TRC
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PHASE IV REMEDY IMPLEMENTATION PLAN
TANK K AREA

Former GE Facility
RTN 3-0518
Wilmington, Massachusetts

Submitted to:

Massachusetts Department of
Environmental Protection – NERO
205 A Lowell Street
Wilmington, Massachusetts 01887

Prepared by:

TRC Environmental Corporation
Boott Mills South, Foot of John Street
Lowell, Massachusetts

TRC Project No. E9202-3402-02250
July 2000

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1.0 INTRODUCTION

This report presents a Remedy Implementation Plan (RIP) as part of Phase IV activities for the Tank K Area at the former GE Facility (site) located at 50 Fordham Road in Wilmington, Massachusetts. The site is listed as a Tier IA site with Release Tracking Number 3-0518. Regulatory oversight is provided by the Massachusetts Department of Environmental Protection (MA DEP). This RIP conforms to the regulatory requirements under 310 CMR 40.0874 of the Massachusetts Contingency Plan (MCP).

Prior activities in the Tank K Area involved the removal of the gasoline-containing underground storage tank (known as Tank K) in 1986 and assessment of the related contamination from prior releases from the tank. Conclusions of these assessments indicated that groundwater in the vicinity of the former Tank K contains gasoline-related compounds. This RIP is designed to remove these compounds from groundwater in the Tank K Area.

The Phase III Remedial Action Plan Addendum for the Tank K Area, prepared by TRC Environmental Corporation (TRC) in January 2000, selected biosparging and soil-vapor extraction (SVE) technology as the remedy to implement at the Tank K Area. This RIP presents the approach for implementation of this technology.

This RIP applies only to the Tank K Area at the site. Additional RIPs will be prepared individually for other areas of concern at the site.

1.1 Site Description

The site property is an approximately 13-acre parcel of land located east of Fordham Road and north of Concord Street within an industrial park in Wilmington and North Reading, Massachusetts. Fordham Road is located along the western property boundary with industrial parcels further to the west of Fordham Road. Commercial and industrial properties are located to the south. Wooded wetlands are located to the east and north. Residential properties are located beyond the wetlands. The site location is indicated on Figure 1-1.

The property buildings were used for manufacturing and supporting research and development by the GE Aerospace Instruments Control Systems Department from the time they were built (1970) through August 1989. A portion of Building 2 was subleased to Converse, Inc. (Converse), a sports shoe manufacturer, from 1973 to 1986, and a portion of Building 1A was subleased to Hamilton Standard, a manufacturer of hydrogen generators, from 1983 to 1985. Converse installed a gasoline tank (Tank K) east of Building 2 and a blowdown tank associated with the steam curing of rubber (Tank L) north of Building 2. Converse removed both tanks in 1986 before vacating the property.

In August 1989, GE's operations at the facility were sold to AMETEK Aerospace Products, Inc. (AMETEK). Martin Marietta acquired GE Aerospace on April 2, 1993. Lockheed Martin Corporation (LMC) assumed environmental responsibility for the site through the merger of Lockheed and Martin Marietta on March 15, 1995. On October 22, 1999, TRC was contracted by LMC to manage all aspects of the investigation and cleanup of the site. The contract designates TRC as an authorized representative of LMC, and covers all managerial and administrative requirements, in addition to the actual cleanup of the site.

AMETEK and GSI Lumonics are the current tenants at the site. The Wilmington Realty Trust currently owns the site. The Tank K Area, as shown on Figure 1-2, is located on the north end of the site to the east of Building 2, which houses the GSI Lumonics operations.

1.2 Overview of Investigation History

At the time of the 1986 removal of Tank K, it was discovered that a gasoline release had occurred from this tank. During the 1990 site-wide Phase II Investigation (*Phase II Comprehensive Site Assessment Report*, prepared by GZA in April 1990), sampling efforts in the Tank K Area identified the presence of gasoline-related compounds in soil and groundwater.

Additional data were gathered in the Tank K Area in 1996 by EMCON to further determine the extent of impacted soil and groundwater. The field work included the installation of six new soil borings and two new groundwater wells, a soil vapor extraction pilot test, and an aquifer test. A report documenting field activities and results was submitted to the MA DEP in January 1997. The results of this investigation revealed that the soils above the water table did not exceed the S-1/GW-1 cleanup standards (i.e. unrestricted or residential area soil). Therefore, soil is not considered to be a medium of concern in the Tank K Area. Groundwater results from this investigation and TRC's recent pilot study indicate that benzene, toluene, ethylbenzene, and xylene (BTEX), as well as methyl tert-butyl ether (MTBE), are present in some wells at concentrations exceeding the GW-1 cleanup standards. The approximate extent of groundwater exceedances in the Tank K Area is shown in Figure 1-2. — not true for MTBE Elevated levels near wetlands;

No methanol preservation through

DEP never approve no remedial to unsaturated soils.

In February 1998, EMCON, on behalf of LMC, conducted a Focused Feasibility Study to compare the remedial alternatives for the Tank K Area with alternatives developed since the Phase III RAP was prepared. The study recommended the implementation of chemical oxidation to treat the groundwater and soils in the Tank K Area. On March 2, 1998, LMC requested DEP approval to change the selected remedy for the Tank K Area, as presented in the Phase III RAP, from soil vapor extraction to in-situ chemical oxidation. This technology was conditionally approved by MA DEP on August 24, 1998, pending the results of a pilot test that included in-situ treatment of saturated soil and groundwater in the Tank K Area via chemical oxidation. The Phase IV RIP, submitted to DEP on April 14, 1998, included in-situ treatment of saturated soil and groundwater in the Tank K Area via chemical oxidation.

The chemical oxidation pilot test was conducted from November 1998 through January 1999. On May 19, 1999, the Chemical Oxidation Tank K Pilot Test letter report was submitted to DEP to document field investigation activities and the results of the pilot test of the recommended chemical oxidation technology. The pilot test was not successful, as it failed to show that it could achieve cleanup standards and indicated that the cost would exceed prior estimates. The letter report included a request for DEP approval to change the remedial action alternative for the Tank K Area based on a reevaluation of other feasible technologies.

To evaluate an alternate remedial technology for the Tank K Area, TRC submitted a work plan for a Biosparging/Soil Vapor Extraction (SVE) Pilot Test in October 1999. On November 2, 1999, DEP approved the work plan, and the pilot test was conducted from November 29 - December 2, 1999. The Phase III Addendum Report, submitted to DEP on January 24, 2000, summarized the pilot test results, concluded that the technology would be effective, and recommended that a full-scale system be implemented.

1.3 Work Rationale

In 1995, MA DEP established the site cleanup goals as the Method 1 S-3/GW-1 standards, as established in the MCP. GW-1 represents potential drinking water aquifers, and is thus appropriate for the site area. S-3 soils have the lowest likelihood of contact with people. S-3 soils are defined as soils that are isolated in the subsurface (greater than 15 foot depth), paved, or otherwise covered with a barrier preventing direct contact with people. This soil type can also be unpaved surface soil, but only adults may be present and only for low frequency and low intensity uses. This standard is appropriate for the site, as it is used for industrial purposes and will continue to remain such for the foreseeable future. Also, the vast majority of the site is either paved or covered by buildings.

Because soils in the Tank K Area currently satisfy S-3 standards, the cleanup goals pertinent to this RIP are limited to the GW-1 standards for BTEX and MTBE in groundwater. The remediation system design is, therefore, based on the removal of BTEX and MTBE to achieve the GW-1 standards summarized in Table 1-1.

No -- Don't have good soil data for Tank K Area.

Table 1-1
Groundwater Remedial Action Cleanup Goals

CONTAMINANT OF CONCERN	GW-1 GROUNDWATER CLEANUP GOAL (µg/l) PER MCP
Benzene	5
Ethylbenzene	700
Toluene	1,000
Xylenes	10,000
MTBE	70

2.0 MANAGEMENT

2.1 Project Organization

2.1.1 Key Contacts

The responsible party for this site is TRC Environmental Corporation (TRC). The contact person at TRC is:

Ms. Paola Macchiaroli, Ph.D., Manager
Boott Mills South, Foot of John Street
Lowell, MA 01852
(978) 656-3582

TRC is responsible for the implementation of this RIP. The Licensed Site Professional (LSP) of Record is:

Mr. Bruce Hoskins, P.E., LSP #7109
URS Corporation
5 Industrial Way
Salem, NH 03079-2830
(603) 893-0616

2.1.2 TRC Personnel

The TRC project field team will include a Site Manager/Health and Safety Officer, a Project Engineer, and engineering assistants and technicians as needed. The Site Manager/Health and Safety Officer will remain on site throughout the duration of the field effort. The LSP will also be on site as needed. The LSP is responsible for ensuring that all work is performed in accordance with the MCP and other applicable regulations, that the work performed does not significantly deviate from that described in this RIP, and that established remediation objectives are met.

2.2 Schedule

The proposed timeline for the Phase IV activities is as follows:

- Public meeting in accordance with the site Public Involvement Plan: August 1, 2000
- End of public comment period: August 24, 2000
- MA DEP approval of the RIP: September 20, 2000
- Begin system installation in the field: October 15, 2000
- Complete system installation: December 1, 2000
- Submit Phase IV As-Built Construction Report: December 31, 2000
- Complete system startup, shakedown, and testing: January 31, 2001
- Submit Phase IV Final Inspection Report: February 20, 2001
- Begin Continual System Operation (Phase V): January 31, 2001

2.3 Inspections and Monitoring

Inspections and system monitoring will be conducted to ensure adequate performance of the remedial action. The types and frequencies of inspections and system monitoring are described in Section 4.3.

2.4 MCP Deliverables

Following system installation, a Phase IV As-Built Construction Report will be prepared, including as-built construction drawings. The As-Built Report will include remediation activities conducted, tests and measurements performed, and any significant modifications of the design as described in this RIP.

After initial system startup, shakedown, and testing, a Phase IV Final Inspection Report will be prepared. The Final Inspection Report will document the findings of the inspection as conducted by the LSP. The final inspection will ensure that the remedial action is being performed in accordance with the RIP and is meeting the projected performance. The Final Inspection Report will be accompanied by a Phase IV Completion Statement, and will include an opinion by the LSP as to whether the RIP implementation has been completed in accordance with the MCP.

System operation after startup will proceed under Phase V of the MCP. Periodic system operation reports will be prepared until the remedial action objectives are achieved and a Response Action Outcome Statement can be prepared. At that time, the remedial system will be permanently shut down.

3.0 ENGINEERING DESIGN

3.1 Remedial Action Goals and Performance Requirements

Response actions in the Tank K Area are limited to groundwater, with the MCP Method 1 GW-1 standards (Table 1-1) serving as the corresponding remedial action goals. The emphasis is on remediation of the area of highest BTEX levels in the vicinity of the historic release from Tank K. As such, this action is considered to be a source control action and does not address all areas of MCL exceedances in groundwater across the site. The latter will be addressed at a later date as part of the sitewide groundwater remedial action program and related risk evaluation.

3.2 Significant Changes/New Information

The Phase III Addendum Report for Tank K was submitted to the MA DEP on January 24, 2000, and no on-site activities related to the Tank K Area have occurred since that time. Therefore, there have been no significant changes in or new information related to site conditions that were not included in previous submittals.

3.3 Remedial Action Area Description

The Tank K Area is located adjacent to the eastern side of Building 2 and extends out into the parking area. The conditions in the Tank K Area can be summarized as follows:

- The subsurface is characterized by 4 to 6 feet of fill underlain by silty fine to coarse sand. The top of bedrock is 30 to 50 feet below ground surface (bgs).
- The depth to groundwater is 3 to 5 feet bgs, near the interface of the fill and natural overburden material. The estimated hydraulic conductivity in the overburden aquifer is 17 ft/day, and the hydraulic gradient is approximately 0.07 ft/ft to the east.
- Volatile petroleum hydrocarbons have been detected in Tank K Area groundwater and soils, with an apparent historic source in a leaking underground fuel storage tank (Tank K).
- no methanol preservation - worthless data
- Based on the most recent (1996) round of soil sampling in the area, no petroleum hydrocarbons or other volatile organic compounds (VOCs) currently exist in unsaturated soils at concentrations exceeding the applicable S-3/GW-1 standards. Therefore, remediation of the unsaturated soils in the Tank K Area is not required. — No
- BTEX constituents and MTBE are the primary compounds of concern in groundwater in the Tank K Area, as their concentrations in monitoring wells in the area exceed GW-1 standards.

The area of concern, as illustrated on Figures 1-2 and 3-1, is the target area for enhancing biodegradation through the implementation of the biosparging/SVE system. This area was defined based primarily on observations and measurements made during TRC's recent pilot test, with consideration given to both previous monitoring results and groundwater flow paths. The following summarizes the basis for the delineation of the area of concern:

1. Based on both a deficiency in dissolved oxygen and elevated VOC levels observed during the pilot test, the area of concern appears to be centered near monitoring well WE-4S (see Figure 1-2). This represents a shift in location to the east when compared to data collected in the past, which can be explained by the anticipated eastward migration of contamination along the observed groundwater flow path in this area. (Well WE-2, which had the highest BTEX readings in 1995, exhibited relatively high dissolved oxygen levels during the 1999 pilot test and is now considered to be upgradient of the primary plume.)

2. The northern boundary of the area of concern has been set approximately halfway between monitoring well WE-7, which exhibited a total BTEX concentration of 4.4 mg/L, and monitoring well GZA-5, which had no detection of VOCs. This location is cross-gradient from well WE-4S with respect to an easterly groundwater flow, and thus a narrower spread of contaminants would be expected in the north-south direction.

3. In the absence of direct field measurements, the southern boundary of the area of concern was set at the same distance from well WE-4S as the northern boundary under the assumption of flow symmetry perpendicular to the primary axis of groundwater flow. This boundary will be confirmed during remedy implementation, as explained in a later section.

4. The eastern boundary, downgradient of well WE-4S, was set approximately halfway between well WE-4S and monitoring well PZ-8S, which exhibited a much lower total BTEX concentration of 0.011 mg/L. The latter point was outside of the observed area of depressed oxygen levels, indicating that little biodegradation was taking place due to the absence of elevated BTEX levels.

5. The western (upgradient) boundary was set approximately half-way between monitoring well WE-2 and monitoring wells WE-1 and WE-3, both of which exhibited non-detect levels of BTEX. As discussed above, well WE-2 is believed to be upgradient of the current plume based on observed dissolved oxygen levels. However, the lack of recent confirmatory data on VOC levels at WE-2 required that the boundary be extended further to the west toward wells WE-1 and WE-3.

3.4 Remedial Action Conceptual Plan

+ S-3/GW-1 stds.

As stated in Section 3.1, the ultimate goal of the remediation program is to reach the MCP Method 1 GW-1 standards (drinking water standards). It is anticipated that the active remediation will be highly effective, and that the planned project duration of 3 to 5 years will be sufficient for the total BTEX concentrations in the area of concern to reach a level in the parts per billion range. However, due to the very low MCL for benzene (5 ug/L GW-1 standard), the resultant concentration in the Tank K Area may not strictly satisfy the GW-1 standard even if the system is operated for a longer time period (i.e., the results may approach an asymptotic limit greater than the GW-1 standard). The remaining risk and the potential for continued natural attenuation will be evaluated at that time within the context of the broader groundwater issues at the site.

The selected remedial alternative for the Tank K Area is biosparging with SVE to treat dissolved BTEX and MTBE. Biosparging involves injection of compressed air below the groundwater table using injection wells or points. As air bubbles move vertically and horizontally through the saturated zone, a portion of the oxygen in the injected air is transferred from the vapor phase into the dissolved phase and becomes available to enhance biodegradation of BTEX and MTBE. The selected remedial alternative mainly relies on this process to reduce contaminant levels in groundwater. The pilot test (TRC, 1999, Biosparging Pilot Test Report) indicated that groundwater in the area of concern is virtually depleted of oxygen. Additional oxygen delivered to the subsurface should, therefore, significantly increase the rate of biodegradation of BTEX and MTBE.

The secondary clean-up mechanism is conventional air sparging through which VOCs are stripped from groundwater and transferred into a vapor phase. An SVE system captures VOCs in the vadose zone using a system of horizontal extraction lines. The soil gas extracted by SVE is captured and treated by a granular activated carbon (GAC) system.

The main function of the SVE component is to capture VOCs removed from the groundwater by biosparging. However, the SVE component of the proposed remediation system also establishes a subsurface air flow and creates conditions for venting and enhanced biodegradation of any residual contamination of soils. Of particular interest is the potential for enhanced degradation of residual soil contamination in the zone that is intermittently wetted due to seasonal changes in the depth to groundwater (i.e., the "smear zone").

