as a stirred tank reactor utilized for the neutralization and precipitation of the influent waste. Reagents, based on the specific waste water being treated, are added to the reaction chamber via metering pumps. The reagent addition is proportionally controlled by the system controller. The effluent flows by gravity from the first stage reaction chamber into the second stage reaction chamber of the CPS.

The second stage reaction chamber is also designed as a stirred tank reactor and is utilized for pre-clarification pH adjustment using chemical reagents. Reagents are added to the reaction chamber, via metering pumps, to complete the required process chemistry. The contents of chamber two gravity overflow into the flocculation chamber.

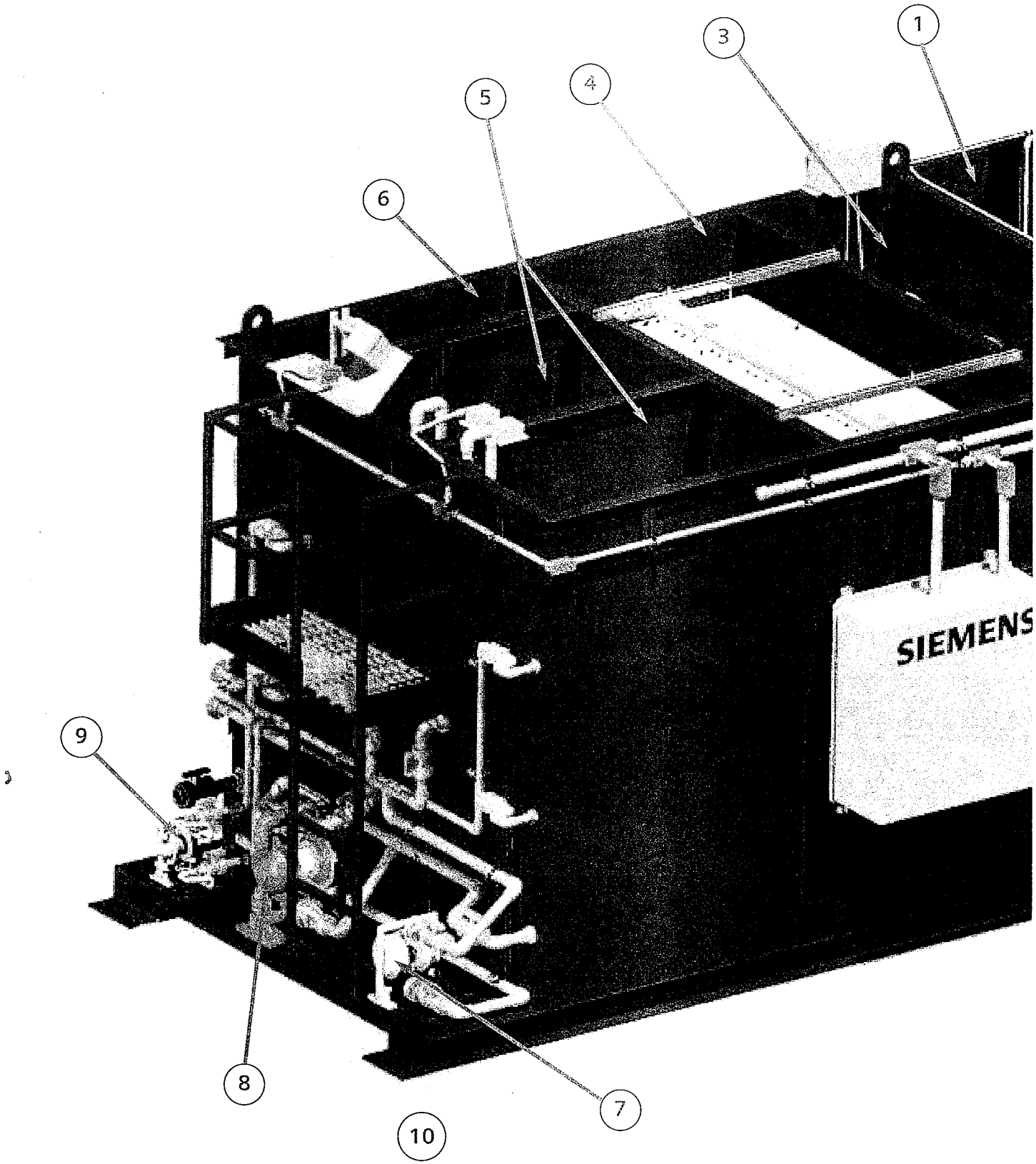
The flocculation chamber, also designed as a stirred tank reactor, is utilized for flocculation of the solid precipitates, using a low-shear paddle wheel mixer. To encourage the coagulation of the particles formed in chambers one and two into larger and faster settling particles, anionic polymer is added via a metering pump. The precipitate from the flocculation chamber flows by gravity into the clarification chamber.

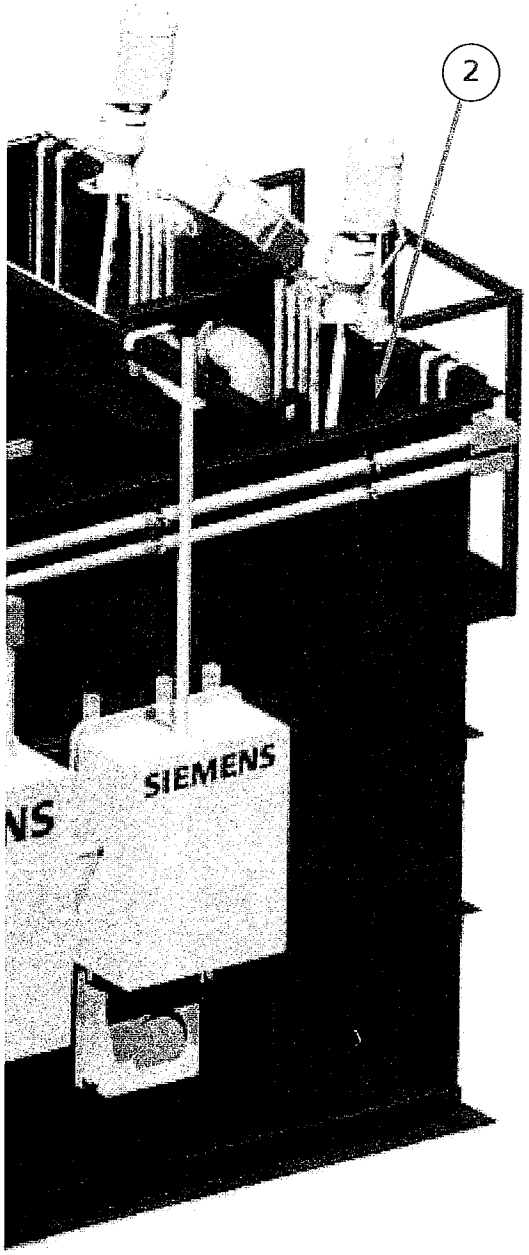
The clarification chamber is designed as an up-flow, inclined tube type clarifier, which allows gravity settling of the precipitate. This chamber is fitted with chevron style, inclined tube modules that provide the settling surface area required and create the laminar flow environment necessary for effective clarification. The precipitate enters the clarifier and settles to the chamber bottom where it is automatically pumped to the sludge thickening chambers. The precipitate-free effluent emerges from the top of the clarifier through a set of weirs and flows by gravity to the effluent clearwell chamber.

Two internal sludge thickening chambers are supplied with the CPS. These chambers are used to thicken the sludge to one to three percent solids prior to filter press dewatering. This thickening time improves the performance and reduces cycle time of the filter press. Two sludge thickening chambers are utilized to allow one to be filled while the other is thickening. Influent sludge valves direct the sludge from the clarifier to the desired thickening chamber. Clear decant from the sludge thickening chambers is transferred back to the influent collection tank via a decant valving manifold for reprocessing.

Prior to being sent to drain, the clarified water gravity flows to the effluent clearwell. An optional final pH transmitter and recorder is used to measure and record the effluent water quality. Effluent from the clearwell is either pumped, via an optional centrifugal transfer pump, or gravity overflows to the drain connection point.

# TotalTreat® CPS Equipment Description






1.First Stage Reaction Chamber
Equipped with a mixer, two chemical metering pumps and a pH (optional ORP) probe, this chamber is used to pre-treat incoming wastewaters. Typically, lowering the pH and adding a coagulant in this step, helps treat metals that are tied up with chelating (complexing) agents.

2. Second Stage Reaction Chamber
As in the previous chamber, this chamber is equipped with a mixer, pH probe and two chemical metering pumps. The pH is evaluated in this chamber to induce the precipitation of insoluble metal hydroxides.

3. Flocculation Chamber
Once the metal hydroxides are precipitated, a polymer is added in this chamber, which allows the small precipitated hydroxides to slowly mix with the polymer. The small particles grow into larger solids which can be easily removed in the clarifier.

4. Clarifier Chamber
Solids that are formed in the flocculation chamber are removed in the clarifier chamber. Inclined tube modules are placed in the clarifier to provide the necessary surface area and laminar flow for effective solids removal.

5. Sludge Thickening Chambers
The underflow or dilute sludge from the clarifier is pumped to one of the two sludge thickening chambers. The sludge is allowed to gravity settle which increases the solids concentration to 1 to 3% prior to being dewatered. High level alarms and manual decant valves are provided.

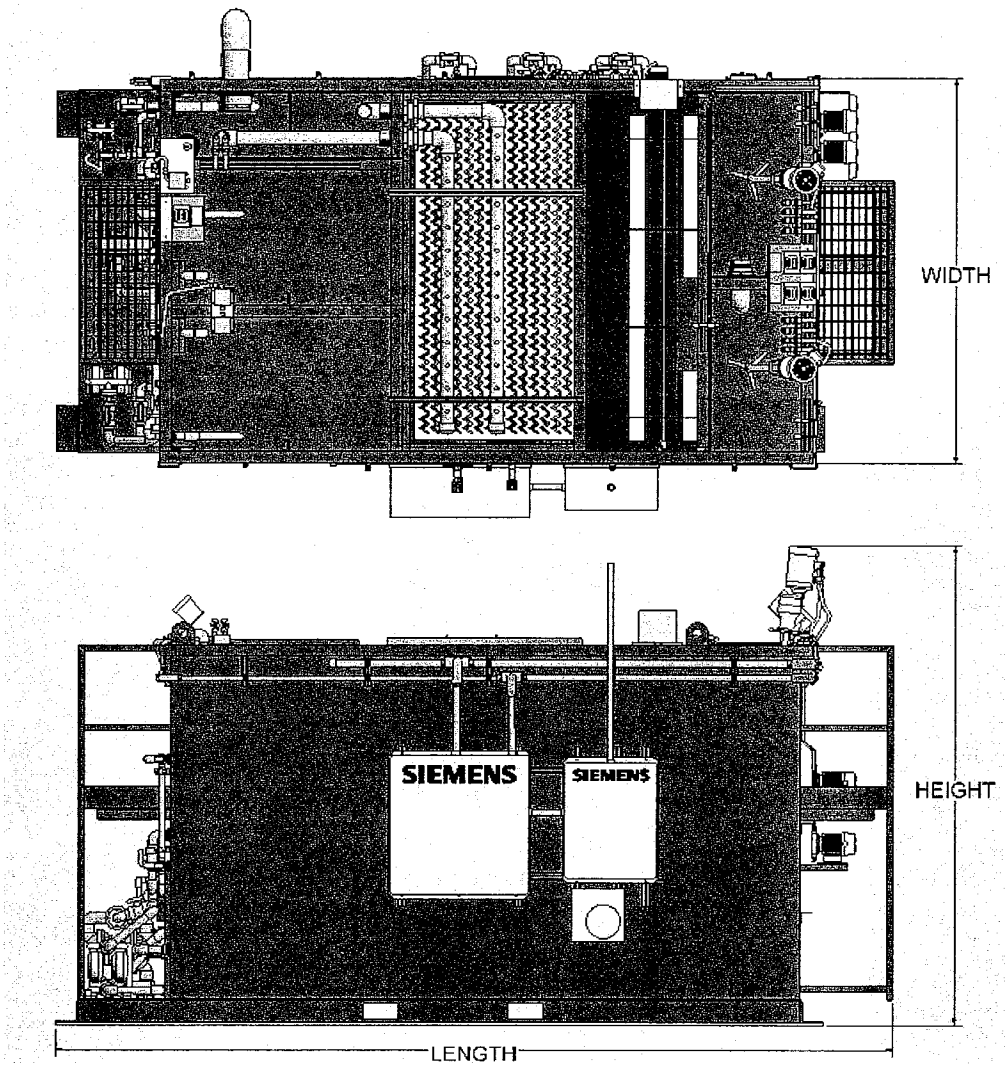
6. Effluent Clearwell Chamber
The clarified effluent is collected in the effluent clearwell chamber. With optional equipment, the pH can be monitored and the waste can be pumped to its final destination. Gravity flow is the standard means of effluent discharge from this chamber.

7. Sludge Transfer Pump
This pump is used to transfer the dilute sludge from the bottom of the clarifier chamber to one of the two sludge thickening chambers.

8. Optional Filter Press Feed Pump
Thickened sludge from the sludge thickening chambers is transferred via this pump to an optional dewatering device, such as a filter press.

9. Optional Decant Pump
An optional small air-operated diaphragm pump can be provided to transfer the decant from the sludge thickening chambers back to the influent collection tank.

10. Modular Design
The system is fully skid-mounted and includes mixers, pH probes, polymer mixing paddlewheel, inclined tube modules, sludge transfer pumps, instrumentation and PLC controller. The system is fully piped, wired and equipped for operation.



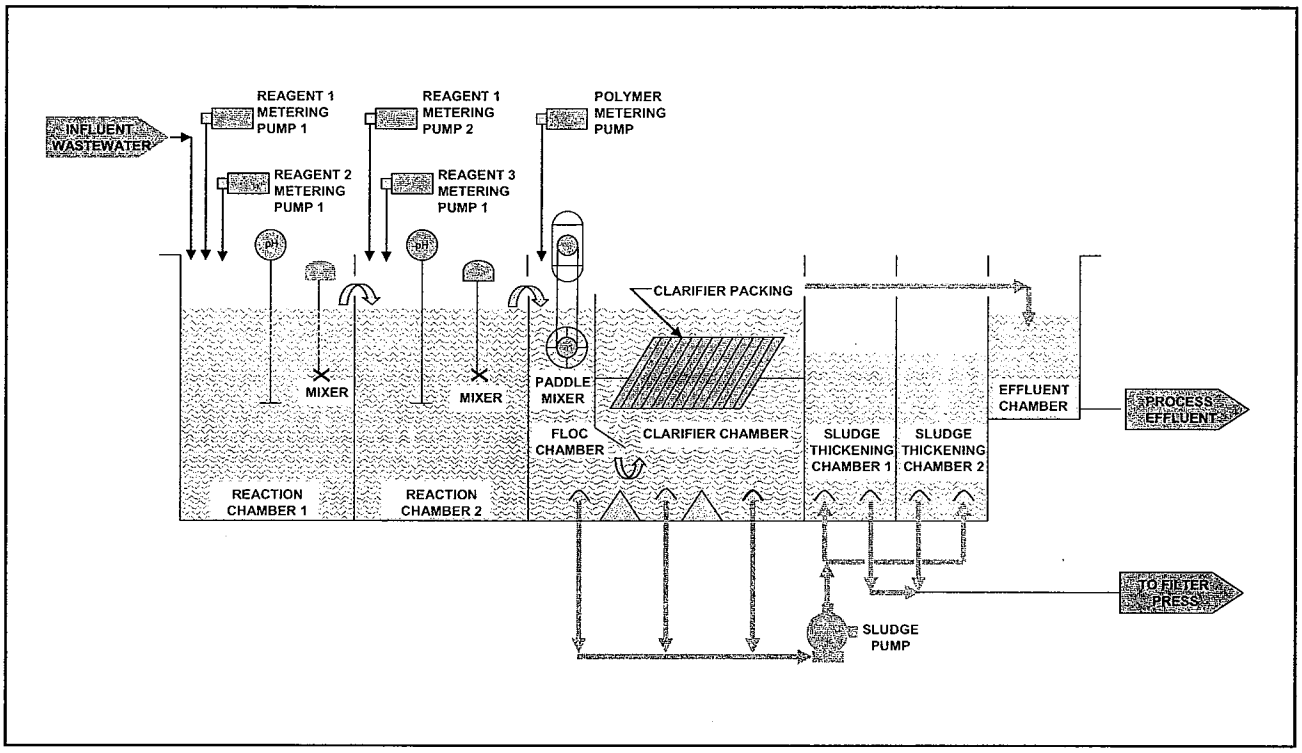

Technical Information

| CONTINUOUS PRECIPITATION SYSTEMS | | |
|---|---|---|
| MODEL* | FLOW RATE** | OVERALL DIMENSIONS (L x W x H) |
| CPS-10-2-SA | 10 gpm (2.3 $m^3/h$) | 11'-6" x 7'-2" x 8'-5" ( 3.5 m x 2.2 m x 2.0 m) |
| CPS-30-2-SA | 30 gpm (6.8 $m^3/h$) | 16'-1" x 7'-2" x 9'-0" (5.0 m x 2.2 m x 2.7 m) |
| CPS-50-2-SA | 50 gpm (11.4 $m^3/h$) | 18'-5" x 11'-1" x 10'-7" (5.6 m x 3.3 m x 3.2 m) |
| CPS-100-2-SA | 100 gpm (22.7 $m^3/h$) | 25'-10" x 10'-10" x 11'-7" (7.9 m x 3.3 m x 3.5 m) |

** Epoxy Coated Carbon Steel is the standard material of construction.*

*** Assumes <500 ppm influent suspended solids and temperature of 40°F<T<120°F (4°C<T<50°C).*

Process Flow Diagram




| OPTIONAL EQUIPMENT | |
|---|---|
| **Item** | **Description** |
| Influent Flow Equalization Tank & Transfer Pump | Tank sized for 60 minutes retention at the rated flow |
| Solids Dewatering Filter Press | Recessed chamber filter press used to dewater the process sludge generated by the CPS unit |
| Reagent Mix Tanks | Used for preparation and storage of the chemical reagents |
| Effluent Flow Meter and Recorder | Paddle wheel type flow meter used to measure and record the treated wastewater flow to the drain connection |
| Instruments | Reaction chamber ORP transmitters/probes, effluent pH transmitter/probe with recorder, and dual pH/ORP transmitters/probes |
| Inclined Plate Separator | Packing of FRP construction |
| Effluent Media Filter | Sand or multi-media filter used to ensure effluent suspended solids limits (<20 ppm) are met |
| Influent Collection Liftstations | Used to collect individual waste streams that are not able to gravity flow, and transfer the wastewater to the influent collection tank |

TotalTreat is a trademark of Siemens, its subsidiaries or affiliates.

The information provided in this brochure contains merely general descriptions or characteristics of performance which in actual case of use do not always apply as described or which may change as a result of further development of the products. An obligation to provide the respective characteristics shall only exist if expressly agreed in the terms of contract.

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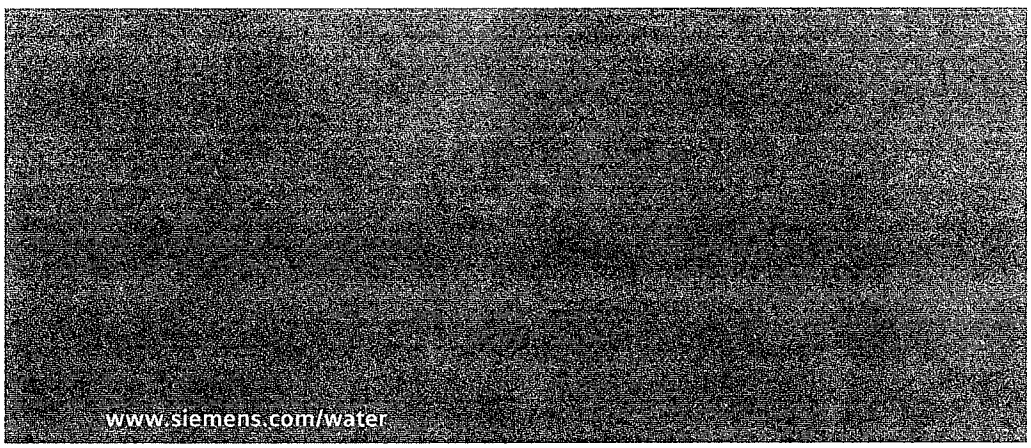


Water Technologies

# Neutralization System

## Fiberglass and HDPE Construction

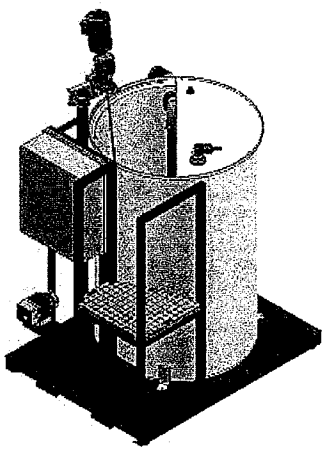
SIEMENS

The Neutralization NS (fiberglass tanks) and NSP (HDPE tanks) systems are typically used as final pH adjustment steps following conventional wastewater treatment or microfiltration systems. They include one reaction tank that is skid-mounted or supplied with a catwalk frame and completely piped and wired. The systems are designed to adjust the pH either up, down or both.

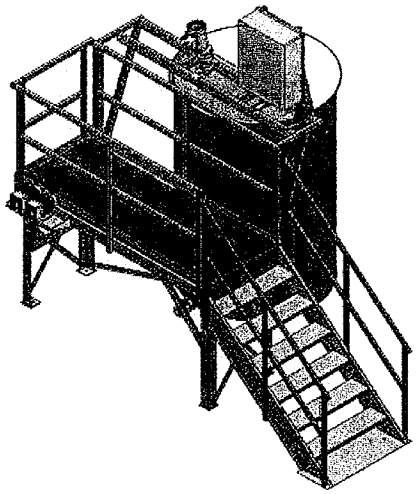
The basic neutralization system configuration has the tank equipped with one Brawn mixer, one LMI chemical feed pump, one GLI pH probe and one GLI pH transmitter. On NS/NSP systems less than 1,000 gallon (3.8 m3) capacity, the units are completely skid-mounted.

The skid frame supports the mixer, probes and chemical pump. An additional chemical metering pump is available as an option. The electrical control box, piping manifolds, conduit and wiring harnesses are also attached to this frame. When necessary, steps are supplied for operator access to the system.

*NSP-500*



*NSP-1000*



**FEATURES**

- Fully assembled at the factory
- Factory tested
- Units are either skid-mounted or catwalk integrated
- Units are match marked for ease of reassembly
- Rapid installation assured by skidded assemblies and mistake proof electrical connections

# Neutralization System

## Fiberglass and HDPE Construction

| NEUTRALIZATION SYSTEM | | | | | | |
|---|---|---|---|---|---|---|
| **Model Number** | **NS/NSP-250** | **NS/NSP-500** | **NS/NSP-1000** | **NS/NSP-1500** | **NS/NSP-2000** | **NS/NSP-3000** |
| Number of Tanks | One | One | One | One | One | One |
| Tank Material | FRP/HDPE | FRP/HDPE | FRP/HDPE | FRP/HDPE | FRP/HDPE | FRP/HDPE |
| Tank Volume | 250 gallons<br>0.95 $m^3$ | 500 gallons<br>1.9 $m^3$ | 1,000 gallons<br>3.8 $m^3$ | 1,500 gallons<br>5.7 $m^3$ | 2,000 gallons<br>7.6 $m^3$ | 3,000 gallons<br>11.4 $m^3$ |
| Type | Vertical Cylindrical | Vertical Cylindrical | Vertical Cylindrical | Vertical Cylindrical | Vertical Cylindrical | Vertical Cylindrical |
| Method of Construction | Skidded | Skidded | Catwalk-Mounted | Catwalk-Mounted | Catwalk-Mounted | Catwalk-Mounted |
| Recommended Through-Put | 20 gpm<br>4.5 $m^3$/hr | 40 gpm<br>9.1 $m^3$/hr | 80 gpm<br>18.2 $m^3$/hr | 125 gpm<br>28.4 $m^3$/hr | 165 gpm<br>37.5 $m^3$/hr | 240 gpm<br>54.5 $m^3$/hr |
| Mixers | 1/4 HP, 120/1/60, TEFC | 1/3 HP, 460/3/60, TEFC | 1/2 HP, 460/3/60, TEFC | 1 HP, 460/3/60, TEFC | 1 HP, 460/3/60, TEFC | 2 HP, 460/3/60, TEFC |
| **VALVES AND PIPING CONNECTIONS** | | | | | | |
| Outlet Connection | 3" Male Pipe Stub | 4" Male Pipe Stub | 4" Male Pipe Stub | 4" Male Pipe Stub | 6" Male Pipe Stub | 8" Male Pipe Stub |
| Drain Valve | 2" True Union Ball Valve | 2" True Union Ball Valve | 2" True Union Ball Valve | 2" True Union Ball Valve | 2" True Union Ball Valve | 2" True Union Ball Valve |
| **INSTRUMENTS** | | | | | | |
| pH Monitors | GLI pH Indicator Transmitter | GLI pH Indicator Transmitter | GLI pH Indicator Transmitter | GLI pH Indicator Transmitter | GLI pH Indicator Transmitter | GLI pH Indicator Transmitter |
| pH Probe | GLI Temperature Compensated | GLI Temperature Compensated | GLI Temperature Compensated | GLI Temperature Compensated | GLI Temperature Compensated | GLI Temperature Compensated |
| Recorder | One (1) Channel Circular Chart Recorder w/Digital Display | One (1) Channel Circular Chart Recorder w/Digital Display | One (1) Channel Circular Chart Recorder w/Digital Display | One (1) Channel Circular Chart Recorder w/Digital Display | One (1) Channel Circular Chart Recorder w/Digital Display | One (1) Channel Circular Chart Recorder w/Digital Display |
| PLC | Siemens | Siemens | Siemens | Siemens | Siemens | Siemens |
| **SKID** | | | | | | |
| Mounting | Each tank is mounted on its own skid. Skids are interlocked for ease of reassembly. | Each tank is mounted on its own skid. Skids are interlocked for ease of reassembly. | Tanks are floor mounted with mixers and all other components mounted off the catwalks. | Tanks are floor mounted with mixers and all other components mounted off the catwalks. | Tanks are floor mounted with mixers and all other components mounted off the catwalks. | Tanks are floor mounted with mixers and all other components mounted off the catwalks. |
| Paint | Near white metal sandblast + 2-3 mil primer + 3-5 mil finish | Near white metal sandblast + 2-3 mil primer + 3-5 mil finish | Near white metal sandblast + 2-3 mil primer + 3-5 mil finish | Near white metal sandblast + 2-3 mil primer + 3-5 mil finish | Near white metal sandblast + 2-3 mil primer + 3-5 mil finish | Near white metal sandblast + 2-3 mil primer + 3-5 mil finish |
| Dimensions (L x W x H) | 80" x 55" x 85"<br>2,032 x 1,397<br>x 2,159 mm | 80" x 55" x 110"<br>2,032 x 1,397<br>x 2,794 mm | 100"x 120" x 145"<br>2,540 x 3,048<br>x 3,683 mm | 100" x 135" x 145"<br>2,540 x 3,429<br>x 3,683 mm | 100" x 145" x 145"<br>2,540 x 3,683<br>x 3,683 mm | 100" x 150" x 170"<br>2,540 x 3,810<br>x 4,318 mm |
| Shipping Weight | 879 lbs<br>399 kg | 1,266 lbs<br>574 kg | 2,445 lbs<br>1109 kg | 2,550 lbs<br>1,156 kg | 2,717 lbs<br>1,232 kg | 3,191 lbs<br>1,447 kg |
| Operating Weight | 2,964 lbs<br>1,344 kg | 5,438 lbs<br>2,467 kg | 10,785 lbs<br>4,892 kg | 15,060 lbs<br>6,831kg | 19,397 lbs<br>8,798 kg | 28,211 lbs<br>12,796 kg |

The information provided in this literature contains merely general descriptions or characteristics of performance which in actual case of use do not always apply as described or which may change as a result of further development of the products. An obligation to provide the respective characteristics shall only exist if expressly agreed in the terms of the contract.

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Water Technologies

# Equalization and Water Storage Tanks

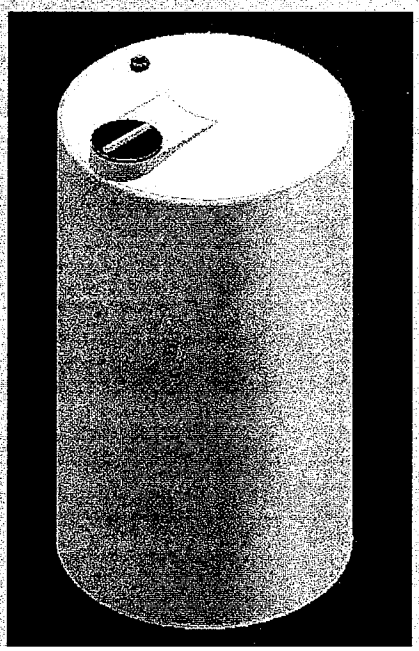
SIEMENS

The Equalization and Water Storage Tanks are specifically designed to be used with the transfer pump system. The tanks are used to provide the proper holding capacity before a wastewater treatment system or to hold purified water from an ion exchange or reverse osmosis system.

The tanks are available in either high density polyethylene (HDPE) or fiberglass (FRP). The tank can be supplied as either open top construction features or with a dome/cover.

The tanks come complete with a level control and all of the associated bulk head fittings.

*EQ 1500*



**FEATURES**

- Non-corrosive construction (HDPE or FRP)
- Level control included
- Sold as stand alone
- Integrate with other wastewater products

# Equalization and Water Storage Tanks

## SPECIFICATIONS

| Model Number | EQ-250-HDPE | EQ-500-HDPE | EQ-1000-HDPE | EQ-1500-HDPE | EQ-3200-HDPE | EQ-6500-HDPE | EQ-9000-HDPE | EQ-10000-HDPE | EQ-12000-HDPE |
|---|---|---|---|---|---|---|---|---|---|
| Tank Volume | 250 gallons 0.95 m³ | 500 gallons 1.9 m³ | 1,000 gallons 3.8 m³ | 1,500 gallons 5.7 m³ | 3,200 gallons 12.1 m³ | 6,500 gallons 24.6 m³ | 9,000 gallons 34.0 m³ | 10,000 gallons 37.9 m³ | 12,000 gallons 45.4 m³ |
| Material of Construction | HDPE Dome Top | HDPE Dome Top | HDPE Dome Top | HDPE Dome Top | HDPE Dome Top | HDPE Dome Top | HDPE Dome Top | HDPE Dome Top | HDPE Dome Top |
| Discharge Nozzle | Determined by pump selection | Determined by pump selection | Determined by pump selection | Determined by pump selection | Determined by pump selection | Determined by pump selection | Determined by pump selection | Determined by pump selection | Determined by pump selection |
| Drain Valve | 2" True Union Ball Valve | 2" True Union Ball Valve | 2" True Union Ball Valve | 2" True Union Ball Valve | 2" True Union Ball Valve | 2" True Union Ball Valve | 2" True Union Ball Valve | 2" True Union Ball Valve | 2" True Union Ball Valve |
| Level Control | Float | Float | Float | Float | Float | Float | Float | Float | Float |
| Dimensions (Dia. x H) | 43" x 59" 1,092 x 1,499 mm | 45-1/2" x 82-3/4" 1,156 x 2,102 mm | 64-1/2" x 88-1/4" 1,638 x 2,242 mm | 64" x 126-1/2" 1,626 x 3,213 mm | 95-3/4" x 116-3/4" 2,432 x 2,965 mm | 120" x 152-1/4" 3,048 x 3,867 mm | 141" x 145" 3,581 x 3,683 mm | 141" x 159" 3,581 x 4,039 mm | 141" x 192" 3,581 x 4,877 mm |
| Manway | 8 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 |
| Shipping Weight | 100 lbs 45 kg | 120 lbs 54 kg | 220 lbs 100 kg | 365 lbs 166 kg | 660 lbs 299 kg | 1,595 lbs 723 kg | 1,940 lbs 880 kg | 2,310 lbs 1,048 kg | 3,100 lbs 1,406 kg |
| Operating Weight | 2,185 lbs 991 kg | 4,290 lbs 1,946 kg | 8,560 lbs 3,883 kg | 12,875 lbs 5,840 kg | 27,348 lbs 12,405 kg | 58,307 lbs 26,448 kg | 77,000 lbs 34,927 kg | 85,710 lbs 38,877 kg | 103,180 lbs 46,802 kg |

| Model Number | EQ-500-FRP | EQ-1000-FRP | EQ-1500-FRP | EQ-3200-FRP | EQ-6500-FRP | EQ-9000-FRP | EQ-10000-FRP | EQ-12000-FRP |
|---|---|---|---|---|---|---|---|---|
| Tank Volume | 500 gallons 1.9 m³ | 1,000 gallons 3.8 m³ | 1,500 gallons 5.7 m³ | 3,200 gallons 12.1 m³ | 6,500 gallons 24.6 m³ | 9,000 gallons 34.0 m³ | 10,000 gallons 37.9 m³ | 12,000 gallons 45.4 m³ |
| Material of Construction | FRP Open Top w/cover | FRP Open Top w/cover | FRP Dome Top | FRP Dome Top | FRP Dome Top | FRP Dome Top | FRP Dome Top | FRP Dome Top |
| Discharge Nozzle | Determined by pump selection | Determined by pump selection | Determined by pump selection | Determined by pump selection | Determined by pump selection | Determined by pump selection | Determined by pump selection | Determined by pump selection |
| Drain Valve | 2" True Union Ball Valve | 2" True Union Ball Valve | 2" True Union Ball Valve | 2" True Union Ball Valve | 2" True Union Ball Valve | 2" True Union Ball Valve | 2" True Union Ball Valve | 2" True Union Ball Valve |
| Level Control | Float | Float | Float | Float | Float | Float | Float | Float |
| Dimensions (Dia. x H) | 42" x 66" 1,067 x 1,676 mm | 60" x 84" 1,524 x 2,134 mm | 72" x 84" 1,829 x 2,134 mm | 96" x 108" 2,438 x 2,743 mm | 96" x 210" 2,438 x 5,334 mm | 120" x 186" 3,048 x 4,724 mm | 120" x 210" 3,048 x 5,334 mm | 144" x 168" 3,658 x 4,267 mm |
| Shipping Weight | 230 lbs 104 kg | 406 lbs 186 kg | 560 lbs 254 kg | 947 lbs 430 kg | 1,596 lbs 724 kg | 1,813 lbs 822 kg | 1,988 lbs 902 kg | 2,390 lbs 1,084 kg |
| Operating Weight | 4,400 lbs 1,996 kg | 8,746 lbs 3,967 kg | 13,070 lbs 5,928 kg | 27,635 lbs 12,535 kg | 55,806 lbs 25,313 kg | 76,873 lbs 34,869 kg | 85,388 lbs 38,731 kg | 102,470 lbs 46,479 kg |

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Water Technologies

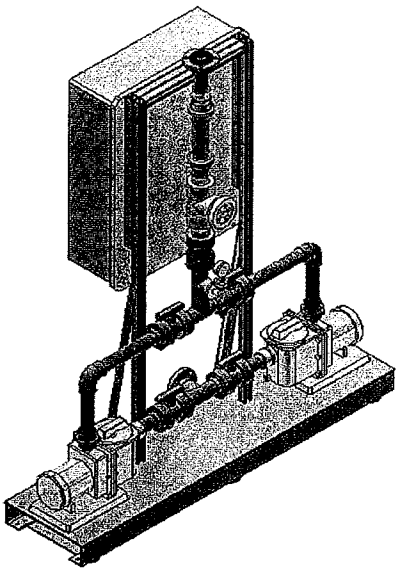
# Transfer Pump Systems (PS-S and PS-D Series)

Low Pressure, Simplex and Duplex

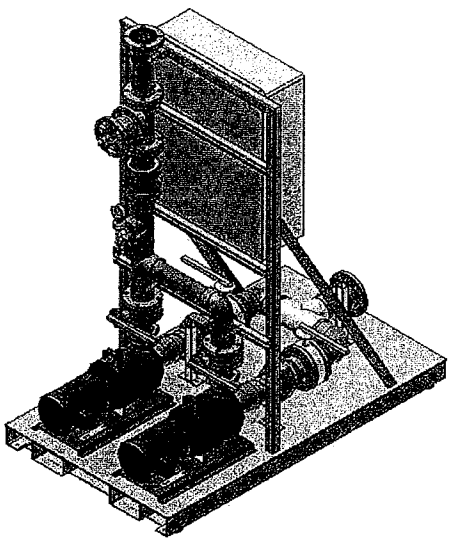
SIEMENS

The Transfer Pump Systems are specifically designed to be used with an existing collection tank or sump tank. The pumps are sized to provide 50 feet of head at the design flow rate. The pump, valves, flow indicator, flow control valve and control panel are mounted on a corrosion resistant painted steel skid. The system can be purchased as a stand alone item or used in conjunction with other standard products. When integrating with other standard products modules, the Transfer Pump System simply interlocks with the other modules. The interconnecting piping (if within 3 feet of the next module) is also provided with the system. On larger horsepower pumps, an electrical drop may be necessary.

*PS-10 through PS-50*



*PS-75 through PS-200*



**FEATURES**

- NEMA-4X electrical enclosure
- Rotometer to indicate flow
- Adjustable diaphragm valve to control flow
- Isolation ball valve to service the pump
- TEFC pump motor
- Pre-piped
- Pre-wired
- Factory tested
- Sold as stand alone
- Integrate with other wastewater products

# Transfer Pump Systems (PS-S and PS-D Series)

## Low Pressure, Simplex and Duplex

| PUMPS | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Model Number | PS-10-S/D | PS-30-S/D | PS-50-S/D | PS-75-S/D | PS-100-S/D | PS-150-S/D | PS-200-S/D | PS-250-S/D | PS-300-S/D |
| Number of Pumps | One/Two | One/Two | One/Two | One/Two | One/Two | One/Two | One/Two | One/Two | One/Two |
| Manufacturer | Serfilco | Serfilco | Serfilco | Serfilco | Serfilco | Serfilco | Serfilco | Serfilco | Serfilco |
| Type | Horizontal | Horizontal | Horizontal | Horizontal | Horizontal | Horizontal | Horizontal | Horizontal | Horizontal |
| Material of Construction | Noryl | Noryl | Noryl | Polyester | Polyester | Polyester | Polyester | Stainless Steel | Stainless Steel |
| Capacity | 10 gpm @ 50' head 2.3 $m^3$/hr @149 kPa | 30 gpm @ 50' head 6.8 $m^3$/hr @ 149 kPa | 50 gpm @ 50' head 11.4 $m^3$/hr @ 149 kPa | 75 gpm @ 50' head 17.0 $m^3$/hr @ 149 kPa | 100 gpm @ 50' head 22.7 $m^3$/hr @ 149 kPa | 150 gpm @ 50' head 34.1 $m^3$/hr @ 149 kPa | 200 gpm @ 50' head 45.4 $m^3$/hr @ 149 kPa | 250 gpm @ 50' head 56.8 $m^3$/hr @ 149 kPa | 300 gpm @ 50' head 68.1 $m^3$/hr @ 149 kPa |
| Motor | 1.0 HP, 460/3/60, TEFC | 1.5 HP, 460/3/60, TEFC | 2 HP, 460/3/60, TEFC | 3 HP, 460/3/60, TEFC | 3 HP, 460/3/60, TEFC | 5 HP, 460/3/60, TEFC | 5 HP, 460/3/60, TEFC | 7.5 HP, 460/3/60, TEFC | 7.5 HP, 460/3/60, TEFC |
| **VALVES** | | | | | | | | | |
| Suction | One/Two PVC Ball Type | One/Two PVC Ball Type | One/Two PVC Ball Type | One/Two PVC Ball Type | One/Two PVC Ball Type | One/Two PVC Ball Type | One/Two PVC Ball Type | One/Two PVC Ball Type | One/Two PVC Ball Type |
| Discharge | One/Two PVC Ball Type | One/Two PVC Ball Type | One/Two PVC Ball Type | One/Two PVC Ball Type | One/Two PVC Ball Type | One/Two PVC Ball Type | One/Two PVC Ball Type | One/Two PVC Ball Type | One/Two PVC Ball Type |
| Discharge Check Valve | One PVC Check Valve | One PVC Check Valve | One PVC Check Valve | One PVC Check Valve | One PVC Check Valve | One PVC Check Valve | One PVC Check Valve | One PVC Check Valve | One PVC Check Valve |
| Discharge Throttle Valve | Diaphragm Type | Diaphragm Type | Diaphragm Type | Diaphragm Type | Diaphragm Type | Diaphragm Type | Diaphragm Type | Diaphragm Type | Diaphragm Type |
| Connection | 2" | 2" | 2" | 3" | 3" | 4" | 4" | 4" | 4" |
| **INSTRUMENTS** | | | | | | | | | |
| Pressure | One Discharge Pressure Gauge | One Discharge Pressure Gauge | One Discharge Pressure Gauge | One Discharge Pressure Gauge | One Discharge Pressure Gauge | One Discharge Pressure Gauge | One Discharge Pressure Gauge | One Discharge Pressure Gauge | One Discharge Pressure Gauge |
| Flowmeter | Rotometer | Rotometer | Rotometer | Rotometer | Paddlewheel | Paddlewheel | Paddlewheel | Paddlewheel | Paddlewheel |
| Level Control | Float | Float | Float | Float | Float | Float | Float | Float | Float |
| **SKID** | | | | | | | | | |
| Mounting | Pumps and piping mounted on steel base | Pumps and piping mounted on steel base | Pumps and piping mounted on steel base | Pumps and piping mounted on steel base | Pumps and piping mounted on steel base | Pumps and piping mounted on steel base | Pumps and piping mounted on steel base | Pumps and piping mounted on steel base | Pumps and piping mounted on steel base |
| Paint | White metal sandblast + 2-3 mil primer + 3-5 mil finish | White metal sandblast + 2-3 mil primer + 3-5 mil finish | White metal sandblast + 2-3 mil primer + 3-5 mil finish | White metal sandblast + 2-3 mil primer + 3-5 mil finish | White metal sandblast + 2-3 mil primer + 3-5 mil finish | White metal sandblast + 2-3 mil primer + 3-5 mil finish | White metal sandblast + 2-3 mil primer + 3-5 mil finish | White metal sandblast + 2-3 mil primer + 3-5 mil finish | White metal sandblast + 2-3 mil primer + 3-5 mil finish |
| Dimensions (L x W x H) | 60"x 18"x 80" 1,524 x 457 x 2,032 mm | 60"x 18"x 80" 1,524 x 457 x 2,032 mm | 60"x 18"x 80" 1,524 x 457 x 2,032 mm | 72"x 42"x 86" 1,829 x 1,067 x 2,032 mm | 72"x 42"x 86" 1,829 x 1,067 x 2,032 mm | 72"x 42"x 86" 1,829 x 1,067 x 2,032 mm | 72"x 42"x 86" 1,829 x 1,067 x 2,032 mm | 72"x 42"x 86" 1,829 x 1,067 x 2,032 mm | 72"x 42"x 86" 1,829 x 1,067 x 2,032 mm |
| Shipping Weight | 475 lbs 215 kg | 475 lbs 215 kg | 475 lbs 215 kg | 989 lbs 449 kg | 1,020 lbs 463 kg | 1,080 lbs 490 kg | 1,200 lbs 544 kg | 1,700 lbs 771 kg | 1,800 lbs 816 kg |
| Operating Weight | 500 lbs 227 kg | 500 lbs 227 kg | 500 lbs 227 kg | 1,014 lbs 460 kg | 1,045 lbs 474 kg | 1,105 lbs 474 kg | 1,225 lbs 556 kg | 1,725 lbs 782 kg | 1,825 lbs 828 kg |

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# HYDRUS

# HF 330m OD Macrolite® Filter

**Design Specifications**

| | |
|---|---|
| Flow Rate at 10 gpm/ft$^2$ | 147 gpm |
| Nominal Clean-Bed Pressure Drop | 7.5 psid |
| Pressure Range | 35 – 125 psig |
| Temperature Range | 35 – 120° F |
| Total Suspended Solids | ≤ 30 mg/L |

**System Components**

| | |
|---|---|
| Media Vessel (qty) Size | (3) 30" x 72" |
| Media Vessel Construction | Wrapped Polyethylene |
| Empty Bed Volume | 25.0 ft$^3$ |
| Media Type | M2 Macrolite® |
| Media Volume (per tank) | 8 ft$^3$ |
| Under Bedding Weight (per tank) | 300 pounds |
| Total Bed Depth | 20" |
| Free Board | 41" |
| Riser Tube | 2.0" PVC |
| Upper Distributor | 0.012" Slots, Engineered Plastic Material |
| Lower Distributor | 0.012" Slots, Polyethylene Hub and Laterals |
| Backwash Control | 7-Day Controller |
| Backwash Type | Countercurrent |
| Unfiltered Water Bypass During Backwash | No |
| Water Used for Backwash | Filtered Water |

**Connections**

| | |
|---|---|
| Inlet / Outlet Connections | E-Clip Adapter |
| Drain Connection | E-Clip Adapter |
| Power, Valve | None |
| Power, Control Box | 12 VDC |

**Part Numbers**

| | |
|---|---|
| System (quantity) | (3) H12281 |
| Smart Start Controller | 12137 |
| Differential Pressure Switch | 59256 |

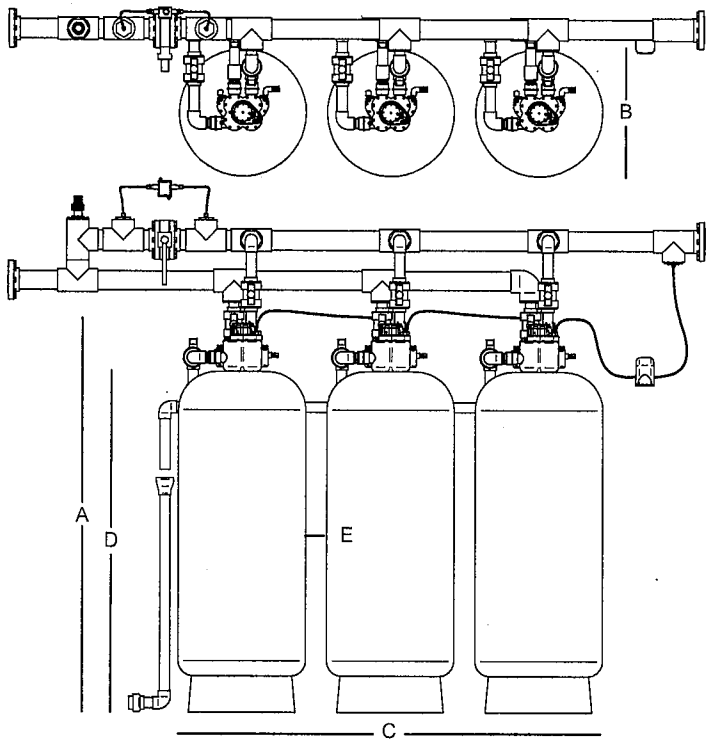
**Backwash Specifications (per tank)**

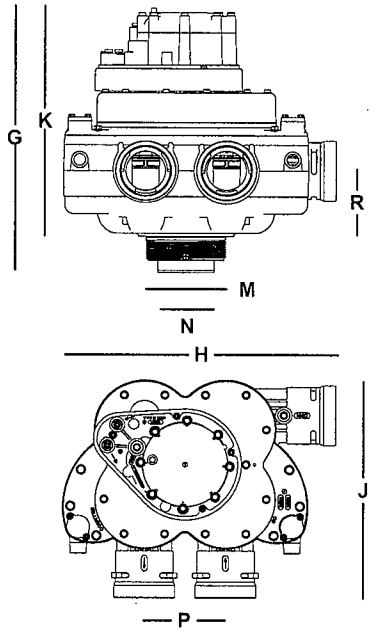
| Sequence | Flow | Time | Volume |
|---|---|---|---|
| Backwash | 39 gpm | 12 minutes | 468 gallons |
| Settle | N/A | 1.5 minutes | N/A |
| Purge | 39 gpm | 4 minutes | 156 gallons |
| Total | N/A | 17.5 minutes | 633 gallons |

**Dimensions and Weight**

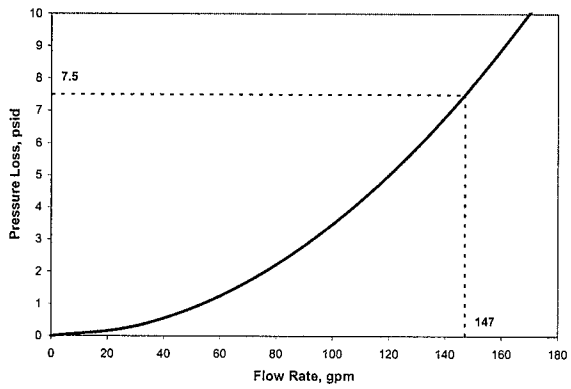
System

| | | |
|---|---|---|
| Overall Height | (A) | 95.5" |
| Overall Depth | (B) | 30" |
| Overall Width | (C) | 98.0" |
| Tank Height | (D) | 83.8" |
| Inter-Tank Spacing | (E) | 4" |
| Shipping Weight | | 3,343 pounds |
| Operating Weight | | **6,094** pounds |




**System Flow Performance**




**Valve**

| | | |
|---|---|---|
| Overall Height | (G) | 13.25" |
| Overall Width | (H) | 14" |
| Overall Depth | (J) | 11" |
| Installed Height | (K) | 11.5" |
| Tank Thread | (M) | 4-8 UN |
| Riser Tube (OD) | (N) | 2.8" |
| Inlet/Outlet Centerline | (P) | 4.06 |
| Inlet/Outlet/Drain Center Installed Height | (R) | 3.34 |
| Valve Weight | | 14.3 pounds |

Kinetico water systems

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# HYDRUS HF 330m OD Macrolite® Filter

### Operating Profile
The filter shall remove suspended solids to a nominal rating of 5 micron. Ceramic based non-consumable media shall be used for the filtration process. The system shall provide filtered water through the use of a multiplex configuration. System backwashes shall be initiated based on the time of day. The programmable timer shall allow backwashes to be programmed over a 7-day period.

### Backwash Control Valve
The backwash control valve shall be top mounted (top of media tank), and manufactured from non-corrosive materials. Control valve shall not weight more than 15 lbs. Control valve shall operate using a minimum outlet pressure of 25 psi. Pressure shall be used to drive all valve functions. Control valve shall incorporate three operational cycles including; service, backwash, and purge. Service cycle shall operate in a down-flow direction. The backwash cycle shall be up-flow and purge shall be down-flow. Control valve shall contain a backwash flow control.

### Media Tanks
The tanks shall be designed for a maximum working pressure of 125 psi and hydrostatically tested at 300 psi. Tanks shall be made of polypropylene and reinforced with a fiberglass wrapping. Tank shall have a 4" threaded top opening. Tank shall be NSF approved. Upper diffuser system shall be of a slot design. Lower distribution system shall be of hub and lateral design. Distribution system shall provide even distribution of backwash water and the collection of processed water.

### Filtering Media
Each system shall use ceramic based filter media capability of operating in an average service flow of 10 gpm per square foot of media. The media shall be solid and of a proper particle size, 40-70 mesh. Backwash shall produce a minimum of 50% bed expansion at a nominal flow rate of 8 gpm per square foot of media.

Kinetico®
water systems


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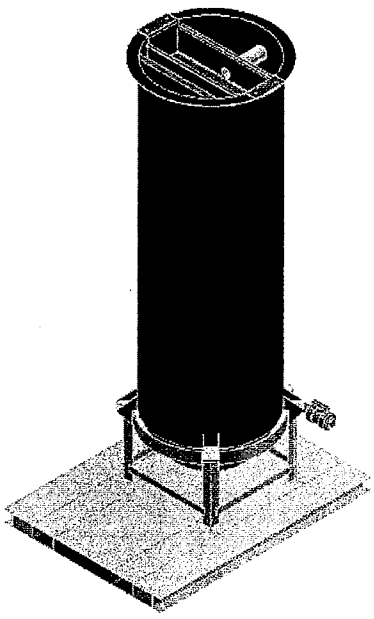
Water Technologies

# Sludge Thickening System (50 Series)

SIEMENS

The Sludge Thickening System is designed to take low concentrated sludge (1-2% solids) and increase the sludge concentration to 4-5% solids by means of gravity settling. Sludges from a Memtek® Microfilter System, a solids separator (clarifier) or a TotalTreat® Continuous Precipitation System system that does not incorporate an integrated sludge aging tank can be further thickened by using a Sludge Thickening System. The system is operated in a continuous mode. It includes a coned bottom FRP tank, FRP inlet baffle, effluent weir trough and a flanged sludge withdrawal nozzle.

*50 Series*



**FEATURES**

- Non-corrosive FRP construction
- Sold as stand alone
- Integrate with other wastewater products

# Sludge Thickening System (50 Series)

| SLUDGE THICKENING SYSTEM | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Model Number | 50-7105-3 | 50-7108-3 | 50-7112-3 | 50-7118-3 | 50-7125-3 | 50-7130-3 | 50-7135-3 | 50-7140-3 | 50-7145-3 |
| Tank Volume | 500 gallons 1.9 $m^3$ | 800 gallons 3.0 $m^3$ | 1,200 gallons 4.5 $m^3$ | 1,800 gallons 6.8 $m^3$ | 2,500 gallons 9.5 $m^3$ | 3,000 gallons 11.4 $m^3$ | 3,500 gallons 13.3 $m^3$ | 4,000 gallons 15.1 $m^3$ | 4,500 gallons 17.0 $m^3$ |
| Effluent Nozzle | 3" Flanged | 3" Flanged | 3" Flanged | 3" Flanged | 3" Flanged | 3" Flanged | 4" Flanged | 4" Flanged | 4" Flanged |
| Sludge Withdrawal Nozzle | 2" Flanged | 2" Flanged | 2" Flanged | 2" Flanged | 2" Flanged | 2" Flanged | 2" Flanged | 2" Flanged | 2" Flanged |
| Drain Valve | 2" True Union Ball Valve | 2" True Union Ball Valve | 2" True Union Ball Valve | 2" True Union Ball Valve | 2" True Union Ball Valve | 2" True Union Ball Valve | 2" True Union Ball Valve | 2" True Union Ball Valve | 2" True Union Ball Valve |
| Dimensions (Dia. x H) | 3'-0" x 10'-8" 914 x 3,251 mm | 4'-0" x 10'-8" 1,219 x 3,251 mm | 5'-0" x 10'-8" 1,524 x 3,251 mm | 6'-0" x 10'-8" 1,829 x 3,251 mm | 7'-0" x 10'-8" 2,134 x 3,251 mm | 8'-0" x 10'-8" 2,438 x 3,251 mm | 8'-0" x 13'-9" 2,438 x 4,191 mm | 9'-0" x 13'-6" 2,743 x 4,115 mm | 9'-0" x 14'-6" 2,743 x 4,420 mm |
| Shipping Weight | 432 lbs 196 kg | 560 lbs 254 kg | 722 lbs 328 kg | 834 lbs 378 kg | 955 lbs 433 kg | 1,095 lbs 497 kg | 2,640 lbs 1,197 kg | 2,726 lbs 1,237 kg | 2,800 lbs 1,270 kg |
| Operating Weight (lbs) | 5,935 lbs 2,692 kg | 9,815 lbs 4,452 kg | 14,315 lbs 6,493 kg | 18,985 lbs 8,612 kg | 23,880 lbs 10,832 kg | 28,665 lbs 13,002 kg | 37,640 lbs 17,073 kg | 42,725 lbs 19,380 kg | 47,800 lbs 21,682 kg |

| Model Number | 50-7150-3 | 50-7155-3 | 50-7160-3 | 50-7165-3 | 50-7170-3 | 50-7180-3 | 50-7190-3 | 50-71100-3 |
|---|---|---|---|---|---|---|---|---|
| Tank Capacity (gallons) | 5,000 gallons 18.9 kg | 5,500 gallons 20.8 kg | 6,000 gallons 22.7 kg | 6,500 gallons 24.6 kg | 7,000 gallons 26.5 kg | 8,000 gallons 30.3 kg | 9,000 gallons 34.0 kg | 10,000 gallons 37.9 kg |
| Effluent Nozzle | 4" Flanged | 4" Flanged | 4" Flanged | 4" Flanged | 4" Flanged | 4" Flanged | 4" Flanged | 4" Flanged |
| Sludge Withdrawal Nozzle | 2" Flanged | 2" Flanged | 2" Flanged | 2" Flanged | 2" Flanged | 2" Flanged | 2" Flanged | 2" Flanged |
| Dimensions (Dia. x H) | 10'-0" x 14'-0" 3,048 x 4,267 mm | 10'-0" x 15'-0" 3,048 x 4x572 mm | 11'-0" x 14'-6" 3,353 x 4,420 mm | 11'-0" x 15'-3" 3,353 x 4,648 mm | 12'-0" x 15'-0" 3,658 x 4,572 mm | 12'-0" x 16'-2" 3,658 x 4,928 mm | 12'-0" x 17'-4" 3,658 x 5,283 mm | 12'-0" x 18'-6" 3,658 x 5,639 mm |
| Shipping Weight | 3,280 lbs 1,488 kg | 3,370 lbs 1,529 kg | 3,980 lbs 1,805 kg | 4,050 lbs 1,837 kg | 4,465 lbs 2,025 kg | 4,975 lbs 2,257 kg | 5,490 lbs 2,490 kg | 6,000 lbs 2,722 kg |
| Operating Weight | 53,280 lbs 24,167 kg | 58,370 lbs 26,476 kg | 63,980 lbs 29,021 kg | 69,050 lbs 31,321 kg | 74,465 lbs 33,777 kg | 84,965 lbs 38,540 kg | 95,465 lbs 43,302 kg | 106,000 lbs 48,081 kg |

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Water Technologies

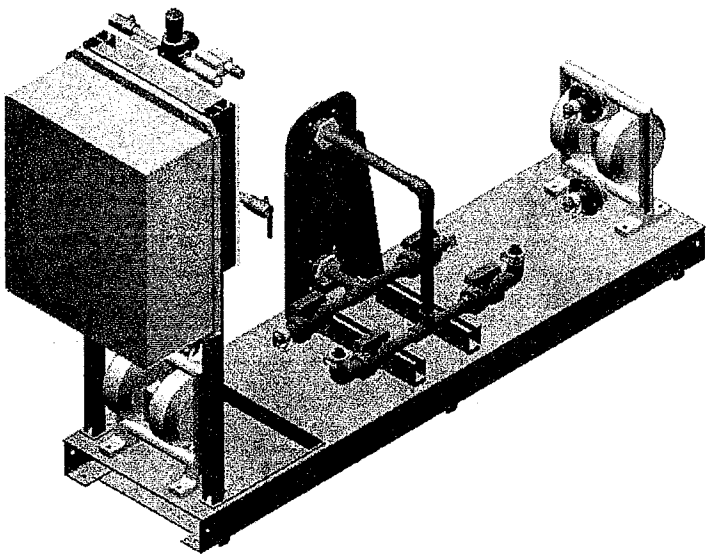
# Air Diaphragm Pump Systems

## Simplex and Duplex

SIEMENS

The Air Diaphragm Pump Systems are specifically designed to be used with an existing collection tank or sump. The pumps are sized to provide 50 feet of head at the design flow rate. The air diaphragm pump, valves and control panel are mounted on a corrosion resistant painted steel skid. The system can be purchased as a stand alone item or used in conjunction with other standard products. When integrating with other standard products modules, the Air Diaphragm Pump System simply interlocks with the other modules. The interconnecting piping (if within 3 feet of the next module) is also provided with the system.

*PS1.OP*



**FEATURES**

- Isolation ball valve to service the pump
- Pre-piped
- Pre-wired
- Factory tested
- Sold as stand alone
- Integrate with other wastewater products

# Air Diaphragm Pump Systems

## Simplex and Duplex

| PUMPS | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Model Number | PS0.5C | PS0.5P | PS1.0C | PS1.0P | PS1.5C | PS1.5P | PS2.0C | PS2.0P | PS3.0C |
| Number of Air Diaphragm Pumps | One/Two | | One/Two | | One/Two | | One/Two | | One/Two |
| Manufacturer | Aro | | Aro | | Aro | | Aro | | Aro |
| Type | Double Diaphram, Air Operated | | Double Diaphram, Air Operated | | Double Diaphram, Air Operated | | Double Diaphram, Air Operated | | Double Diaphram, Air Operated |
| Material of Construction | Cast Iron | Polypro | Double Diaphram, Air Operated | Polypro | Cast Iron | Polypro | Cast Iron | Polypro | Cast Iron |
| Flow rate | 3-12 gpm 0.68-2.7 $m^3$/hr | 3-12 gpm 0.68-2.7 $m^3$/hr | 12-35 gpm 2.7-7.9 $m^3$/hr | 10-40 gpm 2.2-9.0 $m^3$/hr | 40-80 gpm 9.0-18.2 $m^3$/hr | 40-110 gpm 9.0-25.0 $m^3$/hr | 60-150 gpm 13.6-34.0 $m^3$/hr | 40-120 gpm 9.0-27.2 $m^3$/hr | 120-210 gpm 27.2-47.7 $m^3$/hr |
| **VALVES** | | | | | | | | | |
| Suction | 2" True Union Ball Valve | | 2" True Union Ball Valve | | 2" True Union Ball Valve | | 3" Butterfly Valve | | 4" Butterfly Valve |
| Discharge | 2" True Union Ball Valve | | 2" True Union Ball Valve | | 2" True Union Ball Valve | | 3" Butterfly Valve | | 4" Butterfly Valve |
| Connection | 2" | | 2" | | 2" | | 3" | | 4" |
| **INSTRUMENTS** | | | | | | | | | |
| Level Control | Float | | Float | | Float | | Float | | Float |
| **SKID** | | | | | | | | | |
| Mounting | Pumps and piping mounted on steel base | | Pumps and piping mounted on steel base | | Pumps and piping mounted on steel base | | Pumps and piping mounted on steel base | | Pumps and piping mounted on steel base |
| Paint | White metal sandblast + 2-3 mil primer + 3-5 mil finish | | White metal sandblast + 2-3 mil primer + 3-5 mil finish | | White metal sandblast + 2-3 mil primer + 3-5 mil finish | | White metal sandblast + 2-3 mil primer + 3-5 mil finish | | White metal sand-blast + 2-3 mil primer + 3-5 mil finish |
| Dimensions (L x W x H) | 80" x 20" x 57" 2,032 x 508 x 1,448 mm | | 80" x 20" x 57" 2,032 x 508 x 1,448 mm | | 80" x 20" x 57" 2,032 x 508 x 1,448 mm | | 82" x 50" x 54" 2,083 x 1,270 x 1,372 mm | | 82" x 50" x 54" 2,083 x 1,270 x 1,372 mm |
| Shipping weight | 500 lbs 227 kg | | 500 lbs 227 kg | | 500 lbs 227 kg | | 800 lbs 227 kg | | 800 lbs 227 kg |

The information provided in this literature contains merely general descriptions or characteristics of performance which in actual case of use do not always apply as described or which may change as a result of further development of the products. An obligation to provide the respective characteristics shall only exist if expressly agreed in the terms of the contract.

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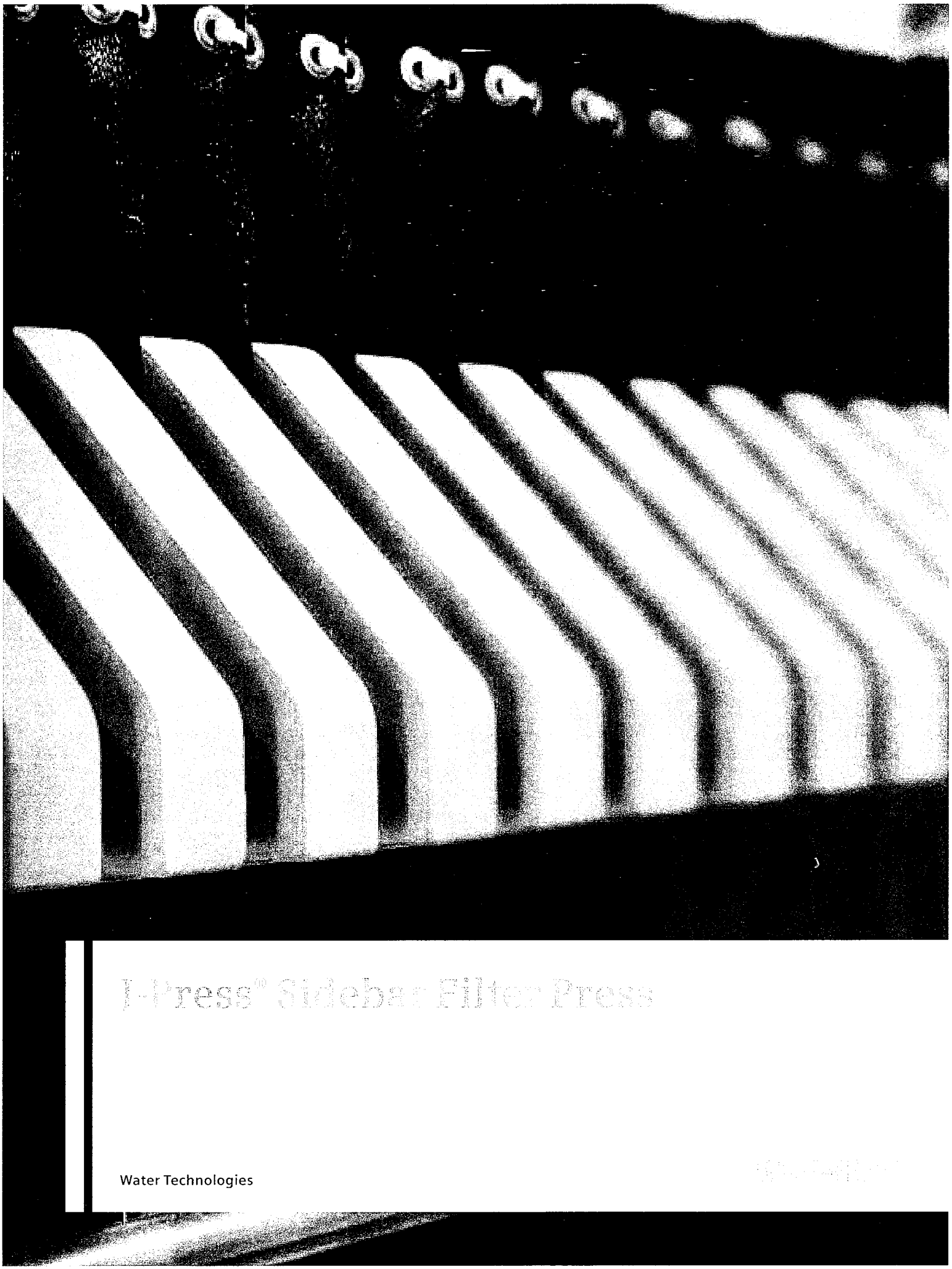
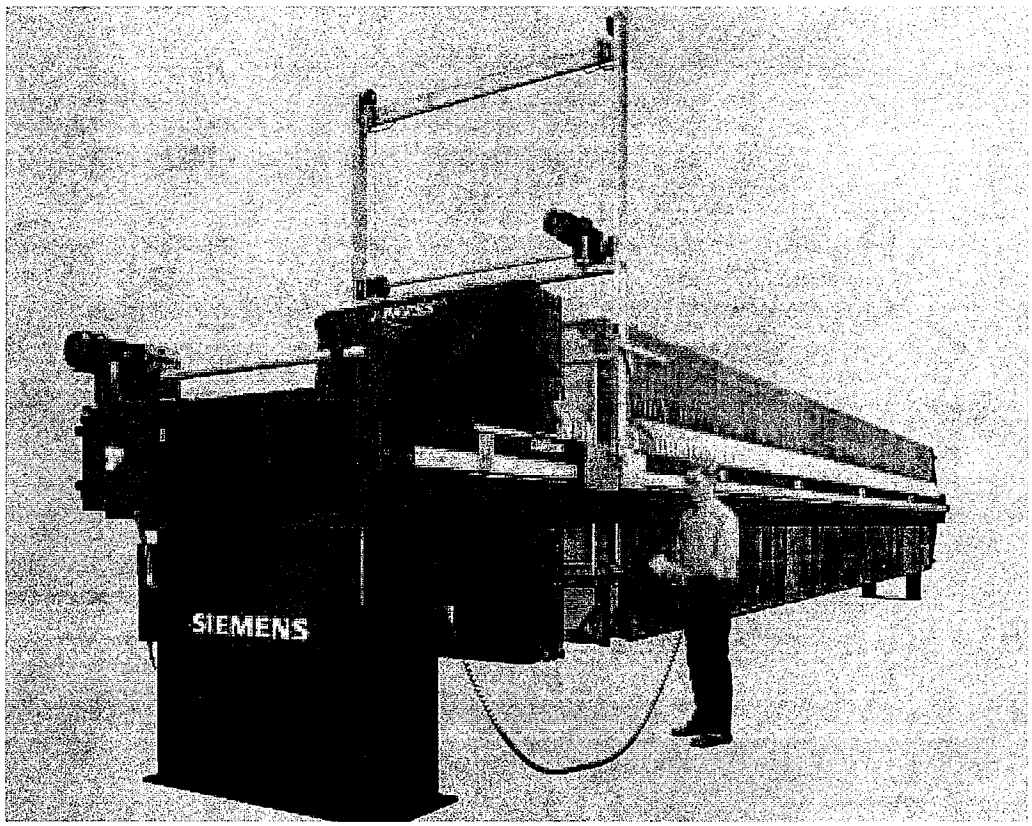
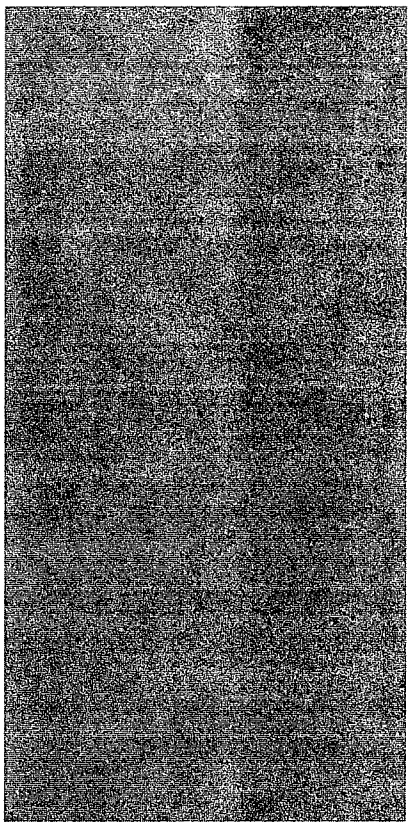


# I-Press® Sidebar Filter Press

Water Technologies

# J-Press® Filter Press – The Industry Standard



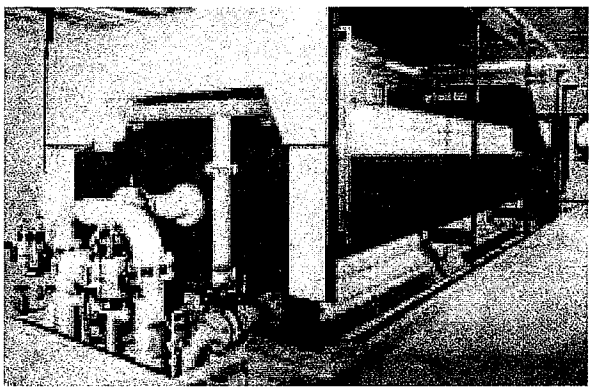
*1.5m x 2.0m Fully automatic with automatic cloth washer.*

### Liquid/Solid Separation Process

The J-Press® sidebar filter press is the cost-effective solution for producing high solids filter cake with extremely high clarity in the liquid effluent. Considered by industry professionals as the premier sidebar filter press, the J-Press® filter press combines rugged construction, precision engineering, ease of operation and a wide range of features and options to tackle the most difficult dewatering problems.

The J-Press® filter press is one of the most versatile dewatering devices on the market, being used in a wide variety of industrial and municipal applications. The J-Press® filter press can be used to recover both solids and liquids from a waste or process stream. With superior materials of construction, the J-Press® filter press is especially useful in the dewatering of aggressive acid and alkali suspensions.

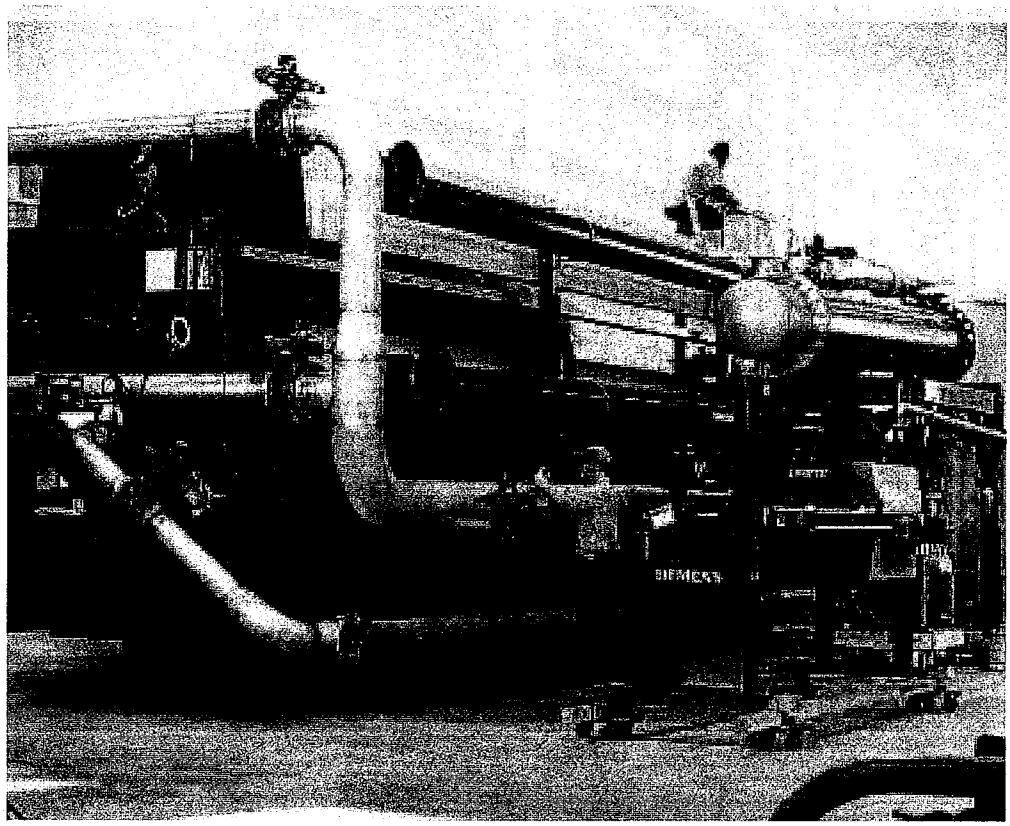
Available in a wide range of sizes and styles, the J-Press® filter press can be configured to provide a dewatering solution to most all process flows from as little as 25 gallons to 1,000,000 gallons per day. It produces consistent results under varying influent conditions.



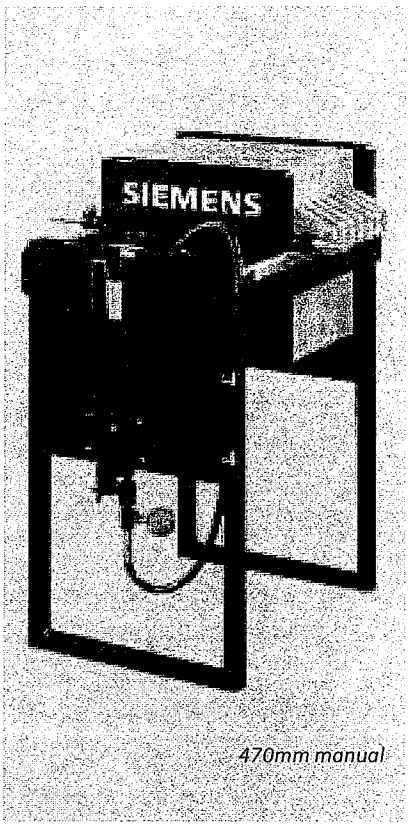
*1500mm fully automatic with automatic cloth washer.*

### CWB Certification

The Canadian Welding Bureau acknowledges that Siemens Water Technologies is certified to CSA Standard W47.1.



*The J-Press® filter press can be configured with highly sophisticated manifolds, controls and cake discharge systems, such as this 2.0m x 2.0m J-Press® filter press built for a prominent municipal wastewater treatment plant.*



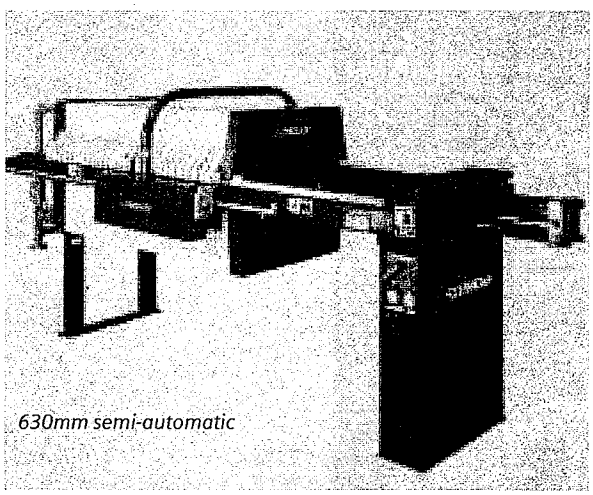

*470mm manual*

*Siemens sidebar presses are available in sizes ranging from 250mm to 2.0m designs, with working pressure ratings of 100psi (7bar) and 225psi (16bar).*

### J-Press® Filter Press, The Industry Leader

In 1978, JWI revolutionized the industry with the introduction of the J-Press® filter press. The J-Press® filter press was the first to feature, in a single design, a self compensating air/hydraulic closure system for ease of maintenance, gasketed filter plates for virtually leak free dewatering, semi-automatic plate shifting for labor savings and safety, automatic pump controls for unattended operation and a superior paint system that provided the highest level of protection from corrosion. The J-Press® filter press quickly set the benchmark for filter press performance.

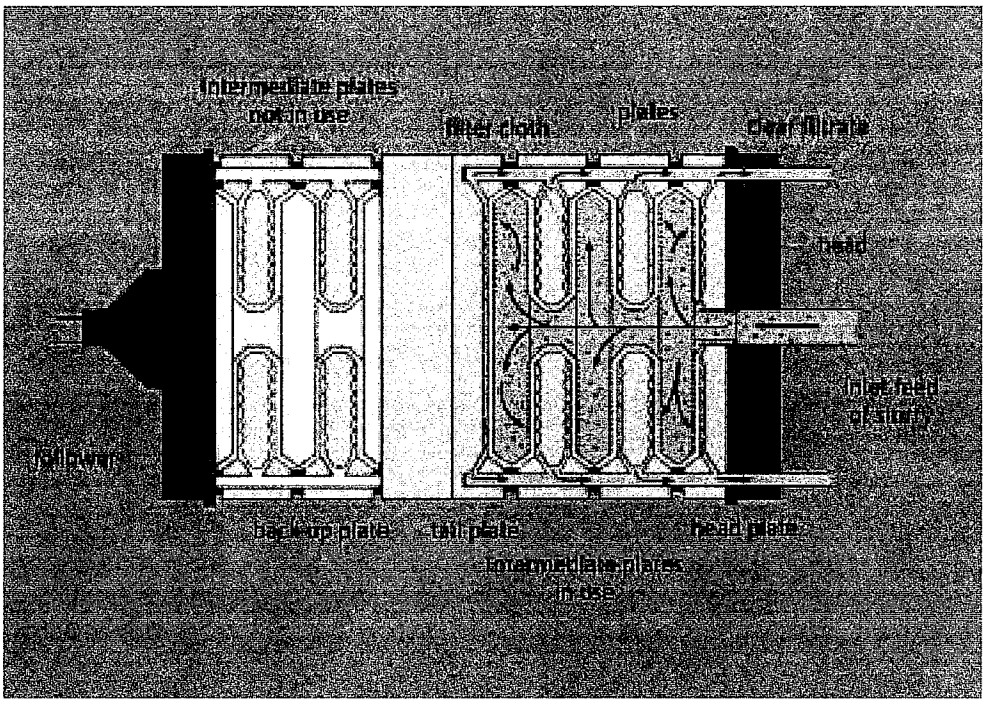
In the ensuing years, the J-Press® filter press evolved, offering options for fully automatic plate shifting, automatic cloth washing, PLC controls and a full complement of ancillary slurry processing and cake handling systems. Being the industry standard, the J-Press® line of filter presses is now the most versatile on the market today, from a manual 250mm pilot press that processes less than 2 lbs of dry solids per batch, to the monster 2.0m fully automatic press that can produce over 10,000 lbs of dry solids per cycle.



*630mm semi-automatic*

### ISO 9001:2000 QMS

The quality management system governing the manufacture of the J-Press® sidebar filter press is ISO 9001:2000 certified.




*Because the J-Press® filter press is a batch dewatering system, the press capacity can be easily adjusted by the changing the effective volume of the filter pack. A back-up plate, in conjunction with the tail plate, can be inserted to reduce the number of chambers used during dewatering.*

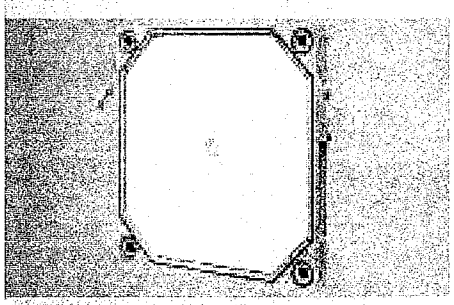
### Uniform, Consistent Cake Solids

The J-Press® filter press is simple to operate. A single switch activates the pneumatic or electrically actuated hydraulic system. The plate stack forms a series of chambers, each covered with a filter cloth. With the plate stack clamped tightly in place, a solids-laden slurry is pumped, under pressure, into the plate chambers through a central feed connection.

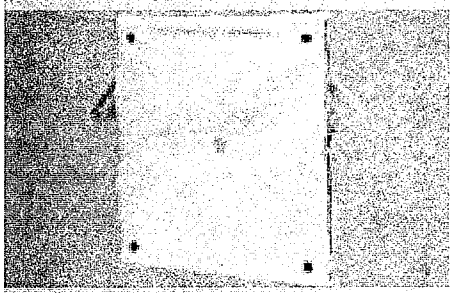
The plate chambers fill uniformly with solids while the pump pressure and flow keep the solids deposited on the vertical surfaces of the plate chambers. Liquid passes through the filter cloths as clean filtrate flows to the end of the press where it is collected at a common manifold.

The solids continue to fill the plate chambers and are compacted in the press by the feed pump until the chambers are completely full. The feed cycle is discontinued and an air blow down is initiated for 5-15 minutes to remove any freestanding water within the cake and the press. The hydraulic closure of the press is then retracted, the individual filter elements are separated and the solids are discharged as "dry" filter cake to an appropriate receptacle or conveyance system.

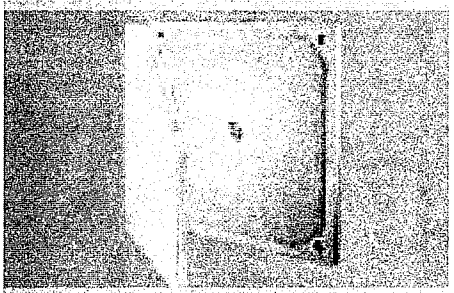
The J-Press® filter press may also be equipped with diaphragm (or membrane) squeeze plates that allow for a mechanical compression of the filter cake, yielding higher dry solids before the cake is discharged from the filter press.



*Gasketed plates form a tight seal due to o-rings around the recessed chamber and filtrate discharge eyes, allowing for a virtually leak free operation.*



*Filter clothes are available for all gasketed and non-gasketed plates (above); material and weave pattern are selected for your specific performance requirements.*



*Diaphragm (or membrane) plates feature flexible drainage surfaces that expand to exert additional pressure on the filter cake, further reducing moisture.*

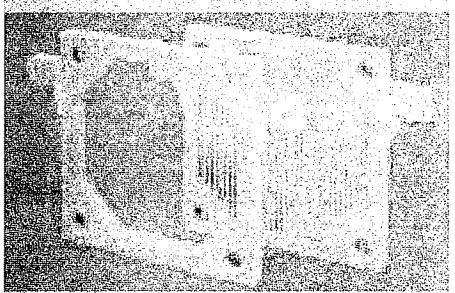
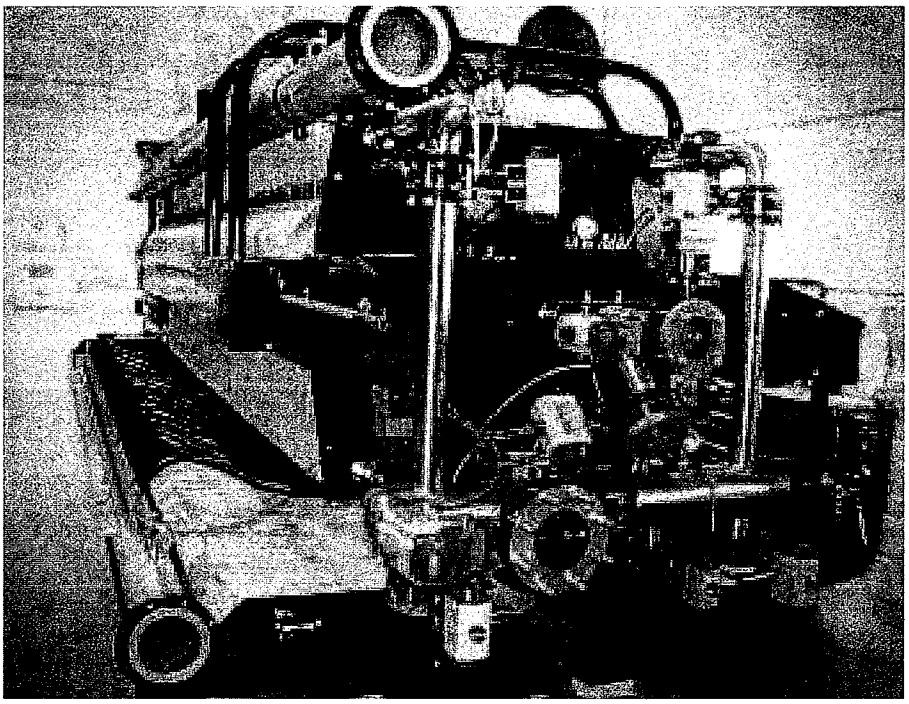
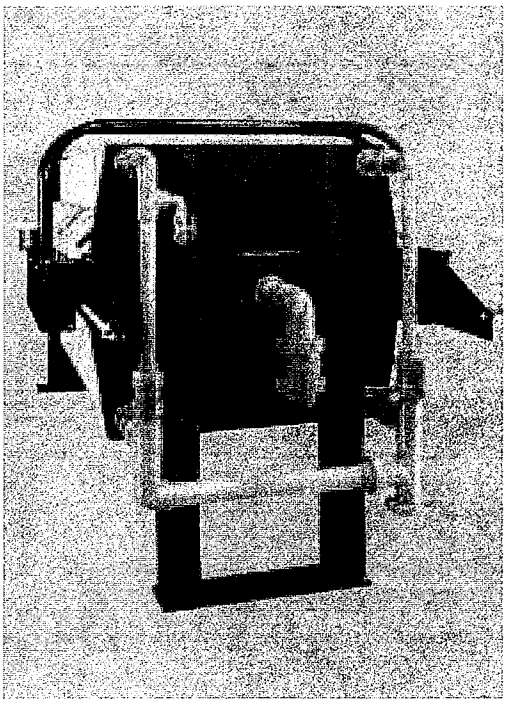


*Plate and frame filter packs are available for polishing applications.*





*J-Press® feed and discharge manifolds are available in a variety of materials from PVC (above right) to stainless steel (above) to suit the application.*

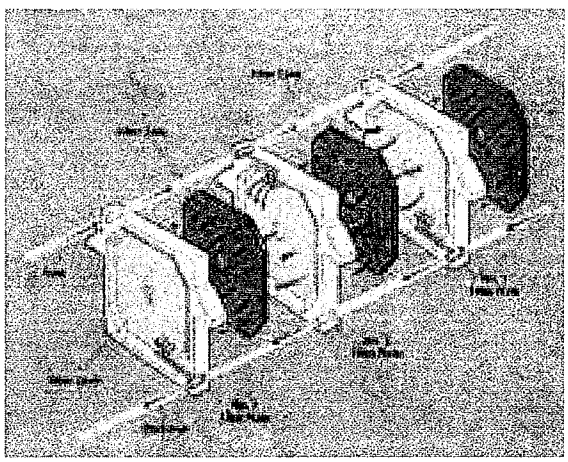
### Superior Filter Plate Technology

Adding to the versatility of the J-Press® filter press is the large selection of filter plates available from Siemens. Based upon the process operating demands, filter plates are selected for each specific application. Filter plates are available in corrosion resistant polypropylene, PVDF and nylon. Plates can be configured as gasketed or non-gasketed, diaphragm (membrane) squeeze, or plate and frame designs.

Like the J-Press® filter press itself, the filter plates can be designed to withstand operating pressures up to 225 psi (16 bar).

### Cake Wash or Air Blowdown

The inherent flexibility of the J-Press® filter press makes it ideal for recovering solids, liquids or both. In processes where the filter cake may need treatment prior to discharge, the J-Press® cake wash/air blowdown manifold can be used to force wash liquid through the cake. The manifold consists of piping and valves connecting the four corner filtrate ports into a common discharge pipe. By closing the appropriate valves, a wash liquid is pumped through the filter cake, and discharged out the diagonally opposed port. This can be followed by a compressed air blowdown, further removing moisture from the cake and filter plate drainage channels.



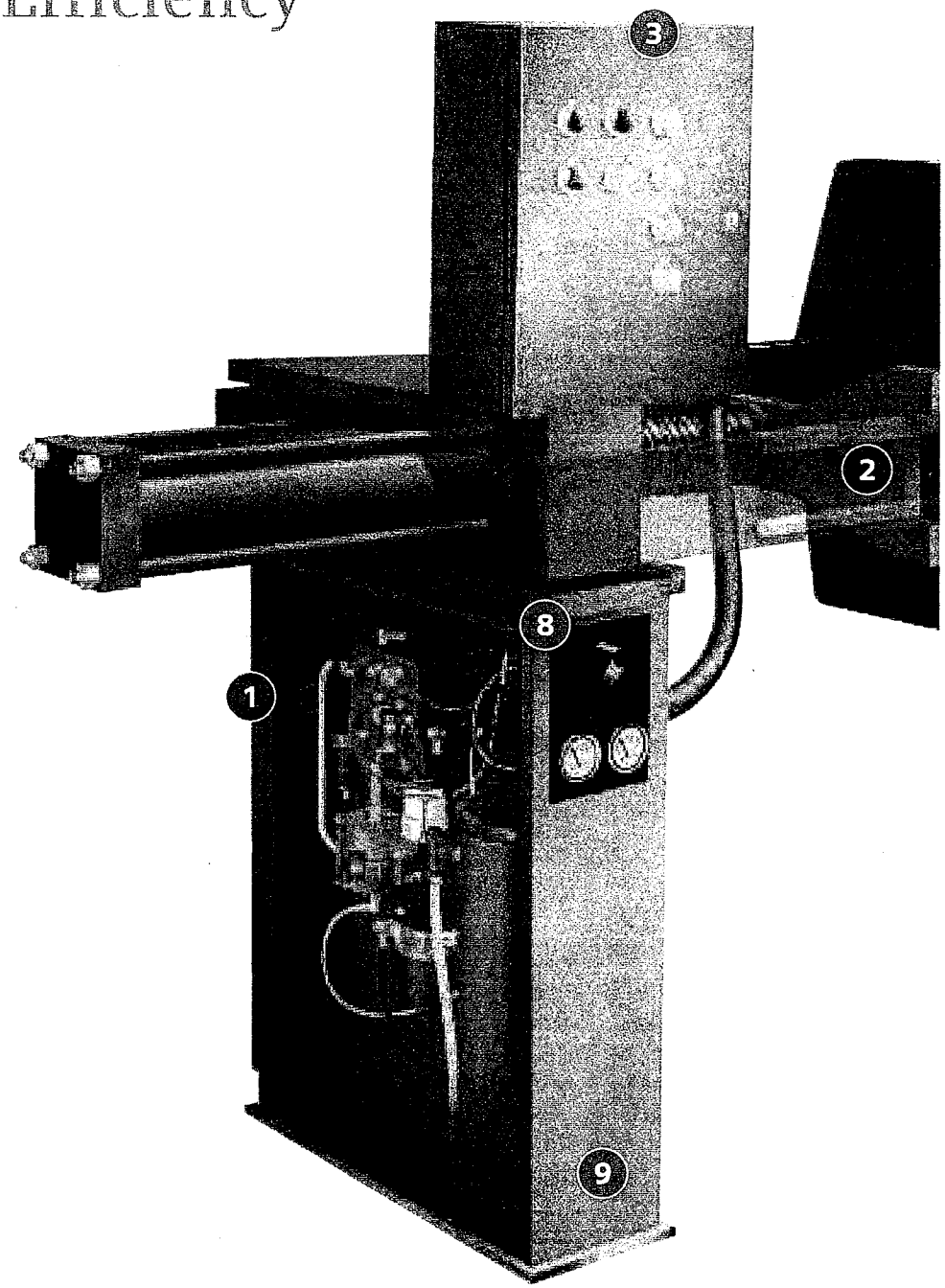
# Engineered Performance and Operating Efficiency

**1. Modularized Hydraulic Closure Systems** — Available with either pneumatic or electric power, the modular power pack delivers up to 5,000 psi of hydraulic pressure to the hydraulic cylinder. The unit automatically compensates for thermal expansion and contraction of the filter pack due to changes in process temperature. Designed to minimize power consumption, the power pack features color coded connections for quick and easy removal and replacement during service and maintenance. The hydraulic pump and associated components are fully enclosed in a steel cabinet for protection from contamination and accidental damage, yet are easily accessible for maintenance through the full width cabinet door.

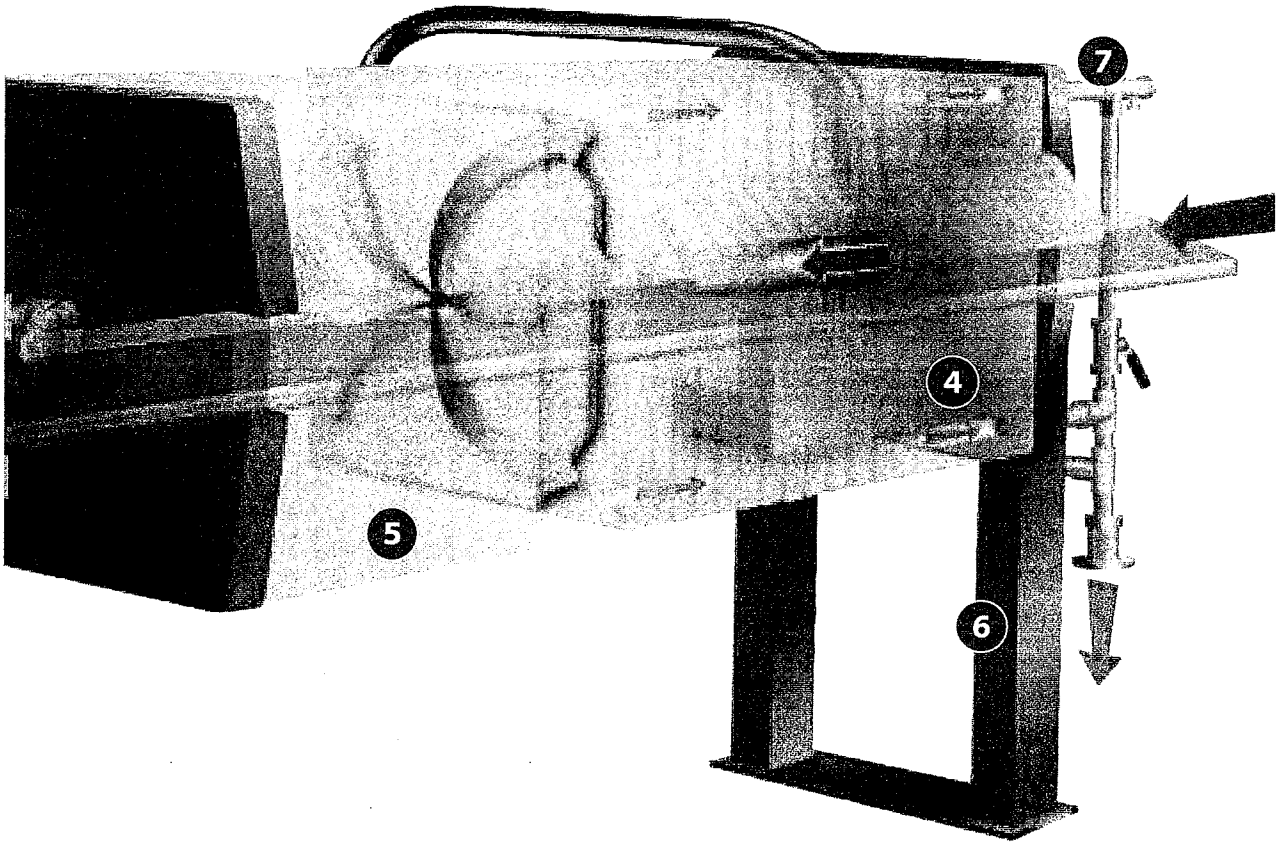
**2. Future Expandability** — The J-Press® filter press can be equipped with an optional expansion piece for future expansion of operating capacity with no need for costly sidebar replacements or frame exchanges. Expanding the capacity is as easy as adding additional filter plates.