A network of vertical biosparging wells (injection points) arranged in rows will be utilized to introduce air into the saturated formation. The rows of injection points will be oriented perpendicular to the direction of the groundwater flow so that the added oxygen is distributed evenly along the entire area of concern.

The remediation system equipment will be located in a small heated enclosure. The main equipment items will be a compressor to deliver air into the saturated zone, a vacuum blower to extract soil gas from the vadose zone, and a GAC system to treat the extracted soil gas. Refer to Figure 3-1 for the general layout of the remedial system, the underground piping, the injection points placement, and the location of the remedial equipment.

3.5 Design and Operating Parameters

3.5.1 Design Criteria, Assumptions, Calculations

The biosparging/SVE pilot test performed in the Tank K Area by TRC in December of 1999 indicated conditions are generally favorable for biosparging. The measurements performed during the pilot test indicated that the dissolved oxygen (DO) was practically depleted in the area of concern, whereas the DO levels outside the area of concern were relatively high. TRC concluded that natural biodegradation of BTEX and MTBE in the area of concern is limited by oxygen and would be enhanced by biosparging.

The design of the biosparging/SVE system was based primarily on the results of the successful field pilot test. The adequacy of this design is demonstrated through a comparison with both the pilot test observations and the results of a more theoretical approach using information found in the technical literature. A summary of the pilot test results is presented below:

- The aquatic environment in the source area is extremely oxygen deficient, in sharp contrast to the highly oxygenated groundwater outside of the area of concern. This indicates that biological degradation of petroleum hydrocarbons actively occurs but is limited by available oxygen. Therefore, applying a biosparging/SVE technology to add oxygen to the aquatic system will significantly accelerate the naturally occurring biodegradation of petroleum hydrocarbons.

- The effectiveness of a direct-push technique (Geoprobe) to install injection points in the area of concern was confirmed. However, some injection wells had to be installed away from the locations designated in the work plan due to refusals. Therefore, a hollow stem drilling technique will be used in conjunction with a Geoprobe to place the injection points at locations designated in this RIP.

- The initial design of the air injection points proved to be adequate. However, larger diameter tubing and larger connection fittings have been incorporated into the full-scale design of the injection points to reduce the injection pressures.

- The compressed air injection rates necessary to achieve effective contaminant removal ranged from 1 to 2 SCFM, consistent with the 1.65 SCFM used in this design (see below).

- Some channeling and pressure buildup occurred during the injection. However, it was found that these effects were temporary and could be alleviated by reducing the injection rates during the initial phase of the test.

- The biosparging radius of influence was determined to be at least 15 feet, and possibly up to 25 feet. Although the observed radius of influence was considered in the spacing of the injection points (see below), it is not necessary to strictly satisfy an overlapping condition when installing the air injection points. The reason is that physical stripping of VOCs from the groundwater, which would require that the areas of influence of the air injection points overlap, is not the primary physical process controlling the effectiveness of the biosparging/ SVE system. Rather, the injected oxygen dissolves and diffuses in groundwater, and is then transported with groundwater flow far beyond the physical zone of influence around the injection points.

- A horizontal SVE extraction line proved to be effective in capturing the VOCs stripped from groundwater. Based on pilot test findings, the depth of the horizontal extraction lines have been somewhat increased for the full-scale system. As expected, the SVE system operated with high flow and low vacuum levels.

?. Not enough time for biodegradation?

- The hydrocarbon mass removal rate was quite low (maximum 0.01 lbs./hour). Approximately 0.1 lbs. of hydrocarbons were removed during the entire test. This finding was utilized to size an air treatment device for the full-scale remediation system.

3.5.1.1 Spacing of Injection Points

Design: The proposed injection points will be installed in a series of parallel rows, as shown in Figure 3-1. The rows will be spaced approximately 40 feet apart along the axis of groundwater flow (i.e., in the direction of groundwater flow), with an approximate 30-foot spacing between individual injection points along a given row (i.e., in a direction perpendicular to groundwater flow).

Basis of Design: A biosparging system relies on enhancing natural biodegradation processes by adding oxygen to the subsurface. As discussed above, it is not necessary to install air injection points with overlapping radii of influence. However, to be conservative, the spacing between the sparge points was established to be consistent with the radius of influence observed during the pilot test. During the field pilot test, increases in dissolved oxygen levels were observed at distances greater than 20 feet from the injection points. Consequently, for purposes of the design, the radius of influence of an individual injection point was assumed to be at least 20 feet. The proposed 40-foot distance between rows of injection points along the axis of groundwater flow is consistent with this finding, with design conservatism provided by the fact that groundwater flow will transport the dissolved oxygen between rows. A lesser spacing (30 feet) was selected in a direction perpendicular to groundwater flow due to the reduced transport of groundwater and dissolved oxygen between adjacent injection points in a given row.

fits w/ 15 ft minimum area of influence (p 9)

3.5.1.2 Number of Injection Points

Design: Given the assumed area of concern (Figure 3-1), the above spacing results in a system configuration of four rows of injection points, with five injection points along each row for a total of 20 injection points.

Basis of Design: Once the spacing between injection points has been established, the required number of rows and injection points per row becomes a function of the size and shape of the area of concern. The footprint of the area of concern shown in Figure 3-1, and thus the proposed configuration of four rows of five injection points, is based on observations made during the pilot test and earlier monitoring data (as previously discussed in Section 3.3). The actual number of rows and injection points along a row will be determined during system installation based on field screening results as the individual injection points are installed. The procedure for this determination is addressed below.

3.5.1.3 Air Injection Rate

Design: The design air injection rate for each injection point is 1.65 standard cubic feet per minute (SCFM), resulting in a total air injection rate of 33 SCFM for the proposed 20 injection points.

Basis of Design: The design air injection rate of 1.65 SCFM was selected based on a series of calculations that incorporate conservative parameter assumptions (see Appendix A). As a result, this air injection rate is considered to be appropriate and sufficient to achieve the remediation objectives even considering the localized variability of actual subsurface conditions and the resultant impact on theoretical system efficiency. The majority of the December 1999 pilot test was performed with positive results using an approximate 2 SCFM air injection rate, which supports the selected 1.65 SCFM air injection rate and demonstrates that the design rate can be achieved and controlled in the field.

3.5.1.4 Summary of Design

The resultant design of the biosparging/SVE system can be summarized as follows:

Total design air injection rate	-	33 SCFM
Number of rows of injection points	-	4 rows
Spacing between rows	-	40 feet
Injection points per each row	-	5 points
Spacing between points	-	30 feet
Total injection points	-	20 points
Design air injection rate per point	-	1.65 SCFM
SVE extraction rate	-	100 SCFM
Number of SVE laterals	-	4 laterals
Soil gas extraction rate per lateral	-	25 SCFM

depth?

3.5.2 Field-Based Design Adjustments

Why not portable GC instead?

This??

The above design configuration is based on the area of concern shown on Figure 3-1. The boundaries of the area of concern may, however, require adjustment during the installation of the biosparging points based on the results of headspace analysis of groundwater samples collected during the installation of the injection points. (See Appendix B for a description of the headspace field screening procedure.) The following procedure will be implemented to ensure an appropriate placement of the injection points and the extraction laterals in relation to the actual area of concern:

1. Begin Row #1 of injection points at location near monitoring well WE-4S in the expected center of the area of contamination. A headspace reading taken at this location will provide the comparative baseline value for other headspace results.

2. Continue the installation of injection points along Row #1 to the north until the boundary of the area of concern is reached. For purposes of this source control remedy, the boundary of the area of concern is defined as the point at which the headspace reading is below the greater of 10 percent of the baseline value or 10 mg/L. why have this higher level option?
(1.2 mg/L)
lesser of?

3. Continue Row #1 to the south until the boundary of the area of concern is reached.

4. Install the next row of injection points (Row #2) 40 feet downgradient of Row #1. Install

is this supposed to be 10 ppmv?

the first injection point in the middle of the row, and then expand Row #2 as described in Steps 2 and 3.

5. Continue installing rows of injection points downgradient until the boundary of the area of concern is reached, as defined above.

6. Install rows of injection wells upgradient of Row #1 by repeating Steps 4 and 5.

7. Install the SVE laterals following the installation of the injection points. One SVE lateral will be installed per row of injection points. The SVE laterals will extend approximately 15 feet beyond the end points of the corresponding row of injection points, as shown on Figure 3-1.

+ hollow stem drilling (p 9)

3.5.3 Biosparging Component

The air injection points will be installed using a direct-push technique (Geoprobe™) to a depth of approximately 10 feet, or approximately 5 feet below the water table. Such a shallow depth of air injection (approximately 5 feet below the groundwater table) is selected because the contaminants of concern are lighter than water and concentrated near the groundwater table. However, the specified depth of injection does not mean that the effect of biosparging is limited to 5 feet below the groundwater table. Over time, the injected oxygen will diffuse to depths greater than 5 feet.

Effective depth okay for gas contamination?

Each air injection point will consist of a stainless steel mesh implant measuring approximately 14" long by 1/2" in diameter. The pore size of the stainless steel mesh will be 0.145 mm to achieve the desired small size air bubbles. The implants will be installed by first driving a probe rod fitted with a threaded anchor point to a depth of approximately 10 feet. After the probe rod has been driven, the implant will be connected to ½" diameter polyethylene tubing and inserted into the borehole. The implant will be surrounded by a filter sand pack, and a 3-foot thick bentonite plug will be constructed above the filter sand pack. The remainder of the borehole will be backfilled with clean sand. Temporary casing will be used to construct the filter sand pack and bentonite plug. Refer to Figure 3-2 for more design details of the air injection point. Refer to Appendix C for calculations to support the selection of an appropriate tubing diameter and required pressure for the design injection rate.

TRC will attempt to install as many injection points as possible using a direct push technique. However, the pilot test indicated refusal in several target locations. Conventional hollow-stem auger drilling will be utilized to install the injection points in those locations where a direct-push technique fails.

A separate ½" diameter polyethylene tube will connect each air injection point to the air compressor in the remedial equipment building. The air supply tubing will be installed in the same trench as the SVE extraction laterals, as shown on Figure 3-3.

A positive displacement pressure blower will be utilized as a source of compressed air. TRC has specified a blower package equipped with an M-D Pneumatic Model 4002-21B2 rotary positive displacement blower. The blower package will include silencers, coolant re-circulation, after-cooler, and necessary instrumentation and piping. Refer to Figure 3-3 and Appendix C for the blower package details.

The configuration of the biosparging points is intended to minimize the potential for short-circuiting of air through the porous subsurface material. Nevertheless, the existing observation wells will be monitored for signs of short-circuiting such as pressure increase. Appropriate measures will be taken (such as reducing the injection pressure and temporary shutdown of particular injection points) to reduce short-circuiting if detected. Refer to Operation Monitoring and Maintenance in Section 4.0 for details on pressure monitoring. In addition, any observed cracks in the asphalt surface of the parking lot within the area of concern will be patched to maintain the impermeable surface and further reduce the potential for short-circuiting of the injected air.

The operation of the biosparging system may cause temporary upwelling of the groundwater. This upwelling is not a negative occurrence and can be controlled. The groundwater table will be monitored and measures will be taken (such as reducing the injection pressure and temporary shutdown of particular injection points) to reduce groundwater upwelling if warranted. Refer to Operation Monitoring and Maintenance in Section 4.0 for details regarding groundwater table monitoring. The aforementioned sealing of cracks in the asphalt surface will also minimize the potential for any temporary upwelling of groundwater to be released to the ground surface.

3.5.4 SVE Component

The main purpose of the SVE system is to capture VOCs in the vadose zone, therefore preventing the discharge of untreated vapors into the atmosphere. The biosparging/SVE pilot test performed by TRC in the Tank K Area indicated that the maximum total hydrocarbon vapors concentration at the SVE influent was only 11.2 ppm_v (approximately 0.01 lbs./hour). It can be argued by a comparison with limits established in other states that such a low level of air emissions does not require an SVE component with air treatment. However, TRC selected a conservative approach and specified an SVE system with GAC air treatment. TRC will evaluate actual emissions of the biosparging/SVE system during the first year of operation and make recommendations regarding the long-term need for operating an SVE component.

The SVE component will utilize horizontal laterals installed in trenches along the rows of injection points (see Figure 3-1). The horizontal extraction lines will be installed to a depth of approximately one foot below grade. Such a shallow placement of extraction lines is necessary due to the very shallow groundwater table. Extraction lines will be installed along the rows of air injection points and will share the trench with the air supply tubing. A total of five SVE extraction laterals will be installed, as shown on Figures 3-1 and 3-2, unless field screening results indicate the need for additional rows.

Each lateral will be approximately 150 feet long, consisting of 2-inch diameter SCH 40 PVC 10 well screen (slot 20). The screened sections will be surrounded by clean sand. Polyethylene plastic liner will be placed on top of the sand bedding to minimize air leakage from the atmosphere. The trench will be sealed with a hot asphalt patch to further minimize leakage from the atmosphere. Each extraction line will be connected to a manifold in the remedial system enclosure using 2-inch PVC SCH 40 piping. Control valves, vacuum gauges, and sampling ports will be installed on each extraction line to allow individual control. Refer to Figure 3-1 for trenching layout and to Figures 3-2 and 3-3 for piping and manifold details. Calculations to support the selection of appropriate diameters of the extraction lines can be found in Appendix D.

A regenerative-type blower has been selected as the vacuum source for the SVE component. The selected blower is a 1.5-horsepower GAST Model R4315A, with a 208-230/460 VAC, 60 hz, 3-phase motor. This blower has a maximum open flow of 127 SCFM. The design air flow is approximately 100 SCFM. Thus, the SVE component flow is approximately 3.0 times greater than the injection flow rate of 33 SCFM. The 3.0 times ratio of extracted to injected flow gives a comfortable safety margin to ensure that the injected air is captured by the SVE component. Refer to Appendix F for the selected blower manufacturer's information.

A small GAC system will be utilized as an air treatment device to treat the soil gas before discharging it into the atmosphere. TRC selected two units (Carbtrol, Model G-2), each with 170 lbs. of carbon. The carbon consumption calculation (refer to Appendix E) indicated that two absorbers with 340 lbs. of carbon will be able to operate 3 to 4 months before breakthrough. Additional details regarding the GAC system piping and instrumentation can be found in the Process and Instrumentation Diagram on Figure 3-2. Refer to Appendix F for the GAC vessel manufacturer's information.

3.5.5 Expected Treatment Efficiency

The proposed biosparging/SVE technology is considered a highly effective approach to remediate BTEX and MTBE impacted groundwater in the Tank K Area. TRC expects that the remedial system will have to be operated for 3 to 5 years to achieve or asymptotically approach the stringent GW-1 criteria. The remedial system was designed with a wide safety margin when selecting the operating parameters. The injection points are spaced with significant overlap between radii of influence. The air injection rate for the biosparging component was selected with a very considerable safety margin. An SVE component with air emissions controls was specified to eliminate air emissions. GAC treatment is a well proven technology for air emission controls and is known to work very well for treatment of BTEX vapors.

3.5.6 Demonstration That Action Will Be Successful

TRC performed a biosparging/SVE pilot test in the Tank K Area (TRC, 1999, Biosparging Pilot Test Report). The test results indicated that the selected technology would be highly appropriate for the site-specific conditions. Several very important design parameters such as biosparging radius of influence, optimum injection rates, SVE extraction rates, vapor concentrations, injection point design details, and SVE laterals construction, were obtained and refined based on the results of the pilot test. Therefore, TRC was able to design the remediation system with a high degree of confidence.

3.5.7 *Work Plans and Procedures*

Ancillary to the successful implementation of this Remedy Implementation Plan for the Tank K Area are the following:

- Emergency Control Procedures
- Waste Management Plan
- Environmental Receptor Protection Plan
- Operation, Maintenance, and Monitoring Plan
- Health and Safety Plan

The first four of these documents are contained within this Remedy Implementation Plan along with the implementing procedures. The Health and Safety Plan for the Tank K Area has previously been prepared and presented in the Remedy Implementation Plan for the Eastern Parking Lot Area (TRC, July, 2000). It is incorporated by reference into this Remedy Implementation Plan.

3.6 Emergency Control Features

3.6.1 *Accidental Spill Control and Containment Systems*

The selected biosparging/SVE technology has low potential for creating spills or discharges of potentially hazardous materials during remediation. The media in use by a biosparging component is low pressure (maximum 12 psi) air with no oil or vapors. The SVE component of the remediation system has equipment that may potentially accumulate contaminated liquid (moisture knockout drum) and solids (GACs).

Control measures will be taken to prevent and control spills or discharges of potentially hazardous materials during remediation activities at the site. Potential spills, leaks or discharge sources include the moisture knockout drum, piping systems, and emissions from the SVE system.

All reasonable measures will be taken to ensure that spills or releases of hazardous materials do not occur or spread. Immediate measures will be taken to control and contain any spill within the immediate location, where feasible, or site boundaries. Immediate measures could include the following:

- Attempt to identify the material and associated hazards
- Secure the boundary of the affected area, and deny entry to unauthorized personnel
- Locate and stop or control the source of the leak by use of applicable means
  - Plug storm-sewer drains and recover spilled material
  - Construct emergency diversionary berms or dikes
- Remove or retrieve any discharged liquids, sludges or solids if possible.

The moisture separator will be equipped with a high-level float control, and thus there will be minimal risk of spills associated with the remedial actions taken on site. The GAC vessels and associated fittings will be regularly inspected to ensure mechanical integrity and minimize the potential spillage of carbon.

Should a spill occur in the area around the moisture knockout drum, spill containment materials such as Speedi-dry or absorbent socks will be positioned near the vessels. Spent absorbent materials and recovered materials will be placed within a DOT-approved 55-gallon drum and promptly disposed in accordance with applicable regulations.

The SVE system will be monitored for the breakthrough of contaminants at the GAC system outlet. The minimum required efficiency of an air control device is 95% (MA DEP's Air Quality Regulations, 310 CMR 7.03). Based on the pilot test results, the maximum influent concentration of hydrocarbon vapors is expected to be 11-12 ppm_v. TRC expects that the sustained vapor concentration will be less than 10 ppm_v. Therefore, the expected 95% efficiency will result in a GAC effluent of less than 0.5 ppm_v. Because existing field monitoring devices (e.g., photoionization detectors) cannot reliably measure vapor concentrations below 1 ppm_v, TRC will interpret readings below 1 ppm_v as Below Detection Limit and continue system operation regardless of the inlet concentration. If SVE air monitoring indicates GAC efficiency below 95%, the remedial system operation will be suspended, the GAC system will be evaluated, and the problem will be corrected (e.g., through GAC vessel replacement).

In the case of an accidental discharge, the appropriate project personnel will be immediately informed of the discharge, including the LSP and Project Manager. In the event that a spill is significant enough to require an emergency response team or the spill has been released to the environment above a reportable quantity, the appropriate personnel and regulatory agencies will be contacted. A list of emergency response telephone numbers is included in the Health and Safety Plan.

3.6.2 Bypass Systems or Safety Cutoffs

The electrical motors of the biosparging system blower and the SVE system vacuum blower will be equipped with high temperature overload relays to deactivate the motors in case the temperature increases above the safe level. The moisture knock-out drum will have a high level switch to deactivate the remediation system if the drum fills up with water.

A pressure relief valve will be installed on the biosparging blower discharge to protect the system from overpressure. A vacuum relief will be installed on the suction side of the SVE blower to limit vacuum. The pressure gauges and other instruments will be utilized to monitor the operating conditions and ensure safe operation.

A basic remote monitoring system will be utilized to monitor system operation. This system will monitor the biosparging system discharge pressure over the phone line via a modem. TRC personnel will be able to determine the status of the remediation system by monitoring this parameter from its office in Lowell, Massachusetts, located only 20 minutes from the site.

3.6.3 Leak Detection Systems

A leak detection system is not applicable because no hazardous liquids or vapors will be handled or generated during the operation of the remediation system.

3.7 Waste Management Plan

The following Waste Management Plan (WMP) has been developed to establish required procedures and protocols for identifying, containing, labeling, storing, handling, and disposing of contaminated materials that will be generated during remedial activities at the Tank K Area. These materials may include gasoline-contaminated soil, groundwater, spent granular activated carbon (GAC) and personal protective equipment (PPE).

3.7.1 Waste Materials

Soil

Minor volumes (less than 5 cubic yards) of contaminated soil will be generated during drilling operations for the installation of the air sparging points. This material will not be used for backfill and will be stored in DOT-approved 55-gallon drums for off-site disposal at an approved landfill or recycling facility. BOLs?

All trenching will be undertaken in a manner to minimize the volume of soil that will be excavated. Contaminated soil is not expected to be encountered during shallow trenching operations (0 to 1 feet) for the installation of the SVE laterals. Field headspace screening of soil will be conducted during trenching activities using standard MA DEP headspace techniques to confirm that the shallow excavated soil is not contaminated. Any uncontaminated soil from the trenching that is not used as backfill on site will be disposed, recycled, or used as general backfill material. If this material is temporarily stored on site, it will be stored in roll-off containers to prevent releases.

Groundwater

Small quantities of contaminated groundwater will be generated during routine operations and performance monitoring of the biosparging remediation system, including SVE condensate collected in the moisture knockout drum and purge water generated during groundwater sampling activities. These small quantities will be treated using the existing on-site groundwater treatment system in the Tank Farm Area. Large quantities of generated wastewater (if applicable) would be containerized and properly disposed off site.

Granular Activated Carbon (GAC)

As previously described, a small GAC system will be installed to treat the SVE soil gas prior to discharging it to the atmosphere. Two Carbitrol Model G-2 units, each with 170 lbs. of carbon, will be utilized to treat the SVE soil gas. The carbon consumption calculation (Appendix E) indicates that the two absorbers with 340 lbs. of carbon will be able to operate 3-4 months before change-out.

Personal Protective Equipment (PPE)

Any spent PPE will be containerized in pails and/or drums and characterized for off-site disposal, as needed.

3.7.3 Waste Storage

Contaminated soil, groundwater, and spent GAC will be containerized in DOT approved 55-gallon drums that will be temporarily stored in the secured and locked equipment enclosure until proper disposal. Appropriate Bill of Lading paperwork and disposal facility acceptance will be expedited to minimize the amount of time the waste materials will be stored on site. copies to DEP

3.7.4 Waste Characterization/Transportation/Disposal

Analytical data will be required to characterize the contaminated soil, groundwater, and spent GAC that will be generated as a result of installation and operation activities of the biosparging remediation system. Soil and water samples will be collected from the 55-gallon drums in which the materials are stored to determine contaminant content and disposal requirements. It is presumed that all wastes will be nonhazardous and will be disposed as MCP remediation waste (wastes that are generated by MCP remedial actions and appropriately managed under the MCP regulations).

Laboratory analysis of all waste materials will be consistent with state and federal requirements for off-site disposal and the proposed facility's operating permit. Waste profile sheets will be completed for submittal to a licensed and appropriate disposal facility for acceptance. TRC will review the status of the selected disposal facilities to confirm that the current operating permits are in compliance with applicable state and federal regulations. The contaminated soil and groundwater will be transported under a Massachusetts Bill of Lading Form.

An authorized representative from TRC will be on-site at the time of shipment to sign the Bill of Lading as the generator. Contaminated soils and/or water arriving at the disposal (processing) facility will be handled in accordance with the requirements of the facility permit. The original Bill of Lading forms will be submitted to MA DEP after they are returned to TRC by the disposal facility. de

3.8 Site-Specific Features Potentially Impacted by Remedial Action

3.8.1 Existing Site Operations

Site access and remedy implementation will be coordinated with Wilmington Trust, the current site owner, and GSI-Lumonics, the current tenant of Building 2 and user of the parking area closest to the remediation area. The proposed remediation activity excavation will affect utilities, building entrances, and parking.

3.8.2 Drainage Features

Implementation of the selected remedy should not significantly alter drainage features at the Site. To the extent possible, all disturbed areas will be restored to original grades and surface conditions (e.g., asphalt).

3.8.3 Natural Resource Areas

Outfall 002 and the wetlands are situated along the eastern boundary of the property, east of the Tank K remediation area. The work will be conducted approximately 300 feet from the wetlands and Outfall 002. Potential impacts to these areas will be prevented as discussed in Section 3.9.

3.8.4 Local Planning and Development

Remediation of the Tank K Area is expected to be completed within 3 to 5 years. The site property is zoned industrial and can continue to be used for industrial or commercial activities. Implementation of the selected remedy should not adversely impact local planning or development. The agreement between the property owners and the current tenant allows for potential expansion of Building 2, and the parties are aware that expansion plans need to be coordinated to prevent impacts to system operations.

3.9 Environmental Receptor Protection Plan

The objective of the Environmental Receptor Protection Plan is to define the environmental protection requirements associated with potential land, water, air and noise impacts during remediation activities at the Tank K Area. This Plan summarizes the protective measures that will be employed to minimize and control any potential pollution releases and to preserve environmental conditions at the site.

Remedial activities at the Tank K Area will be conducted in the area shown in Figure 3-1. The biosparging air supply lines and SVE extraction lines will be installed underground and the remaining remediation equipment (compressor, blower, water knockout drum, GAC etc.) will be housed in a secured and locked equipment enclosure to prevent unauthorized access and potential vandalism. During installation activities, all applicable work zones will be delineated (as described in Section 7.0) and maintained throughout the duration of the installation activities to closely monitor site activities. In addition, access to the work zone will be controlled (as described in Section 7.0) to prevent unauthorized entry.

3.9.1 Protection of Land Resources

Except for the small volume of soil removed during installation of the air injection points, which can be compared to the routine installation of monitoring wells, no contaminated soils are expected to be encountered during system installation. As such, the implementation of the biosparging/SVE system will be a "clean" operation and special measures to protect land resources will not be required. The location of the wetlands more than 300 feet from the field operations further demonstrates the lack of need for special protection measures.

The most significant volume of soil to be removed is associated with the trenching for the SVE laterals. Even in this case, however, because the laterals will be installed one at a time and backfilling will occur immediately upon laying the PVC pipe (i.e., the same day as soil removal), there is little potential for a release to impact land resources. This soil is expected to be clean, and any soil over and above that needed as backfill will be stored in an enclosed roll-off container until removed from the site. Any areas disturbed as a result of remedial activities will be restored as necessary to their existing condition following completion of remedial activities.

3.9.2 Temporary Protection of Disturbed Areas

As indicated in the previous section, preventative erosion and sedimentation control measures will not be necessary given the types of field operations and the fact that all soil stored on site will be contained in roll-off containers. The trenches for the SVE laterals are only one foot deep by one foot wide, and thus the disturbed area will remain minimal under the plan to excavate a new trench only after the previous trench has been backfilled.

3.9.3 Noise Protection

Protection against the effects of noise exposure will be provided when the sound levels exceed those limits established by 29 CFR 1929.52 (Occupational Noise Exposure Standards). TRC will provide hearing protection to employees involved in the Tank K remedial activities to minimize potential exposures to noise levels greater than the permissible exposure limits. Although levels greater than permissible limits are not anticipated for the biosparging compressor and blower, the noise levels from this equipment will be minimized by housing this equipment in a secured and locked equipment enclosure.

3.9.4 Waste Disposal

Procedures for the characterization, handling, labeling, storage, transportation, and disposal of waste generated as a result of remedial activities in the Tank K Area are detailed in the Waste Management Plan (Section 3.7). Wastes addressed under this plan include contaminated soil, groundwater, spent GAC, and personal protective equipment (PPE).

3.9.5 Historical Resources Protection

There are no known historical areas on the former GE site.

3.9.6 Wetland and Water Resource Protection

All remedial activities in the Tank K Area will be monitored, managed and controlled to avoid impacts to the wetland areas to the east of the Tank K Area. Site environmental receptors, including the wetlands, will be protected during construction and operation of the remedial action alternatives.

A Determination of Applicability or Notice of Intent is not required by the North Reading Conservation Commission since the boundary of the work area is more than 100 feet from the wetlands (see Figure 3-1). The work area is not located in the wetland buffer zone (within 100 feet of the wetlands), and hence is not subject to 310 CMR 10.02. However, TRC will issue a letter to the North Reading Conservation Commission notifying them of the start of remedial actions.

Daily inspections of any control measures determined to be necessary will be conducted during system installation, and any necessary maintenance will be performed to ensure proper protection of the wetland areas. In addition, the emergency control features detailed in Section 3.6 will be used to prevent and/or control accidental spills and releases.

3.9.7 Air Resources Protection

Activities will be conducted to comply with all dust regulations imposed by local air pollution agencies. At no time will dust generation be allowed to exceed 1 mg/m^3 without implementing appropriate controls. During the progress of work, the contractor will conduct operations and maintain the areas of activities, including sweeping and sprinkling water where necessary, to minimize the creation and dispersion of dust. Water will not be used if it results in hazardous or objectionable conditions such as icing. Any stockpiled soil will be secured with a 6-mil polyethylene covering to eliminate particulate emissions. During all trenching and installation activities, constant air quality monitoring will be conducted in accordance with the HASP.

3.9.8 Erosion and Sedimentation Control Procedures

As discussed in Sections 3.9.1 and 3.9.2 above, no special sedimentation control procedures will be needed to protect land and environmental resources due to the nature of the remediation program.

Prior to any excavation work, a roll-off container for soil storage will be brought to the site and clearly designated for soil storage. The stockpiled soil will be covered with 6-mil (or higher) gauge polyethylene sheeting. The polyethylene will be adequately secured to prevent damage or loss by wind or other elements.

4.0 OPERATION, MAINTENANCE AND MONITORING

This Operation, Maintenance, and Monitoring Plan (OM&M Plan) has been developed to ensure the effectiveness of the remedial activities at the Tank K Area of the Former GE facility in Wilmington, MA. This OM&M Plan is a required element of the RIP as described under 310 CMR 40.0874(d) of the MCP and is intended to be used for the operation of the biosparging and SVE remediation systems.

4.1 Contacts

The contact person at TRC is:

Ms. Paola Macchiaroli, Ph.D., Project Manager
TRC Environmental Corporation
Boott Mills South, Foot of John Street
Lowell, MA 01852
(978) 656-3582

The Licensed Site Professional (LSP) of Record is:

Mr. Bruce Hoskins, P.E., LSP #7109
URS Corporation
5 Industrial Way
Salem, NH 03079-2830
(603) 893-0616

4.2 General Operating Procedures

The main equipment item of the biosparging system will be a compressor to deliver air into the saturated zone. The main equipment items of the SVE system will be a vacuum blower to extract soil gas from the vadose zone, a water knockout vessel, and a GAC system to treat the extracted soil gas. The main equipment items of both systems will be secured and manifolded to their respective biosparge points and SVE laterals in a locked equipment enclosure. A brief description of the operational requirements for each major system element is provided below:

Biosparging Compressor. The source of compressed air will be an M-D Pneumatic Model 4002-21B2 rotary positive displacement blower (or equivalent) with silencers, coolant re-circulation, after cooler, and necessary instrumentation and piping. The air compressor will be capable of delivering 1.65 SCFM per injection point or 33-SCFM for the entire 20-point system. The biosparging wells will be connected through a manifold system to a single pipe connected to the air compressor located within the locked equipment enclosure.

Soil Vapor Extraction (SVE) Blower. The vapor extraction blower will be a GAST Model R4315A (or equivalent) driven by a 1.5-horsepower motor (208-230/460 VAC, 60Hz, three phase). In this configuration, the blower has a maximum open flow of 127 SCFM. The design air flow is expected to be within approximately 100 SCFM. The SVE laterals will be connected through a manifold system to a single pipe connected to the SVE blower located within the locked equipment enclosure.

Water Knockout Vessel. Some groundwater may be inadvertently extracted during SVE system operation. A 30-gallon water knockout vessel will be installed upstream of the SVE blower to separate and collect any extracted groundwater. To prevent overflows, the water knockout vessel will be equipped with a high-level float control switch to shut down the system in the event the knockout drum fills with water to a pre-set level. The water knockout vessel will be located within the locked equipment enclosure.

Granular Activated Carbon System. Two Carbitrol, Model G-2 GAC units, each with 170 lbs. of carbon, will be connected in series and utilized to treat the SVE system effluent prior to discharging it into the atmosphere. The carbon consumption calculation indicated that this specific GAC setup will be able to operate four months before breakthrough of VOCs. The GAC system will be monitored for breakthrough of VOCs in accordance with Section 4.3 Monitoring Program. Breakthrough will be determined to have occurred when total VOCs reduction is less than 95%. The extracted soil gas will be monitored at the influent of unit GAC-1, between units GAC-1 and GAC-2, and at the effluent of unit GAC-2. If breakthrough is detected between units GAC-1 and GAC-2, unit GAC-1 will be replaced with new granular activated carbon and will become the secondary treatment unit. Unit GAC-2 will become the primary treatment unit.