**3. Automatic Pump Control System (APCS)** — For smaller presses, the APCS automatically controls the filling cycle, gradually increasing the feed pressure of the slurry feed pump to ensure a uniform formation of filter cake in the filter plate chambers. The uniform cake formation enhances the dewaterability of the incoming slurry. The APCS includes a hydraulic pressure safety device that shuts down the feeding cycle if a loss in hydraulic pressure occurs. For larger presses, filter press filling is controlled by a PLC.

**4. Plate Shifter/Cloth Washing** — The J-Press® filter press is available with either semi-automatic or fully automatic plate shifting systems (depending on size). The semi-automatic plate shifter is an operator driven plate shifting device that reduces manpower requirements during cake discharge. Further reductions in manpower are available with fully automatic shifting systems. The patented Siemens pry, bump and weigh system offers the additional advantage of positive cake discharge from each chamber further reducing the requirement for operator interface with the filter press during cake discharge.



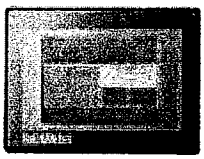

A cloth washing system can also be added to the automatic plate shifting system to provide a periodic high pressure cleaning cycle for the filter cloths. Operating in as little as 20 seconds per plate, the automatic high pressure cloth washing system can restore the porosity of the filter cloths to like new condition. Washing the cloths at regular intervals not only improves performance but prolongs the working life of the cloth as well.




**5. Numerous Filter Pack Options** — A wide selection of filter plate materials and styles makes the J-Press® filter press one of the most versatile dewatering devices on the market. With materials of construction ranging from polypropylene to PVDF and nylon, the J-Press® filter press can be designed to handle virtually any feed slurry no matter how corrosive or chemically aggressive. Filter plates are available in recessed gasketed, recessed non-gasketed and diaphragm (or membrane) squeeze designs that can dewater everything from the easiest metal hydroxide slurry to difficult organic solids. The J-Press® filter press can readily adapt to changes in product and process applications by simply changing the filter cloths or the filter plates, giving the system great operational flexibility.

**6. Robust Frame Construction** — The J-Press® filter press is a ruggedly built unit made of fabricated steel plate. Precision alignment and machining of the structural components provide for even distribution of all pressures and stresses generated during operation. Frame strength is based upon the filter press operating pressure of either 100 psi (7 bar) or 225 psi (16 bar).

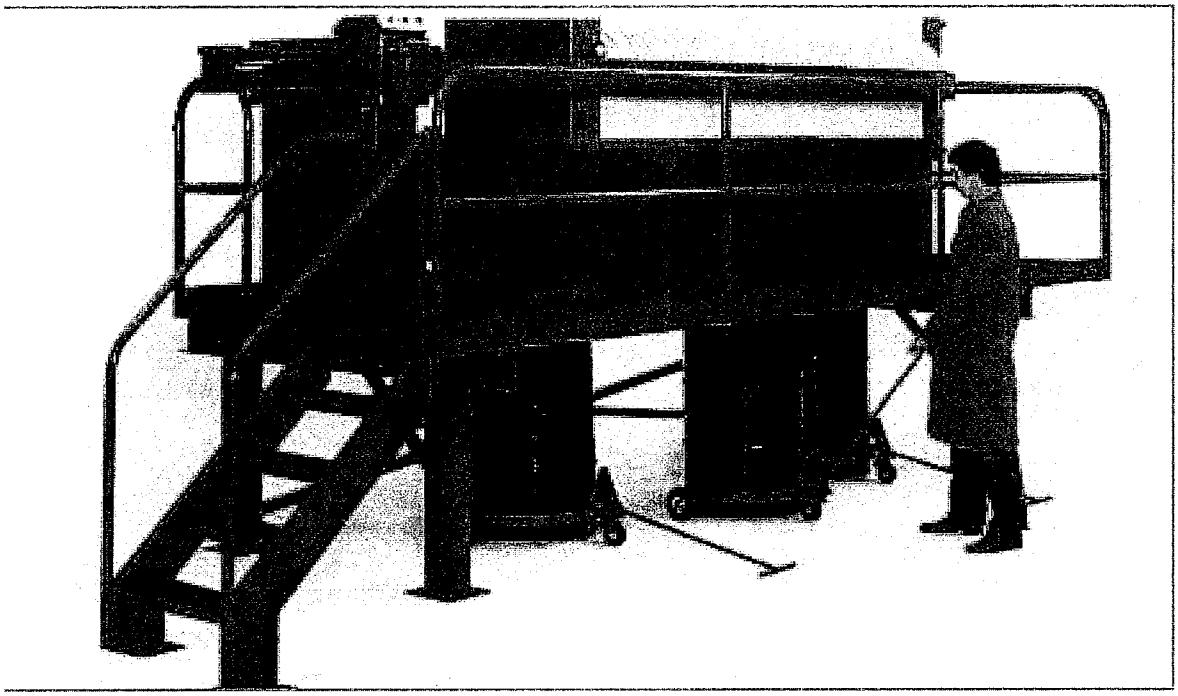
**7. Manifold Piping** — Like the filter plates, manifold piping is supplied in a variety of non-metallic and metallic materials suited to meet the rigors of the application. Manifolds can also be configured in a variety of inlet, discharge and valve options to maximize the versatility of the filter press. With the appropriate manifold, a filter press can be designed to perform both pre and post dewatering operations that enhance both the dewaterability of the material and the quality of the final cake.

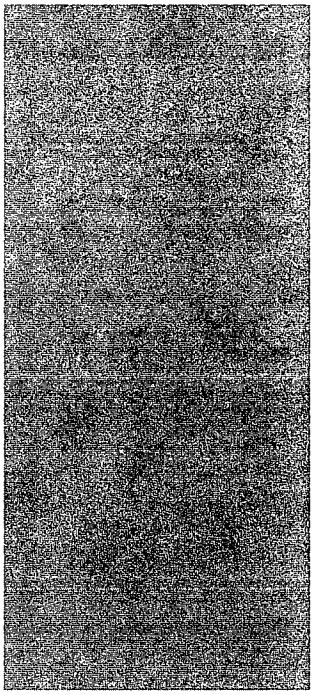


**8. Control Systems** — Filter press control can be as simple as a single switch for opening and closing to as complex as a fully integrated PLC with Ethernet or wireless capabilities for remote monitoring and operation. The PLC system provides the most advanced and complete press operation available, from automatic feed pressure adjustment, to cycle frequency, cake discharge, cloth wash and air blowdown.

**9. Superior Paint System** — Each J-Press® filter press is sandblasted to an SSPC-10 near white finish before being primed and finished with a high quality, single coat aliphatic polyurea, fast clad DTM urethane paint system that results in a durable, chemically resistant finish averaging 6-9 mils in thickness (other paint systems are available on request).

# Material Handling Systems

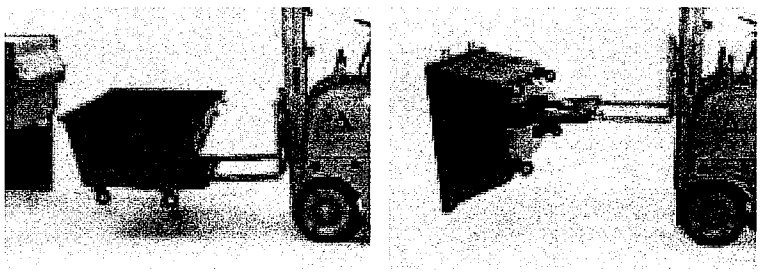




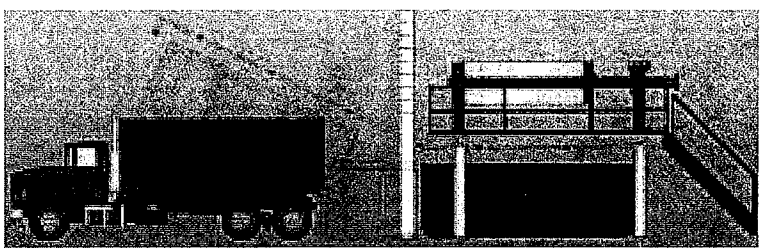
*The J-Press® filter press is available with a wide range of material handling solutions for small or large volume cake discharge.*

The J-Press® filter press installation can be configured to accommodate a wide range of material handling systems for discharged cake. Dumpsters, equipped with casters and self-dumping forklift mounts are the most common method for smaller presses. The drum disposal system, also for smaller presses, allows easy removal of discharged cake. This system includes a series of chutes that catch the filter cake as it falls from the press and directs it into 55-gallon (200L) drums. The J-Press® filter press is typically mounted on a platform, with catwalks, railings and stairs.

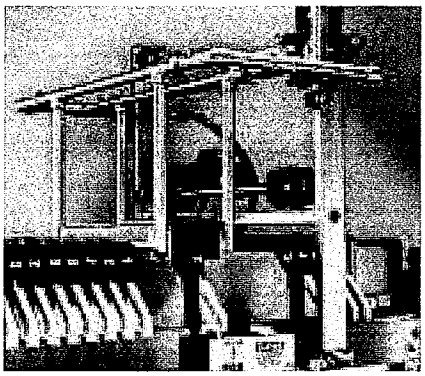
For larger presses, or presses that require transfer to downstream drying systems, Siemens can engineer a belt or screw conveyance as an integrated component of your process configuration. Roll-off container and truck-loading systems are also available. Your Siemens representative works closely with you to design, install and support the most efficient handling system for your specific needs.



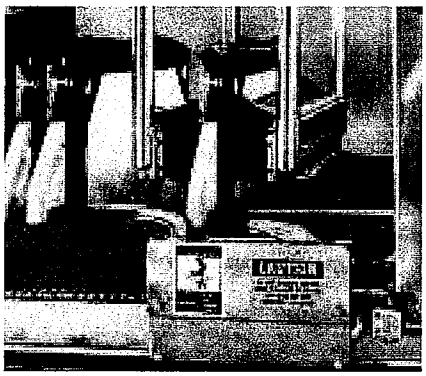
*Self-dumping dumpsters*



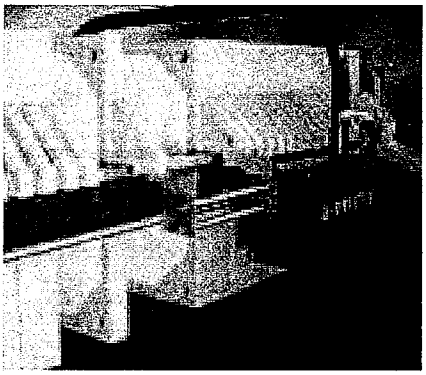
# Full Range of Features and Options



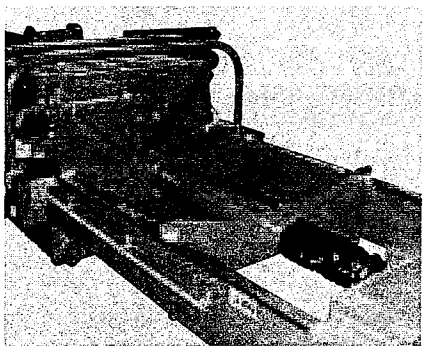
*Fully automatic cloth washer*



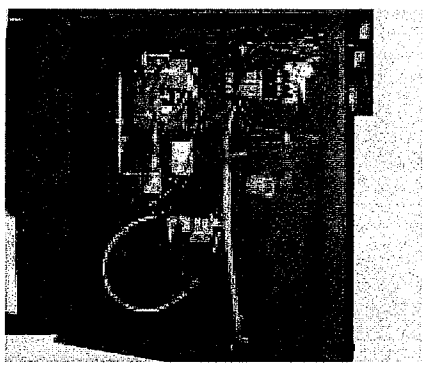
*Fully automatic plate shifter*



*Semi-automatic plate shifter*



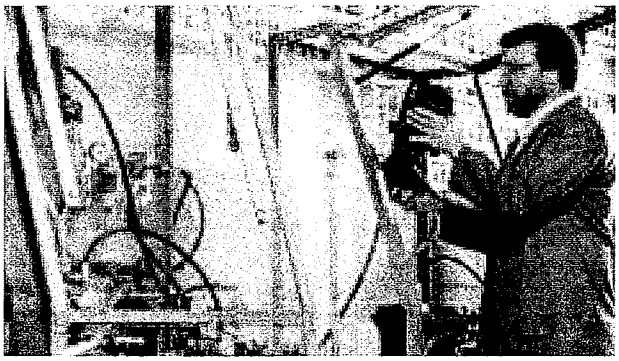
*Optional expansion allows you to build your press to meet future needs, then increase capacity simply by adding additional filter plates.*

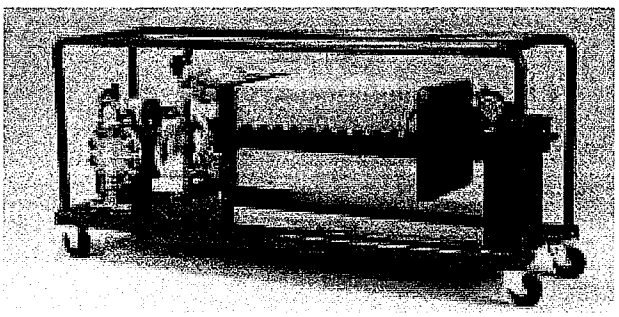


*Exclusive integrated hydraulic circuit technology automatically compensates for varying pressures and temperatures. The enclosed steel cabinet and leak-free design minimize maintenance.*

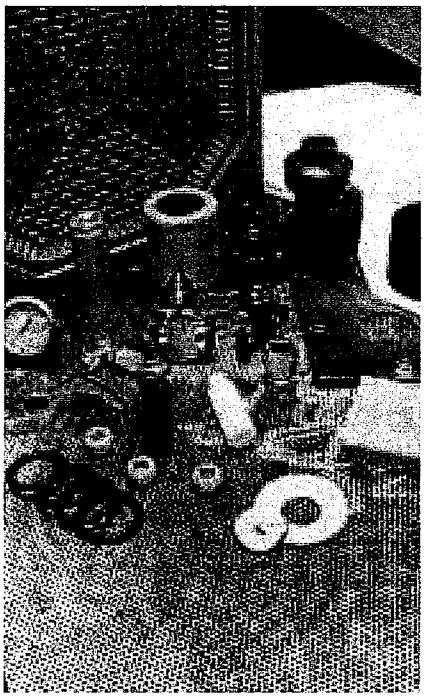
**Siemens has the expertise and engineering capabilities to manufacture filter presses to meet the demands of your particular operation. Adaptability to applications, processes and capacities is the underlying value of J-Press® filter press. Features include:**

- Full range of capacities: 250mm to 2.0m x 2.0m
- Low and high pressure: 100 psi (7 bar), 225 psi (16 bar), higher pressure available – consult factory
- Standard plate packs:
  Non-Gasketed Plates
  Gasketed Plates
  Diaphragm Squeeze Plates
  Plate and Frame
- Stainless Steel Sidebar Covers
- Closure Systems:
  Manual
  Automatic Closure (Air/Hydraulic)
  Automatic Closure (Electric/Hydraulic)
- Control Systems:
  Standard Control Panel
  Automatic Pump Control System
  PLC Control
- Standard Manifolds:
  Air Blow Down Manifold
  Double End Feed Manifold
  Core Blow Down Manifold
  Cake Wash Manifold
  Precoat Manifold (other configurations available — consult factory)
- Expansion options available for future capacity
- Plate Shifting:
  Air Operated Semi-Auto Plate Shifter
  Automatic Pry Shifter
  Automatic Pry Shifter and Bump
  Automatic Pry Shifter, Bump and Weigh (ACDDS)
  Multi-Plate Pull
- Automatic Cloth Washing
- Material handling:
  Filter Cake Dumpster
  Extended Legs and Chute
  Platform, Drum Disposal System
  Platform, Roll-off Container System
- Cake Conveyors
- Drip Trays:
  Manual
  Automatic
- Spread Leg Design:
- Safety:
  Splash Curtain
  Safety Guard
  Safety Light Curtains
  Deadman Control Button
  Safety Tripwire
  Hyd. Clamp Pressure/Feed Pump Interlock
  Hyd. Control System/Press Pressure Interlock
  Hyd. Clamp Pressure/Squeeze System Interlock
- Custom Paint Systems:
  Nicklad® Coating





*Portable pilot filter press*





*Our large parts distribution center ensures that many parts are available for same day shipment.*

### Laboratory Services — an Informed Decision is the Best Decision

Siemens maintains a fully-staffed, state-of-the-art laboratory for determining the most effective liquid/solids separation techniques for your specific application. Capabilities range from feasibility testing of your materials to providing portable pilot units for on-site testing. This customer-focused resource produces tangible results. We can determine the most effective feed pressures, fill times, filter media and sludge conditioning.

In addition to ensuring a better informed equipment purchase, this valuable service is also available to help you maintain maximum performance of your J-Press® filter press.

### An Ongoing Investment in Your Satisfaction

**Preventative Maintenance Services** We can customize a cost-effective program for your specific equipment, application, and environment that translates into lower maintenance cost and years of worry-free operation.

**Parts Repair Service** Our professional service staff can quickly and reliably answer your technical questions and troubleshoot your specific requirements, schedule parts shipments, and arrange for an on-site service call. Our factory-trained and qualified service engineers travel throughout the world to help ensure equipment runs efficiently. From basic maintenance to complex Program Logic Control (PLC) interfaces and beyond, we have the experience and capability.

**Refurbishment Services** We can provide a partial or complete rehabilitation of your equipment to a warranted like-new condition, at your site or ours.

**For more information on our Aftermarket Services, call 800.245.3006.**

### Aftermarket Services

- Factory-based customer service support
- Expert technical consulting
- Same-day shipment on many service and spare parts
- Worldwide repair and preventative maintenance services
- Emergency support services
- Equipment retrofits, upgrades, and refurbishments
- Training
- Testing, evaluative and customized services



## Specification/Selection Charts

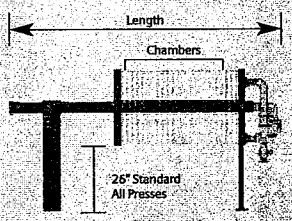
The following formula may be used for establishing J-Press® filter press volume ($ft^3$) (L) for most dewatering applications:

$$\text{Total Filter Press Volume } (ft^3)\ (L) = \frac{\text{Total volume of product feed (gallons) (liters)} \times \text{\% solids concentration of product feed*} \times \text{8.34 (lbs per gallon of water) (1kg/L) (density of water)} \times \text{specific gravity of feed slurry}}{\text{Density of wet filter cake** (lbs/ft}^3\text{)(kg/L)} \times \text{\% dry solids content of filter cake*}} \quad \text{or} \quad \frac{\text{lbs (kg) dry solids}}{\text{cake density (lbs/ft}^3\text{)(kg/L) x \% cake solids}}$$

* % concentration should be expressed in decimal form (e.g. 2% = .02).
**Density of wet filter cake = Specific gravity of wet filter cake x the density of water

For dewatering applications where feed solids are less than 1%, the dewatering area is the controlling parameter rather than volume. For such applications, contact Siemens for size recommendations. Also, for advice on sizing for any application, contact Siemens or our authorized representative.

| PRESS | MEASUREMENT | MINIMUM | MAXIMUM |
|---|---|---|---|
| 250mm | Volume ($ft^3$) | 0.1 | 0.4 |
| | Volume (L) | 2.8 | 11.3 |
| Height 15" (381mm) | Length (in) | 24.0 | 38.0 |
| Width 18.5" (470mm) | Length (mm) | 607.0 | 975.0 |
| 470mm | Volume ($ft^3$) | 0.5 | 4.0 |
| | Volume (L) | 14.2 | 113.0 |
| Height 45.8" (1162mm) | Length (in) | 41.0 | 93.0 |
| Width 33.0" (838mm) | Length (mm) | 1041.0 | 2362.0 |
| 630mm | Volume ($ft^3$) | 2.0 | 8.0 |
| | Volume (L) | 57.0 | 227.0 |
| Height 51.0" (1299mm) | Length (in) | 85.0 | 129.0 |
| Width 36.0" (916mm) | Length (mm) | 2168.0 | 3277.0 |
| 800mm | Volume ($ft^3$) | 8.0 | 25.0 |
| | Volume (L) | 227.0 | 708.0 |
| Height 58.0" (1473mm) | Length (in) | 122.0 | 196.0 |
| Width 43.5" (1105mm) | Length (mm) | 3099.0 | 4978.0 |
| 1000mm | Volume ($ft^3$) | 25.0 | 55.0 |
| | Volume (L) | 708.0 | 1558.0 |
| Height 66.5" (1689mm) | Length (in) | 175.0 | 260.0 |
| Width 51.5" (1308mm) | Length (mm) | 4445.0 | 6604.0 |
| 1200mm | Volume ($ft^3$) | 50.0 | 125.0 |
| | Volume (L) | 1416.0 | 3540.0 |
| Height 74.5" (1892mm) | Length (in) | 217.0 | 356.0 |
| Width 60.0" (1524mm) | Length (mm) | 5512.0 | 9042.0 |
| 1500mm | Volume ($ft^3$) | 130.0 | 270.0 |
| | Volume (L) | 3682.0 | 7646.0 |
| Height 95.7" (2432mm) | Length (in) | 313.0 | 500.0 |
| Width 74.9" (1903mm) | Length (mm) | 7950.0 | 12,700.0 |
| 1.5 x 2.0M | Volume ($ft^3$) | 275.0 | 350.0 |
| | Volume (L) | 7788.0 | 9912.0 |
| Height 136.6" (3470mm) | Length (in) | 430.0 | 507.0 |
| Width 79.0" (2007mm) | Length (mm) | 10,922.0 | 14,097.0 |
| 2.0 x 2.0M | Volume ($ft^3$) | 300.0 | 600.0 |
| | Volume (L) | 8496.0 | 16,992.0 |
| Height 106.0" (2692mm) | Length (in) | 405.0 | 562.0 |
| Width 137.0" (3480mm) | Length (mm) | 10,287.0 | 14,275.0 |




*Notes:*

- *Based on 32mm cake thickness, 100psi (7bar).*
- *Additional sizes and capacities available — consult factory.*
- *All dimensions are approximate and should only be used for reference.*
- *Dimensions do not include optional equipment such as plate shifters, cloth washers or piping manifolds.*



www.siemens.com/water

# Tetra Tech

Foster Plaza 7
Pittsburgh, PA 15220
(412) 921-7231
(412) 921-4040 Fax

Ion Exchange Treatment of
Groundwater

Proposal # 283231

Prepared By:

**SIEMENS**

Monday, February 1, 2010

SIEMENS

**Siemens Water Technologies Corp.**
Monday, February 1, 2010
Proposal # 283231

Joe Logan
Foster Plaza 7
661 Andersen Drive
Pittsburgh, PA 15220

Proposal # 283231

Dear Joe:

Siemens is pleased to provide Tetra Tech with this proposal for portable Wastewater Ion Exchange Service.

Based on information you have provided, we have proposed a system that will meet your technical requirements simply and economically.

**1.0 Siemens - A Leader in Environmental Service**

Siemens through its Environmental Services facility is the only company in the United States that has the technology, and more importantly, all of the necessary permits to regenerate resins from any industrial rinse water process, including those that are determined to be a hazardous waste. These two factors - technology and permitting - enable Siemens to provide Tetra Tech Nus with the peace of mind, knowing that you are in full compliance with federal, state and local regulations.

Here are some very important points to consider before choosing Siemens:

- Pursuant to MN Rule 7045.0452, Subpart 3c, Siemens has all the appropriate permits to accept and process your wastes.
- All Siemens Ion Exchange tanks are approved as transportable hazardous waste containers by the US Department of Transportation.
- Siemens is an approved carrier for transportation of Hazardous Waste.
- Siemens can provide manifesting of all waste transported by Siemens.
- Siemens can provide the proper labels for marking hazardous ion exchange resin containers.

We are certain that you will agree that our unique service will provide your business with many operating advantages compared to other methods of handling your wastewater.

We look forward to providing our quality products and services to Tetra Tech. If you have any questions, please contact me at 813-620-0900.

Sincerely,

Jay Dwyer
Technical Sales Representative
Siemens

## 2.0 Basis of Design

No sample was provided; therefore, all recommendations are estimates based on the following information. A feed water sample to the ion exchange tanks is required to properly size and specify the type of media tanks required for your application. From this sample Siemens will do engineering and prepare a proposal, which will include an annual budget (Exhibit C to the Service Contract). If a water sample has not been analyzed by Siemens at the time of this proposal because wastewater was not available or there was not access to the wastewater, any estimates in this proposal are budgetary and the design should be considered preliminary.

2.1 Treatment Goal:

Ion exchange treatment post-WWT and carbon to discharge standards for cadmium

2.2 Influent Parameters:

Peak Flowrate = 80gpm

2.3 Effluent Quality Requirements

Cadmium = <5ppb

**If any of this information is inaccurate, please contact me immediately.**

## 3.0 Proposed System and Operating Parameters

3.1 Siemens will provide the following system components:

Ion Exchange Tanks - Rental Tanks:
Two (2) 60 cu ft special cation tanks, one online and one standby

Ion exchange tanks will be used to remove dissolved cadmium. Siemens does not sell the exchange tanks.

Hoses:
One (1) set inlet/outlet hoses, 3" EPDM 150psi-rated, and 3" stainless steel fittings

3.2 This treatment system is designed to run within the following parameters:

TANKS MUST BE PLACED POST-CARBON to protect resin from oxidizers or oils/grease
Maximum operating temperature of 120°F
Minimum flow rate of 50gpm, Maximum flow rate of 150gpm
Maximum pressure of 100psig (Maximum pressure of 50psig @> 110°F)
Influent pH range of 3 to 8 S.U.

**4.0 Scope of Work**

4.1 Siemens Responsibilities

- Under normal operating conditions, Siemens will have available fresh replacement ion exchange and carbon tanks ready for delivery to Tetra Tech. All fresh tanks delivered are non-hazardous.
- Siemens will pick up all spent tanks from Tetra Tech's facility and transport the spent tanks to Siemens's, Roseville, Minnesota facility for processing.
- All tanks will be processed at Siemens's fully permitted RCRA Part B facilities.
- All tanks will be verified for proper flow and pressure tested for leaks and returned to the fresh tank float.
- Siemens maintains consistent resin quality through rigorous quality assurance testing and resin replacement as required.

4.2 Customer Responsibilities

- Any pre or post ion exchange pH adjust (if required)
- Any pre or post filtration as required, a maximum of 20 micron cartridge pre-filtration is required with all ion exchange systems.
- All plumbing to and from the process and discharge point within 5 feet of the ion exchange tanks.
- All permits, permit fees, and inspections as required.
- If applicable, work schedules indicating times during which interruption in normal service are permissible. All labor rates quoted in this proposal are for straight time, non-union labor.
- Suitable drains.
- Suitable lighting for all equipment.
- All electrical power as required to within 5 feet of the equipment, including overload protection.
- Any double containment required for the system.
- Free and clear access to treatment site.
- Dock access and material handling equipment capable of safely handling specified ion exchange tanks.
- Regulated plant air supply (if required).
- City or DI water supply (if required).
- System operation, including maintenance and water quality monitoring.

**5.0 Compensation to Processor (refer to Exhibit C)**

**6.0 Getting Started**

It is required that the following documents be accurately completed and signed, where applicable, and returned to Siemens prior to delivery of equipment.

6.1 - **Signed** Siemens Waste Treatment Service Agreement (See Section 8)
6.2 - **Signed** Waste Profile Sheet (Exhibit A)
6.3 - Siemens Lab Analysis (Exhibit B) - **Sample required before tanks can be returned to Siemens**
6.4 - PO for System Installation or Parts **(Please Reference EXHIBIT C)**
6.5 - Blanket PO for Rent, Regeneration and Transportation **(Please Reference EXHIBIT C)**

**7.0 Delivery**

Shipment will occur within 10 working days after receipt of the completed documents in Section 6.0.

For all direct shipments by third-party transporters, freight will be billed at actual cost plus $85.

# 8.0 WASTE TREATMENT, METAL RECOVERY, WATER RE-USE PROCESSING, TRANSPORTATION AND DISPOSAL SERVICES AGREEMENT

This agreement is entered into this _____day of _____by and between Siemens Water Technologies Corp.. ("Processor") and Tetra Tech ("Generator").

WHERAS, Processor has a facility located at 2430 Rose Place, Roseville, MN. ("Processor's Facility") and the necessary licenses and permits to recover, treat, transfer, transport, and temporarily store (collectively "Handle") certain regulated and unregulated hazardous/industrial waste; and

WHEREAS, Generator desires Processor to Handle certain waste material generated by Generator at its facility at Foster Plaza 7, 661 Andersen Drive, Pittsburgh, P ("Generator's address") which waste material is described in the Waste Profile Sheet included in Exhibit A, attached hereto and made a part hereof.

NOW, THEREFORE, the parties agree as follows:

I. Processor Services

1.1 Processor shall handle the Waste Material in a careful, workmanlike, and lawful manner, and in accordance with all applicable state and federal regulations.

II. Compensation for Services

2.1 Compensation to Processor shall be as specified in Exhibit C attached hereto and made a part hereof.
2.2 Generator shall pay Processor within ten (10) days after the date of each invoice. Generator shall pay interest on any unpaid balance at the rate of one and one-half percent (1-1/2%) per month, commencing upon the expiration of such thirty (30) day period.
2.3 Processor may adjust prices specified in Exhibit C on the Agreement's anniversary date or with thirty (30) days notice.

III. Waste Analysis

3.1 For all Waste Material to be Handled by Processor, Generator shall: (1) provide a detailed written physical and chemical description or analysis of the waste material (the waste profile sheet included in Exhibit A), (2) package, mark, label and placard each shipment and provide to Processor appropriate shipping documents, manifests, or other such documentation as prescribed by Processor, or required by law , and (3) maintain all records with respect to the Waste Material as required by law.
3.2 Generator shall immediately communicate to Processor any changes in the composition of the Waste Material and any additional information obtained by Generator at any time during the term of this Agreement indicating that the Waste Material may present a hazard or risk to persons or the environment which is not set forth in Exhibits A or B (if included with this agreement) or was not generally known as of the date of this Agreement.
3.3 At any time and at its own expense, Processor shall have the right to perform analysis of Waste Material delivered by Generator hereunder. IV.

Nonconforming Waste Material

4.1 Waste Material shall be considered nonconforming if: (1) it has constituents, characteristics, components or properties not specified in Exhibits A or B (if included with this agreement), (2) it has constituents, characteristics, components or properties designated as unacceptable to the Processor in Exhibit D, or (3) if constituents therein exceed designated concentration levels specified in Exhibits A or B.
4.2 If Processor determines within thirty (30) days after delivery of Waste Material from Generator's Facility that the Waste Material is nonconforming pursuant to 4.1 above, Processor shall immediately notify Generator, and shall, at Processor's election, either arrange with Generator for the satisfactory disposition of such Waste Material upon mutually agreeable terms and conditions, or reject and return such nonconforming Waste Material to Generator without further obligation. If Processor elects to reject and return the Waste Material, Generator shall promptly arrange for its return and shall pay reasonable charges for Processor's Handling and time involved up to the time of the return.
4.3 At any time, Processor may, upon reasonable grounds to believe that Waste Material furnished by Generator is nonconforming, so notify Generator and require that Generator have a sample or samples thereof chemically analyzed by a qualified, reputable, independent laboratory acceptable to Processor. The results of such chemical analysis shall be furnished to Processor. If the chemical analysis demonstrates that the Waste Material is not nonconforming, Processor shall pay the costs of the analysis. If the chemical analysis demonstrate that the waste material is nonconforming, Generator shall pay the cost of the analysis.
4.4 Any waste containing any of the Prohibited Wastes as specified in the Processor's RCRA Part B Operating Permit, and in Exhibit D to this agreement shall be considered non-conforming.

V. Ion Exchange Resin

5.1 Processor shall supply to Generator such ion exchange resin canisters as the parties determine are appropriate after inspection and analysis by Processor of Generator's process and waste. Generator shall be responsible for utilizing each canister only on the process for which it is intended. Generator acknowledges the necessity of segregating rinse tank wastes as agreed with Processor. Generator agrees to monitor its use of the canisters and employ a fresh canister promptly as each canister's resin is exhausted. Any and all costs (including increased processing costs or replacement costs) incurred by Processor's Facility as a result of Generator's intentionally wrought or negligent use of any ion exchange resin canister shall be solely the responsibility of Generator; provided such costs shall not exceed the replacement cost of such ion exchange resin and/or canister.
5.2 Processor will conduct periodic ion exchange capacity tests on resin processed at Processor's Facility, and all canisters supplied to Generator, at the time of delivery, shall contain resin having an acceptable ion exchange capacity.
5.3 Resin canisters supplied hereunder shall be free from defects in material and workmanship. Processor shall not be liable for any incidental or consequential damages for any breach of warranty. PROCESSOR MAKES NO WARRANTY, EXPRESS OR IMPLIED, EXCEPT AS IS EXPRESSLY SET FORTH HEREIN. Processor's liability and Generator's exclusive remedy are expressly limited to removal from Generator's Facility and disposal of any defective canister and replacement thereof with another resin canister within a reasonable time period.

VI. Title

6.1 Title to and liability for conforming Waste Material shall pass from Generator to Processor when the loading operation of the Waste Material onto vehicles provided by the Processor has been completed and said vehicles are ready to leave the facility of the Generator. If transportation is provided by the Generator, then title passes from Generator to Processor when unloaded at Processor's site.

6.2 Title and liability for non-conforming Waste Material shall at all times remain with the Generator, unless, upon the discovery that the Waste Material is non-conforming, Processor agrees in writing to perform services under this Agreement.

6.3 Should Processor revoke acceptance of any nonconforming Waste Material as provided in IV above, title to and liability for such Waste Material shall revest in Generator at the time such revocation is communicated to Generator, regardless of who has physical possession of such Waste Material. Processor shall take all reasonable steps appropriate to protect the Waste Material until Generator can properly retake possession thereof.

6.4 Processor shall have title to all materials recovered from Generator's waste material.

VII. Collection and Transportation

7.1 The party providing transportation for the Waste Material from Generator's Facility to Processor's Facility shall comply with all federal, state, and local statutes, rules, regulations and ordinances applicable to the moving, handling, securing and transporting of such Waste Material. Generator is legally responsible to provide the proper Department of Transportation and Resource Conservation and Recovery Act shipping papers and labels, and/or any other such papers and labels required by applicable law, which shall accompany the Waste Material. Processor will assist Generator in determining proper labeling and shipping documentation.

7.2 Generator shall provide safe, satisfactory roadways and approaches to the point of loading at Generator's Facility. To the extent that Waste Material to be shipped from Generator's Facility is contained in canisters, totes or drums, Generator shall be solely responsible for loading the Waste Material onto vehicles provided by Processor, and Generator assumes full risk of loss to all equipment and premises of both parties, to the extent that such loss results from the negligence of its employees, officers, agents or subcontractors ("Generator Personnel"). To the extent that Processor's employees, officers, agents or subcontractors ("Processor's Personnel") engage in loading of canisters of Waste Material or in connecting of piping from Generator's process equipment to vehicles supplied by Processor, Processor assumes full risk of loss to all equipment and premises of both parties, to the extent that such loss results from the negligence of Processor's Personnel. Each of Generator and Processor shall indemnify, defend and hold harmless the other (and in the case of Processor, its partners and affiliates) from any and all costs and expenses (including attorney's fees) relating to: (1) liability, claims and demands arising from personal injury or death of personnel of any persons, including the other party's employees, officers, agents, or subcontractors, arising out of the negligence of Generator's Personnel or Processor's Personnel respectively while engaged in such loading activities, and (2) loss or damage to any property arising out of or in any manner connected with such loading activities.

7.3 To the extent that Processor Personnel enter Generator's Facility in performance of services hereunder, Generator shall ensure such Processor Personnel a safe working environment.

7.4 If an emergency should occur at Generator's Facility while Processor Personnel are on the premises, Generator shall make available to such Processor Personnel its emergency services, including first aid, to the same extent that emergency services would be available to an employee, agent or subcontractor of Generator at the same facility.

VIII. Insurance, Liability, Indemnification

8.1 Processor shall maintain adequate general liability insurance; Worker's Compensation Insurance in accordance with the laws of the State of Minnesota; adequate automobile personal injury and property damage insurance; and environmental insurance covering bodily injury and property damage caused to third parties by a sudden accidental occurrence in such amounts as may be legally required.

8.2 Processor shall indemnify, save harmless and defend Generator against any and all claims, liabilities, penalties, forfeitures, suits and costs and expenses incident thereto (including costs of investigation, defense, settlement and reasonable attorney's fees), resulting from death or bodily injuries to any person, destruction or damage to any property, contamination of or adverse effects on the environment, or any violation of governmental regulations or orders to the extent such results from the imposition of strict liability with respect to Waste Material delivered to Processor by Generator.

8.3 Generator shall indemnify, save harmless and defend Processor against any and all claims, liabilities, penalties, forfeitures, suits and the costs and expenses incident thereto (including costs of investigation, defense, settlement and reasonable attorney's fees), resulting from death or bodily injuries to any person, destruction or damage to any property, contamination of or adverse effects on the environment, or any violation of governmental regulations or orders to the extent (1) such is caused by the negligence or intentional wrongdoing of Generator or any of its agents or employees, (2) such is caused by Generator's delivery to Processor of nonconforming Waste Material.

IX. LIMITATION OF LIABILITY

9.1Notwithstanding anything else to the contrary, Processor shall not be liable for any consequential, incidental, special, punitive or other indirect damages, and Seller's total liability arising at any time from the sale or use of the Processor's services shall not exceed the purchase price paid for processors services. These limitations apply whether the liability is based on the contract, tort, strict liability or any other theory.

X. Representations and Warranties

10.1 Processor warrants and represents to Generator that: (1) it will during the term hereof possess the equipment, plant and employee resources required to perform this Agreement; and (2) it will be at all times while the services hereunder are being performed by it, duly licensed and authorized to Handle the Waste Material; and (3) it will comply with all applicable federal, state and local laws, regulation, rules, orders, decisions and ordinances pertaining to its Handling of the Waste Material.

10.2 Generator warrants and represents to Processor that: (1) the composition of all Waste Material to be delivered to Processor conforms to Exhibits A and B; (2) Generator will during the term of this Agreement communicate to Processor any and all changes in the composition of its Waste Material and any additional potential hazards and risks associated with the Waste Material learned of by Generator; and (3) Generator will hold clear title to all Waste Material to be transferred hereunder; and (4) the Waste Material will conform to the shipping papers and labels which accompany it; and (5) Generator is under no legal restraint or order and shall be under no legal restraint or order which would prohibit transfer by it of possession or title of the Waste Material to Processor for Handling; and (6) Generator will comply with all applicable federal, state and local laws, regulations, rules, orders, decisions and ordinances pertaining to its activities pursuant to this Agreement. XI. Excuse of Performance

11.1 The parties agree that any delay or failure of either party to perform its obligations hereunder, except for the payment of money for services already rendered, shall be excused if and to the extent caused by acts of God, strikes, action of regulatory agencies (including loss by Processor of any license, permit or other authorization

necessary for fulfilling its obligations hereunder), fire, flood, windstorm, explosion, riot, war, sabotage or other cause or causes beyond reasonable control of the party affected ("Force Majeure"), provided that prompt notice of such delay is given by such party to the other and each of the parties hereto shall be diligent in attempting to remove such cause or causes. In the event that the Force Majeure is not rectified within thirty (30) days of the date of such notice, each of the parties shall have the right to terminate this Agreement effective immediately upon written notice to the other party.

XII. Term of Agreement

12.1 The term of this agreement shall be from the date hereof and automatically renewed on the anniversary date thereof for a like period until such time as either party terminates the agreement in accordance with the provisions contained herein.

XIII. Termination of Agreement

13.1 Either party may terminate this Agreement if the other party (1) has been adjudicated a bankrupt, or (2) has filed a voluntary petition in bankruptcy, or (3) has made an assignment for the benefit of creditors, or (4) a receiver has been appointed for such party.
13.2 Furthermore, either party may terminate this Agreement without cause by giving the other party thirty (30) days written notice of termination.

IN WITNESS WHEREOF, the parties have caused this Agreement to be executed by the duly authorized representatives.

**Siemens Water Technologies Corp.**

NAME: _____

SIGNATURE: _____

TITLE: _____

DATE: _____

**GENERATOR**

NAME: _____

SIGNATURE: _____

TITLE: _____

DATE: _____

Generator acknowledges that Processor is required to comply with applicable export laws and regulations relating to the sale, exportation, transfer, assignment, disposal and usage of the services provided under the Contract, including any export license requirements. Purchaser agrees that such services shall not at any time directly or indirectly be used, exported, sold, transferred, assigned or otherwise disposed of in a manner which will result in non-compliance with such applicable export laws and regulations. It shall be a condition of the continuing performance by Processor of its obligations hereunder that compliance with such export laws and regulations be maintained at all times. GENERATOR AGREES TO INDEMNIFY AND HOLD PROCESSOR HARMLESS FROM ANY AND ALL COSTS, LIABILITIES, PENALTIES, SANCTIONS AND FINES RELATED TO NON-COMPLIANCE WITH APPLICABLE EXPORT LAWS AND REGULATIONS.

EXHIBITS:

Exhibit A: Waste Profile Sheet
Waste profile sheets to be provided after receipt and analysis of a feed water sample.

Exhibit B: Siemens Lab Report
A feed water sample to the ion exchange tanks is required to properly size and specify the type of media tanks required for your application. From this sample Siemens will do engineering and prepare a proposal, which will include an annual budget (Exhibit C to the Service Contract). If a water sample has not been analyzed by Siemens at the time of this proposal because wastewater was not available or there was not access to the wastewater, any estimates in this proposal are budgetary and the design should be considered preliminary.

Exhibit C: Quotation for Compensation to Processor

Exhibit D: Prohibited Wastes

# EXHIBIT C

# QUOTATION FOR COMPENSATION TO PROCESSOR

Proposal # 283231
Monday, February 1, 2010

## INITIAL INSTALLATION AND ACCESSORIES

| Part Number | Description | Quantity | Unit | Rate | Amount |
|---|---|---|---|---|---|
| RSLABSDI | RECOVERY SERV SDI LAB ANALYSIS FEE | 1 | EA | $ 625.00 | $ 625.00 |
| WXSCC6000CNWFR | WX TANK 60 CUBIC FOOT SELECTIVE MEDIA STEEL | 2 | EA | $ 17,311.00 | $ 34,622.00 |
| HOSES | INLET AND OUTLET HOSE | 1 | SET | $ 2,000.00 | $ 2,000.00 |
| | | | | **TOTAL START UP COSTS** | **$ 37,247.00** |

## TANK RENTAL

| Part Number | Description | Quantity | Unit | Rate | Amount |
|---|---|---|---|---|---|
| WXRENTAL | RENTAL OF WWIX 60CF SCC TANK | 2 | EA | $ 1,000.00 | $ 2,000.00 |
| | | | | **MONTHLY RENTAL TOTAL** | **$ 2,000.00** |
| | | | | **ANNUAL RENTAL TOTAL** | **$ 24,000.00** |

## RESIN REGENERATION & MEDIA PROCESSING

All tanks will be changed out based on quality or a minimum of every six (6) months

| Part Number | Description | Qty/Yr | Unit | Rate | Amount |
|---|---|---|---|---|---|
| WXSCC6000CNWFR | WX TANK 60 CUBIC FOOT SELECTIVE MEDIA STEEL | 2 | EA | $ 17,311.00 | $ 34,622.00 |
| | | | | **ESTIMATED RESIN TOTAL** | **$ 34,622.00** |
| | | | | **ESTIMATED 1st YEAR TOTAL:** | **$ 95,869.00** |

Usage estimates above are based on lab analysis and/or industry knowledge. It is important to remember that ion exchange loading rates can vary significantly based on any process changes made or fluctuations in influent contaminant concentrations.

## TRANSPORTATION

**Customer shall pay to Siemens shipping and transportation charges as determined at the time of each shipment.**

Notes:

1. Siemens requires a hard copy Purchase Order in the amount listed as 'ESTIMATE' - 1st Year Total.
2. Media Processing and Transportation charges will be incurred as tanks are delivered.
3. All annual quantities of units in Media Processing and Transportation sections are estimates.
4. All charges are plus any applicable taxes. This quote is good for 90 days.

# EXHIBIT D
# PROHIBITED WASTES

1. Waste Oil

Waste Oil of any kind including but not limited to waste hydraulic oil, waste emulsified oil, waste cutting oil, oil laden metal shavings, oil laden "floor dry" compounds, grinding swarf, waste cooling or cutting oils, transformer oil, waste lubricants, used oil coating baths, water soluble oils and paint strippers, unless previously approved by Processor.

2. Organic Solvents

Organic solvents of any kind including but not limited to: trichloroethane, trichloroethylene, dichloromethane (methylene chloride), naptha, kerosene, gasoline, alcohols, methylethyl ketone (MEK), acetone, benzene, toluene, tetrachloroethane and carbon tetrachloride, unless previously approved by Processor.

3. Toxic Organics

Toxic organic compounds of any kind, which contain toxic organics higher than nominal concentration. Toxic organics shall be defined as those compounds listed in 40 CFR 433.11, as it may be amended. The CRTF will not accept contamination in wastes by TTO in concentration equal to or greater than 2.13 mg/L. Concentrated toxic organics will not be accepted for treatment at the CTRF. Specific examples of unacceptable toxic organics include but are not limited to: vapor degreasing compounds (chlorinated hydrocarbons), cresylic acid emulsion cleaners, and vapor degreaser sludge.

4. Radioactive Materials

Any material exhibiting radioactivity above background levels, including artificial radioisotopes and naturally occurring radioisotopes; any material which is exposed to radioisotopes or radiation which becomes radioactive from such exposure; radiation sources used for thickness gauging; and equipment used to contain radiation sources.

5. Reactive Compounds

Any compounds which cause or could possibly cause undesirable reactions when mixed with other wastes in either Generator's holding tanks or the Processor's holding tanks and chemicals that are unstable alone or that can react with common contaminants listed for each Waste Category to cause a highly exothermic reaction or release explosive gases. Prohibited compounds include but are not limited to reducing agents in chrome or sulfate copper etch wastes, oxidizing agents in chelated wastes; and powerful reducing or oxidizing agents of any type other than those specifically listed as acceptable in Exhibit A. Examples of unacceptable reactive compounds are: hydrazine, sodium hydrosulfite, sodium borohydride,chlorate compounds and perchlorate compounds (other than ion exchange resin used to remove perchlorates from wastewater).

6. Mercury

Elemental mercury and all compounds of mercury.

7. Scrap Metals

All solid scrap including but not limited to: circuit board scrap, scrap or ruined plating work, drums, equipment or components (tanks, liners, etc.), anodes, anode baskets and chemical containers, unless previously approved by Processor.

8. Particulate Material

Particulate material larger than 1/4 inch in diameter in any liquid waste is unacceptable to the Processor. Such material includes but is not limited to: lost parts in process bath dumps (screws, nuts, etc.); cigarette butts, mop strings and rags in floor wash water; and sludge or crystal particles that may not be broken up by the agitation caused by pumping.

## HiPOx Preliminary and Budgetary Estimate
## P2461 Tetra Tech Baltimore No.2

| Description | P2461 Tetra Tech Baltimore #2 | | | |
|---|---|---|---|---|
| Condition | Case 1: 50 gpm, 1,4-Dioxane Removal | | Case 2: 100 gpm, 1,4-Dioxane Removal | |
| Flow Rate (gpm) | 50 | | 100 | |
| **Design Criteria** | | | | |
| Contaminant | 1,4-Dioxane | | 1,4-Dioxane | |
| Influent Concentration (ug/l) | 725 | | 725 | |
| Treatment Target Concentration (ug/l) | 6.1 | | 6.1 | |
| **Ozone** | | | | |
| Ozone Concentration (wt %) | 10 | | 10 | |
| Applied Ozone Dose (mg/l) | 35.4 | | 35.4 | |
| Ozone Demand (ppd) | 21.3 | | 42.5 | |
| Unit Energy Consumption (kWh/lb O3) | 6.00 | | 6.00 | |
| Annual Energy Consumption (kWh/yr) | 46587 | | 93174 | |
| Unit Energy Cost ($/kWh) | $0.10 | | $0.10 | |
| Annual Energy Cost ($/yr) | $4,659 | | $9,317 | |
| **Oxygen** | **w/LOX** | | **w/LOX** | |
| Oxygen Flow Rate (scfm) | 1.62 | | 3.25 | |
| Annual Oxygen Consumption (100 scf) | 8529 | | 17058 | |
| Unit Oxygen Cost ($/100 scf) | $0.80 | | $0.80 | |
| Annual LOX Cost ($/yr) | $6,823 | | $13,646 | |
| **Oxygen** | **w/VSA** | | **w/VSA** | |
| Power Consumption (kW) | 2.5 | | 5.0 | |
| Annual Energy Consumption (kWh/yr) | 21958 | | 43916 | |
| Unit Energy Cost (S/kWh) | $0.10 | | $0.10 | |
| Annual Energy Cost ($/yr) | $2,196 | | $4,392 | |
| **Hydrogen Peroxide** | | | | |
| Hydrogen Peroxide Dose (mg/l) | 15.8 | | 15.8 | |
| Hydrogen Peroxide Concentration (wt %) | 35 | | 35 | |
| Hydrogen Peroxide Usage (gpd) | 2.9 | | 5.7 | |
| Annual Hydrogen Peroxide Usage (gal/yr) | 1047 | | 2094 | |
| Unit Hydrogen Peroxide Cost ($/gal) | $3.50 | | $3.50 | |
| Annual Hydrogen Peroxide Cost ($/yr) | $3,664 | | $7,328 | |
| **Consumable Costs** | **w/LOX** | **w/VSA** | **w/LOX** | **w/VSA** |
| Annual Energy Cost ($/yr) | $4,659 | $6,854 | $9,317 | $13,709 |
| Annual Oxygen Cost ($/yr) | $6,823 | $0 | $13,646 | $0 |
| Annual Hydrogen Peroxide Cost ($/yr) | $3,664 | $3,664 | $7,328 | $7,328 |
| **Total ($/yr)** | **$15,146** | **$8,323** | **$30,291** | **$16,645** |
| Total ($/1000 gal) | $0.576 | $0.317 | $0.576 | $0.317 |
| **Captial Equipment Costs** | **w/LOX** | **w/VSA** | **w/LOX** | **w/VSA** |
| **Total Sale Price** | **$237,437** | **$277,787** | **$327,322** | **$377,759** |

Notes:

1. This is a preliminary and budgetary estimate. Bench testing and further scope definition is necessary for a firm estimate/proposal.
2. All equipment will be pre-assembled as much as possible and provided in skid-mounted subassemblies.
3. Containerization of most of the equipment is available as an option for an additional price.
4. Consumable costs assume 100% utilization for 365 days per year.

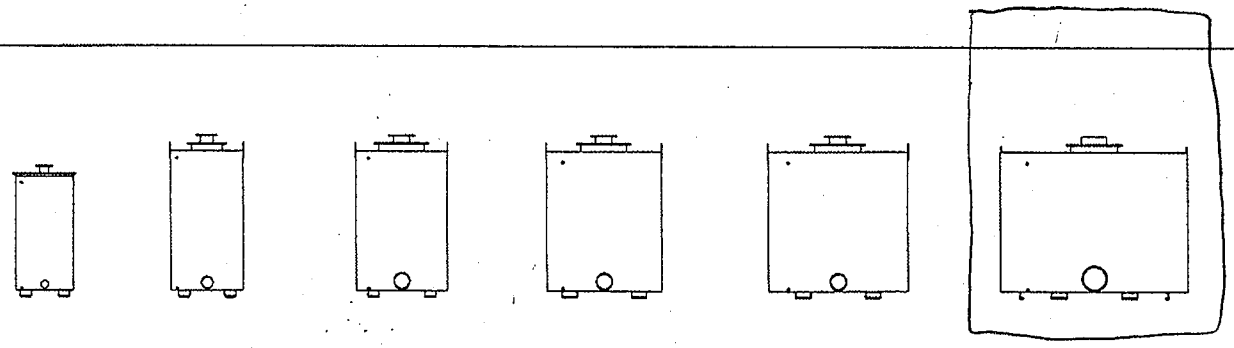
50 gpm case: 420 cfm
100 gpm case: 850 cfm.

CARBONAIR
www.carbonair.com

# GPC Round Series Carbon Vessels

Carbonair's gas phase carbon absorbers are designed to provide an efficient and economical means to control odor, toxic vapors, and corrosive gases. Several types of activated carbons are available for a variety of applications. 50 SPM

**Specifications***



| Model | GPC 5R | GPC 7R | GPC 13R | GPC 20R | GPC 28R | GPC 50R |
|---|---|---|---|---|---|---|
| Flow Range (cfm) | 40 - 380 | 76 - 500 | 120 - 800 | 200 - 1800 | 240 - 2200 | 480 - 4000 |
| Carbon Capacity (lb) | 500 | 1000 | 1500 | 2000 | 3000 | 5000 |
| Vessel Diameter or Plot Size | 2'-6" | 3'-2" | 4' | 5' | 6' | 8' |
| Vessel Height | **5'-7"** | **7'-0"** | **7'-0"** | **7'-0"** | **7'-3"** | **7'-0"** |
| Bed Area ($ft^2$) | 4.9 | 7.9 | 12.6 | 19.6 | 28.3 | 50 |
| Empty Weight (lb) | 550 | 790 | 1090 | 1425 | 1795 | 3970 |
| Operating Weight (lb) | 1050 | 1790 | 2590 | 3425 | 4795 | 8970 |
| Influent Connection (NPS)** | 4" | 6" | 8" | 8" | 8" | 12" |
| Effluent Connection (NPS)** | 4" | 6" | 8" | 8" | 8" | 12" |

Design Features

- **Welded steel construction**
- **Fork pockets for easy lifting**
- **Corrosion resistant acrylic polyurethane coated interior and exterior**
- **Steel grate and stainless steel screen**
- **Access port**

Options

- ☐ Influent/effluent sample and pressure taps
- ☐ Influent/effluent ducting
- ☐ Humidity control
- ☐ Discharge stack
- ☐ Blowers
- ☐ Complete line of granular activated carbon

Service Centers


**FLORIDA**
4710 Dignan Street
Jacksonville, FL 32254
800.241.7833
904.387.4465
904.387.5058 Fax

**MINNESOTA**
7500 Boone Ave N #101
Brooklyn Park, MN 55428
800.526.4999
763.315.4771
763.315.4614 Fax

**TEXAS**
4889 Hunter Rd. Bldg 1-C
San Marcos, TX 78666
800.893.5937
512.392.0085
512.392.0066 Fax

**VIRGINIA**
4003 West Main Street
Salem, VA 24153
800.204.0324
540.380.5913
540.380.5920 Fax


*Specifications subject to change without notice.

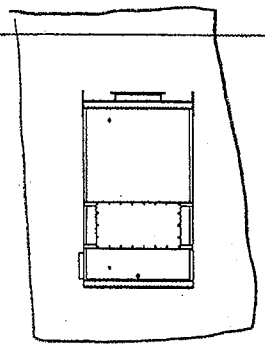
CARBONAIR
www.carbonair.com

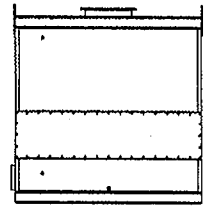
1000 scfm

# GPC Series Carbon Vessels

Carbonair's gas phase carbon absorbers are designed to provide an efficient and economical means to control odor, toxic vapors, and corrosive gases. Several types of activated carbons are available for a variety of applications.

**Specifications***





| Model | GPC 70 | GPC 120 |
|---|---|---|
| Flow Range (cfm) | 700 - 7000 | 1200 - 12,000 |
| Carbon Capacity (lb) | 10,000 | 13,500 |
| Vessel Diameter or Plot Size | **5'-0" x 16'-0"** | **8'-0" x 16'-6"** |
| Vessel Height | 8'-5" | 8'-6" |
| Bed Area (ft²) | 70 | 119 |
| Empty Weight (lb) | 5850 | 9250 |
| Operating Weight (lb) | 15,850 | 22,750 |
| Influent Connection (NPS)** | **12 3/4" (2)** | **12 3/4" (2)** |
| Effluent Connection (NPS)** | **12 3/4" (2)** | **12 3/4" (2)** |

Design Features

- **Welded steel construction**
- **Corrosion resistant acrylic polyurethane coated interior and exterior**
- **Steel grate and stainless steel screen**
- **Access port**

Options

- ☐ Influent/effluent sample and pressure taps
- ☐ Influent/effluent ducting
- ☐ Humidity control
- ☐ Discharge stack
- ☐ Blowers
- ☐ Complete line of granular activated carbon

Service Centers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**VIRGINIA**
4003 West Main Street
Salem, VA 24153
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540.380.5913
540.380.5920 Fax


*Specifications subject to change without notice.

TETRA TECH
BALTIMORE NO. 2
4/9/2010

| | Design Basis #2 | Cleanup Goal | 50 gpm Mass lb/hr | 50 gpm Mass lb/day | 50 gpm Mass lb/mo | 50 gpm Mass ton/yr | 100 gpm Mass lb/hr | 100 gpm Mass lb/day | 100 gpm Mass lb/mo | 100 gpm Mass ton/yr | GAC Loading lb/100 lb GAC | 50 gpm lb GAC/mo | 50 gpm ton GAC/mo | 100 gpm lb GAC/mo | 100 gpm ton GAC/mo |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Volatile Organics (ug/L)** | | | | | | | | | | | | | | | |
| 1,1,1-TRICHLOROETHANE | 94 | 200 | 0.0024 | 0.056 | 1.7 | 0.01 | 0.0047 | 0.113 | 3.4 | 0.02 | 6 | 28 | | 56 | |
| 1,1-DICHLOROETHENE | **89** | 3 | 0.0022 | 0.053 | 1.6 | 0.01 | 0.0045 | 0.107 | 3.2 | 0.02 | **6** | 27 | | 53 | |
| 1,2,4-TRICHLOROBENZENE | 411 | 70 | 0.0103 | 0.247 | 7.4 | 0.05 | 0.0206 | 0.494 | 14.8 | 0.09 | 6 | 123 | | 247 | |
| 1,2-DICHLOROETHANE | **119** | 5 | 0.0030 | 0.071 | 2.1 | 0.01 | 0.0060 | 0.143 | 4.3 | 0.03 | 6 | 36 | | 71 | |
| BENZENE | **5** | 5 | 0.0001 | 0.003 | 0.1 | 0.00 | 0.0003 | 0.006 | 0.2 | 0.00 | **12** | 1 | | 2 | |
| CHLOROBENZENE | 270 | 100 | 0.0068 | 0.162 | 4.9 | 0.03 | 0.0135 | 0.324 | 9.7 | 0.06 | 6 | 81 | | 162 | |
| CHLOROFORM | 77 | 80 | 0.0019 | 0.046 | 1.4 | 0.01 | 0.0038 | 0.092 | 2.8 | 0.02 | 6 | 23 | | 46 | |
| CIS-1,2-DICHLOROETHENE | **9050** | 70 | 0.2264 | 5.434 | 163.0 | 0.99 | 0.4529 | 10.869 | 326.1 | 1.98 | **7** | 2,329 | | 4,658 | |
| METHYLENE CHLORIDE | **10** | 5 | 0.0003 | 0.006 | 0.2 | 0.00 | 0.0005 | 0.012 | 0.4 | 0.00 | 6 | 3 | | 6 | |
| NAPHTHALENE | **21** | 0.65 | 0.0005 | 0.013 | 0.4 | 0.00 | 0.0011 | 0.025 | 0.8 | 0.00 | 20 | 2 | | 4 | |
| TOLUENE | 127 | 1000 | 0.0032 | 0.076 | 2.3 | 0.01 | 0.0063 | 0.152 | 4.6 | 0.03 | 12 | 19 | | 38 | |
| TRANS-1,2-DICHLOROETHENE | 110 | 100 | 0.0028 | 0.066 | 2.0 | 0.01 | 0.0055 | 0.132 | 4.0 | 0.02 | **7** | 28 | | 57 | |
| TRICHLOROETHENE | **15000** | 5 | 0.3753 | 9.007 | 270.2 | 1.64 | 0.7506 | 18.014 | 540.4 | 3.29 | **20** | 1,351 | | 2,702 | |
| VINYL CHLORIDE | **2475** | 2 | 0.0619 | 1.486 | 44.6 | 0.27 | 0.1238 | 2.972 | 89.2 | 0.54 | **0** | | | | |
| **Volatile Organics - SIM (ug/L)** | | | | | | | | | | | | | | | |
| 1,4-DIOXANE | **725** | 6.1 | | | | | | | | | | | | | |
| **Petroleum Hydrocarbons (ug/L)** | | | | | | | | | | | | | | | |
| DIESEL RANGE ORGANICS | **420** | 47 | 0.0105 | 0.252 | 7.6 | 0.05 | 0.0210 | 0.504 | 15.1 | 0.1 | 20 | 38 | | 76 | |
| GASOLINE RANGE ORGANICS | **3500** | 47 | 0.0876 | 2.102 | 63.1 | 0.38 | 0.1751 | 4.203 | 126.1 | 0.8 | 20 | 315 | | 631 | |

| | | | | |
|---|---|---|---|---|
| **Total** | 4,404 | 2.2 | 8,808 | 4.4 |

# QED Air Stripper Model ver. 2.01

4/9/2010

## Site Data

**Name:** J Logan

**e-mail:** joe.logan@tetratech.com

**Project:** Baltimore

**Units:** English

**Altitude:** 10 ft

**Air Temp:** 55 F

**Flow:** 50 gpm

**Water Temp:** 55 F

**Stripper:** EZ-Tray 8.x - Click for details

**Stripper Air Flow:** 420 cfm

**Stripper Max Flow:** 75 gpm

## Water Results

| Contaminant | Influent (ppb) | Target (ppb) | 4-Tray Results (ppb) | 4-Tray % Removal | 6-Tray Results (ppb) | 6-Tray % Removal |
|---|---|---|---|---|---|---|
| 1,1,1-trichloroethane | 94 | 200 | < 1 | 100.000 | < 1 | 100.000 |
| 1,1-dichloroethane | 119 | 5 | < 1 | 100.000 | < 1 | 100.000 |
| 1,1-dichloroethylene | 89 | 3 | < 1 | 100.000 | < 1 | 100.000 |
| 1,2,4-trichlorobenzene | 411 | 70 | 62.7 | 84.745 | 32.3 | 92.141 |
| benzene | 6 | 5 | < 1 | 100.000 | < 1 | 100.000 |
| c-1,2-dichloroethylene | 9050 | 70 | 27.8 | 99.693 | 1.6 | 99.982 |
| chlorobenzene | 270 | 100 | 3.0 | 98.889 | < 1 | 100.000 |
| chloroform (trichloromethane) | 81 | 80 | < 1 | 100.000 | < 1 | 100.000 |
| methylene chloride | 10 | 5 | < 1 | 100.000 | < 1 | 100.000 |
| t-1,2-dichloroethylene | 110 | 100 | < 1 | 100.000 | < 1 | 100.000 |
| toluene | 127 | 1000 | < 1 | 100.000 | < 1 | 100.000 |
| trichloroethylene (TCE) | 15000 | 5 | 16.2 | 99.892 | < 1 | 100.000 |
| vinyl chloride (chloroethylene) | 2475 | 2 | < 1 | 100.000 | < 1 | 100.000 |

## Air Results

| Contaminant | 4-Tray (ppmV) | 4-Tray (lb/hr) | 6-Tray (ppmV) | 6-Tray (lb/hr) |
|---|---|---|---|---|
| 1,1,1-trichloroethane | 0.2630 | 0.00235 | 0.2631 | 0.00235 |
| 1,1-dichloroethane | 0.4467 | 0.00296 | 0.4488 | 0.00298 |
| 1,1-dichloroethylene | 0.3427 | 0.00223 | 0.3428 | 0.00223 |
| 1,2,4-trichlorobenzene | 0.7167 | 0.00872 | 0.7792 | 0.00948 |
| benzene | 0.0285 | 0.00015 | 0.0287 | 0.00015 |
| c-1,2-dichloroethylene | 34.7486 | 0.22588 | 34.8496 | 0.22654 |
| chlorobenzene | 0.8856 | 0.00668 | 0.8945 | 0.00675 |
| chloroform (trichloromethane) | 0.2502 | 0.00200 | 0.2530 | 0.00202 |
| methylene chloride | 0.0421 | 0.00024 | 0.0435 | 0.00025 |
| t-1,2-dichloroethylene | 0.4221 | 0.00274 | 0.4236 | 0.00275 |

| | | | | |
|---|---|---|---|---|
| toluene | 0.5118 | 0.00316 | 0.5144 | 0.00318 |
| trichloroethylene (TCE) | 42.5803 | 0.37514 | 42.6249 | 0.37553 |
| vinyl chloride (chloroethylene) | 14.7831 | 0.06195 | 14.7859 | 0.06196 |

## Notes

*Copyright -- QED Treatment Equipment, PO Box 3726, Ann Arbor, MI 48106.*

*PH-> 1-800-624-2026 or 1-734-995-2547, FX-> 1-734-995-1170. E-mail->info@qedenv.com. WEB->www.qedenv.com.*

*The QED modeler estimates unit performance for the listed contaminants.*
***Results assume -***

1. *dissolved-phase contaminant within a water matrix*
2. *clean stripper air*
3. *no surfactants, oil, grease or other immiscible phase(s) in the influent*
4. *unit operated within the given parameters and as instructed in the O&M manual*

*Stripper performance shall meet or exceed either the required effluent concentration(s) or effluent estimates, whichever is greater, for the conditions supplied and assumes the influent concentrations of each contaminant are less than 25% solubility in water. QED makes no claim of the model's accuracy beyond the 25% solubility in water limit.*

## Contact Us

*Fill out your contact and project information and click Send to have a QED Treatment application specialist contact you.*

**Name -** J Logan

**Company -** Company

**Phone -** Phone **Fax -** Fax

**e-mail -** joe.logan@tetratech.com **Project -** Baltimore

Application Notes

Send Reset

## Save Data

*Use the following URL to reconstruct your data form for future remodeling*

*with changes. This URL can be saved in any text file for record keeping and later retrieval. This run's URL:*

```
http://64.9.214.199/cgi-bin/remodel.pl?
u=e&tw=55&ta=55&f=50&a=10&s=8.x&n=J+Log&e=joe.logan@tetratech.com&p=B
alti&c=9,94;15,119;16,89;21,411;63,6;81,9050;88,270;91,81;150,10;178,
110;186,127;189,15000;195,2475;
```

# QED Air Stripper Model ver. 2.01

4/9/2010

## Site Data

**Name:** J Logan

**e-mail:** joe.logan@tetratech.com

**Project:** Baltimore

**Units:** English

**Altitude:** 10 ft

**Air Temp:** 55 F

**Flow:** 100 gpm

**Water Temp:** 55 F

**Stripper:** EZ-Tray 16.x - Click for details

**Stripper Air Flow:** 850 cfm

**Stripper Max Flow:** 150 gpm

## Water Results

| Contaminant | Influent (ppb) | Target (ppb) | 4-Tray Results (ppb) | 4-Tray % Removal | 6-Tray Results (ppb) | 6-Tray % Removal |
|---|---|---|---|---|---|---|
| 1,1,1-trichloroethane | 94 | 200 | < 1 | 100.000 | < 1 | 100.000 |
| 1,1-dichloroethane | 119 | 5 | < 1 | 100.000 | < 1 | 100.000 |
| 1,1-dichloroethylene | 89 | 3 | < 1 | 100.000 | < 1 | 100.000 |
| 1,2,4-trichlorobenzene | 411 | 70 | 61.5 | 85.036 | 31.4 | 92.360 |
| benzene | 6 | 5 | < 1 | 100.000 | < 1 | 100.000 |
| c-1,2-dichloroethylene | 9050 | 70 | 27.1 | 99.701 | 1.6 | 99.982 |
| chlorobenzene | 270 | 100 | 3.0 | 98.889 | < 1 | 100.000 |
| chloroform (trichloromethane) | 81 | 80 | < 1 | 100.000 | < 1 | 100.000 |
| methylene chloride | 10 | 5 | < 1 | 100.000 | < 1 | 100.000 |
| t-1,2-dichloroethylene | 110 | 100 | < 1 | 100.000 | < 1 | 100.000 |
| toluene | 127 | 1000 | < 1 | 100.000 | < 1 | 100.000 |
| trichloroethylene (TCE) | 15000 | 5 | 15.8 | 99.895 | < 1 | 100.000 |
| vinyl chloride (chloroethylene) | 2475 | 2 | < 1 | 100.000 | < 1 | 100.000 |

## Air Results

| Contaminant | 4-Tray (ppmV) | 4-Tray (lb/hr) | 6-Tray (ppmV) | 6-Tray (lb/hr) |
|---|---|---|---|---|
| 1,1,1-trichloroethane | 0.2599 | 0.00470 | 0.2600 | 0.00471 |
| 1,1-dichloroethane | 0.4415 | 0.00593 | 0.4435 | 0.00596 |
| 1,1-dichloroethylene | 0.3387 | 0.00446 | 0.3387 | 0.00446 |
| 1,2,4-trichlorobenzene | 0.7107 | 0.01750 | 0.7720 | 0.01901 |
| benzene | 0.0282 | 0.00030 | 0.0283 | 0.00030 |
| c-1,2-dichloroethylene | 34.3426 | 0.45180 | 34.4398 | 0.45308 |
| chlorobenzene | 0.8754 | 0.01337 | 0.8840 | 0.01350 |
| chloroform (trichloromethane) | 0.2474 | 0.00401 | 0.2500 | 0.00405 |
| methylene chloride | 0.0416 | 0.00048 | 0.0430 | 0.00050 |
| t-1,2-dichloroethylene | 0.4172 | 0.00549 | 0.4186 | 0.00551 |

| | | | | |
|---|---|---|---|---|
| toluene | 0.5058 | 0.00632 | 0.5084 | 0.00636 |
| trichloroethylene (TCE) | 42.0806 | 0.75029 | 42.1235 | 0.75106 |
| vinyl chloride (chloroethylene) | 14.6093 | 0.12391 | 14.6120 | 0.12393 |

## Notes

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*PH-> 1-800-624-2026 or 1-734-995-2547, FX-> 1-734-995-1170. E-mail->info@qedenv.com. WEB->www.qedenv.com.*

*The QED modeler estimates unit performance for the listed contaminants.*
***Results assume -***

1. *dissolved-phase contaminant within a water matrix*
2. *clean stripper air*
3. *no surfactants, oil, grease or other immiscible phase(s) in the influent*
4. *unit operated within the given parameters and as instructed in the O&M manual*

*Stripper performance shall meet or exceed either the required effluent concentration(s) or effluent estimates, whichever is greater, for the conditions supplied and assumes the influent concentrations of each contaminant are less than 25% solubility in water. QED makes no claim of the model's accuracy beyond the 25% solubility in water limit.*

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**Company -** Company

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**e-mail -** joe.logan@tetratech.com

**Project -** Baltimore

Application Notes

Send Reset

## Save Data

*Use the following URL to reconstruct your data form for future remodeling*

*with changes. This URL can be saved in any text file for record keeping and later retrieval. This run's URL:*

```
http://64.9.214.199/cgi-bin/remodel.pl?
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8,110;186,127;189,15000;195,2475;
```

## ENGINEERING DATA SHEET
## BLOWERS: ALL MODELS FOR AIR STRIPPERS

REF — ITEMS and SPECIFICATIONS

2.1.1, 2.2.2.2 2.3.2.2 — EZ-STACKER STRIPPER BLOWERS

| Model No. | Type* | Used on Stripper | Electrical Specifications | Max CFM | Motor HP |
|---|---|---|---|---|---|
| 805188 | R | 2.4P | 115-230V/1PH/TEFC | 145 | 2.0 |
| 805189 | R | 2.4P | 115-230V/1PH/EXP | 145 | 2.0 |
| 805190 | R | 2.4P | 230/460V/3PH/TEFC | 145 | 2.0 |
| 805191 | R | 2.4P | 230/460V/3PH/EXP | 145 | 2.0 |
| 805192 | R | 2.6P | 115-230V/1PH/TEFC | 180 | 3.0 |
| 805193 | R | 2.6P | 115-230V/1PH/EXP | 180 | 3.0 |
| 805194 | R | 2.6P | 230/460V/3PH/TEFC | 180 | 3.0 |
| 805195 | R | 2.6P | 230/460V/3PH/EXP | 180 | 3.0 |
| 807034 | P | 4.4P,4.6P | 230/460V/3PH/TEFC | 600 | 5.0 |
| 807035 | P | 4.4P,4.6P | 230/1PH/TEFC | 600 | 5.0 |
| 807036 | P | 4.4P,4.6P | 230/460V/3PH/EXP | 600 | 5.0 |

* R-Regenerative type, P-Pressure type

2.1.1, 2.2.2.2 2.3.2.2 — EZ-TRAY STRIPPER BLOWERS

| Model No. | Type* | Used on Stripper | Electrical Specifications | Max CFM | Motor HP |
|---|---|---|---|---|---|
| 807034 | P | 4.4,6.4,8.4 | 230/460V/3PH/TEFC | 600 | 5.0 |
| 807035 | P | 4.4,6.4,8.4 | 115-230V/1PH/TEFC | 600 | 5.0 |
| 807036 | P | 4.4,6.4,8.4 | 230/460V/3PH/EXP | 600 | 5.0 |
| 807037 | P | 12.4,16.4 | 230/460V/3PH/TEFC | 1100 | 7.5 |
| 807038 | P | 12.4,16.4 | 230V/1PH/TEFC | 1100 | 7.5 |
| 807039 | P | 12.4,16.4 | 230/460V/3PH/EXP | 1100 | 7.5 |
| 807040 | P | 24.4 | 230/460V/3PH/TEFC | 2200 | 15.0 |
| 807041 | P | 24.4 | 230/460V/3PH/EXP | 2200 | 15.0 |
| 807139 | P | 4.6,6.6,8.6 | 230/460V/3PH/TEFC | 500 | 5.0 |
| 807140 | P | 4.6,6.6,8.6 | 115-230V/1PH/TEFC | 500 | 5.0 |
| 807141 | P | 4.6,6.6,8.6 | 230/460V/3PH/EXP | 500 | 5.0 |
| 807142 | P | 12.6,16.6 | 230/460V/3PH/TEFC | 1000 | 7.5 |
| 807143 | P | 12.6,16.6 | 230V/1PH/TEFC | 1000 | 7.5 |
| 807144 | P | 12.6,16.6 | 230/460V/3PH/EXP | 1000 | 7.5 |
| 807145 | P | 24.6 | 230/460V/3PH/TEFC | 1700 | 15.0 |
| 807146 | P | 24.6 | 230/460V/3PH/EXP | 1700 | 15.0 |

* P-Pressure type

(Note: To use this Data Sheet in a specification, either reproduce the whole table above and indicate which model number is being specified, or include only the data for the model selected.)


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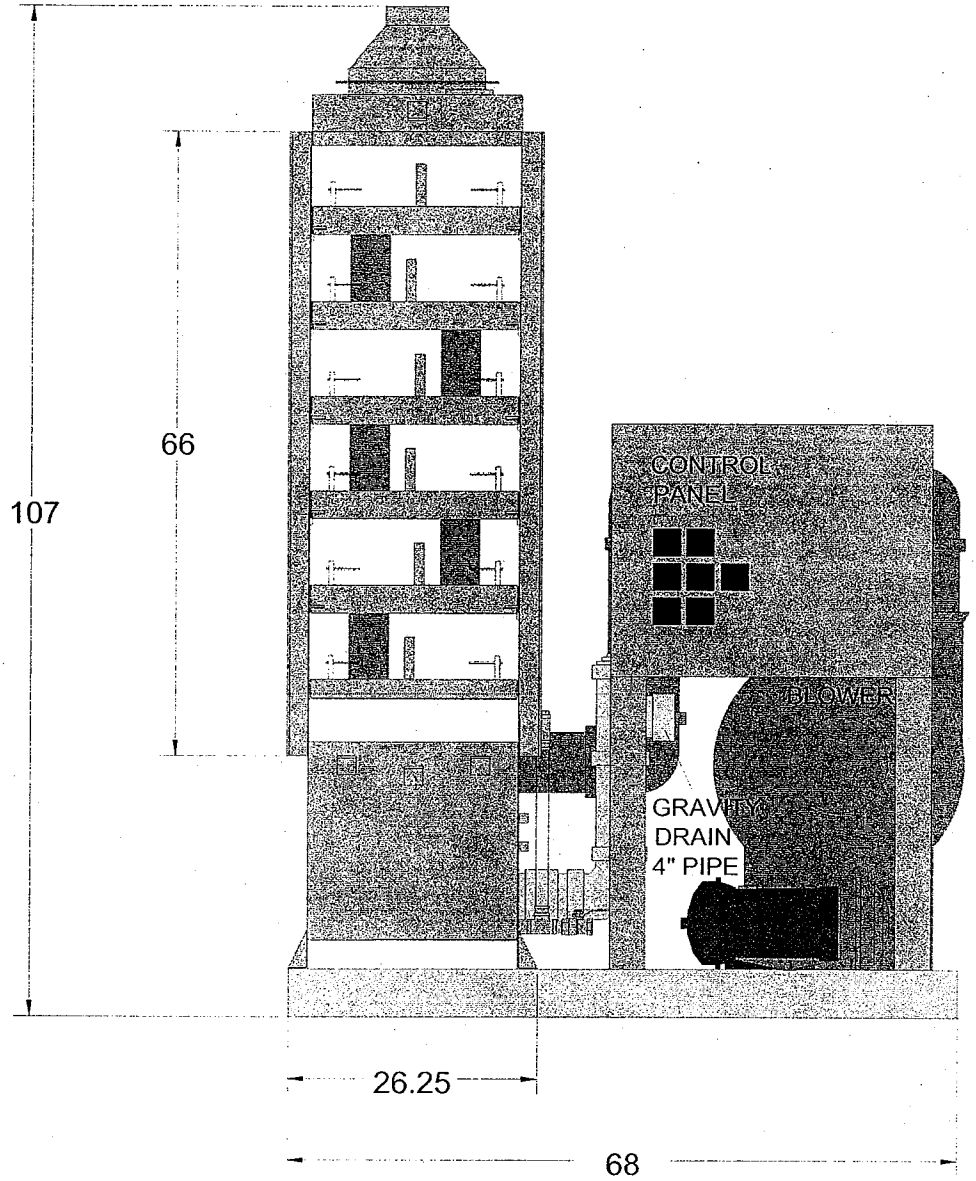
# QED EZ-Tray Model 8.6 - Front View

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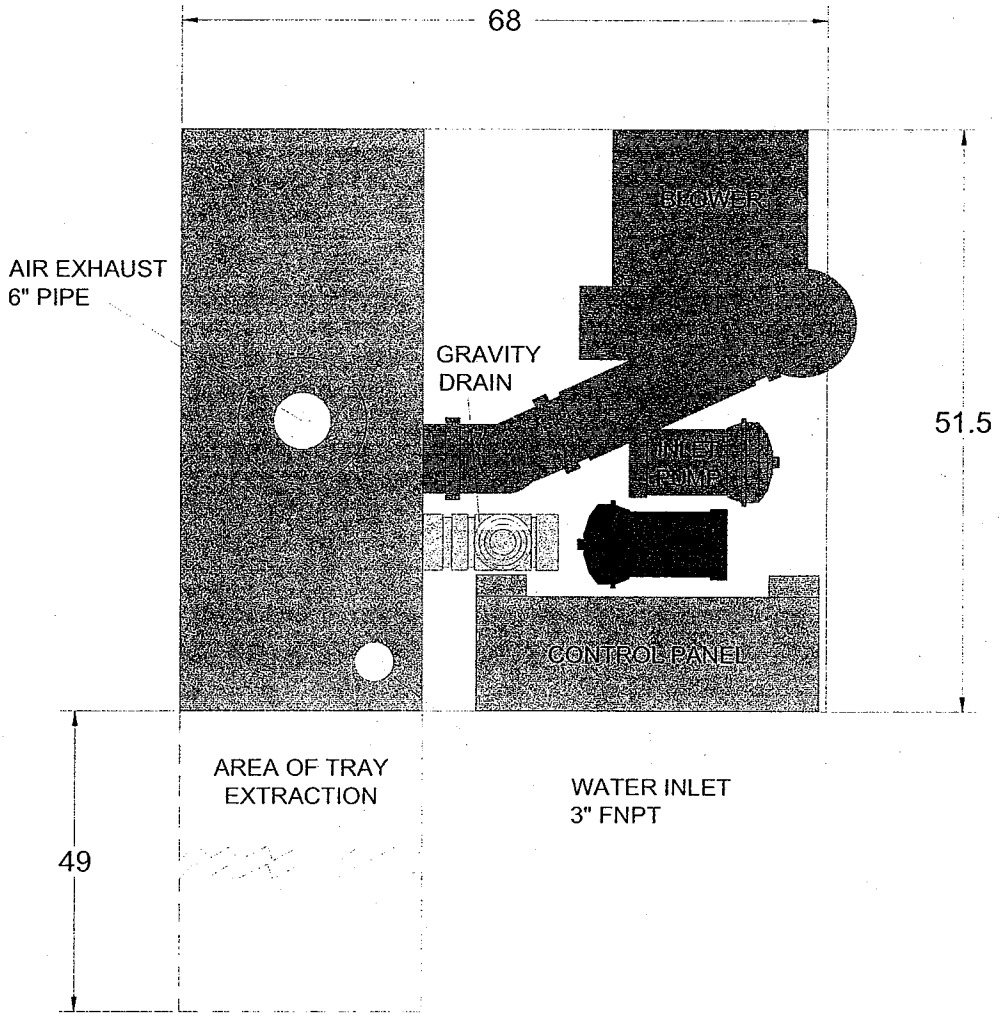
# QED EZ-Tray Model 8.6 - Top View

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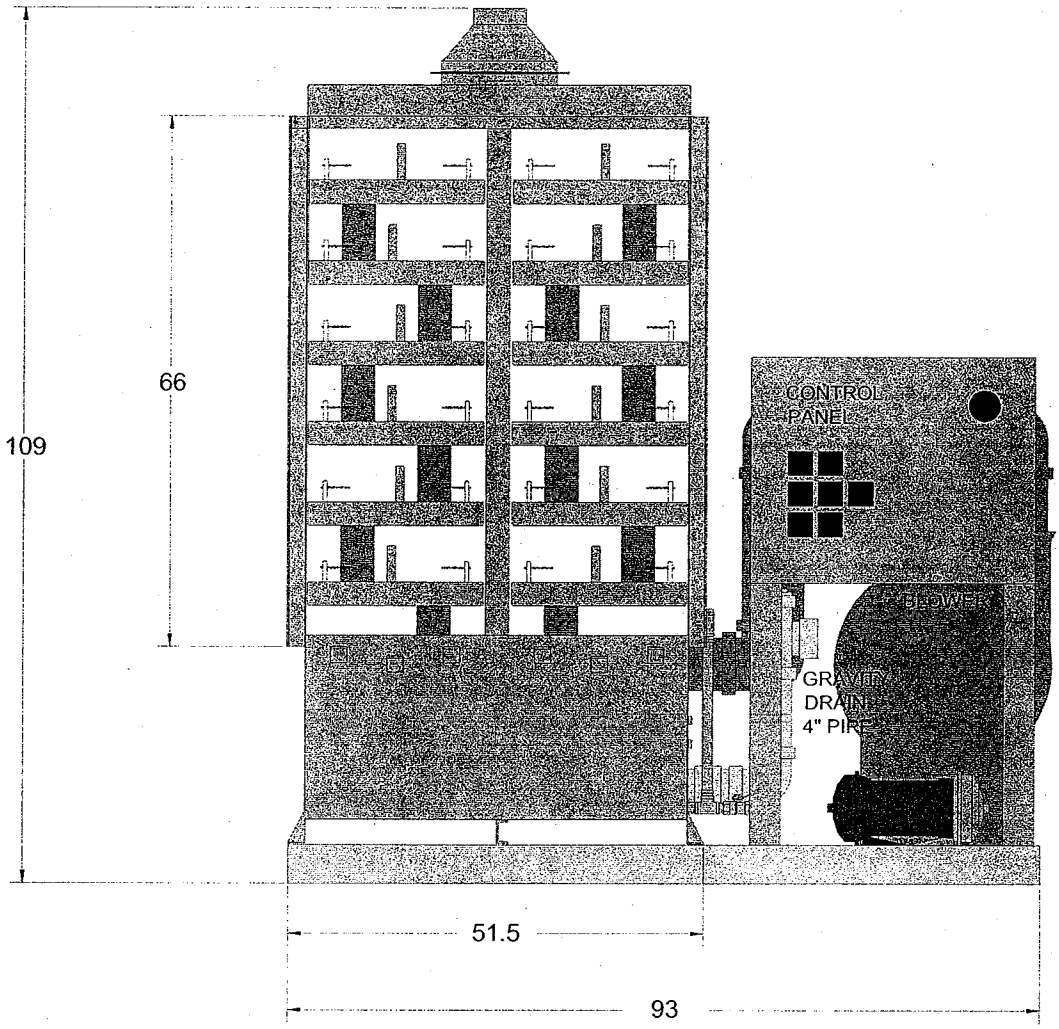
# QED EZ-Tray Model 16.6 - Front View

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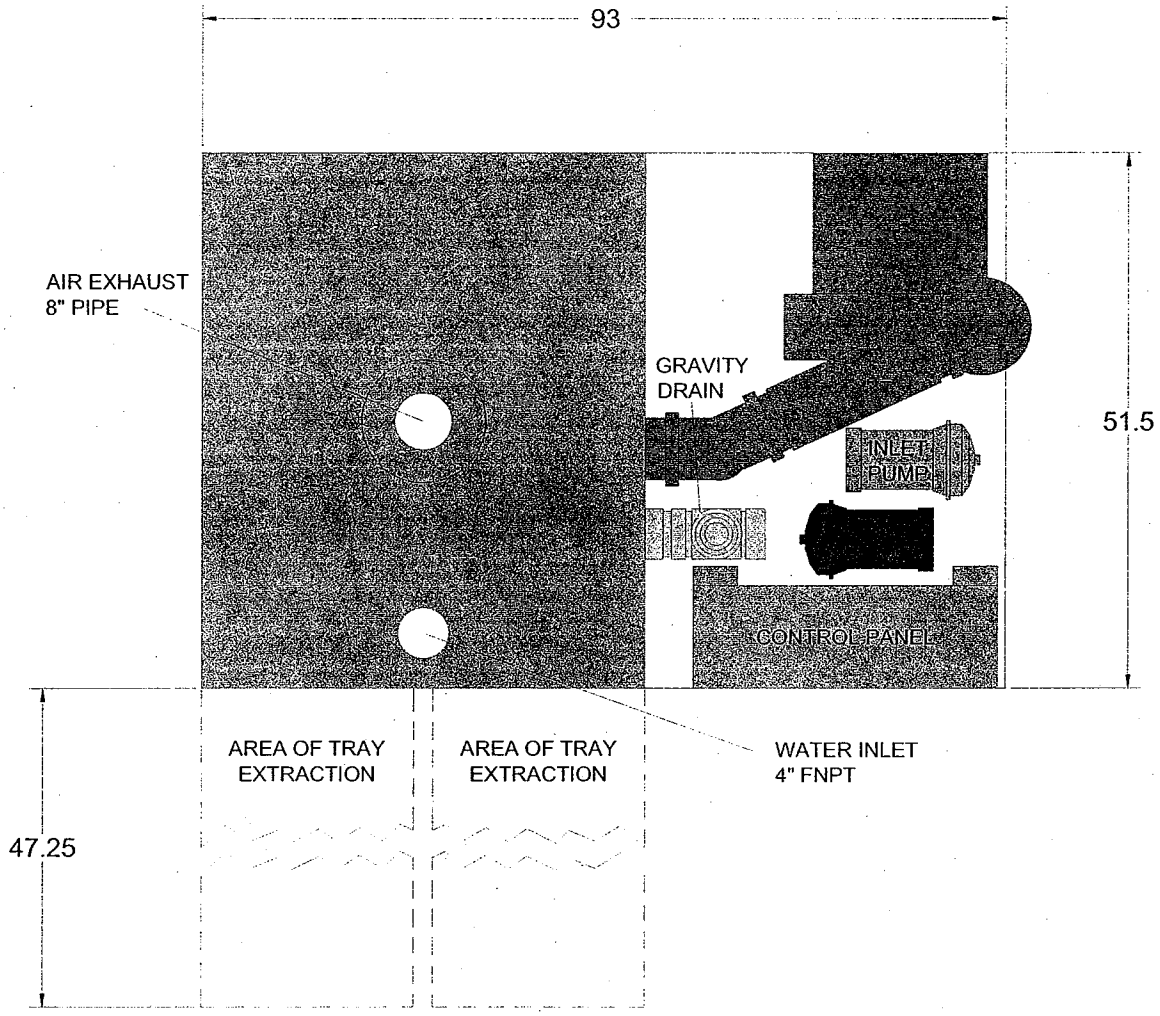
# QED EZ-Tray Model 16.6 - Top View

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# GROUNDWATER TREATMENT SYSTEM PROCESS DESCRIPTIONS

## PROCESS DESCRIPTION - ALTERNATIVE G-2

Component 1: Hydraulic Control

This component would consist of installing an array of groundwater extraction wells and operating this array for a period of up to 50 years. Modeling results for this component are provided in Appendix B. Design calculations for this component are provided in Appendix D

Based on the results of groundwater modeling, sixteen extraction wells at various extraction depths would be sufficient to intercept the contaminated groundwater before it reaches Frog Mortar Creek. Seven wells would be screened within the upper zone (approximately 35 feet deep), five wells would be screened within the intermediate zone (approximately 65 feet deep), and four would be screened within the lower zone (approximately 90 feet deep). Each well screen would be a minimum of 10 feet long. The total groundwater extraction rate is estimated to be 40 gpm. The locations of the extraction wells are shown on Figure 4-1.

Groundwater extraction wells would be installed at depths ranging from approximately 35 to 90 feet bgs. A submersible centrifugal pump equipped with level controls to turn the pump on and off would be installed in each groundwater extraction well. The discharge line from each pump would be provided with a flow meter, flow control valve, shut-off valve, and pressure gauges. Valves and instrumentation would be housed in a subsurface concrete vault with a hinged hatchway. Piping within the vault would be protected from freezing.

Each of these pumps would be connected to a piping network that would convey the extracted groundwater to a pump station on-site (see Figure 4-1). From there, the groundwater would be pumped to an off-site treatment system located near Eastern Boulevard. Because the concentrations of TCE and vinyl chloride in many of the wells the extracted groundwater will be conveyed through double walled piping.

Component 2: Ex-Situ Treatment of Groundwater

Based on recent groundwater modeling, the total groundwater extraction rate was estimated to be approximately 40 gpm. The treatment system conceptual design is sized for a maximum instantaneous flow of 50 gpm. This component would consist of installing an on-site treatment

system and operating the system as long as groundwater is being extracted. As shown on Figure 4-2, the extracted groundwater would enter the system at a feed tank; then flow through a metals removal system, filter unit, air stripper, advanced oxidation system, the liquid-phase GAC unit; and exit the system from the GAC unit. Sludge generated by the metals removal step would be thickened, dewatered, and disposed off-site. The treatment system is described further below and a process flow diagram (PFD) of the system is shown on Figure 4-2. A conceptual layout of the treatment building is shown on Figure 4-3. Design calculations for this component are provided in Appendix C. The following description is typical and the description of the final system will depend on the vendor-specific equipment selected.

The purpose of the Feed Tank is to provide control of water flow through the treatment system. The tank would also blend the groundwater from the various extraction wells to dampen variations in the quality of the influent to treatment system. In addition, side streams from the wastewater treatment system process will also be sent to the Feed Tank. The Feed Tank could also be used to provide additional treatment, as may be required, such as pH adjustment. The Feed Tank would be a nominal 10,000 gallon capacity.

The groundwater flow would be pumped by the Feed Pump, a 50 gpm centrifugal pump, to the metals removal system. The groundwater enters a 600-gallon Primary pH Adjustment Tank equipped with a 0.5 horsepower (hp) Adjustment Tank Mixer. In this tank, the pH is adjusted to 10 with caustic soda (12 gallons per day of 50 percent solution), and hydrogen peroxide (3.5 gallons per day of 35 percent solution) is added for the oxidation and precipitation of iron and manganese. The groundwater then enters a 600-gallon Secondary pH Adjustment Tank equipped with a 0.5 hp mixer. In this tank, the pH is adjusted to 11 with caustic soda for the precipitation of other metals, such as cadmium. The groundwater then flows into the Flocculation Tank equipped with a 0.5 hp flocculation mixer and mixed with a polymer (approximately 6 lb/day) to coagulate and flocculate the suspended solids. The groundwater then flows into the Clarifier where solids settle out. The Clarifier would be equipped with tube settlers. The clarified effluent flows into a Final pH Adjustment Tank where hydrochloric acid (3 gallons per day of 35 percent solution) is added to return the pH back into the range of 6 to 9 for discharge after final treatment. The Final pH Adjustment Tank would be 1,000 gallons with a 1 hp mixer. Chemicals would be stored in drums or tote tanks, depending on usage rates.

Neutralized groundwater flows by gravity into the Clarified Water Feed Tank (750 gallons), from which it is pumped through to the air stripper treatment system by the Clarified Water Pump (3 hp). The clarified water is pumped directly to the air stripper then through a sand filter. Groundwater flows to the top of an air stripper where the groundwater would then cascade down through the multiple trays of a low-profile-type air stripper unit where a countercurrent of air would volatilize the VOCs, and the treated groundwater would be collected in a sump at the bottom of the air stripper unit. The air stripper unit would include four trays and be equipped with a 420 cubic feet per minute (cfm) centrifugal blower to provide the necessary countercurrent of air. Another pump would convey the treated groundwater to the AOP and GAC units.

The sand filter will remove the balance of the suspended solids (including precipitated iron and manganese), as well as any particulate generated in the stripper. By removing suspended solids, the Sand Filter will also remove metals so that discharge limitations are met. There would be three Sand Filter tanks in parallel, two on-line and one off-line. As solids accumulate, the pressure drop in the Sand Filter increases. When a pre-set pressure drop is reached, the off-line sand filter will automatically be brought on line while the original sand filter is taken off-line. The off-line Sand Filter will be backwashed, as described further below.

For the purposes of this GW/FS, the HiPOx system is described in the process description although other processes can be used. Water from the air stripper enters the HiPOx unit where ozone and hydrogen peroxide are added to the groundwater to oxidize organic compounds. Ozone is generated by an ozone generator that uses a stream of oxygen produced by a vacuum swing absorption (VSA) system Excess ozone is oxidized in the HiPOx unit prior to venting. The treated groundwater then flows through the GAC system.

A GAC system is provided to polish the groundwater, to remove remaining DRO and GRO compounds, and to provide contingency treatment in the event that the AOP unit is malfunctioning. There are two GAC Tanks, each containing 4,000 pounds (lb) GAC, in series in a lead-lag configuration. When the GAC in the lead tank reaches capacity (based on analytical testing of the influent and effluent), the flow will be switched to the lag tank while the first tank

is taken off-line so that the GAC can be replaced with fresh GAC. After the GAC is replaced, the GAC Tank is put back on-line in the lag position.

Following GAC treatment, the treated water flows to the discharge piping to an existing sewer that is connected to the sanitary sewer system. A flow meter and totalizer measures the total discharge to the POTW.

The gas exhausting from the top of the air stripper unit would pass through an offgas treatment unit to remove volatilized contaminants prior to venting to atmosphere. The offgas treatment unit would consist of an electric heater followed by two vapor-phase GAC adsorption units, each holding 4,000 lb of GAC and operating in parallel or series followed by two PPZ adsorption units, each holding 3,000 lb of PPZ. The purpose of the exhaust gas heater would be to reduce the relative humidity of the air stripper unit off gas from near 100 percent to approximately 50 percent to allow efficient operation of the vapor-phase GAC adsorption units. The majority of the VOCs in the extracted vapors would be removed by the lead vapor-phase GAC adsorption unit, with the lag unit provided for polishing purposes. Upon exhaustion of the carbon of the lead vapor-phase GAC unit, it would be taken out for disposal or regeneration. The lag vapor-phase GAC adsorption unit would then be placed in the lead position and a fresh unit would be placed in the lag position. Because vinyl chloride is poorly sorbed by GAC, PPZ is used. The vinyl chloride is oxidized by the potassium permanganate. The PPZ units are in a parallel configuration only due to their high capacity and long bed life. Upon exhaustion of the PPZ unit, it would be taken out for disposal.

For discharge to surface water, the contaminant concentrations must also conform to WQCs. For cadmium, the PRG is 5 µg/L, and conventional treatment by pH adjustment, clarification, and filtration cannot meet this level. To meet the cadmium requirement, an ion exchange (IE) unit would be provided following the GAC unit. Cartridge filters would be required upstream of the IE system to prevent clogging of the IE resin and to further remove metals sorbed onto fine suspended solids that pass through the sand filters. There would be two tanks each containing 60 $ft^3$ of cationic IE resin. One tank would be on line and the second tank would be on standby. The effluent would be routinely monitored for cadmium, and as the concentration approached the PRG, the tank would be taken offline, and the standby tank would be brought into service. The

resin would be regenerated off-site by a resin regeneration service. For a small system such as this, the resin and tank would be removed from the site and replace with another tank filled with fresh resin. The new tank would be backwashed to remove fines, and the tank would be placed in standby mode.

Part of the treated water will be diverted to a Backwash Supply Tank (5,000 Gallons). This tank would be equipped with level switches to divert treated water into the tank when it is not full. When the tank is full, all treated water flows to the sanitary sewer. The Backwash Supply Tank is sized to provide sufficient water for one backwash cycle each of a Sand Filter and GAC Tank.

When a Sand Filter requires backwash, the Backwash Pump is activated and 40 gpm flows upward through the sand filter, suspending the sand, and carrying the solids out of the sand filter to the Waste Backwash Tank. Each backwash cycle requires approximately 800 gallons of water. After backwash is complete, the Backwash Pump is stopped, and the Sand Filter is ready to be used when the next on line Sand Filter reaches capacity.

Similarly, when the GAC in a GAC Tank is replaced, fines are generated during transfer of the GAC, and these are removed by backwashing. When a GAC Tank requires backwash, the Backwash Pump is activated and 50 gpm flows upward through the GAC tank carrying the fines out of the tank to the Waste Backwash Tank.

Because the backwash is a relatively large volume of water generated over a short period of time, the waste backwash water is directed to the Waste Backwash Tank (5,000 Gallons) so that it can be fed into the treatment system at a low rate. The water in the Waste Backwash Tank is metered back to the Feed Tank by the Waste Backwash Transfer Pump over a 20-hour period at approximately 1 gpm.

Settled sludge (approximately 200 lb/day of dry solids) in the Clarifier is periodically transferred to a 10-foot diameter Sludge Thickener Tank by a 15 gpm Clarified Underflow Pump. In the Sludge Thickener the solids content of the sludge is increased by gravity sedimentation from approximately 0.5 percent (by weight) to approximately 4 percent (by weight). Thickened sludge is periodically transferred from the bottom of the Thickener to an 80 cubic feet ($ft^3$) recessed plate type Filter Press by a 60 gpm Filter Press Feed Pump. In the Filter Press, the solids content

of the thickened sludge is increased from approximately 4 percent by weight to 25- to 35 percent (by weight) to form a solid cake which would be stored in a roll-off container and later hauled away for appropriate disposal. Supernatant water from the Thickener and filtrate water from the Filter Press are collected in the 4,700-gallon Filtrate Tank and returned from there to the Feed Tank by a 15 gpm Filtrate Transfer Pump.

A compressed air system will be used to operate air-operated diaphragm pumps for Sludge Transfer, Filter Press Feed, and other air-operated equipment.

The DRA site is bordered by the taxiways and runways, the MDANG property, and Frog Mortar Creek which makes access for routine maintenance difficult, so the location of the treatment building is planned to be off of the Martin State Airport property. The estimated size of the building is 130 feet by 60 feet, and an area of approximately 180 feet by 120 feet would be needed to accommodate construction, parking, and deliveries. The tentative location is assumed to be along Lynbrook Road at the Martin State Airport property line (see Figure 4-4). Figure 4-4 also shows an alternative location along the property line approximately 800 feet to the west. The properties would need to be purchased or leased. The Groundwater Treatment Plant Building will be designed to contain spills within the building. Spilled water will flow or be directed into the building sump and transferred by a Sump Pump to the Feed Tank.

Influent, effluent, and intermediate locations in the process will be sampled routinely to monitor the effectiveness and progress of the treatment. These results will also be used to determine if GAC needs to be replaced.

Component 3: Discharge to POTW and Surface Water

Treated groundwater would be initially discharged to the Baltimore County sanitary sewer system and treated at the City of Baltimore Back River Wastewater Treatment Plant. The discharge from the groundwater treatment system would be pumped and tied into an existing sanitary sewer near the proposed treatment building. The discharge to the sanitary sewer would be metered and routinely sampled to comply with Baltimore County Industrial Wastewater Discharge Standards. The design discharge rate of 50 gpm is greater than the 25,000 gallons per

day (gpd) threshold for a significant industrial user, so reporting is required twice per year and annual user fees are required in addition to sewage service charges.

After the extraction and treatment system has been in operation for 2 to 3 years, the extraction flow rates, groundwater concentrations, and treated water concentrations will be well established. Using the data from plant operation, an NPDES permit application for a discharge to surface water can be prepared. This will include developing an MDE-approved estuary model to calculate effluent limitations, field calibration of the model, and obtaining effluent limitations from the MDE. The treated water would be discharged to surface water through a submerged multiple diffuser outfall.

## PROCESS DESCRIPTION - ALTERNATIVE G-3

Component 1: Hydraulic Control

This component would consist of installing an array of groundwater extraction wells and piping as described for Component 1 in Alternative G-2. As in Alternative G-2, the system would operate up to 50 years. The locations of the extraction wells are shown on Figure 4-5.

Component 2: Ex-Situ Treatment of Groundwater

As in Alternative G-2, the total groundwater extraction rate is approximately 40 gpm, but because of uncertainties in the groundwater extraction rates and to provide flexibility for future operation, the treatment system conceptual design is sized for 100 gpm, although the system is assumed to operate at 50 gpm. The additional flow capacity would allow significant recirculation to facilitate in-situ treatment of the HCAs. This component would consist of installing an on-site treatment system and operating this system for up to 50 years, and the process is essentially the same as the treatment system in Alternative G-2, and is described below.

As shown on Figure 4-6, the extracted groundwater would enter the system at a feed tank, then flow through a metals removal system, filter unit, air stripper, advanced oxidation system, the liquid-phase GAC unit, IE unit; and exit the system. Sludge generated by the metals removal step would be thickened, dewatered, and disposed off-site. The treatment system is described further below and a PFD of the system is shown on Figure 4-6. A conceptual layout of the treatment building is shown on Figure 4-7. Design calculations for this component are provided in Appendix C. The following description closely follows Alternative G-2, but has been modified to reflect the larger size of the equipment for the higher design flow rate.

The purpose of the Feed Tank is to provide control of water flow through the treatment system. The tank would also blend the groundwater from the various extraction wells to dampen variations in the quality of the influent to treatment system. In addition, side streams from the wastewater treatment system process will also be sent to the Feed Tank. The Feed Tank could also be used to provide additional treatment, as may be required, such as pH adjustment. The Feed Tank would be sized at 23,000 gallons.

The groundwater flow would be pumped by the Feed Pump, a 100 gpm centrifugal pump to the metals removal system. The groundwater enters a 1,200-gallon Primary pH Adjustment Tank equipped with a 0.5 hp Adjustment Tank Mixer. In this tank, the pH is adjusted to 10 with caustic soda (24 gallons per day of 50 percent solution) and hydrogen peroxide (7 gallons per day of 35 percent solution) is added for the oxidation and precipitation of iron and manganese. The groundwater then enters a 1,200-gallon Secondary pH Adjustment Tank equipped with a 0.5 hp mixer. In this tank, the pH is adjusted to 11 with caustic soda for the precipitation of other metals, such as cadmium. The groundwater then flows into the Flocculation Tank equipped with a 0.5 hp flocculation tank mixer and mixed with a polymer (approximately 12 lb/day) to coagulate and flocculate the suspended solids. The groundwater then flows into the Clarifier where solids settle out. The Clarifier would be an equipped with tube settlers. The clarified effluent flows into a Final pH Adjustment Tank where hydrochloric acid (6 gallons per day of 35 percent solution) is added to return the pH back into the range of 6 to 9 for subsequent discharge. The Final pH Adjustment would be 2,000 gallons with a 1 hp mixer. Chemicals would be stored in drums or tote tanks, depending on usage rates.

Neutralized groundwater flows by gravity into the Clarified Water Feed Tank (1,500 gallons), from which it is pumped through the rest of the treatment system by the Clarified Water Pump (5 hp). The clarified water is pumped directly to the air stripper then through a sand filter. Groundwater flows to the top of an air stripper where the groundwater would then cascade down through the multiple trays of a low-profile-type air stripper unit where a countercurrent of air would volatilize the VOCs, and the treated groundwater would be collected in a sump at the bottom of the air stripper unit. The air stripper unit would include four trays and be equipped with a 850 cfm centrifugal blower to provide the necessary countercurrent of air. Another pump would convey the treated groundwater to the AOP and GAC units.

The sand filter will remove the balance of the suspended solids (including precipitated iron and manganese), as well as any particulate generated in the stripper. By removing suspended solids, the Sand Filter will also remove metals so that discharge limitations are met. There would be three Sand Filter tanks in parallel, two on-line and one off-line. As solids accumulate, the pressure drop in the Sand Filter increases. When a pre-set pressure drop is reached, the off-line

sand filter will automatically be brought on line while the original sand filter is taken off-line. The off-line Sand Filter will be backwashed, as described further below.

For the purposes of this GW/FS, the HiPOx system is described in the process description although other processes can be used. Water from the air stripper enters the HiPOx unit where ozone and hydrogen peroxide are added to the groundwater to oxidize organic compounds. Ozone is generated by an ozone generator that uses a stream of oxygen produced by a vacuum swing absorption (VSA) system Excess ozone is oxidized in the HiPOx unit prior to venting. The treated groundwater then flows through the GAC system.

A GAC system is provided to polish the groundwater, to remove remaining DRO and GRO compounds, and to provide contingency treatment in the event that the AOP unit is malfunctioning. There are two GAC Tanks, each containing 8,000 lb GAC, in series in a lead-lag configuration. When the GAC in the lead tank reaches capacity (based on analytical testing of the influent and effluent), the flow will be switched to the lag tank and while the first tank is taken off-line so that the GAC can be replaced with fresh GAC. After the GAC is replaced, the GAC Tank is put back on-line in the lag position.

For re-injection of the treated groundwater, the contaminant concentrations must meet the groundwater PRGs, and for discharge to surface water, the contaminant concentrations must also conform to WQCs. For cadmium, the PRG is 5 µg/L, and conventional treatment by pH adjustment, clarification, and filtration cannot meet this level. To meet the cadmium requirement, an IE unit would be provided following the GAC unit. Cartridge filters would be required upstream of the IE system to prevent clogging of the IE resin and to further remove metals sorbed onto fine suspended solids. There would be two tanks each containing 60 $ft^3$ of cationic IE resin. One tank would be on-line and the second tank would be on standby. The effluent would be routinely monitored for cadmium, and as the concentration approached the PRG, the tank would be taken off-line, and the standby tank would be brought into service. For a small system such as this, the resin and tank would be removed from the site and replaced with another tank filled with fresh resin. The new tank would be backwashed to remove fines, and the tank would be placed in standby mode.

Following IE treatment, part of the treated water would be pumped through the discharge piping to an existing Baltimore County sanitary sewer system and treated at the City of Baltimore Back River Wastewater Treatment Plant, and the rest is pumped to the injection wells. Flow meters and totalizers measure the discharge to the POTW and to the injection wells.

The gas exhausting from the top of the air stripper unit would pass through an offgas treatment unit to remove volatilized contaminants prior to venting to atmosphere. The offgas treatment unit would consist of an electric exhaust gas dryer followed by two vapor-phase GAC adsorption units, each holding 9,000 lb of GAC and operating in series and lead/lag configuration, which would be followed by two PPZ adsorption units, each holding 6,000 lb of PPZ. The purpose of the exhaust gas dryer would be to reduce the relative humidity of the air stripper unit off gas from near 100 percent to approximately 50 percent to allow efficient operation of the vapor-phase GAC adsorption units. The majority of the VOCs in the extracted vapors would be removed by the lead vapor-phase GAC adsorption unit, with the lag unit provided for polishing purposes. Upon exhaustion of the carbon of the lead vapor-phase GAC unit, it would be taken out for disposal or regeneration. The lag vapor-phase GAC adsorption unit would then be placed in the lead position and a fresh unit would be placed in the lag position. Because vinyl chloride is poorly sorbed by GAC, PPZ is used. The vinyl chloride is oxidized by the potassium permanganate. Like the GAC, the PPZ units are in a lead/lag configuration. Upon exhaustion of the PPZ of the lead unit, it would be taken out for disposal.

Part of the treated water will be diverted to a Backwash Supply Tank (5,000 Gallons). This tank would be equipped with level switches to divert flow into the tank when it is not full. When the tank is full, all treated water flows to the sanitary sewer. The Backwash Supply Tank is sized to provide sufficient water for one backwash cycle each of a Sand Filter and GAC Tank.

When a Sand Filter requires backwash, the Backwash Pump is activated and 40 gpm flows upward through the sand filter, suspending the sand, and carrying the solids out of the sand filter to the Waste Backwash Tank. After backwash is complete, the Backwash Pump is stopped, and the Sand Filter is ready to be used when the on line Sand Filter reaches capacity.

Similarly, when the GAC in a GAC Tank is replaced, fines are generated during transfer of the GAC, and these are removed by backwashing. When a GAC Tank requires backwash, the

Backwash Pump is activated and 40 gpm flows upward through the GAC tank, carrying the fines out of the tank to the Waste Backwash Tank.

Because the backwash flow rate is significantly larger in proportion to the groundwater extraction rate, the waste backwash water is directed to the Waste Backwash Tank (5,000 Gallons). The water in the Waste Backwash Tank is metered back to the Feed Tank by the Waste Backwash Transfer Pump over a 20-hour period at approximately 1 gpm.

Settled sludge (approximately 400 lb/day dry solids) in the Clarifier is periodically transferred to a 16-foot diameter Sludge Thickener Tank by a 15 gpm Clarified Underflow Pump. In the Thickener the solids content of the sludge is increased by gravity sedimentation from approximately 0.5 percent (by weight) to approximately 4 percent (by weight). Thickened sludge is periodically transferred from the bottom of the Thickener to a 160 $ft^3$ recessed plate type filter press by a 100 gpm Filter Press Feed Pump. In the Filter Press, the solids content of the thickened sludge is increased from approximately 4 percent by weight to 25- to 35 percent (by weight) to form a solid cake which would be stored in a roll-off container and later hauled away for appropriate disposal. Supernatant water from the Sludge Thickener-Decanting Tank and filtrate water from the Filter Press are collected in the 9,200-gallon Filtrate Tank and returned from there to the Feed Tank by a 25 gpm Filtrate Transfer Pump.

Some of the treated groundwater would be injected through approximately six injection wells located upgradient of the HCAs, as shown on Figure 4-5. Four wells would be screened in the shallow zone and two wells would be screened in the intermediate zone. The total injection rate would be approximately 13 gpm. Prior to injection, sodium lactate, an electron donor, would be added to promote bioremediation through reductive dechlorination. This will reduce concentrations of TCE, cis-1,2-DCE, and vinyl chloride, reduce the total loading of contaminants on the groundwater treatment system, and may shorten the overall time for remediation. The estimated feed rate of sodium lactate is 150 lb/day. The sodium lactate feed system is described below in Component 3. This portion of the alternative may be installed following the initial installation of the extraction wells and the groundwater treatment system, potentially in conjunction with the soil remedy.

Groundwater that is not re-injected would be discharged to the POTW or surface water, as described in Alternative G-2.

A compressed air system will be used to operate air-operated diaphragm pumps for Sludge Transfer, Filter Press Feed, and other air-operated equipment.

The DRA site is bordered by the taxiways and runways, the MDANG property, and Frog Mortar Creek which makes access for routine maintenance difficult, so the location of the treatment building is assumed to be off of the Martin State Airport property. The estimated size of the building is 155 feet by 65 feet, and an area of approximately 200 feet by 130 feet would be needed to accommodate construction, parking, and deliveries. The tentative location is assumed to be along Lynbrook Road at the Martin State Airport property line (see Figure 4-4). Figure 4-4 also shows an alternative location along the property line approximately 800 feet to the west. The properties would need to be purchased or leased. Other potential locations to be considered include the MSA/MDANG property along Lynbrook Road adjacent to the property line or on the MDANG property near the DRA Site. The Groundwater Treatment Plant Building will be designed to contain spills within the building. Spilled water will flow or be directed into the building sump and transferred by a Sump Pump to the Feed Tank.

Influent, effluent, and intermediate locations in the process will be sampled routinely to monitor the effectiveness and progress of the treatment. These results will also be used to determine if GAC needs to be replaced.

Component 3: Reinjection of Treated Groundwater

Some of the groundwater would be reinjected in the vicinity of the HCAs. The reinjection would enhance the flushing rate of contaminants from these areas, and an ED would be mixed with the injected groundwater to promote anaerobic reductive dechlorination of the cVOCs. There would be six injection wells in areas contaminated with cVOCs, as shown on Figure 4-5. There would be no reinjection of groundwater in areas contaminated only with 1,4-dioxane. Four wells would be screened in the shallow zone, and two wells would be screened in the intermediate zone. The total flow rate to shallow zone wells would be approximately 10 gpm, and the total flow rate to

the intermediate zone wells would be 3 gpm. The total injection rate would be approximately 13 gpm.

As noted, sodium lactate would be added to the injected groundwater at a rate of approximately 150 lb/day. Sodium lactate solution would be prepared in a 500 gallon tank and injected into the injection well piping at approximately 4 gallons per hour. The injection of groundwater and electron donor would be intermittent to allow for the ED to be flushed away from the wells to minimize clogging of the wells. When there is no reinjection, all treated groundwater would be discharged to the POTW. This portion of the alternative may be installed following the initial installation of the extraction wells and the groundwater treatment system, potentially in conjunction with the soil remedy.

Component 4: Discharge to POTW and Surface Water

This component is the same as Component 3 in Alternative G-2. Because the potential discharge rate of 100 gpm is greater than the 25,000 gpd threshold for a significant industrial user, reporting would be required twice per year and annual user fees are required in addition to sewage service charges. Per Alternative G-2, a surface water discharge permit would be obtained at a later date.

## PROCESS DESCRIPTION - ALTERNATIVE G-4

Component 1: Hydraulic Control

This component would consist of installing an array of groundwater extraction wells and piping as described for Component 1 in Alternative G-2. As in Alternative G-2, the system would operate for up to 50 years. The locations of the extraction wells are shown on Figure 4-8.

Component 2: Extraction of Groundwater from the HCAs

This component would consist of installing groundwater extraction wells downgradient from the HCAs and operating them for up to 50 years. Modeling results for this component are provided in Appendix B. Design calculations for this component are provided in Appendix D.

Seven extraction wells would be sufficient to extract contaminated groundwater from the HCAs. Three wells would be screened within the upper zone (approximately 35 feet deep), two wells would be screened within the intermediate zone (approximately 65 feet deep), and two would be screened within the lower zone (approximately 90 feet deep). Each well screen would be a minimum of 10 feet long. The groundwater extraction rate from the HCAs is estimated to be 28 gpm. Six wells extract groundwater contaminated with cVOCs, and 1,4-dioxane, and one well extracts groundwater contaminated only with 1,4-dioxane. The locations of the extraction wells are shown on Figure 4-8.

A submersible centrifugal pump equipped with level controls to turn the pump on and off would be installed in each groundwater extraction well. The discharge line from each pump would be provided with a flow meter, manual flow control valve, shut-off valve, and pressure gauges. Valves and instrumentation would be housed in a subsurface concrete vault at each wellhead with a hinged hatchway. Piping within the vault would be protected from freezing.

Each of these pumps would be connected to a piping network that would convey the extracted groundwater to the pump station. Because the concentrations of TCE and vinyl chloride in many of the wells are greater than the TCLP criteria, and because the contaminated groundwater will be conveyed through clean areas, the extracted groundwater will be conveyed through double walled pipes.

As with the hydraulic barrier extraction wells, the system would operate for up to 50 years.

Component 3: Ex-Situ Treatment of Groundwater

Because of the groundwater extracted from the HCAs, the total groundwater flow rate requiring treatment will be higher, and the process will be essentially as described in Alternative G-3. Based on the model, the total groundwater extraction rate is approximately 70 gpm, but because of uncertainties in the groundwater extraction rates, the treatment system conceptual design is sized for 100 gpm. This component would consist of installing an on-site treatment system and operating this system as long as groundwater is extracted. As shown on Figure 4-9, the extracted groundwater would enter the system at a feed tank, then flow through a metals removal system, filter unit, air stripper, advanced oxidation system, the liquid-phase GAC unit, IE unit; and exit the system. Sludge generated by the metals removal step would be thickened, dewatered, and disposed off-site. The treatment system is as described for Alternative G-3 and a PFD of the system is shown on Figure 4-9. Design calculations for this component are provided in Appendix C.

Component 4: Reinjection of Treated Groundwater

This component is the same as Component 3 in Alternative G-3.

Component 5: Discharge to POTW and Surface Water

This component is the same as Component 3 in Alternative G-2. Because the potential discharge rate of 100 gpm is greater than the 25,000 gpd threshold for a significant industrial user, reporting would be required twice per year and annual user fees are required in addition to sewage service charges.

## PROCESS DESCRIPTION - ALTERNATIVE G-5

Component 1: Hydraulic Control

This component would consist of installing an array of groundwater extraction wells and piping as described for Component 1 in Alternative G-2. As in Alternative G-2, the system would operate for up to 50 years. The locations of the extraction wells are shown on Figure 4-10.

Component 2: Ex-Situ Treatment of Groundwater

This component is the same as Component 2 in Alternative G-3. No reinjection is included in this alternative, so injection wells would not be required. An IE unit would be required for future discharge to surface water. Figure 4-11 shows a PFD of the process.

Component 3: In-Situ Bioremediation of HCAs

This component would consist of injecting an oil-based electron donor, such as EOS (EOS Remediation LLC), into the groundwater through dedicated injection wells in the HCAs to promote biological reductive dechlorination of the cVOCs. Design calculations for this component are provided in Appendix D. Modeling results for this component are provided in Appendix B.

EOS would be injected into the subsurface along lines (barriers) perpendicular to the groundwater flow direction (see Figure 4- 10). The spacing between the lines across the HCAs was based on the groundwater travel time in 5 years, the typical length of time that EOS remains effective. Thus, short plumes or plumes with relatively high velocity may be treated with a single barrier at the downgradient edge of the plume, and longer plumes or plumes with relatively slow velocity would require multiple barriers along the length of the plume. The spacing between the injection wells would be 10 feet. The estimated number of injection wells in each barrier and the quantity of EOS injected is summarized below. Because of the low alkalinity of the groundwater, a buffered EOS product is expected to be required. A pilot study would be performed to confirm well spacing and EOS application rate.

Under this alternative, EOS would be injected into the subsurface via permanent wells so that a subsequent injection can be made at a later date, if needed. A pump capable of a pumping rate of

5 to 10 gpm would be necessary to ensure the proper application of the EOS and to minimize application time. A subcontractor would provide the mixing and injection equipment, and the injections would be completed in a relatively short period of time.

| Plume Location (COC, Zone, and nearby well) | Number of Barriers | Number of Wells per Barrier | Total EOS Added, lb | Total Water Added, gallons |
|---|---|---|---|---|
| TCE Upper (DMW11) | 4 | 10 | 8,100 | 10,000 |
| TCE Intermediate (DMW9) | 1 | 70 | 46,000 | 55,000 |
| DCE Intermediate (DMW1) | 1 | 20 | 13,000 | 16,000 |
| Vinyl Chloride Upper (MW20) | 10 | 40 | 80,000 | 95,000 |

As a conservative cost assumption, a second injection of EOS would be applied to half of the injection wells after 5 years. Appendix C includes the cost information provided by EOS Remediation, Inc. Monitoring wells on both sides of each HCA would be used to monitor the progress and effectiveness of the EOS.

Component 4: Discharge to POTW and Surface Water

This component is the same as Component 4 in Alternative G-2.

# PRB SYSTEM AND VENDOR QUOTE

LOCKHEED MARTIN
MARTIN STATE AIRPORT
DRA FS
PRB
2/10/10

The PRB must also consider the groundwater and COC travel time. The longest distance to travel is from the DMW11 cluster (shallow depth only). For the main plume, the distance is from the edge of the taxiway for all depths.

From a figure, the distance from DMW11 to the PRB is about 1,000 feet.

From the edge of the taxiway to the PRB, the distance is approximately 650 feet.

This information was used for the attached spreadsheet that estimates the number of times maintenance must be performed (at 10 year intervals).

Because of the slow groundwater velocities and TCE velocity, a long period of time is required for treatment, particularly in the shallow zone.

LOCKHEED MARTIN
MARTIN STATE AIRPORT - DUMP ROAD AREA SITE
PRB - GENERAL CALCULATIONS
TREATMENT TIME
1/28/2010

Estimate groundwater travel distance for each groundwater zone for a 10 year period.
Base this on TCE velocity from model, (No pumping)

| TCE velocity | ft/d | ft/y | ft/10-yr |
|---|---|---|---|
| VTCE Shallow (U) | 0.006 | 2.19 | 22 |
| VTCE Intermediate (I) | 0.013 | 4.7 | 47 |
| VTCE Deep (L) | 0.05 | 18.25 | 183 |

| Groundwater velocity | | |
|---|---|---|
| ft/d | ft/y | ft/10-yr |
| 0.04 | 14.6 | 146 |
| 0.09 | 32.85 | 328.5 |
| 0.4 | 146 | 1,460 |

| | |
|---|---|
| Distance from cluster DMW-11 to PRB, feet | 1,000 |
| Distance from taxiway edge to PRB, feet | 650 |

Number of 10-year periods to cover distances:

| DMW-11 to PRB | TCE based | GW Vel based | Total time TCE based years |
|---|---|---|---|
| VTCE Shallow (U) | 46 | 7 | 457 |
| VTCE Intermediate (I) | 21 | 3 | 211 |
| VTCE Deep (L) | 5 | 0.7 | 55 |

| Taxiway to PRB | TCE based | GW Vel based | TCE based years |
|---|---|---|---|
| VTCE Shallow (U) | 30 | 4 | 297 |
| VTCE Intermediate (I) | 14 | 2 | 137 |
| VTCE Deep (L) | 4 | 0.4 | 36 |

| Run | Unit | groundwater velocity (ft/d) | 1,4d diox velocity (ft/d) | TCE retardation | TCE velocity (ft/d) |
|---|---|---|---|---|---|
| No pumping | Upper | 0.02 - 0.06 | 0.02 - 0.06 | 6.9 | 0.0029 - 0.0086 |
| | Intermediate | 0.06 - 0.12 | 0.06 - 0.12 | 6.9 | 0.0087 - 0.017 |
| | Lower | 0.3 - 0.5 | 0.3 - 0.5 | 6.9 | 0.043 - 0.072 |
| pumping | Upper | 0.05 - 0.08 | 0.05 - 0.08 | 6.9 | 0.0072 - 0.012 |
| | Intermediate | 0.25 | 0.25 | 6.9 | 0.036 |
| | Lower | 0.6 - 0.95 | 0.6 - 0.95 | 6.9 | 0.087 - 0.14 |

Table 1. Summary of Groundwater Flow and Solute Transport Model Parameter Values

Flow Model Parameter Values

| Unit | Layer | Unit | Kx (ft/day) | Ky (ft/day) | Kz (ft/day) | Sy | S |
|---|---|---|---|---|---|---|---|
| Upper | 1 | Upper | 4.5 | 4.5 | 0.45 | 0.25 | |
| | 2 | Upper | 4.5 | 4.5 | 0.45 | | |
| | 3 | Upper | 4.5 | 4.5 | 0.45 | | |
| | 4 | Upper | 9 | 9 | 0.9 | | |
| | 5 | Upper | 4.5 | 4.5 | 0.45 | | |
| | 6 | Upper | 4 | 4 | 0.4 | | |
| Intermed. | 7 | Intermed. | 5 | 5 | 0.5 | | 0.0001 |
| | 8 | Intermed. | 20 | 20 | 2 | | |
| | 9 | Intermed. | 20 | 20 | 2 | | |
| Lower | 10 | Lower | 1.4 | 1.4 | 0.14 | | 1.00E-05 |
| | 11 | Lower | 100 | 100 | 10 | | |
| Intermed aquitard | 12 | Intermed aquitard | 0.5 | 0.5 | 0.05 | | 0.0001 |
| | 13 | Intermed aquitard | 0.5 | 0.5 | 0.05 | | |
| | 14 | Intermed aquitard | 0.5 | 0.5 | 0.05 | | |
| Deep confined | 15 | Deep confined | 30 | 30 | 3 | | 0.0001 |

Note: The recharge rate for unpaved area is 0.00152 ft/day (6.7 in/yr) ; for the paved area is 1e-005 ft/day (0.044 in/yr).

Transport Model Parameter Values

| Bulk density ($lb/ft^3$) | Effective Porosity | Kd ($ft^3/lb$) | | | Dispersivity (ft) | | | R | | | Half Life (yr) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | TCE | DCE | VC | $D_L$ | $D_H$ | $D_V$ | TCE | DCE | VC | TCE | DCE | VC |
| 110 | 0.28 | 0.9 | 0.18 | 0.1 | 32.8 | 3.28 | 0.328 | 6.9 | 2.2 | 1.6 | 5.9 | 12 | 4.2 |

Notes: 1) DCE/TCE yield 0.738; DCE/VC yield 0.644
2) 1,4 dioxane assumed to undergo no degradation

enviro**metal** technologies inc.
*an Adventus company*

# Revised PRB Design

**To:** Joseph W. Logan, Tetra Tech NUS, Inc., joe.logan@tetratech.com

**From:** Andrzej Przepiora, Mike Duchene, EnviroMetal Technologies Inc.

**Date:** 27 January 2010

**Re:** **Revised Design for a Potential Application of a Granular Iron PRB at a Site in Baltimore, MD – 32276.88**

EnviroMetal Technologies Inc. (ETI) has prepared a revised cost estimate for using a granular iron permeable reactive barrier (PRB) for groundwater remediation at a site in Baltimore, MD, based on updated design parameters (Table 1) received from Tetra Tech NUS Inc. on 22 January 2010.

To date, granular iron PRBs have been installed at over 150 sites in the United States, Canada, Europe, Japan, and Australia. The earliest commercial applications in California and Belfast, Ireland have been in operation for the past 15 years. These installations have performed consistently with the expectation that they will continue to perform for another 5 to 10 years without any maintenance.

Using data from these sites, we have prepared a preliminary cost estimate for an *in-situ* PRB system at the site. Further detailed design information would be required in order to refine this cost estimate.

## PRB Technology Implementation

ETI's typical approach to applying our PRB technology involves an initial review of hydrogeologic data and site visit/meeting. Treatability testing with site groundwater may be undertaken to obtain design parameters for use in the field application, however for more common volatile organic compounds (VOCs), ETI's database of degradation rates can be used. ETI then acts as part of the design and implementation team to assist with the PRB installation. ETI assistance is provided on a professional time and expense basis for this work. For a description of ETI's involvement and cost, please refer to Attachment A and Table 2.

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**Cost Estimate for PRB Application**

Figure 1 shows the design of the proposed iron PRB, which includes distinct aquifer zones with varying groundwater velocities and VOC concentrations. The dimensions of each zone, along with the anticipated VOC concentrations, groundwater velocity are shown in Figure 1. The residence time (RT) for each zone was determined using ETI's database of half-lives and the site cleanup targets (Figure 1, Table 1). Using the RT and the groundwater flow velocity, the theoretical iron thickness (IT) was determined (the theoretical iron thickness are in parentheses in Figure 1). Granular iron is mixed with similar grain size native sand, as a bulking agent, where the construction thickness may be wider than the required iron amount. To ensure that the contaminants contact iron as they pass through the PRB and recognizing that there may be some segregation during mixing and placement, ETI's recommends that the iron/sand mixture contains minimum of 20 percent by volume. Therefore, we have assumed that the PRB will be installed in a 2.5 ft wide trench and backfilled with 20% iron/sand mix resulting in a 100% iron thickness equivalent of 0.5 ft. As seen on Figure 1, the equivalent iron thickness of 0.5 will apply to all sections of the PRB.

The total volume and cost of iron needed for the Upper Aquifer, Intermediate Aquifer and Lower Aquifer are shown in Table 1.

The simplest configuration that could be applied to this site is a continuous wall. An installation method that could be considered for construction of continuous PRB to a depth of 81 ft is biopolymer slurry trenching.

Biopolymer Trenching - Installation of a treatment zone of iron using biopolymer (biodegradable) slurry is similar to constructing a conventional impermeable slurry wall. The biopolymer slurry used is typically guar based. As the trench is excavated, the biopolymer slurry provides stability to the trench walls. Granular iron can then be placed into the trench through the slurry. After some time, the biopolymer slurry breaks down (i.e. become less viscous) allowing groundwater to flow through the iron treatment zone. The assumed cost of installing a continuous iron wall by this method is $\$30/ft^2$. A mobilization/ demobilization cost of about $100,000 was assumed.

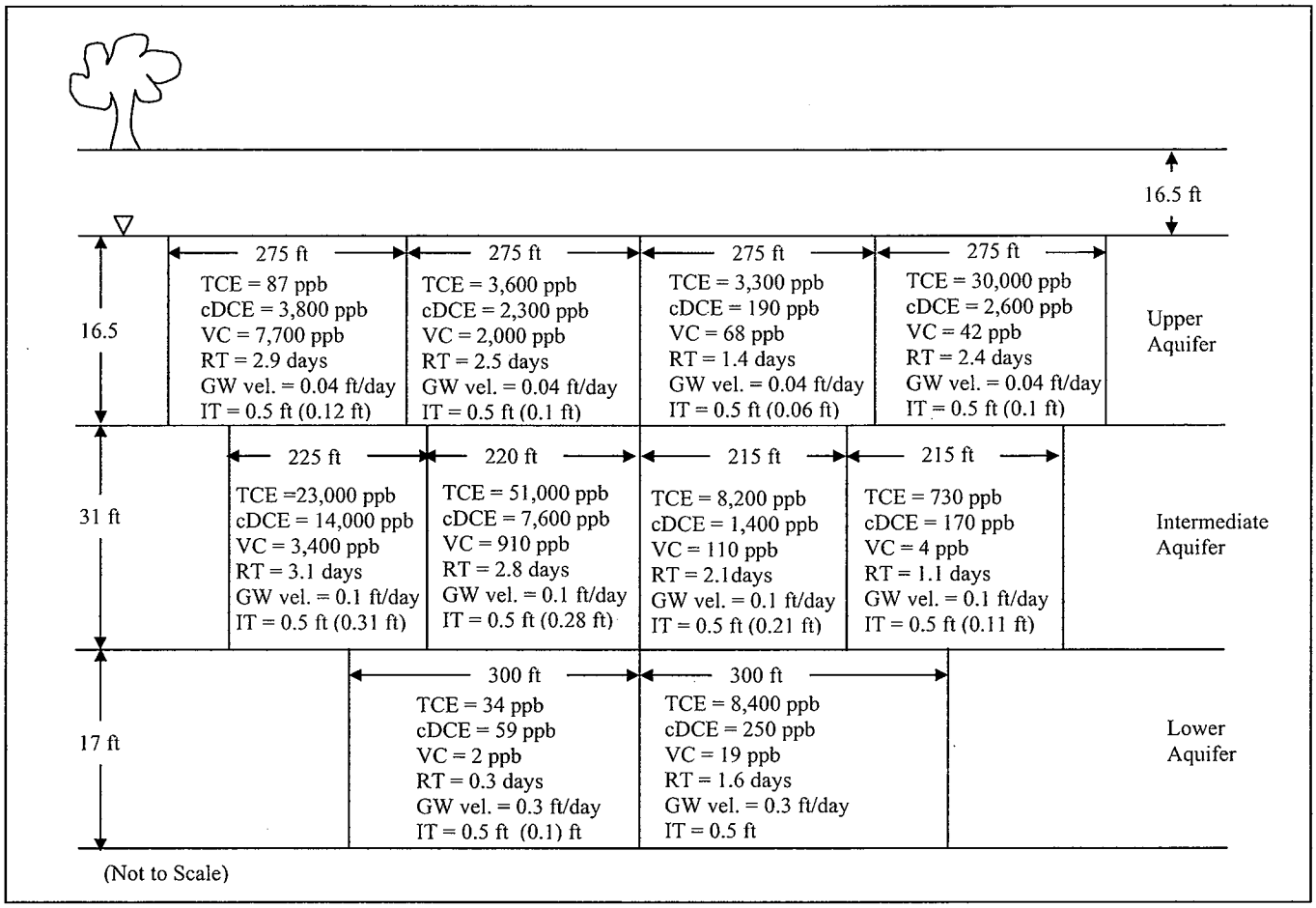


Figure 1: Conceptual design for the proposed PRB ( RT - residence time, IT - iron thickness).

Table 2 summarizes the installation costs discussed above. Refinement of these costs will require more detailed site information. The site license fee for use of the patented technology is typically 15% of capital cost (construction and delivered iron costs). The site lines fee would be at least 12% for project of this magnitude. Costs for activities such as site preparation, permitting, site construction management, soil disposal, etc., which are not included in the above estimate, should also be taken into account.

**Table 1: Summary of PRB Design Parameters**

| **Parameters** | **Conceptual Design Value** | | |
|---|---|---|---|
| **Organic Parameters** [a] | **Anticipated Influent Concentration** [a] **(µg/L)** | | **Regulatory Limit** [a] **(µg/L)** |
| TCE | 34 – 51,000 | | 10 |
| cDCE | 59 – 14,000 | | 1,100 |
| VC | 2 – 7,700 | | 4 |
| ***Residence time (days)*** | **0.3 – 3.1** | | |
| | Upper | Intermediate | Lower |
| **Groundwater Velocity (ft/day)** | 0.04 | 0.1 | 0.3 |
| **Dimensions** [a] | | | |
| PRB width (ft) | 1,100 | 875 | 600 |
| Depth to Plume Bottom (ft) | 33 | 64 | 81 |
| Saturated Plume Thickness (ft) | 16.5 | 31 | 17 |
| **Required Iron Amount and Cost (US$)** | | | |
| Practical Iron Flow-Through Thickness [b] (ft) | 0.5 [c] | 0.5 [c] | 0.5 [c] |
| Granular Iron Volume ($ft^3$) | 9,075 | 13,563 | 5,100 |
| Granular Iron Amount [d] (ton) | 681 | 1,017 | 383 |
| Delivered Granular Iron Cost [e] (US$750/ton) | $510,000 | $763,000 | $287,000 |

[a] Provided by Tetra Tech NUS Inc.
[b] Iron thickness is directly proportional to groundwater flow velocity
[c] Assumes a trench width of 2.5 ft and a 20% iron by volume with the balance mixed with sand
[d] Assuming a bulk density for the iron material of 0.075 ton/$ft^3$
[e] Based on current iron costs

**Table 2: PRB Cost Estimate for a Site in Baltimore, MD**

| **PRB Implementation** | **Estimated Cost (US$)** |
|---|---|
| ETI Assistance with Data Assessment, Field Design and Implementation [a] | $8,000 - $10,000 |
| Bench Scale Testing [b] | $20,000 |
| Estimated Contractors Installation Cost: | |
| Delivered Iron Material | $1,560,000 |
| Iron/Sand Mixing | $100,000 |
| Mobilization/Demobilization | $100,000 |
| Construction [c] (73,625 $ft^2$ @ $30/$ft^2$) | $2,210,000 |
| **Subtotal** | **$3,970,000** |
| ETI's License Fee (12% minimum) | $476,400 |
| **TOTAL** | **$4,446,400** |

Detailed cost estimates can be provided upon request.

[a] Based on professional time and expenses.
[b] Costs of sample collection and shipment are not included.
[c] Based on cost data from other sites. Would need to be refined based on a more complete review of site data and quotation from construction contractors. Does not include costs for activities such as site preparation/restoration, permitting, soil/water disposal, site construction management, etc.

# IN-SITU BIOREMEDIATION AND VENDOR QUOTE

LOCKHEED MARTIN
MARTIN STATE AIRPORT
DRA FS
In-Situ Bioremediation of HCAs
1/28/10

High concentration areas (HCAs) are treated by EOS in Alternative G-5. Because remediation does not need to be immediate, the HCAs will be treated using a barrier approach rather than a grid approach.

The barriers will be assumed to last 5 years.

There are 6 HCA that have TCE, cis-1,2-DCE and or vinyl chloride (VC). Of these, two HCAs overlap other HCAs, so only 4 areas need to be treated.

Groundwater velocities and retardation factors were the same as those used in the model.

The attached spreadsheet shows the TCE velocity for each groundwater zone. TCE was used because it is the slowest of the three COCs. The table shows the velocity and the distance covered in 5 years (as ft/5-yr).

For was area, the length and width was measured from the figures. Each length (distance parallel to the groundwater flow) was compared to the 5-year travel distance. If the length was longer than the 5-year travel distance, then the length was divided into segments, each of which is the length of the 5-year travel distance. Barriers were then drawn the width of each area spaced according to the 5-year travel distance.

MARYLAND SITE
IN-SITU BIOREMEDIATION - NUMBER OF BORINGS
1/22/2010

Estimate number of borings for each area.
Use flow-through approach, rather than grid.
Assume 5-year travel gap between injection lines, based on TCE velocity. (Conservative because velocity of DCE and VC will be faster.)

| TCE velocity | ft/d | ft/y | ft/5-yr |
|---|---|---|---|
| VTCE Shallow (U) | 0.01 | 3.65 | 18 |
| VTCE Intermediate (I) | 0.036 | 13.1 | 66 |
| VTCE Deep (L) | 0.1 | 36.5 | 183 |

Assume borings at 15' spacing.
Assume permanent injection wells with 10' screens for distribution.

| Area Name | Depth interval | Thickness of interval, feet | Length, feet | # of 5-year intervals | Number of rows | Width, feet | Number of boring locations | Number of wells | Depth of wells, Feet | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| TCE Upper | U | 10 | 100 | 5.5 | 4 | 100 | 27 | 27 | 20 | |
| TCE Intermediate | I | 20 | 150 | 2.3 | 1 | 350 | 23 | 47 | 30 and 40 | |
| DCE Upper West | U | 10 | 100 | 5.5 | NA | 150 | NA | NA | NA | captured by TCE U |
| DCE Upper East | U | 10 | 100 | 5.5 | NA | 150 | NA | NA | NA | captured by VC U |
| DCE Intermediate | I | 20 | 150 | 2.3 | 1 | 100 | 7 | 13 | 45 and 55 | |
| VC Upper | U | 10 | 200 | 11.0 | 10 | 400 | 267 | 267 | 20 | |

# of 5-Year intervals = Length/[(ft/5-yr) for that interval]
Number of rows is # of intervals less 1. Round down.
Number of boring locations is no. of rows x [(width)/15' (Spacing)]
Number of wells is number of borings times thickness/10'

**AquaBupH requirement**

Per vendor, typical range is 1.5 to 2 lb/cy of saturated soil
Estimate, use 1.75 lb/cy, then check with EOS tool spreadsheet.
Per vondor, quantity of AquaBupH is 1.25 x EOS.

| Area Name | Thickness of interval, feet | Length, feet | Width, feet | Vol, ft3 | Vol, cy | Estimated lb EOS | lb EOS (EOS Tool), per row | Number of rows | Total lb EOS (EOS Tool) | Total lb Aqua- bupH (at 1.25 EOS) |
|---|---|---|---|---|---|---|---|---|---|---|
| TCE Upper | 10 | 100 | 100 | 100,000 | 3,704 | 6,481 | 1,615 | 4 | 6,460 | 8,075 |
| TCE Intermediate | 20 | 150 | 350 | 1,050,000 | 38,889 | 68,056 | 36,945 | 1 | 36,945 | 46,181 |
| DCE Intermediate | 20 | 150 | 100 | 300,000 | 11,111 | 19,444 | 10,479 | 1 | 10,479 | 13,099 |
| VC Upper | 10 | 200 | 400 | 800,000 | 29,630 | 51,852 | 6,360 | 10 | 63,600 | 79,500 |
| **Total** | | | | | | 145,833 | | | 117,484 | **146,855** |

| | |
|---|---|
| Drums (at 420 lb/drum) | 350 |

| Run | Unit | groundwater velocity (ft/d) | 1,4d diox velocity (ft/d) | TCE retardation | TCE velocity (ft/d) |
|---|---|---|---|---|---|
| No pumping | Upper | 0.02 - 0.06 | 0.02 - 0.06 | 6.9 | 0.0029 - 0.0086 |
| | Intermediate | 0.06 - 0.12 | 0.06 - 0.12 | 6.9 | 0.0087 - 0.17 |
| | Lower | 0.3 - 0.5 | 0.3 - 0.5 | 6.9 | 0.043 - 0.072 |
| pumping | Upper | 0.05 - 0.08 | 0.05 - 0.08 | 6.9 | 0.0072 - 0.012 |
| | Intermediate | 0.25 | 0.25 | 6.9 | 0.036 |
| | Lower | 0.6 - 0.95 | 0.6 - 0.95 | 6.9 | 0.087 - 0.14 |

0 0.017

Table 1. Summary of Groundwater Flow and Solute Transport Model Parameter Values

Flow Model Parameter Values

| Unit | Layer | Unit | Kx (ft/day) | Ky (ft/day) | Kz (ft/day) | Sy | S |
|---|---|---|---|---|---|---|---|
| Upper | 1 | Upper | 4.5 | 4.5 | 0.45 | 0.25 | |
| | 2 | Upper | 4.5 | 4.5 | 0.45 | | |
| | 3 | Upper | 4.5 | 4.5 | 0.45 | | |
| | 4 | Upper | 9 | 9 | 0.9 | | |
| | 5 | Upper | 4.5 | 4.5 | 0.45 | | |
| | 6 | Upper | 4 | 4 | 0.4 | | |
| Intermed. | 7 | Intermed. | 5 | 5 | 0.5 | | 0.0001 |
| | 8 | Intermed. | 20 | 20 | 2 | | |
| | 9 | Intermed. | 20 | 20 | 2 | | |
| Lower | 10 | Lower | 1.4 | 1.4 | 0.14 | | 1.00E-05 |
| | 11 | Lower | 100 | 100 | 10 | | |
| Intermed aquitard | 12 | Intermed aquitard | 0.5 | 0.5 | 0.05 | | 0.0001 |
| | 13 | Intermed aquitard | 0.5 | 0.5 | 0.05 | | |
| | 14 | Intermed aquitard | 0.5 | 0.5 | 0.05 | | |
| Deep confined | 15 | Deep confined | 30 | 30 | 3 | | 0.0001 |

Note: The recharge rate for unpaved area is 0.00152 ft/day (6.7 in/yr) ; for the paved area is 1e-005 ft/day (0.044 in/yr).

Transport Model Parameter Values

| Bulk density ($lb/ft^3$) | Effective Porosity | Kd ($ft^3/lb$) | | | Dispersivity (ft) | | | R | | | Half Life (yr) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | TCE | DCE | VC | $D_L$ | $D_H$ | $D_V$ | TCE | DCE | VC | TCE | DCE | VC |
| 110 | 0.28 | 0.9 | 0.18 | 0.1 | 32.8 | 3.28 | 0.328 | 6.9 | 2.2 | 1.6 | 5.9 | 12 | 4.2 |

Notes: 1) DCE/TCE yield 0.738; DCE/VC yield 0.644
2) 1,4 dioxane assumed to undergo no degradation

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MW-34S
MW-34I
A
MW-33I
B
MW-16S
MW-16I
MW-16D
MW-17S
MW-17I
W'
MW-15S
MW-15I
MW-15D
MW-18S
MW-18I
VC-U
DCE U-E
NCU)
MW-04
TCE I
DMW-03S
DMW-03I
DMW-03D
D
W
MW-07
DMW-09I
DMW-09D
DMW-09S
X'
C
MW-26S
MW-20S
MW-20I
MW-20D
DMW-02S
DMW-10S
DMW-10I
DMW-08S
DMW-08I
DMW-08D
DMW-04S
DMW-04I
Y'
X
MW-25S
MW-25I
MW-21D
MW-22D
Y
DMW-11S
DMW-11I
U
TCE
DCE U-W
DCE I
DMW-05S
DMW-05I
DMW-05D
Z'
TAXIWAY TANGO
DMW-07S
DMW-07I
DMW-07D
DMW-06I
DMW-06D
DMW-06S
A'
V'
MW-23S
MW-23D
MW-19S
MW-19I
MW-19D
Z
TT-12
MW-01
MW-06
MW-24S
MW-24I
TT-13
AIRPORT RUNWAY
MW-32S
MW-32I
D'
V
MW-30D
C'
MW-31D
MW-29D
B'

*FROG MORTAR CREEK*

**Figure 4-4**
**Cross Section Plan View**

**Legend**

- Monitoring Wells
- Cross Sections
- Airfield Surface Line
- Facility Area

All location IDs begin with "MSA-".

***Lockheed Martin Martin State Airport***
***Middle River, Maryland***

0 50 100 200 Feet

N

DATE MODIFIED: 12/18/09

CREATED BY: JEE

Tetra Tech, Inc.

1/22/10

EOS Remediation, Inc.

# EOS® BARRIER DESIGN WORKSHEET

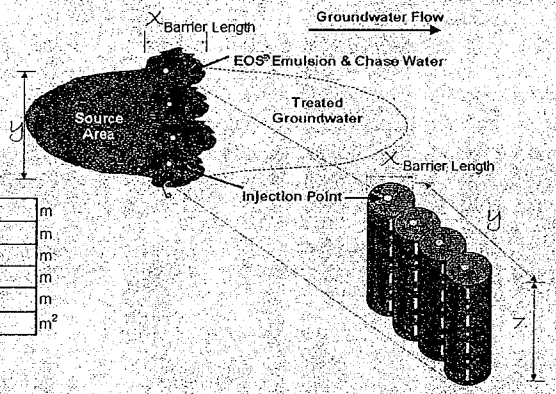
U.S. Version 2.1e, Rev. Date: February 6, 2008
www.EOSRemediation.com

Help

| | |
|---|---|
| Site Name: | Baltimore |
| Location: | TCE U - one line |
| Project No.: | |

## Step 1: Select a Substrate from the EOS® Family of Bioremediation Products

Substrate Selected (pick from drop down list) | EOS® 598B42 (Preferred for Chlorinateds)
For Product Literature Click Here




## Step 2: EOS® Consumption During Contaminant Biodegradation / Biotransformation

### Section A: Treatment Area Dimensions

| | | | | |
|---|---|---|---|---|
| Length of treatment area parallel to groundwater flow, "x" | 15 | ft | 4.6 | m |
| Width of treatment area perpendicular to groundwater flow, "y" | 100 | ft | 30.5 | m |
| Minimum depth to contamination | 5 | ft | 1.5 | m |
| Maximum depth of contamination | 15 | ft | 4.6 | m |
| Treatment thickness, "z" | 10 | ft | 3.0 | m |
| Treatment zone cross-sectional area, $A = y * z$ | 1,000 | $ft^2$ | 92.9 | $m^2$ |

### Section B: Groundwater Flow Rate / Site Data

Soil Characteristics

| | | | | |
|---|---|---|---|---|
| Nominal Soil Type (pick from drop down list) | Silty Sand | | | |
| Total Porosity (accept default or enter $n$) | 0.28 | (decimal) | | |
| Effective Porosity (accept default or enter $n_e$) | 0.17 | (decimal) | | |
| Soil bulk density, (1-n)*2.65 g/cc (accept calculated or enter dry bulk density) | 1.91 | g/cc | 119 | lbs / $ft^3$ |

Hydraulic Characteristics

| | | | | |
|---|---|---|---|---|
| Hydraulic Conductivity (accept default or enter $K$) | 4.5 | ft/day | 1.6E-03 | cm/sec |
| Hydraulic Gradient (accept default or enter $i$) | 0.0025 | ft/ft | | |

Note: Since the hydraulic gradient ($i = dh/dx$) is negative, we ask you to enter "-i" in the EOS® Design Tool so that you can enter a positive number for convenience.

| | | | | |
|---|---|---|---|---|
| Non-reactive Transport Velocity, $V_x = -(K \times i) / n_e$ | 0.07 | ft/day | 0.020 | m/day |
| Groundwater flow rate through treatment zone, $Q = -KiA$ | 84.15 | gallons/day | 318.56 | L/day |

### Section C: Calculated Contact Length

| | | | | |
|---|---|---|---|---|
| Contact time ($\tau$) between oil and contaminants (accept default or enter $\tau$) | | 60 | typical values 60 to 180 days, see comment | |
| Calculated Contact Length ($x$) = $\tau * V_x$ | Suggested Minimum | 5.0 | ft | 1.5 m |

| | | | | |
|---|---|---|---|---|
| Treatment zone volume | 15,000 | $ft^3$ | 424.8 | $m^2$ |
| Treatment zone groundwater volume (volume * effective porosity) | 19,074 | gallons | 72,208 | L |

### Section D: Design Lifespan For One Application

| | | | |
|---|---|---|---|
| | 7 | year(s) | typical values 5 to 10 years |
| Estimated total groundwater volume treated over design life | 234,077 | gallons | 886,140 L |

### Section E: Electron Acceptors

| Inputs | Typical Value | GW Conc. (mg/L) | MW (g/mole) | e⁻ equiv / mole | Stoichiometry *Contaminant/H₂ (wt/wt $H_2$)* | Hydrogen Demand ($g\ H_2$) |
|---|---|---|---|---|---|---|
| Dissolved Oxygen (DO) | 0 to 8 | 2 | 32.0 | 4 | 7.94 | 223.2935801 |
| Nitrate Nitrogen ($NO_3^-$ - N) | 1 to 10 | | 62.0 | 5 | 12.30 | |
| Sulfate ($SO_4^{2-}$) | 10 to 500 | 400 | 96.1 | 8 | 11.91 | 29753.50878 |
| Tetrachloroethene (PCE), $C_2Cl_4$ | | | 165.8 | 8 | 20.57 | |
| Trichloroethene (TCE), $C_2HCl_3$ | | 36 | 131.4 | 6 | 21.73 | 1468.300736 |
| cis-1,2-dichloroethene (c-DCE), $C_2H_2Cl_2$ | | 41 | 96.9 | 4 | 24.05 | 1510.927935 |
| Vinyl Chloride (VC), $C_2H_3Cl$ | | 4.1 | 62.5 | 2 | 31.00 | 117.1825138 |
| Carbon tetrachloride, $CCl_4$ | | | 153.8 | 8 | 19.08 | |
| Chloroform, $CHCl_3$ | | | 119.4 | 6 | 19.74 | |
| *sym*-tetrachloroethane, $C_2H_2Cl_4$ | | | 167.8 | 8 | 20.82 | |
| 1,1,1-Trichloroethane (TCA), $CH_3CCl_3$ | | | 133.4 | 6 | 22.06 | |
| 1,1-Dichloroethane (DCA), $CH_2CHCl_2$ | | | 99.0 | 4 | 24.55 | |
| loroethane, $C_2H_5Cl$ | | | 64.9 | 2 | 32.18 | |
| rchlorate, $ClO_4^-$ | | | 99.4 | 8 | 12.33 | |
| Hexavalent Chromium, Cr[VI] | | | 52.0 | 3 | 17.20 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| User added | | | | | | | | |
| User added | | | | | | | | |
| User added | | | | | | | | |

## Section F: Additional Hydrogen Demand and Carbon Losses

| Generation (Potential Amount Formed) | Typical Value | GW Conc. (mg/L) | MW (g/mole) | e⁻ equiv./ mole | Stoichiometry *Contaminant-/ $H_2$ (wt/wt $H_2$)* | Hydrogen Demand ($g\ H_2$) | DOC Released *(moles)* |
|---|---|---|---|---|---|---|---|
| Estimated Amount of $Fe^{2+}$ Formed | 10 to 100 | 50 | 55.8 | 1 | 55.41 | 799.6605126 | |
| Estimated Amount of Manganese ($Mn^{2+}$) Formed | | 5 | 54.9 | 2 | 27.25 | 162.5725047 | |
| Estimated Amount of $CH_4$ Formed | 5 to 20 | 10 | 16.0 | 8 | 1.99 | 4453.845768 | |
| Target Amount of DOC to Release | 60 to 100 | 100 | 12.0 | | | | 7377.74 |

**Design Safety Factor:** 2.0 typical values 1 to 3

**Calculations assume:**

1.) all reactions go to completion during passage through emulsified edible oil treated zone; and,

2.) perfect reaction stoichiometry.

### EOS® Requirement Calculations Based on Hydrogen Demand and Carbon Losses

| | | |
|---|---|---|
| Stoichiometric Hydrogen Demand | 169.6 | pounds |
| DOC Released | 842.4 | pounds |

**EOS® Requirement Based on Hydrogen Demand and Carbon Loss**

1,615 lbs

### Step 3: EOS® Requirement Based on Attachment by Aquifer Material

**Soil Characteristics**

Effective treatment thickness, "$z_e$" (typically less than 40%): 0.25

For Additional Information on Effective Thickness, Click Here

Weight of sediment to be treated: 446,672 lbs

Sorptive Capacity of Soil (accept default or enter site specific value): 0.0020 lbs EOS® / lbs sediment

**EOS® Attachment by Aquifer Material[1]**

- Fine sand with some clay 0.001 to 0.002 lbs EOS® / lbs soil
- Sand with higher silt/clay content 0.002 to 0.004 lbs EOS® / lbs soil

[1]Default values provided based on laboratory studies completed by NCSU

For Additional Data, Click Here

**EOS® Requirement Based on Oil Entrapment by Aquifer Material**

893 lbs

### Summary – How much EOS® do you need?

**Suggested Quantity of EOS® for Your Project:** 4 drums

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†Exclusive license agreement with Solutions-IES under U.S. Patent # 6,398,960, European Union Patent # EP 1 315 675 and several other pending international patents.
††EOS® is a registered trademark of EOS Remediation, Inc.

1/22/10

EOS Remediation, Inc.

# EOS® BARRIER DESIGN WORKSHEET

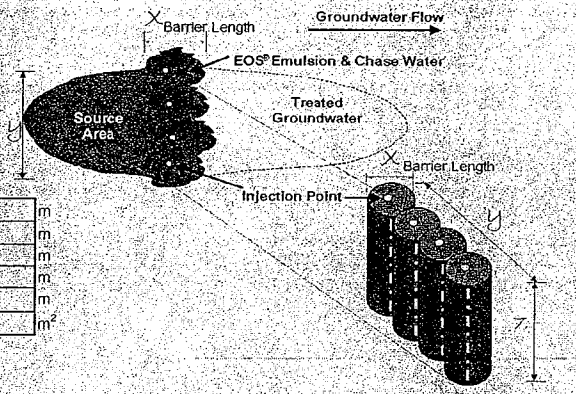
U.S. Version 2.1e, Rev. Date: February 6, 2008
www.EOSRemediation.com

Help

| | |
|---|---|
| Site Name: | Baltimore |
| Location: | TCE I - 1 line |
| Project No.: | |

## Step 1: Select a Substrate from the EOS® Family of Bioremediation Products

Substrate Selected (pick from drop down list): EOS® 598B42 (Preferred for Chlorinateds)
For Product Literature Click Here




## Step 2: EOS® Consumption During Contaminant Biodegradation / Biotransformation

### Section A: Treatment Area Dimensions

| | | | | |
|---|---|---|---|---|
| Length of treatment area parallel to groundwater flow, "x" | 15 | ft | 4.6 | m |
| Width of treatment area perpendicular to groundwater flow, "y" | 350 | ft | 106.7 | m |
| Minimum depth to contamination | 20 | ft | 6.1 | m |
| Maximum depth of contamination | 40 | ft | 12.2 | m |
| Treatment thickness, "z" | 20 | ft | 6.1 | m |
| Treatment zone cross-sectional area, A = y * z | 7,000 | ft² | 650.3 | m² |

### Section B: Groundwater Flow Rate / Site Data

Soil Characteristics

| | | | | |
|---|---|---|---|---|
| Nominal Soil Type (pick from drop down list) | Silty Sand | | | |
| Total Porosity (accept default or enter *n*) | 0.28 | (decimal) | | |
| Effective Porosity (accept default or enter $n_e$) | 0.17 | (decimal) | | |
| Soil bulk density: (1-n)*2.65 g/cc (accept calculated or enter dry bulk density) | 1.91 | g/cc | 119 | lbs / ft³ |

lic Characteristics

| | | | | |
|---|---|---|---|---|
| ulic Conductivity (accept default or enter *K*) | 20 | ft/day | 7.1E-03 | cm/sec |
| Hydraulic Gradient (accept default or enter *i*) | 0.002 | ft/ft | | |

Note: Since the hydraulic gradient ($i = dh/dx$) is negative, we ask you to enter -*i* in the EOS® Design Tool so that you can enter a positive number for convenience.

| | | | | |
|---|---|---|---|---|
| Non-reactive Transport Velocity, $V_x = -(K \times i)/n_e$ | 0.24 | ft/day | 0.072 | m/day |
| Groundwater flow rate through treatment zone, $Q = -KiA$ | 2094.40 | gallons/day | 7,928.72 | L/day |

### Section C: Calculated Contact Length

| | | | | |
|---|---|---|---|---|
| Contact time ($\tau$) between oil and contaminants (accept default or enter $\tau$) | 60 | typical values 60 to 180 days, see comment | | |
| Calculated Contact Length ($x$) = $\tau$ * $V_x$ | 14.1 | ft | 4.3 | m |

| | | | | |
|---|---|---|---|---|
| Treatment zone volume | 105,000 | ft³ | 2,973.3 | m³ |
| Treatment zone groundwater volume (volume * effective porosity) | 133,518 | gallons | 505,456 | L |

### Section D: Design Lifespan For One Application

| | | | | |
|---|---|---|---|---|
| Estimated total groundwater volume treated over design life | 7 | year(s) | typical values 5 to 10 years | |
| | 5,484,710 | gallons | 20,763,328 | L |

### Section E: Electron Acceptors

| Inputs | Typical Value | GW Conc. (mg/L) | MW (g/mole) | e⁻ equiv./ mole | Stoichiometry *Contaminant/H₂* (wt/wt $H_2$) | Hydrogen Demand ($g H_2$) |
|---|---|---|---|---|---|---|
| Dissolved Oxygen (DO) | 0 to 8 | 2 | 32.0 | 4 | 7.94 | 5232.035715 |
| Nitrate Nitrogen ($NO_3^-$ - N) | 1 to 10 | | 62.0 | 5 | 12.30 | |
| Sulfate ($SO_4^{2-}$) | 10 to 500 | 400 | 96.1 | 8 | 11.91 | 697160.3056 |
| Tetrachloroethene (PCE), $C_2Cl_4$ | | | 165.8 | 8 | 20.57 | |
| Trichloroethene (TCE), $C_2HCl_3$ | | 14.4 | 131.4 | 6 | 21.73 | 13761.61712 |
| cis-1,2-dichloroethene (c-DCE), $C_2H_2Cl_2$ | | 13.6 | 96.9 | 4 | 24.05 | 11743.38409 |
| Vinyl Chloride (VC), $C_2H_3Cl$ | | 3.4 | 62.5 | 2 | 31.00 | 2276.943917 |
| Carbon tetrachloride, $CCl_4$ | | | 153.8 | 8 | 19.08 | |
| Chloroform, $CHCl_3$ | | | 119.4 | 6 | 19.74 | |
| *sym*-tetrachloroethane, $C_2H_2Cl_4$ | | | 167.8 | 8 | 20.82 | |
| 1,1,1-Trichloroethane (TCA), $CH_3CCl_3$ | | | 133.4 | 6 | 22.06 | |
| 1,1-Dichloroethane (DCA), $CH_2CHCl_2$ | | | 99.0 | 4 | 24.55 | |
| ethane, $C_2H_5Cl$ | | | 64.9 | 2 | 32.18 | |
| orate, $ClO_4^-$ | | | 99.4 | 8 | 12.33 | |
| Hexavalent Chromium, Cr[VI] | | | 52.0 | 3 | 17.20 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| User added | | | | | | | | |
| dded | | | | | | | | |
| dded | | | | | | | | |

## Section F: Additional Hydrogen Demand and Carbon Losses

| Generation (Potential Amount Formed) | Typical Value | GW Conc. (mg/L) | MW (g/mole) | e- equiv./ mole | Stoichiometry *Contaminant / $H_2$* (wt/wt $H_2$) | Hydrogen Demand (g $H_2$) | DOC Released (moles) |
|---|---|---|---|---|---|---|---|
| Estimated Amount of $Fe^{2+}$ Formed | 10 to 100 | 50 | 55.8 | 1 | 55.41 | 18737.00246 | |
| Estimated Amount of Manganese ($Mn^{2+}$) Formed | | 5 | 54.9 | 2 | 27.25 | 3809.268276 | |
| Estimated Amount of $CH_4$ Formed | 5 to 20 | 10 | 16.0 | 8 | 1.99 | 104358.9346 | |
| Target Amount of DOC to Release | 60 to 100 | 100 | 12.0 | | | | 172869.27 |

**Design Safety Factor:** 2.0 typical values 1 to 3

**Calculations assume:**

1.) all reactions go to completion during passage through emulsified edible oil treated zone; and,

2.) perfect reaction stoichiometry.

### EOS® Requirement Calculations Based on Hydrogen Demand and Carbon Losses

| | | |
|---|---|---|
| Stoichiometric Hydrogen Demand | 3,775.7 | pounds |
| DOC Released | 19,738.9 | pounds |

**EOS® Requirement Based on Hydrogen Demand and Carbon Loss**

36,945 lbs

### Step 3: EOS® Requirement Based on Attachment by Aquifer Material

**Soil Characteristics**

Effective treatment thickness, "$z_e$" (typically less than 40%): 0.25

For Additional Information on Effective Thickness, Click Here

Weight of sediment to be treated: 3,126,704 lbs

ive Capacity of Soil (accept default or enter site specific value): 0.0020 lbs EOS® / lbs sediment

**EOS® Attachment by Aquifer Material[1]**

- Fine sand with some clay 0.001 to 0.002 lbs EOS® / lbs soil
- Sand with higher silt/clay content 0.002 to 0.004 lbs EOS® / lbs soil

[1]Default values provided based on laboratory studies completed by NCSU

For Additional Data, Click Here

**EOS® Requirement Based on Oil Entrapment by Aquifer Material**

6,253 lbs

### Summary – How much EOS® do you need?

**Suggested Quantity of EOS® for Your Project:** 88 drums

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†Exclusive license agreement with Solutions-IES under U.S. Patent # 6,398,960, European Union Patent # EP 1 315 675 and several other pending international patents.

††EOS® is a registered trademark of EOS Remediation, Inc.

1/22/10

EOS Remediation, Inc.

# EOS® BARRIER DESIGN WORKSHEET

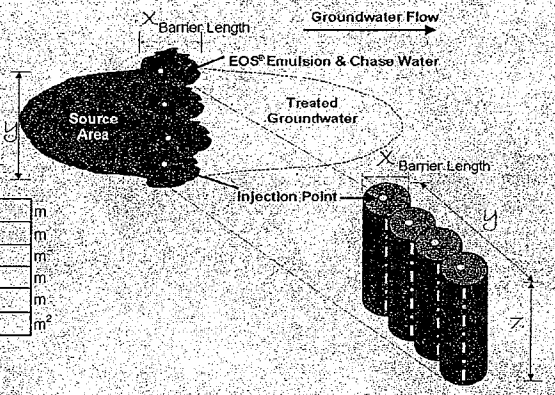
U.S. Version 2.1e, Rev. Date: February 6, 2008
www.EOSRemediation.com

Help

| | |
|---|---|
| Site Name: | Maryland |
| Location: | DCE intermediate - 1 line |
| Project No.: | |

## Step 1: Select a Substrate from the EOS® Family of Bioremediation Products

Substrate Selected (pick from drop down list) | EOS® 598B42 (Preferred for Chlorinateds)
For Product Literature Click Here




## Step 2: EOS® Consumption During Contaminant Biodegradation / Biotransformation

### Section A: Treatment Area Dimensions

| | | | | |
|---|---|---|---|---|
| Length of treatment area parallel to groundwater flow, "x" | 15 | ft | 4.6 | m |
| Width of treatment area perpendicular to groundwater flow, "y" | 100 | ft | 30.5 | m |
| Minimum depth to contamination | 35 | ft | 10.7 | m |
| Maximum depth of contamination | 55 | ft | 16.8 | m |
| Treatment thickness, "z" | 20 | ft | 6.1 | m |
| Treatment zone cross-sectional area, A = y * z | 2,000 | $ft^2$ | 185.8 | $m^2$ |

### Section B: Groundwater Flow Rate / Site Data

Soil Characteristics

| | | | | |
|---|---|---|---|---|
| Nominal Soil Type (pick from drop down list) | Silty Sand | | | |
| Total Porosity (accept default or enter $n$) | 0.28 | (decimal) | | |
| Effective Porosity (accept default or enter $n_e$) | 0.17 | (decimal) | | |
| Soil bulk density, (1-n)*2.65 g/cc (accept calculated or enter dry bulk density) | 1.91 | g/cc | 119 | lbs / $ft^3$ |

Hydraulic Characteristics

| | | | | |
|---|---|---|---|---|
| Hydraulic Conductivity (accept default or enter $K$) | 20 | ft/day | 7.1E-03 | cm/sec |
| Hydraulic Gradient (accept default or enter $i$) | 0.002 | ft/ft | | |

Note: Since the hydraulic gradient ($i = -dh/dx$) is negative, we ask you to enter $i$ in the EOS® Design Tool so that you can enter a positive number for convenience.

| | | | | |
|---|---|---|---|---|
| Non-reactive Transport Velocity, $V_x = -(K \times i)/n_e$ | 0.24 | ft/day | 0.072 | m/day |
| Groundwater flow rate through treatment zone, $Q = -KiA$ | 598.40 | gallons/day | 2,265.35 | L/day |

### Section C: Calculated Contact Length

| | | | | |
|---|---|---|---|---|
| Contact time ($\tau$) between oil and contaminants (accept default or enter $\tau$) | 60 | typical values 60 to 180 days, see comment | | |
| Calculated Contact Length ($x$) = $\tau * V_x$ | 14.1 | ft | 4.3 | m |

| | | | | |
|---|---|---|---|---|
| Treatment zone volume | 30,000 | $ft^3$ | 849.5 | $m^3$ |
| Treatment zone groundwater volume (volume * effective porosity) | 38,148 | gallons | 144,416 | L |

### Section D: Design Lifespan For One Application

| | | | | |
|---|---|---|---|---|
| | 7 | year(s) | typical values 5 to 10 years | |
| Estimated total groundwater volume treated over design life | 1,567,060 | gallons | 5,932,379 | L |

### Section E: Electron Acceptors

| Inputs | Typical Value | GW Conc (mg/L) | MW (g/mole) | e⁻ equiv./ mole | Stoichiometry *Contaminant/H₂* (wt/wt $H_2$) | Hydrogen Demand (g $H_2$) |
|---|---|---|---|---|---|---|
| Dissolved Oxygen (DO) | 0 to 8 | 2 | 32.0 | 4 | 7.94 | 1494.867347 |
| Nitrate Nitrogen ($NO_3$ - N) | 1 to 10 | | 62.0 | 5 | 12.30 | |
| Sulfate ($SO_4^{2-}$) | 10 to 500 | 400 | 96.1 | 8 | 11.91 | 199188.6587 |
| Tetrachloroethene (PCE), $C_2Cl_4$ | | | 165.8 | 8 | 20.57 | |
| Trichloroethene (TCE), $C_2HCl_3$ | | 7.7 | 131.4 | 6 | 21.73 | 2102.469282 |
| cis-1,2-dichloroethene (c-DCE), $C_2H_2Cl_2$ | | 6.8 | 96.9 | 4 | 24.05 | 1677.626298 |
| Vinyl Chloride (VC), $C_2H_3Cl$ | | 1.7 | 62.5 | 2 | 31.00 | 325.2777024 |
| Carbon tetrachloride, $CCl_4$ | | | 153.8 | 8 | 19.08 | |
| Chloroform, $CHCl_3$ | | | 119.4 | 6 | 19.74 | |
| *sym*-tetrachloroethane, $C_2H_2Cl_4$ | | | 167.8 | 8 | 20.82 | |
| 1,1,1-Trichloroethane (TCA), $CH_3CCl_3$ | | | 133.4 | 6 | 22.06 | |
| 1,1-Dichloroethane (DCA), $CH_3CHCl_2$ | | | 99.0 | 4 | 24.55 | |
| hloroethane, $C_2H_5Cl$ | | | 64.9 | 2 | 32.18 | |
| rchlorate, $ClO_4$ | | | 99.4 | 8 | 12.33 | |
| Hexavalent Chromium, Cr[VI] | | | 52.0 | 3 | 17.20 | |

| | | | | |
|---|---|---|---|---|
| User added | | | | |
| er added | | | | |
| er added | | | | |

## Section F: Additional Hydrogen Demand and Carbon Losses

| Generation (Potential Amount Formed) | Typical Value | GW Conc (mg/L) | MW (g/mole) | e equiv./ mole | Stoichiometry *Contaminant / $H_2$ (wt/wt $H_2$)* | Hydrogen Demand *(g $H_2$)* | DOC Released *(moles)* |
|---|---|---|---|---|---|---|---|
| Estimated Amount of $Fe^{2+}$ Formed | 10 to 100 | 50 | 55.8 | 1 | 55.41 | 5353.429276 | |
| Estimated Amount of Manganese ($Mn^{2+}$) Formed | | 5 | 54.9 | 2 | 27.25 | 1088.362364 | |
| Estimated Amount of $CH_4$ Formed | 5 to 20 | 10 | 16.0 | 8 | 1.99 | 29816.83846 | |
| Target Amount of DOC to Release | 60 to 100 | 100 | 12.0 | | | | 49391.22 |

**Design Safety Factor:** 2.0 typical values 1 to 3

**Calculations assume:**

1.) all reactions go to completion during passage through emulsified edible oil treated zone; and,

2.) perfect reaction stoichiometry

### EOS® Requirement Calculations Based on Hydrogen Demand and Carbon Losses

| | | |
|---|---|---|
| Stoichiometric Hydrogen Demand | 1,061.9 | pounds |
| DOC Released | 5,639.7 | pounds |

**EOS® Requirement Based on Hydrogen Demand and Carbon Loss**

10,479 lbs

### Step 3: EOS® Requirement Based on Attachment by Aquifer Material

**Soil Characteristics**

Effective treatment thickness, "$z_e$" (typically less than 40%): 0.25

For Additional Information on Effective Thickness, Click Here

Weight of sediment to be treated: 893,344 lbs

Sorptive Capacity of Soil (accept default or enter site specific value): 0.0020 lbs EOS® / lbs sediment

**EOS® Attachment by Aquifer Material†**

- Fine sand with some clay 0.001 to 0.002 lbs EOS® / lbs soil
- Sand with higher silt/clay content 0.002 to 0.004 lbs EOS® / lbs soil

†Default values provided based on laboratory studies completed by NCSU

For Additional Data, Click Here

**EOS® Requirement Based on Oil Entrapment by Aquifer Material**

1,787 lbs

### Summary – How much EOS® do you need?

**Suggested Quantity of EOS® for Your Project:** 25 drums

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†Exclusive license agreement with Solutions-IES under U.S. Patent # 6,398,960, European Union Patent # EP 1 315 675 and several other pending international patents.
††EOS® is a registered trademark of EOS Remediation, Inc.

1/22/10

EOS Remediation, Inc.

# EOS® BARRIER DESIGN WORKSHEET

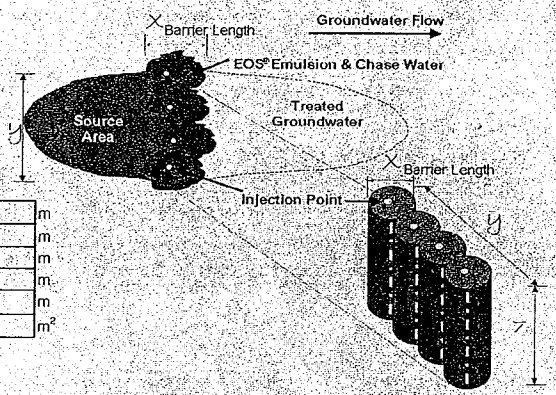
U.S. Version 2.1e, Rev. Date: February 6, 2008
www.EOSRemediation.com

Help

| | |
|---|---|
| Site Name: | Maryland |
| Location: | VC Upper 1 line |
| Project No.: | |

## Step 1: Select a Substrate from the EOS® Family of Bioremediation Products

Substrate Selected (pick from drop down list) | EOS® 598B42 (Preferred for Chlorinateds)
For Product Literature Click Here




## Step 2: EOS® Consumption During Contaminant Biodegradation / Biotransformation

### Section A: Treatment Area Dimensions

| | | | | |
|---|---|---|---|---|
| Length of treatment area parallel to groundwater flow, "x" | 15 | ft | 4.6 | m |
| Width of treatment area perpendicular to groundwater flow, "y" | 400 | ft | 121.9 | m |
| Minimum depth to contamination | 10 | ft | 3.0 | m |
| Maximum depth of contamination | 20 | ft | 6.1 | m |
| Treatment thickness, "z" | 10 | ft | 3.0 | m |
| Treatment zone cross-sectional area, A = y * z | 4,000 | ft² | 371.6 | m² |

### Section B: Groundwater Flow Rate / Site Data

Soil Characteristics

| | | | | |
|---|---|---|---|---|
| Nominal Soil Type (pick from drop down list) | Silty Sand | | | |
| Total Porosity (accept default or enter $n$) | 0.28 | (decimal) | | |
| Effective Porosity (accept default or enter $n_e$) | 0.17 | (decimal) | | |
| Soil bulk density, (1-n)*2.65 g/cc (accept calculated or enter dry bulk density) | 1.91 | g/cc | 119 | lbs / ft³ |

Hydraulic Characteristics

| | | | | |
|---|---|---|---|---|
| Hydraulic Conductivity (accept default or enter $K$) | 4.5 | ft/day | 1.6E-03 | cm/sec |
| Hydraulic Gradient (accept default or enter $i$) | 0.0025 | ft/ft | | |

Note: Since the hydraulic gradient ($i = dh/dx$) is negative, we ask you to enter -$i$ in the EOS® Design Tool so that you can enter a positive number for convenience.

| | | | | |
|---|---|---|---|---|
| Non-reactive Transport Velocity, $V_x = -(K \times i) / n_e$ | 0.07 | ft/day | 0.020 | m/day |
| Groundwater flow rate through treatment zone, $Q = -KiA$ | 336.60 | gallons/day | 1,274.26 | L/day |

### Section C: Calculated Contact Length

| | | | | |
|---|---|---|---|---|
| Contact time ($\tau$) between oil and contaminants (accept default or enter $\tau$) | | 60 | typical values 60 to 180 days, see comment | |
| Calculated Contact Length ($x$) = $\tau$ * $V_x$ | Suggested Minimum | 5.0 | ft | 1.5 m |

| | | | | |
|---|---|---|---|---|
| Treatment zone volume | 60,000 | ft³ | 1,699.0 | m² |
| Treatment zone groundwater volume (volume * effective porosity) | 76,296 | gallons | 288,832 | L |

### Section D: Design Lifespan For One Application

| | | | |
|---|---|---|---|
| | 7 | year(s) | typical values 5 to 10 years |
| Estimated total groundwater volume treated over design life | 936,309 | gallons | 3,544,561 L |

### Section E: Electron Acceptors

| Inputs | Typical Value | GW Conc. (mg/L) | MW (g/mole)* | e⁻ equiv./ mole | Stoichiometry *Contaminant/H₂* (wt/wt $H_2$) | Hydrogen Demand (g $H_2$) |
|---|---|---|---|---|---|---|
| Dissolved Oxygen (DO) | 0 to 8 | 2 | 32.0 | 4 | 7.94 | 893.1743206 |
| Nitrate Nitrogen ($NO_3^-$ - N) | 1 to 10 | | 62.0 | 5 | 12.30 | |
| Sulfate ($SO_4^{2-}$) | 10 to 500 | 400 | 96.1 | 8 | 11.91 | 119014.0351 |
| Tetrachloroethene (PCE), $C_2Cl_4$ | | | 165.8 | 8 | 20.57 | |
| Trichloroethene (TCE), $C_2HCl_3$ | | 0.2 | 131.4 | 6 | 21.73 | 32.62890524 |
| cis-1,2-dichloroethene (c-DCE), $C_2H_2Cl_2$ | | 6.6 | 96.9 | 4 | 24.05 | 972.8901826 |
| Vinyl Chloride (VC), $C_2H_3Cl$ | | 56 | 62.5 | 2 | 31.00 | 6402.16661 |
| Carbon tetrachloride, $CCl_4$ | | | 153.8 | 8 | 19.08 | |
| Chloroform, $CHCl_3$ | | | 119.4 | 6 | 19.74 | |
| sym-tetrachloroethane, $C_2H_2Cl_4$ | | | 167.8 | 8 | 20.82 | |
| 1,1,1-Trichloroethane (TCA), $CH_3CCl_3$ | | | 133.4 | 6 | 22.06 | |
| 1,1-Dichloroethane (DCA), $CH_2CHCl_2$ | | | 99.0 | 4 | 24.55 | |
| Chloroethane, $C_2H_5Cl$ | | | 64.9 | 2 | 32.18 | |
| Perchlorate, $ClO_4^-$ | | | 99.4 | 8 | 12.33 | |
| Hexavalent Chromium, Cr[VI] | | | 52.0 | 3 | 17.20 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| User added | | | | | | | | |
| n added | | | | | | | | |
| added | | | | | | | | |

## Section F: Additional Hydrogen Demand and Carbon Losses

| Generation (Potential Amount Formed) | Typical Value | GW Conc. (mg/L) | MW (g/mole) | e⁻ equiv./ mole | Stoichiometry *Contaminant / $H_2$ (wt/wt $H_2$)* | Hydrogen Demand *(g $H_2$)* | DOC Released *(moles)* |
|---|---|---|---|---|---|---|---|
| Estimated Amount of $Fe^{2+}$ Formed | 10 to 100 | 50 | 55.8 | 1 | 55.41 | 3198.642051 | |
| Estimated Amount of Manganese ($Mn^{2+}$) Formed | | 5 | 54.9 | 2 | 27.25 | 650.290019 | |
| Estimated Amount of $CH_4$ Formed | 5 to 20 | 10 | 16.0 | 8 | 1.99 | 17815.38307 | |
| Target Amount of DOC to Release | 60 to 100 | 100 | 12.0 | | | | 29510.96 |

**Design Safety Factor:** 2.0 typical values 1 to 3

**Calculations assume:**

1.) all reactions go to completion during passage through emulsified edible oil treated zone; and,

2.) perfect reaction stoichiometry

### EOS® Requirement Calculations Based on Hydrogen Demand and Carbon Losses

| | | |
|---|---|---|
| Stoichiometric Hydrogen Demand | 656.3 | pounds |
| DOC Released | 3,369.7 | pounds |

**EOS® Requirement Based on Hydrogen Demand and Carbon Loss**

6,360 lbs

## Step 3: EOS® Requirement Based on Attachment by Aquifer Material

### Soil Characteristics

Effective treatment thickness, "$Z_e$" (typically less than 40%): 0.25

For Additional Information on Effective Thickness, Click Here

Weight of sediment to be treated: 1,786,688 lbs

orptive Capacity of Soil (accept default or enter site specific value): 0.0020 lbs EOS® / lbs sediment

**EOS® Attachment by Aquifer Material[1]**

- Fine sand with some clay 0.001 to 0.002 lbs EOS® / lbs soil
- Sand with higher silt/clay content 0.002 to 0.004 lbs EOS® / lbs soil

[1]Default values provided based on laboratory studies completed by NCSU

For Additional Data, Click Here

**EOS® Requirement Based on Oil Entrapment by Aquifer Material**

3,573 lbs

## Summary – How much EOS® do you need?

**Suggested Quantity of EOS® for Your Project:** 16 drums

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†Exclusive license agreement with Solutions-IES under U.S. Patent # 6,398,960, European Union Patent # EP 1 315 675 and several other pending international patents.
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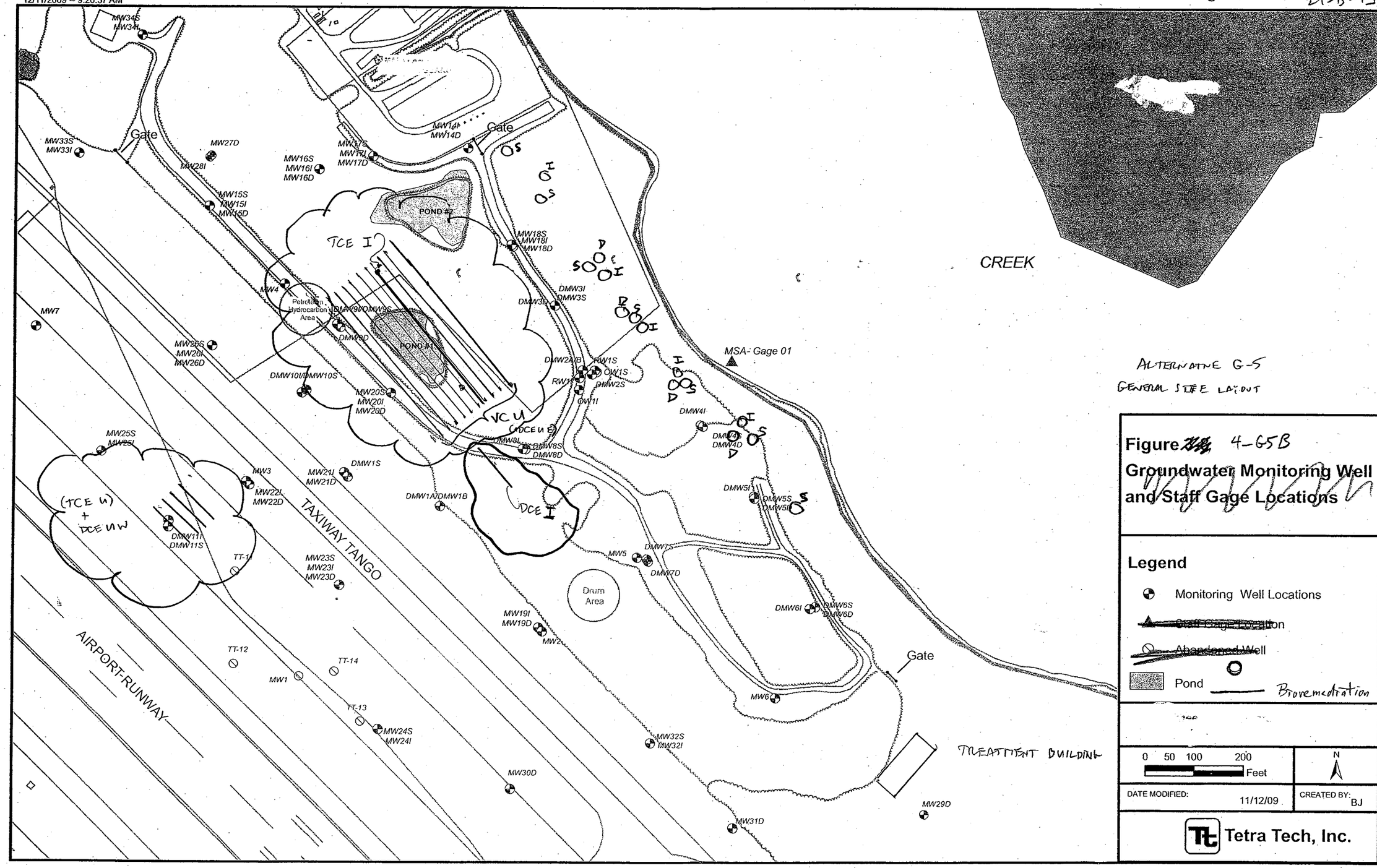
Map Document: (K:\GProject\...ad Fig 3-8_12 10 2009.mxd)
12/11/2009 -- 9:20:57 AM

Hydraulic Control Wells
- ISB Barrier lines.

G-5 [ISB-1]




SENT TO EOS

ALTERNATIVE G-5
GENERAL SITE LAYOUT

**Figure 4-G5B**
**Groundwater Monitoring Well and Staff Gage Locations**

**Legend**

- Monitoring Well Locations
- ~~Staff Gage Location~~
- ~~Abandoned Well~~
- Pond
- Bioremediation injection well lines

0 50 100 200 Feet

N

DATE MODIFIED: 11/12/09

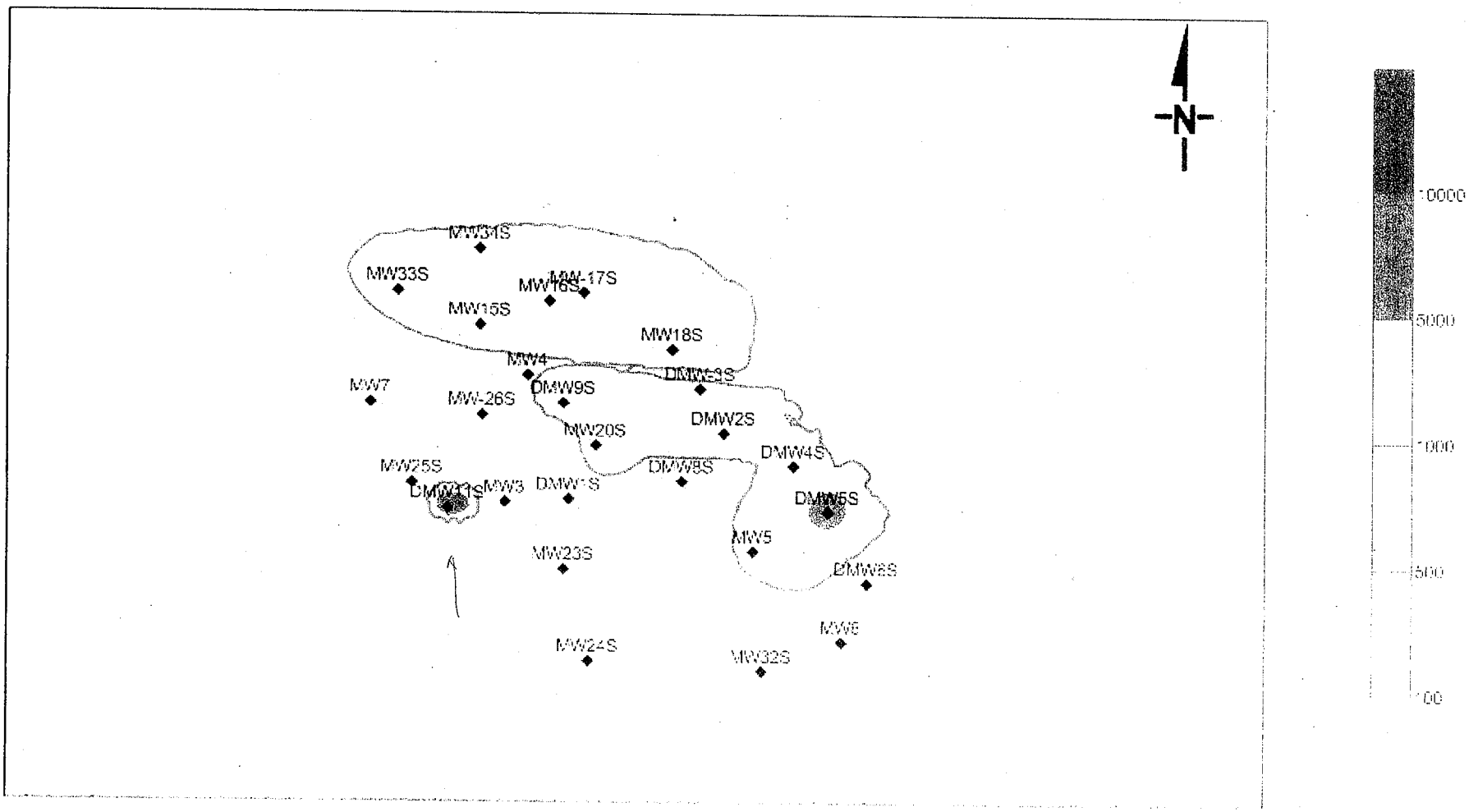
CREATED BY: BJ

Tetra Tech, Inc.