Gauges, Controls, and Valves. A variety of temperature, pressure, and vacuum gauges, flow meters, sample ports, and valves will be installed to monitor and control the biosparging and SVE systems. Adjusting the valves, based on gauge, flow meter and sample port readings, will allow the biosparging and SVE systems to operate in a balanced, efficient manner.

Heater. The equipment enclosure will be heated to allow winter operation. A 1.5 kw fan-forced heater with thermostat control will be installed for this purpose.

4.2.1 Start-Up

Prior to startup of the biosparging and SVE systems, in-field groundwater parameters will be measured to establish baseline conditions. These baseline measurements will be used to evaluate the performance of the biosparging and SVE systems. The following groundwater monitoring wells and parameters will be measured:

- Depth to the groundwater table in existing observation wells WE-2, WE-4S, WE-4D, WE-7, WE-8 and WE-9 ✓ WE-2D?
- individual VOCs VOCs, dissolved oxygen (DO), oxygen reduction potential (ORP), pH and temperature in observation wells WE-2, WE-4S, WE-4D, WE-7, WE-8 and WE-9

Procedures detailed in Section 4.3 will be followed to establish baseline conditions. Subsequent monitoring of these locations and parameters after start-up of the biosparging and SVE systems (also specified in Section 4.3) will be used to determine the performance of these remedial systems.

Each piece of equipment and the remedial system as a whole will be tested to ensure proper working order. Prior to startup, wiring and support components for the equipment will be verified to be complete and tested. Tests, meter readings, and specified electrical characteristics will verify compliance with the recommended requirements of the equipment or system manufacturer. The equipment specifications, operation instructions, and maintenance manuals are included as Appendix F of this RIP and will be part of the on-site OM&M Plan.

During system startup, the designated OM&M technician will be instructed in operation, maintenance and trouble-shooting of the system. Each piece of equipment will be checked for proper lubrication, settings, control sequences, and for other conditions that may cause poor performance, system failure, damage, or a safety hazard. The testing will be completed under the supervision of experienced personnel and/or manufacturer representatives, and in accordance with the manufacturers' instructions.

As detailed in Section 3.5.1 of this RIP, the start-up settings of the biosparging and SVE systems will be as follows:

Total design injection rate	-	33 SCFM
Air injection rate per point	-	1.65 SCFM
SVE extraction rate	-	100 SCFM

These settings may be adjusted if subsequent monitoring (Section 4.3) indicates the remediation system is not operating at optimal efficiency. These settings and any adjustments will be indicated on the monitoring forms that will be part of the on-site OM&M Plan and are included as Appendix G.

4.2.2 Testing

Each item of equipment will be tested for start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance, and shutdown. Testing procedures will be derived from the equipment specifications, operation instructions, and maintenance manuals supplied by the manufacturer. As specified earlier, this information is attached as Appendix F and will be part of the on-site OM&M Plan. If additional system and/or site specific operational data becomes apparent during startup and testing, this information will be incorporated into an addendum to the OM&M Plan, as appropriate.

4.2.3 Shutdown

The electrical motors of the biosparging blower and the SVE blower will be equipped with high temperature overload relays to deactivate the motors if temperatures increase above safe levels. The moisture knockout vessel will have a high-level float control switch to deactivate the remediation system in the event the knockout drum fills with water to a pre-set level. In both cases, the biosparging and SVE systems will automatically shut down.

To minimize and/or mitigate shutdown periods, a basic remote monitoring system will be utilized to monitor system operation. This system will monitor the biosparging system discharge pressure and will allow TRC personnel to determine, via a telephone and modem, whether the system is operating properly.

Routine system monitoring, as detailed in Section 4.3, will be conducted to ensure proper operation of the biosparging and SVE systems. At a minimum, the systems will be manually shut down if the routine monitoring indicates the following:

- The temperature of the compressed air from the biosparging compressor (as measured prior to the copper air cooling loop) is above the predetermined critical value of 300°F. A temperature above the predetermined critical value of 300°F indicates that the biosparge compressor is malfunctioning. The biosparging and SVE systems will be shut-down and will not be restarted until corrective actions have been taken. Corrective actions will be detailed in the on-site OM&M Plan.

- VOC breakthrough is detected between SVE treatment unit GAC-1 and GAC-2, as determined by treatment efficiency. The granular activated carbon of unit GAC-1 will be replaced and this unit will become the secondary unit and unit GAC-2 will become the primary treatment unit. Vapor monitoring will be conducted at the restart of the system to ensure that 95% treatment efficiency is being achieved at the primary GAC unit.

4.2.4 Maintenance

Maintenance requirements specified by the manufacturer and identified during system start-up and testing will be documented after the system is installed and operational. At a minimum, maintenance will be conducted as suggested by the manufacturer and will be performed as part of the routine system monitoring (Section 4.3 Monitoring Program). In cases of potential system malfunctions and shutdowns, maintenance will be conducted on an as-needed basis to ensure timely and efficient operation of the remediation system. All maintenance activities will be recorded on system-specific maintenance inspection forms (Appendix G) that will be part of the on-site OM&M Plan.

4.2.5 Emergency/Contingency Procedures

System emergency control features were described previously in Section 3.6.

4.3 Remedial Action Monitoring Program

Monitoring will consist of two components: systems monitoring and performance monitoring. Systems monitoring will include: 1) maintenance monitoring, as suggested by the equipment manufacturer and as deemed necessary through start-up and testing; and 2) operation monitoring (i.e. pressure, temperature, injection rates, etc.) to ensure that the systems are operating in a balanced and optimal manner. SVE soil gas monitoring will also be conducted as part of operation monitoring to ensure that the SVE treatment system is in compliance with MA DEP Air Quality Regulations. Performance monitoring will include groundwater monitoring of selected on-site observation wells to determine system effectiveness and the degree of clean-up (performance) achieved by the remedial system.

4.3.1 Systems Monitoring

Monitoring and upkeep of equipment will be conducted in accordance with the manufacturer's instructions, which are attached as Appendix F. Systems monitoring inspection forms (Appendix G) have been prepared to summarize currently anticipated items for the biosparging and SVE remediation system monitoring. These forms may be modified to reflect any modified requirements determined during start-up testing. These inspection forms will be included with the on-site OM&M Plan and will be completed by the OM&M technician during monitoring activities.

As previously discussed in Section 4.2.3, the remediation systems will be equipped with high level water and pressure sensors for automatic shutdown in case of system malfunctions. This automatic shutdown system is also equipped with a basic remote monitoring system to minimize and/or mitigate shutdown time periods. In addition, other shutdown scenarios, included in Section 4.2.3, will be followed to prevent system malfunctions.

4.3.1.1 Biosparging System

The components of the biosparging system monitoring are outlined on the Systems Monitoring Inspection Forms (Appendix G). In general, biosparging monitoring will include: 1) temperature and pressure of the air compressor discharge prior to the air cooling copper loop; 2) temperature and pressure of the air compressor discharge after the air cooling loop; and 3) flow (SCFM) to the individual air sparging points. Temperature and pressure will be measured using dedicated gauges and the flow will be measured using dedicated flow meters installed at each sparge point.

4.3.1.2 SVE System

The components of the SVE system monitoring are outlined on the Systems Monitoring Inspection Form. In general, SVE monitoring will include: 1) vacuum at each extraction line; 2) vapor concentration at each extraction line; 3) vacuum at the manifold before the water knockout vessel; 4) vacuum pressure after the water knockout vessel; 5) pressure after the vacuum blower; and 6) vapor monitoring of the SVE vapor treatment system. As with the biosparging system, pressure will be monitored using dedicated gauges.

Vapor monitoring for VOCs at each extraction line and the vapor treatment system will be conducted using a photoionzation detector (PID) or equivalent. Air flow rates through the SVE system will be determined by comparing the measured vacuum pressure(s) to the blower curve supplied by the blower manufacturer. Mass removal rates of contaminants (BTEX and MTBE) will be calculated from the air flow rates and measured PID readings.

Vapor monitoring of the SVE treatment system will be conducted to ensure that the treatment system is in compliance with MA DEP Air Quality Regulations, 310 CMR 7.03 (2)-(4) and (14). The system will be operated such that the system consistently reduces VOC levels in the SVE effluent stream by at least 95 percent. Vapor monitoring will be conducted: 1) before treatment unit GAC-1; 2) between treatment units GAC-1 and GAC-2; and 3) after treatment unit GAC-2. PID readings below 1 ppm will be interpreted as Below the Detection Limit and system operation will be continued. As previously described in Section 4.2.3, if VOC breakthrough is detected between treatment units GAC-1 and GAC-2, the system will be temporarily shut-down and appropriate changeout measures will be implemented.

Records will be prepared and maintained to demonstrate emission compliance, including:

1. VOC concentrations in air prior to control and after control
2. Overall VOC reduction efficiency of the air pollution control system in percent by weight
3. Maintenance records of the system
4. Monthly operating hours of the system
5. Repair records.

4.3.1.3 Frequency/Duration of Systems Monitoring

Systems monitoring will be conducted at the following frequency for the duration of system operation after startup:

First Month	Three (3) times the first week Two (2) times the second and third week One (1) time the fourth week
Second Month	Every two (2) weeks
Duration of System Operation	Monthly after the second month of operation

4.3.2 Performance Monitoring

Performance monitoring of groundwater will consist of two components: 1) in-field parameter testing; and 2) laboratory analytical testing. Performance Monitoring Forms (Appendix G) have been prepared for in-field parameter testing and may be modified following start-up testing. These monitoring forms will be included with the on-site OM&M Plan and will be completed by the OM&M technician during monitoring activities.

4.3.2.1 In-Field Groundwater Monitoring WE-2D?

Existing groundwater observation wells WE-2, WE-4S, WE-4D, WE-7, WE-8 and WE-9 will be monitored as part of the in-field parameter testing. This list may change after start-up of the remediation system based on the results of performance monitoring. As described in Section 4.2.1, these wells will also be sampled prior to start-up of the remediation system to establish baseline conditions. After start-up, these wells will be sampled at the frequency detailed below for the following parameters: !

- Depth to groundwater
- Dissolved Oxygen (DO)
- Oxidation/Reduction Potential (ORP)

- pH
- Temperature
- Pressure

Depth to groundwater in the observation wells will be recorded using a Solinst electronic water level indicator. Pressure will be measured by a standard pressure gauge (0 to 15 psi range). The remaining parameters, DO, ORP, pH and temperature, will be measured using a portable YSI-650 multiple parameter meter with a flow-through cell. Groundwater will be pumped through the flow-through cell using a Geotek peristaltic pump.

4.3.2.2 Laboratory Analytical Testing

WE-2S
-2D
-4D ?

Groundwater samples will be collected from existing groundwater monitoring wells WE-4S, WE-7, WE-8, and WE-9, and will be sent to a Massachusetts certified laboratory for analyses of VOCs by Method 8020C. Sample collection will be conducted in accordance with MA DEP sampling protocols. As indicated in Section 4.2.1, a round of groundwater samples will be collected before system start-up to reflect baseline conditions. After start-up, analytical testing of groundwater will be conducted at these wells at the frequency detailed below.

4.3.2.3 Frequency/Duration of Performance Monitoring

In-field groundwater monitoring will be conducted at the following frequency:

First Month	End of the first week of operation Fourth week of operation
First Year	Quarterly
Duration of System Operation	Annually

Groundwater sampling for laboratory analyses will be conducted on an annual basis until the results of two consecutive rounds of sampling indicate that the remediation system has reduced VOC levels in the groundwater to concentrations that are less than applicable MCP Method 1 GW-1 standards. At that time, the remediation systems will be shut-down and post-remedial groundwater sampling will be conducted every quarter (3 months) for one year to confirm that the remediation system has reduced VOC levels below applicable MCP Method 1 GW-1 standards. ok

4.3.3 Inspection and Monitoring Reports

Information and data collected as part of the operation, maintenance, and monitoring of the remedial actions at the Tank K Area will be documented in routine Inspection and Monitoring Reports. These reports will be prepared and submitted to the Massachusetts Department of Environmental Protection in accordance with 310 CMR 40.0892(5) of the MCP.

The Inspection and Monitoring Reports will contain the following:

- A description of the type and frequency of inspection and/or monitoring activities conducted.
- A description of any significant modifications to the inspection and/or monitoring program since the preceding Inspection and Monitoring Report.
- A description of any conditions or problems noted during the inspection and/or monitoring period, which are or may be affecting the performance of the remedial action.
- A description of the measures taken to correct conditions which are affecting the performance of the remedial action.
- The results of sampling analyses and screening conducted as part of the monitoring and/or inspection program.
- The name, license number, signature and seal of the LSP.

These Inspection and Monitoring Reports will be submitted every six months following start-up of the Tank K remedial system.

5.0 HEALTH AND SAFETY PLAN

The Health and Safety Plan for all remedial response actions at the former GE site was previously prepared and presented as an attachment to the Remedy Implementation Plan for the Eastern Parking Lot Area. It is incorporated by reference into this Remedy Implementation Plan for the Tank K Area.

6.0 REQUIRED PERMITS, APPROVALS, OR LICENSES

The actions presented in this RIP will not re quire any permits, special approvals, or licenses. Approval of this RIP will be required from MA DEP in accordance with the MCP. Public notification requirements will be performed in accordance with the Public Involvement Plan for this site. In addition, a notice of commencement of remediation will be sent to the North Reading Conservation Commission.

7.0 PROPERTY ACCESS ISSUES

To prevent both exposure and migration of contamination by personnel or equipment, work areas and PPE requirements will be clearly identified. All signs required by federal and state regulations will be posted to give notice of the work area to site personnel and visitors prior to remedial activities. An exterior sign will be posted detailing whom to notify in case of emergency, including points of contact, job title, and phone number(s) where the contact may be reached 24-hours a day.

During installation of the biosparging system, the limits of the work area will be delineated. Temporary caution tape and traffic cones/drums, as appropriate, will be installed outside the active work area prior to startup of installation activities. Pedestrian traffic will be rerouted as necessary by TRC and GSI Lumonics staff. Traffic along construction routes to the site will be kept at a minimum and will not hinder flow or direction of regular GSI Lumonics facility staff. Relocation of parking will be coordinated with GSI Lumonics and will be conducted to minimize impacts to GSI Lumonics operations. A traffic lane will be maintained to allow access to the parking lot and to allow continued operation of shipping/receiving.

The biosparging air supply lines and SVE extraction lines will be installed underground and the remaining remediation equipment (compressor, blower, water knockout drum, GAC etc.) will be housed in a secured and locked equipment enclosure to prevent unauthorized access and potential vandalism. The equipment enclosure will be located as shown in Figure 3-1 and will not impact operations at the GSI Lumonics facility.

Mobilization of heavy equipment will be scheduled during business hours and GSI Lumonics will be notified at least 48 hours prior to mobilization to ensure that GSI Lumonics personnel are aware of the vehicle type, size, and weight. Traffic control during demobilization operations will also be monitored. All equipment will be logged out by TRC and will be dispersed accordingly to prevent buildup at the site gate.

Emergency vehicle access will be maintained at all times in the event of an emergency. During installation excavation activities a clear means of road access of at least 25 feet in width around the perimeter of the work area will be maintained for fire department and emergency response vehicles access to buildings at the site. Traffic remediation activity and parking areas will be monitored by TRC personnel. A designated area will be made available for parking for construction personnel.

8.0 REFERENCES

TRC, Biosparging Pilot Test Report, Tank K Area, December 1999.

Norris, R.D., Hinchee, R.E., Brown, R.A., McCarty, P.L., Semprini, L., Wilson, J.T., Kampbell, D.H., Reinhard, M., Bower, E.J., Borden, R.C., Vogel, T.M., Thomas, J.M., and C.H. Ward. 1994. Handbook of Bioremediation. Boca Raton, FL:CRC Press.

A Review of Technologies. Ada, OK: U.S. Environmental Protection Agency, Office of Research and Development. EPA/5R-93/124.

Riser-Roberts, E. 1992. Bioremediation of Petroleum Contaminated Sites. NCEL, Port Hueneme, CA: C. K. Smoley Publishers, CRC Press.

Flathman, P.E. and D.E. Jerger. 1994. Bioremediation Field Experience. Environmental Research Laboratory, Ada, OK: Lewis Publishers, CRC Press, Inc.

Weston, Inc., Roy F. 1988. Remedial Technologies for Leaking Underground Storage Tanks. University of Massachusetts, Amherst, MA: Lewis Publishers.