HIGH CONCENTRATION AREAS

JJB

# TCE - Upper Surficial Aquifer




L
W

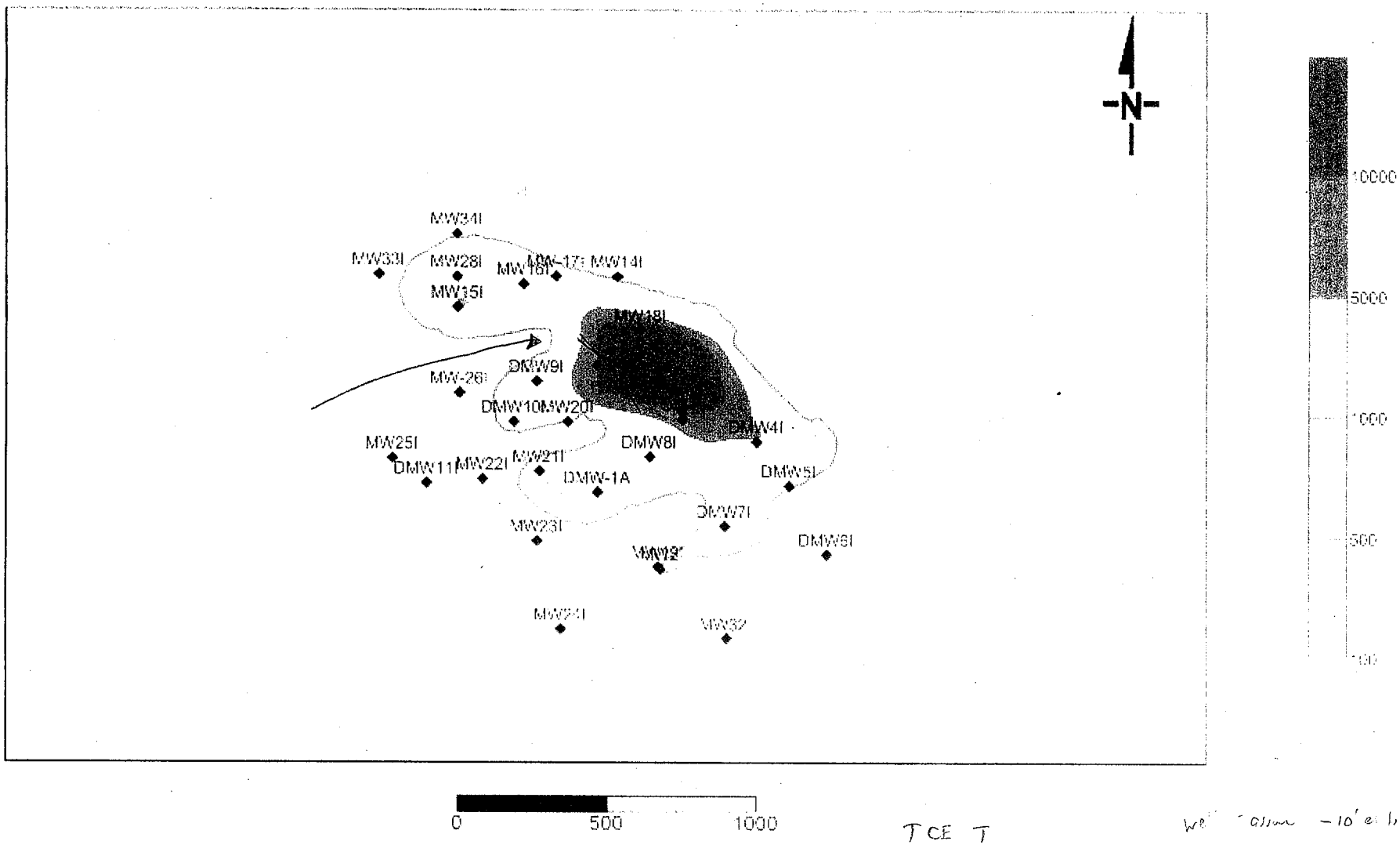
0 500 1000

TCE U
L 100'
W 100'

Based on MW 25
Water [illegible] el 0 to el = 10
TD ~ 20

(4)

# TCE - Intermediate Surficial Aquifer




TCE I

L 150'

W 350'

well assume -10' et b -30'

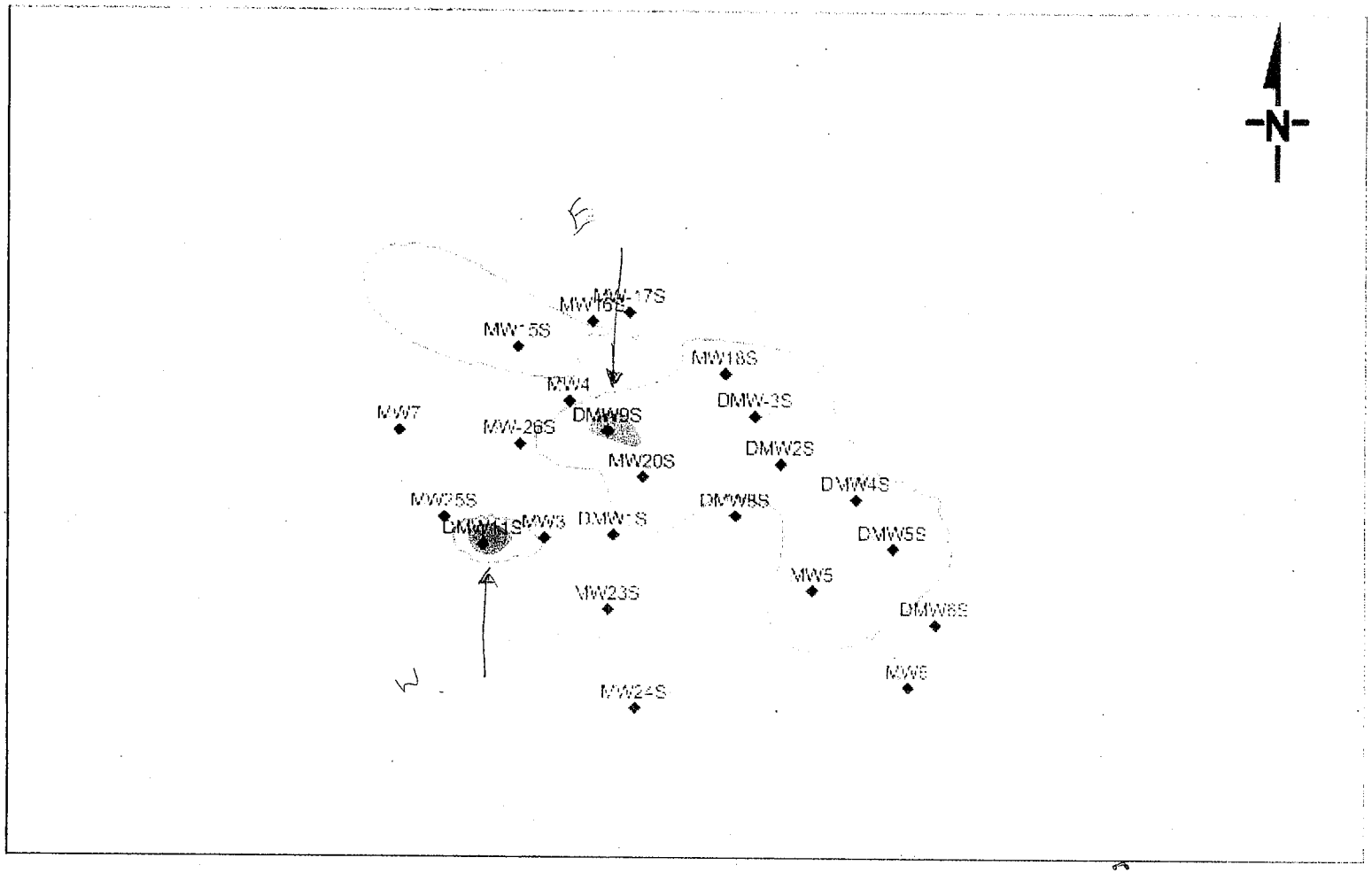
TD

~~8~~ 40'

From File

(1)

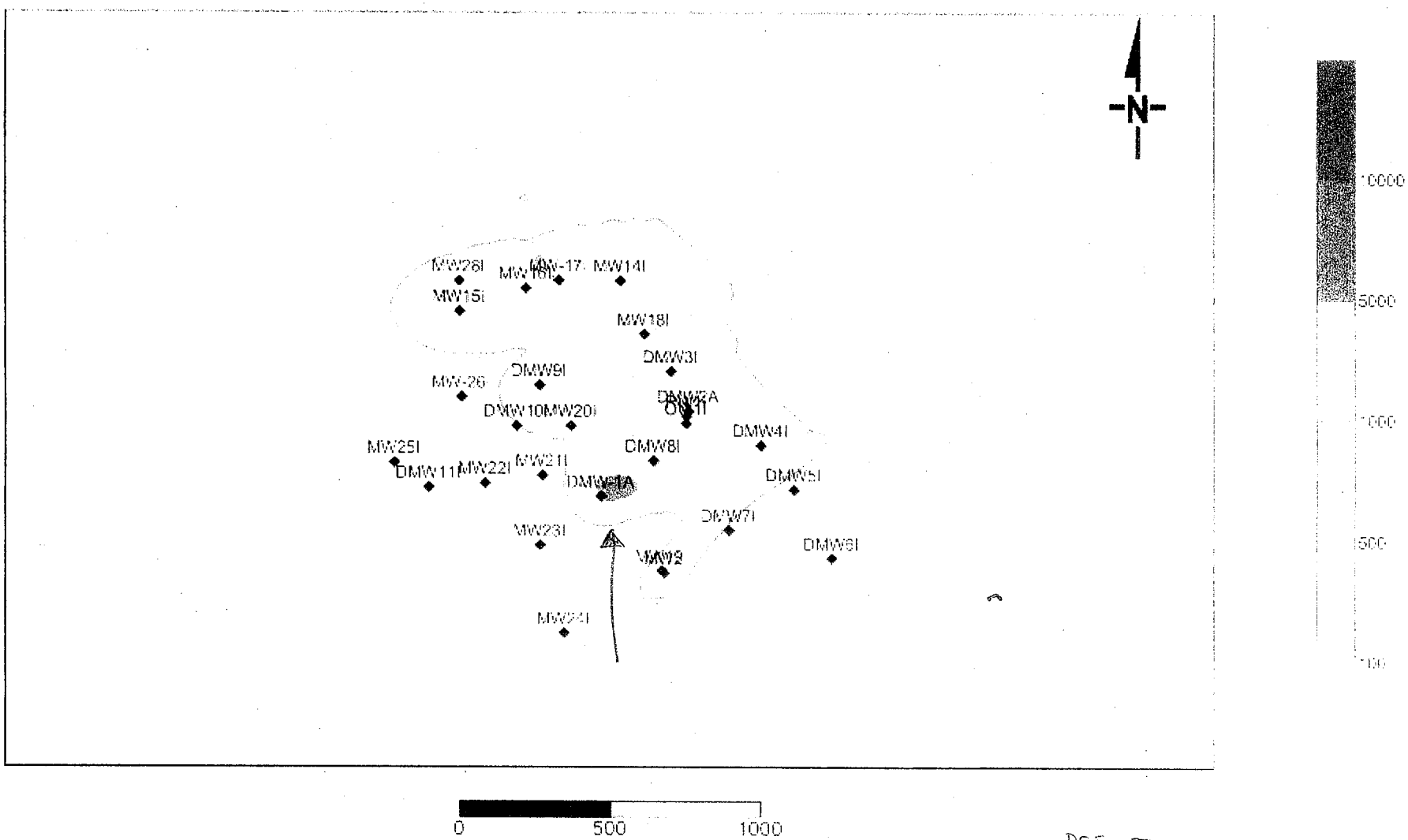
# CIS-1,2-DCE - Upper Surficial Aquifer




DCE U - Bad Wet L - 100' W 150'

DCE M - FAIR L - 100' W 150'

# CIS-1,2-DCE - Intermediate Surficial Aquifer




DCE I

L 150'

W 100'

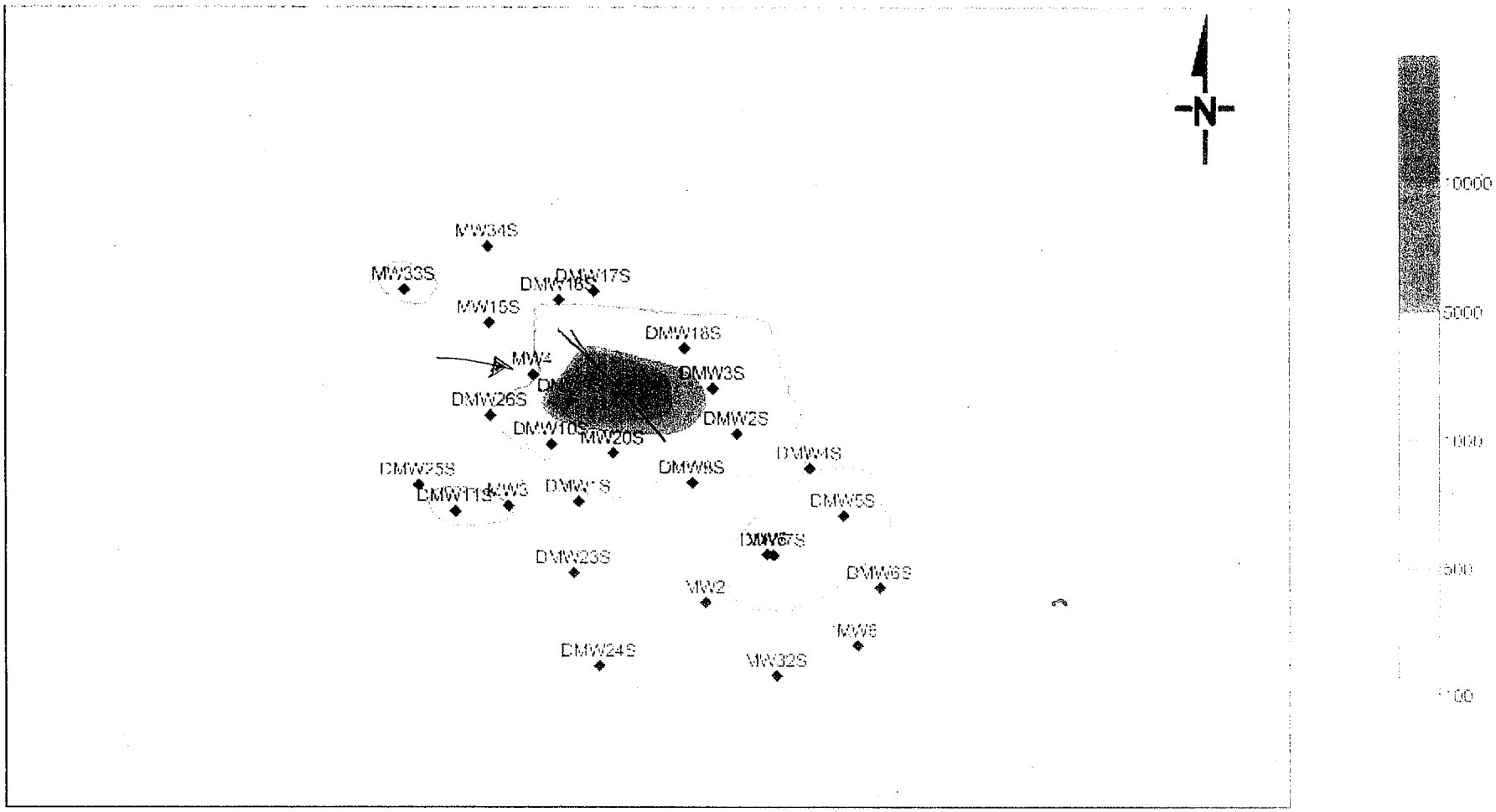
Assume

-39 [illegible] ✓

✓ TD = 55' ✓

(1)

# VINYL CHLORIDE - Upper Surficial Aquifer




VC - U

L 200'

W 400'

-10 elev 0 el

TD = 20'

(10)

From Fig

## Logan, Joe

**From:** Mark Kluger [mkluger@dajak.com]
**Sent:** Friday, January 22, 2010 9:03 AM
**To:** Logan, Joe
**Cc:** Tim Parker; Gary Birk
**Subject:** RE: EOS/AquabupH estimate

Because AquaBupH contains less oil a pound than EOS 598B42, EOS Remediation typically recommends that you use 25% more AquaBupH than EOS 598B42. Thus, you would inject about 148,000 of AquaBupH into your matrix. The cost would be about $320,000 excluding shipping and taxes, if applicable.

dajak
Characterization & Remediation Technologies

Mark Kluger
302-655-6651 (office)
302-494-6050 (mobile)
www.dajak.com

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**From:** Logan, Joe [mailto:Joe.Logan@tetratech.com]
**Sent:** Friday, January 22, 2010 7:42 AM
**To:** Mark Kluger
**Subject:** EOS/AquabupH estimate

Hi Mark

I used the EOS Tool to estimate a quantity of AquaBupH. (I used the EOS598B42 "setting". Please let me know if this is appropriate.)

My estimated total quantity is118,000 lb. (And this was in the same order of magnitude of the 1.5 - 2 lb/cy value that you suggested.)

What would be the cost for this. The site is in Maryland, near Baltimore.

Thanks

Joe

**Joseph W. Logan, Jr.** | **Process Engineer**
Direct: 412.921.7231 | Main: 412.921.7090 | Personal Fax: 412.921.4040
joe.logan@tetratech.com

Tetra Tech NUS, Inc. | Environmental Engineering
661 Andersen Drive Foster Plaza 7 | Pittsburgh, PA 15220 | www.ttnus.com

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No virus found in this incoming message.
Checked by AVG - www.avg.com
Version: 9.0.730 / Virus Database: 271.1.1/2637 - Release Date: 01/21/10 14:34:00

# APPENDIX F
# COST ESTIMATES

## ALTERNATIVE F-2:

## HYDRAULIC CONTROLS BY EXTRACTION, EX-SITU TREATMENT OF GROUNDWATER, DISCHARGE TO POTW, MONITORING, AND LUCS

**LOCKHEED MARTIN**
**Martin State Airport**
**Middle River, Maryland**
**Dump Road Area Site**
**Alternative G-2: Hydraulic Controls by Extraction, Ex-Situ Treatment of Groundwater, Discharge to POTW, Monitoring, and LUCs**
**Capital Cost**

10/20/2010 11:07 AM

| Item | Quantity | Unit | Unit Cost Subcontract | Unit Cost Material | Unit Cost Labor | Unit Cost Equipment | Extended Cost Subcontract | Extended Cost Material | Extended Cost Labor | Extended Cost Equipment | Subtotal |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1 PROJECT PLANNING & DOCUMENTS** | | | | | | | | | | | |
| 1.1 Bench Testing | 1 | ls | $30,000.00 | | | | $30,000 | $0 | $0 | $0 | $30,000 |
| 1.2 Land Finders Fee | 1 | ls | $100,000.00 | | | | $100,000 | $0 | $0 | $0 | $100,000 |
| **2 MOBILIZATION AND DEMOBILIZATION** | | | | | | | | | | | |
| 2.1 Site Support Facilities (trailers, phone, electric, etc.) | 1 | ls | | $1,000.00 | | $3,500.00 | $0 | $1,000 | $0 | $3,500 | $4,500 |
| 2.2 Equipment Mobilization/Demobilization | | | | | | | | $40,000 | $20,000 | $40,000 | $100,000 |
| **3 FIELD SUPPORT AND SITE ACCESS** | | | | | | | | | | | |
| 3.1 Office Trailer | 12 | mo | | | | $360.00 | $0 | $0 | $0 | $4,320 | $4,320 |
| 3.2 Field Office Equipment, Utilities, & Support | 12 | mo | | $470.00 | | | $0 | $5,640 | $0 | $0 | $5,640 |
| 3.3 Storage Trailer | 12 | mo | | | | $92.50 | $0 | $0 | $0 | $1,110 | $1,110 |
| 3.4 Survey Support | 15 | day | $1,075.00 | | | | $16,125 | $0 | $0 | $0 | $16,125 |
| 3.5 Site Superintendent | 252 | day | | $164.00 | $384.64 | | $0 | $41,328 | $96,929 | $0 | $138,257 |
| 3.5.1 Resident Engineering (1.5 persons) | 0 | day | | $164.00 | $307.68 | | $0 | $0 | $0 | $0 | $0 |
| 3.6 Site Health & Safety and QA/QC | 252 | day | | $164.00 | $307.68 | | $0 | $41,328 | $77,535 | $0 | $118,863 |
| 3.7 Underground Utility Clearance | 1 | ls | $10,000.00 | | | | $10,000 | $0 | $0 | $0 | $10,000 |
| 3.8 Access Road & Parking | 500 | sy | | $15.50 | $1.05 | $1.94 | $0 | $7,750 | $525 | $970 | $9,245 |
| 3.9 Clearing and Grubbing | 3 | acre | $10,000.00 | | | | $30,000 | $0 | $0 | $0 | $30,000 |
| 3.10 Directional Drill Under Taxiway Tango | 0 | ls | $50,000.00 | | | | $0 | $0 | $0 | $0 | $0 |
| **4 DECONTAMINATION** | | | | | | | | | | | |
| 4.1 Decontamination Services | 12 | mo | | $1,220.00 | $2,245.00 | $1,550.00 | $0 | $14,640 | $26,940 | $18,600 | $60,180 |
| 4.2 Temporary Equipment Decon Pad | 1 | ls | | $1,500.00 | $2,000.00 | $300.00 | $0 | $1,500 | $2,000 | $300 | $3,800 |
| 4.3 Decon Water | 2,000 | gal | | $0.20 | | | $0 | $400 | $0 | $0 | $400 |
| 4.4 Decon Water Storage Tank, 6,000 gallon | 12 | mo | | | | $771.00 | $0 | $0 | $0 | $9,252 | $9,252 |
| 4.5 Clean Water Storage Tank, 4,000 gallon | 12 | mo | | | | $693.00 | $0 | $0 | $0 | $8,316 | $8,316 |
| 4.6 Disposal of Decon Waste (liquid & solid) | 12 | mo | $985.00 | | | | $11,820 | $0 | $0 | $0 | $11,820 |
| **5 EXTRACTION SYSTEM** | | | | | | | | | | | |
| 5.1 Install Extraction Wells, 16 wells | 930 | lf | $100.00 | | | | $93,000 | $0 | $0 | $0 | $93,000 |
| 5.1.1 Well Development (1 day/well) | 16 | days | $1,500.00 | $164.00 | $307.68 | | $24,000 | $2,624 | $4,923 | $0 | $31,547 |
| 5.2 Extraction Well Head/Vault (incl controls and other det | 16 | ea | $5,000.00 | | | | $80,000 | $0 | $0 | $0 | $80,000 |
| 5.3 Insulate/Heat Trace Well Head, 16 wells | 160 | lf | | $5.87 | $3.89 | | $0 | $939 | $622 | $0 | $1,562 |
| 5.4 Submersible Pump w/ Controls, 0.5 hp | 16 | ea | | $1,000.00 | $236.00 | | $0 | $16,000 | $3,776 | $0 | $19,776 |
| 5.5 Well Piping, 1" dia. PVC Sch 80 | 930 | lf | | $1.70 | $3.25 | | $0 | $1,581 | $3,023 | $0 | $4,604 |
| 5.6 Pump Station | 1 | ea | | $30,000.00 | $1,800.00 | $400.00 | $0 | $30,000 | $1,800 | $400 | $32,200 |
| 5.7 Pump Station Pumps, 50 gpm, 3 hp | 2 | ea | | $781.20 | $200.00 | | $0 | $1,562 | $400 | $0 | $1,962 |
| 5.8 Transfer Piping, 1" dia. PVC Sch 80, Double Wall | 0 | lf | | $12.44 | $15.69 | | $0 | $0 | $0 | $0 | $0 |
| 5.9 Transfer Piping Fittings, 1" dia. PVC Sch 80, Double W | 0 | ea | | $124.40 | $156.90 | | $0 | $0 | $0 | $0 | $0 |
| 5.10 Transfer Piping Valves, 1" dia. PVC Ball | 0 | ea | | $30.30 | $18.10 | | $0 | $0 | $0 | $0 | $0 |
| 5.11 Transfer Piping, 2" dia. PVC Sch 80, Double Wall | 400 | lf | | $20.23 | $20.88 | | $0 | $8,092 | $8,352 | $0 | $16,444 |
| 5.12 Transfer Piping Fittings, 2" dia. PVC Sch 80, Double W | 128 | ea | | $202.30 | $208.80 | | $0 | $25,894 | $26,726 | $0 | $52,621 |
| 5.13 Transfer Piping Valves, 2" dia. PVC Ball | 64 | ea | | $70.50 | $24.50 | | $0 | $4,512 | $1,568 | $0 | $6,080 |
| 5.14 Transfer Piping, 4" dia. PVC Sch 80, Double Wall | 4,050 | lf | | $22.14 | $31.72 | | $0 | $89,667 | $128,466 | $0 | $218,133 |
| 5.15 Transfer Piping Fittings, 4" dia. PVC Sch 80, Double W | 128 | ea | | $221.40 | $317.20 | | $0 | $28,339 | $40,602 | $0 | $68,941 |
| 5.16 Transfer Piping Valves, 4" dia. PVC Ball | 4 | ea | | $610.00 | $37.50 | | $0 | $2,440 | $150 | $0 | $2,590 |
| 5.17 Backhoe/Loader | 40 | day | | | $343.60 | $387.60 | $0 | $0 | $13,744 | $15,504 | $29,248 |
| 5.18 Site Labor (3 laborers) | 120 | day | | | $264.80 | | $0 | $0 | $31,776 | $0 | $31,776 |
| **6 TREATMENT SYSTEM** | | | | | | | | | | | |
| 6.1 Equipment Building, 155' by 65' | 7,800 | sf | $125.00 | | | | $975,000 | $0 | $0 | $0 | $975,000 |
| 6.2 Property Acquisition | 26,875 | sf | $20.00 | | | | $537,500 | $0 | $0 | $0 | $537,500 |
| 6.3 Equipment Building Foundation | 179 | cy | $400.00 | | | | $71,600 | $0 | $0 | $0 | $71,600 |
| 6.4 Water Supply Pipe, 2" Polyetheylene | 300 | lf | | $2.49 | $5.06 | $1.17 | $0 | $747 | $1,518 | $351 | $2,616 |
| 6.5 Water Supply Valves & Meters | 1 | ls | $3,000.00 | | | | $3,000 | $0 | $0 | $0 | $3,000 |
| 6.6 Feed Tank, 10,200 gallons | 1 | ea | | $15,300.00 | $1,440.00 | | $0 | $15,300 | $1,440 | $0 | $16,740 |
| 6.7 Feed Tank Foundation | 5 | cy | $400.00 | | | | $2,000 | $0 | $0 | $0 | $2,000 |
| 6.8 Feed Tank Mixer, 10 hp | 1 | ea | | $6,600.00 | $1,245.00 | | $0 | $6,600 | $1,245 | $0 | $7,845 |
| 6.9 Feed Pump, 50 gpm, 1.5 hp | 2 | ea | | $781.20 | $200.00 | | $0 | $1,562 | $400 | $0 | $1,962 |
| 6.10 Piping, 2" PVC Sch 80 | 300 | lf | | $3.93 | $13.65 | | $0 | $1,179 | $4,095 | $0 | $5,274 |
| 6.11 Pipe Fittings, 2" PVC Sch 80 | 50 | ea | | $39.30 | $136.50 | | $0 | $1,965 | $6,825 | $0 | $8,790 |
| 6.12 Piping Valves, 2" dia. PVC Ball | 20 | ea | | $76.50 | $24.50 | | $0 | $1,530 | $490 | $0 | $2,020 |
| 6.13 Piping, 4" PVC Sch 80 | 1,600 | lf | | $11.15 | $16.30 | | $0 | $17,840 | $26,080 | $0 | $43,920 |
| 6.14 Pipe Fittings, 4" PVC Sch 80 | 300 | ea | | $111.50 | $163.00 | | $0 | $33,450 | $48,900 | $0 | $82,350 |
| 6.15 Piping Valves, 4" dia. PVC Butterfly | 120 | ea | | $733.26 | $43.00 | | $0 | $87,991 | $5,160 | $0 | $93,151 |
| 6.16 Piping, 6" PVC Sch 80 | 100 | lf | | $24.50 | $19.75 | | $0 | $2,450 | $1,975 | $0 | $4,425 |
| 6.17 Pipe Fittings, 6" PVC Sch 80 | 10 | ea | | $245.00 | $197.50 | | $0 | $2,450 | $1,975 | $0 | $4,425 |
| 6.18 Piping Valves, 6" dia. PVC Butterfly | 5 | ea | | $879.94 | $65.00 | | $0 | $4,400 | $325 | $0 | $4,725 |
| 6.19 Air Stripper Piping | 100 | lf | | $24.50 | $19.75 | | $0 | $2,450 | $1,975 | $0 | $4,425 |
| 6.20 Air Stripper Fittings | 20 | ea | | $245.00 | $197.50 | | $0 | $4,900 | $3,950 | $0 | $8,850 |
| 6.21 Air Stripper Valves | 10 | ea | | $879.94 | $65.00 | | $0 | $8,799 | $650 | $0 | $9,449 |
| *Metals Removal Package* | 1 | ls | | $293,000.00 | $134,032.50 | | $0 | $293,000 | $134,033 | $0 | $427,033 |
| - Primary pH Adjustment Tank, 600 gallons | 1 | ea | | | | | | | | | |
| - Primary pH Adjustment Tank Mixer, 0.5 hp | 1 | ea | | | | | | | | | |
| - Secondary pH Adjustment Tank, 600 gallons | 1 | ea | | | | | | | | | |
| - Secondary pH Adjustment Tank Mixer, 0.5 hp | 1 | ea | | | | | | | | | |
| - H2O2 Feed System, 20 lb/day | 1 | ea | | | | | | | | | |
| - NaOH Feed System, 24 lb/day; 5 gal/day | 1 | ea | | | | | | | | | |
| - Floc Tank, 400 gallons | 1 | ea | | | | | | | | | |
| - Floc Mixer, 0.5 hp | 1 | ea | | | | | | | | | |
| - Polymer Feed system, 6 lb/day | 1 | ea | | | | | | | | | |
| - Clarifier, 2,000 gallons | 1 | ea | | | | | | | | | |
| - Sludge Transfer Pump, 15 gpm, AODD | 2 | ea | | | | | | | | | |
| - Final pH Adjustment Tank, 1,000 gallons | 1 | ea | | | | | | | | | |
| - Final pH Adjustment Tank Mixer, 0.5 hp | 1 | ea | | | | | | | | | |
| - Acid (HCl) Feed System, 22 lb/day: 6.3 gal/day | 1 | ea | | | | | | | | | |
| - Clarified Water Feed Tank, 750 gallons | 1 | ea | | | | | | | | | |
| - SF Feed Pump, 50 gpm, 5 hp | 2 | ea | | | | | | | | | |
| - Sand Filter, 2.5' dia. by 6' high | 3 | ea | | | | | | | | | |
| - Cartridges Filters, 10 micron | 2 | ea | | | | | | | | | |
| - Thickener, 12' dia. by 15' high | 1 | ea | | | | | | | | | |
| - FP Feed Pump, 60 gpm, AODD | 2 | ea | | | | | | | | | |
| - Filter Press, 130 cf | 1 | ea | | | | | | | | | |
| 6.22 Air Stripper, 6 Tray, 420 cfm | 1 | ea | | $35,000.00 | $3,500.00 | | $0 | $35,000 | $3,500 | $0 | $38,500 |
| 6.23 Air Stripper Effluent Pump, 50 gpm, 3 hp | 2 | ea | | $781.20 | $200.00 | | $0 | $1,562 | $400 | $0 | $1,962 |
| 6.24 Vapor-Phase GAC System | 2 | ea | | $5,000.00 | $1,200.00 | | $0 | $10,000 | $2,400 | $0 | $12,400 |
| 6.25 PPI Zeolite System | 2 | ea | | $2,000.00 | $500.00 | | $0 | $4,000 | $1,000 | $0 | $5,000 |
| 6.26 HiPOx System | 1 | ea | | $280,000.00 | $1,360.00 | | $0 | $280,000 | $1,360 | $0 | $281,360 |
| 6.27 Ion Exchange System, 60 cf resin; 450 gallons | 2 | ea | | $2,700.00 | $0.00 | | $0 | $5,400 | $0 | $0 | $5,400 |
| 6.28 Liquid Phase GAC System, 4,000 lbs. | 2 | ea | | $28,000.00 | $2,076.00 | | $0 | $56,000 | $4,152 | $0 | $60,152 |
| 6.29 Backwash Supply Tank, 4,500 gallons | 1 | ea | | $6,750.00 | $750.00 | | $0 | $6,750 | $750 | $0 | $7,500 |
| 6.30 Backwash Supply Tank Foundation | 3 | cy | $400.00 | | | | $1,200 | $0 | $0 | $0 | $1,200 |
| 6.31 Backwash Pump, 40 gpm, 1 hp | 2 | ea | | $735.00 | $122.00 | | $0 | $1,470 | $244 | $0 | $1,714 |
| 6.32 Waste Backwash Tank, 4,500 gallon | 1 | ea | | $6,750.00 | $750.00 | | $0 | $6,750 | $750 | $0 | $7,500 |
| 6.33 Waste Backwash Tank Foundation | 3 | cy | $400.00 | | | | $1,200 | $0 | $0 | $0 | $1,200 |
| 6.34 Waste Backwash Transfer Pump, 1 gpm, 0.5 hp | 2 | ea | | $339.60 | $84.00 | | $0 | $679 | $168 | $0 | $847 |
| 6.35 Filtrate Tank, 4,700 gallons | 1 | ea | | $7,050.00 | $698.00 | | $0 | $7,050 | $698 | $0 | $7,748 |
| 6.36 Filtrate Tank Foundation | 4 | cy | $400.00 | | | | $1,600 | $0 | $0 | $0 | $1,600 |
| 6.37 Filtrate Tank Mixer, 5 hp | 1 | ea | | $5,500.00 | $1,073.00 | | $0 | $5,500 | $1,073 | $0 | $6,573 |
| 6.38 Filtrate Transfer Pump, 15 gpm, 0.5 hp | 2 | ea | | $339.60 | $84.00 | | $0 | $679 | $168 | $0 | $847 |
| 6.39 Air Compressor System, 50 scfm, 100 psi | 1 | ea | | $8,900.00 | $1,450.00 | | $0 | $8,900 | $1,450 | $0 | $10,350 |
| 6.40 Sump Pump, 10 gpm, 0.5 hp | 2 | ea | | $283.20 | $83.50 | | $0 | $566 | $167 | $0 | $733 |
| 6.41 Discharge Pump Tank, 750 gallons | 0 | ea | | $1,500.00 | $163.00 | | $0 | $0 | $0 | $0 | $0 |
| 6.42 Discharge Pump, 50 gpm, 1.5 hp | 0 | ea | | $535.20 | $133.00 | | $0 | $0 | $0 | $0 | $0 |
| 6.43 ED Tank, 500 gallon | 0 | ea | | $1,225.00 | $311.40 | | $0 | $0 | $0 | $0 | $0 |
| 6.44 ED Tank Mixer & Stand, 0.5 hp | 0 | ea | | $1,666.00 | $415.20 | | $0 | $0 | $0 | $0 | $0 |
| 6.45 ED Feed Pump, 4 gallons/hr | 0 | ea | | $1,500.00 | $415.20 | | $0 | $0 | $0 | $0 | $0 |
| 6.46 Discharge Pipe (POTW and SW), 4" Polyetheylene | 800 | lf | | $11.00 | $16.00 | $1.17 | $0 | $8,800 | $12,800 | $936 | $22,536 |
| 6.47 Outfall Diffuser | 1 | ls | $50,000.00 | | | | $50,000 | $0 | $0 | $0 | $50,000 |
| 6.48 Utility Service Line | 1 | ls | | $59,808.50 | $15,691.40 | | $0 | $59,809 | $15,691 | $0 | $75,500 |
| 6.49 Electrical and Controls | 1 | ls | | $223,785.00 | $109,790.00 | | $0 | $223,785 | $109,790 | $0 | $333,575 |
| 6.50 System Start-Up and Testing | 1 | ls | | $3,000.00 | $65,550.00 | | $0 | $3,000 | $65,550 | $0 | $68,550 |
| **7 MONITORING WELL INSTALLATION** | | | | | | | | | | | |
| 7.1 Well Installation (4 wells) | 290 | lf | $45.00 | | | | $13,050 | $0 | $0 | $0 | $13,050 |
| 7.2 Protective Well Casing & Apron | 4 | ea | $750.00 | | | | $3,000 | $0 | $0 | $0 | $3,000 |
| **8 INJECTION WELLS** | | | | | | | | | | | |
| 8.1 Well Installation (6 wells) | 0 | lf | $100.00 | | | | $0 | $0 | $0 | $0 | $0 |
| 8.2 Injection Well Head/Vault (incl controls and other detai | 0 | ea | $5,000.00 | | | | $0 | $0 | $0 | $0 | $0 |

**LOCKHEED MARTIN**
**Martin State Airport**
**Middle River, Maryland**
**Dump Road Area Site**
**Alternative G-2: Hydraulic Controls by Extraction, Ex-Situ Treatment of Groundwater, Discharge to POTW, Monitoring, and LUCs**
**Capital Cost**

| Item | Quantity | Unit | Unit Cost Subcontract | Unit Cost Material | Unit Cost Labor | Unit Cost Equipment | Extended Cost Subcontract | Extended Cost Material | Extended Cost Labor | Extended Cost Equipment | Subtotal |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 8.3 Main Header Pipe, 2" PVC | 0 | lf | | $1.97 | $5.64 | | $0 | $0 | $0 | $0 | $0 |
| 8.4 Main Header Pipe Fittings, 2" PVC | 0 | ea | | $19.70 | $56.40 | | $0 | $0 | $0 | $0 | $0 |
| 8.5 Piping Valves, 2" dia. PVC Ball | 0 | ea | | $76.50 | $24.50 | | $0 | $0 | $0 | $0 | $0 |
| 8.6 Well Piping, 1" dia. PVC | 0 | lf | | $0.76 | $2.35 | | $0 | $0 | $0 | $0 | $0 |
| 8.7 Pipe Fittings, 2" PVC | 0 | ea | | $7.60 | $23.50 | | $0 | $0 | $0 | $0 | $0 |
| 8.8 Piping Valves, 1" dia. PVC Ball | 0 | ea | | $30.30 | $18.10 | | $0 | $0 | $0 | $0 | $0 |
| **9 WASTE DISPOSAL** | | | | | | | | | | | |
| 9.1 Decon Fluids | 1,100 | gal | $1.00 | | | | $1,100 | $0 | $0 | $0 | $1,100 |
| 9.2 Well Development Water (5,000 gal/well) | 80,000 | gal | $1.00 | | | | $80,000 | $0 | $0 | $0 | $80,000 |
| 9.3 Drill Cuttings (12-inch dia boreholes, non-haz) | 25 | cy | $100.00 | | | | $2,500 | $0 | $0 | $0 | $2,500 |
| 9.4 Soil Excavate (2700 lf, 3'x4' trench, non-haz) | 880 | cy | $100.00 | | | | $88,000 | $0 | $0 | $0 | $88,000 |
| **10 IMPORTED CLEAN FILL** | | | | | | | | | | | |
| 10.1 Import and place clean backfill | 880 | cy | $25.00 | | | | $22,000 | $0 | $0 | $0 | $22,000 |
| 10.2 Stabilize and restore disturbed areas (3 acres) | 101,000 | sy | $8.00 | | | | $808,000 | $0 | $0 | $0 | $808,000 |
| **Subtotal** | | | | | | | $3,055,695 | $1,577,552 | $953,004 | $103,559 | $5,689,810 |
| Overhead on Labor Cost @ 30% | | | | | | | | | $285,901 | | $285,901 |
| G & A on Labor, Material, Equipment, & Subs Cost @ 10% | | | | | | | $305,570 | $157,755 | $95,300 | $10,356 | $568,981 |
| Tax on Materials and Equipment Cost @ 6% | | | | | | | | $94,653 | | $6,214 | $100,867 |
| **Total Direct Cost** | | | | | | | $3,361,265 | $1,829,960 | $1,334,206 | $120,128 | $6,645,559 |
| Indirects on Total Direct Cost @ 25% | | | | | | | | | | | $1,661,390 |
| Profit on Total Direct Cost @ 10% | | | | | | | | | | | $664,556 |
| **Subtotal** | | | | | | | | | | | $8,971,504 |
| Health & Safety Monitoring @ 2% | | | | | | | | | | | $179,430 |
| **Subtotal** | | | | | | | | | | | $9,150,935 |
| Record Drawings and Completion Report 1% | | | | | | | | | | | $91,509 |
| **Feasibility Study Level Costs** | | | | | | | | | | | $9,242,444 |
| Design Cost | | | | | | | | | | | $831,820 |
| Engineering Contingency 20% | | | | | | | | | | | $1,848,489 |

**LOCKHEED MARTIN**
**Martin State Airport**
**Middle River, Maryland**
**Dump Road Area Site**

**Alternative G-2: Hydraulic Controls by Extraction, Ex-Situ Treatment of Groundwater, Discharge to POTW, Monitoring, and LUCs**
**Operation and Maintenance Cost for Years 1 through 5**

| | Item | Quantity | Unit | Unit Cost | Subtotal | Notes |
|---|---|---|---|---|---|---|
| **Treatment System per year** | | | | | | |
| 1 | Energy - Electric | 563,000 | kWh | $0.12 | $67,560 | |
| 2 | System Maintenance | 1 | ls | $87,718 | $87,718 | 5% of Installed Equipment Cost |
| 3 | Liquid Phase GAC Replacement | 8,000 | lbs | $2.00 | $16,000 | |
| 4 | Vapor Phase GAC Replacement | 48,000 | lbs | $2.00 | $96,000 | |
| 5 | PPI Zeolite Replacement | 36,000 | lbs | $2.25 | $81,000 | |
| 6 | PPI Zeolite Disposal | 18 | ton | $66.00 | $1,188 | assume non-hazardous |
| 7 | Treatment Plant Chemicals | | | | | |
| | a) Hydrogen Peroxide - Fe/Mn Oxidation (12 lbs/day) | 4,380 | lbs | $2.00 | $8,760 | |
| | b) NaOH (220 lbs/day) | 80,300 | lbs | $0.35 | $28,105 | |
| | c) Polymer (6 lbs/day) | 2,190 | lbs | $1.00 | $2,190 | |
| | d) Hydrochloric Acid (22 lbs/day) | 8,030 | lbs | $0.80 | $6,424 | |
| | e) Hydrogen Peroxide - HiPOx (2.1 gal/day) | 1,059 | gal | $3.50 | $3,705 | |
| 8 | Sludge Disposal | 86 | ton | $65.00 | $5,590 | 4,000 cf per year @ 70 lb/cf |
| 9 | Sanitary Sewer Fees | 3513 | 1K cf | $35.89 | $126,082 | 1,000 cubic feet @ $35.89 |
| 10 | Sanitary Sewer Annual Fees | 1 | year | $3,000.00 | $3,000 | |
| 11 | Sanitary Sewer Analysis | 2 | ea | $450.00 | $900 | |
| 12 | NPDES Analysis | 0 | ea | $350.00 | $0 | monthly sampling @ 1 location |
| 13 | Ion Exchange Replacement | | | | | |
| | a) tanks | 0 | year | $24,000.00 | $0 | |
| | b) resin | 0 | year | $35,000.00 | $0 | |
| 14 | Cartridge Filters, 25 micron | 0 | ea | $3.91 | $0 | |
| 15 | Process Monitoring (VOCs, 1,4-D, metals), Aqueous | 48 | ea | $350.00 | $16,800 | monthly sampling @ 4 locations |
| 16 | Process Monitoring (VOCs ), Vapor | 36 | ea | $150.00 | $5,400 | monthly sampling @ 3 locations |
| 17 | Potable Water | 50,000 | gal | $0.20 | $10,000 | |
| 18 | Miscellaneous Services (sanitation, rubbish) | 1 | ls | $1,000.00 | $1,000 | |
| 19 | Treatment Plant Operator | 2,496 | hours | $65.00 | $162,240 | 48 hours per week |
| 20 | Quarterly Reports | 4 | ea | $2,500.00 | $10,000 | |
| | | | | **Total** | **$739,661** | |

**LOCKHEED MARTIN**
**Martin State Airport**
**Middle River, Maryland**
**Dump Road Area Site**

**Alternative G-2: Hydraulic Controls by Extraction, Ex-Situ Treatment of Groundwater, Discharge to POTW, Monitoring, and LUCs**
**Operation and Maintenance Cost for Years 6 through 10**

| | Item | Quantity | Unit | Unit Cost | Subtotal | Notes |
|---|---|---|---|---|---|---|
| **Treatment System per year** | | | | | | |
| 1 | Energy - Electric | 563,000 | kWh | $0.12 | $67,560 | |
| 2 | System Maintenance | 1 | ls | $87,718 | $87,718 | 5% of Installed Equipment Cost |
| 3 | Liquid Phase GAC Replacement | 6,000 | lbs | $2.00 | $12,000 | |
| 4 | Vapor Phase GAC Replacement | 36,000 | lbs | $2.00 | $72,000 | |
| 5 | PPI Zeolite Replacement | 27,000 | lbs | $2.25 | $60,750 | |
| 6 | PPI Zeolite Disposal | 13.5 | ton | $66.00 | $891 | assume non-hazardous |
| 7 | Treatment Plant Chemicals | | | | | |
| | a) Hydrogen Peroxide - Fe/Mn Oxidation (9 lbs/day) | 3,285 | lbs | $2.00 | $6,570 | |
| | b) NaOH (165 lbs/day) | 60,225 | lbs | $0.35 | $21,079 | |
| | c) Polymer (5 lbs/day) | 1,643 | lbs | $1.00 | $1,643 | |
| | d) Hydrochloric Acid (17 lbs/day) | 6,023 | lbs | $0.80 | $4,818 | |
| | e) Hydrogen Peroxide - HiPOx (1.6 gal/day) | 794 | gal | $3.50 | $2,779 | |
| 8 | Sludge Disposal | 65 | ton | $65.00 | $4,225 | 4,000 cf per year @ 70 lb/cf |
| 9 | Sanitary Sewer Fees | 0 | 1K cf | $35.89 | $0 | 1,000 cubic feet @ $35.89 |
| 10 | Sanitary Sewer Annual Fees | 0 | year | $3,000.00 | $0 | |
| 11 | Sanitary Sewer Analysis | 0 | ea | $450.00 | $0 | |
| 12 | NPDES Analysis | 12 | ea | $350.00 | $4,200 | monthly sampling @ 1 location |
| 13 | Ion Exchange Replacement | | | | | |
| | a) tanks | 1 | year | $18,000.00 | $18,000 | |
| | b) resin | 1 | year | $26,250.00 | $26,250 | |
| 14 | Cartridge Filters, 25 micron | 98 | ea | $3.91 | $383 | |
| 15 | Process Monitoring (VOCs, 1,4-D, metals), Aqueous | 48 | ea | $350.00 | $16,800 | monthly sampling @ 4 locations |
| 16 | Process Monitoring (VOCs ), Vapor | 36 | ea | $150.00 | $5,400 | monthly sampling @ 3 locations |
| 17 | Potable Water | 50,000 | gal | $0.20 | $10,000 | |
| 18 | Miscellaneous Services (sanitation, rubbish) | 1 | ls | $1,000.00 | $1,000 | |
| 19 | Treatment Plant Operator | 2,496 | hours | $65.00 | $162,240 | 48 hours per week |
| 20 | Quarterly Reports | 4 | ea | $2,500.00 | $10,000 | |
| | | | | **Total** | **$596,305** | |

**LOCKHEED MARTIN**
**Martin State Airport**
**Middle River, Maryland**
**Dump Road Area Site**

**Alternative G-2: Hydraulic Controls by Extraction, Ex-Situ Treatment of Groundwater, Discharge to POTW, Monitoring, and LUCs**
**Operation and Maintenance Cost for Years 11 through 30**

| | Item | Quantity | Unit | Unit Cost | Subtotal | Notes |
|---|---|---|---|---|---|---|
| **Treatment System per year** | | | | | | |
| 1 | Energy - Electric | 563,000 | kWh | $0.12 | $67,560 | |
| 2 | System Maintenance | 1 | ls | $87,718 | $87,718 | 5% of Installed Equipment Cost |
| 3 | Liquid Phase GAC Replacement | 4,000 | lbs | $2.00 | $8,000 | |
| 4 | Vapor Phase GAC Replacement | 24,000 | lbs | $2.00 | $48,000 | |
| 5 | PPI Zeolite Replacement | 18,000 | lbs | $2.25 | $40,500 | |
| 6 | PPI Zeolite Disposal | 9 | ton | $66.00 | $594 | assume non-hazardous |
| 7 | Treatment Plant Chemicals | | | | | |
| | a) Hydrogen Peroxide - Fe/Mn Oxidation (6 lbs/day) | 2,190 | lbs | $2.00 | $4,380 | |
| | b) NaOH (110 lbs/day) | 40,150 | lbs | $0.35 | $14,053 | |
| | c) Polymer (3 lbs/day) | 1,095 | lbs | $1.00 | $1,095 | |
| | d) Hydrochloric Acid (11 lbs/day) | 4,015 | lbs | $0.80 | $3,212 | |
| | e) Hydrogen Peroxide - HiPOx (1.0 gal/day) | 529 | gal | $3.50 | $1,852 | |
| 8 | Sludge Disposal | 43 | ton | $65.00 | $2,795 | 4,000 cf per year @ 70 lb/cf |
| 9 | Sanitary Sewer Fees | 0 | 1K cf | $35.89 | $0 | 1,000 cubic feet @ $35.89 |
| 10 | Sanitary Sewer Annual Fees | 0 | year | $3,000.00 | $0 | |
| 11 | Sanitary Sewer Analysis | 0 | ea | $450.00 | $0 | |
| 12 | NPDES Analysis | 12 | ea | $350.00 | $4,200 | monthly sampling @ 1 location |
| 13 | Ion Exchange Replacement | | | | | |
| | a) tanks | 1 | year | $12,000.00 | $12,000 | |
| | b) resin | 1 | year | $17,500.00 | $17,500 | |
| 14 | Cartridge Filters, 25 micron | 65 | ea | $3.91 | $254 | |
| 15 | Process Monitoring (VOCs, 1,4-D, metals), Aqueous | 48 | ea | $350.00 | $16,800 | monthly sampling @ 4 locations |
| 16 | Process Monitoring (VOCs ), Vapor | 36 | ea | $150.00 | $5,400 | monthly sampling @ 3 locations |
| 17 | Potable Water | 50,000 | gal | $0.20 | $10,000 | |
| 18 | Miscellaneous Services (sanitation, rubbish) | 1 | ls | $1,000.00 | $1,000 | |
| 19 | Treatment Plant Operator | 2,496 | hours | $65.00 | $162,240 | 48 hours per week |
| 20 | Quarterly Reports | 4 | ea | $2,500.00 | $10,000 | |
| | | | | **Total** | **$519,153** | |

**LOCKHEED MARTIN**
**Martin State Airport**
**Middle River, Maryland**
**Dump Road Area Site**
**Alternative G-2: Hydraulic Controls by Extraction, Ex-Situ Treatment of Groundwater, Discharge to POTW, Monitoring, and LUCs**

**Annual Cost**

| Item | Item Cost year 1 | Item Cost years 2 - 3 | Item Cost years 4 - 30 | Notes |
|---|---|---|---|---|
| Site Inspection: Visit | $1,620 | $1,620 | $1,620 | One-day visit to verify LUC RD |
| Site Inspection: Report | $1,680 | $1,680 | $1,680 | |
| Groundwater Sampling | $57,440 | $28,720 | $14,360 | Labor and supplies to collect samples from 40 wells using a crew of two, quarterly year 1, semi-annual years 2 & 3, annual years 4-30. |
| Groundwater Sampling Analysis/Water | $61,600 | $30,800 | $15,400 | Analyze groundwater samples |
| Sampling Report | $33,600 | $16,800 | $8,400 | |
| **TOTAL** | **$155,940** | **$79,620** | **$41,460** | |

**LOCKHEED MARTIN**
**Martin State Airport**
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**Middle River, Maryland**
**Alternative G-2: Hydraulic Controls by Extraction, Ex-Situ Treatment of Groundwater, Discharge to POTW, Monitoring, and LUCs**
**Present Worth Analysis**

| Year | Capital Cost | Operation & Maintenance Cost | Annual Cost | Total Year Cost | Annual Discount Rate at 7% | Present Worth | Current Value 2% inflation |
|---|---|---|---|---|---|---|---|
| 0 | $11,922,753 | | | $11,922,753 | 1.000 | $11,922,753 | 11,922,753 |
| 1 | | $739,661 | $155,940 | $895,601 | 0.935 | $837,387 | 913,513 |
| 2 | | $739,661 | $79,620 | $819,281 | 0.873 | $715,232 | 852,380 |
| 3 | | $739,661 | $79,620 | $819,281 | 0.816 | $668,533 | 869,428 |
| 4 | | $739,661 | $41,460 | $781,121 | 0.763 | $595,995 | 845,511 |
| 5 | | $739,661 | $41,460 | $781,121 | 0.713 | $556,939 | 862,421 |
| 6 | | $596,305 | $41,460 | $637,765 | 0.666 | $424,751 | 718,227 |
| 7 | | $596,305 | $41,460 | $637,765 | 0.623 | $397,328 | 732,591 |
| 8 | | $596,305 | $41,460 | $637,765 | 0.582 | $371,179 | 747,243 |
| 9 | | $596,305 | $41,460 | $637,765 | 0.544 | $346,944 | 762,188 |
| 10 | | $596,305 | $41,460 | $637,765 | 0.508 | $323,985 | 777,432 |
| 11 | | $519,153 | $41,460 | $560,613 | 0.475 | $266,291 | 697,052 |
| 12 | | $519,153 | $41,460 | $560,613 | 0.444 | $248,912 | 710,993 |
| 13 | | $519,153 | $41,460 | $560,613 | 0.415 | $232,654 | 725,213 |
| 14 | | $519,153 | $41,460 | $560,613 | 0.388 | $217,518 | 739,717 |
| 15 | | $519,153 | $41,460 | $560,613 | 0.362 | $202,942 | 754,511 |
| 16 | | $519,153 | $41,460 | $560,613 | 0.339 | $190,048 | 769,601 |
| 17 | | $519,153 | $41,460 | $560,613 | 0.317 | $177,714 | 784,993 |
| 18 | | $519,153 | $41,460 | $560,613 | 0.296 | $165,941 | 800,693 |
| 19 | | $519,153 | $41,460 | $560,613 | 0.277 | $155,290 | 816,707 |
| 20 | | $519,153 | $41,460 | $560,613 | 0.258 | $144,638 | 833,041 |
| 21 | | $519,153 | $41,460 | $560,613 | 0.242 | $135,668 | 849,702 |
| 22 | | $519,153 | $41,460 | $560,613 | 0.226 | $126,699 | 866,696 |
| 23 | | $519,153 | $41,460 | $560,613 | 0.211 | $118,289 | 884,030 |
| 24 | | $519,153 | $41,460 | $560,613 | 0.197 | $110,441 | 901,711 |
| 25 | | $519,153 | $41,460 | $560,613 | 0.184 | $103,153 | 919,745 |
| 26 | | $519,153 | $41,460 | $560,613 | 0.172 | $96,425 | 938,140 |
| 27 | | $519,153 | $41,460 | $560,613 | 0.161 | $90,259 | 956,903 |
| 28 | | $519,153 | $41,460 | $560,613 | 0.150 | $84,092 | 976,041 |
| 29 | | $519,153 | $41,460 | $560,613 | 0.141 | $79,046 | 995,561 |
| 30 | | $519,153 | $41,460 | $560,613 | 0.131 | $73,440 | 1,015,473 |
| | | $17,062,889 | $1,434,600 | | | | 36,940,210 |

**TOTAL PRESENT WORTH $20,180,489**

## Dump Road Area Groundwater Containment System Design Costs

| | |
|---|---|
| Feasibility Study Level Capital Costs (Excluding Contingency) | $9,242,444 |
| Total Design Costs @ 9% of FS Level Capital Costs *(excluding contingency)* | $831,820 |
| 30% Design Cost (Procurement EESHBDF-02384_R631) @ 26% of Line 6 | $216,273 |
| 60% Design Cost @ 44% of line 6 | $366,001 |
| 90% Design Cost @ 20% of line 6 | $166,364 |
| 100% Design Cost @ 10% of line 6 | $83,182 |

## ALTERNATIVE F-3:

## HYDRAULIC CONTROLS BY EXTRACTION, EX-SITU TREATMENT OF GROUNDWATER, RE-INJECTION OF GROUNDWATER, DISCHARGE TO POTW, MONITORING, AND LUCS

**LOCKHEED MARTIN**
**Martin State Airport**
**Middle River, Maryland**
**Dump Road Area Site**
**Alternative G-3: Hydraulic Controls by Extraction, Ex-Situ Treatment of Groundwater, Re-injection of Groundwater, Discharge to POTW, Monitoring, and LUCs**
**Capital Cost**

| Item | Quantity | Unit | Unit Cost Subcontract | Unit Cost Material | Unit Cost Labor | Unit Cost Equipment | Extended Cost Subcontract | Extended Cost Material | Extended Cost Labor | Extended Cost Equipment | Subtotal |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1 PROJECT PLANNING & DOCUMENTS** | | | | | | | | | | | |
| 1.1 Bench Testing | 1 | ls | $30,000.00 | | | | $30,000 | $0 | $0 | $0 | $30,000 |
| 1.2 Land Finders Fee | 1 | ls | $100,000.00 | | | | $100,000 | $0 | $0 | $0 | $100,000 |
| **2 MOBILIZATION AND DEMOBILIZATION** | | | | | | | | | | | |
| 2.1 Site Support Facilities (trailers, phone, electric, etc.) | 1 | ls | | $1,000.00 | | $3,500.00 | $0 | $1,000 | $0 | $3,500 | $4,500 |
| 2.2 Equipment Mobilization/Demobilization | | | | | | | | $40,000 | $30,000 | $40,000 | $110,000 |
| **3 FIELD SUPPORT AND SITE ACCESS** | | | | | | | | | | | |
| 3.1 Office Trailer | 12 | mo | | | | $360.00 | $0 | $0 | $0 | $4,320 | $4,320 |
| 3.2 Field Office Equipment, Utilities, & Support | 12 | mo | | $470.00 | | | $0 | $5,640 | $0 | $0 | $5,640 |
| 3.3 Storage Trailer | 12 | mo | | | | $92.50 | $0 | $0 | $0 | $1,110 | $1,110 |
| 3.4 Survey Support | 15 | day | $1,075.00 | | | | $16,125 | $0 | $0 | $0 | $16,125 |
| 3.5 Site Superintendent | 252 | day | | $164.00 | $384.64 | | $0 | $41,328 | $96,929 | $0 | $138,257 |
| 3.5.1 Resident Engineering (1.5 persons) | 0 | day | | $164.00 | $307.68 | | $0 | $0 | $0 | $0 | $0 |
| 3.6 Site Health & Safety and QA/QC | 252 | day | | $164.00 | $307.68 | | $0 | $41,328 | $77,535 | $0 | $118,863 |
| 3.7 Underground Utility Clearance | 1 | ls | $10,000.00 | | | | $10,000 | $0 | $0 | $0 | $10,000 |
| 3.8 Access Road & Parking | 500 | sy | | $15.50 | $1.05 | $1.94 | $0 | $7,750 | $525 | $970 | $9,245 |
| 3.9 Clearing and Grubbing | 3 | acre | $10,000.00 | | | | $30,000 | $0 | $0 | $0 | $30,000 |
| 3.10 Directional Drill Under Taxiway Tango | 1 | ls | $50,000.00 | | | | $50,000 | $0 | $0 | $0 | $50,000 |
| **4 DECONTAMINATION** | | | | | | | | | | | |
| 4.1 Decontamination Services | 12 | mo | | $1,220.00 | $2,245.00 | $1,550.00 | $0 | $14,640 | $26,940 | $18,600 | $60,180 |
| 4.2 Temporary Equipment Decon Pad | 1 | ls | | $1,500.00 | $2,000.00 | $300.00 | $0 | $1,500 | $2,000 | $300 | $3,800 |
| 4.3 Decon Water | 2,000 | gal | | $0.20 | | | $0 | $400 | $0 | $0 | $400 |
| 4.4 Decon Water Storage Tank, 6,000 gallon | 12 | mo | | | | $771.00 | $0 | $0 | $0 | $9,252 | $9,252 |
| 4.5 Clean Water Storage Tank, 4,000 gallon | 12 | mo | | | | $693.00 | $0 | $0 | $0 | $8,316 | $8,316 |
| 4.6 Disposal of Decon Waste (liquid & solid) | 12 | mo | $985.00 | | | | $11,820 | $0 | $0 | $0 | $11,820 |
| **5 EXTRACTION SYSTEM** | | | | | | | | | | | |
| 5.1 Install Extraction Wells, 16 wells | 930 | lf | $100.00 | | | | $93,000 | $0 | $0 | $0 | $93,000 |
| 5.1.1 Well Development (1 day/well) | 16 | days | $1,500.00 | $164.00 | $307.68 | | $24,000 | $2,624 | $4,923 | $0 | $31,547 |
| 5.2 Extraction Well Head/Vault (incl controls and other det | 16 | ea | $5,000.00 | | | | $80,000 | $0 | $0 | $0 | $80,000 |
| 5.3 Insulate/Heat Trace Well Head, 16 wells | 160 | lf | | $5.87 | $3.89 | | $0 | $939 | $622 | $0 | $1,562 |
| 5.4 Submersible Pump w/ Controls, 0.5 hp | 16 | ea | | $1,000.00 | $236.00 | | $0 | $16,000 | $3,776 | $0 | $19,776 |
| 5.5 Well Piping, 1" dia. PVC Sch 80 | 930 | lf | | $1.70 | $3.25 | | $0 | $1,581 | $3,023 | $0 | $4,604 |
| 5.6 Pump Station | 1 | ea | | $30,000.00 | $1,800.00 | $400.00 | $0 | $30,000 | $1,800 | $400 | $32,200 |
| 5.7 Pump Station Pumps, 100 gpm, 3 hp | 2 | ea | | $883.20 | $210.00 | | $0 | $1,766 | $420 | $0 | $2,186 |
| 5.8 Transfer Piping, 1" dia. PVC Sch 80, Double Wall | 0 | lf | | $12.44 | $15.69 | | $0 | $0 | $0 | $0 | $0 |
| 5.9 Transfer Piping Fittings, 1" dia. PVC Sch 80, Double W | 0 | ea | | $124.40 | $156.90 | | $0 | $0 | $0 | $0 | $0 |
| 5.10 Transfer Piping Valves, 1" dia. PVC Ball | 0 | ea | | $30.30 | $18.10 | | $0 | $0 | $0 | $0 | $0 |
| 5.11 Transfer Piping, 2" dia. PVC Sch 80, Double Wall | 400 | lf | | $20.23 | $20.88 | | $0 | $8,092 | $8,352 | $0 | $16,444 |
| 5.12 Transfer Piping Fittings, 2" dia. PVC Sch 80, Double W | 128 | ea | | $202.30 | $208.80 | | $0 | $25,894 | $26,726 | $0 | $52,621 |
| 5.13 Transfer Piping Valves, 2" dia. PVC Ball | 64 | ea | | $70.50 | $24.50 | | $0 | $4,512 | $1,568 | $0 | $6,080 |
| 5.14 Transfer Piping, 4" dia. PVC Sch 80, Double Wall | 4,050 | lf | | $22.14 | $31.72 | | $0 | $89,667 | $128,466 | $0 | $218,133 |
| 5.15 Transfer Piping Fittings, 4" dia. PVC Sch 80, Double W | 128 | ea | | $221.40 | $317.20 | | $0 | $28,339 | $40,602 | $0 | $68,941 |
| 5.16 Transfer Piping Valves, 4" dia. PVC Ball | 4 | ea | | $610.00 | $37.50 | | $0 | $2,440 | $150 | $0 | $2,590 |
| 5.17 Backhoe/Loader | 40 | day | | | $343.60 | $387.60 | $0 | $0 | $13,744 | $15,504 | $29,248 |
| 5.18 Site Labor (3 laborers) | 120 | day | | | $264.80 | | $0 | $0 | $31,776 | $0 | $31,776 |
| **6 TREATMENT SYSTEM** | | | | | | | | | | | |
| 6.1 Equipment Building, 155' by 65' | 10,075 | sf | $125.00 | | | | $1,259,375 | $0 | $0 | $0 | $1,259,375 |
| 6.2 Property Acquisition | 26,875 | sf | $20.00 | | | | $537,500 | $0 | $0 | $0 | $537,500 |
| 6.3 Equipment Building Foundation | 256 | cy | $400.00 | | | | $102,400 | $0 | $0 | $0 | $102,400 |
| 6.4 Water Supply Pipe, 2" Polyetheylene | 300 | lf | | $2.49 | $5.06 | $1.17 | $0 | $747 | $1,518 | $351 | $2,616 |
| 6.5 Water Supply Valves & Meters | 1 | ls | $3,000.00 | | | | $3,000 | $0 | $0 | $0 | $3,000 |
| 6.6 Feed Tank, 23,000 gallons | 1 | ea | | $30,000.00 | $3,200.00 | | $0 | $30,000 | $3,200 | $0 | $33,200 |
| 6.7 Feed Tank Foundation | 6 | cy | $400.00 | | | | $2,400 | $0 | $0 | $0 | $2,400 |
| 6.8 Feed Tank Mixer, 15 hp | 1 | ea | | $8,200.00 | $1,465.00 | | $0 | $8,200 | $1,465 | $0 | $9,665 |
| 6.9 Feed Pump, 100 gpm, 1.5 hp | 2 | ea | | $883.20 | $210.00 | | $0 | $1,766 | $420 | $0 | $2,186 |
| 6.10 Piping, 2" PVC Sch 80 | 300 | lf | | $3.93 | $13.65 | | $0 | $1,179 | $4,095 | $0 | $5,274 |
| 6.11 Pipe Fittings, 2" PVC Sch 80 | 50 | ea | | $39.30 | $136.50 | | $0 | $1,965 | $6,825 | $0 | $8,790 |
| 6.12 Piping Valves, 2" dia. PVC Ball | 20 | ea | | $76.50 | $24.50 | | $0 | $1,530 | $490 | $0 | $2,020 |
| 6.13 Piping, 4" PVC Sch 80 | 1,600 | lf | | $11.15 | $16.30 | | $0 | $17,840 | $26,080 | $0 | $43,920 |
| 6.14 Pipe Fittings, 4" PVC Sch 80 | 300 | ea | | $111.50 | $163.00 | | $0 | $33,450 | $48,900 | $0 | $82,350 |
| 6.15 Piping Valves, 4" dia. PVC Butterfly | 120 | ea | | $733.26 | $43.00 | | $0 | $87,991 | $5,160 | $0 | $93,151 |
| 6.16 Piping, 6" PVC Sch 80 | 100 | lf | | $24.50 | $19.75 | | $0 | $2,450 | $1,975 | $0 | $4,425 |
| 6.17 Pipe Fittings, 6" PVC Sch 80 | 10 | ea | | $245.00 | $197.50 | | $0 | $2,450 | $1,975 | $0 | $4,425 |
| 6.18 Piping Valves, 6" dia. PVC Butterfly | 5 | ea | | $879.94 | $65.00 | | $0 | $4,400 | $325 | $0 | $4,725 |
| 6.19 Air Stripper Piping | 100 | lf | | $29.40 | $19.75 | | $0 | $2,940 | $1,975 | $0 | $4,915 |
| 6.20 Air Stripper Fittings | 20 | ea | | $352.80 | $197.50 | | $0 | $7,056 | $3,950 | $0 | $11,006 |
| 6.21 Air Stripper Valves | 10 | ea | | $1,055.93 | $65.00 | | $0 | $10,559 | $650 | $0 | $11,209 |
| *Metals Removal Package* | 1 | ls | | $347,000.00 | $134,032.50 | | $0 | $347,000 | $134,033 | $0 | $481,033 |
| - Primary pH Adjustment Tank, 1,100 gallons | 1 | ea | | | | | | | | | |
| - Primary pH Adjustment Tank Mixer, 0.5 hp | 1 | ea | | | | | | | | | |
| - Secondary pH Adjustment Tank, 1,100 gallons | 1 | ea | | | | | | | | | |
| - Secondary pH Adjustment Tank Mixer, 0.5 hp | 1 | ea | | | | | | | | | |
| - H2O2 Feed System, 32 lb/day | 1 | ea | | | | | | | | | |
| - NaOH Feed System, 38 lb/day; 8 gal/day | 1 | ea | | | | | | | | | |
| - Floc Tank, 770 gallons | 1 | ea | | | | | | | | | |
| - Floc Mixer, 0.5 hp | 1 | ea | | | | | | | | | |
| - Polymer Feed system, 10 lb/day | 1 | ea | | | | | | | | | |
| - Clarifier, 3,700 gallons | 1 | ea | | | | | | | | | |
| - Sludge Transfer Pump, 15 gpm, AODD | 2 | ea | | | | | | | | | |
| - Final pH Adjustment Tank, 1,500 gallons | 1 | ea | | | | | | | | | |
| - Final pH Adjustment Tank Mixer, 1 hp | 1 | ea | | | | | | | | | |
| - Acid (HCl) Feed System, 35 lb/day: 10 gal/day | 1 | ea | | | | | | | | | |
| - Clarified Water Feed Tank, 1,100 gallons | 1 | ea | | | | | | | | | |
| - SF Feed Pump, 80 gpm, 5 hp | 2 | ea | | | | | | | | | |
| - Sand Filter, 2.5' dia. by 6' high | 3 | ea | | | | | | | | | |
| - Cartridges Filters, 10 micron | 2 | ea | | | | | | | | | |
| - Thickener, 14' dia. by 12' high | 1 | ea | | | | | | | | | |
| - FP Feed Pump, 80 gpm, AODD | 2 | ea | | | | | | | | | |
| 6.22 - Filter Press, 130 cf | 1 | ea | | | | | | | | | |
| 6.23 Air Stripper, 6 Tray, 850 cfm | 1 | ea | | $55,000.00 | $4,000.00 | | $0 | $55,000 | $4,000 | $0 | $59,000 |
| 6.24 Air Stripper Effluent Pump, 100 gpm, 3 hp | 2 | ea | | $883.20 | $210.00 | | $0 | $1,766 | $420 | $0 | $2,186 |
| 6.25 Vapor-Phase GAC System | 2 | ea | | $8,000.00 | $1,200.00 | | $0 | $16,000 | $2,400 | $0 | $18,400 |
| 6.26 PPI Zeolite System | 2 | ea | | $3,000.00 | $500.00 | | $0 | $6,000 | $1,000 | $0 | $7,000 |
| 6.27 HiPOx System | 1 | ea | | $380,000.00 | $1,360.00 | | $0 | $380,000 | $1,360 | $0 | $381,360 |
| 6.28 Ion Exchange System, 60 cf resin; 450 gallons | 2 | ea | | $2,700.00 | $0.00 | | $0 | $5,400 | $0 | $0 | $5,400 |
| 6.29 Liquid Phase GAC System, 8,000 lbs. | 2 | ea | | $42,000.00 | $2,076.00 | | $0 | $84,000 | $4,152 | $0 | $88,152 |
| 6.30 Backwash Supply Tank, 5,000 gallons | 1 | ea | | $7,500.00 | $750.00 | | $0 | $7,500 | $750 | $0 | $8,250 |
| 6.31 Backwash Supply Tank Foundation | 3 | cy | $400.00 | | | | $1,200 | $0 | $0 | $0 | $1,200 |
| 6.32 Backwash Pump, 40 gpm, 1 hp | 2 | ea | | $735.00 | $122.00 | | $0 | $1,470 | $244 | $0 | $1,714 |
| 6.33 Waste Backwash Tank, 5,000 gallon | 1 | ea | | $7,500.00 | $750.00 | | $0 | $7,500 | $750 | $0 | $8,250 |
| 6.34 Waste Backwash Tank Foundation | 3 | cy | $400.00 | | | | $1,200 | $0 | $0 | $0 | $1,200 |
| 6.35 Waste Backwash Transfer Pump, 1 gpm, 0.5 hp | 2 | ea | | $339.60 | $84.00 | | $0 | $679 | $168 | $0 | $847 |
| 6.36 Filtrate Tank, 9,000 gallons | 1 | ea | | $13,500.00 | $1,410.00 | | $0 | $13,500 | $1,410 | $0 | $14,910 |
| 6.37 Filtrate Tank Foundation | 4 | cy | $400.00 | | | | $1,600 | $0 | $0 | $0 | $1,600 |
| 6.38 Filtrate Tank Mixer, 7.5 hp | 1 | ea | | $6,300.00 | $1,240.00 | | $0 | $6,300 | $1,240 | $0 | $7,540 |
| 6.39 Filtrate Transfer Pump, 30 gpm, 0.5 hp | 2 | ea | | $499.00 | $96.00 | | $0 | $998 | $192 | $0 | $1,190 |
| 6.40 Air Compressor System, 50 scfm, 100 psi | 1 | ea | | $8,900.00 | $1,450.00 | | $0 | $8,900 | $1,450 | $0 | $10,350 |
| 6.41 Sump Pump, 10 gpm, 0.5 hp | 2 | ea | | $283.20 | $83.50 | | $0 | $566 | $167 | $0 | $733 |
| 6.42 Discharge Pump Tank, 1,500 gallons | 1 | ea | | $3,000.00 | $450.00 | | $0 | $3,000 | $450 | $0 | $3,450 |
| 6.43 Discharge Pump, 100 gpm, 2 hp | 2 | ea | | $535.20 | $133.00 | | $0 | $1,070 | $266 | $0 | $1,336 |
| 6.44 ED Tank, 500 gallon | 1 | ea | | $1,225.00 | $311.40 | | $0 | $1,225 | $311 | $0 | $1,536 |
| 6.45 ED Tank Mixer & Stand, 0.5 hp | 1 | ea | | $1,666.00 | $415.20 | | $0 | $1,666 | $415 | $0 | $2,081 |
| 6.46 ED Feed Pump, 4 gallons/hr | 2 | ea | | $1,500.00 | $415.20 | | $0 | $3,000 | $830 | $0 | $3,830 |
| 6.47 Discharge Pipe (POTW and SW), 4" Polyetheylene | 800 | lf | | $11.00 | $16.00 | $1.17 | $0 | $8,800 | $12,800 | $936 | $22,536 |
| 6.48 Outfall Diffuser | 1 | ls | $50,000.00 | | | | $50,000 | $0 | $0 | $0 | $50,000 |
| 6.49 Utility Service Line | 1 | ls | | $59,808.50 | $15,691.40 | | $0 | $59,809 | $15,691 | $0 | $75,500 |
| 6.50 Electrical and Controls | 1 | ls | | $286,083.76 | $176,543.40 | | $0 | $286,084 | $176,543 | $0 | $462,627 |
| 6.51 System Start-Up and Testing | 1 | ls | | $3,000.00 | $65,550.00 | | $0 | $3,000 | $65,550 | $0 | $68,550 |
| **7 MONITORING WELL INSTALLATION** | | | | | | | | | | | |
| 7.1 Well Installation (4 wells) | 290 | lf | $45.00 | | | | $13,050 | $0 | $0 | $0 | $13,050 |
| 7.2 Protective Well Casing & Apron | 4 | ea | $750.00 | | | | $3,000 | $0 | $0 | $0 | $3,000 |
| **8 INJECTION WELLS** | | | | | | | | | | | |
| 8.1 Well Installation (6 wells) | 270 | lf | $100.00 | | | | $27,000 | $0 | $0 | $0 | $27,000 |
| 8.2 Injection Well Head/Vault (incl controls and other detai | 6 | ea | $5,000.00 | | | | $30,000 | $0 | $0 | $0 | $30,000 |

**LOCKHEED MARTIN**
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**Dump Road Area Site**
**Alternative G-3: Hydraulic Controls by Extraction, Ex-Situ Treatment of Groundwater, Re-injection of Groundwater, Discharge to POTW, Monitoring, and LUCs**
**Capital Cost**

| Item | Quantity | Unit | Unit Cost Subcontract | Unit Cost Material | Unit Cost Labor | Unit Cost Equipment | Extended Cost Subcontract | Extended Cost Material | Extended Cost Labor | Extended Cost Equipment | Subtotal |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 8.3 Main Header Pipe, 2" PVC | 3,860 | lf | | $1.97 | $5.64 | | $0 | $7,604 | $21,770 | $0 | $29,375 |
| 8.4 Main Header Pipe Fittings, 2" PVC | 12 | ea | | $19.70 | $56.40 | | $0 | $236 | $677 | $0 | $913 |
| 8.5 Piping Valves, 2" dia. PVC Ball | 4 | ea | | $76.50 | $24.50 | | $0 | $306 | $98 | $0 | $404 |
| 8.6 Well Piping, 1" dia. PVC | 950 | lf | | $0.76 | $2.35 | | $0 | $722 | $2,233 | $0 | $2,955 |
| 8.7 Pipe Fittings, 2" PVC | 60 | ea | | $7.60 | $23.50 | | $0 | $456 | $1,410 | $0 | $1,866 |
| 8.8 Piping Valves, 1" dia. PVC Ball | 8 | ea | | $30.30 | $18.10 | | $0 | $242 | $145 | $0 | $387 |
| **9 WASTE DISPOSAL** | | | | | | | | | | | |
| 9.1 Decon Fluids | 2,200 | gal | $1.00 | | | | $2,200 | $0 | $0 | $0 | $2,200 |
| 9.2 Well Development Water (5,000 gal/well) | 160,000 | gal | $1.00 | | | | $160,000 | $0 | $0 | $0 | $160,000 |
| 9.3 Drill Cuttings (12-inch dia boreholes, non-haz) | 50 | cy | $100.00 | | | | $5,000 | $0 | $0 | $0 | $5,000 |
| 9.4 Soil Excavate (2700 lf, 3'x4' trench, non-haz) | 1,800 | cy | $100.00 | | | | $180,000 | $0 | $0 | $0 | $180,000 |
| **10 IMPORTED CLEAN FILL** | | | | | | | | | | | |
| 10.1 Import and place clean backfill | 1,800 | cy | $25.00 | | | | $45,000 | $0 | $0 | $0 | $45,000 |
| 10.2 Stabilize and restore disturbed areas (3 acres) | 21,100 | sy | $8.00 | | | | $168,800 | $0 | $0 | $0 | $168,800 |
| **Subtotal** | | | | | | | $3,037,670 | $1,899,765 | $1,061,806 | $103,559 | $6,102,801 |
| Overhead on Labor Cost @ 30% | | | | | | | | | $318,542 | | $318,542 |
| G & A on Labor, Material, Equipment, & Subs Cost @ 10% | | | | | | | $303,767 | $189,977 | $106,181 | $10,356 | $610,280 |
| Tax on Materials and Equipment Cost @ 6% | | | | | | | | $113,986 | | $6,214 | $120,199 |
| **Total Direct Cost** | | | | | | | $3,341,437 | $2,203,728 | $1,486,529 | $120,128 | $7,151,822 |
| Indirects on Total Direct Cost @ 25% | | | | | | | | | | | $1,787,956 |
| Profit on Total Direct Cost @ 10% | | | | | | | | | | | $715,182 |
| **Subtotal** | | | | | | | | | | | $9,654,960 |
| Health & Safety Monitoring @ 2% | | | | | | | | | | | $193,099 |
| **Subtotal** | | | | | | | | | | | $9,848,059 |
| Record Drawings and Completion Report 1% | | | | | | | | | | | $98,481 |
| **Feasibility Study Level Costs** | | | | | | | | | | | $9,946,540 |
| Design Cost | | | | | | | | | | | $895,189 |
| Engineering Contingency 20% | | | | | | | | | | | $1,989,308 |

**LOCKHEED MARTIN**
**Martin State Airport**
**Middle River, Maryland**
**Dump Road Area Site**

**Alternative G-3: Hydraulic Controls by Extraction, Ex-Situ Treatment of Groundwater, Re-injection of Groundwater, Discharge to POTW, Monitoring, and LUCs**
**Operation and Maintenance Cost for Years 1 through 5**

| | Item | Quantity | Unit | Unit Cost | Subtotal | Notes |
|---|---|---|---|---|---|---|
| **Treatment System per year** | | | | | | |
| 1 | Energy - Electric | 563,000 | kWh | $0.12 | $67,560 | |
| 2 | System Maintenance | 1 | ls | $100,541 | $100,541 | 5% of Installed Equipment Cost |
| 3 | Liquid Phase GAC Replacement | 8,000 | lbs | $2.00 | $16,000 | |
| 4 | Vapor Phase GAC Replacement | 48,000 | lbs | $2.00 | $96,000 | |
| 5 | PPI Zeolite Replacement | 36,000 | lbs | $2.25 | $81,000 | |
| 6 | PPI Zeolite Disposal | 18 | ton | $66.00 | $1,188 | assume non-hazardous |
| 7 | Treatment Plant Chemicals | | | | | |
| | a) Hydrogen Peroxide - Fe/Mn Oxidation (12 lbs/day) | 4,380 | lbs | $2.00 | $8,760 | |
| | b) NaOH (220 lbs/day) | 80,300 | lbs | $0.35 | $28,105 | |
| | c) Polymer (6 lbs/day) | 2,190 | lbs | $1.00 | $2,190 | |
| | d) Hydrochloric Acid (22 lbs/day) | 8,030 | lbs | $0.80 | $6,424 | |
| | e) Hydrogen Peroxide - HiPOx (2.1 gal/day) | 1,059 | gal | $3.50 | $3,705 | |
| 8 | Sludge Disposal | 86 | ton | $65.00 | $5,590 | 4,000 cf per year @ 70 lb/cf |
| 9 | Sanitary Sewer Fees | 3513 | 1K cf | $35.89 | $126,082 | 1,000 cubic feet @ $35.89 |
| 10 | Sanitary Sewer Annual Fees | 1 | year | $3,000.00 | $3,000 | |
| 11 | Sanitary Sewer Analysis | 2 | ea | $450.00 | $900 | |
| 12 | NPDES Analysis | 0 | ea | $350.00 | $0 | monthly sampling @ 1 location |
| 13 | Ion Exchange Replacement | | | | | |
| | a) tanks | 0 | year | $24,000.00 | $0 | |
| | b) resin | 0 | year | $35,000.00 | $0 | |
| 14 | Cartridge Filters, 25 micron | 0 | ea | $3.91 | $0 | |
| 15 | Process Monitoring (VOCs, 1,4-D, metals), Aqueous | 48 | ea | $350.00 | $16,800 | monthly sampling @ 4 locations |
| 16 | Process Monitoring (VOCs ), Vapor | 36 | ea | $150.00 | $5,400 | monthly sampling @ 3 locations |
| 17 | Potable Water | 50,000 | gal | $0.20 | $10,000 | |
| 18 | Miscellaneous Services (sanitation, rubbish) | 1 | ls | $1,000.00 | $1,000 | |
| 19 | Treatment Plant Operator | 2,496 | hours | $65.00 | $162,240 | 48 hours per week |
| 20 | Quarterly Reports | 4 | ea | $2,500.00 | $10,000 | |
| | | | | **Total** | **$752,484** | |
| 21 | Electron Donor Addition (injection) | 54750 | lbs | $2.00 | **$109,500** | for year one and year two only |

**LOCKHEED MARTIN**
**Martin State Airport**
**Middle River, Maryland**
**Dump Road Area Site**

**Alternative G-3: Hydraulic Controls by Extraction, Ex-Situ Treatment of Groundwater, Re-injection of Groundwater, Discharge to POTW, Monitoring, and LUCs**
**Operation and Maintenance Cost for Years 6 through 10**

| | Item | Quantity | Unit | Unit Cost | Subtotal | Notes |
|---|---|---|---|---|---|---|
| **Treatment System per year** | | | | | | |
| 1 | Energy - Electric | 563,000 | kWh | $0.12 | $67,560 | |
| 2 | System Maintenance | 1 | ls | $100,541 | $100,541 | 5% of Installed Equipment Cost |
| 3 | Liquid Phase GAC Replacement | 6,000 | lbs | $2.00 | $12,000 | |
| 4 | Vapor Phase GAC Replacement | 36,000 | lbs | $2.00 | $72,000 | |
| 5 | PPI Zeolite Replacement | 27,000 | lbs | $2.25 | $60,750 | |
| 6 | PPI Zeolite Disposal | 13.5 | ton | $66.00 | $891 | assume non-hazardous |
| 7 | Treatment Plant Chemicals | | | | | |
| | a) Hydrogen Peroxide - Fe/Mn Oxidation (9 lbs/day) | 3,285 | lbs | $2.00 | $6,570 | |
| | b) NaOH (165 lbs/day) | 60,225 | lbs | $0.35 | $21,079 | |
| | c) Polymer (5 lbs/day) | 1,643 | lbs | $1.00 | $1,643 | |
| | d) Hydrochloric Acid (17 lbs/day) | 6,023 | lbs | $0.80 | $4,818 | |
| | e) Hydrogen Peroxide - HiPOx (1.6 gal/day) | 794 | gal | $3.50 | $2,779 | |
| 8 | Sludge Disposal | 65 | ton | $65.00 | $4,225 | 4,000 cf per year @ 70 lb/cf |
| 9 | Sanitary Sewer Fees | 0 | 1K cf | $35.89 | $0 | 1,000 cubic feet @ $35.89 |
| 10 | Sanitary Sewer Annual Fees | 0 | year | $3,000.00 | $0 | |
| 11 | Sanitary Sewer Analysis | 0 | ea | $450.00 | $0 | |
| 12 | NPDES Analysis | 12 | ea | $350.00 | $4,200 | monthly sampling @ 1 location |
| 13 | Ion Exchange Replacement | | | | | |
| | a) tanks | 1 | year | $18,000.00 | $18,000 | |
| | b) resin | 1 | year | $26,250.00 | $26,250 | |
| 14 | Cartridge Filters, 25 micron | 98 | ea | $3.91 | $383 | |
| 15 | Process Monitoring (VOCs, 1,4-D, metals), Aqueous | 48 | ea | $350.00 | $16,800 | monthly sampling @ 4 locations |
| 16 | Process Monitoring (VOCs ), Vapor | 36 | ea | $150.00 | $5,400 | monthly sampling @ 3 locations |
| 17 | Potable Water | 50,000 | gal | $0.20 | $10,000 | |
| 18 | Miscellaneous Services (sanitation, rubbish) | 1 | ls | $1,000.00 | $1,000 | |
| 19 | Treatment Plant Operator | 2,496 | hours | $65.00 | $162,240 | 48 hours per week |
| 20 | Quarterly Reports | 4 | ea | $2,500.00 | $10,000 | |
| | | | | **Total** | **$609,128** | |

**LOCKHEED MARTIN**
**Martin State Airport**
**Middle River, Maryland**
**Dump Road Area Site**

**Alternative G-3: Hydraulic Controls by Extraction, Ex-Situ Treatment of Groundwater, Re-injection of Groundwater, Discharge to POTW, Monitoring, and LUCs**
**Operation and Maintenance Cost for Years 11 through 30**

| | Item | Quantity | Unit | Unit Cost | Subtotal | Notes |
|---|---|---|---|---|---|---|
| **Treatment System per year** | | | | | | |
| 1 | Energy - Electric | 563,000 | kWh | $0.12 | $67,560 | |
| 2 | System Maintenance | 1 | ls | $100,541 | $100,541 | 5% of Installed Equipment Cost |
| 3 | Liquid Phase GAC Replacement | 4,000 | lbs | $2.00 | $8,000 | |
| 4 | Vapor Phase GAC Replacement | 24,000 | lbs | $2.00 | $48,000 | |
| 5 | PPI Zeolite Replacement | 18,000 | lbs | $2.25 | $40,500 | |
| 6 | PPI Zeolite Disposal | 9 | ton | $66.00 | $594 | assume non-hazardous |
| 7 | Treatment Plant Chemicals | | | | | |
| | a) Hydrogen Peroxide - Fe/Mn Oxidation (6 lbs/day) | 2,190 | lbs | $2.00 | $4,380 | |
| | b) NaOH (110 lbs/day) | 40,150 | lbs | $0.35 | $14,053 | |
| | c) Polymer (3 lbs/day) | 1,095 | lbs | $1.00 | $1,095 | |
| | d) Hydrochloric Acid (11 lbs/day) | 4,015 | lbs | $0.80 | $3,212 | |
| | e) Hydrogen Peroxide - HiPOx (1.0 gal/day) | 529 | gal | $3.50 | $1,852 | |
| 8 | Sludge Disposal | 43 | ton | $65.00 | $2,795 | 4,000 cf per year @ 70 lb/cf |
| 9 | Sanitary Sewer Fees | 0 | 1K cf | $35.89 | $0 | 1,000 cubic feet @ $35.89 |
| 10 | Sanitary Sewer Annual Fees | 0 | year | $3,000.00 | $0 | |
| 11 | Sanitary Sewer Analysis | 0 | ea | $450.00 | $0 | |
| 12 | NPDES Analysis | 12 | ea | $350.00 | $4,200 | monthly sampling @ 1 location |
| 13 | Ion Exchange Replacement | | | | | |
| | a) tanks | 1 | year | $12,000.00 | $12,000 | |
| | b) resin | 1 | year | $17,500.00 | $17,500 | |
| 14 | Cartridge Filters, 25 micron | 65 | ea | $3.91 | $254 | |
| 15 | Process Monitoring (VOCs, 1,4-D, metals), Aqueous | 48 | ea | $350.00 | $16,800 | monthly sampling @ 4 locations |
| 16 | Process Monitoring (VOCs ), Vapor | 36 | ea | $150.00 | $5,400 | monthly sampling @ 3 locations |
| 17 | Potable Water | 50,000 | gal | $0.20 | $10,000 | |
| 18 | Miscellaneous Services (sanitation, rubbish) | 1 | ls | $1,000.00 | $1,000 | |
| 19 | Treatment Plant Operator | 2,496 | hours | $65.00 | $162,240 | 48 hours per week |
| 20 | Quarterly Reports | 4 | ea | $2,500.00 | $10,000 | |
| | | | | **Total** | **$531,976** | |

**LOCKHEED MARTIN**
**Martin State Airport**
**Middle River, Maryland**
**Dump Road Area Site**

**Alternative G-3: Hydraulic Controls by Extraction, Ex-Situ Treatment of Groundwater, Re-injection of Groundwater, Discharge to POTW, Monitoring, and LUCs**
**Annual Cost**

| Item | Item Cost year 1 | Item Cost years 2 - 3 | Item Cost years 4 - 30 | Notes |
|---|---|---|---|---|
| Site Inspection: Visit | $1,620 | $1,620 | $1,620 | One-day visit to verify LUC RD |
| Site Inspection: Report | $1,680 | $1,680 | $1,680 | |
| Groundwater Sampling | $57,440 | $28,720 | $14,360 | Labor and supplies to collect samples from 40 wells using a crew of two, quarterly year 1, semi-annual years 2 & 3, annual years 4-30. |
| Groundwater Sampling Analysis/Water | $61,600 | $30,800 | $15,400 | Analyze groundwater samples |
| Sampling Report | $33,600 | $16,800 | $8,400 | |
| **TOTAL** | **$155,940** | **$79,620** | **$41,460** | |

**LOCKHEED MARTIN**
**Martin State Airport**
**Dump Road Area Site**
**Middle River, Maryland**
**Alternative G-3: Hydraulic Controls by Extraction, Ex-Situ Treatment of Groundwater, Re-injection of Groundwater, Discharge to POTW, Monitoring, and LUCs**
**Present Worth Analysis**

| Year | Capital Cost | Operation & Maintenance Cost | Annual Cost | Total Year Cost | Annual Discount Rate at 7% | Present Worth | Current Value 2% inflation |
|---|---|---|---|---|---|---|---|
| 0 | $12,831,036 | | | $12,831,036 | 1.000 | $12,831,036 | 12,831,036 |
| 1 | | $861,984 | $155,940 | $1,017,924 | 0.935 | $951,759 | 1,038,283 |
| 2 | | $861,984 | $79,620 | $941,604 | 0.873 | $822,021 | 979,645 |
| 3 | | $752,484 | $79,620 | $832,104 | 0.816 | $678,997 | 883,036 |
| 4 | | $752,484 | $41,460 | $793,944 | 0.763 | $605,780 | 859,391 |
| 5 | | $752,484 | $41,460 | $793,944 | 0.713 | $566,082 | 876,579 |
| 6 | | $609,128 | $41,460 | $650,588 | 0.666 | $433,292 | 732,668 |
| 7 | | $609,128 | $41,460 | $650,588 | 0.623 | $405,316 | 747,321 |
| 8 | | $609,128 | $41,460 | $650,588 | 0.582 | $378,642 | 762,268 |
| 9 | | $609,128 | $41,460 | $650,588 | 0.544 | $353,920 | 777,513 |
| 10 | | $609,128 | $41,460 | $650,588 | 0.508 | $330,499 | 793,063 |
| 11 | | $531,976 | $41,460 | $573,436 | 0.475 | $272,382 | 712,996 |
| 12 | | $531,976 | $41,460 | $573,436 | 0.444 | $254,606 | 727,256 |
| 13 | | $531,976 | $41,460 | $573,436 | 0.415 | $237,976 | 741,801 |
| 14 | | $531,976 | $41,460 | $573,436 | 0.388 | $222,493 | 756,637 |
| 15 | | $531,976 | $41,460 | $573,436 | 0.362 | $207,584 | 771,770 |
| 16 | | $531,976 | $41,460 | $573,436 | 0.339 | $194,395 | 787,205 |
| 17 | | $531,976 | $41,460 | $573,436 | 0.317 | $181,779 | 802,949 |
| 18 | | $531,976 | $41,460 | $573,436 | 0.296 | $169,737 | 819,008 |
| 19 | | $531,976 | $41,460 | $573,436 | 0.277 | $158,842 | 835,388 |
| 20 | | $531,976 | $41,460 | $573,436 | 0.258 | $147,947 | 852,096 |
| 21 | | $531,976 | $41,460 | $573,436 | 0.242 | $138,772 | 869,138 |
| 22 | | $531,976 | $41,460 | $573,436 | 0.226 | $129,597 | 886,521 |
| 23 | | $531,976 | $41,460 | $573,436 | 0.211 | $120,995 | 904,251 |
| 24 | | $531,976 | $41,460 | $573,436 | 0.197 | $112,967 | 922,336 |
| 25 | | $531,976 | $41,460 | $573,436 | 0.184 | $105,512 | 940,783 |
| 26 | | $531,976 | $41,460 | $573,436 | 0.172 | $98,631 | 959,598 |
| 27 | | $531,976 | $41,460 | $573,436 | 0.161 | $92,323 | 978,790 |
| 28 | | $531,976 | $41,460 | $573,436 | 0.150 | $86,015 | 998,366 |
| 29 | | $531,976 | $41,460 | $573,436 | 0.141 | $80,854 | 1,018,333 |
| 30 | | $531,976 | $41,460 | $573,436 | 0.131 | $75,120 | 1,038,700 |
| | | $17,666,585 | $1,434,600 | | | | 38,604,724 |

**TOTAL PRESENT WORTH** **$21,445,871**

## Dump Road Area Groundwater Containment System Design Costs

| | |
|---|---|
| Feasibility Study Level Capital Costs (Excluding Contingency) | $9,946,540 |
| Total Design Costs @ 9% of FS Level Capital Costs *(excluding contingency)* | $895,189 |
| 30% Design Cost (Procurement EESHBDF-02384_R631) @ 26% of Line 6 | $232,749 |
| 60% Design Cost @ 44% of line 6 | $393,883 |
| 90% Design Cost @ 20% of line 6 | $179,038 |
| 100% Design Cost @ 10% of line 6 | $89,519 |

## ALTERNATIVE FF4:

## HYDRAULIC CONTROLS BY EXTRACTION, EXTRACTION OF HCA, EX-SITU TREATMENT OF GROUNDWATER, RE-INJECTION OF GROUNDWATER, DISCHARGE TO POTW, MONITORING, AND LUCS

**LOCKHEED MARTIN**
**Martin State Airport**
**Middle River, Maryland**
**Dump Road Area Site**
**Alternative G-4: Hydraulic Controls by Extraction, Extraction of HCA, Ex-Situ Treatment of Groundwater, Re-injection of Groundwater, Discharge to POTW, Monitoring, and LUCs**
**Capital Cost**

| Item | Quantity | Unit | Unit Cost Subcontract | Unit Cost Material | Unit Cost Labor | Unit Cost Equipment | Extended Cost Subcontract | Extended Cost Material | Extended Cost Labor | Extended Cost Equipment | Subtotal |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1 PROJECT PLANNING & DOCUMENTS** | | | | | | | | | | | |
| 1.1 Bench Testing | 1 | ls | $30,000.00 | | | | $30,000 | $0 | $0 | $0 | $30,000 |
| 1.2 Land Finders Fee | 1 | ls | $100,000.00 | | | | $100,000 | $0 | $0 | $0 | $100,000 |
| **2 MOBILIZATION AND DEMOBILIZATION** | | | | | | | | | | | |
| 2.1 Site Support Facilities (trailers, phone, electric, etc.) | 1 | ls | | $1,000.00 | | $3,500.00 | $0 | $1,000 | $0 | $3,500 | $4,500 |
| 2.2 Equipment Mobilization/Demobilization | | | | | | | | $40,000 | $27,000 | $40,000 | $107,000 |
| **3 FIELD SUPPORT AND SITE ACCESS** | | | | | | | | | | | |
| 3.1 Office Trailer | 12 | mo | | | | $360.00 | $0 | $0 | $0 | $4,320 | $4,320 |
| 3.2 Field Office Equipment, Utilities, & Support | 12 | mo | | $470.00 | | | $0 | $5,640 | $0 | $0 | $5,640 |
| 3.3 Storage Trailer | 12 | mo | | | | $92.50 | $0 | $0 | $0 | $1,110 | $1,110 |
| 3.4 Survey Support | 15 | day | $1,075.00 | | | | $16,125 | $0 | $0 | $0 | $16,125 |
| 3.5 Site Superintendent | 252 | day | | $164.00 | $384.64 | | $0 | $41,328 | $96,929 | $0 | $138,257 |
| 3.5.1 Resident Engineering (1.5 persons) | 0 | day | | $164.00 | $307.68 | | $0 | $0 | $0 | $0 | $0 |
| 3.6 Site Health & Safety and QA/QC | 252 | day | | $164.00 | $307.68 | | $0 | $41,328 | $77,535 | $0 | $118,863 |
| 3.7 Underground Utility Clearance | 1 | ls | $10,000.00 | | | | $10,000 | $0 | $0 | $0 | $10,000 |
| 3.8 Access Road & Parking | 500 | sy | | $15.50 | $1.05 | $1.94 | $0 | $7,750 | $525 | $970 | $9,245 |
| 3.9 Clearing and Grubbing | 3 | acre | $10,000.00 | | | | $30,000 | $0 | $0 | $0 | $30,000 |
| 3.10 Directional Drill Under Taxiway Tango | 1 | ls | $50,000.00 | | | | $50,000 | $0 | $0 | $0 | $50,000 |
| **4 DECONTAMINATION** | | | | | | | | | | | |
| 4.1 Decontamination Services | 12 | mo | | $1,220.00 | $2,245.00 | $1,550.00 | $0 | $14,640 | $26,940 | $18,600 | $60,180 |
| 4.2 Temporary Equipment Decon Pad | 1 | ls | | $1,500.00 | $2,000.00 | $300.00 | $0 | $1,500 | $2,000 | $300 | $3,800 |
| 4.3 Decon Water | 2,000 | gal | | $0.20 | | | $0 | $400 | $0 | $0 | $400 |
| 4.4 Decon Water Storage Tank, 6,000 gallon | 12 | mo | | | | $771.00 | $0 | $0 | $0 | $9,252 | $9,252 |
| 4.5 Clean Water Storage Tank, 4,000 gallon | 12 | mo | | | | $693.00 | $0 | $0 | $0 | $8,316 | $8,316 |
| 4.6 Disposal of Decon Waste (liquid & solid) | 12 | mo | $985.00 | | | | $11,820 | $0 | $0 | $0 | $11,820 |
| **5 EXTRACTION SYSTEM** | | | | | | | | | | | |
| 5.1 Install Extraction Wells, 23 wells | 1,350 | lf | $100.00 | | | | $135,000 | $0 | $0 | $0 | $135,000 |
| 5.1.1 Well Development (1 day/well) | 23 | days | $1,500.00 | $164.00 | $307.68 | | $34,500 | $3,772 | $7,077 | $0 | $45,349 |
| 5.2 Extraction Well Head/Vault (incl controls and other det | 23 | ea | $5,000.00 | | | | $115,000 | $0 | $0 | $0 | $115,000 |
| 5.3 Insulate/Heat Trace Well Head, 16 wells | 230 | lf | | $5.87 | $3.89 | | $0 | $1,350 | $895 | $0 | $2,245 |
| 5.4 Submersible Pump w/ Controls, 0.5 hp | 23 | ea | | $1,000.00 | $236.00 | | $0 | $23,000 | $5,428 | $0 | $28,428 |
| 5.5 Well Piping, 1" dia. PVC Sch 80 | 1,350 | lf | | $1.70 | $3.25 | | $0 | $2,295 | $4,388 | $0 | $6,683 |
| 5.6 Pump Station | 1 | ea | | $30,000.00 | $1,800.00 | $400.00 | $0 | $30,000 | $1,800 | $400 | $32,200 |
| 5.7 Pump Station Pumps, 100 gpm, 3 hp | 2 | ea | | $883.20 | $210.00 | | $0 | $1,766 | $420 | $0 | $2,186 |
| 5.8 Transfer Piping, 1" dia. PVC Sch 80, Double Wall | 0 | lf | | $12.44 | $15.69 | | $0 | $0 | $0 | $0 | $0 |
| 5.9 Transfer Piping Fittings, 1" dia. PVC Sch 80, Double W | 0 | ea | | $124.40 | $156.90 | | $0 | $0 | $0 | $0 | $0 |
| 5.10 Transfer Piping Valves, 1" dia. PVC Ball | 0 | ea | | $30.30 | $18.10 | | $0 | $0 | $0 | $0 | $0 |
| 5.11 Transfer Piping, 2" dia. PVC Sch 80, Double Wall | 1,600 | lf | | $20.23 | $20.88 | | $0 | $32,368 | $33,408 | $0 | $65,776 |
| 5.12 Transfer Piping Fittings, 2" dia. PVC Sch 80, Double W | 128 | ea | | $202.30 | $208.80 | | $0 | $25,894 | $26,726 | $0 | $52,621 |
| 5.13 Transfer Piping Valves, 2" dia. PVC Ball | 64 | ea | | $70.50 | $24.50 | | $0 | $4,512 | $1,568 | $0 | $6,080 |
| 5.14 Transfer Piping, 4" dia. PVC Sch 80, Double Wall | 4,050 | lf | | $22.14 | $31.72 | | $0 | $89,667 | $128,466 | $0 | $218,133 |
| 5.15 Transfer Piping Fittings, 4" dia. PVC Sch 80, Double W | 128 | ea | | $221.40 | $317.20 | | $0 | $28,339 | $40,602 | $0 | $68,941 |
| 5.16 Transfer Piping Valves, 4" dia. PVC Ball | 4 | ea | | $610.00 | $37.50 | | $0 | $2,440 | $150 | $0 | $2,590 |
| 5.17 Backhoe/Loader | 40 | day | | | $343.60 | $387.60 | $0 | $0 | $13,744 | $15,504 | $29,248 |
| 5.18 Site Labor (3 laborers) | 120 | day | | | $264.80 | | $0 | $0 | $31,776 | $0 | $31,776 |
| **6 TREATMENT SYSTEM** | | | | | | | | | | | |
| 6.1 Equipment Building, 155' by 65' | 10,075 | sf | $125.00 | | | | $1,259,375 | $0 | $0 | $0 | $1,259,375 |
| 6.2 Property Acquisition | 26,875 | sf | $20.00 | | | | $537,500 | $0 | $0 | $0 | $537,500 |
| 6.3 Equipment Building Foundation | 256 | cy | $400.00 | | | | $102,400 | $0 | $0 | $0 | $102,400 |
| 6.4 Water Supply Pipe, 2" Polyetheylene | 300 | lf | | $2.49 | $5.06 | $1.17 | $0 | $747 | $1,518 | $351 | $2,616 |
| 6.5 Water Supply Valves & Meters | 1 | ls | $3,000.00 | | | | $3,000 | $0 | $0 | $0 | $3,000 |
| 6.6 Feed Tank, 23,000 gallons | 1 | ea | | $30,000.00 | $3,200.00 | | $0 | $30,000 | $3,200 | $0 | $33,200 |
| 6.7 Feed Tank Foundation | 6 | cy | $400.00 | | | | $2,400 | $0 | $0 | $0 | $2,400 |
| 6.8 Feed Tank Mixer, 15 hp | 1 | ea | | $8,200.00 | $1,465.00 | | $0 | $8,200 | $1,465 | $0 | $9,665 |
| 6.9 Feed Pump, 100 gpm, 1.5 hp | 2 | ea | | $883.20 | $210.00 | | $0 | $1,766 | $420 | $0 | $2,186 |
| 6.10 Piping, 2" PVC Sch 80 | 300 | lf | | $3.93 | $13.65 | | $0 | $1,179 | $4,095 | $0 | $5,274 |
| 6.11 Pipe Fittings, 2" PVC Sch 80 | 50 | ea | | $39.30 | $136.50 | | $0 | $1,965 | $6,825 | $0 | $8,790 |
| 6.12 Piping Valves, 2" dia. PVC Ball | 20 | ea | | $76.50 | $24.50 | | $0 | $1,530 | $490 | $0 | $2,020 |
| 6.13 Piping, 4" PVC Sch 80 | 1,600 | lf | | $11.15 | $16.30 | | $0 | $17,840 | $26,080 | $0 | $43,920 |
| 6.14 Pipe Fittings, 4" PVC Sch 80 | 300 | ea | | $111.50 | $163.00 | | $0 | $33,450 | $48,900 | $0 | $82,350 |
| 6.15 Piping Valves, 4" dia. PVC Butterfly | 120 | ea | | $733.26 | $43.00 | | $0 | $87,991 | $5,160 | $0 | $93,151 |
| 6.16 Piping, 6" PVC Sch 80 | 100 | lf | | $24.50 | $19.75 | | $0 | $2,450 | $1,975 | $0 | $4,425 |
| 6.17 Pipe Fittings, 6" PVC Sch 80 | 10 | ea | | $245.00 | $197.50 | | $0 | $2,450 | $1,975 | $0 | $4,425 |
| 6.18 Piping Valves, 6" dia. PVC Butterfly | 5 | ea | | $879.94 | $65.00 | | $0 | $4,400 | $325 | $0 | $4,725 |
| 6.19 Air Stripper Piping | 100 | lf | | $29.40 | $19.75 | | $0 | $2,940 | $1,975 | $0 | $4,915 |
| 6.20 Air Stripper Fittings | 20 | ea | | $352.80 | $197.50 | | $0 | $7,056 | $3,950 | $0 | $11,006 |
| 6.21 Air Stripper Valves | 10 | ea | | $1,055.93 | $65.00 | | $0 | $10,559 | $650 | $0 | $11,209 |
| *Metals Removal Package* | 1 | ls | | $347,000.00 | $134,032.50 | | $0 | $347,000 | $134,033 | $0 | $481,033 |
| - Primary pH Adjustment Tank, 1,100 gallons | 1 | ea | | | | | | | | | |
| - Primary pH Adjustment Tank Mixer, 0.5 hp | 1 | ea | | | | | | | | | |
| - Secondary pH Adjustment Tank, 1,100 gallons | 1 | ea | | | | | | | | | |
| - Secondary pH Adjustment Tank Mixer, 0.5 hp | 1 | ea | | | | | | | | | |
| - H2O2 Feed System, 32 lb/day | 1 | ea | | | | | | | | | |
| - NaOH Feed System, 38 lb/day; 8 gal/day | 1 | ea | | | | | | | | | |
| - Floc Tank, 770 gallons | 1 | ea | | | | | | | | | |
| - Floc Mixer, 0.5 hp | 1 | ea | | | | | | | | | |
| - Polymer Feed system, 10 lb/day | 1 | ea | | | | | | | | | |
| - Clarifier, 3,700 gallons | 1 | ea | | | | | | | | | |
| - Sludge Transfer Pump, 15 gpm, AODD | 2 | ea | | | | | | | | | |
| - Final pH Adjustment Tank, 1,500 gallons | 1 | ea | | | | | | | | | |
| - Final pH Adjustment Tank Mixer, 1 hp | 1 | ea | | | | | | | | | |
| - Acid (HCl) Feed System, 35 lb/day: 10 gal/day | 1 | ea | | | | | | | | | |
| - Clarified Water Feed Tank, 1,100 gallons | 1 | ea | | | | | | | | | |
| - SF Feed Pump, 80 gpm, 5 hp | 2 | ea | | | | | | | | | |
| - Sand Filter, 2.5' dia. by 6' high | 3 | ea | | | | | | | | | |
| - Cartridges Filters, 10 micron | 2 | ea | | | | | | | | | |
| - Thickener, 14' dia. by 12' high | 1 | ea | | | | | | | | | |
| - FP Feed Pump, 80 gpm, AODD | 2 | ea | | | | | | | | | |
| 6.22 - Filter Press, 130 cf | 1 | ea | | | | | | | | | |
| 6.23 Air Stripper, 6 Tray, 850 cfm | 1 | ea | | $55,000.00 | $4,000.00 | | $0 | $55,000 | $4,000 | $0 | $59,000 |
| 6.24 Air Stripper Effluent Pump, 100 gpm, 3 hp | 2 | ea | | $883.20 | $210.00 | | $0 | $1,766 | $420 | $0 | $2,186 |
| 6.25 Vapor-Phase GAC System | 2 | ea | | $8,000.00 | $1,200.00 | | $0 | $16,000 | $2,400 | $0 | $18,400 |
| 6.26 PPI Zeolite System | 2 | ea | | $3,000.00 | $500.00 | | $0 | $6,000 | $1,000 | $0 | $7,000 |
| 6.27 HiPOx System | 1 | ea | | $380,000.00 | $1,360.00 | | $0 | $380,000 | $1,360 | $0 | $381,360 |
| 6.28 Ion Exchange System, 60 cf resin; 450 gallons | 2 | ea | | $2,700.00 | $0.00 | | $0 | $5,400 | $0 | $0 | $5,400 |
| 6.29 Liquid Phase GAC System, 8,000 lbs. | 2 | ea | | $42,000.00 | $2,076.00 | | $0 | $84,000 | $4,152 | $0 | $88,152 |
| 6.30 Backwash Supply Tank, 5,000 gallons | 1 | ea | | $7,500.00 | $750.00 | | $0 | $7,500 | $750 | $0 | $8,250 |
| 6.31 Backwash Supply Tank Foundation | 3 | cy | $400.00 | | | | $1,200 | $0 | $0 | $0 | $1,200 |
| 6.32 Backwash Pump, 40 gpm, 1 hp | 2 | ea | | $735.00 | $122.00 | | $0 | $1,470 | $244 | $0 | $1,714 |
| 6.33 Waste Backwash Tank, 5,000 gallon | 1 | ea | | $7,500.00 | $750.00 | | $0 | $7,500 | $750 | $0 | $8,250 |
| 6.34 Waste Backwash Tank Foundation | 3 | cy | $400.00 | | | | $1,200 | $0 | $0 | $0 | $1,200 |
| 6.35 Waste Backwash Transfer Pump, 1 gpm, 0.5 hp | 2 | ea | | $339.60 | $84.00 | | $0 | $679 | $168 | $0 | $847 |
| 6.36 Filtrate Tank, 9,000 gallons | 1 | ea | | $13,500.00 | $1,410.00 | | $0 | $13,500 | $1,410 | $0 | $14,910 |
| 6.37 Filtrate Tank Foundation | 4 | cy | $400.00 | | | | $1,600 | $0 | $0 | $0 | $1,600 |
| 6.38 Filtrate Tank Mixer, 7.5 hp | 1 | ea | | $6,300.00 | $1,240.00 | | $0 | $6,300 | $1,240 | $0 | $7,540 |
| 6.39 Filtrate Transfer Pump, 30 gpm, 0.5 hp | 2 | ea | | $499.00 | $96.00 | | $0 | $998 | $192 | $0 | $1,190 |
| 6.40 Air Compressor System, 50 scfm, 100 psi | 1 | ea | | $8,900.00 | $1,450.00 | | $0 | $8,900 | $1,450 | $0 | $10,350 |
| 6.41 Sump Pump, 10 gpm, 0.5 hp | 2 | ea | | $283.20 | $83.50 | | $0 | $566 | $167 | $0 | $733 |
| 6.42 Discharge Pump Tank, 1,500 gallons | 1 | ea | | $3,000.00 | $450.00 | | $0 | $3,000 | $450 | $0 | $3,450 |
| 6.43 Discharge Pump, 100 gpm, 2 hp | 2 | ea | | $535.20 | $133.00 | | $0 | $1,070 | $266 | $0 | $1,336 |
| 6.44 ED Tank, 500 gallon | 1 | ea | | $1,225.00 | $311.40 | | $0 | $1,225 | $311 | $0 | $1,536 |
| 6.45 ED Tank Mixer & Stand, 0.5 hp | 1 | ea | | $1,666.00 | $415.20 | | $0 | $1,666 | $415 | $0 | $2,081 |
| 6.46 ED Feed Pump, 4 gallons/hr | 2 | ea | | $1,500.00 | $415.20 | | $0 | $3,000 | $830 | $0 | $3,830 |
| 6.47 Discharge Pipe (POTW and SW), 4" Polyetheylene | 800 | lf | | $11.00 | $16.00 | $1.17 | $0 | $8,800 | $12,800 | $936 | $22,536 |
| 6.48 Outfall Diffuser | 1 | ls | $50,000.00 | | | | $50,000 | $0 | $0 | $0 | $50,000 |
| 6.49 Utility Service Line | 1 | ls | | $59,808.50 | $15,691.40 | | $0 | $59,809 | $15,691 | $0 | $75,500 |
| 6.50 Electrical and Controls | 1 | ls | | $286,083.76 | $176,543.40 | | $0 | $286,084 | $176,543 | $0 | $462,627 |
| 6.51 System Start-Up and Testing | 1 | ls | | $3,000.00 | $65,550.00 | | $0 | $3,000 | $65,550 | $0 | $68,550 |
| **7 MONITORING WELL INSTALLATION** | | | | | | | | | | | |
| 7.1 Well Installation (4 wells) | 290 | lf | $45.00 | | | | $13,050 | $0 | $0 | $0 | $13,050 |
| 7.2 Protective Well Casing & Apron | 4 | ea | $750.00 | | | | $3,000 | $0 | $0 | $0 | $3,000 |
| **8 INJECTION WELLS** | | | | | | | | | | | |
| 8.1 Well Installation (6 wells) | 270 | lf | $100.00 | | | | $27,000 | $0 | $0 | $0 | $27,000 |
| 8.2 Injection Well Head/Vault (incl controls and other detai | 6 | ea | $5,000.00 | | | | $30,000 | $0 | $0 | $0 | $30,000 |

**LOCKHEED MARTIN**
**Martin State Airport**
**Middle River, Maryland**
**Dump Road Area Site**
**Alternative G-4: Hydraulic Controls by Extraction, Extraction of HCA, Ex-Situ Treatment of Groundwater, Re-injection of Groundwater, Discharge to POTW, Monitoring, and LUCs**
**Capital Cost**

| Item | Quantity | Unit | Unit Cost Subcontract | Unit Cost Material | Unit Cost Labor | Unit Cost Equipment | Extended Cost Subcontract | Extended Cost Material | Extended Cost Labor | Extended Cost Equipment | Subtotal |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 8.3 Main Header Pipe, 2" PVC | 3,860 | lf | | $1.97 | $5.64 | | $0 | $7,604 | $21,770 | $0 | $29,375 |
| 8.4 Main Header Pipe Fittings, 2" PVC | 12 | ea | | $19.70 | $56.40 | | $0 | $236 | $677 | $0 | $913 |
| 8.5 Piping Valves, 2" dia. PVC Ball | 4 | ea | | $76.50 | $24.50 | | $0 | $306 | $98 | $0 | $404 |
| 8.6 Well Piping, 1" dia. PVC | 950 | lf | | $0.76 | $2.35 | | $0 | $722 | $2,233 | $0 | $2,955 |
| 8.7 Pipe Fittings, 2" PVC | 60 | ea | | $7.60 | $23.50 | | $0 | $456 | $1,410 | $0 | $1,866 |
| 8.8 Piping Valves, 1" dia. PVC Ball | 8 | ea | | $30.30 | $18.10 | | $0 | $242 | $145 | $0 | $387 |
| **9 WASTE DISPOSAL** | | | | | | | | | | | |
| 9.1 Decon Fluids | 2,000 | gal | $1.00 | | | | $2,000 | $0 | $0 | $0 | $2,000 |
| 9.2 Well Development Water (5,000 gal/well) | 145,000 | gal | $1.00 | | | | $145,000 | $0 | $0 | $0 | $145,000 |
| 9.3 Drill Cuttings (12-inch dia boreholes, non-haz) | 35 | cy | $100.00 | | | | $3,500 | $0 | $0 | $0 | $3,500 |
| 9.4 Soil Excavate (2700 lf, 3'x4' trench, non-haz) | 1,600 | cy | $100.00 | | | | $160,000 | $0 | $0 | $0 | $160,000 |
| **10 IMPORTED CLEAN FILL** | | | | | | | | | | | |
| 10.1 Import and place clean backfill | 1,600 | cy | $25.00 | | | | $40,000 | $0 | $0 | $0 | $40,000 |
| 10.2 Stabilize and restore disturbed areas (3 acres) | 19,140 | sy | $8.00 | | | | $153,120 | $0 | $0 | $0 | $153,120 |
| **Subtotal** | | | | | | | $3,067,790 | $1,933,314 | $1,089,305 | $103,559 | $6,193,969 |
| Overhead on Labor Cost @ 30% | | | | | | | | | $326,792 | | $326,792 |
| G & A on Labor, Material, Equipment, & Subs Cost @ 10% | | | | | | | $306,779 | $193,331 | $108,931 | $10,356 | $619,397 |
| Tax on Materials and Equipment Cost @ 6% | | | | | | | | $115,999 | | $6,214 | $122,212 |
| **Total Direct Cost** | | | | | | | $3,374,569 | $2,242,645 | $1,525,027 | $120,128 | $7,262,369 |
| Indirects on Total Direct Cost @ 25% | | | | | | | | | | | $1,815,592 |
| Profit on Total Direct Cost @ 10% | | | | | | | | | | | $726,237 |
| **Subtotal** | | | | | | | | | | | $9,804,199 |
| Health & Safety Monitoring @ 2% | | | | | | | | | | | $196,084 |
| **Subtotal** | | | | | | | | | | | $10,000,283 |
| Record Drawings and Completion Report 1% | | | | | | | | | | | $100,003 |
| **Feasibility Study Level Costs** | | | | | | | | | | | $10,100,286 |
| Deign Cost | | | | | | | | | | | $909,026 |
| Engineering Contingency 20% | | | | | | | | | | | $2,020,057 |

**LOCKHEED MARTIN**
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**Middle River, Maryland**
**Dump Road Area Site**
**Alternative G-4: Hydraulic Controls by Extraction, Extraction of HCA, Ex-Situ Treatment of Groundwater, Re-injection of Groundwater, Discharge to POTW, Monitoring, and LUCs**
**Operation and Maintenance Cost for Years 1 through 5**

| | Item | Quantity | Unit | Unit Cost | Subtotal | Notes |
|---|---|---|---|---|---|---|
| **Treatment System per year** | | | | | | |
| 1 | Energy - Electric | 778,000 | kWh | $0.12 | $93,360 | |
| 2 | System Maintenance | 1 | ls | $103,544 | $103,544 | 5% of Installed Equipment Cost |
| 3 | Liquid Phase GAC Replacement | 16,000 | lbs | $2.00 | $32,000 | |
| 4 | Vapor Phase GAC Replacement | 96,000 | lbs | $2.00 | $192,000 | |
| 5 | PPI Zeolite Replacement | 72,000 | lbs | $2.25 | $162,000 | |
| 6 | PPI Zeolite Disposal | 36 | ton | $66.00 | $2,376 | assume non-hazardous |
| 7 | Treatment Plant Chemicals | | | | | |
| | a) Hydrogen Peroxide - Fe/Mn Oxidation (12 lbs/day) | 8,760 | lbs | $2.00 | $17,520 | |
| | b) NaOH (220 lbs/day) | 160,600 | lbs | $0.35 | $56,210 | |
| | c) Polymer (6 lbs/day) | 4,380 | lbs | $1.00 | $4,380 | |
| | d) Hydrochloric Acid (22 lbs/day) | 16,060 | lbs | $0.80 | $12,848 | |
| | e) Hydrogen Peroxide - HiPOx (2.1 gal/day) | 2,081 | gal | $3.50 | $7,284 | |
| 8 | Sludge Disposal | 175 | ton | $65.00 | $11,375 | 4,000 cf per year @ 70 lb/cf |
| 9 | Sanitary Sewer Fees | 7025 | 1K cf | $35.89 | $252,127 | 1,000 cubic feet @ $35.89 |
| 10 | Sanitary Sewer Annual Fees | 1 | year | $3,000.00 | $3,000 | |
| 11 | Sanitary Sewer Analysis | 2 | ea | $450.00 | $900 | |
| 12 | NPDES Analysis | 0 | ea | $350.00 | $0 | monthly sampling @ 1 location |
| 13 | Ion Exchange Replacement | | | | | |
| | a) tanks | 0 | year | $24,000.00 | $0 | |
| | b) resin | 0 | year | $35,000.00 | $0 | |
| 14 | Cartridge Filters, 25 micron | 0 | ea | $3.91 | $0 | |
| 15 | Process Monitoring (VOCs, 1,4-D, metals), Aqueous | 48 | ea | $350.00 | $16,800 | monthly sampling @ 4 locations |
| 16 | Process Monitoring (VOCs ), Vapor | 36 | ea | $150.00 | $5,400 | monthly sampling @ 3 locations |
| 17 | Potable Water | 50,000 | gal | $0.20 | $10,000 | |
| 18 | Miscellaneous Services (sanitation, rubbish) | 1 | ls | $1,000.00 | $1,000 | |
| 19 | Treatment Plant Operator | 2,496 | hours | $65.00 | $162,240 | 48 hours per week |
| 20 | Quarterly Reports | 4 | ea | $2,500.00 | $10,000 | |
| | | | | **Total** | **$1,156,364** | |
| 21 | Electron Donor Addition (injection) | 54,750 | lbs | $2.00 | **$109,500** | for year one and year two only |

**LOCKHEED MARTIN**
**Martin State Airport**
**Middle River, Maryland**
**Dump Road Area Site**
**Alternative G-4: Hydraulic Controls by Extraction, Extraction of HCA, Ex-Situ Treatment of Groundwater, Re-injection of Groundwater, Discharge to POTW, Monitoring, and LUCs**
**Operation and Maintenance Cost for Years 6 through 10**

| | Item | Quantity | Unit | Unit Cost | Subtotal | Notes |
|---|---|---|---|---|---|---|
| **Treatment System per year** | | | | | | |
| 1 | Energy - Electric | 778,000 | kWh | $0.12 | $93,360 | |
| 2 | System Maintenance | 1 | ls | $103,544 | $103,544 | 5% of Installed Equipment Cost |
| 3 | Liquid Phase GAC Replacement | 12,000 | lbs | $2.00 | $24,000 | |
| 4 | Vapor Phase GAC Replacement | 72,000 | lbs | $2.00 | $144,000 | |
| 5 | PPI Zeolite Replacement | 54,000 | lbs | $2.25 | $121,500 | |
| 6 | PPI Zeolite Disposal | 27.0 | ton | $66.00 | $1,782 | assume non-hazardous |
| 7 | Treatment Plant Chemicals | | | | | |
| | a) Hydrogen Peroxide - Fe/Mn Oxidation (9 lbs/day) | 6,570 | lbs | $2.00 | $13,140 | |
| | b) NaOH (165 lbs/day) | 120,450 | lbs | $0.35 | $42,158 | |
| | c) Polymer (5 lbs/day) | 3,285 | lbs | $1.00 | $3,285 | |
| | d) Hydrochloric Acid (17 lbs/day) | 12,045 | lbs | $0.80 | $9,636 | |
| | e) Hydrogen Peroxide - HiPOx (1.6 gal/day) | 1,561 | gal | $3.50 | $5,463 | |
| 8 | Sludge Disposal | 130 | ton | $65.00 | $8,450 | 4,000 cf per year @ 70 lb/cf |
| 9 | Sanitary Sewer Fees | 0 | 1K cf | $35.89 | $0 | 1,000 cubic feet @ $35.89 |
| 10 | Sanitary Sewer Annual Fees | 0 | year | $3,000.00 | $0 | |
| 11 | Sanitary Sewer Analysis | 0 | ea | $450.00 | $0 | |
| 12 | NPDES Analysis | 12 | ea | $350.00 | $4,200 | monthly sampling @ 1 location |
| 13 | Ion Exchange Replacement | | | | | |
| | a) tanks | 1 | year | $18,000.00 | $18,000 | |
| | b) resin | 1 | year | $26,250.00 | $26,250 | |
| 14 | Cartridge Filters, 25 micron | 196 | ea | $3.91 | $766 | |
| 15 | Process Monitoring (VOCs, 1,4-D, metals), Aqueous | 48 | ea | $350.00 | $16,800 | monthly sampling @ 4 locations |
| 16 | Process Monitoring (VOCs ), Vapor | 36 | ea | $150.00 | $5,400 | monthly sampling @ 3 locations |
| 17 | Potable Water | 50,000 | gal | $0.20 | $10,000 | |
| 18 | Miscellaneous Services (sanitation, rubbish) | 1 | ls | $1,000.00 | $1,000 | |
| 19 | Treatment Plant Operator | 2,496 | hours | $65.00 | $162,240 | 48 hours per week |
| 20 | Quarterly Reports | 4 | ea | $2,500.00 | $10,000 | |
| | | | | **Total** | **$824,974** | |

**LOCKHEED MARTIN**
**Martin State Airport**
**Middle River, Maryland**
**Dump Road Area Site**
**Alternative G-4: Hydraulic Controls by Extraction, Extraction of HCA, Ex-Situ Treatment of Groundwater, Re-injection of Groundwater, Discharge to POTW, Monitoring, and LUCs**
**Operation and Maintenance Cost for Years 11 through 30**

| | Item | Quantity | Unit | Unit Cost | Subtotal | Notes |
|---|---|---|---|---|---|---|
| **Treatment System per year** | | | | | | |
| 1 | Energy - Electric | 778,000 | kWh | $0.12 | $93,360 | |
| 2 | System Maintenance | 1 | ls | $103,544 | $103,544 | 5% of Installed Equipment Cost |
| 3 | Liquid Phase GAC Replacement | 8,000 | lbs | $2.00 | $16,000 | |
| 4 | Vapor Phase GAC Replacement | 48,000 | lbs | $2.00 | $96,000 | |
| 5 | PPI Zeolite Replacement | 36,000 | lbs | $2.25 | $81,000 | |
| 6 | PPI Zeolite Disposal | 18 | ton | $66.00 | $1,188 | assume non-hazardous |
| 7 | Treatment Plant Chemicals | | | | | |
| | a) Hydrogen Peroxide - Fe/Mn Oxidation (6 lbs/day) | 4,380 | lbs | $2.00 | $8,760 | |
| | b) NaOH (110 lbs/day) | 80,300 | lbs | $0.35 | $28,105 | |
| | c) Polymer (3 lbs/day) | 2,190 | lbs | $1.00 | $2,190 | |
| | d) Hydrochloric Acid (11 lbs/day) | 8,030 | lbs | $0.80 | $6,424 | |
| | e) Hydrogen Peroxide - HiPOx (1.0 gal/day) | 1,041 | gal | $3.50 | $3,642 | |
| 8 | Sludge Disposal | 88 | ton | $65.00 | $5,720 | 4,000 cf per year @ 70 lb/cf |
| 9 | Sanitary Sewer Fees | 0 | 1K cf | $35.89 | $0 | 1,000 cubic feet @ $35.89 |
| 10 | Sanitary Sewer Annual Fees | 0 | year | $3,000.00 | $0 | |
| 11 | Sanitary Sewer Analysis | 0 | ea | $450.00 | $0 | |
| 12 | NPDES Analysis | 12 | ea | $350.00 | $4,200 | monthly sampling @ 1 location |
| 13 | Ion Exchange Replacement | | | | | |
| | a) tanks | 1 | year | $12,000.00 | $12,000 | |
| | b) resin | 1 | year | $17,500.00 | $17,500 | |
| 14 | Cartridge Filters, 25 micron | 130 | ea | $3.91 | $508 | |
| 15 | Process Monitoring (VOCs, 1,4-D, metals), Aqueous | 48 | ea | $350.00 | $16,800 | monthly sampling @ 4 locations |
| 16 | Process Monitoring (VOCs ), Vapor | 36 | ea | $150.00 | $5,400 | monthly sampling @ 3 locations |
| 17 | Potable Water | 50,000 | gal | $0.20 | $10,000 | |
| 18 | Miscellaneous Services (sanitation, rubbish) | 1 | ls | $1,000.00 | $1,000 | |
| 19 | Treatment Plant Operator | 2,496 | hours | $65.00 | $162,240 | 48 hours per week |
| 20 | Quarterly Reports | 4 | ea | $2,500.00 | $10,000 | |
| | | | | **Total** | **$685,581** | |

**LOCKHEED MARTIN**
**Martin State Airport**
**Middle River, Maryland**
**Dump Road Area Site**

**Alternative G-4: Hydraulic Controls by Extraction, Extraction of HCA, Ex-Situ Treatment of Groundwater, Re-injection of Groundwater, Discharge to POTW, Monitoring, and LUCs**
**Annual Cost**

| Item | Item Cost year 1 | Item Cost years 2 - 3 | Item Cost years 4 - 30 | Notes |
|---|---|---|---|---|
| Site Inspection: Visit | $1,620 | $1,620 | $1,620 | One-day visit to verify LUC RD |
| Site Inspection: Report | $1,680 | $1,680 | $1,680 | |
| Groundwater Sampling | $57,440 | $28,720 | $14,360 | Labor and supplies to collect samples from 40 wells using a crew of two, quarterly year 1, semi-annual years 2 & 3, annual years 4-30. |
| Groundwater Sampling Analysis/Water | $61,600 | $30,800 | $15,400 | Analyze groundwater samples |
| Sampling Report | $33,600 | $16,800 | $8,400 | |
| **TOTAL** | **$155,940** | **$79,620** | **$41,460** | |

**LOCKHEED MARTIN**
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**Middle River, Maryland**

**Alternative G-4: Hydraulic Controls by Extraction, Extraction of HCA, Ex-Situ Treatment of Groundwater, Re-injection of Groundwater, Discharge to POTW, Monitoring, and LUCs**
**Present Worth Analysis**

| Year | Capital Cost | Operation & Maintenance Cost | Annual Cost | Total Year Cost | Annual Discount Rate at 7% | Present Worth | Current Value 2% inflation |
|---|---|---|---|---|---|---|---|
| 0 | $13,029,368 | | | $13,029,368 | 1.000 | $13,029,368 | 13,029,368 |
| 1 | | $1,265,864 | $155,940 | $1,421,804 | 0.935 | $1,329,387 | 1,450,240 |
| 2 | | $1,265,864 | $79,620 | $1,345,484 | 0.873 | $1,174,608 | 1,399,842 |
| 3 | | $1,156,364 | $79,620 | $1,235,984 | 0.816 | $1,008,563 | 1,311,636 |
| 4 | | $1,156,364 | $41,460 | $1,197,824 | 0.763 | $913,940 | 1,296,563 |
| 5 | | $1,156,364 | $41,460 | $1,197,824 | 0.713 | $854,049 | 1,322,494 |
| 6 | | $824,974 | $41,460 | $866,434 | 0.666 | $577,045 | 975,745 |
| 7 | | $824,974 | $41,460 | $866,434 | 0.623 | $539,788 | 995,260 |
| 8 | | $824,974 | $41,460 | $866,434 | 0.582 | $504,264 | 1,015,165 |
| 9 | | $824,974 | $41,460 | $866,434 | 0.544 | $471,340 | 1,035,469 |
| 10 | | $824,974 | $41,460 | $866,434 | 0.508 | $440,148 | 1,056,178 |
| 11 | | $685,581 | $41,460 | $727,041 | 0.475 | $345,345 | 903,984 |
| 12 | | $685,581 | $41,460 | $727,041 | 0.444 | $322,806 | 922,064 |
| 13 | | $685,581 | $41,460 | $727,041 | 0.415 | $301,722 | 940,505 |
| 14 | | $685,581 | $41,460 | $727,041 | 0.388 | $282,092 | 959,316 |
| 15 | | $685,581 | $41,460 | $727,041 | 0.362 | $263,189 | 978,502 |
| 16 | | $685,581 | $41,460 | $727,041 | 0.339 | $246,467 | 998,072 |
| 17 | | $685,581 | $41,460 | $727,041 | 0.317 | $230,472 | 1,018,033 |
| 18 | | $685,581 | $41,460 | $727,041 | 0.296 | $215,204 | 1,038,394 |
| 19 | | $685,581 | $41,460 | $727,041 | 0.277 | $201,390 | 1,059,162 |
| 20 | | $685,581 | $41,460 | $727,041 | 0.258 | $187,577 | 1,080,345 |
| 21 | | $685,581 | $41,460 | $727,041 | 0.242 | $175,944 | 1,101,952 |
| 22 | | $685,581 | $41,460 | $727,041 | 0.226 | $164,311 | 1,123,991 |
| 23 | | $685,581 | $41,460 | $727,041 | 0.211 | $153,406 | 1,146,471 |
| 24 | | $685,581 | $41,460 | $727,041 | 0.197 | $143,227 | 1,169,400 |
| 25 | | $685,581 | $41,460 | $727,041 | 0.184 | $133,776 | 1,192,788 |
| 26 | | $685,581 | $41,460 | $727,041 | 0.172 | $125,051 | 1,216,644 |
| 27 | | $685,581 | $41,460 | $727,041 | 0.161 | $117,054 | 1,240,977 |
| 28 | | $685,581 | $41,460 | $727,041 | 0.150 | $109,056 | 1,265,796 |
| 29 | | $685,581 | $41,460 | $727,041 | 0.141 | $102,513 | 1,291,112 |
| 30 | | $685,581 | $41,460 | $727,041 | 0.131 | $95,242 | 1,316,935 |
| | | $23,837,314 | $1,434,600 | | | | 46,852,405 |

**TOTAL PRESENT WORTH** **$24,758,344**

## Dump Road Area Groundwater Containment System Design Costs

| | |
|---|---|
| Feasibility Study Level Capital Costs (Excluding Contingency) | $10,100,286 |
| Total Design Costs @ 9% of FS Level Capital Costs *(excluding contingency)* | $909,026 |
| 30% Design Cost (Procurement EESHBDF-02384_R631) @ 26% of Line 6 | $236,347 |
| 60% Design Cost @ 44% of line 6 | $399,971 |
| 90% Design Cost @ 20% of line 6 | $181,805 |
| 100% Design Cost @ 10% of line 6 | $90,903 |

## ALTERNATIVE F-5:

## HYDRAULIC CONTROLS BY EXTRACTION, EX-SITU TREATMENT OF GROUNDWATER, IN-SITU BIOREMEDIATION OF HCA, DISCHARGE TO POTW, MONITORING, AND LUCS

**LOCKHEED MARTIN**
**Martin State Airport**
**Middle River, Maryland**
**Dump Road Area Site**
**Alternative G-5: Hydraulic Controls by Extraction, Ex-Situ Treatment of Groundwater, In-Situ Bioremediation of HCA, Discharge to POTW, Monitoring, and LUCs**
**Capital Cost**

10/20/2010 11:09 AM

| Item | Quantity | Unit | Unit Cost Subcontract | Unit Cost Material | Unit Cost Labor | Unit Cost Equipment | Extended Cost Subcontract | Extended Cost Material | Extended Cost Labor | Extended Cost Equipment | Subtotal |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1 PROJECT PLANNING & DOCUMENTS** | | | | | | | | | | | |
| 1.1 Bench Testing | 1 | ls | $30,000.00 | | | | $30,000 | $0 | $0 | $0 | $30,000 |
| 1.2 Land Finders Fee | 1 | ls | $100,000.00 | | | | $100,000 | $0 | $0 | $0 | $100,000 |
| **2 MOBILIZATION AND DEMOBILIZATION** | | | | | | | | | | | |
| 2.1 Site Support Facilities (trailers, phone, electric, etc.) | 1 | ls | | $1,000.00 | | $3,500.00 | $0 | $1,000 | $0 | $3,500 | $4,500 |
| 2.2 Equipment Mobilization/Demobilization | | | | | | | | $50,000 | $30,000 | $50,000 | $130,000 |
| **3 FIELD SUPPORT AND SITE ACCESS** | | | | | | | | | | | |
| 3.1 Office Trailer | 12 | mo | | | | $360.00 | $0 | $0 | $0 | $4,320 | $4,320 |
| 3.2 Field Office Equipment, Utilities, & Support | 12 | mo | | $470.00 | | | $0 | $5,640 | $0 | $0 | $5,640 |
| 3.3 Storage Trailer | 12 | mo | | | | $92.50 | $0 | $0 | $0 | $1,110 | $1,110 |
| 3.4 Survey Support | 15 | day | $1,075.00 | | | | $16,125 | $0 | $0 | $0 | $16,125 |
| 3.5 Site Superintendent | 252 | day | | $164.00 | $384.64 | | $0 | $41,328 | $96,929 | $0 | $138,257 |
| 3.5.1 Resident Engineering (1.5 persons) | 0 | day | | $164.00 | $307.68 | | $0 | $0 | $0 | $0 | $0 |
| 3.6 Site Health & Safety and QA/QC | 252 | day | | $164.00 | $307.68 | | $0 | $41,328 | $77,535 | $0 | $118,863 |
| 3.7 Underground Utility Clearance | 1 | ls | $10,000.00 | | | | $10,000 | $0 | $0 | $0 | $10,000 |
| 3.8 Access Road & Parking | 500 | sy | | $15.50 | $1.05 | $1.94 | $0 | $7,750 | $525 | $970 | $9,245 |
| 3.9 Clearing and Grubbing | 3 | acre | $10,000.00 | | | | $30,000 | $0 | $0 | $0 | $30,000 |
| 3.10 Directional Drill Under Taxiway Tango | 1 | ls | $50,000.00 | | | | $50,000 | $0 | $0 | $0 | $50,000 |
| **4 DECONTAMINATION** | | | | | | | | | | | |
| 4.1 Decontamination Services | 12 | mo | | $1,220.00 | $2,245.00 | $1,550.00 | $0 | $14,640 | $26,940 | $18,600 | $60,180 |
| 4.2 Temporary Equipment Decon Pad | 1 | ls | | $1,500.00 | $2,000.00 | $300.00 | $0 | $1,500 | $2,000 | $300 | $3,800 |
| 4.3 Decon Water | 2,000 | gal | | $0.20 | | | $0 | $400 | $0 | $0 | $400 |
| 4.4 Decon Water Storage Tank, 6,000 gallon | 12 | mo | | | | $771.00 | $0 | $0 | $0 | $9,252 | $9,252 |
| 4.5 Clean Water Storage Tank, 4,000 gallon | 12 | mo | | | | $693.00 | $0 | $0 | $0 | $8,316 | $8,316 |
| 4.6 Disposal of Decon Waste (liquid & solid) | 12 | mo | $985.00 | | | | $11,820 | $0 | $0 | $0 | $11,820 |
| **5 EXTRACTION SYSTEM** | | | | | | | | | | | |
| 5.1 Install Extraction Wells, 16 wells | 930 | lf | $100.00 | | | | $93,000 | $0 | $0 | $0 | $93,000 |
| 5.1.1 Well Development (1 day/well) | 16 | days | $1,500.00 | $164.00 | $307.68 | | $24,000 | $2,624 | $4,923 | $0 | $31,547 |
| 5.2 Extraction Well Head/Vault (incl controls and other det | 16 | ea | $5,000.00 | | | | $80,000 | $0 | $0 | $0 | $80,000 |
| 5.3 Insulate/Heat Trace Well Head, 16 wells | 160 | lf | | $5.87 | $3.89 | | $0 | $939 | $622 | $0 | $1,562 |
| 5.4 Submersible Pump w/ Controls, 0.5 hp | 16 | ea | | $1,000.00 | $236.00 | | $0 | $16,000 | $3,776 | $0 | $19,776 |
| 5.5 Well Piping, 1" dia. PVC Sch 80 | 930 | lf | | $1.70 | $3.25 | | $0 | $1,581 | $3,023 | $0 | $4,604 |
| 5.6 Pump Station | 1 | ea | | $30,000.00 | $1,800.00 | $400.00 | $0 | $30,000 | $1,800 | $400 | $32,200 |
| 5.7 Pump Station Pumps, 100 gpm, 3 hp | 2 | ea | | $883.20 | $210.00 | | $0 | $1,766 | $420 | $0 | $2,186 |
| 5.8 Transfer Piping, 1" dia. PVC Sch 80, Double Wall | 0 | lf | | $12.44 | $15.69 | | $0 | $0 | $0 | $0 | $0 |
| 5.9 Transfer Piping Fittings, 1" dia. PVC Sch 80, Double W | 0 | ea | | $124.40 | $156.90 | | $0 | $0 | $0 | $0 | $0 |
| 5.10 Transfer Piping Valves, 1" dia. PVC Ball | 0 | ea | | $30.30 | $18.10 | | $0 | $0 | $0 | $0 | $0 |
| 5.11 Transfer Piping, 2" dia. PVC Sch 80, Double Wall | 400 | lf | | $20.23 | $20.88 | | $0 | $8,092 | $8,352 | $0 | $16,444 |
| 5.12 Transfer Piping Fittings, 2" dia. PVC Sch 80, Double W | 128 | ea | | $202.30 | $208.80 | | $0 | $25,894 | $26,726 | $0 | $52,621 |
| 5.13 Transfer Piping Valves, 2" dia. PVC Ball | 64 | ea | | $70.50 | $24.50 | | $0 | $4,512 | $1,568 | $0 | $6,080 |
| 5.14 Transfer Piping, 4" dia. PVC Sch 80, Double Wall | 4,050 | lf | | $22.14 | $31.72 | | $0 | $89,667 | $128,466 | $0 | $218,133 |
| 5.15 Transfer Piping Fittings, 4" dia. PVC Sch 80, Double W | 128 | ea | | $221.40 | $317.20 | | $0 | $28,339 | $40,602 | $0 | $68,941 |
| 5.16 Transfer Piping Valves, 4" dia. PVC Ball | 4 | ea | | $610.00 | $37.50 | | $0 | $2,440 | $150 | $0 | $2,590 |
| 5.17 Backhoe/Loader | 40 | day | | | $343.60 | $387.60 | $0 | $0 | $13,744 | $15,504 | $29,248 |
| 5.18 Site Labor (3 laborers) | 120 | day | | | $264.80 | | $0 | $0 | $31,776 | $0 | $31,776 |
| **6 TREATMENT SYSTEM** | | | | | | | | | | | |
| 6.1 Equipment Building, 155' by 65' | 10,075 | sf | $125.00 | | | | $1,259,375 | $0 | $0 | $0 | $1,259,375 |
| 6.2 Property Acquisition | 26,875 | sf | $20.00 | | | | $537,500 | $0 | $0 | $0 | $537,500 |
| 6.3 Equipment Building Foundation | 256 | cy | $400.00 | | | | $102,400 | $0 | $0 | $0 | $102,400 |
| 6.4 Water Supply Pipe, 2" Polyetheylene | 300 | lf | | $2.49 | $5.06 | $1.17 | $0 | $747 | $1,518 | $351 | $2,616 |
| 6.5 Water Supply Valves & Meters | 1 | ls | $3,000.00 | | | | $3,000 | $0 | $0 | $0 | $3,000 |
| 6.6 Feed Tank, 23,000 gallons | 1 | ea | | $30,000.00 | $3,200.00 | | $0 | $30,000 | $3,200 | $0 | $33,200 |
| 6.7 Feed Tank Foundation | 6 | cy | $400.00 | | | | $2,400 | $0 | $0 | $0 | $2,400 |
| 6.8 Feed Tank Mixer, 15 hp | 1 | ea | | $8,200.00 | $1,465.00 | | $0 | $8,200 | $1,465 | $0 | $9,665 |
| 6.9 Feed Pump, 100 gpm, 1.5 hp | 2 | ea | | $883.20 | $210.00 | | $0 | $1,766 | $420 | $0 | $2,186 |
| 6.10 Piping, 2" PVC Sch 80 | 300 | lf | | $3.93 | $13.65 | | $0 | $1,179 | $4,095 | $0 | $5,274 |
| 6.11 Pipe Fittings, 2" PVC Sch 80 | 50 | ea | | $39.30 | $136.50 | | $0 | $1,965 | $6,825 | $0 | $8,790 |
| 6.12 Piping Valves, 2" dia. PVC Ball | 20 | ea | | $76.50 | $24.50 | | $0 | $1,530 | $490 | $0 | $2,020 |
| 6.13 Piping, 4" PVC Sch 80 | 1,600 | lf | | $11.15 | $16.30 | | $0 | $17,840 | $26,080 | $0 | $43,920 |
| 6.14 Pipe Fittings, 4" PVC Sch 80 | 300 | ea | | $111.50 | $163.00 | | $0 | $33,450 | $48,900 | $0 | $82,350 |
| 6.15 Piping Valves, 4" dia. PVC Butterfly | 120 | ea | | $733.26 | $43.00 | | $0 | $87,991 | $5,160 | $0 | $93,151 |
| 6.16 Piping, 6" PVC Sch 80 | 100 | lf | | $24.50 | $19.75 | | $0 | $2,450 | $1,975 | $0 | $4,425 |
| 6.17 Pipe Fittings, 6" PVC Sch 80 | 10 | ea | | $245.00 | $197.50 | | $0 | $2,450 | $1,975 | $0 | $4,425 |
| 6.18 Piping Valves, 6" dia. PVC Butterfly | 5 | ea | | $879.94 | $65.00 | | $0 | $4,400 | $325 | $0 | $4,725 |
| 6.19 Air Stripper Piping | 100 | lf | | $29.40 | $19.75 | | $0 | $2,940 | $1,975 | $0 | $4,915 |
| 6.20 Air Stripper Fittings | 20 | ea | | $352.80 | $197.50 | | $0 | $7,056 | $3,950 | $0 | $11,006 |
| 6.21 Air Stripper Valves | 10 | ea | | $1,055.93 | $65.00 | | $0 | $10,559 | $650 | $0 | $11,209 |
| *Metals Removal Package* | 1 | ls | | $347,000.00 | $134,032.50 | | $0 | $347,000 | $134,033 | $0 | $481,033 |
| - Primary pH Adjustment Tank, 1,100 gallons | 1 | ea | | | | | | | | | |
| - Primary pH Adjustment Tank Mixer, 0.5 hp | 1 | ea | | | | | | | | | |
| - Secondary pH Adjustment Tank, 1,100 gallons | 1 | ea | | | | | | | | | |
| - Secondary pH Adjustment Tank Mixer, 0.5 hp | 1 | ea | | | | | | | | | |
| - H2O2 Feed System, 32 lb/day | 1 | ea | | | | | | | | | |
| - NaOH Feed System, 38 lb/day; 8 gal/day | 1 | ea | | | | | | | | | |
| - Floc Tank, 770 gallons | 1 | ea | | | | | | | | | |
| - Floc Mixer, 0.5 hp | 1 | ea | | | | | | | | | |
| - Polymer Feed system, 10 lb/day | 1 | ea | | | | | | | | | |
| - Clarifier, 3,700 gallons | 1 | ea | | | | | | | | | |
| - Sludge Transfer Pump, 15 gpm, AODD | 2 | ea | | | | | | | | | |
| - Final pH Adjustment Tank, 1,500 gallons | 1 | ea | | | | | | | | | |
| - Final pH Adjustment Tank Mixer, 1 hp | 1 | ea | | | | | | | | | |
| - Acid (HCl) Feed System, 35 lb/day: 10 gal/day | 1 | ea | | | | | | | | | |
| - Clarified Water Feed Tank, 1,100 gallons | 1 | ea | | | | | | | | | |
| - SF Feed Pump, 80 gpm, 5 hp | 2 | ea | | | | | | | | | |
| - Sand Filter, 2.5' dia. by 6' high | 3 | ea | | | | | | | | | |
| - Cartridges Filters, 10 micron | 2 | ea | | | | | | | | | |
| - Thickener, 14' dia. by 12' high | 1 | ea | | | | | | | | | |
| - FP Feed Pump, 80 gpm, AODD | 2 | ea | | | | | | | | | |
| 6.22 - Filter Press, 130 cf | 1 | ea | | | | | | | | | |
| 6.23 Air Stripper, 6 Tray, 850 cfm | 1 | ea | | $55,000.00 | $4,000.00 | | $0 | $55,000 | $4,000 | $0 | $59,000 |
| 6.24 Air Stripper Effluent Pump, 100 gpm, 3 hp | 2 | ea | | $883.20 | $210.00 | | $0 | $1,766 | $420 | $0 | $2,186 |
| 6.25 Vapor-Phase GAC System | 2 | ea | | $8,000.00 | $1,200.00 | | $0 | $16,000 | $2,400 | $0 | $18,400 |
| 6.26 PPI Zeolite System | 2 | ea | | $3,000.00 | $500.00 | | $0 | $6,000 | $1,000 | $0 | $7,000 |
| 6.27 HiPOx System | 1 | ea | | $380,000.00 | $1,360.00 | | $0 | $380,000 | $1,360 | $0 | $381,360 |
| 6.28 Ion Exchange System, 60 cf resin; 450 gallons | 2 | ea | | $2,700.00 | $0.00 | | $0 | $5,400 | $0 | $0 | $5,400 |
| 6.29 Liquid Phase GAC System, 8,000 lbs. | 2 | ea | | $42,000.00 | $2,076.00 | | $0 | $84,000 | $4,152 | $0 | $88,152 |
| 6.30 Backwash Supply Tank, 5,000 gallons | 1 | ea | | $7,500.00 | $750.00 | | $0 | $7,500 | $750 | $0 | $8,250 |
| 6.31 Backwash Supply Tank Foundation | 3 | cy | $400.00 | | | | $1,200 | $0 | $0 | $0 | $1,200 |
| 6.32 Backwash Pump, 40 gpm, 1 hp | 2 | ea | | $735.00 | $122.00 | | $0 | $1,470 | $244 | $0 | $1,714 |
| 6.33 Waste Backwash Tank, 5,000 gallon | 1 | ea | | $7,500.00 | $750.00 | | $0 | $7,500 | $750 | $0 | $8,250 |
| 6.34 Waste Backwash Tank Foundation | 3 | cy | $400.00 | | | | $1,200 | $0 | $0 | $0 | $1,200 |
| 6.35 Waste Backwash Transfer Pump, 1 gpm, 0.5 hp | 2 | ea | | $339.60 | $84.00 | | $0 | $679 | $168 | $0 | $847 |
| 6.36 Filtrate Tank, 9,000 gallons | 1 | ea | | $13,500.00 | $1,410.00 | | $0 | $13,500 | $1,410 | $0 | $14,910 |
| 6.37 Filtrate Tank Foundation | 4 | cy | $400.00 | | | | $1,600 | $0 | $0 | $0 | $1,600 |
| 6.38 Filtrate Tank Mixer, 7.5 hp | 1 | ea | | $6,300.00 | $1,240.00 | | $0 | $6,300 | $1,240 | $0 | $7,540 |
| 6.39 Filtrate Transfer Pump, 30 gpm, 0.5 hp | 2 | ea | | $499.00 | $96.00 | | $0 | $998 | $192 | $0 | $1,190 |
| 6.40 Air Compressor System, 50 scfm, 100 psi | 1 | ea | | $8,900.00 | $1,450.00 | | $0 | $8,900 | $1,450 | $0 | $10,350 |
| 6.41 Sump Pump, 10 gpm, 0.5 hp | 2 | ea | | $283.20 | $83.50 | | $0 | $566 | $167 | $0 | $733 |
| 6.42 Discharge Pump Tank, 1,500 gallons | 1 | ea | | $3,000.00 | $450.00 | | $0 | $3,000 | $450 | $0 | $3,450 |
| 6.43 Discharge Pump, 100 gpm, 2 hp | 2 | ea | | $535.20 | $133.00 | | $0 | $1,070 | $266 | $0 | $1,336 |
| 6.44 ED Tank, 500 gallon | 1 | ea | | $1,225.00 | $311.40 | | $0 | $1,225 | $311 | $0 | $1,536 |
| 6.45 ED Tank Mixer & Stand, 0.5 hp | 1 | ea | | $1,666.00 | $415.20 | | $0 | $1,666 | $415 | $0 | $2,081 |
| 6.46 ED Feed Pump, 4 gallons/hr | 2 | ea | | $1,500.00 | $415.20 | | $0 | $3,000 | $830 | $0 | $3,830 |
| 6.47 Discharge Pipe (POTW and SW), 4" Polyetheylene | 800 | lf | | $11.00 | $16.00 | $1.17 | $0 | $8,800 | $12,800 | $936 | $22,536 |
| 6.48 Outfall Diffuser | 1 | ls | $50,000.00 | | | | $50,000 | $0 | $0 | $0 | $50,000 |
| 6.49 Utility Service Line | 1 | ls | | $59,808.50 | $15,691.40 | | $0 | $59,809 | $15,691 | $0 | $75,500 |
| 6.50 Electrical and Controls | 1 | ls | | $286,083.76 | $176,543.40 | | $0 | $286,084 | $176,543 | $0 | $462,627 |
| 6.51 System Start-Up and Testing | 1 | ls | | $3,000.00 | $65,550.00 | | $0 | $3,000 | $65,550 | $0 | $68,550 |
| **7 MONITORING WELL INSTALLATION** | | | | | | | | | | | |
| 7.1 Well Installation (4 wells) | 290 | lf | $45.00 | | | | $13,050 | $0 | $0 | $0 | $13,050 |
| 7.2 Protective Well Casing & Apron | 4 | ea | $750.00 | | | | $3,000 | $0 | $0 | $0 | $3,000 |
| **8 INJECTION WELLS - ISB** | | | | | | | | | | | |
| 8.1 Well Installation | 12,250 | lf | $45.00 | | | | $551,250 | $0 | $0 | $0 | $551,250 |
| 8.2 Protective Well Casing & Apron | 530 | ea | $125.00 | | | | $66,250 | $0 | $0 | $0 | $66,250 |

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**Capital Cost**

| | Item | Quantity | Unit | Unit Cost Subcontract | Unit Cost Material | Unit Cost Labor | Unit Cost Equipment | Extended Cost Subcontract | Extended Cost Material | Extended Cost Labor | Extended Cost Equipment | Subtotal |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8.3 | Injection Labor and Equipment | 14 | day | | | $794.40 | $200.00 | $0 | $0 | $11,122 | $2,800 | $13,922 |
| 8.4 | EOS | 1 | ls | | $320,000.00 | | | $0 | $320,000 | $0 | $0 | $320,000 |
| **9** | **WASTE DISPOSAL** | | | | | | | | | | | |
| 9.1 | Decon Fluids | 1,100 | gal | $1.00 | | | | $1,100 | $0 | $0 | $0 | $1,100 |
| 9.2 | Well Development Water (5,000 gal/well) | 80,000 | gal | $1.00 | | | | $80,000 | $0 | $0 | $0 | $80,000 |
| 9.3 | Drill Cuttings (12-inch dia boreholes, non-haz) | 25 | cy | $100.00 | | | | $2,500 | $0 | $0 | $0 | $2,500 |
| 9.4 | Soil Excavate (2700 lf, 3'x4' trench, non-haz) | 880 | cy | $100.00 | | | | $88,000 | $0 | $0 | $0 | $88,000 |
| **10** | **IMPORTED CLEAN FILL** | | | | | | | | | | | |
| 10.1 | Import and place clean backfill | 880 | cy | $25.00 | | | | $22,000 | $0 | $0 | $0 | $22,000 |
| 10.2 | Stabilize and restore disturbed areas (3 acres) | 10,600 | sy | $8.00 | | | | $84,800 | $0 | $0 | $0 | $84,800 |

| | | | | | |
|---|---|---|---|---|---|
| **Subtotal** | $3,315,570 | $2,220,198 | $1,046,595 | $116,359 | $6,698,723 |
| Overhead on Labor Cost @ 30% | | | $313,979 | | $313,979 |
| G & A on Labor, Material, Equipment, & Subs Cost @ 10% | $331,557 | $222,020 | $104,660 | $11,636 | $669,872 |
| Tax on Materials and Equipment Cost @ 6% | | $133,212 | | $6,982 | $140,193 |
| **Total Direct Cost** | $3,647,127 | $2,575,430 | $1,465,233 | $134,976 | $7,822,767 |
| Indirects on Total Direct Cost @ 25% | | | | | $1,955,692 |
| Profit on Total Direct Cost @ 10% | | | | | $782,277 |
| **Subtotal** | | | | | $10,560,736 |
| Health & Safety Monitoring @ 2% | | | | | $211,215 |
| **Subtotal** | | | | | $10,771,950 |
| Record Drawings and Completion Report 1% | | | | | $107,720 |
| **Feasibility Study Level Costs** | | | | | $10,879,670 |
| Design Cost | | | | | $870,374 |
| Engineering Contingency 20% | | | | | $2,175,934 |

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**Operation and Maintenance Cost for Years 1 through 5**

| | Item | Quantity | Unit | Unit Cost | Subtotal | Notes |
|---|---|---|---|---|---|---|
| **Treatment System per year** | | | | | | |
| 1 | Energy - Electric | 563,000 | kWh | $0.12 | $67,560 | |
| 2 | System Maintenance | 1 | ls | $100,541 | $100,541 | 5% of Installed Equipment Cost |
| 3 | Liquid Phase GAC Replacement | 8,000 | lbs | $2.00 | $16,000 | |
| 4 | Vapor Phase GAC Replacement | 48,000 | lbs | $2.00 | $96,000 | |
| 5 | PPI Zeolite Replacement | 36,000 | lbs | $2.25 | $81,000 | |
| 6 | PPI Zeolite Disposal | 18 | ton | $66.00 | $1,188 | assume non-hazardous |
| 7 | Treatment Plant Chemicals | | | | | |
| | a) Hydrogen Peroxide - Fe/Mn Oxidation (12 lbs/day) | 4,380 | lbs | $2.00 | $8,760 | |
| | b) NaOH (220 lbs/day) | 80,300 | lbs | $0.35 | $28,105 | |
| | c) Polymer (6 lbs/day) | 2,190 | lbs | $1.00 | $2,190 | |
| | d) Hydrochloric Acid (22 lbs/day) | 8,030 | lbs | $0.80 | $6,424 | |
| | e) Hydrogen Peroxide - HiPOx (2.1 gal/day) | 1,059 | gal | $3.50 | $3,705 | |
| 8 | Sludge Disposal | 86 | ton | $65.00 | $5,590 | 4,000 cf per year @ 70 lb/cf |
| 9 | Sanitary Sewer Fees | 3513 | 1K cf | $35.89 | $126,082 | 1,000 cubic feet @ $35.89 |
| 10 | Sanitary Sewer Annual Fees | 1 | year | $3,000.00 | $3,000 | |
| 11 | Sanitary Sewer Analysis | 2 | ea | $450.00 | $900 | |
| 12 | NPDES Analysis | 0 | ea | $350.00 | $0 | monthly sampling @ 1 location |
| 13 | Ion Exchange Replacement | | | | | |
| | a) tanks | 0 | year | $24,000.00 | $0 | |
| | b) resin | 0 | year | $35,000.00 | $0 | |
| 14 | Cartridge Filters, 25 micron | 0 | ea | $3.91 | $0 | |
| 15 | Process Monitoring (VOCs, 1,4-D, metals), Aqueous | 48 | ea | $350.00 | $16,800 | monthly sampling @ 4 locations |
| 16 | Process Monitoring (VOCs ), Vapor | 36 | ea | $150.00 | $5,400 | monthly sampling @ 3 locations |
| 17 | Potable Water | 50,000 | gal | $0.20 | $10,000 | |
| 18 | Miscellaneous Services (sanitation, rubbish) | 1 | ls | $1,000.00 | $1,000 | |
| 19 | Treatment Plant Operator | 2,496 | hours | $65.00 | $162,240 | 48 hours per week |
| 20 | Quarterly Reports | 4 | ea | $2,500.00 | $10,000 | |
| | | | | **Total** | **$752,484** | |
| 21 | Re-Application of EOS for Year 5 | 1 | ls | $233,745.00 | **$233,745** | |

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**Operation and Maintenance Cost for Years 6 through 10**

| | Item | Quantity | Unit | Unit Cost | Subtotal | Notes |
|---|---|---|---|---|---|---|
| **Treatment System per year** | | | | | | |
| 1 | Energy - Electric | 563,000 | kWh | $0.12 | $67,560 | |
| 2 | System Maintenance | 1 | ls | $100,541 | $100,541 | 5% of Installed Equipment Cost |
| 3 | Liquid Phase GAC Replacement | 6,000 | lbs | $2.00 | $12,000 | |
| 4 | Vapor Phase GAC Replacement | 36,000 | lbs | $2.00 | $72,000 | |
| 5 | PPI Zeolite Replacement | 27,000 | lbs | $2.25 | $60,750 | |
| 6 | PPI Zeolite Disposal | 13.5 | ton | $66.00 | $891 | assume non-hazardous |
| 7 | Treatment Plant Chemicals | | | | | |
| | a) Hydrogen Peroxide - Fe/Mn Oxidation (9 lbs/day) | 3,285 | lbs | $2.00 | $6,570 | |
| | b) NaOH (165 lbs/day) | 60,225 | lbs | $0.35 | $21,079 | |
| | c) Polymer (5 lbs/day) | 1,643 | lbs | $1.00 | $1,643 | |
| | d) Hydrochloric Acid (17 lbs/day) | 6,023 | lbs | $0.80 | $4,818 | |
| | e) Hydrogen Peroxide - HiPOx (1.6 gal/day) | 794 | gal | $3.50 | $2,779 | |
| 8 | Sludge Disposal | 65 | ton | $65.00 | $4,225 | 4,000 cf per year @ 70 lb/cf |
| 9 | Sanitary Sewer Fees | 0 | 1K cf | $35.89 | $0 | 1,000 cubic feet @ $35.89 |
| 10 | Sanitary Sewer Annual Fees | 0 | year | $3,000.00 | $0 | |
| 11 | Sanitary Sewer Analysis | 0 | ea | $450.00 | $0 | |
| 12 | NPDES Analysis | 12 | ea | $350.00 | $4,200 | monthly sampling @ 1 location |
| 13 | Ion Exchange Replacement | | | | | |
| | a) tanks | 1 | year | $18,000.00 | $18,000 | |
| | b) resin | 1 | year | $26,250.00 | $26,250 | |
| 14 | Cartridge Filters, 25 micron | 98 | ea | $3.91 | $383 | |
| 15 | Process Monitoring (VOCs, 1,4-D, metals), Aqueous | 48 | ea | $350.00 | $16,800 | monthly sampling @ 4 locations |
| 16 | Process Monitoring (VOCs ), Vapor | 36 | ea | $150.00 | $5,400 | monthly sampling @ 3 locations |
| 17 | Potable Water | 50,000 | gal | $0.20 | $10,000 | |
| 18 | Miscellaneous Services (sanitation, rubbish) | 1 | ls | $1,000.00 | $1,000 | |
| 19 | Treatment Plant Operator | 2,496 | hours | $65.00 | $162,240 | 48 hours per week |
| 20 | Quarterly Reports | 4 | ea | $2,500.00 | $10,000 | |
| | | | | **Total** | **$609,128** | |

**LOCKHEED MARTIN**
**Martin State Airport**
**Middle River, Maryland**
**Dump Road Area Site**
**Alternative G-5: Hydraulic Controls by Extraction, Ex-Situ Treatment of Groundwater, In-Situ Bioremediation of HCA, Discharge to POTW, Monitoring, and LUCs**
**Operation and Maintenance Cost for Years 11 through 30**

| | Item | Quantity | Unit | Unit Cost | Subtotal | Notes |
|---|---|---|---|---|---|---|
| **Treatment System per year** | | | | | | |
| 1 | Energy - Electric | 563,000 | kWh | $0.12 | $67,560 | |
| 2 | System Maintenance | 1 | ls | $100,541 | $100,541 | 5% of Installed Equipment Cost |
| 3 | Liquid Phase GAC Replacement | 4,000 | lbs | $2.00 | $8,000 | |
| 4 | Vapor Phase GAC Replacement | 24,000 | lbs | $2.00 | $48,000 | |
| 5 | PPI Zeolite Replacement | 18,000 | lbs | $2.25 | $40,500 | |
| 6 | PPI Zeolite Disposal | 9 | ton | $66.00 | $594 | assume non-hazardous |
| 7 | Treatment Plant Chemicals | | | | | |
| | a) Hydrogen Peroxide - Fe/Mn Oxidation (6 lbs/day) | 2,190 | lbs | $2.00 | $4,380 | |
| | b) NaOH (110 lbs/day) | 40,150 | lbs | $0.35 | $14,053 | |
| | c) Polymer (3 lbs/day) | 1,095 | lbs | $1.00 | $1,095 | |
| | d) Hydrochloric Acid (11 lbs/day) | 4,015 | lbs | $0.80 | $3,212 | |
| | e) Hydrogen Peroxide - HiPOx (1.0 gal/day) | 529 | gal | $3.50 | $1,852 | |
| 8 | Sludge Disposal | 43 | ton | $65.00 | $2,795 | 4,000 cf per year @ 70 lb/cf |
| 9 | Sanitary Sewer Fees | 0 | 1K cf | $35.89 | $0 | 1,000 cubic feet @ $35.89 |
| 10 | Sanitary Sewer Annual Fees | 0 | year | $3,000.00 | $0 | |
| 11 | Sanitary Sewer Analysis | 0 | ea | $450.00 | $0 | |
| 12 | NPDES Analysis | 12 | ea | $350.00 | $4,200 | monthly sampling @ 1 location |
| 13 | Ion Exchange Replacement | | | | | |
| | a) tanks | 1 | year | $12,000.00 | $12,000 | |
| | b) resin | 1 | year | $17,500.00 | $17,500 | |
| 14 | Cartridge Filters, 25 micron | 65 | ea | $3.91 | $254 | |
| 15 | Process Monitoring (VOCs, 1,4-D, metals), Aqueous | 48 | ea | $350.00 | $16,800 | monthly sampling @ 4 locations |
| 16 | Process Monitoring (VOCs ), Vapor | 36 | ea | $150.00 | $5,400 | monthly sampling @ 3 locations |
| 17 | Potable Water | 50,000 | gal | $0.20 | $10,000 | |
| 18 | Miscellaneous Services (sanitation, rubbish) | 1 | ls | $1,000.00 | $1,000 | |
| 19 | Treatment Plant Operator | 2,496 | hours | $65.00 | $162,240 | 48 hours per week |
| 20 | Quarterly Reports | 4 | ea | $2,500.00 | $10,000 | |
| | | | | **Total** | **$531,976** | |

**LOCKHEED MARTIN**
**Martin State Airport**
**Middle River, Maryland**
**Dump Road Area Site**

**Alternative G-5: Hydraulic Controls by Extraction, Ex-Situ Treatment of Groundwater, In-Situ Bioremediation of HCA, Discharge to POTW, Monitoring, and LUCs**
**Annual Cost**

| Item | Item Cost year 1 | Item Cost years 2 - 3 | Item Cost years 4 - 30 | Notes |
|---|---|---|---|---|
| Site Inspection: Visit | $1,620 | $1,620 | $1,620 | One-day visit to verify LUC RD |
| Site Inspection: Report | $1,680 | $1,680 | $1,680 | |
| Groundwater Sampling | $57,440 | $28,720 | $14,360 | Labor and supplies to collect samples from 40 wells using a crew of two, quarterly year 1, semi-annual years 2 & 3, annual years 4-30. |
| Groundwater Sampling Analysis/Water | $61,600 | $30,800 | $15,400 | Analyze groundwater samples |
| Sampling Report | $33,600 | $16,800 | $8,400 | |
| **TOTAL** | **$155,940** | **$79,620** | **$41,460** | |

**LOCKHEED MARTIN**
**Martin State Airport**
**Dump Road Area Site**
**Middle River, Maryland**
**Alternative G-5: Hydraulic Controls by Extraction, Ex-Situ Treatment of Groundwater, In-Situ Bioremediation of HCA, Discharge to POTW, Monitoring, and LUCs**
**Present Worth Analysis**

| Year | Capital Cost | Operation & Maintenance Cost | Annual Cost | Total Year Cost | Annual Discount Rate at 7% | Present Worth | Current Value 2% inflation |
|---|---|---|---|---|---|---|---|
| 0 | $13,925,977 | | | $13,925,977 | 1.000 | $13,925,977 | 13,925,977 |
| 1 | | $986,229 | $155,940 | $1,142,169 | 0.935 | $1,067,928 | 1,165,013 |
| 2 | | $986,229 | $79,620 | $1,065,849 | 0.873 | $930,487 | 1,108,910 |
| 3 | | $752,484 | $79,620 | $832,104 | 0.816 | $678,997 | 883,036 |
| 4 | | $752,484 | $41,460 | $793,944 | 0.763 | $605,780 | 859,391 |
| 5 | | $752,484 | $41,460 | $793,944 | 0.713 | $566,082 | 876,579 |
| 6 | | $609,128 | $41,460 | $650,588 | 0.666 | $433,292 | 732,668 |
| 7 | | $609,128 | $41,460 | $650,588 | 0.623 | $405,316 | 747,321 |
| 8 | | $609,128 | $41,460 | $650,588 | 0.582 | $378,642 | 762,268 |
| 9 | | $609,128 | $41,460 | $650,588 | 0.544 | $353,920 | 777,513 |
| 10 | | $609,128 | $41,460 | $650,588 | 0.508 | $330,499 | 793,063 |
| 11 | | $531,976 | $41,460 | $573,436 | 0.475 | $272,382 | 712,996 |
| 12 | | $531,976 | $41,460 | $573,436 | 0.444 | $254,606 | 727,256 |
| 13 | | $531,976 | $41,460 | $573,436 | 0.415 | $237,976 | 741,801 |
| 14 | | $531,976 | $41,460 | $573,436 | 0.388 | $222,493 | 756,637 |
| 15 | | $531,976 | $41,460 | $573,436 | 0.362 | $207,584 | 771,770 |
| 16 | | $531,976 | $41,460 | $573,436 | 0.339 | $194,395 | 787,205 |
| 17 | | $531,976 | $41,460 | $573,436 | 0.317 | $181,779 | 802,949 |
| 18 | | $531,976 | $41,460 | $573,436 | 0.296 | $169,737 | 819,008 |
| 19 | | $531,976 | $41,460 | $573,436 | 0.277 | $158,842 | 835,388 |
| 20 | | $531,976 | $41,460 | $573,436 | 0.258 | $147,947 | 852,096 |
| 21 | | $531,976 | $41,460 | $573,436 | 0.242 | $138,772 | 869,138 |
| 22 | | $531,976 | $41,460 | $573,436 | 0.226 | $129,597 | 886,521 |
| 23 | | $531,976 | $41,460 | $573,436 | 0.211 | $120,995 | 904,251 |
| 24 | | $531,976 | $41,460 | $573,436 | 0.197 | $112,967 | 922,336 |
| 25 | | $531,976 | $41,460 | $573,436 | 0.184 | $105,512 | 940,783 |
| 26 | | $531,976 | $41,460 | $573,436 | 0.172 | $98,631 | 959,598 |
| 27 | | $531,976 | $41,460 | $573,436 | 0.161 | $92,323 | 978,790 |
| 28 | | $531,976 | $41,460 | $573,436 | 0.150 | $86,015 | 998,366 |
| 29 | | $531,976 | $41,460 | $573,436 | 0.141 | $80,854 | 1,018,333 |
| 30 | | $531,976 | $41,460 | $573,436 | 0.131 | $75,120 | 1,038,700 |
| | | $17,915,075 | $1,434,600 | | | | 39,955,659 |

**TOTAL PRESENT WORTH $22,765,447**

## Dump Road Area Groundwater Containment System Design Costs

| | |
|---|---|
| Feasibility Study Level Capital Costs (Excluding Contingency) | $10,879,670 |
| Total Design Costs @ 8% of FS Level Capital Costs *(excluding contingency)* | $870,374 |
| 30% Design Cost (Procurement EESHBDF-02384_R631) @ 26% of Line 6 | $226,297 |
| 60% Design Cost @ 44% of line 6 | $382,964 |
| 90% Design Cost @ 20% of line 6 | $174,075 |
| 100% Design Cost @ 10% of line 6 | $87,037 |

## ALTERNATIVE F-6:

## ZVI-PRB, MONITORING, AND LUCS [NO GROUNDWATER TREATMENT]

**LOCKHEED MARTIN**
**Martin State Airport**
**Middle River, Maryland**
**Dump Road Area Site**
**Alternative G-6: ZVI-PRB, Monitoring, and LUCs [No groundwater treatment]**
**Capital Cost**

| | Item | Quantity | Unit | Unit Cost Subcontract | Unit Cost Material | Unit Cost Labor | Unit Cost Equipment | Extended Cost Subcontract | Extended Cost Material | Extended Cost Labor | Extended Cost Equipment | Subtotal |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1** | **PROJECT PLANNING & DOCUMENTS** | | | | | | | | | | | |
| 1.1 | Bench Testing | 1 | ls | $38,000.00 | | | | $38,000 | $0 | $0 | $0 | $38,000 |
| 1.2 | Land Finders Fee | 1 | ls | $100,000.00 | | | | $100,000 | $0 | $0 | $0 | $100,000 |
| **2** | **MOBILIZATION AND DEMOBILIZATION** | | | | | | | | | | | |
| 2.1 | Site Support Facilities (trailers, phone, electric, etc.) | 1 | ls | | $1,000.00 | | $3,500.00 | $0 | $1,000 | $0 | $3,500 | $4,500 |
| 2.2 | Equipment Mobilization/Demobilization | | | | | | | | $60,000 | $30,000 | $60,000 | $150,000 |
| **3** | **FIELD SUPPORT AND SITE ACCESS** | | | | | | | | | | | |
| 3.1 | Office Trailer | 9 | mo | | | | $360.00 | $0 | $0 | $0 | $3,240 | $3,240 |
| 3.2 | Field Office Equipment, Utilities, & Support | 9 | mo | | $470.00 | | | $0 | $4,230 | $0 | $0 | $4,230 |
| 3.3 | Storage Trailer | 9 | mo | | | | $92.50 | $0 | $0 | $0 | $833 | $833 |
| 3.4 | Survey Support | 10 | day | $1,075.00 | | | | $10,750 | $0 | $0 | $0 | $10,750 |
| 3.5 | Site Superintendent | 189 | day | | $164.00 | $384.64 | | $0 | $30,996 | $72,697 | $0 | $103,693 |
| 3.5.1 | Resident Engineering (1.5 persons) | 0 | day | | $164.00 | $307.68 | | $0 | $0 | $0 | $0 | $0 |
| 3.6 | Site Health & Safety and QA/QC | 189 | day | | $164.00 | $307.68 | | $0 | $30,996 | $58,152 | $0 | $89,148 |
| 3.7 | Underground Utility Clearance | 1 | ls | $10,000.00 | | | | $10,000 | $0 | $0 | $0 | $10,000 |
| 3.8 | Access Road & Parking | 500 | sy | | $15.50 | $1.05 | $1.94 | $0 | $7,750 | $525 | $970 | $9,245 |
| 3.9 | Clearing and Grubbing | 1 | acre | $10,000.00 | | | | $10,000 | $0 | $0 | $0 | $10,000 |
| 3.10 | Directional Drill Under Taxiway Tango | 0 | ls | $50,000.00 | | | | $0 | $0 | $0 | $0 | $0 |
| **4** | **DECONTAMINATION** | | | | | | | | | | | |
| 4.1 | Decontamination Services | 3 | mo | | $1,220.00 | $2,245.00 | $1,550.00 | $0 | $3,660 | $6,735 | $4,650 | $15,045 |
| 4.2 | Temporary Equipment Decon Pad | 1 | ls | | $1,500.00 | $2,000.00 | $300.00 | $0 | $1,500 | $2,000 | $300 | $3,800 |
| 4.3 | Decon Water | 3,000 | gal | | $0.20 | | | $0 | $600 | $0 | $0 | $600 |
| 4.4 | Decon Water Storage Tank, 6,000 gallon | 3 | mo | | | | $771.00 | $0 | $0 | $0 | $2,313 | $2,313 |
| 4.5 | Clean Water Storage Tank, 4,000 gallon | 3 | mo | | | | $693.00 | $0 | $0 | $0 | $2,079 | $2,079 |
| 4.6 | Disposal of Decon Waste (liquid & solid) | 3 | mo | $985.00 | | | | $2,955 | $0 | $0 | $0 | $2,955 |
| **5** | **MONITORING WELL INSTALLATION** | | | | | | | | | | | |
| 5.1 | Well Installation (15 wells) | 2,700 | lf | $45.00 | | | | $121,500 | $0 | $0 | $0 | $121,500 |
| 5.2 | Protective Well Casing & Apron | 15 | ea | $750.00 | | | | $11,250 | $0 | $0 | $0 | $11,250 |
| **6** | **PRB Installation** | | | | | | | | | | | |
| 6.1 | Subcontractor Labor & Equipment | 1 | ls | $2,440,000.00 | | | | $2,440,000 | $0 | $0 | $0 | $2,440,000 |
| 6.2 | PRB Materials | 2,080 | ton | | $750.00 | | | $0 | $1,560,000 | $0 | $0 | $1,560,000 |
| 6.3 | Field Oversight | 100 | day | $414.00 | | | | $41,400 | $0 | $0 | $0 | $41,400 |
| 6.4 | Waste Characterization | 30 | ea | $785.00 | $30.00 | $50.00 | $30.00 | $23,550 | $900 | $1,500 | $900 | $26,850 |
| 6.5 | Waste Transportation and Disposal, Subtitle C | 5,200 | ton | $235.00 | | | | $1,222,000 | $0 | $0 | $0 | $1,222,000 |
| 6.6 | Topsoil, 4" thick | 55 | cy | | $23.00 | $1.68 | $4.21 | $0 | $1,265 | $92 | $232 | $1,589 |
| 6.7 | Seed Area | 4,840 | sy | $3.48 | | | | $16,843 | $0 | $0 | $0 | $16,843 |
| 6.8 | License Fee - 12% | 1 | ls | $484,968.00 | | | | $484,968 | $0 | $0 | $0 | $484,968 |
| **7** | **WASTE DISPOSAL (other than PRB)** | | | | | | | | | | | |
| 7.1 | Decon Fluids | 1,000 | gal | $1.00 | | | | $1,000 | $0 | $0 | $0 | $1,000 |
| 7.2 | Well Development Water (5,000 gal/well) | 75,000 | gal | $1.00 | | | | $75,000 | $0 | $0 | $0 | $75,000 |
| 7.3 | Drill Cuttings (12-inch dia boreholes, non-haz) | 24 | cy | $100.00 | | | | $2,400 | $0 | $0 | $0 | $2,400 |

| | | | | | |
|---|---|---|---|---|---|
| **Subtotal** | $4,611,616 | $1,702,897 | $171,701 | $79,016 | $6,565,230 |
| Overhead on Labor Cost @ 30% | | | $51,510 | | $51,510 |
| G & A on Labor, Material, Equipment, & Subs Cost @ 10% | $461,162 | $170,290 | $17,170 | $7,902 | $656,523 |
| Tax on Materials and Equipment Cost @ 6% | | $102,174 | | $4,741 | $106,915 |
| **Total Direct Cost** | $5,072,778 | $1,975,361 | $240,381 | $91,659 | $7,380,178 |
| Indirects on Total Direct Cost @ 25% | | | | | $1,845,045 |
| Profit on Total Direct Cost @ 10% | | | | | $738,018 |
| **Subtotal** | | | | | $9,963,241 |
| Health & Safety Monitoring @ 2% | | | | | $199,265 |
| **Subtotal** | | | | | $10,162,505 |
| Record Drawings and Completion Report 1% | | | | | $101,625 |
| **Feasibility Study Level Costs** | | | | | $10,264,130 |
| Design Cost | | | | | $923,772 |
| Engineering Contingency 20% | | | | | $2,052,826 |

**LOCKHEED MARTIN**
**Martin State Airport**
**Middle River, Maryland**
**Dump Road Area Site**
**Alternative G-6: ZVI-PRB, Monitoring, and LUCs [No groundwater treatment]**
**Capital Cost**

| Item | Quantity | Unit | Unit Cost Subcontract | Unit Cost Material | Unit Cost Labor | Unit Cost Equipment | Extended Cost Subcontract | Extended Cost Material | Extended Cost Labor | Extended Cost Equipment | Subtotal |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1 PROJECT PLANNING & DOCUMENTS** | | | | | | | | | | | |
| 1.1 Bench Testing | 1 | ls | $38,000.00 | | | | $38,000 | $0 | $0 | $0 | $38,000 |
| 1.2 Land Finders Fee | 1 | ls | $100,000.00 | | | | $100,000 | $0 | $0 | $0 | $100,000 |
| **2 MOBILIZATION AND DEMOBILIZATION** | | | | | | | | | | | |
| 2.1 Site Support Facilities (trailers, phone, electric, etc.) | 1 | ls | | $1,000.00 | | $3,500.00 | $0 | $1,000 | $0 | $3,500 | $4,500 |
| 2.2 Equipment Mobilization/Demobilization | | | | | | | | $60,000 | $30,000 | $60,000 | $150,000 |
| **3 FIELD SUPPORT AND SITE ACCESS** | | | | | | | | | | | |
| 3.1 Office Trailer | 9 | mo | | | | $360.00 | $0 | $0 | $0 | $3,240 | $3,240 |
| 3.2 Field Office Equipment, Utilities, & Support | 9 | mo | | $470.00 | | | $0 | $4,230 | $0 | $0 | $4,230 |
| 3.3 Storage Trailer | 9 | mo | | | | $92.50 | $0 | $0 | $0 | $833 | $833 |
| 3.4 Survey Support | 10 | day | $1,075.00 | | | | $10,750 | $0 | $0 | $0 | $10,750 |
| 3.5 Site Superintendent | 189 | day | | $164.00 | $384.64 | | $0 | $30,996 | $72,697 | $0 | $103,693 |
| 3.5.1 Resident Engineering (1.5 persons) | 0 | day | | $164.00 | $307.68 | | $0 | $0 | $0 | $0 | $0 |
| 3.6 Site Health & Safety and QA/QC | 189 | day | | $164.00 | $307.68 | | $0 | $30,996 | $58,152 | $0 | $89,148 |
| 3.7 Underground Utility Clearance | 1 | ls | $10,000.00 | | | | $10,000 | $0 | $0 | $0 | $10,000 |
| 3.8 Access Road & Parking | 500 | sy | | $15.50 | $1.05 | $1.94 | $0 | $7,750 | $525 | $970 | $9,245 |
| 3.9 Clearing and Grubbing | 1 | acre | $10,000.00 | | | | | | | | $10,000 |
| 3.10 Directional Drill Under Taxiway Tango | 0 | ls | $50,000.00 | | | | | | | | $0 |
| **4 DECONTAMINATION** | | | | | | | | | | | |
| 4.1 Decontamination Services | 3 | mo | | $1,220.00 | $2,245.00 | $1,550.00 | $0 | $3,660 | $6,735 | $4,650 | $15,045 |
| 4.2 Temporary Equipment Decon Pad | 1 | ls | | $1,500.00 | $2,000.00 | $300.00 | $0 | $1,500 | $2,000 | $300 | $3,800 |
| 4.3 Decon Water | 3,000 | gal | | $0.20 | | | $0 | $600 | $0 | $0 | $600 |
| 4.4 Decon Water Storage Tank, 6,000 gallon | 3 | mo | | | | $771.00 | $0 | $0 | $0 | $2,313 | $2,313 |
| 4.5 Clean Water Storage Tank, 4,000 gallon | 3 | mo | | | | $693.00 | $0 | $0 | $0 | $2,079 | $2,079 |
| 4.6 Disposal of Decon Waste (liquid & solid) | 3 | mo | $985.00 | | | | $2,955 | $0 | $0 | $0 | $2,955 |
| **5 MONITORING WELL INSTALLATION** | | | | | | | | | | | |
| 5.1 Well Installation (15 wells) | 2,700 | lf | $45.00 | | | | $121,500 | $0 | $0 | $0 | $121,500 |
| 5.2 Protective Well Casing & Apron | 15 | ea | $750.00 | | | | $11,250 | $0 | $0 | $0 | $11,250 |
| **6 PRB Installation** | | | | | | | | | | | |
| 6.1 Subcontractor Labor & Equipment | 1 | ls | $2,440,000.00 | | | | $2,440,000 | $0 | $0 | $0 | $2,440,000 |
| 6.2 PRB Materials | 2,080 | ton | | $750.00 | | | $0 | $1,560,000 | $0 | $0 | $1,560,000 |
| 6.3 Field Oversight | 100 | day | $414.00 | | | | $41,400 | $0 | $0 | $0 | $41,400 |
| 6.4 Waste Characterization | 30 | ea | $785.00 | $30.00 | $50.00 | $30.00 | $23,550 | $900 | $1,500 | $900 | $26,850 |
| 6.5 Waste Transportation and Disposal, Subtitle C | 5,200 | ton | $235.00 | | | | $1,222,000 | $0 | $0 | $0 | $1,222,000 |
| 6.6 Topsoil, 4" thick | 55 | cy | | $23.00 | $1.68 | $4.21 | $0 | $1,265 | $92 | $232 | $1,589 |
| 6.7 Seed Area | 4,840 | sy | $3.48 | | | | $16,843 | $0 | $0 | $0 | $16,843 |
| 6.8 License Fee - 12% | 1 | ls | $484,968.00 | | | | $484,968 | $0 | $0 | $0 | $484,968 |
| **7 WASTE DISPOSAL (other than PRB)** | | | | | | | | | | | |
| 7.1 Decon Fluids | 0 | gal | $1.00 | | | | $0 | $0 | $0 | $0 | $0 |
| 7.2 Well Development Water (5,000 gal/well) | 0 | gal | $1.00 | | | | $0 | $0 | $0 | $0 | $0 |
| 7.3 Drill Cuttings (12-inch dia boreholes, non-haz) | 0 | cy | $100.00 | | | | $0 | $0 | $0 | $0 | $0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Subtotal** | | $4,523,216 | $1,702,897 | $171,701 | $79,016 | $6,486,830 |
| Overhead on Labor Cost @ 30% | | | | $51,510 | | $51,510 |
| G & A on Labor, Material, Equipment, & Subs Cost @ 10% | | $452,322 | $170,290 | $17,170 | $7,902 | $647,683 |
| Tax on Materials and Equipment Cost @ 6% | | | $102,174 | | $4,741 | $106,915 |
| **Total Direct Cost** | | $4,975,538 | $1,975,361 | $240,381 | $91,659 | $7,282,938 |
| Indirects on Total Direct Cost @ 25% | | | | | | $1,820,735 |
| Profit on Total Direct Cost @ 10% | | | | | | $728,294 |
| **Subtotal** | | | | | | $9,831,967 |
| Health & Safety Monitoring @ 2% | | | | | | $196,639 |
| **Subtotal** | | | | | | $10,028,606 |
| Record Drawings and Completion Report 1% | | | | | | $100,286 |
| **Feasibility Study Level Costs** | | | | | | $10,128,892 |
| Engineering Contingency 20% | | | | | | $2,025,778 |

**LOCKHEED MARTIN**
**Martin State Airport**
**Middle River, Maryland**
**Dump Road Area Site**
**Alternative G-6: ZVI-PRB, Monitoring, and LUCs [No groundwater treatment]**

**Annual Cost**

| Item | Item Cost year 1 | Item Cost years 2 - 3 | Item Cost years 4 - 30 | Notes |
|---|---|---|---|---|
| Site Inspection: Visit | $1,620 | $1,620 | $1,620 | One-day visit to verify LUC RD |
| Site Inspection: Report | $1,680 | $1,680 | $1,680 | |
| Groundwater Sampling | $79,840 | $39,920 | $19,960 | Labor and supplies to collect samples from 40 wells using a crew of two, quarterly year 1, semi-annual years 2 & 3, annual years 4-30. |
| Groundwater Sampling Analysis/Water | $84,000 | $42,000 | $21,000 | Analyze groundwater samples |
| Sampling Report | $33,600 | $16,800 | $8,400 | |
| **TOTAL** | **$200,740** | **$102,020** | **$52,660** | |

**LOCKHEED MARTIN**
**Martin State Airport**
**Dump Road Area Site**
**Middle River, Maryland**

**Alternative G-6: ZVI-PRB, Monitoring, and LUCs [No groundwater treatment]**
**Present Worth Analysis**

| Year | Capital Cost | Operation & Maintenance Cost | Annual Cost | Total Year Cost | Annual Discount Rate at 7% | Present Worth | Current Value 2% inflation |
|---|---|---|---|---|---|---|---|
| 0 | $13,240,728 | | | $13,240,728 | 1.000 | $13,240,728 | 13,240,728 |
| 1 | | $25,000 | $200,740 | $225,740 | 0.935 | $211,067 | 230,255 |
| 2 | | $25,000 | $102,020 | $127,020 | 0.873 | $110,888 | 132,152 |
| 3 | | $25,000 | $102,020 | $127,020 | 0.816 | $103,648 | 134,795 |
| 4 | | $25,000 | $52,660 | $77,660 | 0.763 | $59,255 | 84,062 |
| 5 | | $100,000 | $52,660 | $152,660 | 0.713 | $108,847 | 168,549 |
| 6 | | $25,000 | $52,660 | $77,660 | 0.666 | $51,722 | 87,458 |
| 7 | | $25,000 | $52,660 | $77,660 | 0.623 | $48,382 | 89,207 |
| 8 | | $25,000 | $52,660 | $77,660 | 0.582 | $45,198 | 90,991 |
| 9 | | $25,000 | $52,660 | $77,660 | 0.544 | $42,247 | 92,811 |
| 10 | | $100,000 | $52,660 | $152,660 | 0.508 | $77,551 | 186,092 |
| 11 | | $25,000 | $52,660 | $77,660 | 0.475 | $36,889 | 96,560 |
| 12 | | $25,000 | $52,660 | $77,660 | 0.444 | $34,481 | 98,492 |
| 13 | | $25,000 | $52,660 | $77,660 | 0.415 | $32,229 | 100,461 |
| 14 | | $25,000 | $52,660 | $77,660 | 0.388 | $30,132 | 102,471 |
| 15 | | $12,154,670 | $52,660 | $12,207,330 | 0.362 | $4,419,054 | 16,429,459 |
| 16 | | $25,000 | $52,660 | $77,660 | 0.339 | $26,327 | 106,611 |
| 17 | | $25,000 | $52,660 | $77,660 | 0.317 | $24,618 | 108,743 |
| 18 | | $25,000 | $52,660 | $77,660 | 0.296 | $22,987 | 110,918 |
| 19 | | $25,000 | $52,660 | $77,660 | 0.277 | $21,512 | 113,136 |
| 20 | | $100,000 | $52,660 | $152,660 | 0.258 | $39,386 | 226,845 |
| 21 | | $25,000 | $52,660 | $77,660 | 0.242 | $18,794 | 117,707 |
| 22 | | $25,000 | $52,660 | $77,660 | 0.226 | $17,551 | 120,061 |
| 23 | | $25,000 | $52,660 | $77,660 | 0.211 | $16,386 | 122,462 |
| 24 | | $25,000 | $52,660 | $77,660 | 0.197 | $15,299 | 124,911 |
| 25 | | $100,000 | $52,660 | $152,660 | 0.184 | $28,089 | 250,455 |
| 26 | | $25,000 | $52,660 | $77,660 | 0.172 | $13,358 | 129,958 |
| 27 | | $25,000 | $52,660 | $77,660 | 0.161 | $12,503 | 132,557 |
| 28 | | $25,000 | $52,660 | $77,660 | 0.150 | $11,649 | 135,208 |
| 29 | | $25,000 | $52,660 | $77,660 | 0.141 | $10,950 | 137,912 |
| 30 | | $25,000 | $52,660 | $77,660 | 0.131 | $10,173 | 140,670 |
| | | $13,179,670 | $1,826,600 | | | | 33,442,694 |

**TOTAL PRESENT WORTH $18,941,901**

## Dump Road Area Groundwater Containment System Design Costs

| | |
|---|---|
| Feasibility Study Level Capital Costs (Excluding Contingency) | $10,264,130 |
| Total Design Costs @ 9% of FS Level Capital Costs *(excluding contingency)* | $923,772 |
| 30% Design Cost (Procurement EESHBDF-02384_R631) @ 26% of Line 6 | $240,181 |
| 60% Design Cost @ 44% of line 6 | $406,460 |
| 90% Design Cost @ 20% of line 6 | $184,754 |
| 100% Design Cost @ 10% of line 6 | $92,377 |

# PROPOSED PLAN

## Interim Remedial Action Groundwater Operable Unit at the Dump Road Area Site at Martin State Airport Middle River, Maryland

January 2012

LOCKHEED MARTIN

### INTRODUCTION

Lockheed Martin Corporation (Lockheed Martin) is seeking public comment on a Proposed Plan for the groundwater Interim Remedial Action (IRA) at the Dump Road Area (DRA) Site at Martin State Airport (MSA) in Middle River, Maryland. The primary goal of this interim action is to capture and treat the contaminated groundwater at the site before it reaches Frog Mortar Creek. This Proposed Plan is the recommended alternative for achieving this goal, and consists of the following:

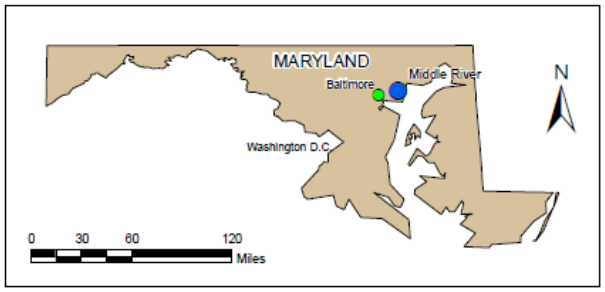
- Extraction of groundwater;
- *Ex situ* treatment (an action that will be accomplished above ground) using a water treatment facility to clean groundwater;
- Reinjection of treated groundwater in high concentration areas;
- Discharge of treated water to the publicly owned treatment works (POTW) or to surface water;
- Monitoring; and
- Land use controls.