U.S. Environmental Protection Agency (EPA). 1992. A Technology Assessment of Soil Vapor Extraction and Air Sparging. Cincinnati, OH: Office of Research and Development. EPA/600/R-92/173.

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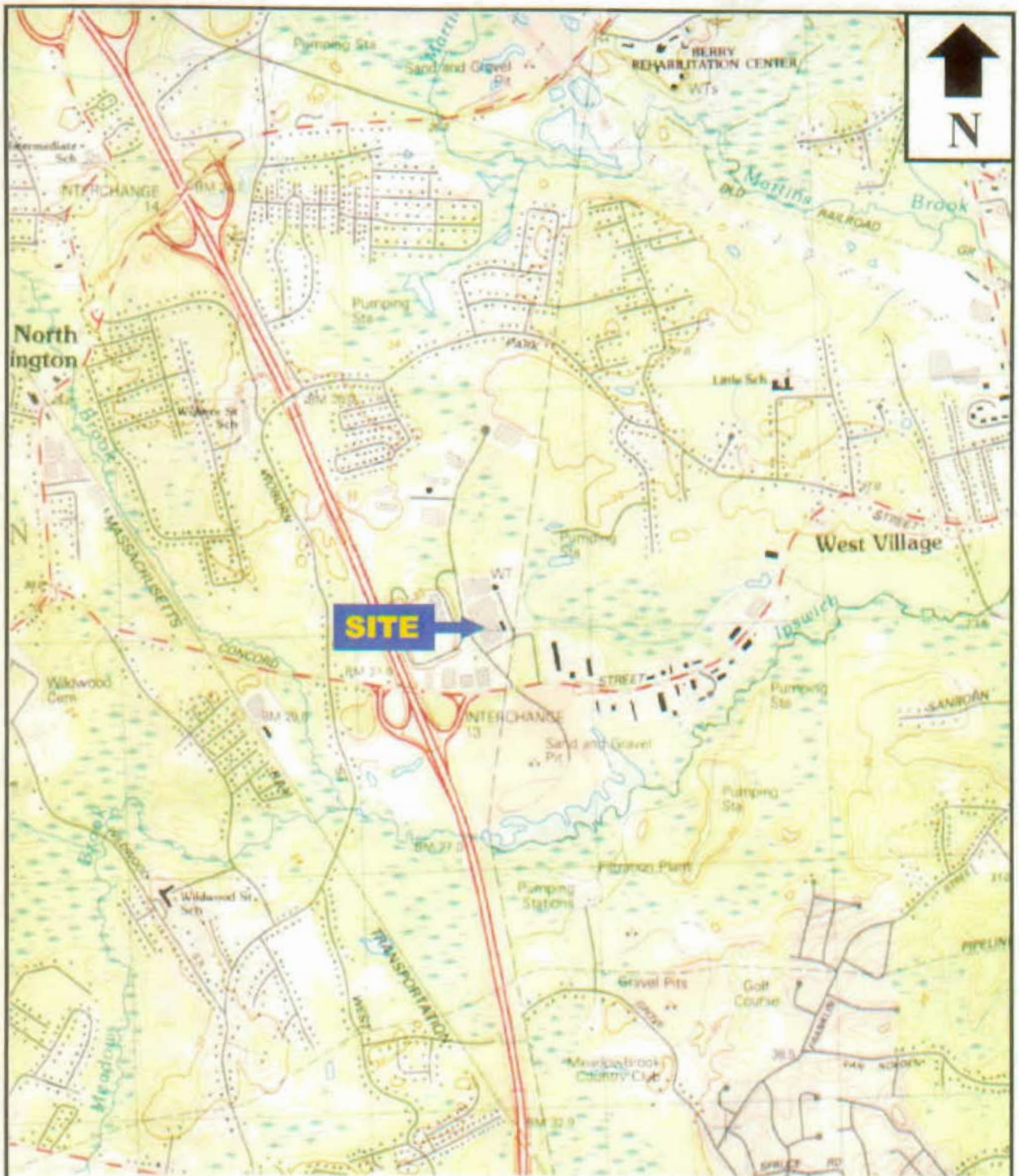
Johnson, R.L. et. al., An Overview of In-Situ Air Sparging, Ground Water Monitoring Review, Vol. 13 No. 4, pp. 127-135, 1993

U.S. EPA, A Technical Assessment of Soil Vapor Extraction and Air Sparging. Office of Research & Development, Washington, D.C. EPA/600/R-92/173-1992.



BASE MAP IS A PORTION OF THE FOLLOWING 7.5' x 15' USGS TOPOGRAPHIC QUADRANGLE: READING, MA 1987

0 1000 2000

Scale in Feet

QUADRANGLE LOCATION

E9202/PIP/TOPO

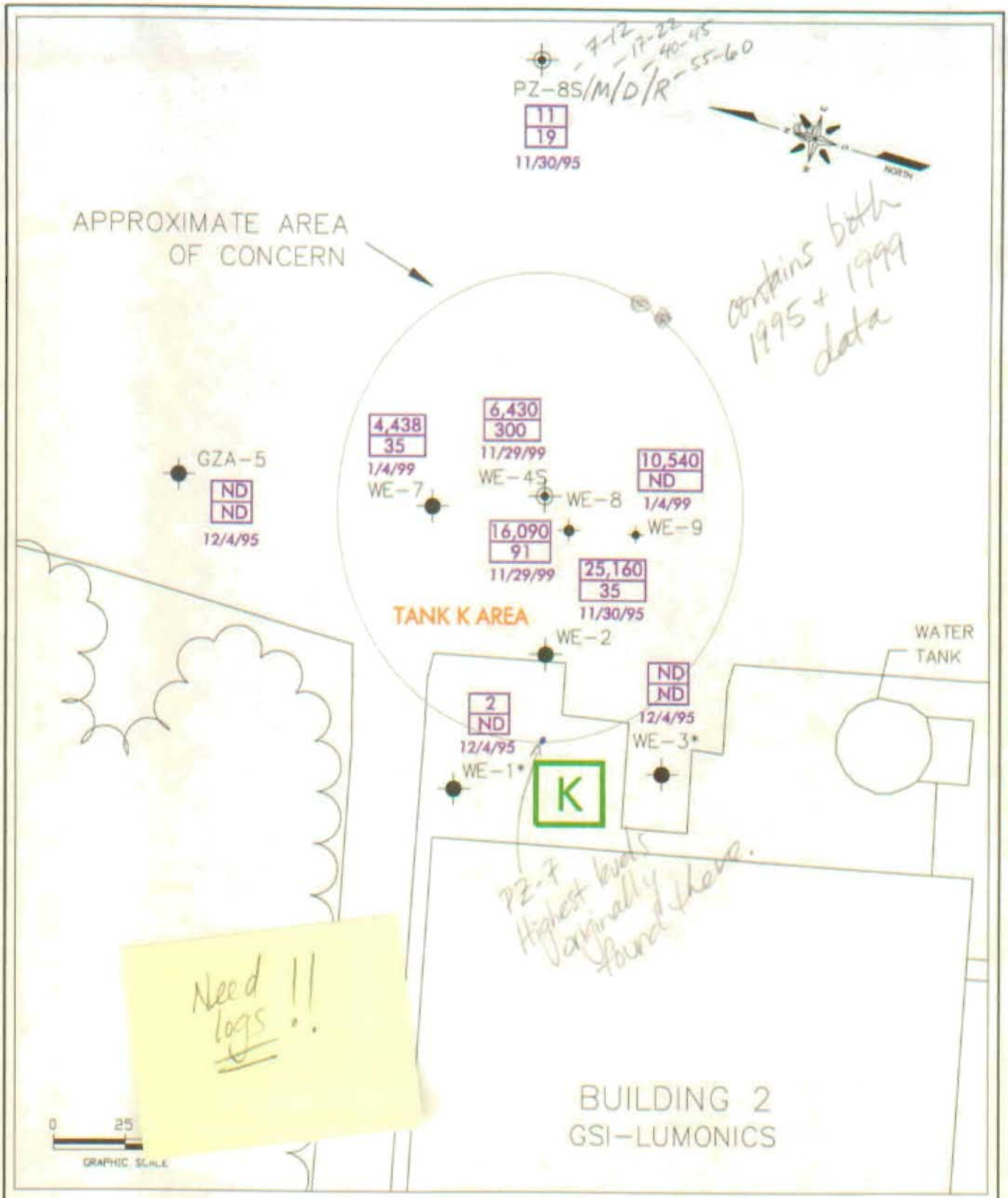
TRC

Boott Mills South
Foot of John Street
Lowell, MA 01852
(978) 970-5600

FORMER GE SITE
WILMINGTON/NORTH READING, MASSACHUSETTS

FIGURE 1-1
SITE LOCATION MAP

Date: 2/00 | Project No. E9202



LEGEND

BUILDING

APPROXIMATE PROPERTY LINE

APPROXIMATE TOWN LINE

APPROXIMATE EDGE OF WATER/STREAM

APPROXIMATE EDGE OF WETLANDS/SWAMP

K FORMER LOCATION OF TANK K

TOTAL BTEX

MTBE

11/30/95 SAMPLING DATE

MULTI-LEVEL MONITORING WELL/PIEZOMETER LOCATION

SINGLE-LEVEL MONITORING WELL/PIEZOMETER LOCATION

NOTE: '*' INDICATES ABANDONED WELL

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Lowell, MA 01852
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FIGURE 1-2
GENERAL AREA OF REMEDIATION

Date: 07/00 | Project No. E8202

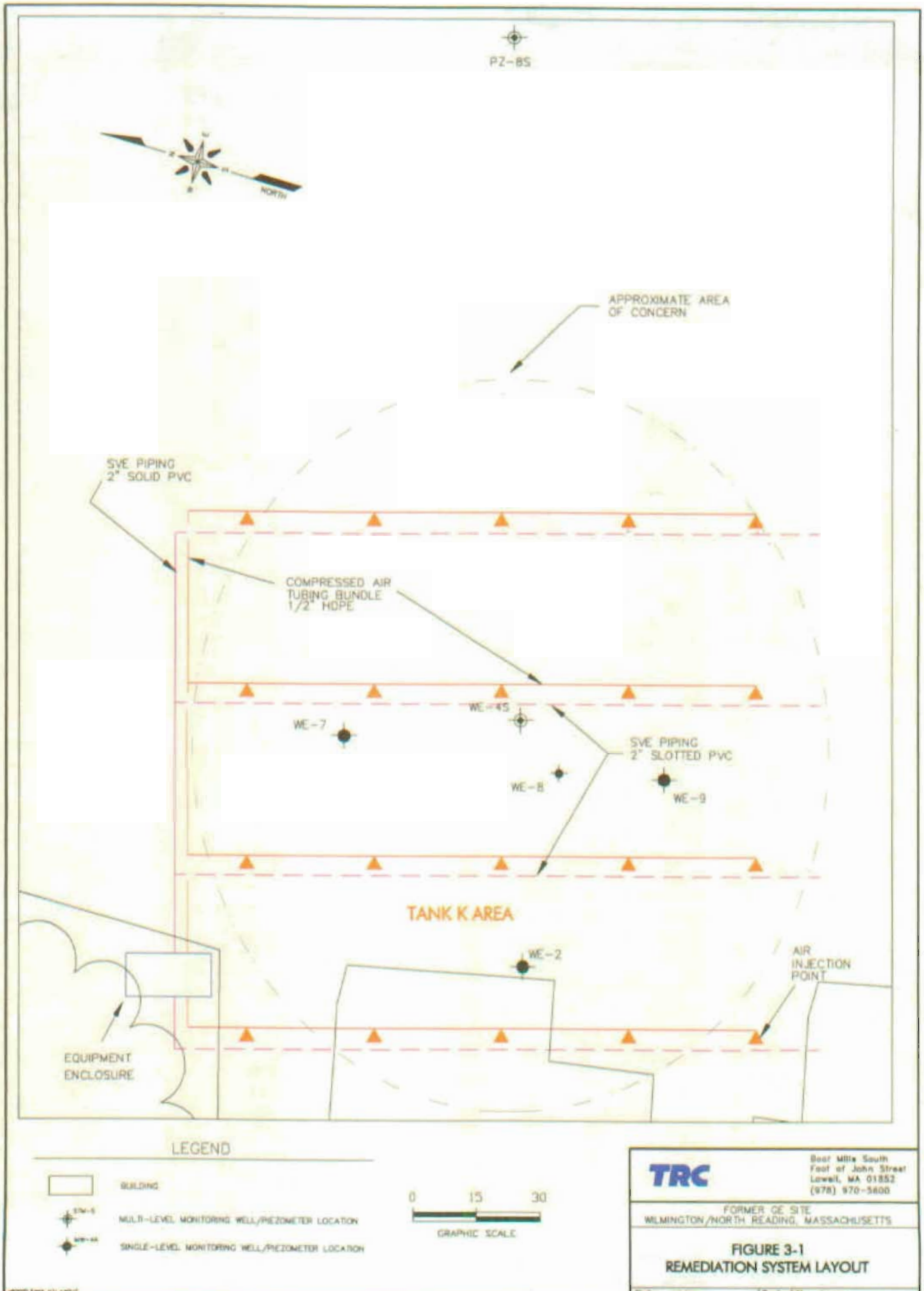


FIGURE 3-1
REMEDIATION SYSTEM LAYOUT

B-1
BIOSPARGE BLOWER
POSITIVE DISPLACEMENT
7.5 HP, 3PH, 230VAC
50 SCFM @ 12PSI

MF-1 AND 2
INLET/OUTLET SILENCERS
2-INCH CONNECTIONS
STODDARD, D33H MODEL

B-2
SVE BLOWER
REGENERATIVE
1.5 HP, 3PH, 230VAC
100 SCFM @ 30in.w.c.

GAC-1 AND 2
GAC VESSEL
55 GAL
VAPOR PHASE

MS-1
MOISTURE
SEPARATOR
30 GALLON

FM-A1 TO E5
VARIABLE
AREA
AIR FLOW
METERS

RPS-1
REMOTE
PRESSURE
SENSOR
(0 TO 15 PSI

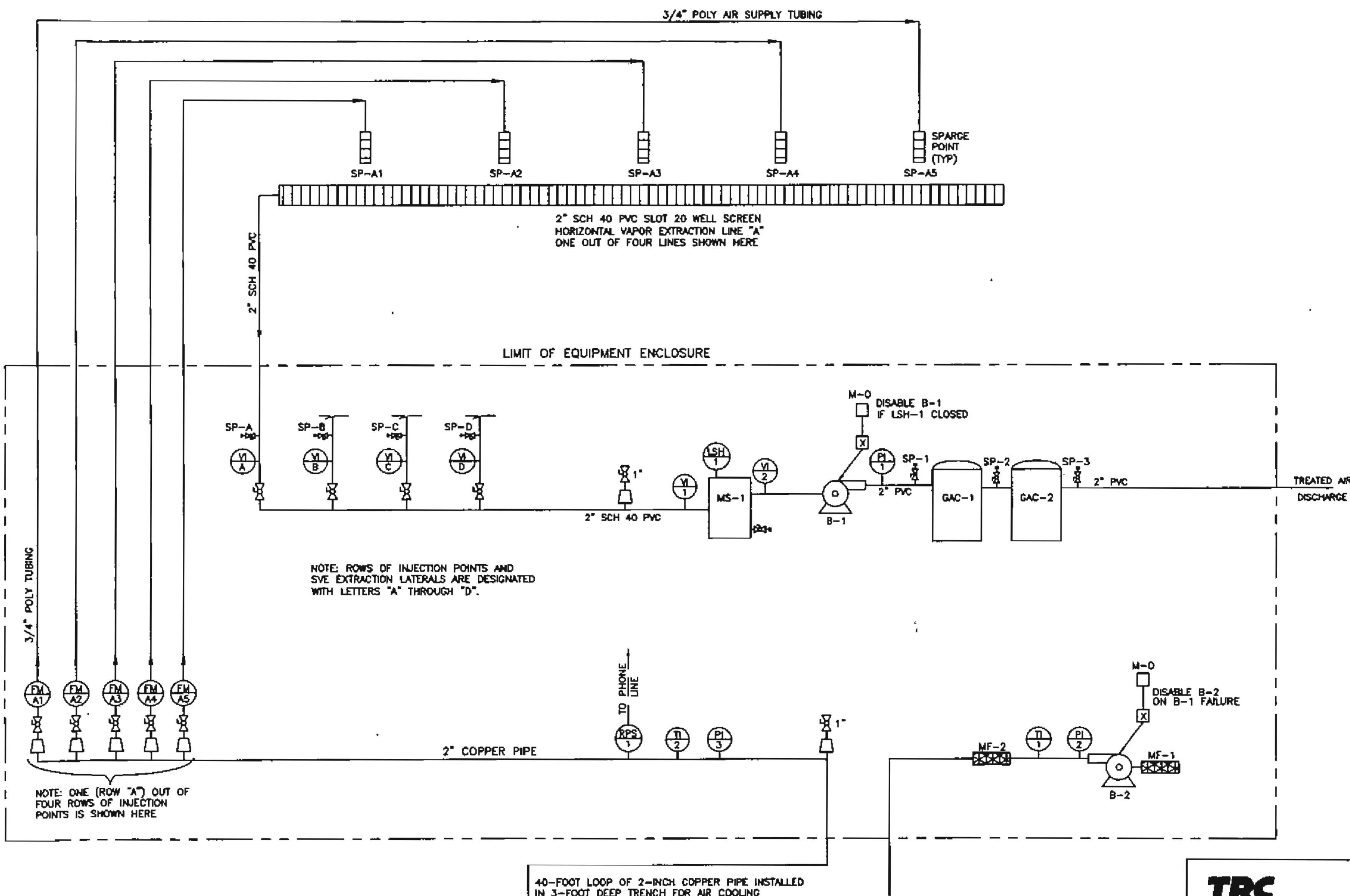
PI-1 TO 2
PRESSURE
INDICATORS
(TYPICAL)