The public is invited to provide written comments on the Proposed Plan between February 8 and March 8, 2012.

This Proposed Plan fact sheet includes a description of the Martin State Airport site and a summary of investigations conducted at the site. This document is based on the *Interim Remedial Action – Feasibility Study for the Groundwater Operable Unit at the Dump Road Area Site at Martin State Airport, Middle River, Maryland, Tetra Tech, October 2010* (Groundwater FS). Also included is a discussion on the Remedial Action Objectives (RAOs) for the site, and a summary of the alternatives evaluated for the site cleanup. A detailed description of the preferred alternative is presented at the end of this document.

### PURPOSE OF THE PREFERRED ALTERNATIVE

The preferred alternative meets the Interim Remedial Action goal in that it captures and treats trichloroethene (TCE), 1,4-dioxane, and other site contaminants before groundwater reaches Frog Mortar Creek. This approach also will provide for additional groundwater extraction and treatment, if it is needed in the future.

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**PUBLIC COMMENT PERIOD – FEBRUARY 8 – March 8, 2012**

**PUBLIC MEETING – FEBRUARY 8, 2012**

# PROPOSED PLAN

**Interim Remedial Action**
**Groundwater Operable Unit at the**
**Dump Road Area Site at Martin State Airport**
**Middle River, Maryland**

January 2012

LOCKHEED MARTIN




## SITE DESCRIPTION

Martin State Airport (MSA) is located at 701 Wilson Point Road in Middle River, Maryland, and is bounded by Frog Mortar Creek to the east and Stansbury Creek to the west. Both creeks join the Chesapeake Bay at the southern side of the airport. The Dump Road Area (DRA) Site is on the southeast portion of Martin State Airport, and is bounded by Frog Mortar Creek to the east and Taxiway Tango and the main airport runway to the west. See the figure to the left for a site wide aerial photograph.

## SITE HISTORY

Martin State Airport was owned and operated by the Glenn L. Martin Company (a predecessor firm of Martin Marietta Corporation, and Lockheed Martin) from approximately 1929 to 1975. The facility was originally used for aircraft manufacturing, which began in 1932. Runways and hangars were built in 1939–1940. The Glenn L. Martin Company consolidated with American Marietta Corporation in September 1961 to form Martin Marietta Corporation. Lockheed Corporation and Martin Marietta merged in 1996 to form Lockheed Martin Corporation. In July 1955, the Maryland Air National Guard (MDANG) began leasing a portion of the property from the Glenn L. Martin Company. In September 1975, the Maryland Aviation Administration (MAA) purchased the land now used as the airfield.




Environmental issues associated with the Dump Road Area Site were initially identified in July 1991, when the Maryland Aviation Administration encountered four drums adjacent to Taxiway Tango during trenching to install an electrical cable. These drums were subsequently disposed of properly in an off-site licensed landfill. The discovery of these buried drums led to an investigation of the surrounding area for possible soil and groundwater contamination. These investigations showed that the Dump Road Area Site had been used as a landfill for wastes associated with industrial activity.

The Maryland Aviation Administration (1991–1997) and Lockheed Martin (1998-present) performed several site investigations and/or sampling events to outline the extent of environmental contamination at the Dump Road Area Site. The early investigations identified four areas of concern:

- Taxiway Tango Median Anomaly
- Drum Area

- Two Existing Ponds
- Petroleum Hydrocarbon Area

These areas of concern were identified based on analyses of soil samples and observations of debris and waste material found at these locations. Site investigations have included monitoring well installation, soil and groundwater sampling, test pit excavations, and geophysical surveys. These investigations also identified the extent of historical landfilling and waste disposal. More than 540 groundwater samples were collected from 87 permanent monitoring wells, 125 temporary monitoring wells, and temporary groundwater sampling points. More than 320 soil samples were collected from approximately 180 borings and 65 test pits or trenches.

**HISTORICAL SITE INVESTIGATIONS**

This Proposed Plan is based on the Groundwater Feasibility Study conducted for the Dump Road Area Site at Martin State Airport. Included within the Feasibility Study were summaries of previous investigations, including a Remedial Investigation (RI).

The Remedial Investigation was conducted to define the lateral and vertical extent of landfill material and groundwater contamination and to provide the basis for remedial designs for the landfill area. The Remedial Investigation included an evaluation of the nature and extent of environmental contamination at the Dump Road Area Site, a human health risk assessment (HHRA), and an Ecological Risk Assessment (ERA). The results of the Remedial Investigation were used in the Groundwater Feasibility Study to establish current environmental conditions and to help choose an appropriate remedial action. A summary of the Remedial Investigation, including the Human Health Risk Assessment and the Ecological Risk Assessment, is presented below.

**Remedial Investigation Results for Groundwater**

Based on the extensive groundwater investigations at this site, TCE, cis-1,2-dichloroethene (DCE), vinyl chloride, and 1,4-dioxane were identified as primary groundwater chemicals of concern (COCs) because they are detected frequently throughout the site at concentrations significantly greater than their preliminary remediation goals (PRGs). Other chemicals detected above preliminary remediation goals, but less frequently, include cadmium and petroleum hydrocarbons. Preliminary remediation goals are concentrations that are established to be protective of human health and the environment.

The following is a summary of the nature and extent of the contamination in groundwater (for the primary chemicals of concern) at the Dump Road Area Site:

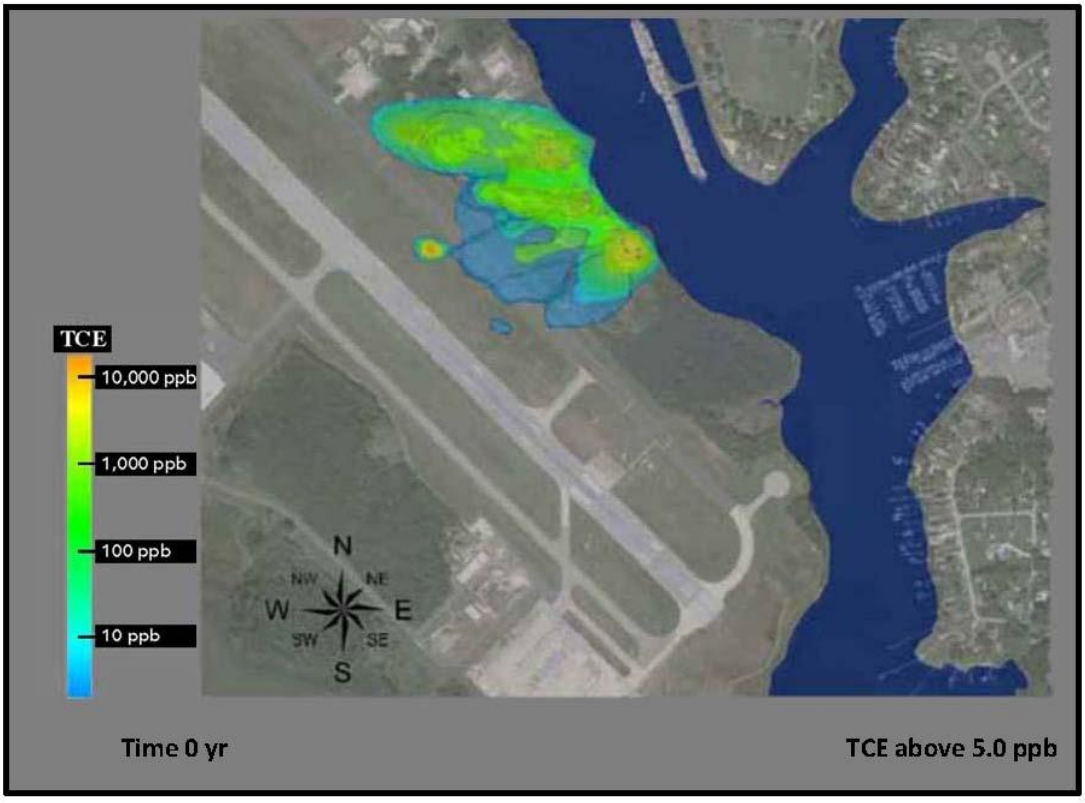
- Concentrations of chlorinated volatile organic compounds (cVOCs) such as TCE, cis-1,2-DCE, and vinyl chloride, which were commonly used in industrial processes in the past, exceeded federal and Maryland groundwater standards throughout a large portion of the investigation area and at multiple depths. The figure on the following page shows the groundwater TCE concentrations throughout the site; the other chlorinated volatile organic compounds listed above follow patterns similar to those seen for TCE.

- The compound 1,4-dioxane was primarily detected in groundwater samples from below the ground surface, down to 45 feet deep. It is generally present in areas containing the highest concentrations of chlorinated volatile organic compounds.

- Concentrations of cadmium exceeded the Maryland groundwater standards in 20 percent of samples. The greatest concentrations of cadmium are co-located with high levels of chlorinated volatile organic compounds from 15 feet to 45 feet below the ground surface.

- Petroleum-related compounds such as benzene, toluene, ethylbenzene, and xylenes (BTEX) were detected less frequently, and at lower concentrations with respect to groundwater standards, than the chlorinated volatile organic compounds.

Groundwater at the site generally flows eastward toward Frog Mortar Creek. Recent sampling in the creek has shown that contaminants such as TCE and vinyl chloride are detectable in the creek. The primary goal of this Interim Remedial Action is to capture and treat the contaminated groundwater before it reaches the creek.




**For** all the Interim Remedial Action (IRA) alternatives addressed in the Groundwater Feasibility Study (FS) (and thus this Proposed Plan), **the primary objective is containment.** Active remediation of groundwater with the highest contaminant concentrations would decrease the duration of containment. Therefore**, limited treatment of the high concentration areas was also considered** in developing some of the remedial alternatives in the Groundwater FS.

Further identification of high concentration areas is planned for 2012 and**,** if needed , additional active remediation of these areas may be added to the IRA at a later date.

**Human Health Risk Assessment**

A Human Health Risk Assessment (HHRA) was conducted in 2010 and included in the Remedial Investigation report. It used the Remedial Investigation results to evaluate the levels that would be necessary to negatively impact human health, and it considered whether people could be exposed to the groundwater contamination under current and likely future land uses. The Human Health Risk Assessment was conducted in accordance with U.S. Environmental Protection Agency (EPA) and Maryland Department of the Environment (MDE) guidelines. The Human Health Risk Assessment considered potential exposure under non-residential (e.g., industrial, recreational) land use scenarios. Although the site is not expected to be used for residential purposes in the foreseeable future, residential land uses also were evaluated to identify what cleanup goals may be required under all potential land uses.

Chemicals of potential concern (COPCs) identified in the Human Health Risk Assessment, based on direct contact exposure, are the following:

- chlorinated volatile organic compounds (via direct contact with soils, groundwater, and pond sediments),
- benzene, toluene, ethylbenzene and xylenes (via soils and groundwater),
- substituted benzene compounds (via soils and groundwater),
- polycyclic aromatic hydrocarbons, referred to as PAHs (via soils and pond sediments), and
- several heavy metals such as cadmium, lead, copper, chromium, nickel (via soils and groundwater).

Groundwater is not currently used as a source of drinking water (potable) or industrial water at the site, nor is such use likely in the future. A groundwater user survey indicated the possibility of wells near Martin State Airport, but these wells, if they exist, would be upgradient of Martin State Airport and would not be affected by any on-site contaminant sources. Groundwater remediation at this site is appropriate due to the risks identified in the Human Health Risk Assessment, and the presence of groundwater contaminants at concentrations greater than EPA and MDE standards.

Ingestion of groundwater at the Dump Road Area Site is expected to be limited to exposures that might occur under an unlikely future residential scenario. Incidental ingestion of groundwater by construction workers might occur during construction/excavation activities. Future workers and residents could be exposed to unacceptable concentrations of volatile organic compounds via vapor intrusion into buildings built over the contaminant plume. Trespassers/visitors could incidentally ingest surface water from the on-site ponds while on site. However,no chemicals of concern were detected in the pond water.

The Human Health Risk Assessment considered only on-site risk and did not specifically evaluate risk in Frog Mortar Creek. Recent surface water data has indicated that groundwater contaminants are likely moving to Frog Mortar Creek. More comprehensive surface water monitoring began in 2011, and monitoring will continue in 2012. The data will be used to conduct risk assessments to evaluate if any negative or undesirable effects to the creek are occurring.

**Ecological Risk Assessment**

An Ecological Risk Assessment also was conducted in 2010 as part of Remedial Investigation activities, in accordance with EPA guidelines, to evaluate risk to potential ecological receptors in surface soil, pond sediment, and groundwater. The central area of the site northwest of Pond No. 1 appears to be the area of greatest ecological risk, based on sampling data. Surface soil ecological chemicals of potential concern for invertebrates and plants include:

- TCE
- cis-1,2-DCE
- copper
- manganese
- antimony
- molybdenum
- chromium
- zinc

Additionally, polycyclic aromatic hydrocarbons are chemicals of potential concern only for soil invertebrates; and cadmium, lead, nickel, and selenium are chemicals of potential concern only for plants. Several metals (mercury, cadmium, lead, and molybdenum) in the surface soil were identified as risks to wildlife (e.g., quail, shrews, and robins). VOCs, PAHs, polychlorinated biphenyls (PCBs), and several metals in Pond No. 1 sediment were considered an ecological risk. For groundwater evaluated as surface water, several VOCs and metals exceeded criteria.

**REMEDIAL ACTION OBJECTIVES**

Remedial Action Objectives (RAOs) are goals that a cleanup plan should achieve. They were established during the Groundwater Feasibility Study, based on investigation data and risk assessments, to assist in the development of remedial alternatives for protection of human health and the environment. At the Dump Road Area Site, the following Remedial Action Objectives were developed for groundwater for the interim remedial action:

- Groundwater RAO No. 1 — Prevent lateral movement of contaminated groundwater toward Frog Mortar Creek.
- Groundwater RAO No. 2 — Prevent human exposure (by showering, drinking and irrigation) to groundwater containing chemical-of-concern concentrations greater than preliminary remediation goals.
- Groundwater RAO No. 3 — Prevent exposure of industrial workers, construction workers, and hypothetical residents to volatile organic compounds resulting from vapor intrusion from groundwater into buildings that cause unacceptable risk (defined as a total incremental lifetime cancer risk [ILCR] greater than $1 \times 10^{-5}$ [or one in 100,000], or a hazard index [HI] greater than 1).

In the Proposed Plan, RAO No. 1 will be met by the installation of the groundwater extraction and treatment system. RAO Nos. 2 and 3 will be met by land use controls such as limiting land use to industrial purposes, prohibiting residential use, and prohibiting surficial aquifer use for drinking and industrial purposes.

As part of Lockheed Martin's **"Go Green"** program, **sustainability** was a factor in selecting the recommended remedial alternative, and sustainability practices will be included in the design, installation, and operation of the IRA for groundwater.

Sustainability practices in general are those that consider economic and natural resources, ecology, human health and safety, quality of life, and reduction of the overall environmental "footprint."

**SUMMARY OF ALTERNATIVES**

Remedial alternatives, or cleanup options, that would meet the Remedial Action Objectives were identified in the Groundwater Feasibility Study and are summarized below. These alternatives are different combinations of methods or plans to restrict access and/or to contain, remove, or treat contamination, in order to protect human health and the environment.

- ***Alternative G-1*** **—** No action

  Alternative G-1 was developed and analyzed as a baseline against which the other alternatives can be compared, as required by the National Oil and Hazardous Substances Pollution Contingency Plan (NCP).

- ***Alternative G-2*** **—** Hydraulic control by extraction, *ex situ* treatment of groundwater, discharge to Baltimore County sanitary sewer or discharge to surface water, monitoring, and land use controls.

  Alternative G-2 was developed as a base case with hydraulic control of the plume only. Groundwater contaminants upgradient of the extraction wells will flow to the extraction wells. This design does not incorporate groundwater cleanup in the high concentration areas.

- ***Alternative G-3*** **—** Hydraulic control by extraction, *ex situ* treatment of groundwater, reinjection of groundwater, discharge to publicly owned treatment works or discharge to surface water, monitoring, and land use controls.

  Alternative G-3 is a modification to Alternative G-2, where a portion of the treated groundwater will be reinjected along with biodegradable chemicals in the high concentration areas to promote *in situ* biological remediation. The treatment system in this alternative is sized for a larger flow rate to address the potential for flexibility in future operations, including the final site groundwater remedy.

- ***Alternative G-4*** **—** Hydraulic control by extraction, extraction in high concentration areas, *ex situ* treatment of groundwater, reinjection of groundwater, discharge to publicly owned treatment works or discharge to surface water, monitoring, and land use controls.

  Alternative G-4 is an extraction and treatment approach similar to Alternative G-3 that includes additional extraction wells in the high concentration areas, along with reinjection of treated groundwater (with amendments to promote biological activity that degrades the contamination). Treating additional groundwater may reduce the time required to restore groundwater quality.

- ***Alternative G-5*** **—** Hydraulic control by extraction, *ex situ* treatment of groundwater, *in situ* bioremediation of high contaminated areas, discharge to publicly owned treatment works or discharge to surface water, monitoring, and land use controls.

  Alternative G-5 is similar to Alternative G-4 in that highly contaminated groundwater in the high concentration areas is treated. In Alternative G-5, highly contaminated groundwater in the high concentration areas is treated *in situ* by adding amendments to promote biological activity that degrades the contamination to reduce the time to restore groundwater quality, but extracted groundwater is not reinjected. The treatment system in this alternative is also sized for a larger flow rate to permit flexibility in future operations.

- ***Alternative G-6*** **—** Zero-valent iron (ZVI) permeable reactive barrier (PRB), monitoring, and land use controls.

  Alternative G-6 uses a permeable reactive barrier for passive treatment instead of a groundwater extraction and treatment system. A description and detailed analysis of all the listed alternatives **are** presented in the Groundwater Feasibility Study.

## What are the evaluation criteria used for selection of the alternative?

### Threshold Criteria (The selected remedy must satisfy these criteria):

**Overall Protection of Human Health and the Environment:** determines whether an alternative eliminates, reduces, or controls threats to public health and the environment.

**Compliance with Applicable or Relevant and Appropriate Requirements (ARARs):** evaluates whether the alternative meets federal and state environmental statutes, regulations, and other requirements that pertain to the site, or whether a waiver is justified.

### Balancing Criteria (These criteria are used to weigh the relative merits of the alternatives):

**Long-Term Effectiveness and Permanence:** considers the ability of an alternative to maintain the reduction of risk over the long-term.

**Reduction of Toxicity, Mobility, or Volume of Contaminants through Treatment:** evaluates an alternative's use of treatment to reduce the amount of contamination present, and to reduce the harmful effects of contaminants and their ability to move in the environment.

**Short-Term Effectiveness:** considers the length of time needed to implement an alternative, and the risk the alternative poses to workers, residents, and the environment during implementation.

**Implementability:** considers the technical and administrative feasibility of implementing the alternative.

**Sustainability:** incorporates the environmental (i.e. resource consumption and waste generation), economic and social effects of each alternative. The evaluation of sustainability is part of Lockheed Martin's 'Go Green' program.

**Cost:** includes estimated capital and annual operation and maintenance costs, as well as a net present worth cost. Present worth cost is the total cost of an alternative over time in terms of today's dollar value. Cost estimates are expected to be accurate within a range of +50 to -30 percent.

### Modifying Criteria (These criteria are also considered during evaluation and may require a modification to the Proposed Plan):

**Regulatory Acceptance:** Decisions by federal, state, and local regulatory agencies affecting aspects of the Proposed Plan will be incorporated as the project planning progresses.

**Community Acceptance** considers whether the local community agrees with the preferred alternative. Comments received on the Proposed Plan are an important indicator of community acceptance.

**COMPARISON OF GROUNDWATER ALTERNATIVES BY CRITERIA**

| Alternative | G-1 | G-2 | G-3 | G-4 | G-5 | G-6 |
|---|---|---|---|---|---|---|
| **Threshold Criteria** | | | | | | |
| Protects human health and the environment | ○ | ● | ● | ● | ● | ● |
| Meets federal and state ARARs | ○ | ● | ● | ● | ● | ● |
| **Balancing Criteria** | | | | | | |
| Provides long-term effectiveness and is permanent | ○ | ⊙ | ● | ● | ● | ⊙ |
| Reduces mobility, toxicity, and volume of contaminants through treatment | ○ | ● | ● | ● | ● | ⊙ |
| Provides short-term protection | ○ | ● | ● | ● | ● | ⊙ |
| Can be implemented | NA | ● | ● | ● | ● | ○ |
| Sustainability | ● | ⊙ | ⊙ | ⊙ | ⊙ | ● |
| Cost ($)<br>• Upfront cost to design and construct the alternative | NA | $12.0 M | $12.9 M | $13.1 M | $14.0 M | $13.3 M |
| • Net present worth of operating and maintaining the system associated with the alternative (30 years) | NA | $8.2 M | $8.6 M | $11.7 M | $8.8 M | $5.7 M |
| • **Total cost net present worth** | **NA** | **$20.2 M** | **$21.5 M** | **$24.8 M** | **$22.8 M** | **$19.0 M** |
| **Modifying Criteria** | | | | | | |
| **Regulatory** agency acceptance | | To be determined after the public comment period. | | | | |
| Community acceptance | | To be determined after the public comment period. | | | | |

Relative comparison of criteria and each alternative:

● – High, ⊙ – Medium, ○ – Low; NA – not applicable

Cost ($): M – million

**SELECTION OF PREFERRED GROUNDWATER ALTERNATIVE**

**Alternative G-3 (hydraulic control by extraction, ex situ treatment of groundwater, reinjection of groundwater, discharge to publicly owned treatment works or surface water, monitoring, and land use controls) was selected as the Proposed Plan for the Interim Remedial Action at the Dump Road Area site.** This alternative meets the primary Interim Remedial Action goal, as it provides for capture and treatment of the contaminated groundwater at the site before it reaches Frog Mortar Creek. It also provides additional groundwater treatment capacity so that the groundwater extraction system can be expanded in the future, particularly after the high concentration areas have been better defined, and the soil and landfill waste are fully managed.

The alternative also provides flexibility for expansion to include groundwater recirculation and *in situ* bioremediation in the high concentration areas to provide some additional destruction of chlorinated volatile organic compounds. Although rated similarly to Alternatives G-2, G-4, and G-5, this alternative provides the significant operational flexibility at a reasonable cost.

Alternative G-2 was not selected primarily because it offers too little flexibility for future operations if higher flow rates or extraction of groundwater from other areas is required. In addition, the overall time to meet preliminary remediation goals under Alternative G-2 is longer than G-3. Alternative G-6 was not selected because 1,4-dioxane and BTEX constituents would not be affected, and the level of metals treated is uncertain. Alternative G-6 has the highest capital cost, and installation of the permeable reactive barrier to the required depth would be very difficult.

Alternatives G-4 and G-5 were not selected because they require a commitment to a greater capital expenditure before the effects of the groundwater capture can be fully evaluated. After several years of Alternative G-3 system operation, components of Alternatives G-4 and/or G-5 could be optimally phased in using data and observations from the Alternative G-3 system operation, and knowledge of the details of the final soil/landfill waste remedy. Therefore, Alternative G-3 was selected to provide hydraulic containment and to allow for a phased approach to remediation of other parts of the plume, such as the high concentration areas.

**The six major design components of the Proposed Plan are:**

(1) hydraulic control of the plume by extraction

(2) *ex situ* treatment of groundwater

(3) reinjection of some of the treated groundwater to the aquifer

(4) discharge of treated groundwater to the publicly owned treatment works or surface water

(5) monitoring

(6) land use controls

Preferred Alternative

G-3

**Detailed design description of the preferred alternative, G-3:**

1) ***Hydraulic Control*** **—** This component includes installing an array of 16 groundwater extraction wells parallel to and near Frog Mortar Creek. The system would operate until containment is no longer required.

2) **Ex situ *treatment of groundwater*** **—** The total groundwater extraction rate to provide containment is expected to be approximately 40 gallons per minute (gpm). The treatment system conceptual design is sized for 100 gpm to conservatively address uncertainties in groundwater extraction rates and to provide flexibility for future expanded operations. The additional flow capacity would allow significant recirculation to facilitate *in situ* treatment of the high concentration areas as part of a future site remedy. This component would consist of installing a treatment system and operating it until containment is no longer required.

   The extracted groundwater would enter the system at a feed tank, then flow through a metals removal system, filter unit, air stripper, advanced oxidation system for the removal of 1,4-dioxane, the liquid-phase granular activated carbon (GAC) and ion exchange (IE) units, and then exit the system. Sludge generated by the metals removal step would be thickened, dewatered, and properly disposed of at a licensed off-site facility.

3) ***Reinjection of treated groundwater*** **—** Following a period of successful operation, some groundwater may be reinjected near the high concentration areas under this alternative. Reinjection would enhance the flushing rate of contaminants from these areas, and a compound would be mixed with the reinjected treated groundwater to promote anaerobic reductive dechlorination of cVOCs, a process in which naturally occurring bacteria break down the contamination.

   Six injection wells would be placed in areas contaminated with high concentrations of chlorinated volatile organic compounds. Treated groundwater would not be reinjected in areas contaminated with 1,4-dioxane only, because the compound is not effective in degrading 1,4-dioxane. Four wells would be screened in the upper zone and two in the intermediate zone. The total flow rate to upper zone wells would be approximately 10 gallons per minute; the total flow rate to the intermediate zone wells would be 3 gallons per minute. The total injection rate would be approximately 13 gallons per minute.

   Sodium lactate would be added to the reinjected treated groundwater as an electron-donor compound to promote treatment of the chlorinated volatile organic compounds. Treated groundwater augmented with the electron-donor compound would be intermittently reinjected to the aquifer to allow the electron-donor compound to be flushed away from the wells. Reinjection facilities may be installed following initial installation of the extraction wells and the groundwater treatment system, potentially in conjunction with the soil/landfill waste remedy.

4) ***Discharge to publicly owned treatment works and surface water*** **—** Reporting would be required twice annually because the potential discharge rate of 100 gallons per minute is greater than the 25,000 gallon per day (gpd) threshold for a significant industrial user. Annual user fees are also required, in addition to sewage service charges. A surface water discharge permit would be obtained after two or three years of operation, once treatment system operating parameters have been established. However, because Baltimore County may not accept the discharge due to treatment capacity issues, discharge to surface water, under permit with the State, may be required from the beginning.

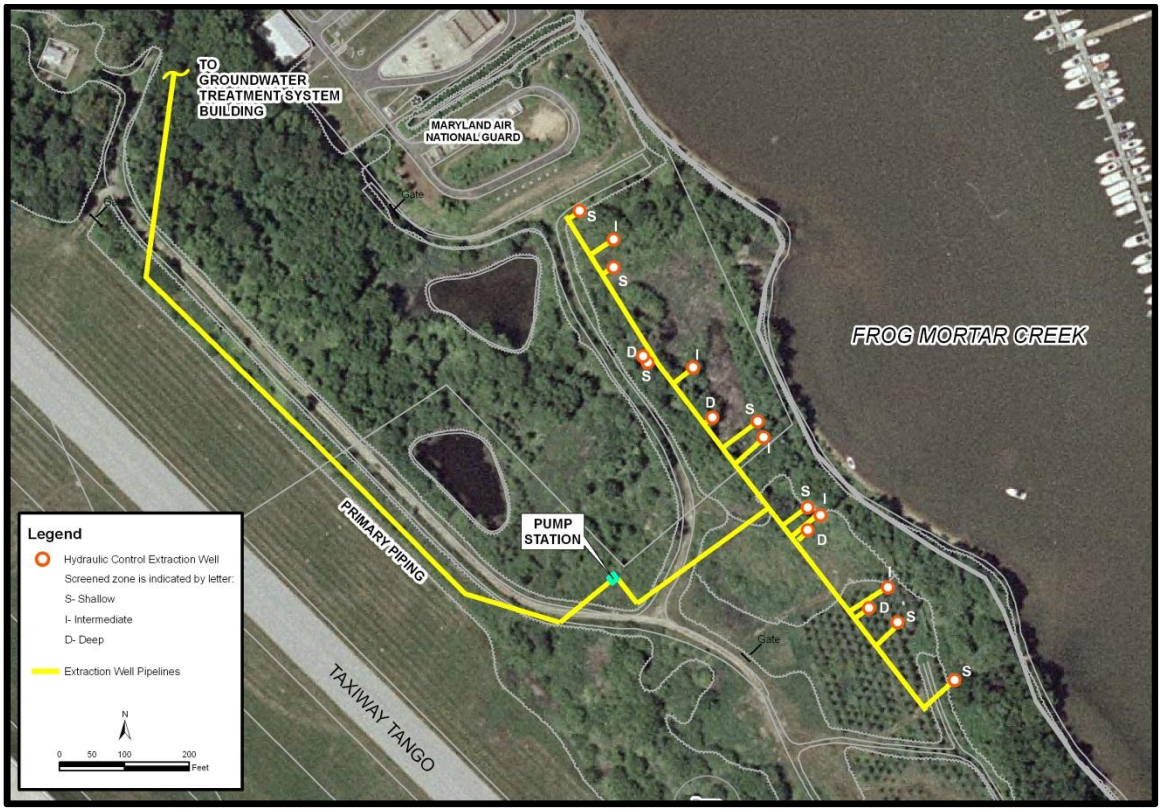
5) ***Monitoring*** **—** Monitoring would consist of regularly measuring groundwater levels and collecting and analyzing groundwater samples to evaluate changes in contaminant concentrations due to extraction. Water level data will be used to confirm hydraulic capture of the plume. Samples would be collected from existing as well as new monitoring wells installed specifically to evaluate system performance. Wells in the monitoring program would include the extraction wells, five three-well clusters in the plume (between the Taxiway Tango and Frog Mortar Creek), two three-well clusters between the runway and Taxiway Tango, and a newly installed pair of two-well clusters (extending into the

intermediate and lower zones), with each pair installed downgradient of the extraction wells. Final selection of monitoring wells will be made in the design phase of the project, with the concurrence of relevant regulatory agencies.

Groundwater samples will be analyzed for volatile organic compounds, 1,4-dioxane, petroleum hydrocarbons, and metals. The extraction wells would be sampled semiannually for the first three years because concentrations in these wells are expected to change quickly. Thereafter, they will be sampled annually. All other wells would be sampled annually. Groundwater sampling and analysis reports would be submitted annually to the relevant regulatory agencies. The groundwater monitoring program would be reviewed at least every five years to determine if changes are needed in sampling frequency, analyses, or the wells that are sampled. Pumping rates of the extraction wells would also be evaluated for optimization.

Additional monitoring wells may need to be installed to monitor the effect of adding the electron-donor to the injection wells.

6) ***Land Use Controls*** **—** Land use controls for groundwater would include limiting land use to industrial purposes, prohibiting residential use, and prohibiting surficial aquifer use for drinking and industrial purposes. Land use controls would also be applied to areas overlying shallow groundwater where volatile organic compound concentrations are greater than the vapor intrusion-based preliminary remediation goals. This land use control would require special construction methods, such as installation of vapor barriers and foundation venting, to prevent unacceptable exposure to volatile organic compounds via vapor intrusion. Deed restrictions would be required to implement the land use controls. Land use controls would be maintained as long as groundwater contaminant concentrations are greater than preliminary remediation goals.



**COMMUNITY PARTICIPATION INFORMATION**

The public is encouraged to participate in the decision-making process for the Dump Road Area Site at Martin State Airport by reviewing and commenting on this Proposed Plan during the public comment period. Dates of public comment period for the Proposed Plan:

February 8, 2012 through March 8, 2012

- **Time and place for a public meeting :**
  February 8, 2012 at the Marshy Point Nature Center, 7130 Marshy Point Road, Middle River, Md.

- **Location of project documents:**
  Essex Public Library
  1110 Eastern Boulevard, Essex, Maryland, 21221,
  open Mon-Thurs. 9 a.m. -9p.m.; Fri-Sat 9 a.m.-5:30 p.m.

  http://www.lockheedmartin.com/us/who-we-are/sustainability/remediation/msa.html

- **Contact information:**
  Gary Cambre - (800) 449-4486; gary.cambre@lmco.com

## GLOSSARY

***This glossary defines the technical terms used in this Proposed Plan. The definitions in this glossary apply specifically to this Proposed Plan, and may have other meanings when used in different circumstances***

**Anaerobic reductive dechlorination** — A natural breakdown or treatment process in which anaerobic bacteria (i.e., bacteria that do not require oxygen) remove chlorine from chlorinated compounds (such as trichloroethene). Once all possible chlorine atoms are taken away, a chemical called 'ethene' is formed, which is not harmful to human health or the environment.

**Applicable or relevant and appropriate requirements (ARARs)** — Environmental cleanup standards and requirements (federal and state laws and regulations) that must be attained during cleanup operations, and maintained at project completion.

**Aquifer** — An underground layer of rock, sand, silt, or clay that contains water in sufficient amounts to serve as sources of groundwater for wells and springs.

**BTEX** - benzene, toluene, ethylbenzene and xylenes.

**Chemical of concern (COC)** — Chemicals, identified by a regulatory agency, that are found at concentrations higher than those considered to be safe, and must be cleaned up and/or monitored.

**Chemical of potential concern (COPC)** — Chemicals identified during a remedial investigation (RI) which are at concentrations that have the potential to harm human health and/or the environment.

**Chlorinated volatile organic compound (cVOCs)** — examples include trichloroethene (TCE) and cis-1,2-dichloroethene (*cis*-1,2-DCE), see VOCs for additional information.

**Containment** — A technology that prevents the movement of contaminants from a site but does not necessarily treat or remove the contaminants.

**cis-1,2-Dichloroethene (cis-1,2-DCE)** – A degradation product of trichloroethene (TCE).

**1,4-Dioxane** — A clear, flammable volatile organic compound mainly used as an industrial solvent or solvent stabilizer in a variety of manufacturing processes, including electronics, metal finishing, fabric cleaning, pharmaceuticals, herbicides, pesticides, antifreeze, and paper. It is also found in household products such as detergents, shampoos, body lotions, dishwashing soap, and cosmetics. It does not break down naturally in the environment, so it tends to linger in soil and groundwater for a very long time.

Ecological Risk Assessment (ERA) — A study that evaluates risk to plants and animals in the ecosystem.

***Ex situ*** — Away from the original location or place where pollutants are found; in this report, *ex situ* means on-site and at the surface, but not in place (under ground).

**Granular activated carbon (GAC)** — Proven treatment method for VOC removal from contaminated groundwater and air stripper off-gas. Would not be effective on metals and its effect on 1,4-dioxane is uncertain.

**Groundwater** — Water found beneath the ground surface that fills open spaces between particles such as sand, soil, and gravel, or that fills cracks and fractures in rock.

**High concentration areas** – Areas where concentrations of TCE, cis-1,2-DCE, or vinyl chloride in the groundwater are significantly greater than preliminary remediation goals and may require additional investigation and/or remediation.

**Human Health Risk Assessment (HHRA)** — A study that evaluates the harmful effects and risks from eating, breathing or touching a chemical (current and future).

**Ion exchange (IE)** — Removal of dissolved ions through exchange with similarly charged ions held on the active sites of a synthetic resin that is contacted with the liquid to be treated.

***In situ*** — For this project, *in situ* means on-site and in place.

**Land use controls** - Engineered and non-engineered (administrative) controls formulated and enforced to regulate current and future land use options. Engineered controls include fencing and posting. Non-engineered controls typically consist of administrative restrictions **– such as deed restrictions** - that prohibit residential development and/or groundwater use.

**National Oil and Hazardous Substances Pollution Contingency Plan (NCP)** — A federal plan that dictates who will, and how to, respond to an oil spill or **a** release, or threat of release**,** of a hazardous substance. It establishes a National Response Team (NRT), which is headed up by EPA, and outlines requirements for accident reporting, spill containment, and cleanup.

**Net present worth** — A present worth analysis that evaluates costs over a specific period of time by discounting all future costs to a common base year. It represents the amount of money that, if invested in the base year and dispersed as needed, would be sufficient to cover all costs associated with the remedial action over its planned life. Net present worth considers both capital (construction) and annual (such as maintenance and labor) costs.

**Operation and maintenance (O&M)** — Activities conducted after a site action has been completed to ensure that the action is effective.

**Polycyclic aromatic hydrocarbon (PAHs)** — A group of carcinogenic compounds derived from the combustion of materials.

**Permeable reactive barrier (PRB)** — Reactive materials placed in the subsurface (by trenching or drilling) to catch contaminated groundwater and change contaminants, as they pass through the barrier, into less harmful environmentally acceptable products.

**Plume** — A body of contaminated groundwater moving away from its source. The movement of contaminants is influenced by such factors as local groundwater flow patterns, aquifer characteristics, and the nature and type of contaminant.

**Preliminary remediation goal (PRG)** — Contaminant concentration goals for soil, sediment, water, and air, listed by land use option, that are considered to be protective to human health and the environment. Customarily used at Superfund, federal facilities, Brownfield, and RCRA sites, PRGs comply with all ARARs. Preliminary remediation goals serve as a target during the initial development, analysis, and selection of cleanup alternatives.

**Remedial action** — The construction or implementation phase of the selected remedial alternative at a site cleanup program.

**Remedial action objectives (RAOs)** — Cleanup objectives that specify contaminants to be cleaned up, the cleanup standard, the area of cleanup, and the time required to achieve cleanup, for the purpose of protecting human health and the environment.

**Remediation** — The process of correcting and/or cleaning up environmental contamination. Remediation involves taking action to reduce, isolate, or remove contamination from an environmental medium (e.g., soil, air, groundwater, surface water), with the goal of preventing exposure of people or animals to that contamination and reducing impact to the environment.

**Trichloroethene (TCE)** — A nonflammable, colorless liquid chemical with a slightly sweet odor, commonly used as an industrial solvent and metal degreaser. TCE is also used in household and consumer products such as typewriter correction fluid, paint removers, adhesives, and spot removers.

**Vapor intrusion** — The movement (migration) of chemical vapors from under the ground into overlying buildings.

**Volatile organic compounds (VOCs)** — A group of chemicals (organic compounds) that will vaporize or evaporate at room temperature into the atmosphere. They often have a sharp smell and can come from many products such as office equipment, adhesives, carpeting, upholstery, paints, petroleum products, solvents, and cleaning products.

**Zero-valent iron (ZVI)** — A type of pure iron, typically in the form of small particles, used in the construction of subsurface reactive walls to treat and reduce the levels of contamination in groundwater.

# APPENDIX E—BUILDING LOCATION ALTERNATIVES ANALYSIS

**Lockheed Martin Corporation**
**6801 Rockledge Drive, MP: CCT 246**
**Bethesda, MD 20817**
**Telephone 301-548-2209**

March 20, 2012 **VIA PRIVATE CARRIER & EMAIL**

Mr. Wayne S. Pennell
Deputy Executive Director
Operations and Maintenance
Maryland Aviation Administration
Terminal Building, Third Floor
P.O. Box 8766, BWI Airport
Baltimore, Maryland 21240-0766

**Re: Martin State Airport, Middle River, Maryland**
**Request for on-Airport Dump Road Area Treatment Building Location**
**and Dump Road Area Interim Remedial Action Proposed Plan Review**

Dear Mr. Pennell,

As you know, Lockheed Martin Corporation (LMC) has proposed an Interim Remedial Action (IRA) treatment system to intercept and treat a plume of volatile organic compound (VOC)- impacted groundwater associated with the former Dump Road Area (DRA) landfill at Martin State Airport, in order to provide containment and preventing the migration of impacted DRA groundwater into Frog Mortar Creek (FMC). Due to the need to construct the treatment system as soon as possible, and the lack of suitable off-airport locations, LMC is requesting that the Maryland Aviation Administration (MAA) approve the construction of a treatment building on the footprint of the Dump Road landfill itself, on MAA's Martin State Airport property.

We have also attached a copy of the IRA Proposed Plan. LMC initiated public review of the DRA IRA by issuing the Proposed Plan at our public information session on February 8, 2012. This Proposed Plan proposes the preferred alternative (interim) remedy first introduced to MAA in October, 2010, in the draft document titled, "*Interim Remedial Action – Feasibility Study for the Groundwater Operable Unit at the Dump Road Area Site at Martin State Airport*."

The public comment period for the Proposed Plan concluded March 8, 2012. Under separate cover letter, Lockheed Martin will provide MAA with the public comments that were received. This Proposed Plan has also been submitted for formal Maryland Department of the Environment consideration and review. The favor of MAA's reply with any comments about the Proposed Plan would be appreciated by May 1, 2012.

The remainder of this letter provides further details of: 1) the evaluations performed to identify potential off-airport treatment building locations; and, 2) the evaluations of on-airport locations and additional requirements associated with the construction of the IRA treatment building on MAA property.

LMC has evaluated several potential off-airport locations for the treatment building. These included locations that would require acquisition of land outside of MSA, as well as locations at our Middle River Complex (MRC). However, all of the off-airport locations carry significant limitations and drawbacks, and LMC believes that on-airport locations in the vicinity of the DRA offer the best combination of constructability, ease of maintenance, and achievable schedule to expedite construction of the DRA IRA and prevent the discharge of VOCs to FMC.

## Background

The DRA at MSA is the location of a 22-acre landfill associated with former industrial operations. The land is currently owned by MAA, and a portion is leased from the MAA by the United States Federal Government (through the National Guard Bureau) for use by the Maryland Air National Guard (MDANG).

Groundwater in the DRA is impacted by volatile organic compounds (VOCs), including trichloroethene (TCE) and associated breakdown products, 1,4-dioxane, and heavy metals. The plume is currently migrating towards FMC, a tidal estuary of Chesapeake Bay. It is our understanding that the Maryland Department of the Environment (MDE) will publish a swimming advisory on their website for a portion of FMC adjacent to the DRA shoreline due to detected concentrations of vinyl chloride in surface water. Signs warning of the advisory are expected to be installed along the shoreline sometime this spring.

The Dump Road IRA will consist of a groundwater extraction and treatment system. A line of 16 extraction wells will be installed between the landfill area and Frog Mortar Creek on the east side of the DRA, as shown on **Figure 1**. The land is wooded, and includes ponds and wetlands within the Chesapeake Bay Critical Area. The current 30% design of the IRA assumes the off airport construction of a treatment building to house the process components of the treatment system. The design calls for an engineered steel building with approximately 14,400 square feet of floor space (80 feet wide by 180 feet long), with a roof peak 26 feet above the floor slab.

*Due to its size, Figure 1 appears on the next page*
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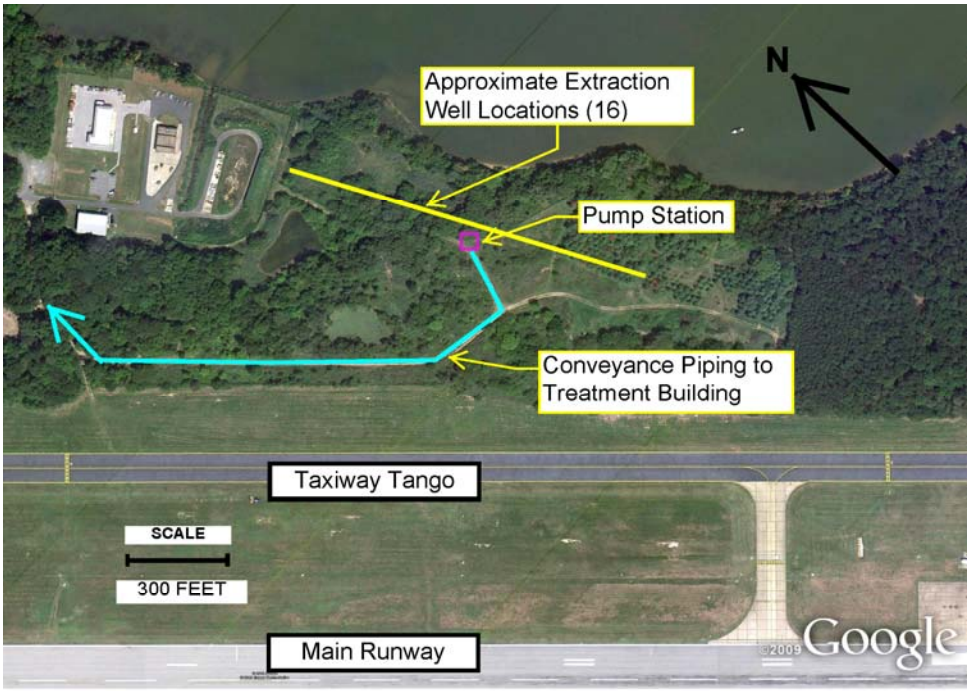


FIGURE 1 - CURRENT 30% DESIGN PUMP STATION AND PIPING LAYOUT
(TREATMENT BUILDING AT AN OFF-AIRPORT LOCATION)

Should the location of the treatment building be some distance from the extraction wells, it will require the construction of a pump station within the DRA (a structure approximately 25 feet square and 15 feet tall) where extracted groundwater from the wells would be pumped for collection. The consolidated flow would then be pumped to the remote treatment building. The treatment steps in the current design include metals removal, air stripping to remove VOCs, activated carbon for the offgas treatment, a chemical oxidation system for destruction of 1,4-dioxane, and ion exchange for final metals treatment prior to a surface water discharge. Discharge to a publicly owned treatment works (POTW) via sanitary sewer has been discouraged by Baltimore County, and LMC understands that a permit for a POTW discharge would only be granted as a last resort.

Operating staff will require daily access to the treatment building. Regular deliveries of treatment-related chemicals and daily maintenance will also be required at the treatment building, as well as occasional access to replace vapor- and liquid-phase activated carbon and removal of accumulated solids generated by the metals-removal step.

The DRA groundwater has elevated concentrations of iron and manganese which will likely lead to significant solids buildup in the raw water piping, requiring frequent maintenance to keep the lines clear. Cleaning could include "pigging," chemical flushes, water jetting, or a combination of techniques. Numerous closely-spaced manhole structures are planned along the entire length of the conveyance piping route between the pump station and the treatment building to provide access for manual cleaning.

Ideally, the treatment building should be located as near as possible to the DRA in order to mitigate the risks and maintenance challenges associated with pumping impacted groundwater long distances.

**Off airport Alternatives**

LMC has evaluated several potential off-airport locations for the treatment building. These included locations that would require acquisition of nearby land outside of MSA, as well as locations at our Middle River Complex (MRC).

LMC performed a local real estate market survey to identify potential off-airport properties that could be acquired for construction of the treatment building. The nearest potentially-suitable private property for locating the treatment plant is located approximately 4,000 feet to the north on Lynbrook Road, while the nearest potentially-suitable parcel that is for sale is over a mile away on Eastern Boulevard. The nearest available parcel at MRC is almost two miles (by pipeline) from the DRA.

The real estate market survey focused on three nearby parcels that were under consideration for acquisition. A local real estate broker was commissioned to approach the property owners to evaluate their interest in selling their property. One property owner refused to meet with the broker; the second property was less desirable because it was leased by multiple tenants, and was likely too small to efficiently fit the treatment building footprint; and the third parcel, located on Lynbrook Road, was part of a larger occupied parcel and the owner was unwilling to sell or subdivide the parcel.

An evaluation of the technical and engineering pros and cons of the various off airport locations was also performed, including the potential parcel on Lynbrook Road and locations at MRC. Piping distances between the pump station in the DRA and the various treatment building locations ranged between 4,000 ft and 11,000 ft. The evaluation of the off-airport alternatives considered piping installation in open trenches between the treatment building and the pump station, as well as an alternative that utilized directional drilling from MRC, under the airport facilities, and ending in the DRA. All the off-airport locations had significant drawbacks, including:

- Long piping runs conveying contaminated groundwater through the entire National Guard Bureau Federal leasehold and along public roads (Lynbrook Road or Eastern Boulevard), or just inside the Martin State Airport northern fence line parallel to Eastern Boulevard in order to reach properties at MRC. These lines will likely require frequent access for cleaning, and long piping distances increase the potential for leaks or damage, with associated potential off airport releases of contaminated water;
- Locations closest to the DRA are at least 4,000 feet away (on Lynbrook Road) and require acquisition of land that is currently not for sale;
- Maintenance situations could entail three teams operating simultaneously in widely spaced locations (inside the treatment building, along the conveyance piping route, and at the extraction wells/pump station), resulting in a large number of maintenance personnel accessing various areas of MAA and MDANG facilities;
- Significant length of return piping for treated water discharge to Frog Mortar Creek outside of the Federal leasehold; and
- Costs over the life of the treatment system will likely increase with distance due to increased construction and long-term maintenance costs.

However, all of the off-airport locations carry significant limitations and drawbacks, and LMC believes that on-airport locations in the vicinity of the DRA offer the best combination of constructability, ease of maintenance, and achievable schedule to expedite construction of the DRA IRA and prevent the groundwater discharge of VOCs to FMC.

## Proposed On airport Alternatives

In consideration of the difficulties associated with locating the treatment building on a parcel off airport property, three on-airport treatment building alternatives have been evaluated.

Potential on airport locations for the treatment building are shown on **Figure 2**. They include:

- Alternative 1: MAA-owned parcel near the DRA on the National Guard Bureau leasehold;
- Alternative 2: MAA-owned land in the DRA adjacent to the planned IRA extraction wells; and
- Alternative 3: MAA-owned land in the DRA, but south of the landfill footprint.

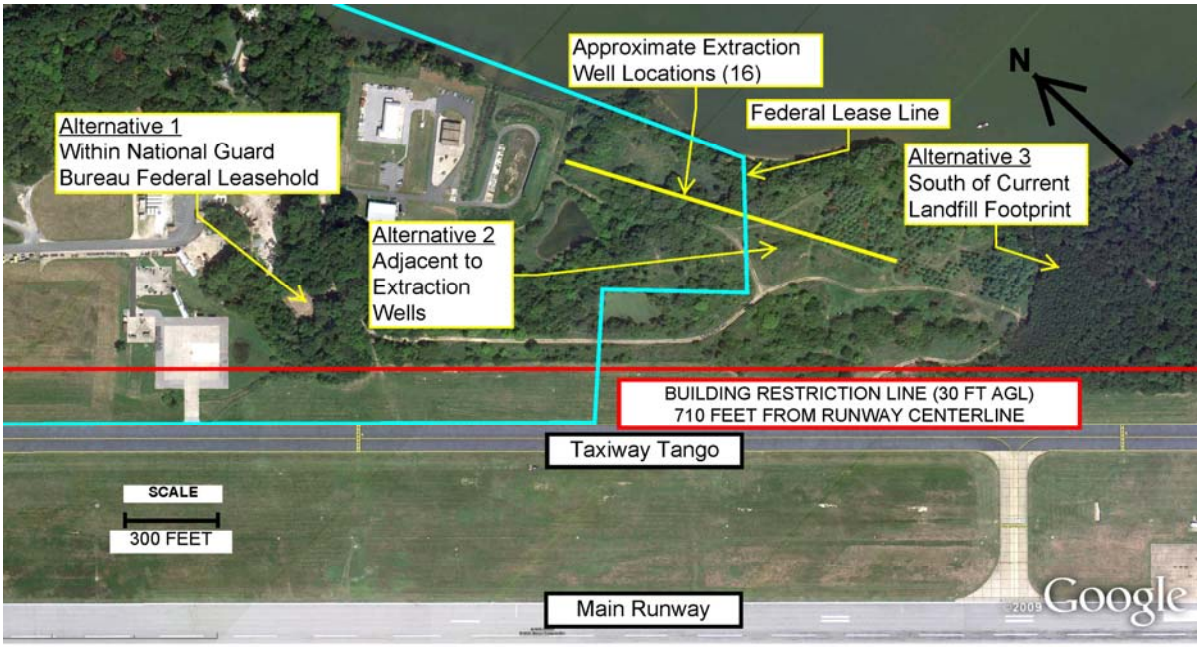


FIGURE 2 - PROPOSED ON-AIRPORT TREATMENT BUILDING LOCATIONS

LMC understands that there are challenges common to all three on-airport locations, including:

- All locations likely require modification to the Airport Layout Plan (ALP), and the need to obtain FAA approval;
- Daily access for maintenance staff and periodic deliveries through the MDANG security portal will be necessary;
- Utilities such as potable water, sanitary sewer, power, and natural gas will need to be conveyed long distances from off the airport property, or access to MDANG utilities will need to be negotiated;
- Due to the proximity of the airport runway and Taxiway Tango, airport safety concerns need to be mitigated both during construction and for the permanent siting of the structure; and
- All three sites are located within the Chesapeake Bay Critical Area, and require significant clearing, grading, and addition of impervious surface. These impacts will likely require mitigation at an off-airport location.

Conversely, all three sites also offer definite advantages when compared to any off-airport location:

- Short piping runs from the extraction wells to the treatment building, easing maintenance and reducing the potential for leaks or damage;
- The sites are in a remote area with no nearby residences and a strong security presence;
- Frog Mortar Creek is very close by for surface water discharge of treated water;
- All system components would be located on state-owned land, likely streamlining the permitting process because the State of Maryland would have sole jurisdiction; and,
- All maintenance tasks would be confined to a relatively small area of the site, streamlining staffing and oversight tasks.

Additional advantages and disadvantages unique to each location are discussed below.

**Alternative 1**

Alternative 1 would place the treatment building close to the DRA, in the southern portion of the National Guard Bureau Federal leasehold (Figure 2). Groundwater pumped from the extraction wells would be consolidated in a pump station, and from there pumped to the treatment building location.

Beyond the advantages common to the three on airport alternatives, Alternative 1 has an additional benefit:

- No waste is believed to be buried at Alternative 1 location, simplifying the process of designing and constructing the treatment building at this location (compared to Alternative 2).

Disadvantages of this alternative include:

- The proposed treatment plant location within the National Guard Bureau Federal leasehold would require modifying a Federal lease between the United States Government and MAA. It is unknown how readily such a modification could be accomplished, if at all; and
- The treatment plant would occupy an area within the MDANG footprint; the area would be unavailable to MDANG for any other use.

**Alternative 2**

Alternative 2 would place the treatment building in the DRA within the landfill footprint, immediately adjacent to the row of extraction wells that will be installed to intercept the groundwater plume (Figure 2). The extraction wells would pump groundwater directly to the treatment building; no pump station would be required.

Specific advantages of this alternative include:

- Very short piping runs from the extraction wells to the treatment building, easing maintenance and reducing the potential for leaks or damage;
- The pump station can been eliminated;

- This location will likely require the removal of fewer trees than Alternatives 1 and 3, and therefore will likely be favored by the stakeholders over Alternatives 1 and 3; and,
- This location offers a direct discharge of treated water to FMC, and will be accomplished outside of the Federal leasehold.

However, this location has a significant disadvantage when compared to Alternatives 1 or 3:

- The treatment building would be located within an area with significant quantities of buried waste, as well as impacted groundwater. Special foundation design may be required, a vapor barrier will be necessary beneath the building, and some consideration will need to be placed on either removing the waste material prior to construction, consolidating it and capping it in place, or some combination.

**Alternative 3**

Alternative 3 would place the treatment building in the DRA south of the landfill footprint, at a location beyond the limits of landfilled waste (Figure 2). In many ways this alternative is similar to Alternative 1. The pump station would be required, and the distance from the pump station to the treatment building is approximately the same for each alternative.

Advantages and disadvantages of Alternative 3 are similar to Alternative 1, with the exception of the need to modify a Federal lease between the United States Government and MAA, since Alternative 3 is not within the National Guard Bureau Federal leasehold.

The advantages include:

- Constructing beyond the limits of waste simplifies the process of designing the treatment building at this location (compared to Alternative 2); and

- This location offers a direct discharge to FMC, accomplished outside of the Federal leasehold.

The primary disadvantage of this location is related to environmental concerns:

- The site is located within the Chesapeake Bay Critical Area, and requires more clearing, grading, and tree removal than Alternatives 1 and 2. Nearby wetlands may also complicate permitting requirements.

## Summary

As demonstrated above, LMC has carefully evaluated potential off-airport locations for constructing the IRA treatment building, but the drawbacks of constructing off-airport are significant, and may also delay implementation of the IRA and our ability to prevent migration of VOCs into Frog Mortar Creek in a timely manner.

***Based on our review of the on airport options, Alternative 2 adjacent to the extraction wells and off the Federal leasehold has clear advantages over Alternatives 1 and 3, and we believe any disadvantages can be managed. Given these considerations, LMC is requesting MAA approval to locate the treatment building adjacent to the extraction wells. A possible building layout is shown below on Figure 3:***

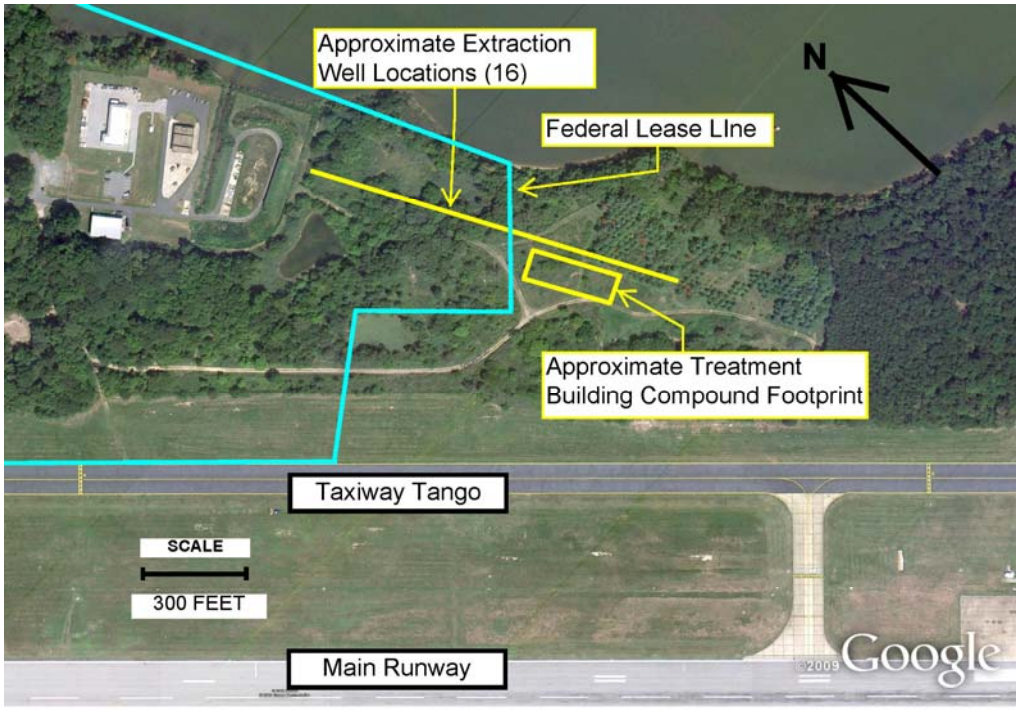


FIGURE 3 - PROPOSED ON-AIRPORT LOCATION FOR TREATMENT BUILDING

LMC is committed to working with MAA to expedite the approval of Alternative 2 as a location for the treatment building, including supporting any permitting requirements and incorporating any design changes necessary to meet the requirements of the FAA, MAA, MDANG, and MDE.

LMC also recognizes that there will be numerous permitting, design, and construction elements that will require coordination and cooperation in order to receive the necessary approvals and complete construction in a timely manner. These include:

- **Building design elements.** Currently the IRA design calls for an engineered steel building, approximately 80 feet wide, 180 feet long, and 26 feet tall at the roof peak above the floor slab. The building would rest on a footprint approximately 120 feet wide and 280 feet long (approximately 34,000 square feet) in order to provide the necessary space for parking, deliveries, and maintenance.
- **Cleared area/tree removal.** In addition to the 34,000 square feet of site impact represented by the building footprint, an additional 90,000 square feet of clearing and road improvements are expected to provide access to the treatment building from the end of the paved portion of Lynbrook Road, as well as permanent access paths to each of 16 extraction wells.
- **Wildlife impacts.** LMC recognizes that there may be limitations to on airport construction from the possible presence of the least tern, as well as nesting bald eagles on the MDANG parcel. We believe that we can construct the treatment building on airport without impacts to these species.
- **Utilities.** The treatment building will require potable water, sanitary sewer, electric power (480-volt, 3-phase, 700-amp service), and natural gas. These could be obtained from MDANG if they have sufficient capacity and approvals can be obtained, or new service lines could be brought on-airport from Eastern Boulevard.

- **Easements.** In addition to easements associated with the buried utilities noted above (water, sewer, power, natural gas), 9 of the planned 16 extraction wells will need to be installed on the Federal leasehold in order to provide capture of the contaminated groundwater plume. Regular access will be required to maintain and clean the wells. In addition, piping and electrical lines will be buried between the extraction wells and the treatment building. The piping will likely require regular access for cleaning.
- **Air emissions.** The current treatment system design includes an air stripper to remove VOCs from groundwater. Although the air stream would be treated to remove VOCs prior to discharge, any residual, post-treatment air discharge emissions may be considered an air emission source for the airport.

LMC is ready to discuss our plans further with MAA once you and your staff have had an opportunity to review this request. LMC stands ready to support efforts associated with obtaining Federal Aviation Administration approval, permitting requirements, and addressing other aspects that may impact Martin State Airport and the Maryland Air National Guard. Please do not hesitate to contact me at 240-460-7508 or tom.d.blackman@lmco.com if you have any questions.

Sincerely,



Thomas D. Blackman
Project Lead, Environmental Remediation

Attachment: **Proposed Plan**, Interim Remedial Action, Groundwater Operable Unit at the Dump Road Area Site (MD-304) at Martin State Airport, Middle River, Maryland

cc: via email with attachment

Christine Kline, Lockheed Martin
Norm Varney, Lockheed Martin
Dale Truskett, Lockheed Martin
Arthur O'Connell, MDE
James Carroll, MDE
Michael Martin, Tetra Tech
Charles M. Baublitz, Operations Manager, Martin State Airport
Robin M. Bowie, Manager, Division of Environmental Compliance
Louisa H. Goldstein, Assistant Attorney General, Office of the Attorney General
Al Pollard, A.A.E., Director, Martin State Airport
Wayne B. Schuster, AICP, C.M., Director, Office of Planning & Environmental Services
Helen M. Tremont, Director, Office of Commercial Management
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175th MANG Commander, care of Walt L. Moddison, Major, USAF

# APPENDIX F—MARTIN STATE AIRPORT WETLAND DELINEATION REPORT

**Task 4 - Wetland Inventory**

# *Martin State Airport*

## Baltimore County, Maryland

Comprehensive Environmental Planning Contract No. MAA-AE-05-004

Prepared for: **Maryland Aviation Administration**
Division of Environmental Planning
P.O. Box 8766
BWI Airport, Maryland 21240-0766

Prepared by: VHB *Vanasse Hangen Brustlin, Inc.*
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April, 2006

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## Introduction

Vanasse Hangen Brustlin, Inc. (VHB) has been contracted by the Maryland Aviation Administration (MAA) to prepare a wetlands inventory for the property comprising Martin State Airport (MTN), located in Baltimore County near Middle River, Maryland (Figure 1). This inventory represents the first inclusive delineation conducted at MTN, evaluating all portions of the airport property simultaneously. While no specific project is pending, this wetland inventory will serve as a management tool to guide future developments in and around MTN, effectively avoiding and minimizing potential impacts to jurisdictional wetlands and waters of the United States.

■

### Project Description

MTN is located east of the town of Middle River, Maryland (Figure 1). It lies atop a peninsula within the Chesapeake Bay. The entire airport property of 775 acres constitutes the Study Area and is bounded by the following (Figure 2):

- North and West: the airport proper is bounded by Eastern Boulevard (MD-150), though a 37-acre wooded parcel north of MD-150 and the Amtrak rail line is also owned by the MAA;
- East: Frog Mortar Creek, and;
- South: Stansbury Creek / Wilson Point Road

Site topography generally slopes gently to the south and east from roughly 30 feet MSL near MD-150 to approximately 8 ft MSL along the shoreline. The steepest gradients occur along the Frog Mortar Creek shoreline, where abundant shore-defense structures have been installed.

## Methodology

Prior to the initiation of the wetland delineation, scientists reviewed published background information to evaluate the airport property for the presence of wetlands and other surface-water resources, hydric soils, and vegetation. This information included the following:

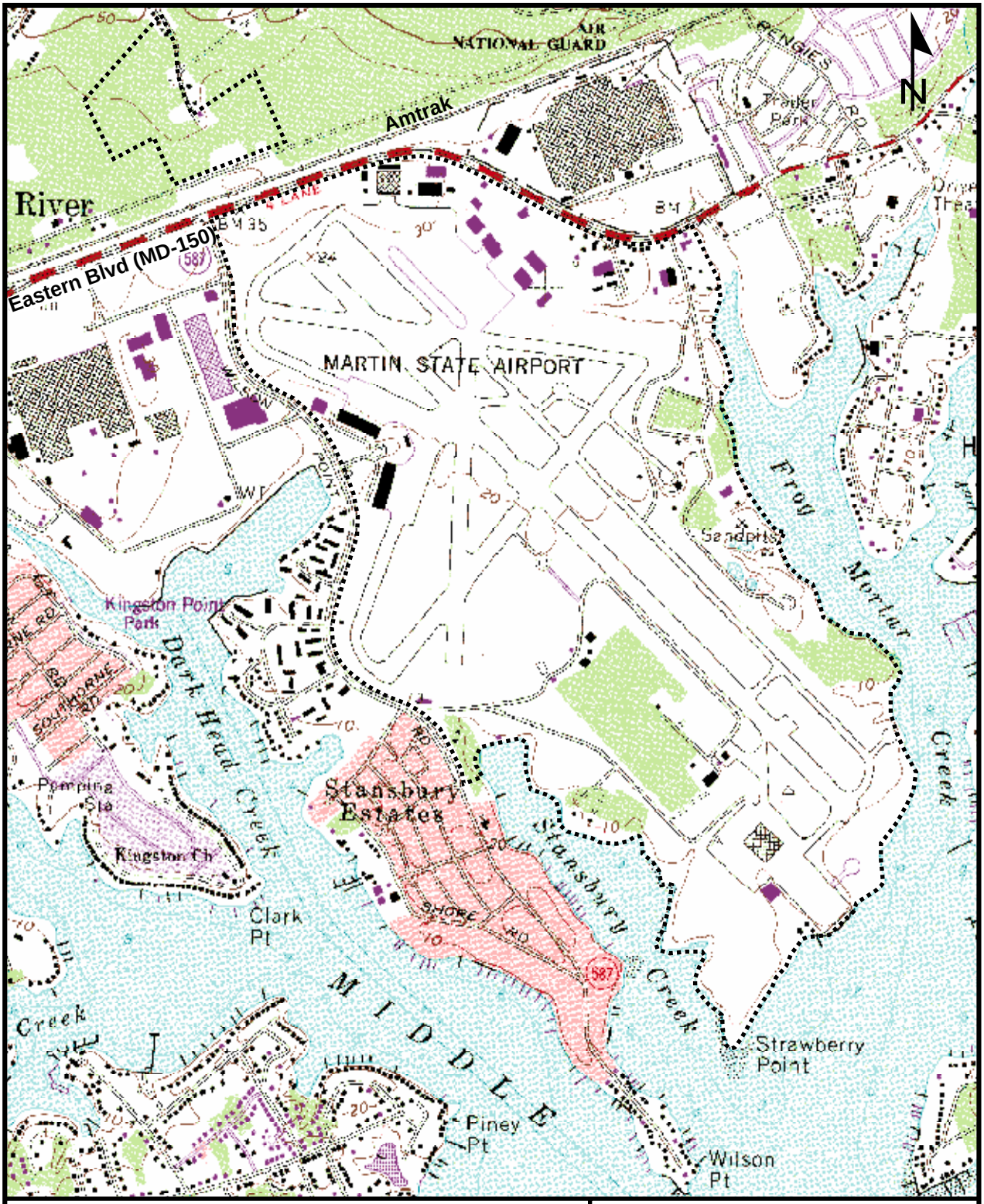
- Soil Survey of Baltimore County, Maryland (USDA, 1976, 2005a, 2005b);




**Figure 1.**
Project Area
Martin State Airport

*Vanasse Hangen Brustlin, Inc.* VHB

Sources: USGS 1996a




Study Area

approximate scale:

0 1500 feet

**Figure 2.**
Project Boundaries
Martin State Airport

*Vanasse Hangen Brustlin, Inc.* VHB

Source: USGS 1996b

- USGS 7.5-Minute Series (Topographic) Quadrangle Map, Middle River, MD (USGS, 1996b)
- National Wetland Inventory Map, Middle River, Maryland (USFWS 1982, 2005a),
- Aerial photographs of the airport property (MDOT 2005)
- Wetland Investigation Report for the Martin State Airport Air Traffic Control Tower Relocation, Baltimore County, Maryland (MAA 2001)

■

## Soils

MTN occurs in the lower coastal plain of Maryland dominated by soil types found within the Sassafras-Woodstown-Fallsington Association and Mattapex-Barclay-Othello Association. These soil associations are commonly located along the eastern side of Baltimore County adjacent to the Chesapeake Bay where they formed from ancient marine sediments and deposits (USDA 1976).

Twelve (12) individual soil mapping units occur on the MTN property (Figure 3). A list of the soils and a brief description of their features are provided below, grouped by their status as hydric, non-hydric, or disturbed. Most of MTN is underlain by disturbed soils.

National, State, and County hydric soil lists are consistent for those soils mapped at MTN (USDA 2005b).

## Hydric Soils

- Elkton loam (Em) – is a deep, poorly drained, hydric soil found on nearly level flats. The permeability is slow to very slow in the subsoil, and the seasonal high water table occurs at the surface to within 1 foot of the surface.

- Fallsington sandy loam (Fa) – is a poorly drained, hydric soil found on nearly level flats. The thick subsoil provides for a slow permeability, and a seasonal high water table is usually found within 6 inches of the surface.

- Pocomoke sandy loam (Po) – is a very poorly drained, hydric soil found on flats and in depressions. Sand is the dominant mineral component with small amounts of silt and clay. Permeability is moderate, and the water table is above or at the surface for most of the year.




| | |
|---|---|
| Em | Elkton loam |
| Fa | Fallsington sandy loam |
| FtB | Fort Mott loamy sand |
| GaB | Galestown loamy sand |
| LoB | Lenior-Urban land complex |
| Ma | Made land |
| MmB | Mattapex-Urban land complex |
| Po | Pocomoke sandy loam |
| SnB | Sassafras-Urban land complex |
| WdA | Woodstown sandy loam |
| WoA | Woodstown Loam (0-2%) |
| WoB | Woodstown loam (2-5%) |

Study Area

approximate scale:

0 — 1500 feet

**Figure 3.**
Soils Series Map
Martin State Airport

*Vanasse Hangen Brustlin, Inc.* VHB

Sources: USDA 1976, 2005a

## Non-Hydric Soils

- Fort Mott loamy sand (FtB) – is a well-drained soil found on level to gently sloping uplands in the Coastal Plain. Permeability is rapid due to the sandy texture found throughout the soil profile.

- Galestown loamy sand, 0 – 5 percent slopes (GaB) – is a somewhat excessively drained on level to moderately sloping soil predominately comprised of sand.

- Woodstown sandy loam, 0 – 2 percent slopes (WdA) – The Woodstown soil consists of moderately well drained, nearly level to gently sloping soils in uplands. Hydric inclusions of Fallsington soils are reported to occur in depressions within this soil series.

- Woodstown loam, 0 – 2 percent slopes (WoA) – contains more silt and less sand than the surface layer of WdA, retains moisture and plant nutrients better, and is later to dry and warm. Hydric inclusions of Fallsington soils are reported to occur in depressions within this soil series.

- Woodstown loam, 2 – 5 percent slopes (WoB) – as per WdA, but found on gently sloping terrain. Hydric inclusions of Fallsington soils are reported to occur in depressions within this soil series.

## Disturbed Soils

- Lenior-Urban land complex, 0 – 5 percent slopes (LoB) – are somewhat poorly drained soils with a heavy clay subsoil that have been cut, filled, graded, or otherwise disturbed.

- Made land (Ma) – are areas that have been created by man primarily from spoil material from excavations or hydraulic dredging.

- Mattapex-Urban land complex, 0 – 5 percent slopes (MmB) – are soils that have been cut, graded, filled, or otherwise disturbed. Most areas contain fill material over 18 inches deep. Most of the developed portions of MTN are underlain by this soil unit. Hydric inclusions of Othello soils are reported to occur in flats within this soil series.

- Sassafras-Urban land complex, 0 – 5 percent slopes (SnB) – are well-drained, nearly level to gently sloping soils that have been cut, filled, graded, or otherwise disturbed, and typically covered with over 18 inches of fill material.

■

## National Wetlands Inventory Mapping

A number of wetlands mapped by the National Wetlands Inventory (USFWS 1982, 2005a) are contained within the MTN Study Limits. Most of these wetlands are palustrine, though estuarine wetlands are mapped around Strawberry Point at the southern terminus of the Study Area (Figure 4). Table 1 summarizes these wetlands, their classification, and location.

**Table 1.**
**WETLANDS MAPPED BY THE NATIONAL WETLANDS INVENTORY**

| Code* | Description | Location |
|---|---|---|
| Palustrine Wetlands | | |
| PFO1A | palustrine, forested, broad-leaved deciduous, temporarily flooded | • In parcel north of MD-150<br>• Forested area at center of airport |
| PF/SS1C | palustrine, forested / scrub-shrub broad-leaved deciduous, seasonally flooded | • Forested area at center of airport |
| PEM1KAhs | palustrine, emergent, persistent, artificially flooded, temporarily flooded, diked / impounded, spoil | • Strawberry Point |
| PUBZ | palustrine, unconsolidated bottom, intermittently exposed / permanent | • Forested area at center of airport<br>• Areas mapped as "sandpits" on Eastern side of MTN ** |
| POWF | palustrine, open water / unknown bottom, semipermanently flooded | • At curve in Wilson Point Road south of Dark Head Creek headwall<br>• In parcel north of MD-150 |
| Estuarine Wetlands | | |
| E2EMP5 | estuarine, intertidal, irregularly flooded, mesohaline | • Strawberry Point |
| E2BBP | estuarine, intertidal, beach-bar, irregularly flooded | • Strawberry Point |

Source: USFWS 1982, 2005a

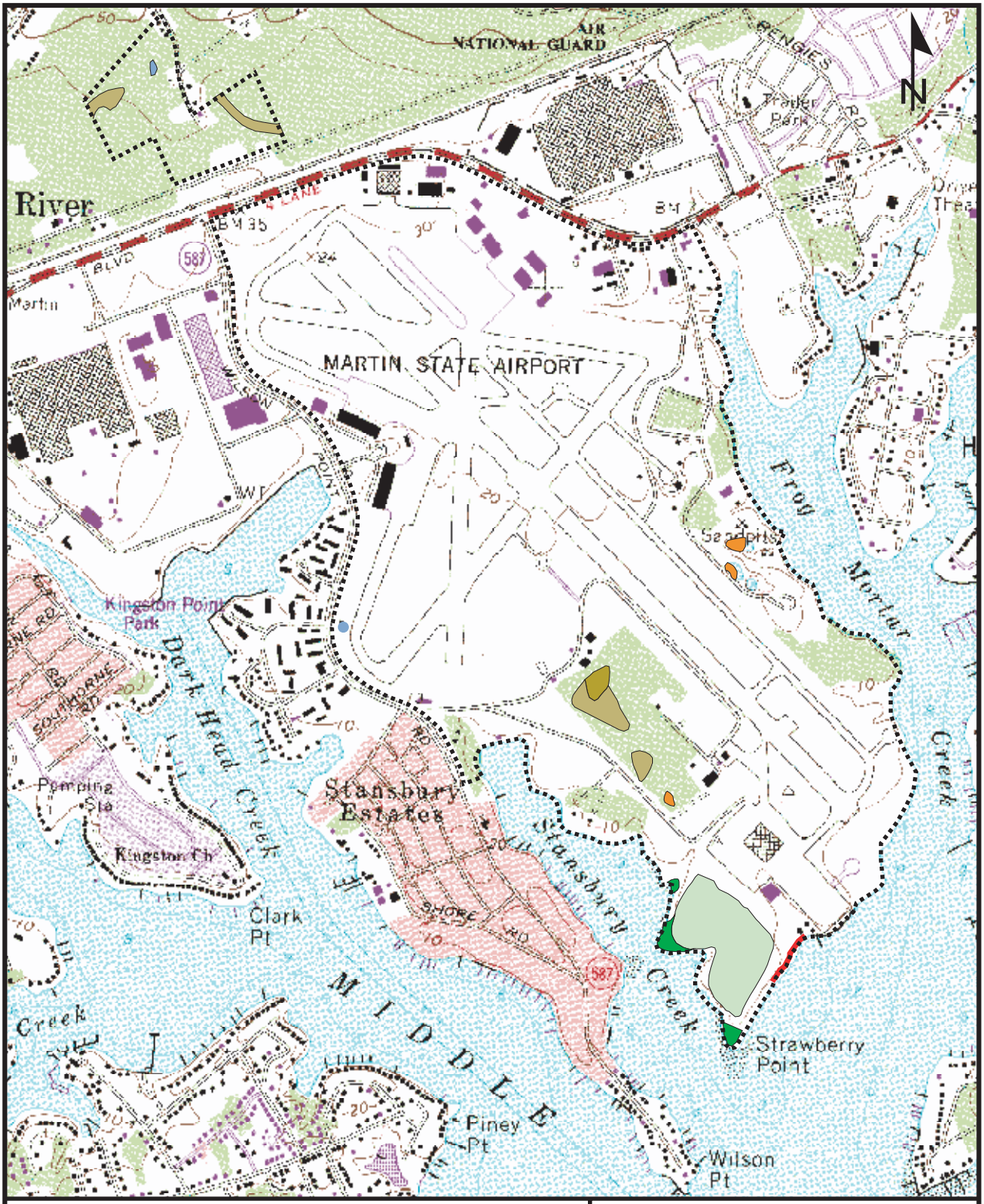
* from *Classification of Wetlands & Deepwater Habitats of the United States,* Cowardin *et al.* 1979

** sandpits reclassified as PUBZ according to USFWS 2005a (were POWZh on USFWS 1982)

■

## Wetlands Inventory

Where parcel size exceeded 5 acres, the wetland delineation at MTN was performed using the comprehensive method described in Part IV, Section (E) of




Palustrine Wetlands
- PFO1A
- PF/SS1C
- PEM1KAHs
- PUBZ
- POWF

Estuarine Wetlands
- E2EMP5
- E2BBP

Study Area

approximate scale:

0 — 1500 feet

**Figure 4.**
National Wetlands Inventory Map
Martin State Airport

*Vanasse Hangen Brustlin, Inc.* VHB

Sources: USFWS 1982, 2005a

the U.S. Army Corps of Engineers (COE) Wetland Delineation Manual (COE 1987, hereafter referred to as the "Manual") and subsequent Corps guidance. This relatively intensive methodology involves the use of observation points along transect lines spaced at varying intervals depending upon the size of the subject tract and the transect baseline established. The interval between observation points was typically 100 feet.

Data collected for each observation point included a description of the soil profile to determine the presence of hydric indicators, notes on the occurrence of any hydrological field indicators, and a record of vegetative composition. All vegetative layers were sampled based on standard plot sizes within each observation point as described below.

- **Trees –** All trees with a diameter at breast height (dbh) greater than 3 inches within a 30-foot radius from the plot center were tallied, noting species and dbh.

- **Saplings/Shrubs –** All saplings/shrubs were tallied by species and height within a radius of 10 feet from the plot center. Saplings and shrubs consisted of all woody stems greater than 3.2 feet in height to a dbh of 3 inches.

- **Herbs –** Both woody and non-woody plants less than 3.2 feet in height within a 3-foot radius from the plot center constituted the herbaceous component of the vegetative sample. The percent aerial coverage of each species was recorded.

- **Vines –** All woody vines greater than 3.2 feet in height within 30 feet of the plot center were tallied simply by number of occurrence.

Where the vegetative community remained unchanged at and between successive observation points, detailed plant sampling was not carried out and reference made to a single representative observation point.

The U.S. Fish and Wildlife Service (USFWS) has assigned an indicator status to most common plants describing the likelihood of their occurrence in wetlands. The 1996 draft edition of the "National List of Plant Species that Occur in Wetlands: Region 1 – Northeast" was consulted to determine the indicator status of plants enumerated at each observation point (USFWS 2005b). Each indicator is defined in Table 2.

Where parcel size was less than 5 acres, a routine determination was carried out, as outlined in Part IV, Section (D) of the Manual. In the interest of site and personnel security, northeastern portions of MTN leased to the Maryland Air National Guard (MANG, see "MANG Area", Figure 5) were subjected to a

cursory examination and verification of a previous delineation confirmed by the COE in February, 2002.

The evaluation of the shoreline and distribution of estuarine wetlands was performed on foot where possible. Where shorelines were inaccessible by foot or where steep conditions or security concerns precluded an onsite investigation, the shoreline was observed from the water with the assistance of the Baltimore County Police Department's Marine Unit.

The wetland delineation took place from 9/19 to 9/22/05, from 10/3 to 10/6/05, and on 3/28/06. All wetland flags were survey-located between 11/1 to 11/3/05 and on 3/28/06 using a Leica Model GS50 backpack Global Positioning System (GPS) receiver and real-time beacon (RTB) antenna having sub-meter accuracy. Wetlands in the MANG area that were not flagged were surveyed by walking their boundary with the GPS unit, or where dense *Phragmites* hindered direct access, mapped using high-resolution aerial photography provided by the MAA (MDOT 2005).

**Table 2.**
**WETLAND PLANT INDICATOR STATUS**

| Indicator Status | Probability of Occurrence in Wetlands |
|---|---|
| OBL (Obligate Wetland) | Occur almost always (estimated probability >99%) under natural conditions in wetlands. |
| FACW (Facultative Wetland) | Usually occur in wetlands (estimated probability 67%-99%), but occasionally found in non-wetlands. |
| FAC (Facultative) | Equally likely to occur in wetlands or non-wetlands (estimated probability 34%-66%). |
| FACU (Facultative Upland) | Usually occur in non-wetlands (estimated probability 67%-99%), but occasionally found in wetlands (estimated probability 1%-33%). |
| UPL (Obligate Upland) | Occur in wetlands in another region, but occur almost always (estimated probability >99%) under natural conditions in non-wetlands in the region specified. |
| NA | No Agreement |
| NI | No Indicator |
| + | Indicates a frequency toward the higher end of the category (*i.e.* more frequently found in wetlands). |
| - | Indicates a frequency toward the lower end of the category (*i.e.* less frequently found in wetlands). |
| * | Tentative assignments based on limited information or conflicting review |

Source: (USFWS 2005b)

## Results

A total of 25 potentially jurisdictional wetland areas were observed and delineated on the Martin State Airport property (Figure 5). Wetlands varied widely in type, from man-made ditches to forested depressions to tidal marshes. To facilitate the discussion of the results, the airport property was subdivided into six geographically discrete tracts generally corresponding to the sequence in which the field investigation proceeded. A description of the wetlands found in each tract is provided in the following sections and they are graphically depicted in Figures 6 through 12 along with tabular data describing their relative size and Cowardin classification. The dominant vegetation encountered in each wetland is summarized in Table 3, organized by stratum with species grouped and color-coded according to their indicator status.

Representative data sheets for each wetland feature and adjoining upland are included in Appendix A, with representative photographs in Appendix B. Data sheets are arranged sequentially by tract number and grouped into wetland and upland data sheets.

■

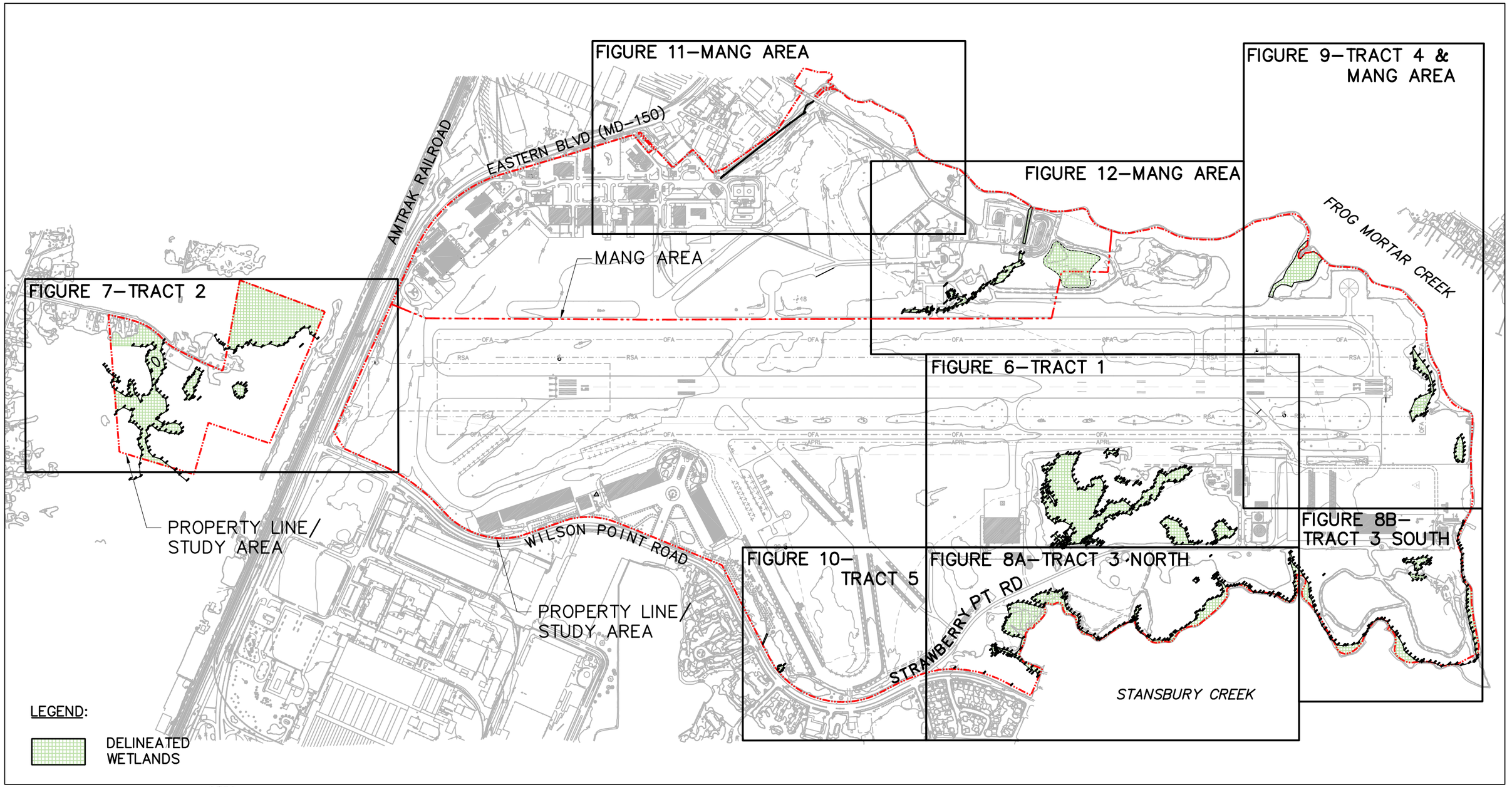
### Tract 1

Tract 1 consists of a rectangular section of wooded land just north of Strawberry Point Road (Figures 5 & 6). This area is approximately 25 acres in size and is underlain primarily by the hydric Elkton loam and disturbed Sassafras-Urban Land Complex soils. Five transects and thirty observations points were utilized to perform the delineation and are depicted in Figure 6.

Excessively dry soil conditions in Tract 1 hindered the soils investigation somewhat. Because of routine auger refusal and in consideration of the history of soil disturbance in the area, the delineation was driven in large part by the distribution of hydrophytic vegetation and hydrologic indicators.

### Wetlands

Six depressional wetlands occur within the Elkton soil mapping unit (Wetlands A through F, Figure 6). At 7.10 acres, Wetland A is the largest system in Tract 1 and the largest single wetland encountered onsite. It incorporates most of the western half of the tract with a narrow finger extending towards the east (Figure 6). Like all of the wetlands in Tract 1, Wetland A is a palustrine forested, broad-leaved deciduous (PFO1) depression with evidence of standing water as indicated by stained leaves and stain lines on tree trunks (Photo B1).




NOTES:

1. BACKGROUND INFORMATION FROM PLAT ENTITLED "AIRPORT LAYOUT PLAN: EXISTING FACILITIES" PREPARED BY DMJM AVIATION AND DATED 10/16/02. BACKGROUND INFORMATION IS FOR PRESENTATION PURPOSES ALONE AND HAS NOT BEEN VERIFIED BY VHB.
2. WETLANDS SURVEYED BY VHB 11/1–3/05 & 3/28/06.

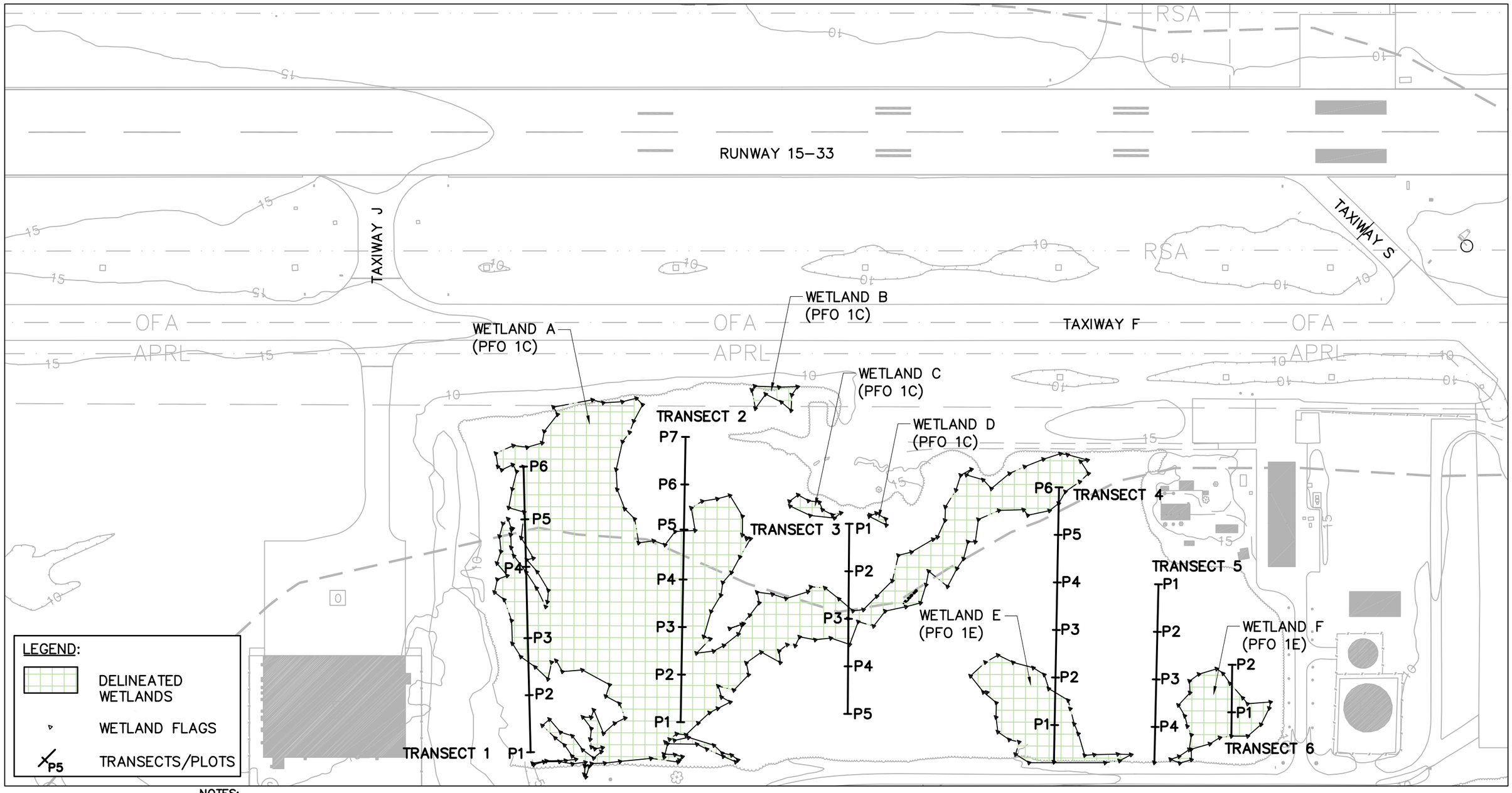
**Vanasse Hangen Brustlin, Inc.**

Figure 5 April 2006

Overview Map
Martin State Airport
Baltimore County, Maryland
Project # 09246.04

Table 3.30
MARTIN STATE AIRPORT WETLAND INVENTORY:
Dominant Vegetation by Tract

| STRATUM | TREES | | | | | | | | | | | | SHRUBS | | | | | | | | | | | | | | | | | | | | HERBACEOUS / ETC | | | | | | | | | | | | | | | | | | |

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2. WETLANDS SURVEYED BY VHB 11/1–3/05 & 3/28/06

| WETLAND SUMMARY TABLE | | |
|---|---|---|
| WETLAND | COWARDIN CLASSIFICATION | SIZE AC–SF |
| A | PFO 1C | 7.10–309,345 |
| B | PFO 1C | 0.06–2,628 |
| C | PFO 1C | 0.05–2,177 |
| D | PFO 1C | 0.01–383 |
| E | PFO 1E | 0.75–32,594 |
| F | PFO 1E | 0.44–19,153 |

**Vanasse Hangen Brustlin, Inc.**

Figure 6 April 2006

Tract 1
Martin State Airport
Baltimore County, Maryland
Project # 09246.04

Surface water accumulates in the wetland during the wet season, overflows into ditches located at the southwestern corner of the tract, and eventually flows southward underneath Strawberry Point Road.

Wetland B is an isolated depression located along the northeastern edge of Tract 1 and adjacent to the mowed grass associated with the airport taxiway. Wetlands C and D are small, artificial PFO1C wetlands. Wetland C is located at the toe of an area of fill material approximately 4 feet in height. Wetland D appears to be the result of the gouging of the soil surface by a bladed dozer. This area was observed having stained leaves with asphalt, bottles, and other debris intermingled.

Wetlands E and F are seasonally flooded / saturated palustrine forested, broad-leaved deciduous wetlands (PFO1E) with vernal pools at their centers (Figure 6, Photo B2). The outer reaches of the wetlands occur as saturated areas within relatively flat terrain. The portion of the wetland identified as the vernal pool maintains a relatively open understory where standing water occurs during the wet season. Maximum depths range from roughly 4 to 6 inches at Wetland E and 8 to 10 inches at Wetland F. Excess water from Wetland E extends into the Strawberry Point Road right-of-way and into a roadside swale. This water is then conveyed to a culvert underneath the road where the water flows southward to a ditch leading to Stanbury Creek. Overflowing water from Wetland F is captured by a small swale cut between the wetland and Strawberry Point Road and conveyed through a small culvert towards Stansbury Creek.

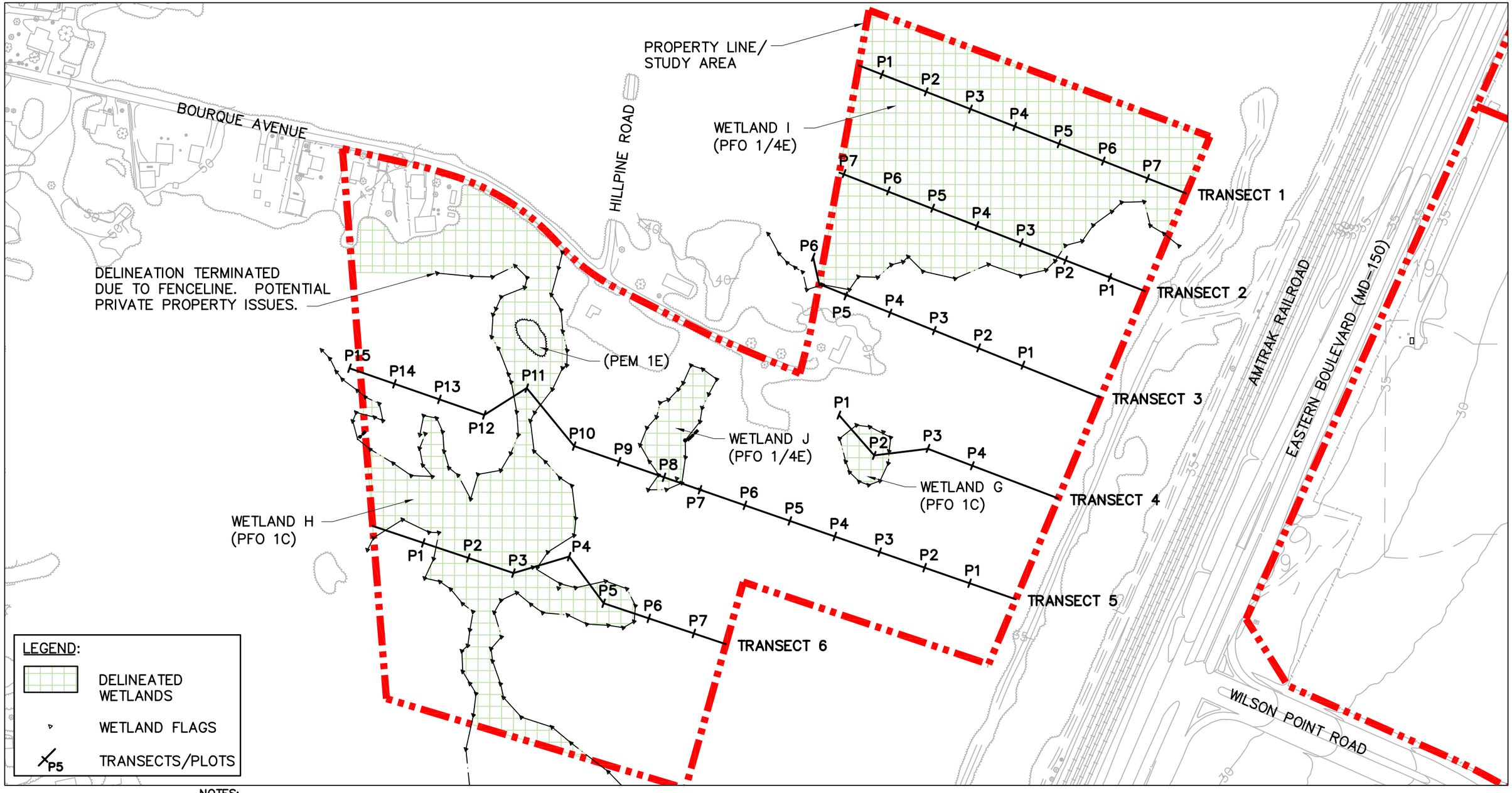
### Uplands

Uplands occur within portions of the Elkton and Sassafras-Urban Land Complex mapping units. The north central portion of the site contains a disturbed area with deposited construction debris and concrete rubble. The dominant upland vegetation in Tract 1 is outlined at the bottom of Table 3.

■

### Tract 2

Tract 2 is a forested parcel measuring roughly 37 acres in size. It is located on the northern side of Eastern Boulevard and the Amtrak rail line (Figures 5 and 7). The entire site is wooded with the exception of an old lot and house currently overgrown with vines and woody shrubs at the end of Bourque Avenue. Six transects and forty-six observation points were located in Tract 2, resulting in the delineation of four wetlands (Wetlands G through J). These are associated with




NOTES:

1. BACKGROUND INFORMATION FROM PLAT ENTITLED "AIRPORT LAYOUT PLAN: EXISTING FACILITIES" PREPARED BY DMJM AVIATION AND DATED 10/16/02. BACKGROUND INFORMATION IS FOR PRESENTATION PURPOSES ALONE AND HAS NOT BEEN VERIFIED BY VHB.
2. WETLANDS SURVEYED BY VHB 11/1-3/05 & 3/28/06

| WETLAND SUMMARY TABLE | | |
|---|---|---|
| WETLAND | COWARDIN CLASSIFICATION | SIZE AC-SF |
| G | PFO 1C | 0.22-9,684 |
| H | PFO 1C | 5.01-218,258 |
| I | PFO 1/4E | 6.63-288,623 |
| J | PFO 1/4E | 0.45-19,540 |

**Vanasse Hangen Brustlin, Inc.**

Figure 7 April 2006

Tract 2
Martin State Airport
Baltimore County, Maryland
Project # 09246.04

the Pocomoke and Fallsington hydric soil types. Uplands occur in areas mapped as Woodstown, Fort Mott, and Galestown soils.

Wetland G is a small forested wetland associated with an isolated vernal pool located just southwest of the old home site; a hydric inclusion in the otherwise upland Woodstown soil type, (Figure 7). Wetland J is a similar feature located just north of Wetland G and west of Bourque Avenue. While this wetland occurs as a slight depression in the landscape, it does not retain the deeper features of other vernal pools in the area. Wetland J also has needle-leaf evergreens (pond pine, *Pinus serotina*).

Wetland H is a larger wetland located at the northernmost end of the property, extending west from the intersection of Bourque Avenue and Hillpine Road. This wetland represents a narrow, but relatively flat drainageway across the landscape (Photo B3). One vernal pool inclusion occurs near Bourque Avenue. Excess surface water from the system flows towards the southwest where it feeds a tributary to Dark Head Creek.

Wetland I is a densely forested, deciduous and needle-leaf evergreen wetland in which surface water ponds much of the year (Photo B4).

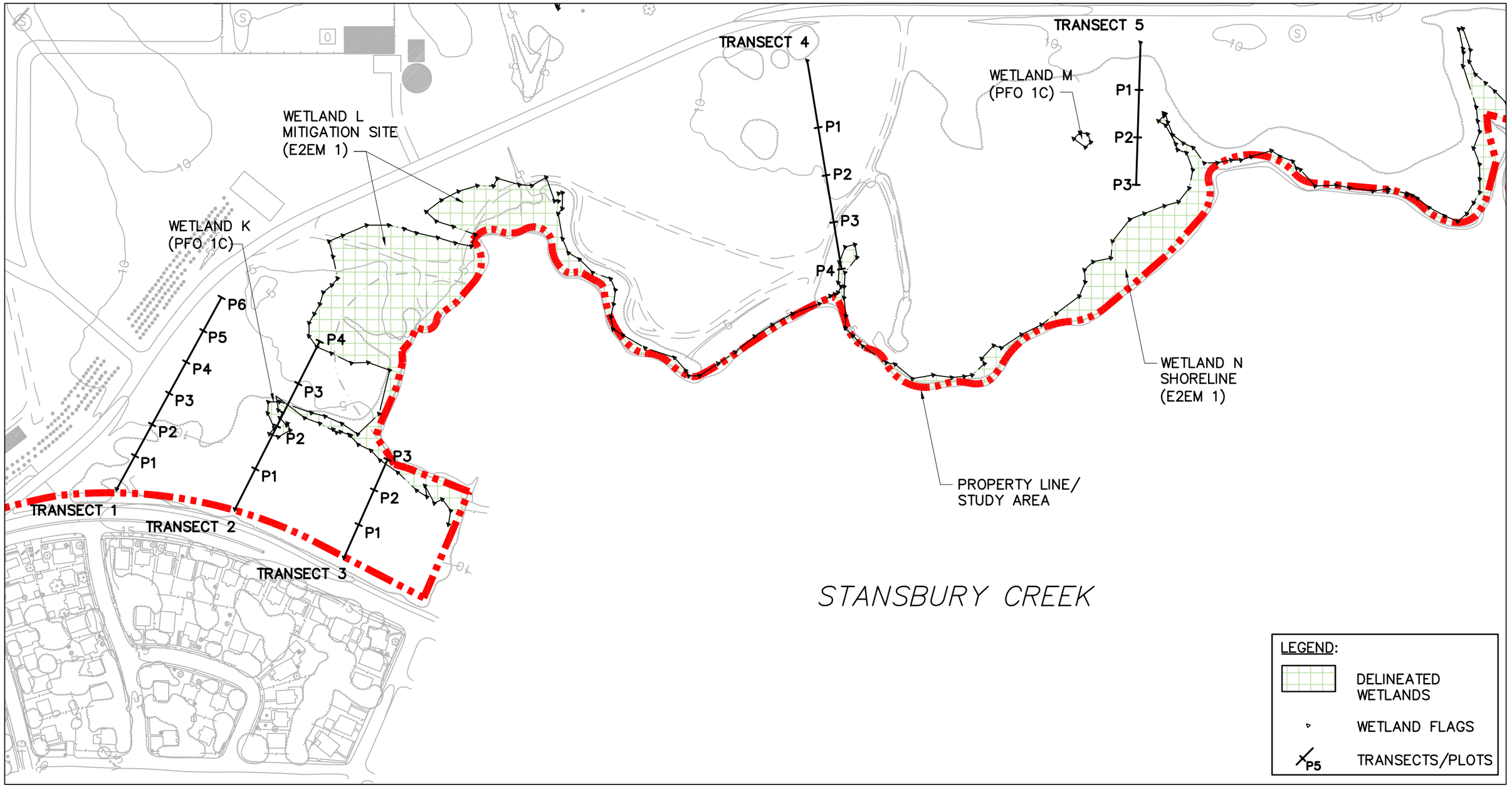
■

## Tract 3

Tract 3 covers all of the airport property between Stansbury Creek and Strawberry Point Road (Figures 5, 8A, 8B). Wetlands on this section of land include a restored system functioning as a mitigation site, two small depressions, and the vegetated shoreline. Soils on Tract 3 include Sassafras-Urban Land Complex, Lenior-Urban Land Complex, and old spoil material simply mapped in the soil survey as Made Land (USDA 1976).

Wetland K within Tract 3 is a small depressional feature located between the toe of a slight ridge and a tidal ditch (Figure 8A). During periods of abundant rainfall or high water table, excess overflows into the ditch.

Wetland L is a tidally influenced, emergent wetland mitigation site (Figure 8A, Photo B5). The majority of the wetland is covered with narrow-leaf cattails (*Typha angustifolia*) though many other species were observed along the edge of the system and planted within its boundary (Table 3). It should be noted that the delineation at Wetland L may differ from the wetland limits depicted within annual monitoring reports for permit compliance. In this case, the latter source should be deemed more accurate, as it is based on the compilation of more detailed hydrologic and vegetative monitoring data.




LEGEND:

- DELINEATED WETLANDS
- WETLAND FLAGS
- P5 TRANSECTS/PLOTS

NOTES:

1. BACKGROUND INFORMATION FROM PLAT ENTITLED "AIRPORT LAYOUT PLAN: EXISTING FACILITIES" PREPARED BY DMJM AVIATION AND DATED 10/16/02. BACKGROUND INFORMATION IS FOR PRESENTATION PURPOSES ALONE AND HAS NOT BEEN VERIFIED BY VHB.
2. WETLANDS SURVEYED BY VHB 11/1–3/05

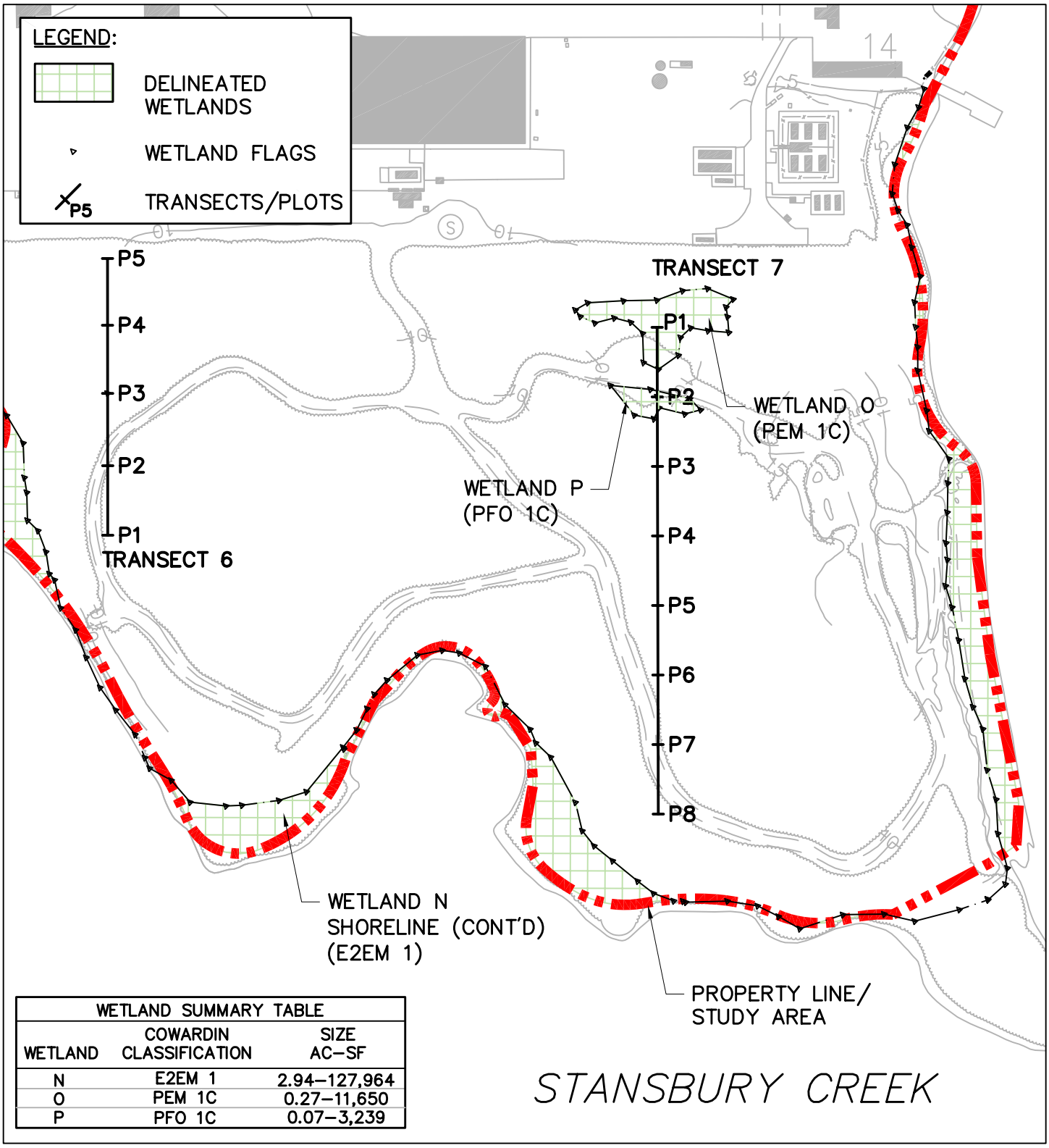
0 100 200 Feet

| WETLAND SUMMARY TABLE | | |
|---|---|---|
| WETLAND | COWARDIN CLASSIFICATION | SIZE AC–SF |
| K | PFO 1C | 0.37–16,042 |
| L | E2EM 1 | 2.32–101,178 |
| M | PFO 1C | 0.01–642 |
| N | E2EM 1 | 2.94–127,964 |

**Vanasse Hangen Brustlin, Inc.**

Figure 8A April 2006

Tract 3 (North Portion)
Martin State Airport
Baltimore County, Maryland
Project # 09246.04




| WETLAND SUMMARY TABLE | | |
|---|---|---|
| WETLAND | COWARDIN CLASSIFICATION | SIZE AC-SF |
| N | E2EM 1 | 2.94-127,964 |
| O | PEM 1C | 0.27-11,650 |
| P | PFO 1C | 0.07-3,239 |

Vanasse Hangen Brustlin, Inc.

0 100 200 Feet

NOTES:

1. BACKGROUND INFORMATION FROM PLAT ENTITLED "AIRPORT LAYOUT PLAN: EXISTING FACILITIES" PREPARED BY DMJM AVIATION AND DATED 10/16/02. BACKGROUND INFORMATION IS FOR PRESENTATION PURPOSES ALONE AND HAS NOT BEEN VERIFIED BY VHB.
2. WETLANDS SURVEYED BY VHB 11/1-3/05 & 3/28/06

Figure 8B April 2006

Tract 3 (South Portion)
Martin State Airport
Baltimore County, Maryland
Project # 09246.04

Wetland M is a small forested wetland located in the center of Tract 3 adjacent to old fill material (Figure 8A). It appears surface runoff is captured within a slight depression abutting the toe of the fill material. The wetland may have inadvertently been created by anthropogenic disturbance.

Wetland N refers to the immediate shoreline of Stanbury Creek associated with a fringe of common reed (*Phragmites australis*) and is thus an estuarine emergent wetland feature (Figures 8A, 8B). Some portions of the shore are lined with rip rap. The *Phragmites* typically occurs as very dense stands just landward of the mean high tide elevation and among the rip rap (Photo B6).

Wetland O occurs as a man-made, isolated depression at the southern end of Tract 3 (Figure 8B). The surrounding landscape of Strawberry Point is characterized by historic fill dirt mounded in a way that allows surface water to slope away from the shoreline and back towards the police station. Runoff eventually makes its way to a low point in the fill mound where a berm is located along the wood line adjacent to the police station. This berm serves to hold the water within a small basin sufficiently wet to encourage the occurrence of emergent hydrophytes (Table 3). Wetland P is a forested extension of Wetland O (Figure 8B), separated from it by an access road.

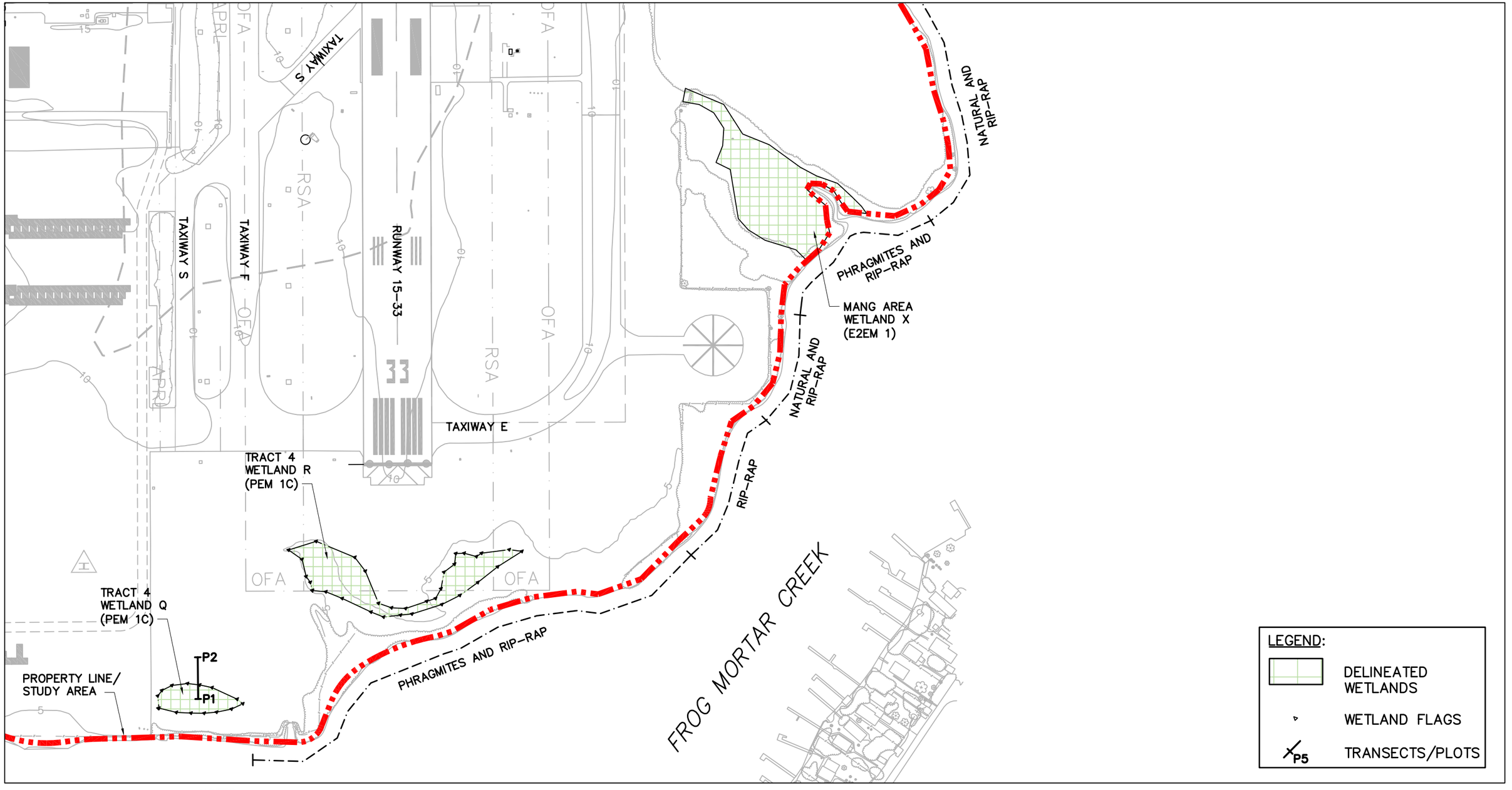
The delineation of Strawberry Point differs appreciably from the NWI mapping (Figure 4). This discrepancy is likely due to the fact that wetlands appearing on NWI maps are often based on photointerpretation, and therefore field-delineated boundaries of these areas can be significantly different than those depicted on NWI maps, especially in areas characterized by heavy vegetation. The tree and shrub strata are dominated by the FACU black cherry (*Prunus serotina*) and FAC sweetgum (*Liquidambar styraciflua*) with occasional stems of the FACU southern red oak (*Quercus falcata*), indicating that upland conditions are prevalent.

■

## Tract 4

Tract 4 includes all of the grassed areas adjacent to main runway and taxiways. No wetland areas occur amongst these features. These maintained areas are shaped and contoured to convey runoff to numerous drop inlets where water enters underground pipes for eventual release to various surrounding creeks and ditches.

However, two wetlands (Wetlands Q and R) occur at the far southern end of the main runway, between the concrete terminus and shoreline of Frog Mortar Creek (Figures 5 and 9). Both of these systems have very similar characteristics. The wetlands occur on compacted soils with a shallow gravel base where rainwater




NOTES:

1. BACKGROUND INFORMATION FROM PLAT ENTITLED "AIRPORT LAYOUT PLAN: EXISTING FACILITIES" PREPARED BY DMJM AVIATION AND DATED 10/16/02. BACKGROUND INFORMATION IS FOR PRESENTATION PURPOSES ALONE AND HAS NOT BEEN VERIFIED BY VHB.
2. WETLANDS SURVEYED BY VHB 11/1-3/05

0 125 250 Feet

| WETLAND SUMMARY TABLE | | |
|---|---|---|
| WETLAND | COWARDIN CLASSIFICATION | SIZE AC-SF |
| Q | PEM 1C | 0.29-12,769 |
| R | PEM 1C | 0.90-39,115 |
| X | E2EM 1 | 1.53-66,697 |

**Vanasse Hangen Brustlin, Inc.**

Figure 9 April 2006

Tract 4 and MANG Area
Martin State Airport
Baltimore County, Maryland
Project # 09246.04

from the concrete runway gathers into very shallow depressions (Photo B7). Between the wetlands and Frog Mortar Creek, a raised gravel road is present which functions as a small berm that helps impound the runoff. This configuration has created the two artificial emergent wetlands totaling 1.19 acres. It is likely that these areas are mowed during dry periods in the summer months.

■

## Tract 5

Tract 5 refers to a small strip of land located between Wilson Point Road and the existing T-hangers (Figures 5 and 10). Two very small wetlands occur within this area. Wetland S is sustained by a hillside seep where water sheetflows across a flat, forested area. Surface water reaches the edge of Wilson Point Road where it accumulates in a small swale leading to a culvert underneath the road.

Wetland T is a small drainage ditch approximately 3 to 4 feet wide designed to capture runoff from the hillside and adjacent airplane hangers and convey the water westward towards a culvert underneath Wilson Point Road (Figure 10). The jurisdictional reach of the ditch extends only 20 to 30 feet across the boundary towards the airport from the roadside fence (Photo B8). Standing water was observed at the lower reaches of the ditch next to the road.

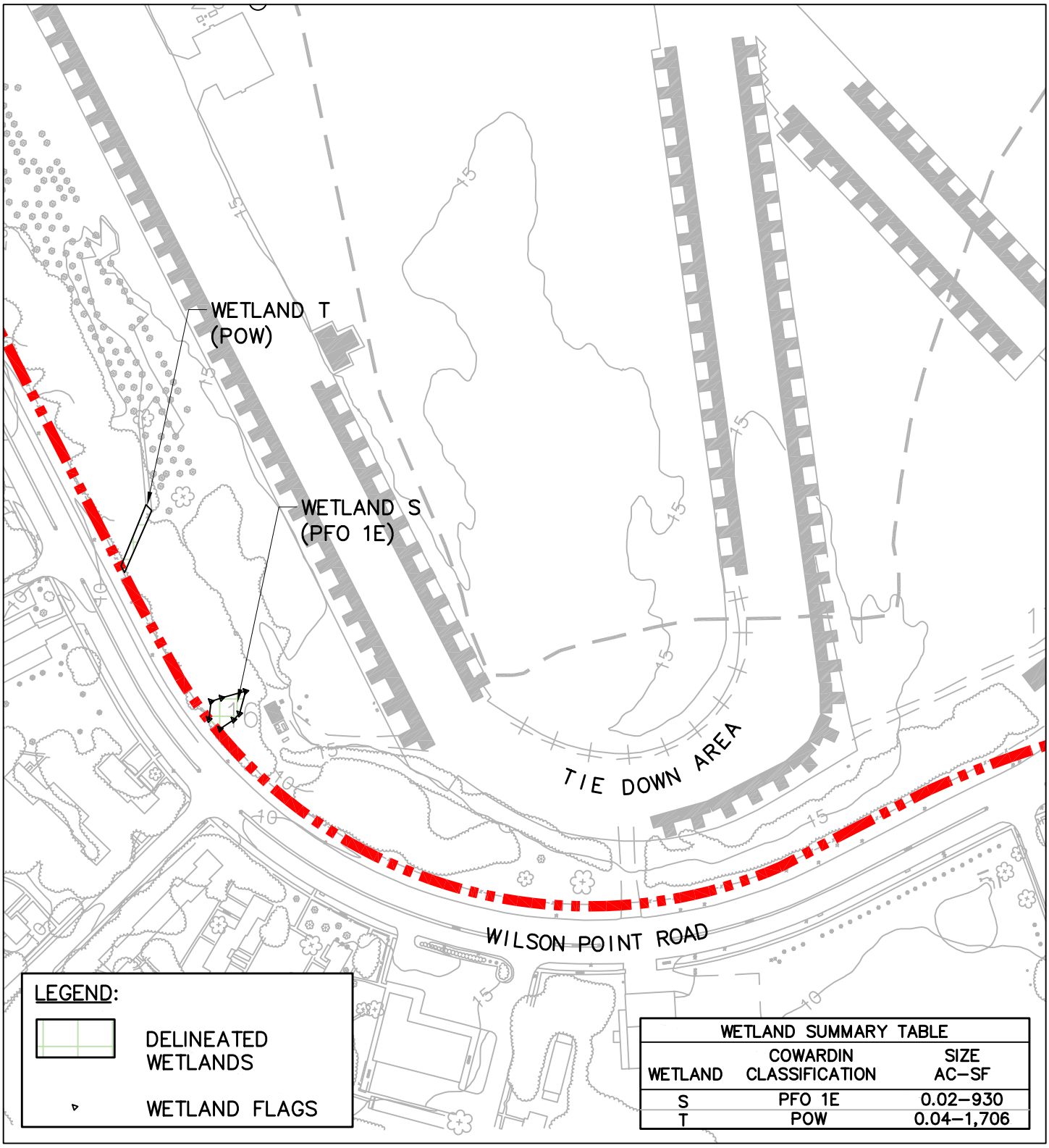
■

## MANG Area

### Wetlands

The MANG area encompasses all of the land east of the taxiways and runway where MANG facilities are located (Figures 5, 11, and 12). This parcel of land has been developed significantly relative to the west side of MTN. The northernmost portion of the MANG area is occupied by office buildings, parking areas, maintenance facilities, and paved tarmacs. The southern part of the tract is underlain by disturbed soils associated with old spoil and dump sites and is overgrown with a variety of plant communities.

Working from north to south, the first wetland system encountered (Wetland U) is a large drainage ditch that collects and conveys runoff from the surrounding impervious surfaces towards the east and into Frog Mortar Creek (Figure 11, Photo B9). The lower portion of this ditch is presumed to be tidally influenced and giant reed is most common (Photo B10).




| WETLAND SUMMARY TABLE | | |
|---|---|---|
| WETLAND | COWARDIN CLASSIFICATION | SIZE AC–SF |
| S | PFO 1E | 0.02–930 |
| T | POW | 0.04–1,706 |

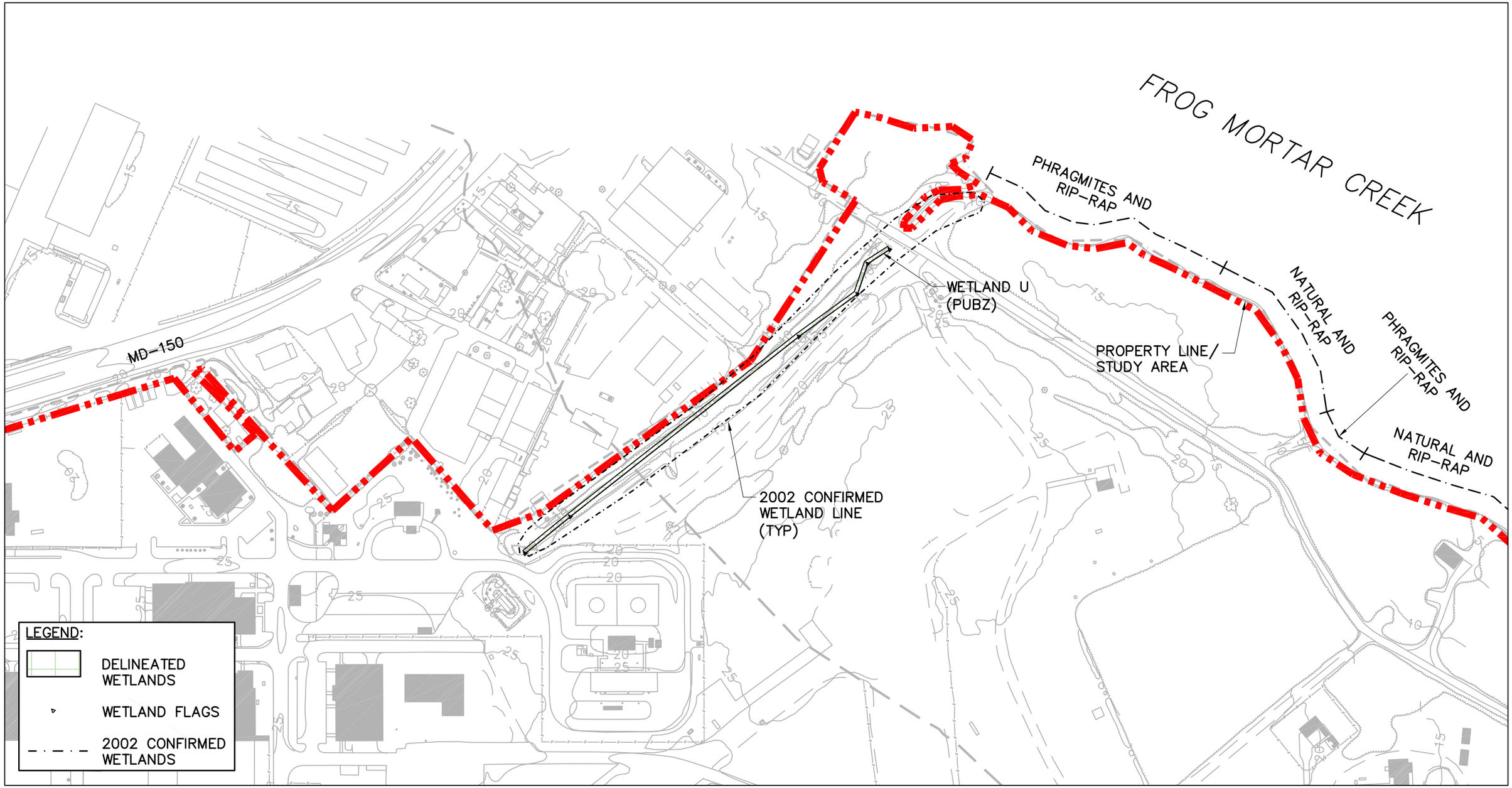
Vanasse Hangen Brustlin, Inc.

0 100 200 Feet

NOTES:

1. BACKGROUND INFORMATION FROM PLAT ENTITLED "AIRPORT LAYOUT PLAN: EXISTING FACILITIES" PREPARED BY DMJM AVIATION AND DATED 10/16/02. BACKGROUND INFORMATION IS FOR PRESENTATION PURPOSES ALONE AND HAS NOT BEEN VERIFIED BY VHB.
2. WETLANDS SURVEYED BY VHB 11/1–3/05

Figure 10 April 2006
Tract 5
Martin State Airport
Baltimore County, Maryland
Project # 09246.04




NOTES:

1. BACKGROUND INFORMATION FROM PLAT ENTITLED "AIRPORT LAYOUT PLAN: EXISTING FACILITIES" PREPARED BY DMJM AVIATION AND DATED 10/16/02. BACKGROUND INFORMATION IS FOR PRESENTATION PURPOSES ALONE AND HAS NOT BEEN VERIFIED BY VHB.
2. WETLANDS SURVEYED BY VHB 11/1-3/05

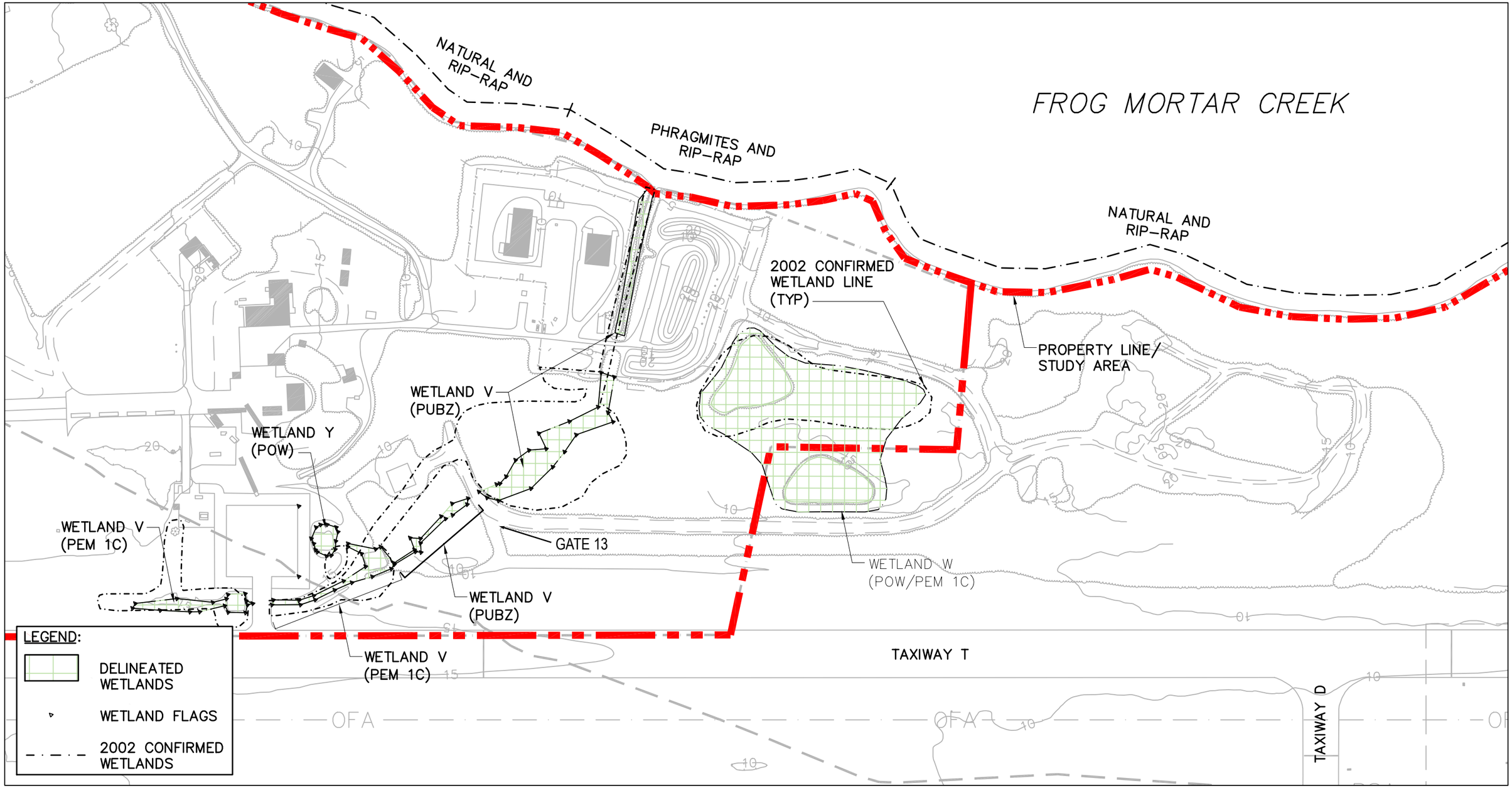
| WETLAND SUMMARY TABLE | | |
|---|---|---|
| WETLAND | COWARDIN CLASSIFICATION | SIZE AC-SF |
| U | PUBZ | 0.19-8,074 |

0 100 200 Feet

**Vanasse Hangen Brustlin, Inc.**

Figure 11 April 2006

MANG Area
Martin State Airport
Baltimore County, Maryland
Project # 09246.04




NOTES:

1. BACKGROUND INFORMATION FROM PLAT ENTITLED "AIRPORT LAYOUT PLAN: EXISTING FACILITIES" PREPARED BY DMJM AVIATION AND DATED 10/16/02. BACKGROUND INFORMATION IS FOR PRESENTATION PURPOSES ALONE AND HAS NOT BEEN VERIFIED BY VHB.
2. WETLANDS SURVEYED BY VHB 11/1-3/05

0 100 200 Feet

| WETLAND SUMMARY TABLE | | |
|---|---|---|
| WETLAND | COWARDIN CLASSIFICATION | SIZE AC-SF |
| V | PEM 1C | 0.25-11,042 |
| V | PUBZ | 0.57-25,017 |
| W | POW/PEM 1C | 2.51-109,224 |
| Y | POW | 0.06-2,764 |

**Vanasse Hangen Brustlin, Inc.**

Figure 12 April 2006

MANG Area
Martin State Airport
Baltimore County, Maryland
Project # 09246.04

East of Taxiway T and adjacent to the engine testing facility, infrastructure is in place to capture, pipe, and release runoff into a 3-foot wide ditch that conveys water through a wooded area near Gate 10 (Photo B11). As the water flows underneath an existing dirt road, it enters a sandy flat and distinct channel that appears to have been formed by flashy rain events (Wetland V, Figure 12). The system fans out into a low energy, absorbing wetland with a heavy sand and silt soil texture populated by scattered smartweeds (*Polygonum* spp.), broadleaf arrowhead (*Sagittaria latifolia*), and false nettle (*Boehmeria cylindrical*) growing in the lowest areas, and box elder (*Acer negundo*) growing along the outer edges. Any excess water not absorbed by the sandy flat eventually enters another ditch that conveys the water eastward to Frog Mortar Creek. It should be noted that the size and configuration of Wetland V varies appreciably from the corresponding wetland delineated in 2002 (Figure 12). In addition, the position of the ditch just north of Gate 13 is offset noticeably to the north. MAA and VHB are currently consulting with MANG staff to resolve these inconsistencies.

Wetland W is located south of the Wetland V and contains two artificial ponds (Figure 12). Both ponds are surrounding by extremely dense stands of giant reed, making a complete inspection difficult. Furthermore, MAA and MANG staff recommended but a cursory evaluation of this area. It appears these ponds are formed from depressions in the landscape resulting from historic dumping and backfilling activities. Signs of past dumping activities include piles of construction debris, concrete rubble, and vegetation typically associated with disturbed sites such as common reed (*Phragmites australis*), Japanese honeysuckle (*Lonicera japonica*), blackberry (*Rubus argutus*), pokeweed (*Phytolacca americana*), and devil's walking stick (*Aralia spinosa*). The ponds are open-water features with no distinguishable outlets.

Wetland W is of a larger size than the corresponding wetland confirmed in 2002, and incorporates the southern pond (Figure 12).

Farther south and adjacent to the Compass Rose lies a monoculture of *Phragmites* functioning as a low marsh approximately 1.53 acres in size (Wetland X, Figure 9). This wetland appears to receive runoff from the airstrip through a piped system before being released into Frog Mortar Creek (Photos B12 and B13).

## Shoreline

Unlike the shoreline in Tract 3 along Stansbury Creek (Figures 8A and 8B), the eastern shoreline along the MANG portion of the airport is far more inaccessible and punctuated by steep sections of riprap. As a result, field personnel evaluated this shoreline from the water with the aid of a Baltimore County Police boat launched from Strawberry Point.

Three general shoreline types arose as a result of this investigation. These include:

- areas of little vegetation dominated by shore defense materials such as riprap;
- areas of *Phragmites* intermingled with riprap, and;
- areas of relatively native vegetation intermingled with rip rap.

The distribution of these shoreline types is presented in Figures 9, 11, and 12. Average width of the vegetated areas was 10 to 15 feet. Native vegetation consisted of saltmarsh cordgrass (*Spartina alterniflora*) and Eastern baccharis (*Baccharis halimifolia*). Some relatively natural, intertidal sandy beaches were noted, transitioning to upland side slopes colonized by red maple (*Acer rubrum*), sweetgum (*Liquidambar styfaciflua*) and various oaks (*Quercus* spp.).

■

## Wetlands Functions & Values Assessment

### Methodology

At the request of the MAA, VHB utilized a methodology to assess functional values based on an approach developed by the New England District of the U.S. Army Corps of Engineers and outlined in the Highway Methodology Workbook: Supplement (COE 1999). This methodology assesses 13 functional values through a "descriptive approach", using both wetland science and judgment in the field. If a particular function is judged to be present by the evaluator, justification for identifying that function is easily documented by descriptive characteristics. The guidebook provides a listing of such characteristics that can be easily referenced on a data form. The data form then provides an "unbiased record of the wetland, including its location, function, appearance, and relationship to its adjacent land use." The 13 functional values that were evaluated are listed below.

- Groundwater Recharge/Discharge
- Floodflow Alteration/Attenuation
- Fish and Shellfish Habitat
- Sediment/Toxicant Retention
- Nutrient Removal
- Production Export
- Sediment/Shoreline Stabilization

- Wildlife Habitat
- Recreation
- Educational/Scientific Value
- Uniqueness/Heritage
- Visual Quality/Aesthetics
- Endangered Species Habitat

## Results

Wetlands at MTN were found to be of varying degrees of quality, ranging from man-made disturbed areas to mature hardwood swamps. The various types of wetlands also account for the wide variety of functional values. Endangered Species Habitat and Recreational values, however, are the only functions not offered by any wetland on the property.

The non-tidal forested systems - including swamps and vernal pools - have unique value for wildlife use and stormwater retention. Tidal systems tend to be thin, vegetated shorelines with the exception of the excavated mitigation area located in Tract 3 (Figure 8A). Many of the other systems in the MANG area offer very little wetland functional values due to significant past disturbances and dumping.

The results of the functional values assessment are summarized in Table 4, and a brief description of the values offered is provided below for each tract.

### Tract 1

The larger wetlands within Tract 1 (A, E, and F, Figure 6) are high-quality forested systems that are unique to the local area. These systems provide stormwater attenuation and wildlife habitat as their primary functions. The smaller, isolated and artificial systems provide a sediment / toxicant removal function alone because of their location adjacent to old fill material and construction debris and depressional setting.

### Tract 2

Tract 2 contains the highest quality wetland systems on the entire airport property. Approximately 35% of this tract is forested wetlands comprised of unique swamp and vernal pool systems. Wetlands G and I (Figure 7) provide a high degree of wildlife habitat, flood storage, and nutrient/sediment removal as points of water collection. Wetland I, in particular, is a mature forest with a wide variety of native plants. Wetland H conveys surface water slowly across the property towards the west, and provides wildlife habitat, floodflow attenuation, and production export values.

Table 4.
WETLAND FUNCTIONS AND VALUES ASSESSMENT

| | TRACT 1 | | | | | | TRACT 2 | | | | TRACT 3 | | | | | | TRACT 4 | | TRACT 5 | | MANG AREA | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Wetland Function/Value** | **A** | **B** | **C** | **D** | **E** | **F** | **G** | **H** | **I** | **J** | **K** | **L** | **M** | **N** | **O** | **P** | **Q** | **R** | **S** | **T** | **U** | **V** | **W** | **X** | **Y** |
| Groundwater Recharge/Discharge | ✓ | | | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | | | | | ★ | | | | | | |
| Floodflow Alternation/Attenuation | ★ | | | | ★ | ★ | ★ | ★ | ★ | ★ | | | | | | | ★ | ★ | | | | ★ | ✓ | | ★ |
| Fish and Shellfish Habitat | | | | | | | | | | | | | | | | | | | | | | | ✓ | | |
| Sediment/Toxicant Retention | ✓ | | ★ | ★ | ✓ | ✓ | ✓ | ★ | ★ | ★ | ★ | ✓ | ★ | | ★ | ★ | ★ | ★ | | | ✓ | ★ | ★ | ★ | ★ |
| Nutrient Removal | ✓ | | | | ✓ | ✓ | | ✓ | ★ | ✓ | ★ | ✓ | | | | | | | | | ★ | ★ | ✓ | ✓ | |
| Production Export | | | | | | | | ✓ | | | | ✓ | | ✓ | | | | | | | | | | ✓ | |
| Sediment/Shoreline Stabilization | | | | | | | | | | | | ★ | | ★ | | | | | | | | | | ★ | |
| Wildlife Habitat | ★ | | | | ★ | ★ | ★ | ★ | ★ | ★ | | ★ | | ★ | ★ | ★ | | | | ★ | | | ★ | | |
| Recreation | | | | | | | | | | | | | | | | | | | | | | | | | |
| Educational/Scientific Value | | | | | ✓ | ✓ | | | | | | ✓ | | | | | | | | | | | | | |
| Uniqueness/Heritage | ✓ | | | | ★ | ★ | ★ | ★ | ✓ | | | ✓ | | | | | | | | | | | | | |
| Visual Quality/Aesthetics | | | | | | | | | | | | ★ | | | | | | | | | | | | | |
| Endangered Species Habitat | | | | | | | | | | | | | | | | | | | | | | | | | |

✓ - Functional value present
★ - Denotes principal function offered by wetland

### Tract 3

Wetlands within Tract 3 (Figures 8A, 8B) are associated chiefly with the tidal shoreline adjacent to Stansbury Creek. The highest valued system is the mitigation site (Wetland L) which provides sediment retention, production export, shoreline stabilization, and wildlife habitat functions. Other wetlands within Tract 3, other than the *Phragmites*-dominated shoreline, are small depressions that offer fewer functional values.

### Tract 4

Wetlands within Tract 4 (Figure 9) at the end of the runway capture surface runoff from the neighboring pavement and grassed areas. Flood storage and sediment/toxicant retention are the only functional values these wetlands provide.

### Tract 5

The two small wetlands within Tract 5 (Figure 10) include the seep and man-made ditch. Each of these systems is too small to provide any significant wetland function. The small seep, which was dry during the field work, offers groundwater discharge functions. Several frogs were observed in the ditch using the standing water for habitat.

### MANG Area

Because the MANG property has experienced years of earth moving, filling, and dumping, wetlands on this parcel are primarily the result of man-made features dominated by invasive species (*Phragmites*). As such, sediment/toxicant retention and nutrient removal appear to be the dominant functions offered. The two ponds, however, offer wildlife habitat for species such as waterfowl and amphibians.

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# Appendix A – DATA FORMS

## TRACT 1 – Wetland Data Sheets

**DATA FORM**
**ROUTINE WETLAND DETERMINATION**
**(1987 COE WETLAND DELINEATION MANUAL)**

PROJECT : Martin State Airport – Tract 1 DATE: 9/19/05
APPLICANT: BWI COUNTY: Baltimore
INVESTIGATOR: A. Sutton, T. Davis STATE: Maryland

Do Normal Circumstances exist on the site? Yes No Community ID Forested Wetland A
Is the site significantly disturbed (Atypical Situation)? Yes No Transect ID T-2
Is the area a potential Problem Area? Yes No Plot ID P-1
(If needed, explain on reverse.)

## V E G E T A T I O N

| Dominant Plant Sp. | Stratum | Indicator | Dominant Plant Sp. | Stratum | Indicator |
|---|---|---|---|---|---|
| 1. Acer rubrum | T | FAC | 9. | | |
| 2. Liquidambar styraciflua | T | FAC | 10. | | |
| 3. Nyssa sylvatica | T | FAC | 11. | | |
| 4. Vaccinium corymbosum | SH | FACW- | 12. | | |
| 5. Smilax rotundifolia | V | FAC | 13. | | |
| 6. | | | 14. | | |
| 7. | | | 15. | | |
| 8. | | | 16. | | |

Percent of Dominant Species that are OBL, FACW or FAC ( EXCLUDING FAC- ). **100**

Remarks: Sample area satisfies the wetland hydrophytic vegetation criterion.

## H Y D R O L O G Y

X Recorded Data (Describe in Remarks):
____ Stream, Lake, or Tide Gauge
X Aerial Photographs
____ Other
____ No Recorded Data Available

Field Observations:

Depth of Surface Water: none (in.)

Depth to Free Water in Pit: 14.4 (in.)

Depth to Saturated Soil: 0.0 (in.)

Wetland Hydrology Indicators:
Primary Indicators:
____ Inundated
X Saturated in Upper 12 inches
____ Water Marks
____ Drift Lines
____ Sediment Deposits
____ Drainage Patterns in Wetlands

Secondary Indicators (2 or more required)

X Oxidized Root Channels in Upper 12 inches
X Water-Stained Leaves
____ Local Soil Survey Data
X Fac-Neutral Test
____ Other (Explain in Remarks)

Remarks: Sufficient field indicators of wetland hydrology present; satisfies criterion

## S O I L S (P-1,T-2)

Map Unit Name
(Series & Phase): Elkton Loam

Drainage Class: Poorly Drained

Field Observations

Taxonomy (Subgroup): Typic endoaquults

Confirm Mapped Type: (YES) NO
see remarks

Profile Description:

| Depth (Inches) | Horizon | Matrix Colors (Munsell Moist) | Mottle Colors (Munsell) Moist) | Mottle Abundance/ Contrast | Texture, Concretions |
|---|---|---|---|---|---|
| 0-2 | O | 10YR 3/1 | | | Saturated loamy sand & organics |
| 2-6 | A | 10YR 3/2 | | | Saturated loamy sand |
| 6-12 | B1 | 5Y 6/2 | 7.5YR 4/6 | com./fine/prom. | Moist clayey f-sand, friable, ox rc |
| 12-17 | B2 | 5Y 6/2 | 7.5YR 4/6 | many/med./prom. | Saturated clayey fine sand, friable |
| 17 | refusal | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

Hydric Soil Indicators:

| | | | |
|---|---|---|---|
| | Histosol | | Concretions |
| | Histic Epipedon | | High Organic Content in Surface |
| | Sulfidic Odor | | Layer in Sandy Soils |
| | Aquic Moisture Regime | | Organic Streaking in sandy Soils |
| | Reducing Conditions | | Listed on Local Hydric Soils List |
| X | Gleyed or Low-Chroma Colors | X | Listed on National Hydric Soils List |
| | | | Other (Explain in Remarks) |

Remarks: Sufficient field indicators of hydric soil present; Satisfies criterion. Soils were not sampled due to extremely hard and dry conditions.

## W E T L A N D  D E T E R M I N A T I O N

Hydrophytic Vegetation Present:? (Yes) No (Circle)
Wetland Hydrology Present? (Yes) No
Hydric Soils Present? (Yes) No

Is this Sampling Point Within a Wetland? (Yes) No (Circle)

Remarks: Sample area satisfies all three mandatory wetland technical criteria and is classified as a PFO1C wetland.

Approved by HQUSACE 3/92

**DATA FORM**
**ROUTINE WETLAND DETERMINATION**
**(1987 COE WETLAND DELINEATION MANUAL)**

PROJECT : Martin State Airport – Tract 1 DATE: 9/20/05
APPLICANT: BWI COUNTY: Baltimore
INVESTIGATOR: A. Sutton, T. Davis STATE: Maryland

Do Normal Circumstances exist on the site? Yes No
Is the site significantly disturbed (Atypical Situation)? Yes (No)
Is the area a potential Problem Area? Yes (No)
(If needed, explain on reverse.)

Community ID Forested Wetland E
Transect ID T-4
Plot ID P-1

## V E G E T A T I O N

| Dominant Plant Sp. | Stratum | Indicator | Dominant Plant Sp. | Stratum | Indicator |
|---|---|---|---|---|---|
| 1. Quercus phellos | T | FAC+ | 9. | | |
| 2. Liquidambar styraciflua | T | FAC | 10. | | |
| 3. Acer rubrum | T | FAC | 11. | | |
| 4. Acer rubrum | SH | FAC | 12. | | |
| 5. Vaccinium corymbosum | SH | FACW- | 13. | | |
| 6. Liquidambar styraciflua | SH | FAC | 14. | | |
| 7. | | | 15. | | |
| 8. | | | 16. | | |

Percent of Dominant Species that are OBL, FACW or FAC ( EXCLUDING FAC- ). **100**

Remarks: Sample area satisfies the wetland hydrophytic vegetation criterion.

## H Y D R O L O G Y

X Recorded Data (Describe in Remarks):
___ Stream, Lake, or Tide Gauge
X Aerial Photographs
___ Other
___ No Recorded Data Available

Field Observations:

Depth of Surface Water: none (in.)

Depth to Free Water in Pit: >18 (in.)

Depth to Saturated Soil: >18 (in.)

Wetland Hydrology Indicators:
Primary Indicators:
___ Inundated
___ Saturated in Upper 12 inches
X Water Marks
___ Drift Lines
___ Sediment Deposits
___ Drainage Patterns in Wetlands

Secondary Indicators (2 or more required)
___ Oxidized Root Channels in Upper 12 inches
X Water-Stained Leaves
___ Local Soil Survey Data
___ Fac-Neutral Test
___ Other (Explain in Remarks)

Remarks: Sufficient field indicators of wetland hydrology present; satisfies criterion.

## S O I L S (P-1,T-4)

Map Unit Name
(Series & Phase): Elkton Loam

Drainage Class: Poorly Drained

Field Observations

Taxonomy (Subgroup): Typic Endoaquults

Confirm Mapped Type: (YES) NO

Profile Description:

| Depth (Inches) | Horizon | Matrix Colors (Munsell Moist) | Mottle Colors (Munsell) Moist) | Mottle Abundance/ Contrast | Texture, Concretions |
|---|---|---|---|---|---|
| 0-2 | | | | | Organic duff; Dry |
| 2-6 | | 10YR 3/1 | | | Clay Loam; Slightly Moist |
| 6-18 | | 2.5Y 4/1 | 2.5Y 5/6 | Com Prom Dist | Clay Loam; Slightly Moist |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

Hydric Soil Indicators:

| | | | |
|---|---|---|---|
| | Histosol | | Concretions |
| | Histic Epipedon | | High Organic Content in Surface |
| | Sulfidic Odor | | Layer in Sandy Soils |
| | Aquic Moisture Regime | | Organic Streaking in sandy Soils |
| | Reducing Conditions | | Listed on Local Hydric Soils List |
| X | Gleyed or Low-Chroma Colors | X | Listed on National Hydric Soils List |
| | | | Other (Explain in Remarks) |

Remarks: Sufficient field indicators of hydric soil present; Satisfies criterion.

## W E T L A N D D E T E R M I N A T I O N

Hydrophytic Vegetation Present:? (Yes) No (Circle)

Wetland Hydrology Present? (Yes) No

Hydric Soils Present? (Yes) No

Is this Sampling Point Within a Wetland? (Yes) No (Circle)

Remarks: Sample area satisfies all three mandatory wetland technical criteria and is classified as a PFO1E wetland.

Approved by HQUSACE 3/92

**DATA FORM**
**ROUTINE WETLAND DETERMINATION**
**(1987 COE WETLAND DELINEATION MANUAL)**

PROJECT : Martin State Airport - Tract 1 DATE: 9/20/05
APPLICANT: BWI COUNTY: Baltimore
INVESTIGATOR: A. Sutton, T. Davis STATE: Maryland

Do Normal Circumstances exist on the site? Yes No
Is the site significantly disturbed (Atypical Situation)? Yes (No)
Is the area a potential Problem Area? Yes (No)
(If needed, explain on reverse.)

Community ID Vernal Pool, Wetland F
Transect ID T-6
Plot ID P-1

## V E G E T A T I O N

| Dominant Plant Sp. | Stratum | Indicator | Dominant Plant Sp. | Stratum | Indicator |
|---|---|---|---|---|---|
| 1. Liquidambar styraciflua | T | FAC | 9. | | |
| 2. Vaccinium corymbosum | SH | FACW- | 10. | | |
| 3. Woodwardia virginica | H | OBL | 11. | | |
| 4. | | | 12. | | |
| 5. | | | 13. | | |
| 6. | | | 14. | | |
| 7. | | | 15. | | |
| 8. | | | 16. | | |

Percent of Dominant Species that are OBL, FACW or FAC ( EXCLUDING FAC- ). **100**

Remarks: Sample area satisfies the wetland hydrophytic vegetation criterion.

## H Y D R O L O G Y

X Recorded Data (Describe in Remarks):
___ Stream, Lake, or Tide Gauge
X Aerial Photographs
___ Other
___ No Recorded Data Available

Field Observations:

Depth of Surface Water: none (in.)

Depth to Free Water in Pit: none (in.)

Depth to Saturated Soil: >18 (in.)

Wetland Hydrology Indicators:
Primary Indicators:
___ Inundated
___ Saturated in Upper 12 inches
X Water Marks
___ Drift Lines
___ Sediment Deposits
___ Drainage Patterns in Wetlands

Secondary Indicators (2 or more required)
___ Oxidized Root Channels in Upper 12 inches
X Water-Stained Leaves
___ Local Soil Survey Data
___ Fac-Neutral Test
___ Other (Explain in Remarks)

Remarks: Sufficient field indicators of wetland hydrology present; satisfies criterion

## S O I L S (P-1,T-6)

Map Unit Name
(Series & Phase): Elkton Loam

Drainage Class: Poorly Drained

Field Observations

Taxonomy (Subgroup): Typic Endoaquults

Confirm Mapped Type: (YES) NO

Profile Description:

| Depth (Inches) | Horizon | Matrix Colors (Munsell Moist) | Mottle Colors (Munsell) Moist) | Mottle Abundance/ Contrast | Texture, Concretions |
|---|---|---|---|---|---|
| 0-3 | | | | | Organic duff; Dry |
| 3-16 | | 10YR 2/1 | | unmottled | Silt Loam; Friable |
| 16-18+ | | 10YR 4/1 | 10YR 5/8 | Com Med Dist | Clay Loam; Friable |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

Hydric Soil Indicators:

| | | | |
|---|---|---|---|
| | Histosol | | Concretions |
| | Histic Epipedon | | High Organic Content in Surface |
| | Sulfidic Odor | | Layer in Sandy Soils |
| | Aquic Moisture Regime | | Organic Streaking in sandy Soils |
| | Reducing Conditions | | Listed on Local Hydric Soils List |
| X | Gleyed or Low-Chroma Colors | X | Listed on National Hydric Soils List |
| | | | Other (Explain in Remarks) |

Remarks: Sufficient field indicators of hydric soil present; Satisfies criterion.

## W E T L A N D D E T E R M I N A T I O N

Hydrophytic Vegetation Present:? (Yes) No (Circle)

Wetland Hydrology Present? (Yes) No

Hydric Soils Present? (Yes) No

Is this Sampling Point Within a Wetland? (Yes) No (Circle)

Remarks: Sample area satisfies all three mandatory wetland technical criteria, and is classified as a PFO1E wetland.

Approved by HQUSACE 3/92

# Appendix A – DATA FORMS

## TRACT 1 – Upland Data Sheets

**DATA FORM**
**ROUTINE WETLAND DETERMINATION**
**(1987 COE WETLAND DELINEATION MANUAL)**

PROJECT : Martin State Airport – Tract 1 DATE: 9/19/05
APPLICANT: BWI COUNTY: Baltimore
INVESTIGATOR: A. Sutton, T. Davis STATE: Maryland

Do Normal Circumstances exist on the site? ~~Yes~~ No
Is the site significantly disturbed (Atypical Situation)? Yes (No)
Is the area a potential Problem Area? Yes (No)
(If needed, explain on reverse.)

Community ID Forested Upland
Transect ID T-3
Plot ID P-1

## V E G E T A T I O N

| Dominant Plant Sp. | Stratum | Indicator | Dominant Plant Sp. | Stratum | Indicator |
|---|---|---|---|---|---|
| 1. Liquidambar styraciflua | T | FAC | 9. | | |
| 2. Acer rubrum | T | FAC | 10. | | |
| 3. Nyssa sylvatica | T | FAC | 11. | | |
| 4. Prunus serotina | SH | FACU | 12. | | |
| 5. Acer rubrum | SH | FAC | 13. | | |
| 6. Clethra alnifolia | H | FAC+ | 14. | | |
| 7. Pteridium aquilinum | H | FACU | 15. | | |
| 8. Toxicodendron radicans | V | FAC | 16. | | |

Percent of Dominant Species that are OBL, FACW or FAC
( EXCLUDING FAC- ). **75**

Remarks: Sample area satisfies the wetland hydrophytic vegetation criterion.

## H Y D R O L O G Y

X Recorded Data (Describe in Remarks):
- Stream, Lake, or Tide Gauge
- X Aerial Photographs
- Other

No Recorded Data Available

Field Observations:

Depth of Surface Water: none (in.)

Depth to Free Water in Pit: none (in.)

Depth to Saturated Soil: none (in.)

Wetland Hydrology Indicators:
Primary Indicators:
- Inundated
- Saturated in Upper 12 inches
- Water Marks
- Drift Lines
- Sediment Deposits
- Drainage Patterns in Wetlands

Secondary Indicators (2 or more required)
- Oxidized Root Channels in Upper 12 inches
- Water-Stained Leaves
- X Local Soil Survey Data
- Fac-Neutral Test
- Other (Explain in Remarks)

Remarks: Sufficient field indicators of wetland hydrology not present; Does not satisfy criterion.

## S O I L S (P-1,T-3)

Map Unit Name
(Series & Phase): Elkton Loam

Drainage Class: Poorly drained

Field Observations

Taxonomy (Subgroup): Typic Endoaquults

Confirm Mapped Type: (YES) NO
see remarks

Profile Description:

| Depth (Inches) | Horizon | Matrix Colors (Munsell Moist) | Mottle Colors (Munsell) Moist) | Mottle Abundance/ Contrast | Texture, Concretions |
|---|---|---|---|---|---|
| 0-2 | A | 7.5YR 2.5/2 | | | Fine loam |
| 2-9 | B1 | 2.5Y 6/6 | 10YR 3/6 | Com., Fine., Dist. | Fine sandy loam |
| | | | 10YR 5/1 | Few, Fine, Dist. | |
| 9-21 | B2 | 10YR 6/6 | 5YR 5/8 | Com., Med.,Dist. | Sandy loam |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

Hydric Soil Indicators:

| | | | |
|---|---|---|---|
| | Histosol | | Concretions |
| | Histic Epipedon | | High Organic Content in Surface |
| | Sulfidic Odor | | Layer in Sandy Soils |
| | Aquic Moisture Regime | | Organic Streaking in sandy Soils |
| | Reducing Conditions | | Listed on Local Hydric Soils List |
| | Gleyed or Low-Chroma Colors | X | Listed on National Hydric Soils List |
| | | | Other (Explain in Remarks) |

Remarks: Insufficient indicators of hydric soil. Does not satisfy criteria

## W E T L A N D  D E T E R M I N A T I O N

Hydrophytic Vegetation Present:? (Yes) No (Circle)
Wetland Hydrology Present? Yes (No)
Hydric Soils Present? Yes (No)

Is this Sampling Point Within a Wetland? Yes (No) (Circle)

Remarks: Sample area does not satisfy all three mandatory wetland technical criteria.

Approved by HQUSACE 3/92

**DATA FORM**
**ROUTINE WETLAND DETERMINATION**
**(1987 COE WETLAND DELINEATION MANUAL)**

PROJECT : Martin State Airport –Tract 1 DATE: 9/20/05
APPLICANT: BWI COUNTY: Baltimore
INVESTIGATOR: A. Sutton, T. Davis STATE: Maryland

Do Normal Circumstances exist on the site? Yes No
Is the site significantly disturbed (Atypical Situation)? Yes (No)
Is the area a potential Problem Area? Yes (No)
(If needed, explain on reverse.)

Community ID Forested Upland
Transect ID T-4
Plot ID P-2

## V E G E T A T I O N

| Dominant Plant Sp. | Stratum | Indicator | Dominant Plant Sp. | Stratum | Indicator |
|---|---|---|---|---|---|
| 1. Nyssa sylvatica | T | FAC | 9. Vaccinium corymbosum | H | FACW- |
| 2. Quercus prinus | T | UPL | 10. | | |
| 3. Liquidambar styraciflua | T | FAC | 11. | | |
| 4. Clethra alnifolia | SH | FAC+ | 12. | | |
| 5. Vaccinium corymbosum | SH | FACW- | 13. | | |
| 6. Ilex opaca | SH | FACU+ | 14. | | |
| 7. Smilax rotundifolia | V | FAC | 15. | | |
| 8. Clethra alnifolia | H | FAC+ | 16. | | |

Percent of Dominant Species that are OBL, FACW or FAC ( EXCLUDING FAC- ). **78**

Remarks: Sample area satisfies the wetland hydrophytic vegetation criterion.

## H Y D R O L O G Y

X Recorded Data (Describe in Remarks):
____ Stream, Lake, or Tide Gauge
X Aerial Photographs
____ Other
____ No Recorded Data Available

Field Observations:

Depth of Surface Water: none (in.)

Depth to Free Water in Pit: none (in.)

Depth to Saturated Soil: none (in.)

Wetland Hydrology Indicators:
Primary Indicators:
____ Inundated
____ Saturated in Upper 12 inches
____ Water Marks
____ Drift Lines
____ Sediment Deposits
____ Drainage Patterns in Wetlands

Secondary Indicators (2 or more required)
____ Oxidized Root Channels in Upper 12 inches
____ Water-Stained Leaves
____ Local Soil Survey Data
____ Fac-Neutral Test
____ Other (Explain in Remarks)

Remarks: Sufficient field indicators of wetland hydrology not present; Does not satisfy criterion

## S O I L S (P-2,T-4)

Map Unit Name
(Series & Phase): Elkton Loam

Drainage Class: Poorly Drained

Field Observations

Taxonomy (Subgroup): Typic Endoaquults

Confirm Mapped Type: (YES) NO

Profile Description:

| Depth (Inches) | Horizon | Matrix Colors (Munsell Moist) | Mottle Colors (Munsell) Moist) | Mottle Abundance/ Contrast | Texture, Concretions |
|---|---|---|---|---|---|
| 0-2 | O | | | | Organic duff; Dry |
| 2-4 | A | 2.5Y 3/1 | | unmottled | Silt Loam; Dry |
| 4-8 | E | 2.5Y 6/2 | | unmottled | Silt Loam; Dry |
| 8-0 | E | 2.5Y 6/2 | 2.5Y 6/3 | Com Med Fnt | Silt Loam; Dry |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

Hydric Soil Indicators:

| | | | |
|---|---|---|---|
| | Histosol | | Concretions |
| | Histic Epipedon | | High Organic Content in Surface |
| | Sulfidic Odor | | Layer in Sandy Soils |
| | Aquic Moisture Regime | | Organic Streaking in sandy Soils |
| | Reducing Conditions | | Listed on Local Hydric Soils List |
| | Gleyed or Low-Chroma Colors | X | Listed on National Hydric Soils List |
| | | | Other (Explain in Remarks) |

Remarks: Sufficient field indicators of hydric soil not present; Does not satisfy criterion.

## W E T L A N D  D E T E R M I N A T I O N

| | | | | |
|---|---|---|---|---|
| Hydrophytic Vegetation Present:? | (Yes) | No | (Circle) | |
| Wetland Hydrology Present? | Yes | (No) | Is this Sampling Point | |
| Hydric Soils Present? | Yes | (No) | Within a Wetland? Yes | (No) (Circle) |

Remarks: Sample area does not satisfy all three mandatory wetland technical criteria.

Approved by HQUSACE 3/92

**DATA FORM**
**ROUTINE WETLAND DETERMINATION**
**(1987 COE WETLAND DELINEATION MANUAL)**

PROJECT : Martin State Airport - Tract 1 DATE: 9/20/05
APPLICANT: BWI COUNTY: Baltimore
INVESTIGATOR: A. Sutton, T. Davis STATE: Maryland

Do Normal Circumstances exist on the site? Yes No
Is the site significantly disturbed (Atypical Situation)? Yes No
Is the area a potential Problem Area? Yes No
(If needed, explain on reverse.)

Community ID Forested Upland
Transect ID T-6
Plot ID P-2

## V E G E T A T I O N

| Dominant Plant Sp. | Stratum | Indicator | Dominant Plant Sp. | Stratum | Indicator |
|---|---|---|---|---|---|
| 1. Quercus alba | T | FACU- | 9. | | |
| 2. Quercus prinus | T | UPL | 10. | | |
| 3. Nyssa sylvatica | T | FAC | 11. | | |
| 4. Clethra alnifolia | SH | FAC+ | 12. | | |
| 5. Vaccinium corymbosum | SH | FACW- | 13. | | |
| 6. Lycopodium clavatum | H | FAC | 14. | | |
| 7. | | | 15. | | |
| 8. | | | 16. | | |

Percent of Dominant Species that are OBL, FACW or FAC ( EXCLUDING FAC- ). **67**

Remarks: Sample area satisfies the wetland hydrophytic vegetation criterion.

## H Y D R O L O G Y

X Recorded Data (Describe in Remarks):
____ Stream, Lake, or Tide Gauge
X Aerial Photographs
____ Other
____ No Recorded Data Available

Field Observations:

Depth of Surface Water: none (in.)

Depth to Free Water in Pit: none (in.)

Depth to Saturated Soil: >18 (in.)

Wetland Hydrology Indicators:
Primary Indicators:
____ Inundated
____ Saturated in Upper 12 inches
____ Water Marks
____ Drift Lines
____ Sediment Deposits
____ Drainage Patterns in Wetlands

Secondary Indicators (2 or more required)
____ Oxidized Root Channels in Upper 12 inches
____ Water-Stained Leaves
____ Local Soil Survey Data
____ Fac-Neutral Test
____ Other (Explain in Remarks)

Remarks: Sufficient field indicators of wetland hydrology no present; Does not satisfy criterion.

## S O I L S (P-2,T-6)

Map Unit Name
(Series & Phase): Mattapex-Urban land complex

Drainage Class: N/A
Field Observations
Confirm Mapped Type: (YES) NO

Taxonomy (Subgroup): N/A

Profile Description:

| Depth (Inches) | Horizon | Matrix Colors (Munsell Moist) | Mottle Colors (Munsell) Moist) | Mottle Abundance/ Contrast | Texture, Concretions |
|---|---|---|---|---|---|
| 0-1 | | | | | Organic duff; Dry |
| 1-3 | | 2.5Y 4/2 | | unmottled | Silt Loam; Friable |
| 3-12+ | | 2.5Y 4/3 | | unmottled | Sandy Loam; Friable |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

Hydric Soil Indicators:

_____ Histosol
_____ Histic Epipedon
_____ Sulfidic Odor
_____ Aquic Moisture Regime
_____ Reducing Conditions
_____ Gleyed or Low-Chroma Colors
_____ Concretions
_____ High Organic Content in Surface
_____ Layer in Sandy Soils
_____ Organic Streaking in sandy Soils
_____ Listed on Local Hydric Soils List
_____ Listed on National Hydric Soils List
_____ Other (Explain in Remarks)

Remarks: Sufficient field indicators of hydric soil not present; Does not satisfy criterion.

## W E T L A N D  D E T E R M I N A T I O N

Hydrophytic Vegetation Present:? (Yes) No (Circle)
Wetland Hydrology Present? Yes (No)
Hydric Soils Present? Yes (No)

Is this Sampling Point Within a Wetland? Yes (No) (Circle)

Remarks: Sample area does not satisfy all three mandatory wetland technical criteria.

Approved by HQUSACE 3/92

# Appendix A – DATA FORMS

## TRACT 2 – Wetland Data Sheets

**DATA FORM**
**ROUTINE WETLAND DETERMINATION**
**(1987 COE WETLAND DELINEATION MANUAL)**

PROJECT : Martin State Airport – Tract 2 DATE: 9/21/05
APPLICANT: BWI COUNTY: Baltimore
INVESTIGATOR: A. Sutton, T. Davis STATE: Maryland

Do Normal Circumstances exist on the site? Yes No Community ID Forested Wetland I
Is the site significantly disturbed (Atypical Situation)? Yes No Transect ID T-1
Is the area a potential Problem Area? Yes No Plot ID P-2
(If needed, explain on reverse.)

## V E G E T A T I O N

| Dominant Plant Sp. | Stratum | Indicator | Dominant Plant Sp. | Stratum | Indicator |
|---|---|---|---|---|---|
| 1. Magnolia virginiana | T | FACW+ | 9. | | |
| 2. Pinus serotina | T | OBL | 10. | | |
| 3. Nyssa sylvatica | T | FAC | 11. | | |
| 4. Clethra alnifolia | SH | FAC+ | 12. | | |
| 5. Nyssa sylvatica | SH | FAC | 13. | | |
| 6. Magnolia virginiana | SH | FACW+ | 14. | | |
| 7. Smilax rotundifolia | V | FAC | 15. | | |
| 8. Clethra alnifolia | H | FAC+ | 16. | | |

Percent of Dominant Species that are OBL, FACW or FAC
( EXCLUDING FAC- ). **100**

Remarks: Sample area satisfies the wetland hydrophytic vegetation criterion.

## H Y D R O L O G Y

X Recorded Data (Describe in Remarks):
____ Stream, Lake, or Tide Gauge
X Aerial Photographs
____ Other
____ No Recorded Data Available

Field Observations:

Depth of Surface Water: none (in.)

Depth to Free Water in Pit: none (in.)

Depth to Saturated Soil: none (in.)

Wetland Hydrology Indicators:
Primary Indicators:
____ Inundated
____ Saturated in Upper 12 inches
____ Water Marks
____ Drift Lines
____ Sediment Deposits
____ Drainage Patterns in Wetlands

Secondary Indicators (2 or more required)
____ Oxidized Root Channels in Upper 12 inches
X Water-Stained Leaves
____ Local Soil Survey Data
X Fac-Neutral Test
____ Other (Explain in Remarks)

Remarks: Sufficient field indicators of wetland hydrology present; satisfies criterion

## S O I L S (P-2,T-1)

Map Unit Name
(Series & Phase): Pocomoke

Drainage Class: Very Poorly Drained

Field Observations

Taxonomy (Subgroup): Typic Umbraquults

Confirm Mapped Type: (YES) NO

Profile Description:

| Depth (Inches) | Horizon | Matrix Colors (Munsell Moist) | Mottle Colors (Munsell) Moist) | Mottle Abundance/ Contrast | Texture, Concretions |
|---|---|---|---|---|---|
| 0-6 | | 10YR 2/1 | | unmottled | Silt Loam; Dry |
| 6-12 | | 10YR 3/1 | | unmottled | Silt Loam; Slightly Moist |
| 12-18+ | | 10YR 4/1 | | unmottled | Silt Loam; Slightly Moist |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

Hydric Soil Indicators:

| | | | |
|---|---|---|---|
| | Histosol | | Concretions |
| | Histic Epipedon | | High Organic Content in Surface |
| | Sulfidic Odor | | Layer in Sandy Soils |
| | Aquic Moisture Regime | | Organic Streaking in sandy Soils |
| | Reducing Conditions | | Listed on Local Hydric Soils List |
| X | Gleyed or Low-Chroma Colors | X | Listed on National Hydric Soils List |
| | | | Other (Explain in Remarks) |

Remarks: Sufficient field indicators of hydric soil present; Satisfies criterion.

## W E T L A N D  D E T E R M I N A T I O N

Hydrophytic Vegetation Present:? (Yes) No (Circle)

Wetland Hydrology Present? (Yes) No

Hydric Soils Present? (Yes) No

Is this Sampling Point Within a Wetland? (Yes) No (Circle)

Remarks: Sample area satisfies all three mandatory wetland technical criteria, and is classified as a PFO1/4E wetland.

Approved by HQUSACE 3/92

**DATA FORM**
**ROUTINE WETLAND DETERMINATION**
**(1987 COE WETLAND DELINEATION MANUAL)**

PROJECT : Martin State Airport – Tract 2 DATE: 9/21/05
APPLICANT: BWI COUNTY: Baltimore
INVESTIGATOR: A. Sutton, T. Davis STATE: Maryland

Do Normal Circumstances exist on the site? Yes No
Is the site significantly disturbed (Atypical Situation)? Yes (No)
Is the area a potential Problem Area? Yes (No)
(If needed, explain on reverse.)

Community ID Forested Vernal Pool G
Transect ID T-4
Plot ID P-2

## V E G E T A T I O N

| Dominant Plant Sp. | Stratum | Indicator | Dominant Plant Sp. | Stratum | Indicator |
|---|---|---|---|---|---|
| 1. Quercus phellos | T | FAC+ | 9. | | |
| 2. Liquidambar styraciflua | T | FAC | 10. | | |
| 3. Smilax rotundifolia | V | FAC | 11. | | |
| 4. Smilax rotundifolia | H | FAC | 12. | | |
| 5. | | | 13. | | |
| 6. | | | 14. | | |
| 7. | | | 15. | | |
| 8. | | | 16. | | |

Percent of Dominant Species that are OBL, FACW or FAC ( EXCLUDING FAC- ). **100**

Remarks: Sample area satisfies the wetland hydrophytic vegetation criterion.

## H Y D R O L O G Y

X Recorded Data (Describe in Remarks):
- Stream, Lake, or Tide Gauge
- X Aerial Photographs
- Other

No Recorded Data Available

Field Observations:

Depth of Surface Water: none (in.)

Depth to Free Water in Pit: none (in.)

Depth to Saturated Soil: none (in.)

Wetland Hydrology Indicators:
Primary Indicators:
- Inundated
- Saturated in Upper 12 inches
- X Water Marks
- Drift Lines
- Sediment Deposits
- Drainage Patterns in Wetlands

Secondary Indicators (2 or more required)
- Oxidized Root Channels in Upper 12 inches
- X Water-Stained Leaves
- Local Soil Survey Data
- Fac-Neutral Test
- Other (Explain in Remarks)

Remarks: Sufficient field indicators of wetland hydrology present; satisfies criterion

## S O I L S (P-2,T-4)

Map Unit Name
(Series & Phase): Fallsington Sandy Loam

Drainage Class: Poorly Drained

Field Observations

Taxonomy (Subgroup): Typic Endoaquults

Confirm Mapped Type: (YES) NO
see remarks

Profile Description:

| Depth (Inches) | Horizon | Matrix Colors (Munsell Moist) | Mottle Colors (Munsell) Moist) | Mottle Abundance/ Contrast | Texture, Concretions |
|---|---|---|---|---|---|
| | | | | | see remarks; |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

Hydric Soil Indicators:

| | | | |
|---|---|---|---|
| | Histosol | | Concretions |
| | Histic Epipedon | | High Organic Content in Surface |
| | Sulfidic Odor | | Layer in Sandy Soils |
| | Aquic Moisture Regime | | Organic Streaking in sandy Soils |
| | Reducing Conditions | | Listed on Local Hydric Soils List |
| | Gleyed or Low-Chroma Colors | X | Listed on National Hydric Soils List |
| | | X | Other (Explain in Remarks) |

Remarks: Sufficient field indicators of hydric soil present; Satisfies criterion. Plot located in a vernal pool; hydric soils are assumed.

## W E T L A N D  D E T E R M I N A T I O N

Hydrophytic Vegetation Present:? (Yes) No (Circle)
Wetland Hydrology Present? (Yes) No
Hydric Soils Present? (Yes) No

Is this Sampling Point Within a Wetland? (Yes) No (Circle)

Remarks: Sample area satisfies all three mandatory wetland technical criteria, and is classified as a PFO1C wetland.

Approved by HQUSACE 3/92

**DATA FORM**
**ROUTINE WETLAND DETERMINATION**
**(1987 COE WETLAND DELINEATION MANUAL)**

PROJECT : Martin State Airport – Tract 2 DATE: 9/21/05
APPLICANT: BWI COUNTY: Baltimore
INVESTIGATOR: A. Sutton, T. Davis STATE: Maryland

Do Normal Circumstances exist on the site? Yes No Community ID Forested Wetland J
Is the site significantly disturbed (Atypical Situation)? Yes (No) Transect ID T-5
Is the area a potential Problem Area? Yes (No) Plot ID P-8
(If needed, explain on reverse.)

## V E G E T A T I O N

| Dominant Plant Sp. | Stratum | Indicator | Dominant Plant Sp. | Stratum | Indicator |
|---|---|---|---|---|---|
| 1. Pinus serotina | T | OBL | 9. Rhododendron viscosum | H | OBL |
| 2. Magnolia virginiana | T | FACW+ | 10. Smilax rotundifolia | H | FAC |
| 3. Quercus falcata | T | FACU- | 11. | | |
| 4. Clethra alnifolia | SH | FAC+ | 12. | | |
| 5. Magnolia virginiana | SH | FACW+ | 13. | | |
| 6. Rhododendron viscosum | SH | OBL | 14. | | |
| 7. Smilax rotundifolia | V | FAC | 15. | | |
| 8. Clethra alnifolia | H | FAC+ | 16. | | |

Percent of Dominant Species that are OBL, FACW or FAC
( EXCLUDING FAC- ). **90**

Remarks: Sample area satisfies the wetland hydrophytic vegetation criterion.

## H Y D R O L O G Y

X Recorded Data (Describe in Remarks):
____ Stream, Lake, or Tide Gauge
X Aerial Photographs
____ Other
____ No Recorded Data Available

Field Observations:

Depth of Surface Water: none (in.)

Depth to Free Water in Pit: none (in.)

Depth to Saturated Soil: none (in.)

Wetland Hydrology Indicators:
Primary Indicators:
____ Inundated
____ Saturated in Upper 12 inches
____ Water Marks
____ Drift Lines
____ Sediment Deposits
____ Drainage Patterns in Wetlands

Secondary Indicators (2 or more required)
____ Oxidized Root Channels in Upper 12 inches
____ Water-Stained Leaves
X Local Soil Survey Data
X Fac-Neutral Test
____ Other (Explain in Remarks)

Remarks: Sufficient field indicators of wetland hydrology present; satisfies criterion

## S O I L S (P-8,T-5)

Map Unit Name
(Series & Phase): Woodstown

Drainage Class: Moderately well-drained

Field Observations

Taxonomy (Subgroup): Aquic Hapludults

Confirm Mapped Type: YES (NO)

Profile Description:

| Depth (Inches) | Horizon | Matrix Colors (Munsell Moist) | Mottle Colors (Munsell) Moist) | Mottle Abundance/ Contrast | Texture, Concretions |
|---|---|---|---|---|---|
| 0-12 | | 2.5Y 3/2 | | Oxid. Rhizo. | Fine Sandy Loam; Dry |
| 12+ | | 2.5Y 6/2 | 2.5Y 3/2 | Com Med Fnt | Fine Sandy Loam; Dry |
| | | | | | |
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Hydric Soil Indicators:

| | | | |
|---|---|---|---|
| | Histosol | | Concretions |
| | Histic Epipedon | | High Organic Content in Surface |
| | Sulfidic Odor | | Layer in Sandy Soils |
| | Aquic Moisture Regime | | Organic Streaking in sandy Soils |
| | Reducing Conditions | | Listed on Local Hydric Soils List |
| X | Gleyed or Low-Chroma Colors | | Listed on National Hydric Soils List |
| | | | Other (Explain in Remarks) |

Remarks: Sufficient field indicators of hydric soil not present; Does not satisfy criterion. Soil does not appear to match the mapped type.

## W E T L A N D  D E T E R M I N A T I O N

Hydrophytic Vegetation Present:? (Yes) No (Circle)
Wetland Hydrology Present? (Yes) No
Hydric Soils Present? (Yes) No

Is this Sampling Point Within a Wetland? (Yes) No (Circle)

Remarks: Sample area does not satisfy all three mandatory wetland technical criteria, and is classified as a PFO1/4E wetland.

Approved by HQUSACE 3/92

**DATA FORM**
**ROUTINE WETLAND DETERMINATION**
**(1987 COE WETLAND DELINEATION MANUAL)**

PROJECT : Martin State Airport – Tract 2 DATE: 9/21/05
APPLICANT: BWI COUNTY: Baltimore
INVESTIGATOR: A. Sutton, T. Davis STATE: Maryland

Do Normal Circumstances exist on the site? (Yes) No
Is the site significantly disturbed (Atypical Situation)? Yes (No)
Is the area a potential Problem Area? Yes (No)
(If needed, explain on reverse.)

Community ID Forested Wetland H
Transect ID T-6
Plot ID P-2

## V E G E T A T I O N

| Dominant Plant Sp. | Stratum | Indicator | Dominant Plant Sp. | Stratum | Indicator |
|---|---|---|---|---|---|
| 1. Quercus palustris | T | FACW | 9. | | |
| 2. Acer rubrum | T | FAC | 10. | | |
| 3. Liquidambar styraciflua | T | FAC | 11. | | |
| 4. Vaccinium corymbosum | SH | FACW- | 12. | | |
| 5. Clethra alnifolia | SH | FAC+ | 13. | | |
| 6. Aronia melanocarpa | SH | FAC | 14. | | |
| 7. Rhododendron viscosum | H | OBL | 15. | | |
| 8. Smilax rotundifolia | V | FAC | 16. | | |

Percent of Dominant Species that are OBL, FACW or FAC ( EXCLUDING FAC- ). **100**

Remarks: Sample area satisfies the wetland hydrophytic vegetation criterion.

## H Y D R O L O G Y

X Recorded Data (Describe in Remarks):
____ Stream, Lake, or Tide Gauge
X Aerial Photographs
____ Other
____ No Recorded Data Available

Field Observations:

Depth of Surface Water: none (in.)

Depth to Free Water in Pit: none (in.)

Depth to Saturated Soil: none (in.)

Wetland Hydrology Indicators:
Primary Indicators:
____ Inundated
____ Saturated in Upper 12 inches
____ Water Marks
____ Drift Lines
X Sediment Deposits
____ Drainage Patterns in Wetlands

Secondary Indicators (2 or more required)
____ Oxidized Root Channels in Upper 12 inches
____ Water-Stained Leaves
____ Local Soil Survey Data
____ Fac-Neutral Test
____ Other (Explain in Remarks)

Remarks: Sufficient field indicators of wetland hydrology present; satisfies criterion.

## S O I L S (P-2,T-6)

Map Unit Name
(Series & Phase): Fallsington Sandy Loam

Drainage Class: Moderately Well Drained

Field Observations

Taxonomy (Subgroup): Typic Endoaquults

Confirm Mapped Type: (YES) NO

Profile Description:

| Depth (Inches) | Horizon | Matrix Colors (Munsell Moist) | Mottle Colors (Munsell) Moist) | Mottle Abundance/ Contrast | Texture, Concretions |
|---|---|---|---|---|---|
| 0-12 | | 2.5Y 2.5/1 | | unmottled | Sandy Loam; Dry |
| 12-16+ | | 2.5Y 5/2 | 10YR 4/4 | Mny Med Prom | Sandy Loam; Dry |
| | | | | | |
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Hydric Soil Indicators:

| | | | |
|---|---|---|---|
| | Histosol | | Concretions |
| | Histic Epipedon | | High Organic Content in Surface |
| | Sulfidic Odor | | Layer in Sandy Soils |
| | Aquic Moisture Regime | | Organic Streaking in sandy Soils |
| | Reducing Conditions | | Listed on Local Hydric Soils List |
| X | Gleyed or Low-Chroma Colors | X | Listed on National Hydric Soils List |
| | | | Other (Explain in Remarks) |

Remarks: Sufficient field indicators of hydric soil present; satisfies criterion.

## W E T L A N D D E T E R M I N A T I O N

Hydrophytic Vegetation Present:? (Yes) No (Circle)

Wetland Hydrology Present? (Yes) No

Hydric Soils Present? (Yes) No

Is this Sampling Point Within a Wetland? (Yes) No (Circle)

Remarks: Sample area satisfies all three mandatory wetland technical criteria, and is classified as a PFO1C wetland.

Approved by HQUSACE 3/92

# Appendix A – DATA FORMS

## TRACT 2 – Upland Data Sheets

**DATA FORM**
**ROUTINE WETLAND DETERMINATION**
**(1987 COE WETLAND DELINEATION MANUAL)**

PROJECT : Martin State Airport – Tract 2 DATE: 9/21/05
APPLICANT: BWI COUNTY: Baltimore
INVESTIGATOR: A. Sutton, T. Davis STATE: Maryland

Do Normal Circumstances exist on the site? Yes No Community ID Forested Upland
Is the site significantly disturbed (Atypical Situation)? Yes No Transect ID T-3
Is the area a potential Problem Area? Yes No Plot ID P-1
(If needed, explain on reverse.)

## V E G E T A T I O N

| Dominant Plant Sp. | Stratum | Indicator | Dominant Plant Sp. | Stratum | Indicator |
|---|---|---|---|---|---|
| 1. Liquidambar styraciflua | T | FAC | 9. Lonicera japonica | V | FAC- |
| 2. Acer rubrum | T | FAC | 10. | | |
| 3. Quercus phellos | T | FAC+ | 11. | | |
| 4. Liquidambar styraciflua | SH | FAC | 12. | | |
| 5. Prunus serotina | SH | FACU | 13. | | |
| 6. Nyssa sylvatica | SH | FAC | 14. | | |
| 7. Parthenocissus quinquefolia | V | FACU | 15. | | |
| 8. Vitis rotundifolia | V | FAC- | 16. | | |

Percent of Dominant Species that are OBL, FACW or FAC ( EXCLUDING FAC- ). **55**

Remarks: Sample area satisfies the wetland hydrophytic vegetation criterion.

## H Y D R O L O G Y

X Recorded Data (Describe in Remarks):
- Stream, Lake, or Tide Gauge
- X Aerial Photographs
- Other

No Recorded Data Available

Field Observations:

Depth of Surface Water: none (in.)

Depth to Free Water in Pit: none (in.)

Depth to Saturated Soil: none (in.)

Wetland Hydrology Indicators:
Primary Indicators:
- Inundated
- Saturated in Upper 12 inches
- Water Marks
- Drift Lines
- Sediment Deposits
- Drainage Patterns in Wetlands

Secondary Indicators (2 or more required)
- Oxidized Root Channels in Upper 12 inches
- Water-Stained Leaves
- Local Soil Survey Data
- Fac-Neutral Test
- Other (Explain in Remarks)

Remarks: Sufficient field indicators of wetland hydrology not present; Does not satisfy criterion.

## S O I L S (P-1,T-3)

Map Unit Name
(Series & Phase): Galestown loamy sand

Drainage Class: Well Drained
Field Observations
Confirm Mapped Type: YES NO

Taxonomy (Subgroup): Psammentic Hapludults

Profile Description:

| Depth (Inches) | Horizon | Matrix Colors (Munsell Moist) | Mottle Colors (Munsell) Moist) | Mottle Abundance/ Contrast | Texture, Concretions |
|---|---|---|---|---|---|
| 0-10 | | 10YR 4/2 | | unmottled | Silt Loam; Dry |
| 10-14+ | | 2.5Y 5/5 | | unmottled | Silt Loam; Dry |
| | | | | | |
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Hydric Soil Indicators:

_____ Histosol
_____ Histic Epipedon
_____ Sulfidic Odor
_____ Aquic Moisture Regime
_____ Reducing Conditions
_____ Gleyed or Low-Chroma Colors
_____ Concretions
_____ High Organic Content in Surface
_____ Layer in Sandy Soils
_____ Organic Streaking in sandy Soils
_____ Listed on Local Hydric Soils List
_____ Listed on National Hydric Soils List
_____ Other (Explain in Remarks)

Remarks: Sufficient field indicators of hydric soil not present; Does not satisfy criterion.

## W E T L A N D  D E T E R M I N A T I O N

Hydrophytic Vegetation Present:? Yes No (Circle)
Wetland Hydrology Present? Yes No
Hydric Soils Present? Yes No

Is this Sampling Point Within a Wetland? Yes No (Circle)

Remarks: Sample area does not satisfy all three mandatory wetland technical criteria. Area of upland appears historically disturbed and left to naturally re-vegetate. Soil has undulations and mounds implying past clearing and/or earthwork. Mounds have same soil consistency as natural ground.

Approved by HQUSACE 3/92

**DATA FORM**
**ROUTINE WETLAND DETERMINATION**
**(1987 COE WETLAND DELINEATION MANUAL)**

PROJECT : Martin State Airport – Tract 2 DATE: 9/21/05
APPLICANT: BWI COUNTY: Baltimore
INVESTIGATOR: A. Sutton, T. Davis STATE: Maryland

Do Normal Circumstances exist on the site? Yes No Community ID Forested Upland
Is the site significantly disturbed (Atypical Situation)? Yes No Transect ID T-4
Is the area a potential Problem Area? Yes No Plot ID P-1
(If needed, explain on reverse.)

## V E G E T A T I O N

| Dominant Plant Sp. | Stratum | Indicator | Dominant Plant Sp. | Stratum | Indicator |
|---|---|---|---|---|---|
| 1. Quercus coccinea | T | UPL | 9. Carya glabra | H | FACU- |
| 2. Pinus virginiana | T | UPL | 10. | | |
| 3. Liquidambar styraciflua | T | FAC | 11. | | |
| 4. Clethra alnifolia | SH | FAC+ | 12. | | |
| 5. Nyssa sylvatica | SH | FAC | 13. | | |
| 6. Acer rubrum | SH | FAC | 14. | | |
| 7. Smilax rotundifolia | V | FAC | 15. | | |
| 8. Clethra alnifolia | H | FAC+ | 16. | | |

Percent of Dominant Species that are OBL, FACW or FAC ( EXCLUDING FAC- ). **67**

Remarks: Sample area satisfies the wetland hydrophytic vegetation criterion.

## H Y D R O L O G Y

X Recorded Data (Describe in Remarks):
- Stream, Lake, or Tide Gauge
- X Aerial Photographs
- Other

No Recorded Data Available

Field Observations:

Depth of Surface Water: none (in.)

Depth to Free Water in Pit: none (in.)

Depth to Saturated Soil: none (in.)

Wetland Hydrology Indicators:
Primary Indicators:
- Inundated
- Saturated in Upper 12 inches
- Water Marks
- Drift Lines
- Sediment Deposits
- Drainage Patterns in Wetlands

Secondary Indicators (2 or more required)
- Oxidized Root Channels in Upper 12 inches
- Water-Stained Leaves
- Local Soil Survey Data
- Fac-Neutral Test
- Other (Explain in Remarks)

Remarks: Sufficient field indicators of wetland hydrology not present; Does not satisfy criterion.

## S O I L S (P-1,T-4)

Map Unit Name
(Series & Phase): Woodstown

Drainage Class: Moderately Well Drained
Field Observations
Confirm Mapped Type: YES NO

Taxonomy (Subgroup): Aquic Hapludults

Profile Description:

| Depth (Inches) | Horizon | Matrix Colors (Munsell Moist) | Mottle Colors (Munsell) Moist) | Mottle Abundance/ Contrast | Texture, Concretions |
|---|---|---|---|---|---|
| 0-3 | | 2.5Y 4/3 | | unmottled | Sandy Loam; Dry |
| 3-12+ | | 2.5Y 6/4 | | unmottled | Sandy Loam; Dry |
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Hydric Soil Indicators:

_____ Histosol
_____ Histic Epipedon
_____ Sulfidic Odor
_____ Aquic Moisture Regime
_____ Reducing Conditions
_____ Gleyed or Low-Chroma Colors
_____ Concretions
_____ High Organic Content in Surface
_____ Layer in Sandy Soils
_____ Organic Streaking in sandy Soils
_____ Listed on Local Hydric Soils List
_____ Listed on National Hydric Soils List
_____ Other (Explain in Remarks)

Remarks: Sufficient field indicators of hydric soil not present; Does not satisfy criterion.

## W E T L A N D  D E T E R M I N A T I O N

Hydrophytic Vegetation Present:? Yes No (Circle)
Wetland Hydrology Present? Yes No
Hydric Soils Present? Yes No

Is this Sampling Point Within a Wetland? Yes No (Circle)

Remarks: Sample area does not satisfy all three mandatory wetland technical criteria.