VI-
VACUUM
INDICATORS
(TYPICAL)

TI-1 TO 2
TEMPERATURE
INDICATORS
(TYPICAL)

LSH-1
HIGH LEVEL
SWITCH

SP-
SAMPLING
PORTS



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Lowell, MA 01852
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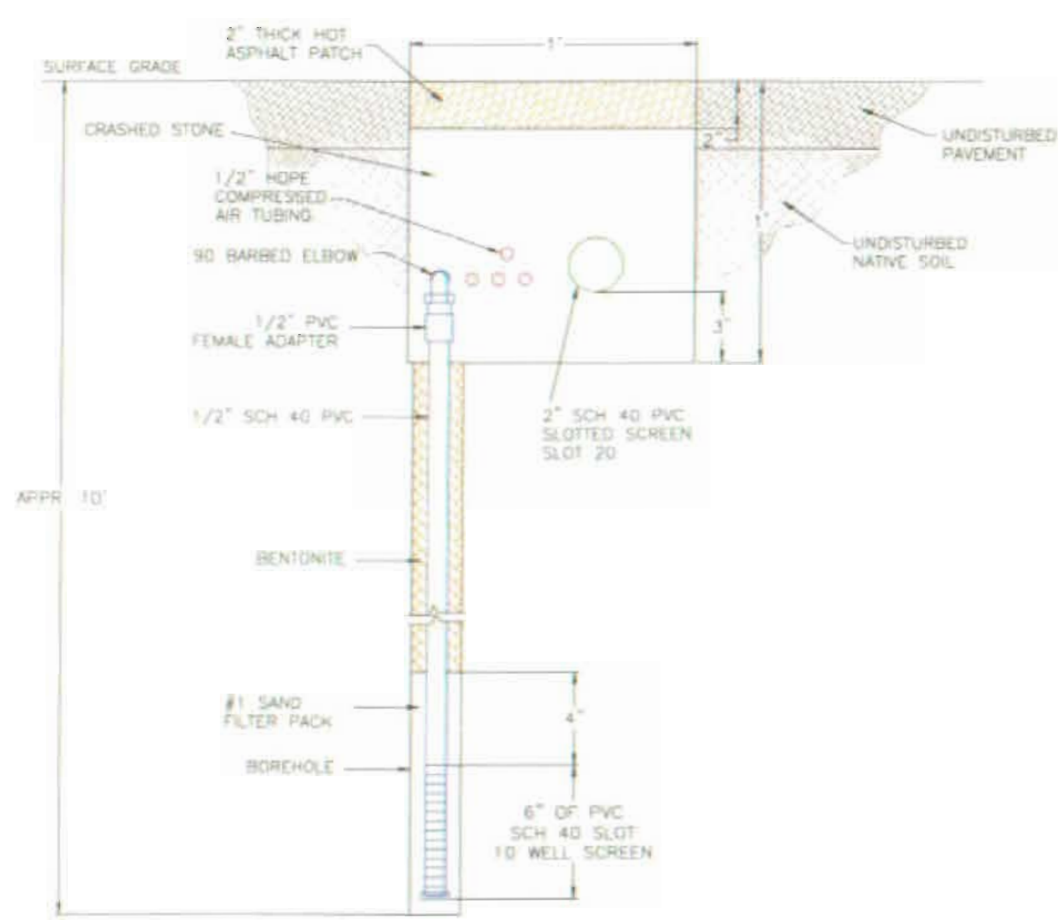
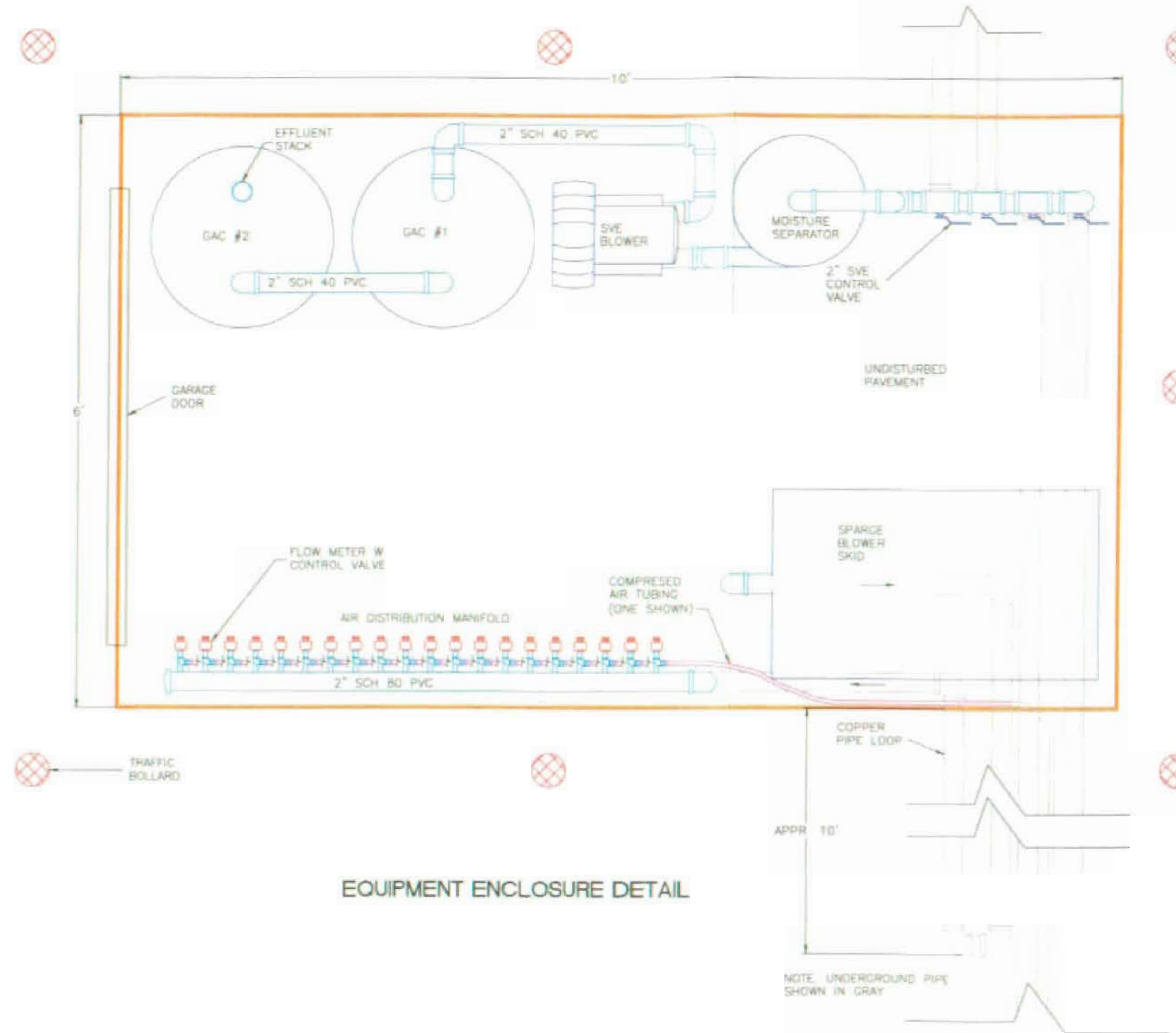
FORMER GE SITE
WILMINGTON/NORTH READING, MASSACHUSETTS

FIGURE 3-2
PROCESS AND
INSTRUMENTATION DIAGRAM



TRENCH CROSS-SECTION DETAIL



EQUIPMENT ENCLOSURE DETAIL

TRC

Boott Mills South
Foot of John Street
Lowell, MA 01852
(978) 970-5600

FORMER GE SITE
WILMINGTON/NORTH READING, MASSACHUSETTS

FIGURE 3-3
EQUIPMENT SCHEMATIC AND SUBSURFACE DETAILS

APPENDIX A

BIOSPARGING/SVE DESIGN PROCEDURE CALCULATIONS

APPENDIX A

BIOSPARGING/SVE DESIGN CALCULATIONS

1. **Estimation of total mass of biodegradable carbon in the subsurface.**
   Assume area of concern (see Figure 3.1) as an ellipse 170 feet long by 150 feet wide with 10 feet of saturated thickness. Mass of water in the area of concern with assumed 30% porosity can be calculated as follows:
   Mw = 3.14 x 170/2 ft x 150/2 ft x 10 ft x 0.3 x 62.4 lbs/ft^3 = 3,747,000 lbs of water.
   Assume (conservatively) that the total average concentration (C) of bio-available carbon in the area of concern is 100 mg/kg. The latter includes BTEX, MTBE and other petroleum hydrocarbons. The total mass of biodegradable carbon in the area of concern can be calculated as

Mc = Mw x C x 1/1,000,000 = 3,747,000 lbs x 100/1,000,000 = 375 lbs to be degraded.

2. **Calculate required amount of dissolved oxygen.**
   Assume (conservatively) that 5 lbs of dissolved oxygen is required to degrade 1 lbs of bio-available carbon (1 to 5 ratio). Therefore the required mass of dissolved oxygen Mdo = Mc x 5 = 375 x 5 = 1,875 lbs of oxygen.

3. **Remediation time frame.**
   Let us assume that the remediation is targeted to be finished in 500 days.

4. **Total oxygen injection rate.**
   Only a small portion of the oxygen in the air injected into the subsurface actually dissolves and becomes available for degradation of TPH and other degradable substances. The major portion of injected air travels upward through the saturated zone and exits into the unsaturated zone. Assume (conservative value from literature) that only 0.5% of injected oxygen goes into solution. Then the total amount of oxygen to be injected during 500 days of the remediation is Mox = Mdo / 0.5% = 1,875 lbs / 0.005 = 375,000 lbs of oxygen over 500 days.

5. **Air injection rate.**
   Based on 21% oxygen content in air the total air injection rate (Q) can be calculated as following:

   Q = Mox /0.075 lbs/ft^3 /500 days / 1440 min/day /21%=
   375,000 lbs/0.075 lbs/ft^3 /500 days / 1440 min/day = 33 ft^3/min.

6. **Number and spacing of injection points.**
   Install injection points and relief wells in several parallel rows as shown on Figure 3. Select four rows of injection points with five injection points per each row. Spacing between the rows will be approximately 40 feet to cover the known extent of the area of concern. A total of 20 injection points will be installed selected. This selection

results in approximately 33 ft^3/min / 20 points = 1.65 ft^3/min air injection rate per point. Space injection points approximately 30 feet apart.

7. **Cross-check the injection rate and spacing with the pilot test results.**
The majority of the December 1999 pilot test was performed (and with good results) using approximately 2 ft^3/min air injection rate per point. Therefore, the above selected air injection rate of 1.65 ft^3/min is achievable and proved to be effective. The air injection points will be spaced 30 apart. Radius of influence (based on increase in dissolved oxygen) was measured at a distance of 20 feet from the injection points. Therefore with 30 feet of spacing between the injection points the radii of influence will overlap approximately 10 feet.

8. **Select SVE extraction rates and extraction laterals configuration.**
SVE extraction rate shall be sufficiently greater than the rate of injection to achieve capture of VOCs stripped from the groundwater. Select SVE extraction rate at approximately 100 SCFM which is 3 times greater than the total injection rate. Each of the four SVE laterals will therefore have 25 SCFM extraction rate. The length of each SVE lateral will be 150 feet.

APPENDIX B

GROUNDWATER FIELD HEADSPACE PROCEDURE

To: ISMTPOutBound@itd.w4@servers["'Rodene Lamkin'" <Rodene.Lamkin@state.ma.us>]
From: "Macchiaroli, Paola" <Paola@TRCSOLUTIONS.com>
Cc: ISMTPOutBound@itd.w4@servers["'Eck, Jennifer'" <Jennifer.Eck@state.ma.us>]
Subject: Tank K RIP clarification
Attachment:
Date: 09/28/2000 3:54 PM

Rodene-

In order to clarify the issues we discussed, we suggest that the second sentence on page 11 be adjusted to read as:

"For purposes of source control remedy, the area of concern is defined as an area where a total dissolved concentration of VOCs in groundwater is greater than 10% of the GW-1 standard for a total of BTEX + MTBE (0.1 * 11,775 ug/L = 1,178 ug/L), equating to approximately 1.2 mg/L. The corresponding vapor concentration would be approximately 13 ppmv (see Appendix B for calculations).

Thank you for your patience. Please call with any other questions.

Paola E. Macchiaroli, Ph.D.
TRC Companies
Boott Mills South
Foot of John Street
Lowell, MA 01852
(978) 656-3582

*** New E-mail: Paola@trcsolutions.com***

978-551-7615

1. Use the following equation to calculate the total dissolved VOCs concentration in g/L

$$C_{VOC} = \frac{V_{vap}(L) * C_{vap} \cdot 10^{-6} \cdot MW \ (g/mol)}{22.4 \ (L/mol) * V_{H2O}(L)} = [g/L]$$

or to convert the total dissolved VOCs concentration from g/L into mg/L multiply the above equation by 10^3 mg/g :

$$C_{VOC} = \frac{V_{vap} \cdot C_{vap} \cdot 10^{-6} \cdot MW}{22.4 \ L/g\text{-}mol * V_{H2O}} * 10^3 \ mg/g = \frac{V_{vap} \cdot C_{vap} \cdot 10^{-3} \cdot MW}{22.4 \ L/g\text{-}mol * V_{H2O}} = [mg/L]$$

where 22.4 L/mol is a molar volume at room temperature and pressure; C_{vap} is PID reading in volumetric parts per million; MW is an average molecular weight (taken as 100 g/mol for the vapors assuming 50% toluene and 50% xylenes); Vvap – flask volume (2L); V_{H2O} = water sample volume (0.1L)

Post-it® Fax Note 7671	Date	# of pages ▶
To Rodin	From Boris Dyshkin	
Co./Dept.	Co. TRC	
Phone #	Phone #	
Fax # 978-661-7615	Fax #	

APPENDIX B

GROUNDWATER FIELD HEADSPACE PROCEDURE

this okay?

The aerial extent of the area of concern will be accurately determined during the installation of the biosparging points. The area of concern is defined as an area where a total dissolved concentration of VOCs in groundwater is 10% of the GW-1 standard for a total of BTEX + MTBE: 0.1 * 11,775 ug/L = 1,178 ug/L or approximately 1.2 mg/L.

The total dissolved VOCs concentration will be determined using a groundwater headspace. The following procedure will be used to determine the total dissolved VOCs concentration based on the measured headspace.

1. Collect a 0.1 liter groundwater sample (V_{H2O}) from a sparge point. Place a sample in a 2.0 liter (V_{vap}) glass flask with a side tube outlet. Seal off the flask with a rubber stopper and a tubing valve.
2. Warm sample water to approximately 150 °F to facilitate volatilization of VOCs. Shake the flask vigorously for 1 to 2 minutes.
3. Connect the flask's outlet to the photoionization detector (PID) and measure the vapor concentration (C_{vap}, ppm_v). Use an in-line moisture filter upstream of the PID.
4. Use the following equation to calculate the total dissolved VOCs concentration (C_{H2O}, mg/L):

$$C_{H2O} = \frac{V_{vap} * C_{vap} * 10^{-3} * MW}{22.4 \text{ L/g-mol} * V_{H2O}}$$

where 22.4 L/g-mol is a molar volume at room temperature and pressure; MW is an average molecular weight (taken as 100 g/mol for the vapors assuming 50% toluene and 50% xylenes); remaining variables are defined above. Based on the above equation, the measured vapor concentration of 10 ppm_v corresponds to approximately 0.9 mg/L of total VOCs.

	GW-1 Std
B	5 ppb
T	1,000
E	700
X	10,000
MTBE	70
Sum	11,775 ppb
10% of Sum	1,178 ppb or 1.2 ppm TVOCs

1.2 mg/L

APPENDIX C

AIR SUPPLY TUBING SIZING CALCULATIONS

APPENDIX C

AIR SUPPLY TUBING SIZING CALCULATIONS

INPUT DATA

1.	Tubing diameter (D)	-	0.5 inches
2.	Maximum tubing length (L)	-	500 feet
3.	Maximum flow per point (Q)	-	2 SCFM
4.	Specific roughness (e)	-	0.00008 inches
5.	Initial pressure (Pin)	-	12 psig or 26.7 psia (3,844.8 lbs/ft^2)
6.	Atmospheric Pressure (Pat)	-	14.7 psia (2,116.8 lbs/ft^2)
7.	Temperature (T)	-	60°F
8.	Air viscosity at 60°F (μ)	-	$3.62 \cdot 10^{-7}$ $lbf\text{-}sec/ft^2$
9.	Air density at 60°F (ρ)	-	0.075 lbs/ft^3
10.	Molecular weight of air (MW)	-	29 lbs-lb-mol
11.	Universal gas constant (R)	-	1545 ft-lbf/lbmol-°R
12.	Gravitational constant (g_c)	-	32.17lbm-ft/$lbf\text{-}sec^2$

CALCULATED PARAMETERS

1. Mass flowrate per unit area (G) - Rst * Q * Pin/Pat/A = 3.34 $lbs/s/ft^2$
   where $A = \pi D^2/4 = 0.00136\ ft^2$

2. Reinolds number (Re) - $D \cdot G / \mu = 371{,}974$

3. Friction factor (f) - 0.0146 (from table)

4. Final pressure (Pout) - $(Pin^2 - f{*}L{*}G^2{*}R{*}T/D/g_c/MW)^{0.5} =$
   = 25.1 psia or 1.6 psi pressure drop - **acceptable pressure drop for this tubing diameter.**

REFERENCES

Davi's Handbook of Applied Hydraulics, McGraw Hill, 1993

APPENDIX D

SVE PIPING SIZING CALCULATIONS

APPENDIX D

SVE PIPING SIZING CALCULATIONS

INPUT DATA

1.	Main pipe diameter (D)	-	4 inches
2.	Main pipe length (L)	-	300 feet
3.	Min pipe flow (Q)	-	120 SCFM
4.	Specific roughness (e)	-	0.00008 inches
5.	Initial pressure at end of line (Pin)	-	-0.5 psig or 14.2 psia (2044.8 lbs/ft^2)
6.	Atmospheric Pressure (Pat)	-	14.7 psia (2,116.8 lbs/ft^2)
7.	Temperature (T)	-	60°F
8.	Air viscosity at 60°F (μ)	-	$3.62 \cdot 10^{-7}$ $lbf\text{-}sec/ft^2$
9.	Air density at 60°F (ρ)	-	0.075 lbs/ft^3
10.	Molecular weight of air (MW)	-	29 lbs-lb-mol
11.	Universal gas constant (R)	-	1545 ft-lbf/lbmol-°R
12.	Gravitational constant (g_c)	-	32.17lbm-ft/$lbf\text{-}sec^2$

CALCULATED PARAMETERS

1. Mass flowrate per unit area (G) - Rst * Q * Pin/Pat/A = 3.12 $lbs/s/ft^2$
   where $A = \pi D^2/4 = 0.087\ ft^2$

2. Reinolds number (Re) - $D \cdot G / \mu =$ 2,783,974

3. Friction factor (f) - 0.0116 (from table)

4. Final pressure (Pout) - $(Pin^2 - f \cdot L \cdot G^2 \cdot R \cdot T/D/g_c/MW)^{0.5} =$
   = 14.05 psia or 0.15 psi pressure drop - **acceptable pressure drop for this pipe diameter.**

REFERENCES

Davi's Handbook of Applied Hydraulics, McGraw Hill, 1993

APPENDIX E

GAC USAGE CALCULATIONS

APPENDIX E

GAC CONSUMPTION RATE ESTIMATION

INITIAL DATA

1. Inlet vapor concentration (C)	-	20 ppm_v or $2*10^{-5}$
2. Design vapor flow (Q)	-	100 SCFM
3. Average molecular weight of vapor stream (MW)	-	100 lb/lb-mol
4. Standard molar volume	-	359 ft^3/lb-mol
5. Assumed carbon adsorption capacity (A)	-	5 to 1 ratio

CALCULATION

1. Daily vapor loading (M)

The following equation can be used to calculate the daily vapor loading:

$$M = \frac{Q\ ft^3}{min} * \frac{1440\ min}{day} * C * \frac{MW\ lb}{lb\text{-}mol} * \frac{lb\text{-}mol}{359\ ft^3} = 0.8\ \text{lb/day of organic vapors}$$

2. Daily carbon consumption rate (G_{ac}) is

$G_{ac} = M * A = 0.8$ lb/day * 5 = 4.0 lbs/day of carbon.

3. Estimated breakthrough time (T).

Assume two standard 55-gal GAC canisters (each @ 180 lbs of GAC) with 360 lbs of GAC total (M_{gac}). The estimated breakthrough time is then as following:

$T = M_{gac} / G_{ac} = 360$ lbs / 4 lbs/day = 90 days before the carbon breakthrough.

REFERENCES

Nyer, E.K., Practical Techniques for Groundwater and Soil Remediation. Boca Raton, FL: Lewis Publishers, CRC Press, Inc., 1993

U.S. Environmental Protection Agency (EPA), Soil Vapor Extraction Technology: Reference Handbook. Cincinnati, OH: Office of Research and Development. EPA/540/2-91/003, 1991a

Johnson, P.C., Stanley, C.C., Kemblowski, M.W., Byers, D.L., and J.D. Colthart, A Practical Approach to the Design, Operation and Monitoring of In Situ Soil-Venting Systems. Ground Water Monitoring Review, Vol. 10, No. 2, pp. 159-178, 1990

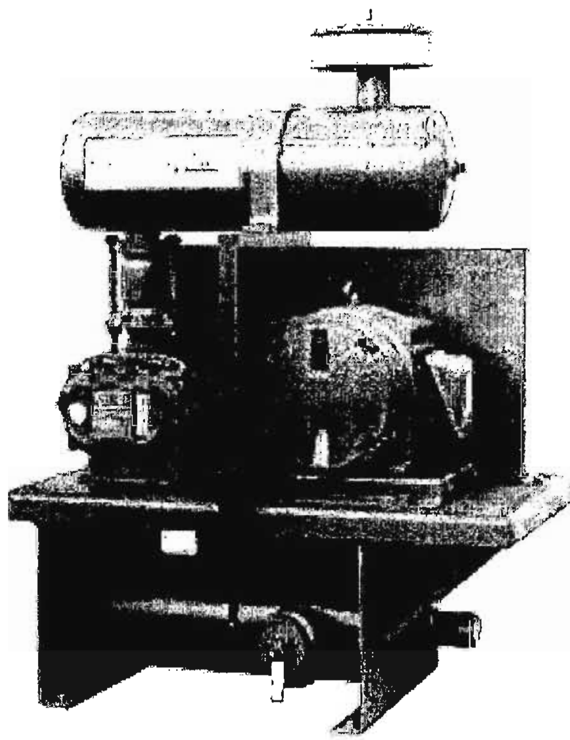
APPENDIX F

EQUIPMENT MANUFACTURING INFORMATION

ROOTSPAK™

UNIVERSAL RAI® PACKAGED UNITS

DISCHARGE PIPE SIZES 2" THRU 6"



BASIC PACKAGE DESCRIPTION

Available through **Authorized Roots Distributors**, RootsPak™ completely assembled, factory-engineered and guaranteed packages incorporate 17 frame sizes of Universal RAI rotary blowers in 3 package arrangements to suit your various installation and application requirements. Flows to 2370 cfm, pressures to 15 psig or vacuums to 16" Hg are possible.

The basic, or type "S", package consists of the blower, V-belt drive, OSHA guard, motor slide base, inlet filter and inlet silencer all mounted on top of a heavy-duty, unitized base/discharge silencer in one compact, easy to install package. A pressure relief valve is mounted on the discharge silencer. A type "F" package is available, with an inlet filter-silencer replacing the separate inlet filter and inlet silencer. For vacuum service, a type "V" package can be supplied with a vacuum relief valve mounted on top of a tee at the blower inlet.

Motor and other accessories are optional. All three arrangements are fully described in the table below and illustrated on the next page.

The combination base/discharge silencer is a rigid, one-piece weldment, reinforced for minimal vibration. The inlet filter is supplied with a 10 micron pleated paper element. All standard components are designed for indoor or outdoor operation.

The Universal RAI blower consists of a grey iron casing, carburized and ground alloy steel timing gears secured to steel shafts with a taper mounting and locknut, and grey iron involute impellers. Oversized anti-friction bearings are used, with a cylindrical roller bearing at the drive shaft on all models to provide increased bearing life and to withstand V-belt pull. The Universal RAI features thrust control, with splash oil lube on the gear end and grease lube on the drive end.

EVERY GROWING PLANT NEEDS ROOTS

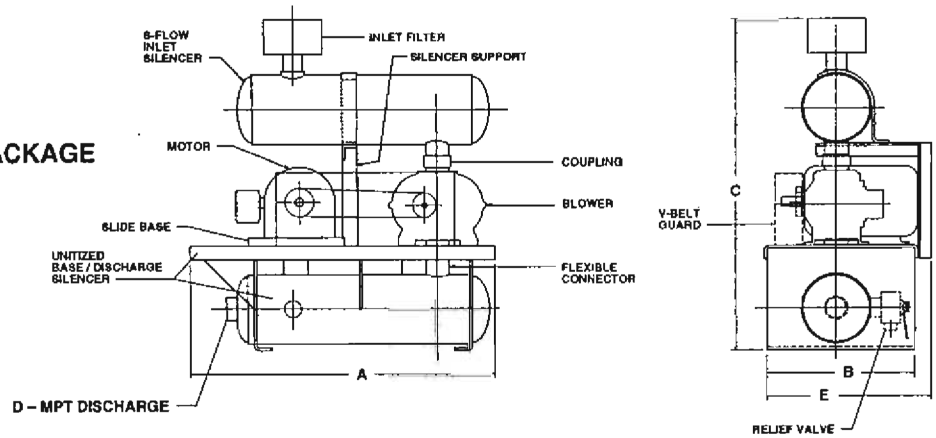
PACKAGE COMPONENTS

TYPE "S" PACKAGE	→ TYPE "F" PACKAGE	TYPE "V" PACKAGE
Universal RAI blower	Universal RAI blower	Universal RAI blower
Unitized base/discharge silencer	Unitized base/discharge silencer	Unitized base/discharge silencer
Inlet filter with weatherhood	Inlet filter-silencer with weatherhood	V-belt drive
Horizontal inlet silencer & support	V-belt drive	OSHA guard
V-belt drive	OSHA guard	Motor slide base
OSHA guard	Motor slide base	Interconnecting fittings
Motor slide base	Interconnecting fittings	Vacuum relief valve
Interconnecting fittings	Pressure relief valve	Shipped completely assembled
Pressure relief valve	Shipped completely assembled	Domestic shipping preparation
Shipped completely assembled	Domestic shipping preparation	Suitable for indoor/outdoor installation
Domestic shipping preparation	Suitable for indoor/outdoor installation	
Suitable for indoor/outdoor installation		

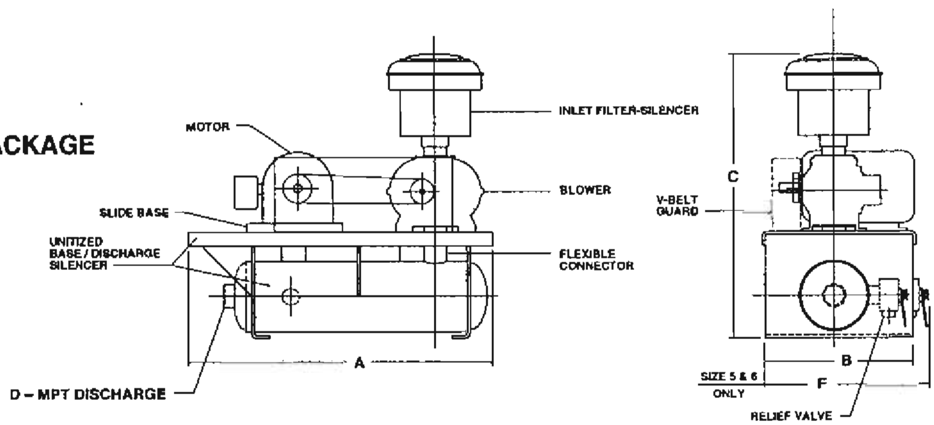
ROOTS DRESSER

OUTLINE DRAWING & DIMENSIONAL TABLE

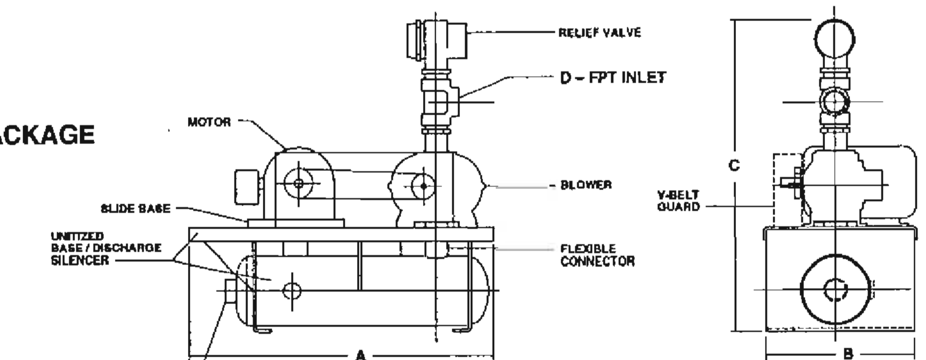
TYPE "S" PACKAGE



TYPE "F" PACKAGE



TYPE "V" PACKAGE



NOTES:
1. All dimensions are in inches.
2. Dimensions are approximate – do not use for construction. Packages may not be exactly as shown.
3. Dimension "C" and approximate weights are for largest blower frame size used.
4. Approximate weights do not include motor.