Approved by HQUSACE 3/92

**DATA FORM**
**ROUTINE WETLAND DETERMINATION**
**(1987 COE WETLAND DELINEATION MANUAL)**

PROJECT : Martin State Airport – Tract 2 DATE: 9/21/05
APPLICANT: BWI COUNTY: Baltimore
INVESTIGATOR: A. Sutton, T. Davis STATE: Maryland

Do Normal Circumstances exist on the site? Yes No Community ID Forested Upland
Is the site significantly disturbed (Atypical Situation)? Yes (No) Transect ID T-5
Is the area a potential Problem Area? Yes (No) Plot ID P-2
(If needed, explain on reverse.)

## V E G E T A T I O N

| Dominant Plant Sp. | Stratum | Indicator | Dominant Plant Sp. | Stratum | Indicator |
|---|---|---|---|---|---|
| 1. Liquidambar styraciflua | T | FAC | 9. | | |
| 2. Quercus phellos | T | FAC+ | 10. | | |
| 3. Betula nigra | T | FACW | 11. | | |
| 4. Nyssa sylvatica | SH | FAC | 12. | | |
| 5. Liquidambar styraciflua | SH | FAC | 13. | | |
| 6. Lonicera japonica | H | FAC- | 14. | | |
| 7. Quercus phellos | H | FAC+ | 15. | | |
| 8. Toxicodendron radicans | V | FAC | 16. | | |

Percent of Dominant Species that are OBL, FACW or FAC ( EXCLUDING FAC- ). **88**

Remarks: Sample area satisfies the wetland hydrophytic vegetation criterion.

## H Y D R O L O G Y

X Recorded Data (Describe in Remarks):
- Stream, Lake, or Tide Gauge
- X Aerial Photographs
- Other

No Recorded Data Available

Field Observations:

Depth of Surface Water: none (in.)

Depth to Free Water in Pit: none (in.)

Depth to Saturated Soil: none (in.)

Wetland Hydrology Indicators:
Primary Indicators:
- Inundated
- Saturated in Upper 12 inches
- Water Marks
- Drift Lines
- Sediment Deposits
- Drainage Patterns in Wetlands

Secondary Indicators (2 or more required)
- Oxidized Root Channels in Upper 12 inches
- Water-Stained Leaves
- Local Soil Survey Data
- Fac-Neutral Test
- Other (Explain in Remarks)

Remarks: Sufficient field indicators of wetland hydrology not present; Does not satisfy criterion.

## S O I L S (P-2,T-5)

Map Unit Name
(Series & Phase): Woodstown

Drainage Class: Moderately Well Drained

Field Observations

Taxonomy (Subgroup): Aquic Hapludults

Confirm Mapped Type: (YES) NO

Profile Description:

| Depth (Inches) | Horizon | Matrix Colors (Munsell Moist) | Mottle Colors (Munsell) Moist) | Mottle Abundance/ Contrast | Texture, Concretions |
|---|---|---|---|---|---|
| 0-10 | | 2.5Y 3/2 | | unmottled | Sandy Loam; Dry |
| 10-18+ | | 10YR 5/4 | | unmottled | Sandy Loam; Dry |
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Hydric Soil Indicators:

_____ Histosol
_____ Histic Epipedon
_____ Sulfidic Odor
_____ Aquic Moisture Regime
_____ Reducing Conditions
_____ Gleyed or Low-Chroma Colors
_____ Concretions
_____ High Organic Content in Surface
_____ Layer in Sandy Soils
_____ Organic Streaking in sandy Soils
_____ Listed on Local Hydric Soils List
_____ Listed on National Hydric Soils List
_____ Other (Explain in Remarks)

Remarks: Sufficient field indicators of hydric soil not present; Does not satisfy criterion.

## W E T L A N D  D E T E R M I N A T I O N

Hydrophytic Vegetation Present:? (Yes) No (Circle)
Wetland Hydrology Present? Yes (No)
Hydric Soils Present? Yes (No)

Is this Sampling Point Within a Wetland? Yes (No) (Circle)

Remarks: Sample area does not satisfy all three mandatory wetland technical criteria.

Approved by HQUSACE 3/92

**DATA FORM**
**ROUTINE WETLAND DETERMINATION**
**(1987 COE WETLAND DELINEATION MANUAL)**

PROJECT : Martin State Airport – Tract 2 DATE: 9/21/05
APPLICANT: BWI COUNTY: Baltimore
INVESTIGATOR: A. Sutton, T. Davis STATE: Maryland

Do Normal Circumstances exist on the site? (Yes) No Community ID Forested Upland
Is the site significantly disturbed (Atypical Situation)? Yes (No) Transect ID T-5
Is the area a potential Problem Area? Yes (No) Plot ID P-12
(If needed, explain on reverse.)

## V E G E T A T I O N

| Dominant Plant Sp. | Stratum | Indicator | Dominant Plant Sp. | Stratum | Indicator |
|---|---|---|---|---|---|
| 1. Pinus serotina | T | OBL | 9. Clethra alnifolia | H | FAC+ |
| 2. Nyssa sylvatica | T | FAC | 10. Sassafras albidum | H | FACU- |
| 3. Sassafras albidum | T | FACU- | 11. | | |
| 4. Clethra alnifolia | SH | FAC+ | 12. | | |
| 5. Vaccinium corymbosum | SH | FACW- | 13. | | |
| 6. Magnolia virginiana | SH | FACW+ | 14. | | |
| 7. Toxicodendron radicans | V | FAC | 15. | | |
| 8. Parthenocissus quinquefolia | V | FACU | 16. | | |

Percent of Dominant Species that are OBL, FACW or FAC
( EXCLUDING FAC- ). **70**

Remarks: Sample area satisfies the wetland hydrophytic vegetation criterion.

## H Y D R O L O G Y

X Recorded Data (Describe in Remarks):
____ Stream, Lake, or Tide Gauge
X Aerial Photographs
____ Other
____ No Recorded Data Available

Field Observations:

Depth of Surface Water: none (in.)

Depth to Free Water in Pit: none (in.)

Depth to Saturated Soil: none (in.)

Wetland Hydrology Indicators:
Primary Indicators:
____ Inundated
____ Saturated in Upper 12 inches
____ Water Marks
____ Drift Lines
____ Sediment Deposits
____ Drainage Patterns in Wetlands

Secondary Indicators (2 or more required)
____ Oxidized Root Channels in Upper 12 inches
____ Water-Stained Leaves
____ Local Soil Survey Data
____ Fac-Neutral Test
____ Other (Explain in Remarks)

Remarks: Sufficient field indicators of wetland hydrology not present; does not satisfy criterion.

## S O I L S (P-12,T-5)

Map Unit Name
(Series & Phase): Woodstown Sandy Loam

Drainage Class: Moderately Well Drained

Field Observations

Taxonomy (Subgroup): Aquic Hapludults

Confirm Mapped Type: YES (NO) **See remarks**

Profile Description:

| Depth (Inches) | Horizon | Matrix Colors (Munsell Moist) | Mottle Colors (Munsell) Moist) | Mottle Abundance/ Contrast | Texture, Concretions |
|---|---|---|---|---|---|
| 0-4 | | 10YR 3/1 | | unmottled | Sandy Loam; Dry |
| 4-10 | | 10YR 4/1 | | unmottled | Sandy Loam; Dry |
| 10-16 | | 10YR 3/2 | | unmottled | Loamy Fine Sand; Dry |
| 16-18+ | | 2.5Y 5/3 | 2.5Y 5/2 & 2.5Y 5/5 | Com Med Fnt Few Fine Prom. | Loamy Fine Sand; Dry |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

Hydric Soil Indicators:

_____ Histosol
_____ Histic Epipedon
_____ Sulfidic Odor
_____ Aquic Moisture Regime
_____ Reducing Conditions
_____ Gleyed or Low-Chroma Colors
_____ Concretions
_____ High Organic Content in Surface
_____ Layer in Sandy Soils
_____ Organic Streaking in sandy Soils
_____ Listed on Local Hydric Soils List
_____ Listed on National Hydric Soils List
_____ Other (Explain in Remarks)

Remarks: Sufficient field indicators of hydric soil not present; does not satisfy criterion. Soil appears to represent a spodosol inclusion. Chroma 3 below spodic layer. Would expect a chroma 2 or less in a hydric soil.

## W E T L A N D D E T E R M I N A T I O N

Hydrophytic Vegetation Present:? (Yes) No (Circle)
Wetland Hydrology Present? Yes (No)
Hydric Soils Present? Yes (No)

Is this Sampling Point Within a Wetland? Yes (No) (Circle)

Remarks: Sample area does not satisfy all three mandatory wetland technical criteria. Plot located in an area that appears to be a transitional zone from a wetland community to an upland community.

Approved by HQUSACE 3/92

**DATA FORM**
**ROUTINE WETLAND DETERMINATION**
**(1987 COE WETLAND DELINEATION MANUAL)**

PROJECT : Martin State Airport – Tract 2 DATE: 9/21/05
APPLICANT: BWI COUNTY: Baltimore
INVESTIGATOR: A. Sutton, T. Davis STATE: Maryland

Do Normal Circumstances exist on the site? (Yes) No
Is the site significantly disturbed (Atypical Situation)? Yes (No)
Is the area a potential Problem Area? Yes (No)
(If needed, explain on reverse.)

Community ID Forested Upland
Transect ID T-6
Plot ID P-4

## V E G E T A T I O N

| Dominant Plant Sp. | Stratum | Indicator | Dominant Plant Sp. | Stratum | Indicator |
|---|---|---|---|---|---|
| 1. Quercus coccinea | T | UPL | 9. Smilax rotundifolia | H | FAC |
| 2. Pinus virginiana | T | UPL | 10. | | |
| 3. Liquidambar styraciflua | SH | FAC | 11. | | |
| 4. Sassafras albidum | SH | FACU- | 12. | | |
| 5. Acer rubrum | SH | FAC | 13. | | |
| 6. Clethra alnifolia | H | FAC+ | 14. | | |
| 7. Vaccinium corymbosum | H | FACW- | 15. | | |
| 8. Sassafras albidum | H | FACU- | 16. | | |

Percent of Dominant Species that are OBL, FACW or FAC ( EXCLUDING FAC- ). **56**

Remarks: Sample area satisfies the wetland hydrophytic vegetation criterion.

## H Y D R O L O G Y

X Recorded Data (Describe in Remarks):
- Stream, Lake, or Tide Gauge
- X Aerial Photographs
- Other

No Recorded Data Available

Field Observations:

Depth of Surface Water: none (in.)

Depth to Free Water in Pit: none (in.)

Depth to Saturated Soil: none (in.)

Wetland Hydrology Indicators:
Primary Indicators:
- Inundated
- Saturated in Upper 12 inches
- Water Marks
- Drift Lines
- Sediment Deposits
- Drainage Patterns in Wetlands

Secondary Indicators (2 or more required)
- Oxidized Root Channels in Upper 12 inches
- Water-Stained Leaves
- Local Soil Survey Data
- Fac-Neutral Test
- Other (Explain in Remarks)

Remarks: Sufficient field indicators of wetland hydrology not present; does not satisfy criterion.

## S O I L S (P-4,T-6)

Map Unit Name
(Series & Phase): Woodstown Sandy Loam

Drainage Class: Moderately Well Drained

Field Observations

Taxonomy (Subgroup): Aquic Hapludults

Confirm Mapped Type: YES (NO)

Profile Description:

| Depth (Inches) | Horizon | Matrix Colors (Munsell Moist) | Mottle Colors (Munsell) Moist) | Mottle Abundance/ Contrast | Texture, Concretions |
|---|---|---|---|---|---|
| 0-6 | | 10YR 4/2 | | unmottled | Sandy Loam; Dry |
| 6-12+ | | 2.5Y 5/5 | | unmottled | Sandy Loam; Dry |
| | | | | | |
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| | | | | | |

Hydric Soil Indicators:

| | |
|---|---|
| _____ Histosol | _____ Concretions |
| _____ Histic Epipedon | _____ High Organic Content in Surface |
| _____ Sulfidic Odor | _____ Layer in Sandy Soils |
| _____ Aquic Moisture Regime | _____ Organic Streaking in sandy Soils |
| _____ Reducing Conditions | _____ Listed on Local Hydric Soils List |
| _____ Gleyed or Low-Chroma Colors | _____ Listed on National Hydric Soils List |
| | _____ Other (Explain in Remarks) |

Remarks: Sufficient field indicators of hydric soil not present; does not satisfy criterion.

## W E T L A N D  D E T E R M I N A T I O N

Hydrophytic Vegetation Present:? (Yes) No (Circle)

Wetland Hydrology Present? Yes (No)

Hydric Soils Present? Yes (No)

Is this Sampling Point Within a Wetland? Yes (No) (Circle)

Remarks: Sample area does not satisfy all three mandatory wetland technical criteria. Plot located on edge of wetland; off-set into uplands.

Approved by HQUSACE 3/92

# Appendix A – DATA FORMS

## TRACT 3 – Wetland Data Sheets

**DATA FORM**
**ROUTINE WETLAND DETERMINATION**
**(1987 COE WETLAND DELINEATION MANUAL)**

PROJECT : Martin State Airport – Tract 3 DATE: 10/4/05
APPLICANT: BWI COUNTY: Baltimore
INVESTIGATOR: A. Sutton, T. Davis STATE: Maryland

Do Normal Circumstances exist on the site? (Yes) No Community ID Forested Wetland K
Is the site significantly disturbed (Atypical Situation)? Yes (No) Transect ID T-2
Is the area a potential Problem Area? Yes (No) Plot ID P-2
(If needed, explain on reverse.)

## V E G E T A T I O N

| Dominant Plant Sp. | Stratum | Indicator | Dominant Plant Sp. | Stratum | Indicator |
|---|---|---|---|---|---|
| 1. Liquidambar styraciflua | T | FAC | 9. | | |
| 2. Acer rubrum | T | FAC | 10. | | |
| 3. Nyssa sylvatica | T | FAC | 11. | | |
| 4. Vaccinium corymbosum | SH | FACW- | 12. | | |
| 5. Liquidambar styraciflua | SH | FAC | 13. | | |
| 6. Acer rubrum | SH | FAC | 14. | | |
| 7. Smilax rotundifolia | V | FAC | 15. | | |
| 8. Toxicodendron radicans | V | FAC | 16. | | |

Percent of Dominant Species that are OBL, FACW or FAC ( EXCLUDING FAC- ). **100**

Remarks: Sample area satisfies the wetland hydrophytic vegetation criterion.

## H Y D R O L O G Y

X Recorded Data (Describe in Remarks):
- Stream, Lake, or Tide Gauge
- X Aerial Photographs
- Other

No Recorded Data Available

Field Observations:

Depth of Surface Water: none (in.)

Depth to Free Water in Pit: none (in.)

Depth to Saturated Soil: none (in.)

Wetland Hydrology Indicators:
Primary Indicators:
- Inundated
- Saturated in Upper 12 inches
- X Water Marks
- Drift Lines
- Sediment Deposits
- Drainage Patterns in Wetlands

Secondary Indicators (2 or more required)
- Oxidized Root Channels in Upper 12 inches
- X Water-Stained Leaves
- Local Soil Survey Data
- Fac-Neutral Test
- Other (Explain in Remarks)

Remarks: Sufficient field indicators of wetland hydrology present; satisfies criterion.

## S O I L S (P-2,T-2)

Map Unit Name
(Series & Phase): Sassafras – Urban Land Complex

Drainage Class: Moderately Well Drained

Field Observations

Taxonomy (Subgroup): Typic Hapludults

Confirm Mapped Type: (YES) NO

Profile Description:

| Depth (Inches) | Horizon | Matrix Colors (Munsell Moist) | Mottle Colors (Munsell) Moist) | Mottle Abundance/ Contrast | Texture, Concretions |
|---|---|---|---|---|---|
| 0-3 | | | | | Organics Dry |
| 3-8 | | 2.5Y 3/1 | | | Sandy Loam; Dry |
| 8-18 | | 2.5Y 4/1 | | w/ OR's | Sandy Loam; Dry |
| | | | | | |
| | | | | | |
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| | | | | | |
| | | | | | |

Hydric Soil Indicators:

| | | | |
|---|---|---|---|
| | Histosol | | Concretions |
| | Histic Epipedon | | High Organic Content in Surface |
| | Sulfidic Odor | | Layer in Sandy Soils |
| | Aquic Moisture Regime | | Organic Streaking in sandy Soils |
| | Reducing Conditions | | Listed on Local Hydric Soils List |
| X | Gleyed or Low-Chroma Colors | X | Listed on National Hydric Soils List |
| | | | Other (Explain in Remarks) |

Remarks: Sufficient field indicators of hydric soil present; satisfies criterion. Soil is an hydric inclusion in an otherwise non-hydric soil.

## W E T L A N D  D E T E R M I N A T I O N

Hydrophytic Vegetation Present:? (Yes) No (Circle)
Wetland Hydrology Present? (Yes) No
Hydric Soils Present? (Yes) No

Is this Sampling Point Within a Wetland? (Yes) No (Circle)

Remarks: Sample area satisfies all three mandatory wetland technical criteria, and is classified as a PFO1C wetland.

Approved by HQUSACE 3/92

**DATA FORM**
**ROUTINE WETLAND DETERMINATION**
**(1987 COE WETLAND DELINEATION MANUAL)**

PROJECT : Wetland Delineation - Tract 3 DATE: 10/4/05
APPLICANT: BWI COUNTY: Baltimore
INVESTIGATOR: A. Sutton, T. Davis STATE: Virginia

Do Normal Circumstances exist on the site? (Yes) No
Is the site significantly disturbed (Atypical Situation)? Yes (No)
Is the area a potential Problem Area? Yes (No)
(If needed, explain on reverse.)

Community ID Mitigation Site (Wetland L)
Transect ID T-2
Plot ID P-4

## V E G E T A T I O N

| Dominant Plant Sp. | Stratum | Indicator | Dominant Plant Sp. | Stratum | Indicator |
|---|---|---|---|---|---|
| 1. Pluchea purpurascens | H | OBL | 9. | | |
| 2. Solidago sempervirens | H | FACW | 10. | | |
| 3. Typha angustifolia | H | OBL | 11. | | |
| 4. | | | 12. | | |
| 5. | | | 13. | | |
| 6. | | | 14. | | |
| 7. | | | 15. | | |
| 8. | | | 16. | | |

Percent of Dominant Species that are OBL, FACW or FAC ( EXCLUDING FAC- ). **100**

Remarks: Sample area satisfies the wetland hydrophytic vegetation criterion.

## H Y D R O L O G Y

X Recorded Data (Describe in Remarks):
- Stream, Lake, or Tide Gauge
- X Aerial Photographs
- Other

No Recorded Data Available

Field Observations:

Depth of Surface Water: none (in.)

Depth to Free Water in Pit: none (in.)

Depth to Saturated Soil: none (in.)

Wetland Hydrology Indicators:
Primary Indicators:
- Inundated
- X Saturated in Upper 12 inches
- Water Marks
- Drift Lines
- Sediment Deposits
- Drainage Patterns in Wetlands

Secondary Indicators (2 or more required)
- Oxidized Root Channels in Upper 12 inches
- Water-Stained Leaves
- Local Soil Survey Data
- Fac-Neutral Test
- Other (Explain in Remarks)

Remarks: Sufficient field indicators of wetland hydrology present; satisfies criterion

## S O I L S (P-4,T-2)

Map Unit Name
(Series & Phase): Lenoir-Urban Land Complex

Drainage Class: Somewhat Poorly Drained

Field Observations

Taxonomy (Subgroup): Aeric Paleaquults

Confirm Mapped Type: (YES) NO

Profile Description:

| Depth (Inches) | Horizon | Matrix Colors (Munsell Moist) | Mottle Colors (Munsell) Moist) | Mottle Abundance/ Contrast | Texture, Concretions |
|---|---|---|---|---|---|
| 0-16 | | 10YR 4/3 | | unmottled | Sandy Loam; Wet |
| 16+ | | Gley 1 4/10Y | Gley 1 4/5GY | Com Med Dist | Clay; Wet |
| | | | | | |
| | | | | | |
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| | | | | | |
| | | | | | |

Hydric Soil Indicators:

| | | | |
|---|---|---|---|
| | Histosol | | Concretions |
| | Histic Epipedon | | High Organic Content in Surface |
| | Sulfidic Odor | | Layer in Sandy Soils |
| | Aquic Moisture Regime | | Organic Streaking in sandy Soils |
| | Reducing Conditions | | Listed on Local Hydric Soils List |
| X | Gleyed or Low-Chroma Colors | | Listed on National Hydric Soils List |
| | | | Other (Explain in Remarks) |

Remarks: Sufficient field indicators of hydric soil present; Satisfies criterion. Soil appears to be disturbed. Clay layer is most likely the original subsoil.

## W E T L A N D D E T E R M I N A T I O N

Hydrophytic Vegetation Present:? (Yes) No (Circle)

Wetland Hydrology Present? (Yes) No

Hydric Soils Present? (Yes) No

Is this Sampling Point Within a Wetland? (Yes) No (Circle)

Remarks: Sample area satisfies all three mandatory wetland technical criteria, and is classified as an E2EM1 wetland. Plot located in a wetland creation site.

Approved by HQUSACE 3/92

**DATA FORM**
**ROUTINE WETLAND DETERMINATION**
**(1987 COE WETLAND DELINEATION MANUAL)**

PROJECT : Martin State Airport - Tract 3 DATE: 10/4/05
APPLICANT: BWI COUNTY: Baltimore
INVESTIGATOR: A. Sutton, T. Davis STATE: Maryland

Do Normal Circumstances exist on the site? (Yes) No
Is the site significantly disturbed (Atypical Situation)? Yes (No)
Is the area a potential Problem Area? Yes (No)
(If needed, explain on reverse.)

Community ID Forested Wetland
Transect ID T-4
Plot ID P-4

## V E G E T A T I O N

| Dominant Plant Sp. | Stratum | Indicator | Dominant Plant Sp. | Stratum | Indicator |
|---|---|---|---|---|---|
| 1. Liquidambar styraciflua | T | FAC | 9. | | |
| 2. Acer rubrum | SH | FAC | 10. | | |
| 3. Onoclea sensibilis | H | FACW | 11. | | |
| 4. Lonicera japonica | H | FAC- | 12. | | |
| 5. Lonicera japonica | V | FAC- | 13. | | |
| 6. Vitis rotundifolia | V | FAC- | 14. | | |
| 7. | | | 15. | | |
| 8. | | | 16. | | |

Percent of Dominant Species that are OBL, FACW or FAC ( EXCLUDING FAC- ). **50**

Remarks: Sample area satisfies the wetland hydrophytic vegetation criterion.

## H Y D R O L O G Y

X Recorded Data (Describe in Remarks):
- Stream, Lake, or Tide Gauge
- X Aerial Photographs
- Other

No Recorded Data Available

Field Observations:

Depth of Surface Water: none (in.)

Depth to Free Water in Pit: none (in.)

Depth to Saturated Soil: none (in.)

Wetland Hydrology Indicators:
Primary Indicators:
- Inundated
- Saturated in Upper 12 inches
- Water Marks
- Drift Lines
- Sediment Deposits
- Drainage Patterns in Wetlands

Secondary Indicators (2 or more required)
- X Oxidized Root Channels in Upper 12 inches
- X Water-Stained Leaves
- Local Soil Survey Data
- Fac-Neutral Test
- Other (Explain in Remarks)

Remarks: Sufficient field indicators of wetland hydrology present; satisfies criterion.

## S O I L S (P-4,T-4)

Map Unit Name
(Series & Phase): Sassafras – Urban Land Complex

Drainage Class: Well Drained
Field Observations
Taxonomy (Subgroup): Typic Hapludults
Confirm Mapped Type: (YES) NO

Profile Description:

| Depth (Inches) | Horizon | Matrix Colors (Munsell Moist) | Mottle Colors (Munsell) Moist) | Mottle Abundance/ Contrast | Texture, Concretions |
|---|---|---|---|---|---|
| 0-8 | | 10YR 3/2 | 7.5YR 4/6 | CMD | Sandy Loam; Dry |
| 8-16+ | | 7.5YR 4/1 | | Oxid. Rhizo. | Silt Loam; Moist |
| | | | | | |
| | | | | | |
| | | | | | |
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Hydric Soil Indicators:

| | | | |
|---|---|---|---|
| | Histosol | | Concretions |
| | Histic Epipedon | | High Organic Content in Surface |
| | Sulfidic Odor | | Layer in Sandy Soils |
| | Aquic Moisture Regime | | Organic Streaking in sandy Soils |
| | Reducing Conditions | | Listed on Local Hydric Soils List |
| X | Gleyed or Low-Chroma Colors | | Listed on National Hydric Soils List |
| | | | Other (Explain in Remarks) |

Remarks: Sufficient field indicators of hydric soil present; satisfies criterion.

## W E T L A N D D E T E R M I N A T I O N

Hydrophytic Vegetation Present:? (Yes) No (Circle)
Wetland Hydrology Present? (Yes) No
Hydric Soils Present? (Yes) No

Is this Sampling Point Within a Wetland? (Yes) No (Circle)

Remarks: Sample area satisfies all three mandatory wetland technical criteria.

Approved by HQUSACE 3/92

**DATA FORM**
**ROUTINE WETLAND DETERMINATION**
**(1987 COE WETLAND DELINEATION MANUAL)**

PROJECT : Martin State Airport – Tract 3 DATE: 10/4/05
APPLICANT: BWI COUNTY: Baltimore
INVESTIGATOR: A. Sutton, T. Davis STATE: Maryland

Do Normal Circumstances exist on the site? (Yes) No
Is the site significantly disturbed (Atypical Situation)? Yes (No)
Is the area a potential Problem Area? Yes (No)
(If needed, explain on reverse.)

Community ID Emergent Wetland O
Transect ID T-7
Plot ID P-1

## V E G E T A T I O N

| Dominant Plant Sp. | Stratum | Indicator | Dominant Plant Sp. | Stratum | Indicator |
|---|---|---|---|---|---|
| 1. Scirpus cyperinus | H | FACW+ | 9. | | |
| 2. Polygonum sagittatum | H | OBL | 10. | | |
| 3. Panicum virgatum | H | FAC | 11. | | |
| 4. | | | 12. | | |
| 5. | | | 13. | | |
| 6. | | | 14. | | |
| 7. | | | 15. | | |
| 8. | | | 16. | | |

Percent of Dominant Species that are OBL, FACW or FAC ( EXCLUDING FAC- ). **100**

Remarks: Sample area satisfies the wetland hydrophytic vegetation criterion.

## H Y D R O L O G Y

X Recorded Data (Describe in Remarks):
_____ Stream, Lake, or Tide Gauge
_____ Aerial Photographs
_____ Other
_____ No Recorded Data Available

Field Observations:

Depth of Surface Water: none (in.)

Depth to Free Water in Pit: none (in.)

Depth to Saturated Soil: none (in.)

Wetland Hydrology Indicators:
Primary Indicators:
_____ Inundated
_____ Saturated in Upper 12 inches
_____ Water Marks
_____ Drift Lines
_____ Sediment Deposits
_____ Drainage Patterns in Wetlands

Secondary Indicators (2 or more required)

X Oxidized Root Channels in Upper 12 inches
X Water-Stained Leaves
_____ Local Soil Survey Data
_____ Fac-Neutral Test
_____ Other (Explain in Remarks)

Remarks: Sufficient field indicators of wetland hydrology present; satisfies criterion

## S O I L S (P-1,T-7)

Map Unit Name
(Series & Phase): Made Land

Drainage Class: N/A
Field Observations
Confirm Mapped Type: (YES) NO

Taxonomy (Subgroup): N/A

Profile Description:

| Depth (Inches) | Horizon | Matrix Colors (Munsell Moist) | Mottle Colors (Munsell) Moist) | Mottle Abundance/ Contrast | Texture, Concretions |
|---|---|---|---|---|---|
| 0-12+ | | Gley 1 4/10Y | | unmottled | Clay; Dry |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
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| | | | | | |
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Hydric Soil Indicators:

| | | | |
|---|---|---|---|
| ___ | Histosol | ___ | Concretions |
| ___ | Histic Epipedon | ___ | High Organic Content in Surface |
| ___ | Sulfidic Odor | ___ | Layer in Sandy Soils |
| ___ | Aquic Moisture Regime | ___ | Organic Streaking in sandy Soils |
| ___ | Reducing Conditions | ___ | Listed on Local Hydric Soils List |
| X | Gleyed or Low-Chroma Colors | ___ | Listed on National Hydric Soils List |
| | | ___ | Other (Explain in Remarks) |

Remarks: Sufficient field indicators of hydric soil present; Satisfies criterion. Plot located in an isolated depression.

## W E T L A N D  D E T E R M I N A T I O N

Hydrophytic Vegetation Present:? (Yes) No (Circle)
Wetland Hydrology Present? (Yes) No
Hydric Soils Present? (Yes) No

Is this Sampling Point Within a Wetland? (Yes) No (Circle)

Remarks: Sample area satisfies all three mandatory wetland technical criteria, and is classified as a PEM1C wetland.

Approved by HQUSACE 3/92

**DATA FORM**
**ROUTINE WETLAND DETERMINATION**
**(1987 COE WETLAND DELINEATION MANUAL)**

PROJECT : Martin State Airport - Tract 3 DATE: 10/4/05 – 3/28/06
APPLICANT: BWI COUNTY: Baltimore
INVESTIGATOR: A. Sutton, T. Davis STATE: Maryland

Do Normal Circumstances exist on the site? (Yes) No Community ID Forested Wetland P
Is the site significantly disturbed (Atypical Situation)? Yes (No) Transect ID T-7
Is the area a potential Problem Area? Yes (No) Plot ID P-2
(If needed, explain on reverse.)

## V E G E T A T I O N

| Dominant Plant Sp. | Stratum | Indicator | Dominant Plant Sp. | Stratum | Indicator |
|---|---|---|---|---|---|
| 1. Liquidambar styraciflua | T | FAC | 9. | | |
| 2. Acer rubrum | T | FAC | 10. | | |
| 3. Prunus serotina | T | FACU | 11. | | |
| 4. Liquidambar styraciflua | SH | FAC | 12. | | |
| 5. Prunus serotina | SH | FACU | 13. | | |
| 6. Quercus falcata | SH | FACU- | 14. | | |
| 7. Acer rubrum | H | FAC | 15. | | |
| 8. Pteridium aquilinum | H | FACU | 16. | | |

Percent of Dominant Species that are OBL, FACW or FAC ( EXCLUDING FAC- ). **50**

Remarks: Sample area does satisfy the wetland hydrophytic vegetation criterion.

## H Y D R O L O G Y

X Recorded Data (Describe in Remarks):
- Stream, Lake, or Tide Gauge
- X Aerial Photographs
- Other

No Recorded Data Available

Field Observations:

Depth of Surface Water: none (in.)

Depth to Free Water in Pit: none (in.)

Depth to Saturated Soil: at surface (in.)

Wetland Hydrology Indicators:
Primary Indicators:
- Inundated
- Saturated in Upper 12 inches
- Water Marks
- Drift Lines
- Sediment Deposits
- Drainage Patterns in Wetlands

Secondary Indicators (2 or more required)
- Oxidized Root Channels in Upper 12 inches
- X Water-Stained Leaves
- Local Soil Survey Data
- Fac-Neutral Test
- X Other (Explain in Remarks)

Remarks: Field indicators of hydrology are limited, but include buttressed tree roots and occasional water-stained leaves.

## S O I L S (P-2,T-7)

Map Unit Name
(Series & Phase): Made Land

Drainage Class: N/A
Field Observations
Confirm Mapped Type: (YES) NO
**See remarks**

Taxonomy (Subgroup): N/A

Profile Description:

| Depth (Inches) | Horizon | Matrix Colors (Munsell Moist) | Mottle Colors (Munsell) Moist) | Mottle Abundance/ Contrast | Texture, Concretions |
|---|---|---|---|---|---|
| 0-12+ | | 2.5Y 5/2 | 10YR 5/6 | Com Med Dist | Silty loam, saturated |
| | | | | | |
| | | | | | |
| | | | | | |
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| | | | | | |
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Hydric Soil Indicators:

| | | | |
|---|---|---|---|
| | Histosol | | Concretions |
| | Histic Epipedon | | High Organic Content in Surface |
| | Sulfidic Odor | | Layer in Sandy Soils |
| | Aquic Moisture Regime | X | Organic Streaking in sandy Soils |
| | Reducing Conditions | | Listed on Local Hydric Soils List |
| X | Gleyed or Low-Chroma Colors | | Listed on National Hydric Soils List |
| | | | Other (Explain in Remarks) |

Remarks: Sufficient field indicators of hydric soil present, satisfies criterion.

## W E T L A N D  D E T E R M I N A T I O N

Hydrophytic Vegetation Present:? Yes (No) (Circle)
Wetland Hydrology Present? Yes (No)
Hydric Soils Present? Yes (No)

Is this Sampling Point Within a Wetland? Yes (No) (Circle)

Remarks: Sample area satisfies all three mandatory wetland technical criteria, and is classified as a PFO1C wetland.

Approved by HQUSACE 3/92

# Appendix A – DATA FORMS

## TRACT 3 – Upland Data Sheets

**Tract 3, Transect 1, Observation Points P1 & P2:**
Area largely mowed and maintained with little natural vegetation.







**DATA FORM**
**ROUTINE WETLAND DETERMINATION**
**(1987 COE WETLAND DELINEATION MANUAL)**

PROJECT : Martin State Airport - Tract 3 DATE: 10/4/05
APPLICANT: BWI COUNTY: Baltimore
INVESTIGATOR: A. Sutton, T. Davis STATE: Maryland

Do Normal Circumstances exist on the site? (Yes) No
Is the site significantly disturbed (Atypical Situation)? Yes (No)
Is the area a potential Problem Area? Yes (No)
(If needed, explain on reverse.)

Community ID Upland Field
Transect ID T-2
Plot ID P-3

## V E G E T A T I O N

| Dominant Plant Sp. | Stratum | Indicator | Dominant Plant Sp. | Stratum | Indicator |
|---|---|---|---|---|---|
| 1. Lonicera japonica | H | FAC- | 9. | | |
| 2. Festuca arundinacea | H | FACU | 10. | | |
| 3. Agrostis alba | H | FACW | 11. | | |
| 4. | | | 12. | | |
| 5. | | | 13. | | |
| 6. | | | 14. | | |
| 7. | | | 15. | | |
| 8. | | | 16. | | |

Percent of Dominant Species that are OBL, FACW or FAC ( EXCLUDING FAC- ). **33**

Remarks: Sample area does not satisfy the wetland hydrophytic vegetation criterion.

## H Y D R O L O G Y

X Recorded Data (Describe in Remarks):
_____ Stream, Lake, or Tide Gauge
X Aerial Photographs
_____ Other
_____ No Recorded Data Available

Field Observations:

Depth of Surface Water: none (in.)

Depth to Free Water in Pit: none (in.)

Depth to Saturated Soil: none (in.)

Wetland Hydrology Indicators:
Primary Indicators:
_____ Inundated
_____ Saturated in Upper 12 inches
_____ Water Marks
_____ Drift Lines
_____ Sediment Deposits
_____ Drainage Patterns in Wetlands

Secondary Indicators (2 or more required)
_____ Oxidized Root Channels in Upper 12 inches
_____ Water-Stained Leaves
_____ Local Soil Survey Data
_____ Fac-Neutral Test
_____ Other (Explain in Remarks)

Remarks: Sufficient field indicators of wetland hydrology not present; does not satisfy criterion.

## S O I L S (P-3,T-2)

Map Unit Name
(Series & Phase): Sassafras – Urban Land Complex

Drainage Class: Moderately Well Drained

Field Observations

Taxonomy (Subgroup): Typic Hapludults

Confirm Mapped Type: YES (NO)

Profile Description:

| Depth (Inches) | Horizon | Matrix Colors (Munsell Moist) | Mottle Colors (Munsell) Moist) | Mottle Abundance/ Contrast | Texture, Concretions |
|---|---|---|---|---|---|
| 0-8 | | 2.5Y 4/3 | | | Sandy Loam; Dry |
| | | | | | |
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Hydric Soil Indicators:

| | |
|---|---|
| ___ Histosol | ___ Concretions |
| ___ Histic Epipedon | ___ High Organic Content in Surface |
| ___ Sulfidic Odor | ___ Layer in Sandy Soils |
| ___ Aquic Moisture Regime | ___ Organic Streaking in sandy Soils |
| ___ Reducing Conditions | ___ Listed on Local Hydric Soils List |
| ___ Gleyed or Low-Chroma Colors | ___ Listed on National Hydric Soils List |
| | ___ Other (Explain in Remarks) |

Remarks: Sufficient field indicators of hydric soil not present; does not satisfy criterion. Soil too hard and dry to auger deeper.

## W E T L A N D  D E T E R M I N A T I O N

Hydrophytic Vegetation Present:? Yes (No) (Circle)
Wetland Hydrology Present? Yes (No)
Hydric Soils Present? Yes (No)

Is this Sampling Point Within a Wetland? Yes (No) (Circle)

Remarks: Sample area does not satisfy all three mandatory wetland technical criteria.

Approved by HQUSACE 3/92

**DATA FORM**
**ROUTINE WETLAND DETERMINATION**
**(1987 COE WETLAND DELINEATION MANUAL)**

PROJECT : Martin State Airport - Tract 3 DATE: 10/4/05
APPLICANT: BWI COUNTY: Baltimore
INVESTIGATOR: A. Sutton, T. Davis STATE: Maryland

Do Normal Circumstances exist on the site? (Yes) No Community ID Forested Upland
Is the site significantly disturbed (Atypical Situation)? Yes (No) Transect ID T-4
Is the area a potential Problem Area? Yes (No) Plot ID P-3
(If needed, explain on reverse.)

## V E G E T A T I O N

| Dominant Plant Sp. | Stratum | Indicator | Dominant Plant Sp. | Stratum | Indicator |
|---|---|---|---|---|---|
| 1. Prunus serotina | T | FACU | 9. | | |
| 2. Liquidambar styraciflua | SH | FAC | 10. | | |
| 3. Rubus argutus | H | FACU | 11. | | |
| 4. Lonicera japonica | H | FAC- | 12. | | |
| 5. Lonicera japonica | V | FAC- | 13. | | |
| 6. | | | 14. | | |
| 7. | | | 15. | | |
| 8. | | | 16. | | |

Percent of Dominant Species that are OBL, FACW or FAC ( EXCLUDING FAC- ). **20**

Remarks: Sample area does not satisfy the wetland hydrophytic vegetation criterion.

## H Y D R O L O G Y

X Recorded Data (Describe in Remarks):
- Stream, Lake, or Tide Gauge
- X Aerial Photographs
- Other

No Recorded Data Available

Field Observations:

Depth of Surface Water: none (in.)

Depth to Free Water in Pit: none (in.)

Depth to Saturated Soil: none (in.)

Wetland Hydrology Indicators:
Primary Indicators:
- Inundated
- Saturated in Upper 12 inches
- Water Marks
- Drift Lines
- Sediment Deposits
- Drainage Patterns in Wetlands

Secondary Indicators (2 or more required)
- Oxidized Root Channels in Upper 12 inches
- Water-Stained Leaves
- Local Soil Survey Data
- Fac-Neutral Test
- Other (Explain in Remarks)

Remarks: Sufficient field indicators of wetland hydrology not present; does not satisfy criterion.

## S O I L S (P-3_T-4)

Map Unit Name
(Series & Phase): Sassafras – Urban Land Complex

Drainage Class: Moderately Well Drained

Field Observations

Taxonomy (Subgroup):

Confirm Mapped Type: YES (NO) See remarks

Profile Description:

| Depth (Inches) | Horizon | Matrix Colors (Munsell Moist) | Mottle Colors (Munsell) Moist) | Mottle Abundance/ Contrast | Texture, Concretions |
|---|---|---|---|---|---|
| 0-7 | | 10YR 4/3 | | | Silt Loam; Dry |
| 7-12+ | | 2.5Y 5/4 | | | Silt Loam; Dry |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

Hydric Soil Indicators:

| | |
|---|---|
| _____ Histosol | _____ Concretions |
| _____ Histic Epipedon | _____ High Organic Content in Surface |
| _____ Sulfidic Odor | _____ Layer in Sandy Soils |
| _____ Aquic Moisture Regime | _____ Organic Streaking in sandy Soils |
| _____ Reducing Conditions | _____ Listed on Local Hydric Soils List |
| _____ Gleyed or Low-Chroma Colors | _____ Listed on National Hydric Soils List |
| | _____ Other (Explain in Remarks) |

Remarks: Sufficient field indicators of hydric soil not present; does not satisfy criterion.

## W E T L A N D  D E T E R M I N A T I O N

Hydrophytic Vegetation Present:? Yes (No) (Circle)

Wetland Hydrology Present? Yes (No)

Hydric Soils Present? Yes (No)

Is this Sampling Point Within a Wetland? Yes (No) (Circle)

Remarks: Sample area does not satisfy all three mandatory wetland technical criteria.

Approved by HQUSACE 3/92

**DATA FORM**
**ROUTINE WETLAND DETERMINATION**
**(1987 COE WETLAND DELINEATION MANUAL)**

PROJECT : Martin State Airport - Tract 3 DATE: 10/4/05
APPLICANT: BWI COUNTY: Baltimore
INVESTIGATOR: A. Sutton, T. Davis STATE: Maryland

Do Normal Circumstances exist on the site? (Yes) No
Is the site significantly disturbed (Atypical Situation)? Yes (No)
Is the area a potential Problem Area? Yes (No)
(If needed, explain on reverse.)

Community ID Forested Upland
Transect ID T-7
Plot ID P-3

## V E G E T A T I O N

| Dominant Plant Sp. | Stratum | Indicator | Dominant Plant Sp. | Stratum | Indicator |
|---|---|---|---|---|---|
| 1. Liquidambar styraciflua | T | FAC | 9. | | |
| 2. Prunus serotina | T | FACU | 10. | | |
| 3. Prunus serotina | SH | FACU | 11. | | |
| 4. Liquidambar styraciflua | SH | FAC | 12. | | |
| 5. Vaccinium corymbosum | SH | FACW- | 13. | | |
| 6. Acer rubrum | H | FAC | 14. | | |
| 7. | | | 15. | | |
| 8. | | | 16. | | |

Percent of Dominant Species that are OBL, FACW or FAC ( EXCLUDING FAC- ). **67**

Remarks: Sample area satisfies the wetland hydrophytic vegetation criterion.

## H Y D R O L O G Y

X Recorded Data (Describe in Remarks):
- Stream, Lake, or Tide Gauge
- X Aerial Photographs
- Other

No Recorded Data Available

Field Observations:

Depth of Surface Water: none (in.)

Depth to Free Water in Pit: none (in.)

Depth to Saturated Soil: none (in.)

Wetland Hydrology Indicators:
Primary Indicators:
- Inundated
- Saturated in Upper 12 inches
- Water Marks
- Drift Lines
- Sediment Deposits
- Drainage Patterns in Wetlands

Secondary Indicators (2 or more required)
- Oxidized Root Channels in Upper 12 inches
- Water-Stained Leaves
- Local Soil Survey Data
- Fac-Neutral Test
- Other (Explain in Remarks)

Remarks: Sufficient field indicators of wetland hydrology not present; does not satisfy criterion.

## S O I L S (P-3,T-7)

Map Unit Name
(Series & Phase): Made Land

Drainage Class: N/A
Field Observations
Confirm Mapped Type: YES NO

Taxonomy (Subgroup): N/A

Profile Description:

| Depth (Inches) | Horizon | Matrix Colors (Munsell Moist) | Mottle Colors (Munsell) Moist) | Mottle Abundance/ Contrast | Texture, Concretions |
|---|---|---|---|---|---|
| 0-2 | O | | | | Organic duff; |
| 2-12+ | | 2.5Y 5/3.5 | | | Loamy Fine Sand; |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

Hydric Soil Indicators:

| | |
|---|---|
| _____ Histosol | _____ Concretions |
| _____ Histic Epipedon | _____ High Organic Content in Surface |
| _____ Sulfidic Odor | _____ Layer in Sandy Soils |
| _____ Aquic Moisture Regime | _____ Organic Streaking in sandy Soils |
| _____ Reducing Conditions | _____ Listed on Local Hydric Soils List |
| _____ Gleyed or Low-Chroma Colors | _____ Listed on National Hydric Soils List |
| | _____ Other (Explain in Remarks) |

Remarks: Sufficient field indicators of hydric soil not present; does not satisfy criterion.

## W E T L A N D  D E T E R M I N A T I O N

Hydrophytic Vegetation Present:? Yes No (Circle)
Wetland Hydrology Present? Yes No
Hydric Soils Present? Yes No

Is this Sampling Point Within a Wetland? Yes No (Circle)

Remarks: Sample area does not satisfy all three mandatory wetland technical criteria.

Approved by HQUSACE 3/92

# Appendix A – DATA FORMS

## TRACT 4 – Wetland Data Sheets

**DATA FORM**
**ROUTINE WETLAND DETERMINATION**
**(1987 COE WETLAND DELINEATION MANUAL)**

PROJECT : Martin State Airport - Tract 4 DATE: 10/6/05
APPLICANT: BWI COUNTY: Baltimore
INVESTIGATOR: A. Sutton, T. Davis STATE: Virginia

Do Normal Circumstances exist on the site? Yes No
Is the site significantly disturbed (Atypical Situation)? Yes (No)
Is the area a potential Problem Area? Yes (No)
(If needed, explain on reverse.)

Community ID Emergent Wetland Q
Transect ID T-1
Plot ID P-1

## V E G E T A T I O N

| Dominant Plant Sp. | Stratum | Indicator | Dominant Plant Sp. | Stratum | Indicator |
|---|---|---|---|---|---|
| 1. Panicum virgatum | H | FAC | 9. | | |
| 2. Typha latifolia | H | OBL | 10. | | |
| 3. Scirpus cyperinus | H | FACW+ | 11. | | |
| 4. Juncus effusus | H | FACW+ | 12. | | |
| 5. | | | 13. | | |
| 6. | | | 14. | | |
| 7. | | | 15. | | |
| 8. | | | 16. | | |

Percent of Dominant Species that are OBL, FACW or FAC ( EXCLUDING FAC- ). **100**

Remarks: Sample area satisfies the wetland hydrophytic vegetation criterion.

## H Y D R O L O G Y

X Recorded Data (Describe in Remarks):
- Stream, Lake, or Tide Gauge
- X Aerial Photographs
- Other

No Recorded Data Available

Field Observations:

Depth of Surface Water: none (in.)

Depth to Free Water in Pit: none (in.)

Depth to Saturated Soil: none (in.)

Wetland Hydrology Indicators:
Primary Indicators:
- Inundated
- Saturated in Upper 12 inches
- Water Marks
- Drift Lines
- Sediment Deposits
- Drainage Patterns in Wetlands

Secondary Indicators (2 or more required)
- X Oxidized Root Channels in Upper 12 inches
- X Water-Stained Leaves
- Local Soil Survey Data
- Fac-Neutral Test
- Other (Explain in Remarks)

Remarks: Sufficient field indicators of wetland hydrology present; satisfies criterion

## S O I L S (P-1,T-1)

Map Unit Name
(Series & Phase): Mattapex - Urban Land Complex

Drainage Class: Moderately Well Drained

Field Observations

Taxonomy (Subgroup): Aquic Hapludults

Confirm Mapped Type: (YES) NO

Profile Description:

| Depth (Inches) | Horizon | Matrix Colors (Munsell Moist) | Mottle Colors (Munsell) Moist) | Mottle Abundance/ Contrast | Texture, Concretions |
|---|---|---|---|---|---|
| 0-4 | | 2.5Y 4/3 | | unmottled | Silt Loam; Slightly Moist |
| 4-12+ | | 2.5Y 6/2 | 10YR 5/6 | Com Med Dist | Silt Loam; Slightly Moist |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

Hydric Soil Indicators:

| | | | |
|---|---|---|---|
| | Histosol | | Concretions |
| | Histic Epipedon | | High Organic Content in Surface |
| | Sulfidic Odor | | Layer in Sandy Soils |
| | Aquic Moisture Regime | | Organic Streaking in sandy Soils |
| | Reducing Conditions | | Listed on Local Hydric Soils List |
| X | Gleyed or Low-Chroma Colors | | Listed on National Hydric Soils List |
| | | | Other (Explain in Remarks) |

Remarks: Sufficient field indicators of hydric soil present; Satisfies criterion.

## W E T L A N D  D E T E R M I N A T I O N

Hydrophytic Vegetation Present:? (Yes) No (Circle)

Wetland Hydrology Present? (Yes) No

Hydric Soils Present? (Yes) No

Is this Sampling Point Within a Wetland? (Yes) No (Circle)

Remarks: Sample area satisfies all three mandatory wetland technical criteria, and is classified as a PEM1C wetland.

Approved by HQUSACE 3/92

# Appendix A – DATA FORMS

## TRACT 4 – Upland Data Sheets

**DATA FORM**
**ROUTINE WETLAND DETERMINATION**
**(1987 COE WETLAND DELINEATION MANUAL)**

PROJECT : Martin State Airport - Tract 4 DATE: 10/6/05
APPLICANT: BWI COUNTY: Baltimore
INVESTIGATOR: A. Sutton, T. Davis STATE: Virginia

Do Normal Circumstances exist on the site? Yes No
Is the site significantly disturbed (Atypical Situation)? Yes (No)
Is the area a potential Problem Area? Yes (No)
(If needed, explain on reverse.)

Community ID Emergent Upland
Transect ID T-1
Plot ID P-2

## V E G E T A T I O N

| Dominant Plant Sp. | Stratum | Indicator | Dominant Plant Sp. | Stratum | Indicator |
|---|---|---|---|---|---|
| 1. Solidago canadensis | H | FACU | 9. | | |
| 2. Setaria italica | H | FACU | 10. | | |
| 3. Andropogon virginicus | H | FACU | 11. | | |
| 4. Panicum virgatum | H | FAC | 12. | | |
| 5. | | | 13. | | |
| 6. | | | 14. | | |
| 7. | | | 15. | | |
| 8. | | | 16. | | |

Percent of Dominant Species that are OBL, FACW or FAC ( EXCLUDING FAC- ). **25**

Remarks: Sample area does not satisfy the wetland hydrophytic vegetation criterion.

## H Y D R O L O G Y

X Recorded Data (Describe in Remarks):
___ Stream, Lake, or Tide Gauge
X Aerial Photographs
___ Other
___ No Recorded Data Available

Field Observations:

Depth of Surface Water: none (in.)

Depth to Free Water in Pit: none (in.)

Depth to Saturated Soil: none (in.)

Wetland Hydrology Indicators:
Primary Indicators:
___ Inundated
___ Saturated in Upper 12 inches
___ Water Marks
___ Drift Lines
___ Sediment Deposits
___ Drainage Patterns in Wetlands

Secondary Indicators (2 or more required)
___ Oxidized Root Channels in Upper 12 inches
___ Water-Stained Leaves
___ Local Soil Survey Data
___ Fac-Neutral Test
___ Other (Explain in Remarks)

Remarks: Sufficient field indicators of wetland hydrology not present; does not satisfy criterion.

## S O I L S (P-2,T-1)

Map Unit Name
(Series & Phase): Mattapex - Urban Land Complex

Drainage Class: Moderately Well Drained

Field Observations

Taxonomy (Subgroup): Aquic Hapludults

Confirm Mapped Type: (YES) NO

Profile Description:

| Depth (Inches) | Horizon | Matrix Colors (Munsell Moist) | Mottle Colors (Munsell) Moist) | Mottle Abundance/ Contrast | Texture, Concretions |
|---|---|---|---|---|---|
| 0-8 | | 2.5Y 5/4 | | unmottled | Sandy Loam; Dry |
| 8-15 | | 2.5Y 5/5 | | unmottled | Sandy Loam; Friable |
| 15+ | | 2.5Y 6/2 | 10YR 5/6 | Com Med Dist | Sandy Loam; Friable |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

Hydric Soil Indicators:

_____ Histosol
_____ Histic Epipedon
_____ Sulfidic Odor
_____ Aquic Moisture Regime
_____ Reducing Conditions
_____ Gleyed or Low-Chroma Colors
_____ Concretions
_____ High Organic Content in Surface
_____ Layer in Sandy Soils
_____ Organic Streaking in sandy Soils
_____ Listed on Local Hydric Soils List
_____ Listed on National Hydric Soils List
_____ Other (Explain in Remarks)

Remarks: Sufficient field indicators of hydric soil not present; Does not satisfy criterion.

## W E T L A N D  D E T E R M I N A T I O N

Hydrophytic Vegetation Present:? Yes (No) (Circle)
Wetland Hydrology Present? Yes (No)
Hydric Soils Present? Yes (No)

Is this Sampling Point Within a Wetland? Yes (No) (Circle)

Remarks: Sample area does not satisfy all three mandatory wetland technical criteria.

Approved by HQUSACE 3/92

# Appendix A – DATA FORMS

## TRACT 5 – Wetland Data Sheet

**DATA FORM**
**ROUTINE WETLAND DETERMINATION**
**(1987 COE WETLAND DELINEATION MANUAL)**

PROJECT : Martin State Airport – Tract 5 DATE: 10/4/05
APPLICANT: BWI COUNTY: Baltimore
INVESTIGATOR: A. Sutton, T. Davis STATE: Maryland

Do Normal Circumstances exist on the site? (Yes) No Community ID Forested Wetland
Is the site significantly disturbed (Atypical Situation)? Yes (No) Transect ID n/a
Is the area a potential Problem Area? Yes (No) Plot ID Wetland S
(If needed, explain on reverse.)

## V E G E T A T I O N

| Dominant Plant Sp. | Stratum | Indicator | Dominant Plant Sp. | Stratum | Indicator |
|---|---|---|---|---|---|
| 1. Fraxinus pennsylvanica | T | FACW | 9. | | |
| 2. Liquidambar styraciflua | T | FAC | 10. | | |
| 3. Cornus amomum | SH | FACW | 11. | | |
| 4. Cornus amomum | H | FACW | 12. | | |
| 5. Lonicera japonica | V | FAC- | 13. | | |
| 6. | | | 14. | | |
| 7. | | | 15. | | |
| 8. | | | 16. | | |

Percent of Dominant Species that are OBL, FACW or FAC ( EXCLUDING FAC- ). **80**

Remarks: Sample area satisfies the wetland hydrophytic vegetation criterion.

## H Y D R O L O G Y

X Recorded Data (Describe in Remarks):
- Stream, Lake, or Tide Gauge
- X Aerial Photographs
- Other

No Recorded Data Available

Field Observations:

Depth of Surface Water: none (in.)

Depth to Free Water in Pit: none (in.)

Depth to Saturated Soil: none (in.)

Wetland Hydrology Indicators:
Primary Indicators:
- Inundated
- Saturated in Upper 12 inches
- Water Marks
- Drift Lines
- Sediment Deposits
- Drainage Patterns in Wetlands

Secondary Indicators (2 or more required)
- X Oxidized Root Channels in Upper 12 inches
- X Water-Stained Leaves
- Local Soil Survey Data
- X Fac-Neutral Test
- Other (Explain in Remarks)

Remarks: Sufficient field indicators of wetland hydrology present; satisfies criterion.

## S O I L S (Wetland S)

Map Unit Name
(Series & Phase): Woodstown Sandy Loam

Drainage Class: Moderately Well Drained

Field Observations

Taxonomy (Subgroup): Aquic Hapludults

Confirm Mapped Type: YES (NO)

Profile Description:

| Depth (Inches) | Horizon | Matrix Colors (Munsell Moist) | Mottle Colors (Munsell) Moist) | Mottle Abundance/ Contrast | Texture, Concretions |
|---|---|---|---|---|---|
| 0-4 | | 2.5 Y 4/2 | | | Silt Loam; Dry |
| 4-12+ | | 2.5 Y 4/2 | 10YR 3/4 | | Silt Loam; Dry |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

Hydric Soil Indicators:

| | | | |
|---|---|---|---|
| | Histosol | | Concretions |
| | Histic Epipedon | | High Organic Content in Surface |
| | Sulfidic Odor | | Layer in Sandy Soils |
| | Aquic Moisture Regime | | Organic Streaking in sandy Soils |
| | Reducing Conditions | | Listed on Local Hydric Soils List |
| X | Gleyed or Low-Chroma Colors | | Listed on National Hydric Soils List |
| | | | Other (Explain in Remarks) |

Remarks: Sufficient field indicators of hydric soil present; satisfies criterion.

## W E T L A N D  D E T E R M I N A T I O N

Hydrophytic Vegetation Present:? (Yes) No (Circle)

Wetland Hydrology Present? (Yes) No

Hydric Soils Present? (Yes) No

Is this Sampling Point Within a Wetland? (Yes) No (Circle)

Remarks: Sample area satisfies all three mandatory wetland technical criteria, and is classified as a PFO1E wetland.

Approved by HQUSACE 3/92

# Appendix B – SITE PHOTOGRAPHS



Photo B1: Wetland A, Tract 1.



Photo B2: Wetland E, Tract 1



Photo B3: Wetland H, Tract 2



Photo B4: Wetland I, Tract 2



Photo B5: Wetland L, Tract 3



Photo B6: Wetland N, Tract 3



Photo B7: Wetland Q, Tract 4.



Photo B8: Wetland T, Tract 5



Photo B9: Wetland U, MANG Area



Photo B10: East end of Wetland A, MANG Area



Photo B11: Wetland V near north end, MANG area



Photo B12: Wetland X near west end, MANG Area



Photo B13: Wetland X, Tract 4.

# APPENDIX G—MOU ADDRESSING WILDLIFE HAZARDS AT AIRPORTS

**Memorandum of Agreement Between**
**the Federal Aviation Administration,**
**the U.S. Air Force,**
**the U.S. Army,**
**the U.S. Environmental Protection Agency,**
**the U.S. Fish and Wildlife Service, and**
**the U.S. Department of Agriculture**
**to Address Aircraft-Wildlife Strikes**

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## PURPOSE

The signatory agencies know the risks that aircraft-wildlife strikes pose to safe aviation.

This Memorandum of Agreement (MOA) acknowledges each signatory agency's respective missions. Through this MOA, the agencies establish procedures necessary to coordinate their missions to more effectively address existing and future environmental conditions contributing to aircraft-wildlife strikes throughout the United States. These efforts are intended to minimize wildlife risks to aviation and human safety, while protecting the Nation's valuable environmental resources.

## BACKGROUND

Aircraft-wildlife strikes are the second leading causes of aviation-related fatalities. Globally, these strikes have killed over 400 people and destroyed more than 420 aircraft. While these extreme events are rare when compared to the millions of annual aircraft operations, the potential for catastrophic loss of human life resulting from one incident is substantial. The most recent accident demonstrating the grievous nature of these strikes occurred in September 1995, when a U.S. Air Force reconnaissance jet struck a flock of Canada geese during takeoff, killing all 24 people aboard.

The Federal Aviation Administration (FAA) and the United States Air Force (USAF) databases contain information on more than 54,000 United States civilian and military aircraft-wildlife strikes reported to them between 1990 and 1999[1]. During that decade, the FAA received reports indicating that aircraft-wildlife strikes, damaged 4,500 civilian U.S. aircraft (1,500 substantially), destroyed 19 aircraft, injured 91 people, and killed 6 people. Additionally, there were 216 incidents where birds struck two or more engines on civilian aircraft, with damage occurring to 26 percent of the 449 engines involved in these incidents. The FAA estimates that during the same decade, civilian U.S. aircraft sustained $4 billion worth of damages and associated losses and 4.7 million hours of aircraft downtime due to aircraft-wildlife strikes. For the same period,

[1] FAA estimates that the 28,150 aircraft-wildlife strike reports it received represent less than 20% of the actual number of strikes that occurred during the decade.

USAF planes colliding with wildlife resulted in 10 Class A Mishaps[2], 26 airmen deaths, and over $217 million in damages.

Approximately 97 percent of the reported civilian aircraft-wildlife strikes involved common, large-bodied birds or large flocks of small birds. Almost 70 percent of these events involved gulls, waterfowl, and raptors (Table 1).

About 90 percent of aircraft-wildlife strikes occur on or near airports, when aircraft are below altitudes of 2,000 feet. Aircraft-wildlife strikes at these elevations are especially dangerous because aircraft are moving at high speeds and are close to or on the ground. Aircrews are intently focused on complex take-off or landing procedures and monitoring the movements of other aircraft in the airport vicinity. Aircrew attention to these activities while at low altitudes often compromises their ability to successfully recover from unexpected collisions with wildlife and to deal with rapidly changing flight procedures. As a result, crews have minimal time and space to recover from aircraft-wildlife strikes.

Increasing bird and wildlife populations in urban and suburban areas near airports contribute to escalating aircraft-wildlife strike rates. FAA, USAF, and Wildlife Services (WS) experts expect the risks, frequencies, and potential severities of aircraft-wildlife strikes to increase during the next decade as the numbers of civilian and military aircraft operations grow to meet expanding transportation and military demands.

## SECTION I.

## SCOPE OF COOPERATION AND COORDINATION

Based on the preceding information and to achieve this MOA's purpose, the signatory agencies:

**A.** Agree to strongly encourage their respective regional and local offices, as appropriate, to develop interagency coordination procedures necessary to effectively and efficiently implement this MOA. Local procedures should clarify time frames and other general coordination guidelines.

**B.** Agree that the term "airport" applies only to those facilities as defined in the attached glossary.

**C.** Agree that the three major activities of most concern include, but are not limited to:

1. airport siting and expansion;

[2] See glossary for the definition of a Class A Mishap and similar terms.

2. development of conservation/mitigation habitats or other land uses that could attract hazardous wildlife to airports or nearby areas; and

3. responses to known wildlife hazards or aircraft-wildlife strikes.

**D.** Agree that "hazardous wildlife" are those animals, identified to species and listed in FAA and USAF databases, that are most often involved in aircraft-wildlife strikes. Many of the species frequently inhabit areas on or near airports, cause structural damage to airport facilities, or attract other wildlife that pose an aircraft-wildlife strike hazard. Table 1 lists many of these species. It is included solely to provide information on identified wildlife species that have been involved in aircraft-wildlife strikes. It is not intended to represent the universe of species concerning the signatory agencies, since more than 50 percent of the aircraft-wildlife strikes reported to FAA or the USAF did not identify the species involved.

**E.** Agree to focus on habitats attractive to the species noted in Table 1, but the signatory agencies realize that it is imperative to recognize that wildlife hazard determinations discussed in Paragraph L of this section may involve other animals.

**F.** Agree that not all habitat types attract hazardous wildlife. The signatory agencies, during their consultative or decisionmaking activities, will inform regional and local land use authorities of this MOA's purpose. The signatory agencies will consider regional, local, and site-specific factors (e.g., geographic setting and/or ecological concerns) when conducting these activities and will work cooperatively with the authorities as they develop and implement local land use programs under their respective jurisdictions. The signatory agencies will encourage these stakeholders to develop land uses within the siting criteria noted in Section 1-3 of FAA Advisory Circular (AC) 150.5200-33 (Attachment A) that do not attract hazardous wildlife. Conversely, the agencies will promote the establishment of land uses attractive to hazardous wildlife outside those siting criteria. Exceptions to the above siting criteria, as described in Section 2.4.b of the AC, will be considered because they typically involve habitats that provide unique ecological functions or values (e.g., critical habitat for federally-listed endangered or threatened species, ground water recharge).

**G.** Agree that wetlands provide many important ecological functions and values, including fish and wildlife habitats; flood protection; shoreline erosion control; water quality improvement; and recreational, educational, and research opportunities. To protect jurisdictional wetlands, Section 404 of the Clean Water Act (CWA) establishes a program to regulate dredge and/or fill activities in these wetlands and navigable waters. In recognizing Section 404 requirements and the Clean Water Action Plan's goal to annually increase the Nation's net wetland acreage by 100,000 acres through 2005, the signatory agencies agree to resolve aircraft-wildlife conflicts. They will do so by

avoiding and minimizing wetland impacts to the maximum extent practicable, and will work to compensate for all associated unavoidable wetland impacts. The agencies agree to work with landowners and communities to encourage and support wetland restoration or enhancement efforts that do not increase aircraft-wildlife strike potentials.

**H.** Agree that the: U.S. Army Corps of Engineers (ACOE) has expertise in protecting and managing jurisdictional wetlands and their associated wildlife; U.S. Environmental Protection Agency (EPA) has expertise in protecting environmental resources; and the U.S. Fish and Wildlife Service (USFWS) has expertise in protecting and managing wildlife and their habitats, including migratory birds and wetlands. Appropriate signatory agencies will cooperatively review proposals to develop or expand wetland mitigation sites, or wildlife refuges that may attract hazardous wildlife. When planning these sites or refuges, the signatory agencies will diligently consider the siting criteria and land use practice recommendations stated in FAA AC 150/5200-33. The agencies will make every effort to undertake actions that are consistent with those criteria and recommendations, but recognize that exceptions to the siting criteria may be appropriate (see Paragraph F of this section).

**I.** Agree to consult with airport proponents during initial airport planning efforts. As appropriate, the FAA or USAF will initiate signatory agency participation in these efforts. When evaluating proposals to build new civilian or military aviation facilities or to expand existing ones, the FAA or the USAF, will work with appropriate signatory agencies to diligently evaluate alternatives that may avoid adverse effects on wetlands, other aquatic resources, and Federal wildlife refuges. If these or other habitats support hazardous wildlife, and there is no practicable alternative location for the proposed aviation project, the appropriate signatory agencies, consistent with applicable laws, regulations, and policies, will develop mutually acceptable measures, to protect aviation safety and mitigate any unavoidable wildlife impacts.

**J.** Agree that a variety of other land uses (e.g., storm water management facilities, wastewater treatment systems, landfills, golf courses, parks, agricultural or aquacultural facilities, and landscapes) attract hazardous wildlife and are, therefore, normally incompatible with airports. Accordingly, new, federally-funded airport construction or airport expansion projects near habitats or other land uses that may attract hazardous wildlife must conform to the siting criteria established in the FAA Advisory Circular (AC) 150/5200-33, Section 1-3.

**K.** Agree to encourage and advise owners and/or operators of non-airport facilities that are known hazardous wildlife attractants (See Paragraph J) to follow the siting criteria in Section 1-3 of AC 150/5200-33. As appropriate, each signatory agency will inform proponents of these or other land uses about the land use's potential to attract hazardous species to airport areas.

The signatory agencies will urge facility owners and/or operators about the critical need to consider the land uses' effects on aviation safety.

**L.** Agree that FAA, USAF, and WS personnel have the expertise necessary to determine the aircraft-wildlife strike potentials of various land uses. When there is disagreement among signatory agencies about a particular land use and its potential to attract hazardous wildlife, the FAA, USAF, or WS will prepare a wildlife hazard assessment. Then, the appropriate signatory agencies will meet at the local level to review the assessment. At a minimum, that assessment will:

1. identify each species causing the aviation hazard, its seasonal and daily populations, and the population's local movements;

2. discuss locations and features on and near the airport or land use attractive to hazardous wildlife; and

3. evaluate the extent of the wildlife hazard to aviation.

**M.** Agree to cooperate with the airport operator to develop a specific, wildlife hazard management plan for a given location, when a potential wildlife hazard is identified. The plan will meet applicable FAA, USAF, and other relevant requirements. In developing the plan, the appropriate agencies will use their expertise and attempt to integrate their respective programmatic responsibilities, while complying with existing laws, regulations, and policies. The plan should avoid adverse impacts to wildlife populations, wetlands, or other sensitive habitats to the maximum extent practical. Unavoidable impacts resulting from implementing the plan will be fully compensated pursuant to all applicable Federal laws, regulations, and policies.

**N.** Agree that whenever a significant aircraft-wildlife strike occurs or a potential for one is identified, any signatory agency may initiate actions with other appropriate signatory agencies to evaluate the situation and develop mutually acceptable solutions to reduce the identified strike probability. The agencies will work cooperatively, preferably at the local level, to determine the causes of the strike and what can and should be done at the airport or in its vicinity to reduce potential strikes involving that species.

**O.** Agree that information and analyses relating to mitigation that could cause or contribute to aircraft-wildlife strikes should, whenever possible, be included in documents prepared to satisfy the National Environmental Policy Act (NEPA). This should be done in coordination with appropriate signatory agencies to inform the public and Federal decision makers about important ecological factors that may affect aviation. This concurrent review of environmental issues will promote the streamlining of the NEPA review process.

**P.** Agree to cooperatively develop mutually acceptable and consistent guidance, manuals, or procedures addressing the management of habitats attractive to

hazardous wildlife, when those habitats are or will be within the siting criteria noted in Section 1-3 of FAA AC 5200-33. As appropriate, the signatory agencies will also consult each other when they propose revisions to any regulations or guidance relevant to the purpose of this MOA, and agree to modify this MOA accordingly.

## SECTION II.
## GENERAL RULES AND INFORMATION

**A.** Development of this MOA fulfills the National Transportation Safety Board's recommendation of November 19, 1999, to form an inter-departmental task force to address aircraft-wildlife strike issues.

**B.** This MOA does not nullify any obligations of the signatory agencies to enter into separate MOAs with the USFWS addressing the conservation of migratory birds, as outlined in Executive Order 13186, *Responsibilities of Federal Agencies to Protect Migratory Birds*, dated January 10, 2001 (66 *Federal Register*, No. 11, pg. 3853).

**C.** This MOA in no way restricts a signatory agency's participation in similar activities or arrangements with other public or private agencies, organizations, or individuals.

**D.** This MOA does not alter or modify compliance with any Federal law, regulation or guidance (e.g., Clean Water Act; Endangered Species Act; Migratory Bird Treaty Act; National Environmental Policy Act; North American Wetlands Conservation Act; Safe Drinking Water Act; or the "no-net loss" policy for wetland protection). The signatory agencies will employ this MOA in concert with the Federal guidance addressing wetland mitigation banking dated March 6, 1995 (60 *Federal Register*, No. 43, pg. 12286).

**E.** The statutory provisions and regulations mentioned above contain legally binding requirements. However, this MOA does not substitute for those provisions or regulations, nor is it a regulation itself. This MOA does not impose legally binding requirements on the signatory agencies or any other party, and may not apply to a particular situation in certain circumstances. The signatory agencies retain the discretion to adopt approaches on a case-by-case basis that differ from this MOA when they determine it is appropriate to do so. Such decisions will be based on the facts of a particular case and applicable legal requirements. Therefore, interested parties are free to raise questions and objections about the substance of this MOA and the appropriateness of its application to a particular situation.

**F.** This MOA is based on evolving information and may be revised periodically without public notice. The signatory agencies welcome public comments on this MOA at any time and will consider those comments in any future revision of this MOA.

**G.** This MOA is intended to improve the internal management of the Executive Branch to address conflicts between aviation safety and wildlife. This MOA does not create any right, benefit, or trust responsibility, either substantively or procedurally. No party, by law or equity, may enforce this MOA against the United States, its agencies, its officers, or any person.

**H.** This MOA does not obligate any signatory agency to allocate or spend appropriations or enter into any contract or other obligations.

**I.** This MOA does not reduce or affect the authority of Federal, State, or local agencies regarding land uses under their respective purviews. When requested, the signatory agencies will provide technical expertise to agencies making decisions regarding land uses within the siting criteria in Section 1-3 of FAA AC 150/5200-33 to minimize or prevent attracting hazardous wildlife to airport areas.

**J.** Any signatory agency may request changes to this MOA by submitting a written request to any other signatory agency and subsequently obtaining the written concurrence of all signatory agencies.

**K.** Any signatory agency may terminate its participation in this MOA within 60 days of providing written notice to the other agencies. This MOA will remain in effect until all signatory agencies terminate their participation in it.

## SECTION III. PRINCIPAL SIGNATORY AGENCY CONTACTS

The following list identifies contact offices for each signatory agency.

Federal Aviation Administration
Office Airport Safety and Standards
Airport Safety and
Compliance Branch (AAS-310)
800 Independence Ave., S.W.
Washington, D.C. 20591
V: 202-267-1799
F: 202-267-7546

U.S. Air Force
HQ AFSC/SEFW
9700 Ave., G. SE, Bldg. 24499
Kirtland AFB, NM 87117
V: 505-846-5679
F: 505-846-0684

U.S. Army
Directorate of Civil Works
Regulatory Branch (CECW-OR)
441 G St., N.W.
Washington, D.C. 20314
V: 202-761-4750
F: 202-761-4150

U.S. Environmental Protection Agy.
Office of Water
Wetlands Division
Ariel Rios Building, MC 4502F
1200 Pennsylvania Ave., SW
Washington, D.C. 20460
V: 202-260-1799
F: 202-260-7546

U.S. Fish and Wildlife Service
Division of Migratory Bird Management
4401 North Fairfax Drive, Room 634
Arlington, VA 22203
V: 703-358-1714
F: 703-358-2272

U.S. Department of Agriculture
Animal and Plant Inspection Service
Wildlife Services
Operational Support Staff
4700 River Road, Unit 87
Riverdale, MD 20737
V: 301-734-7921
F: 301-734-5157

**Signature Page**

Original Signed by:
***Woodie Woodward*** **12/17/2002**

Associate Administrator for Airports, Federal Aviation Administration — Date

Original Signed by:
***Kenneth W. Hess*** **27 May 2003**

Chief of Safety, U. S. Air Force — Date

Original Signed by:
***R.L. Brownlee*** **December 9, 2002**

Assistant Secretary of the Army (Civil Works), U.S. Army — Date

Original Signed by:
***G. Tracy Mehan, III*** **1/17/03**

Assistant Administrator, Office of Water, U.S. Environmental Protection Agency — Date

Original Signed by:
***Paul R. Schmidt*** **7/29/03**

Assistant Director, Migratory Birds and State Programs, U.S. Fish and Wildlife Service — Date

Original Signed by:
***Richard D Curnow*** **9 January 2003**

***Acting*** Deputy Administrator, Wildlife Services U.S. Department of Agriculture — Date

## GLOSSARY

This glossary defines terms used in this MOA.

**Airport.** All USAF airfields or all public use airports in the FAA's National Plan of Integrated Airport Systems (NPIAS). Note: There are over 18,000 civil-use airports in the U.S., but only 3,344 of them are in the NPIAS and, therefore, under FAA's jurisdiction.

**Aircraft-wildlife strike.** An aircraft-wildlife strike is deemed to have occurred when:

1. a pilot reports that an aircraft struck 1 or more birds or other wildlife;
2. aircraft maintenance personnel identify aircraft damage as having been caused by an aircraft-wildlife strike;
3. personnel on the ground report seeing an aircraft strike 1 or more birds or other wildlife;
4. bird or other wildlife remains, whether in whole or in part, are found within 200 feet of a runway centerline, unless another reason for the animal's death is identified; or
5. the animal's presence on the airport had a significant, negative effect on a flight (i.e., aborted takeoff, aborted landing, high-speed emergency stop, aircraft left pavement area to avoid collision with animal)

(Source: *Wildlife Control Procedures Manual*, Technical Publication 11500E, 1994).

**Aircraft-wildlife strike hazard.** A potential for a damaging aircraft collision with wildlife on or near an airport (14 CFR 139.3).

**Bird Sizes**. Title 40, Code of Federal Regulations, Part 33.76 classifies birds according to weight:

small birds weigh less than 3 ounces (oz).
medium birds weigh more than 3 oz and less than 2.5 lbs.
large birds weigh greater than 2.5 lbs.

**Civil aircraft damage classifications.** The following damage descriptions are based on the *Manual on the International Civil Aviation Organization Bird Strike Information System*:

**Minor:** The aircraft is deemed airworthy upon completing simple repairs or replacing minor parts and an extensive inspection is not necessary.

**Substantial:** Damage or structural failure adversely affects an aircraft's structural integrity, performance, or flight characteristics. The damage normally requires major repairs or the replacement of the entire affected component. Bent fairings or cowlings; small dents; skin punctures; damage to wing tips, antenna, tires or brakes, or engine blade damage not requiring blade replacement are specifically excluded.

**Destroyed:** The damage sustained makes it inadvisable to restore the aircraft to an airworthy condition.

**Significant Aircraft-Wildlife Strikes**. A significant aircraft-wildlife strike is deemed to have occurred when any of the following applies:

1. a civilian, U.S. air carrier aircraft experiences a multiple aircraft-bird strike or engine ingestion;
2. a civilian, U.S. air carrier aircraft experiences a damaging collision with wildlife other than birds; or
3. a USAF aircraft experiences a Class A, B, or C mishap as described below:

    A. **Class A Mishap:** Occurs when at least one of the following applies:
        1. total mishap cost is $1,000,000 or more;
        2. a fatality or permanent total disability occurs; and/or
        3. an Air Force aircraft is destroyed.
    B. **Class B Mishap:** Occurs when at least one of the following applies:
        1. total mishap cost is $200,000 or more and less than $1,000,000; and/or
        2. a permanent partial disability occurs and/or 3 or more people are hospitalized;
    C. **Class C Mishap:** Occurs when at least one of the following applies:
        1. cost of reported damage is between $20,000 and $200,000;
        2. an injury causes a lost workday (i.e., duration of absence is at least 8 hours beyond the day or shift during which mishap occurred); and/or
        3. an occupational illness causing absence from work at any time.

**Wetlands.** An ecosystem requiring constant or recurrent, shallow inundation or saturation at or near the surface of the substrate. The minimum essential characteristics of a wetland are recurrent, sustained inundation or saturation at or

near the surface and the presence of physical, chemical, and biological features indicating recurrent, sustained inundation, or saturation. Common diagnostic wetland features are hydric soils and hydrophytic vegetation. These features will be present, except where specific physiochemical, biotic, or anthropogenic factors have removed them or prevented their development.

(Source the 1987 Delineation Manual; 40 CFR 230.3(t)).

**Wildlife.** Any wild animal, including without limitation any wild mammal, bird, reptile, fish, amphibian, mollusk, crustacean, arthropod, coelenterate, or other invertebrate, including any part, product, egg, or offspring there of (50 CFR 10.12, *Taking, Possession, Transportation, Sale, Purchase, Barter, Exportation, and Importation of Wildlife and Plants*). As used in this MOA, "wildlife" includes feral animals and domestic animals while out of their owner's control (14 CFR 139.3, *Certification and Operations: Land Airports Serving CAB-Certificated Scheduled Air Carriers Operating Large Aircraft (Other Than Helicopters)*)

**Table 1.** Identified wildlife species, or groups, that were involved in two or more aircraft-wildlife strikes, that caused damage to one or more aircraft components, or that had an adverse effect on an aircraft's flight. Data are for 1990-1999 and involve only civilian, U.S. aircraft.

| Birds | No. reported strikes |
|---|---|
| Gulls (all spp.) | 874 |
| Geese (primarily, Canada geese) | 458 |
| Hawks (primarily, Red-tailed hawks) | 182 |
| Ducks (primarily Mallards.) | 166 |
| Vultures (primarily, Turkey vulture) | 142 |
| Rock doves | 122 |
| Doves (primarily, mourning doves) | 109 |
| Blackbirds | 81 |
| European starlings | 55 |
| Sparrows | 52 |
| Egrets | 41 |
| Shore birds (primarily, Killdeer & Sandpipers) | 40 |
| Crows | 31 |
| Owls | 24 |
| Sandhill cranes | 22 |
| American kestrels | 15 |
| Great blue herons | 15 |
| Pelicans | 14 |
| Swallows | 14 |
| Eagles (Bald and Golden) | 14 |
| Ospreys | 13 |
| Ring-necked pheasants | 11 |
| Herons | 11 |
| Barn-owls | 9 |
| American robins | 8 |
| Meadowlarks | 8 |
| Buntings (snow) | 7 |
| Cormorants | 6 |
| Snow buntings | 6 |
| Brants | 5 |
| Terns (all spp.) | 5 |
| Great horned owls | 5 |
| Horned larks | 4 |
| Turkeys | 4 |
| Swans | 3 |
| Mockingbirds | 3 |
| Quails | 3 |
| Homing pigeons | 3 |
| Snowy owls | 3 |
| Anhingas | 2 |

| Birds | No. reported strikes |
|---|---|
| Ravens | 2 |
| Kites | 2 |
| Falcons | 2 |
| Peregrine falcons | 2 |
| Merlins | 2 |
| Grouse | 2 |
| Hungarian partridges | 2 |
| Spotted doves | 2 |
| Thrushes | 2 |
| Mynas | 2 |
| Finches | 2 |
| ***Total known birds*** | 2,612 |

| Mammals | No. reported strikes |
|---|---|
| Deer (primarily, White-tailed deer) | 285 |
| Coyotes | 16 |
| Dogs | 10 |
| Elk | 6 |
| Cattle | 5 |
| Bats | 4 |
| Horses | 3 |
| Pronghorn antelopes | 3 |
| Foxes | 2 |
| Raccoons | 2 |
| Rabbits | 2 |
| Moose | 2 |
| ***Total known mammals*** | 340 |

Ring-billed gulls were the most commonly struck gulls. The U.S. ring-billed gull population increased steadily at about 6% annually from 1966-1988. Canada geese were involved in about 90% of the aircraft-goose strikes involving civilian, U.S. aircraft from 1990-1998. Resident (non-migratory) Canada goose populations increased annually at 13% from 1966-1998. Red-tailed hawks accounted for 90% of the identified aircraft-hawk strikes for the 10-year period. Red-tailed hawk populations increased annually at 3% from 1966 to 1998. Turkey vultures were involved in 93% of he identified aircraft-vulture strikes. The U.S. Turkey vulture populations increased at annually at 1% between 1966 and 1998. Deer, primarily white-tailed deer, have also adapted to urban and airport areas and their populations have increased dramatically. In the early 1900's, there were about 100,000 white-tailed deer in the U.S. Current estimates are that the U.S. population is about 24 million.

# APPENDIX H—WETLAND DEWATERING ANALYSIS

TETRA TECH

# TECHNICAL MEMORANDUM

**TO:** Maryland Aviation Administration (MAA)

**FROM:** Dan Burnell, Fred Kolberg, Chris Pike, and Mike Martin (Tetra Tech, Inc.)

**DATE:** May 16, 2013

**RE:** Wetland #3 Water Balance Analysis during future recovery well pumping associated with the Interim Remedial Action (IRA) at Dump Road Area (DRA) of Martin State Airport (MSA)

This technical memorandum summarizes the results of a water balance modeling analysis of Wetland #3 during planned future recovery well pumping at the DRA. The simulated well pumping is associated with the containment of contaminated groundwater by the propose Interim Remedial Action (IRA). The objective of the water balance modeling was to assess the potential effect of recovery well pumping on water levels in Wetland #3 over time. Although recognized as a non-tidal wetland, Wetland #3 has developed through ponding of surface drainage in a depression on top of the Dump Road Area landfill. This area is impounded along the Frog Mortar Creek shoreline by an artificial berm.

A detailed discussion of the modeling approach and results is provided below.

## Background Information

Although the designated area of Wetland #3 is approximately 18,960 $ft^2$, field observations indicate that only a portion of this area has standing water. The estimated depth of the water in Wetland #3 is approximately 2 ft. Based on topographic maps, the estimated elevation of water in Wetland #3 is approximately 8.5 ft feet above North American Vertical Datum (NAVD) 1988. An examination of potentiometric surface maps at DRA indicates that the elevation of the water table is approximately 1.5 ft feet above NAVD 1988 in the vicinity of Wetland #3. The higher water elevation of Wetland #3 than the water table indicates that Wetland #3 is a recharge area for local groundwater. The relatively high difference (7 ft) in hydraulic heads between Wetland #3 and the water table indicates that the sediments beneath Wetland #3 have a low hydraulic conductivity. This is consistent with the clay sediments observed in shallow borings and test pits located near Wetland #3. The hydraulic conductivity of clays range from $10^{-6}$ to $10^{-9}$ cm/s, and is typically lower in the vertical direction as a result of anisotropy, Based on design groundwater extraction rates for each of the recovery wells, the calibrated groundwater flow model indicated

that the drawdown of the water table will be approximately 1 ft in the area beneath Wetland #3 during operation of the groundwater IRA recovery well system at DRA. The potential effect on water levels over time in Wetland #3 as a result of the lowered water table from recovery well pumping is discussed below.

**Wetland #3 Water Balance Modeling Analysis**

A simple water balance modeling approach was applied to examine potential changes in water levels of Wetland #3 over time as a result of the planned groundwater IRA recovery well pumping at DRA. In this modeling analysis, the water level of Wetland #3 is assumed to be initially in a dynamic equilibrium in which the rate of inflow into the wetland from precipitation is equal to the rate of outflow from the wetland as a result of leakage to the water table. The amount of leakage from the wetland was estimated using Darcy's law Q=KiA where K is vertical hydraulic conductivity of sediments beneath wetland, is hydraulic gradient across the sediments, and A is the wetland area. For the model water balance simulation, at time zero, the water table elevation is lowered by 1 ft to represent the effect of recovery well pumping. This increases the vertical hydraulic gradient and thus the amount of leakage of water from Wetland #3.

The water balance model was applied to examine the change in wetland elevation over time as a result of recovery well pumping. Based on the accuracy of water level elevation measurements and seasonal variability of wetland elevations, a 0.1 ft decrease in wetland elevation was chosen as the criterion for concluding that there is a measureable impact to the wetland. Using the calibrated MODFLOW flow model, the estimated water table drawdown is approximately 1 ft. beneath the wetland. Although vertical hydraulic conductivity data are not available for the sediments beneath the wetland, soil logs indicate the presence of lower permeability clays, which is consistent with the approximate 7 ft head difference between the water level of Wetland # 3 and the water table. Based on the uncertainty of the vertical hydraulic conductivity of sediments beneath Wetland #3, a range of possible values was examined in the model calculations.

**Modeling Results**

The results of the water balance model calculations indicate that the rate of change in the water level of Wetland #3 becomes very slow for low values of the vertical hydraulic conductivity of the sediments beneath this wetland. Based on a 5 year monitoring period, the water balance calculations indicate that the recovery well system will not impact the wetland (< 0.1 ft decrease) if the vertical hydraulic conductivity of the sediments beneath the wetland is less than $1 \times 10^{-8}$ cm/s. Sensitivity analyses indicate that the vertical hydraulic conductivity and monitoring period are the most sensitive model parameters. Over a longer monitoring period, greater decreases in wetland elevation may occur.

Characterization of the hydrogeologic conditions in and around Wetland #3 is planned in late 2013 and the data from those studies will assist in subsequent assessment of potential long-term impacts to Wetland #3.

## Conclusion

Wetland #3 is a non-tidal wetland that has developed in a bermed depression on the landfilled portion of the Dump Road Area. A vertical head difference of about 7 feet exists between the Wetland #3 water level and the underlying water table due to the low hydraulic conductivity of the sediments and soil beneath the wetland. Modeling of groundwater levels during pumping from the proposed extraction wells in the area of Wetland #3 predicts that the pumping will increase the separation between the perched water of Wetlands #3 and the local water table by approximately 1 foot. Based on the low permeability of the clays beneath the wetland, water balance modeling of the potential effects of this water-table drawdown indicates it is unlikely to have a significant impact on the water level in Wetland #3. Characterization of the hydrogeologic conditions in and around Wetland #3 is planned in late 2013, and the data from those studies will assist in assessment of potential long-term impacts to Wetland #3. No additional actions to monitor the current hydrology of Wetland #3 or to assess the potential long term impact from pumping of the extraction wells are recommended at this time.

# APPENIDX I—MEPA FORM

## MARYLAND ENVIRONMENTAL ASSESSMENT FORM

| | | | YES | NO | COMMENTS |
|---|---|---|---|---|---|
| **A** | **Land Use Considerations** | | | | |
| | 1 | Will the action be within the 100 year flood plain? | X | | Tidal floodplain only |
| | 2 | Will the action require a permit for construction or alteration within the 50 year flood plain? | | X | Tidal floodplain only |
| | 3 | Will the action require a permit for dredging, filling, draining, or alteration of a wetland? | X | | |
| | 4 | Will the action require a permit for the construction or operation of facilities for solid waste disposal including dredge and excavation spoil? | | X | |
| | 5 | Will the action occur on slopes exceeding 15 percent? | X | | |
| | 6 | Will the action require a grading plan or a sediment control permit? | X | | |
| | 7 | Will the action require a mining permit for deep or surface mining? | | X | |
| | 8 | Will the action require a permit for drilling a gas or oil well? | | X | |
| | 9 | Will the action require a permit for airport construction? | X | | |
| | 10 | Will the action require a permit for the crossing of the Potomac River by conduits, cables, or other like devices? | | X | |
| | 11 | Will the action affect the use of a public recreation area, park, forest, wildlife management area, scenic river, or wildland? | | X | |
| | 12 | Will the action affect the use of any natural or man-made features that are unique to the county, State, or nation? | | X | |
| | 13 | Will the action affect the use of an archaeological or historical site or structure? | | X | |
| **B** | **Water Use Considerations** | | | | |
| | 14 | Will the action require a permit for the change of the course, current, or cross section of a stream or other body of water? | X | | |
| | 15 | Will the action require the construction alteration, or removal of a dam, | | X | |

| | | | YES | NO | COMMENTS |
|---|---|---|---|---|---|
| | | reservoir, or waterway obstruction? | | | |
| | 16 | Will the action change the overland flow of storm water or reduce the absorption capacity of the ground? | X | | |
| | 17 | Will the action require a permit for the drilling of a water well? | X | | |
| | 18 | Will the action require a permit for water appropriation? | X | | |
| | 19 | Will the action require a permit for the construction and operation of facilities treatment or distribution of water? | X | | |
| | 20 | Will the project require a permit for the construction and operation of facilities for sewage treatment or land disposal of liquid waste derivatives? | | X | |
| | 21 | Will the action result in any discharge into surface or subsurface water? | X | | |
| | 22 | If so, will the discharge affect ambient water quality limits or require a discharge permit? | X | | |
| **C** | **Air Use Considerations** | | | | |
| | 23 | Will the action result in any discharge into the air? | X | | |
| | 24 | If so, will the discharge affect ambient air quality limits or produce a disagreeable odor? | | X | |
| | 25 | Will the action generate additional noise which differs in character or level from present conditions? | | X | |
| | 26 | Will the action preclude future use of related air space? | | X | |
| | 27 | Will the action generate any radiological, electrical, magnetic, or light influences? | | X | |
| **D** | **Plants and Animals** | | | | |
| | 28 | Will the action cause the disturbance, reduction, or loss of any rare, unique, or valuable plant or animal? | | X | |
| | 29 | Will the action result in the significant reduction or loss of any fish or wildlife habitats? | | X | |
| | 30 | Will the action require a permit for the use of pesticides, herbicides, or other biological, chemical, or radiological control agents? | | X | |

| | | | YES | NO | COMMENTS |
|---|---|---|---|---|---|
| **E** | **Socio-Economic** | | | | |
| | 31 | Will the action result in a preemption of division of properties or impair their economic use? | | X | |
| | 32 | Will the action cause relocation of activities or structures, or result in a change in the population density or distribution? | | X | |
| | 33 | Will the action alter land values? | | X | |
| | 34 | Will the action affect traffic flow and volume? | | X | |
| | 35 | Will the action affect the production, extraction, harvest, or potential use of a scarce or economically important resource? | | X | |
| | 36 | Will the action require a license to construct a sawmill or other plant for manufacture of forest products? | | X | |
| | 37 | Is the action in accord with federal, state, regional, and local comprehensive or functional plans—including zoning? | X | | |
| | 38 | Will the action affect the employment opportunities for persons in the area? | | X | |
| | 39 | Will the action affect the ability of the area to attract new sources of tax revenue? | | X | |
| | 40 | Will the action discourage present sources of tax revenue from remaining in the area, or affirmatively encourage them to relocate elsewhere? | | X | |
| | 41 | Will the action affect the ability of the area to attract tourism? | | X | |
| **F** | **Other Considerations** | | | | |
| | 42 | Could the action endanger the public health, safety, or welfare? | | X | |
| | 43 | Could the action be eliminated without deleterious effects to the public health, safety, welfare, or the natural environment? | | X | |
| | 44 | Will the action be of Statewide significance? | | X | |
| | 45 | Are there any other plans or actions (federal, State, county, or private) that, in conjunction with the subject action, | | X | |

| | | | YES | NO | COMMENTS |
|---|---|---|---|---|---|
| | | could result in a cumulative or synergistic impact on the public health, safety, welfare, or environment? | | | |
| | 46 | Will the action require additional power generation or transmission capacity? | | X | |
| | **G** | **Conclusion.** | | | |
| | 47 | This Agency will develop a complete Environmental Effects Report on the proposed action. | X | | |
| **Additional State Requirements** | | | | | |
| | 48 | Tree Impacts | X | | |
| | 49 | Chesapeake Critical Area | X | | |

# APPENIDX J—PUBLIC OUTREACH

Public Notice of Availability and Public Workshop Announcement

MARYLAND AVIATION ADMINISTRATION

DRAFT ENVIRONMENTAL ASSESSMENT
FOR THE PROPOSED DUMP ROAD AREA GROUNDWATER PLUME TREATMENT FACILITY AT
MARTIN STATE AIRPORT
MIDDLE RIVER, MARYLAND

Lockheed Martin Corporation, a tenant of and on behalf of the Maryland Aviation Administration (MAA) pursuant to the National Environmental Policy Act of 1969 (42 USC 4321, et seq.), its implementing regulations (40 CFR Parts 1500-1508), and Federal Aviation Administration (FAA) directives (Orders 5050.4B, *Airport Environmental Handbook* and 1050.1E, *Environmental Impacts: Policies and Procedures*), has completed a Draft Environmental Assessment (EA) for the proposed Groundwater Plume Treatment Facility at Martin State Airport in Middle River, Maryland. MAA proposes to undertake the project on the approved Airport Layout Plan by the FAA.

The primary purpose of the proposed Groundwater Plume Treatment Facility is to control migration of the contaminated groundwater plume from the Dump Road Area (DRA) at concentrations that can lead to exceedances of water quality standards in adjacent Frog Mortar Creek. Groundwater in the DRA is currently impacted by elevated levels of volatile organic compounds (VOCs), petroleum hydrocarbons, 1,4-dioxane, and heavy metals, and the groundwater contamination plume is currently migrating into adjacent Frog Mortar Creek, a tidal estuary of Chesapeake Bay. The proposed facility will pump and extract groundwater from beneath the DRA in order to gain hydraulic control of the contamination plume and limit the migration of contaminated groundwater into Frog Mortar Creek.

This action will also comply with the regulatory requirements of the Maryland Hazardous Substance Response Plan (MDHSRP). With respect to meeting the requirements of MDHSRP, the purposes of the proposed project are to: assist in compliance with COMAR Title 26, Subtitle 14; and fulfill the intent of the initial cleanup phase of the MDHSRP process, which is to achieve the applicable cleanup criteria at the property.

Concentrations of certain contaminants in DRA groundwater exceed federal/Maryland water quality standards or risk-based exposure criteria. Individually, or taken together, these impacts render the groundwater in the affected area a risk to human health and the environment which requires remedial action. Remediation of the site is also necessary to address the VOC levels in Frog Mortar Creek, and to comply with COMAR Title 26, Subtitle 14.

The Draft EA is available online at http://www.marylandaviation.com/content/environmental/environmentaldocs.html. Hard copies are available for review at the following locations during regular business hours until November 21, 2014:

Federal Aviation Administration
Washington Airports District Office
23723 Air Freight Lane, Suite 210
Dulles, VA 20166

Maryland Aviation Administration
Office of Planning and Environmental Services
991 Corporate Boulevard
Linthicum, MD 21090

Essex Public Library
Attn: Mr. Bob Maranto, Branch Manager
1110 Eastern Boulevard
Essex, MD 21221

Martin State Airport
701 Wilson Point Road
Administration Building
First Floor
Baltimore, MD 21220

In addition, a public workshop will be conducted to demonstrate the information presented in the EA. The public workshop, which will be held as an "open house" forum, is scheduled for November 6, 2014 from 4 p.m. to 8 p.m. at the Wilson Point Fire Hall, 1100 Wilson Point Road, Middle River, Maryland 21220. This forum is designed to inform the public of the proposed action and associated alternatives as well as anticipated impacts.

Written comments on the Draft EA are requested from interested parties and will be accepted if postmarked or received by 5:00 pm Eastern Time on November 21, 2014. Comments should be submitted in writing to:

Ms. Robin M. Bowie
Manager, Division of Environmental Planning
Maryland Aviation Administration
Baltimore/Washington International Thurgood Marshall Airport
P.O. Box 8766
BWI Airport, MD 21240