Discharge Pipe Size	Blower Frame Sizes	A	B	C (Maximum)			D	E	F	Approx. Net Weight (Maximum)		
				Type "S"	Type "F"	Type "V"				Type "S"	Type "F"	Type "V"
2	22, 24, 32, 33, 42	39.00	23.00	48.00	36.38	37.75	2	25.18	–	325	295	290
2-1/2	36, 45, 53	44.50	27.00	58.13	57.13	43.25	2-1/2	29.18	–	510	400	415
3	45, 47, 56, 65	51.50	29.25	68.13	56.38	47.75	3	32.50	–	835	725	710
4	47, 56, 59, 68, 76	56.00	32.50	82.06	64.50	60.93	4	35.75	–	1174	1037	1012
5	59, 68, 711	66.00	34.50	82.75	71.38	69.50	5	37.75	35.50	1501	1280	1250
6	615, 711, 718	68.50	34.50	99.13	98.00	72.50	6	37.75	37.62	1837	1495	1330

ROOTS DRESSER

ROOTSPAK™ PERFORMANCE TABLE

FRAME SIZE	SPEED RPM	1 PSI		2 PSI		3 PSI		4 PSI		5 PSI		6 PSI		7 PSI		10 PSI		11 PSI		12 PSI		15 PSI		MAX. VACUUM		
		CFM	BHP	CFM	BHP	CFM	BHP	CFM	BHP	CFM	BHP	CFM	BHP	CFM	BHP	CFM	BHP	CFM	BHP	CFM	BHP	CFM	BHP	"Hg	CFM	BHP
	1160	10	0.2	7	0.3	4	0.3	2	0.4															4	6	0.3
22	3600	49	0.6	46	0.8	43	1.1	41	1.3	39	1.6	38	1.8	36	2.1	32	2.8	31	3.1	29	3.3			14	28	2.0
	5275	76	0.8	73	1.2	70	1.6	68	1.9	66	2.3	64	2.7	63	3.1	59	4.2	57	4.5	56	4.9			15	53	3.1
	1160	24	0.3	19	0.4	15	0.6	11	0.8	8	0.9													6	12	0.6
24	3600	102	0.8	97	1.3	93	1.8	89	2.3	86	2.8	83	3.3	81	3.8									14	69	3.8
	5275	156	1.2	150	1.9	146	2.7	143	3.4	140	4.2	137	4.9	135	5.6									15	119	5.8
	1160	40	0.4	34	0.6	30	0.9	27	1.1	24	1.3	21	1.6	19	1.8									10	18	1.3
32	2800	113	1.0	108	1.6	104	2.1	101	2.7	98	3.2	95	3.8	93	4.3	86	6.0	84	6.5	82	7.1	77	8.7	15	78	4.5
	3600	149	1.3	144	2.0	140	2.7	137	3.4	134	4.1	131	4.8	129	5.5	122	7.7	120	8.4	118	9.1	113	11.2	15	114	5.8
	1160	55	0.5	48	0.8	43	1.1	39	1.4	35	1.7	31	2.1	28	2.4									10	27	1.7
33	2800	156	1.2	149	2.0	144	2.7	140	3.5	136	4.2	132	5.0	129	5.7	120	8.0	118	8.7	116	9.5			14	113	5.6
	3600	205	1.6	199	2.5	193	3.5	189	4.5	185	5.4	181	6.4	178	7.4	170	10.3	167	11.2	165	12.2			15	159	7.6
	1160	95	0.7	85	1.2	78	1.7	72	2.3	66	2.8	61	3.3	57	3.8									10	55	2.7
36	2800	262	2.0	253	3.3	245	4.5	239	5.8	234	7.0	229	8.3	224	9.5									12	213	7.9
	3600	344	2.9	334	4.5	327	6.1	321	7.7	315	9.3	310	10.9	306	12.5									15	278	12.7
	860	38	0.4	32	0.6	28	0.9	24	1.1	21	1.3	18	1.5	15	1.8									8	19	1.1
42	1760	92	0.8	87	1.3	82	1.8	78	2.2	75	2.7	72	3.1	69	3.6	62	5.0	60	5.5	58	5.9			14	56	3.5
	3600	204	1.7	198	2.6	194	3.6	190	4.5	186	5.5	183	6.4	181	7.4	173	10.2	171	11.2	169	12.1	163	15.0	15	164	7.6
	860	79	0.6	68	1.1	60	1.5	53	2.0	48	2.4	42	2.9	37	3.4									8	46	1.9
45	1760	188	1.3	177	2.2	169	3.1	162	4.1	156	5.0	151	5.9	146	6.9	133	9.6							12	134	5.8
	3600	410	3.4	400	5.3	392	7.2	385	9.1	379	11.0	374	12.9	369	14.8	356	20.5							15	339	15.0
	860	105	0.8	92	1.4	82	2.0	73	2.6	66	3.2	59	3.8	53	4.4									8	63	2.5
47	1760	249	1.6	236	2.8	225	4.0	217	5.3	209	6.5	203	7.7	196	8.9									12	181	7.5
	3600	542	4.5	529	7.0	519	9.5	510	12.0	503	14.3	496	17.0	490	19.5									15	452	19.8
	700	72	0.6	63	1.0	56	1.4	51	1.8	46	2.2	42	2.6	38	3.0									10	36	2.2
53	1760	211	1.7	203	2.7	196	3.7	191	4.7	186	5.7	181	6.7	177	7.7	167	10.8	163	11.8	160	12.8			14	158	7.5
	2850	355	3.3	346	5.0	340	6.6	334	8.2	329	9.9	325	11.5	321	13.2	310	18.1	307	19.7	304	21.3	295	26.2	15	296	13.2
	700	123	0.9	110	1.6	100	2.2	92	2.9	85	3.6	78	4.3	72	4.9									10	70	3.5
56	1760	358	2.6	345	4.6	335	6.0	326	7.7	319	9.4	312	11.1	306	12.8	290	17.9							14	276	12.3
	2850	598	5.2	585	8.0	575	10.7	567	13.5	560	16.2	553	19.0	547	21.7	531	30.0							15	510	21.9
	700	187	1.2	170	2.2	158	3.2	147	4.2	138	5.1	130	6.1											8	135	4.1
59	1760	529	3.9	513	6.4	500	8.9	490	11.4	480	13.8	472	16.3	464	18.8									12	445	15.6
	2850	881	7.8	865	11.8	852	15.8	842	19.9	832	23.9	824	27.9	816	31.9									15	770	32.1
	700	140	1.0	126	1.8	116	2.6	107	3.3	100	4.1	93	4.8	86	5.5	70	7.8							12	71	4.7
65	1760	400	3.4	387	5.3	377	7.2	368	9.1	360	11.0	353	12.8	347	14.7	330	20.4	325	22.3	320	24.2	307	29.8	16	300	15.8
	2350	546	5.2	532	7.7	522	10.3	513	12.8	506	15.3	499	17.8	492	20.3	475	27.4	470	30.4	466	32.9	452	40.5	16	445	21.6
	700	224	1.5	203	2.7	187	3.9	172	5.1	160	6.3	149	7.5	139	8.7									10	135	6.2
68	1760	643	4.9	621	7.9	605	10.9	591	14.0	579	17.0	567	20.0	557	23.1	530	32.2	522	35.2	515	38.2			15	495	23.5
	2350	876	7.3	855	11.4	838	15.4	824	19.5	812	23.5	801	27.6	790	31.6	763	43.8	755	47.8	748	51.9			16	715	34.0
	700	420	2.6	380	4.8	351	7.1	323	9.3	301	11.6	279	13.8											8	292	9.1
615	1760	1205	8.1	1164	13.9	1133	19.5	1107	25.2	1084	30.8	1063	36.5											12	997	35.0
	2350	1641	11.9	1601	19.3	1570	27.0	1544	34.6	1521	43.2	1500	49.8											12	1433	47.5
	575	195	1.3	179	2.3	168	3.3	158	4.3	150	5.4	142	6.4	134	7.4	115	10.4							12	117	6.2
76	1400	526	4.0	511	6.4	500	9.0	490	11.5	481	13.9	473	16.4	466	18.8	447	26.3	441	28.7	436	31.2	421	38.6	16	413	20.4
	2050	788	6.9	772	10.5	761	14.2	751	17.8	742	21.4	734	25.0	727	28.6	708	39.5	703	43.1	697	46.7	682	57.6	16	674	30.6
	575	362	2.2	336	4.0	316	5.9	299	7.7	284	9.6	271	11.4	258	13.3	226	18.8							12	228	11.2
711	1400	970	6.5	944	11.0	925	15.5	908	20.0	893	24.5	880	29.0	867	33.5	835	47.1							15	793	34.4
	2050	1450	10.9	1424	17.5	1404	24.1	1387	30.7	1373	37.3	1359	43.9	1347	50.5	1315	70.3							16	1256	54.6
	575	600	3.3	563	6.3	534	9.3	510	12.3	489	15.4	470	18.4											10	446	15.0
718	1400	1590	9.7	1553	17.0	1524	24.3	1500	31.6	1479	39.0	1460	46.3											12	1398	44.6
	2050	2370	15.7	2333	26.9	2304	37.2	2280	47.9	2259	58.6	2240	69.4											12	2178	66.4

Notes: 1. Pressure ratings based on inlet air at standard pressure of 14.7 psia, standard temperature of 68°F, and specific gravity of 1.0.
2. Vacuum ratings based on inlet air at standard temperature of 68°F, discharge pressure of 30" Hg and specific gravity of 1.0.

ROOTSPAK™ TECHNICAL DATA

Blower Frame Size	MAXIMUM RECOMMENDED FLOW / PRESSURE / VACUUM FOR SILENCER SIZES LISTED BELOW				
	Type "S" and "F" Packages			Type "V" Package	
	Part Number	Part Number	Maximum Flow / Pressure / Horsepower	Part Number	Maximum Flow / Horsepower
22	22-1.5-2S	22-1.5-2F	75 CFM / 3-12 PSIG / 5 HP	22-2V	75 CFM / 14" Hg
24	24-2-2S	24-2-2F	140 CFM / 3-7 PSIG / 7.5 HP	24-2V	140 CFM / 14" Hg
32	32-1.5-2S	32-1.5-2F	100 CFM / 7-15 PSIG / 10 HP	–	–
32	32-2-2S	32-2-2F	140 CFM / 7-15 PSIG / 15 HP	32-2V	110 CFM / 15" Hg
33	33-2-2S	33-2-2F	150 CFM / 6-12 PSIG / 10 HP	33-2V	160 CFM / 14" Hg
36	36-2.5-2.5S	36-2.5-2.5F	200 CFM / 3-7 PSIG / 10 HP	36-2.5V	250 CFM / 14" Hg
36	36-3-2.5S	36-3-2.5F	300 CFM / 3-7 PSIG / 15 HP	–	–
42	42-2-2S	42-2-2F	140 CFM / 9-15 PSIG / 15 HP	42-2V	160 CFM / 14" Hg
45	45-2.5-2.5S	42-2.5-2.5F	200 CFM / 5-10 PSIG / 15 HP	45-2.5V	220 CFM / 14" Hg
45	45-3-2.5S	42-3-2.5F	240 CFM / 5-10 PSIG / 15 HP	–	–
45	45-3-3S	45-3-3F	300 CFM / 5-10 PSIG / 20 HP	45-3V	350 CFM / 14" Hg
47	47-3-3S	47-3-3F	400 CFM / 3-7 PSIG / 15 HP	47-3V	400 CFM / 14" Hg
47	47-4-4S	47-4-4F	530 CFM / 3-7 PSIG / 20 HP	47-4V	430 CFM / 14" Hg
47	47-4-3S	47-4-3F	400 CFM / 3-7 PSIG / 20 HP	–	–
53	53-2.5-2.5S	53-2.5-2.5F	200 CFM / 9-15 PSIG / 15 HP	53-2.5V	250 CFM / 14" Hg
53	53-3-2.5S	53-3-2.5F	300 CFM / 9-15 PSIG / 25 HP	–	–
56	56-4-3S	56-4-3F	400 CFM / 5-10 PSIG / 25 HP	56-3V	370 CFM / 14" Hg
56	56-4-4S	56-4-4F	550 CFM / 5-10 PSIG / 30 HP	56-4V	510 CFM / 14" Hg
59	59-4-4S	59-4-4F	550 CFM / 3-7 PSIG / 20 HP	59-4V	700 CFM / 14" Hg
59	59-5-4S	59-5-4F	700 CFM / 3-7 PSIG / 25 HP	59-5V	780 CFM / 14" Hg
65	65-3-3S	65-3-3F	300 CFM / 9-15 PSIG / 30 HP	65-3V	370 CFM / 16" Hg
68	68-4-4S	68-4-4F	550 CFM / 6-12 PSIG / 30 HP	68-4V	580 CFM / 16" Hg
68	68-5-4S	68-5-4F	700 CFM / 6-12 PSIG / 40 HP	–	–
68	68-5-5S	68-5-5F	850 CFM / 6-12 PSIG / 50 HP	68-5V	700 CFM / 16" Hg
615	615-6-6S	615-6-6F	1350 CFM / 3-7 PSIG / 40 HP	615-6V	1400 CFM / 12" Hg
76	76-4-4S	76-4-4F	550 CFM / 9-15 PSIG / 40 HP	76-4V	670 CFM / 16" Hg
711	711-6-5S	711-6-5F	1000 CFM / 5-10 PSIG / 50 HP	711-5V	1050 CFM / 16" Hg
711	711-6-6S	711-6-6F	1350 CFM / 5-10 PSIG / 50 HP	711-6V	1250 CFM / 16" Hg
718	718-8-6S	718-8-6F	2000 CFM / 3-7 PSIG / 75 HP	–	–

Notes: Silencer sizes are shown in each Part Number.

Example:

22-1.5-2S	22 Universal RAI blower, 1-1/2" inlet silencer, 2" discharge silencer
22-2-2F	22 Universal RAI blower, 2" inlet filter-silencer, 2" discharge silencer
22-2V	22 Universal RAI blower, 2" discharge silencer

DESIGN & CONSTRUCTION FEATURES

1. Factory engineered, factory guaranteed
2. Compact package designed for ease of handling and installation
3. Indoor or outdoor operation (when ordered with suitable motor enclosure)
4. Blower manufactured in an ISO 9001 certified facility and covered by an 18/24 month uncontested warranty
5. Refer to bulletin B-12X95 for Universal RAI blower details

Contact your Authorized Roots Distributor for complete drawing and application information on the exact RootsPak to fill your application needs. Roots' wide selection ensures proper pipe sizing, eliminating head loss, thus providing more efficient operation. Roots offers the widest selection of any blower packager in the industry. Offering the RootsPak through Roots' Authorized Distributor network guarantees the highest quality package available.

DRESSER INDUSTRIES, INC.
ROOTS DIVISION
900 WEST MOUNT STREET
TELEPHONE: 765/827-9200
http://www.rootsblower.com/
CONNERSVILLE, INDIANA 47331
FAX: 765/825-7669

The original ROOTS blower™

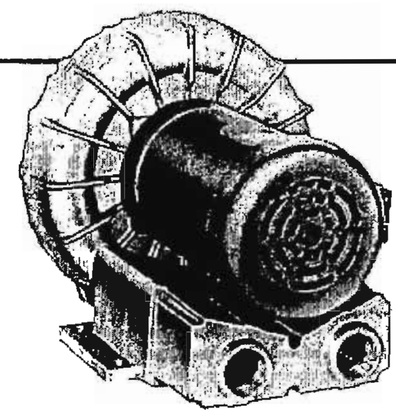
S-12X91 (Was S-5121P) Revised July, 1997

Printed in U.S.A.

Oilless Regenerative Blowers, Motor Mounted to 127 cfm

GAST

REGENAIR® R4P Series



MODEL R4P115

65" H_2O MAX. PRESSURE, 127 CFM OPEN FLOW
60" H_2O MAX. VACUUM, 125 CFM OPEN FLOW

MODEL R4P315A

63" H_2O MAX. PRESSURE, 127 CFM OPEN FLOW
59" H_2O MAX. VACUUM, 125 CFM OPEN FLOW

PRODUCT FEATURES

- Oilless operation
- TEFC motor mounted
- Can be mounted in any plane
- Rugged construction/low maintenance
- Class B insulation on motors
- Automatic restart thermal protection on single phase models

COMMON MOTOR OPTIONS

- 115/208-230V, 60 Hz; 110/220-240V, 50 Hz, single phase
- 208-230/460V, 60 Hz; 190-220/380-415V, 50 Hz, three phase

RECOMMENDED ACCESSORIES

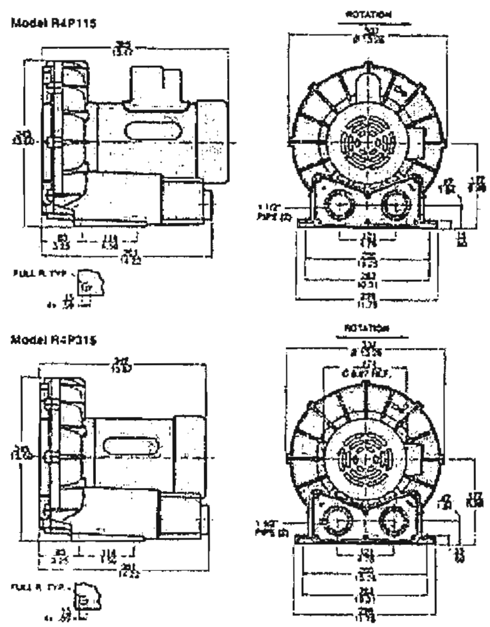
- Pressure gauge AE133
- Filter AJ126D (pressure)
- Vacuum gauge AJ497
- In-line filter AJ151E (vacuum)
- Muffler AJ121D
- Relief valve AG258
- Nema motor starter size – 1/0 (R4P115), 00/00 (R4P315A), for 60 Hz operation
- Moisture separator RMS200 (vacuum)

Various brand name motors are used on any model at the discretion of Gast Mfg. Corp.

Important Notice:

Pictorial, performance and dimensional data is subject to change without notice.

Product Dimensions Metric (mm) U.S. Imperial (inches)

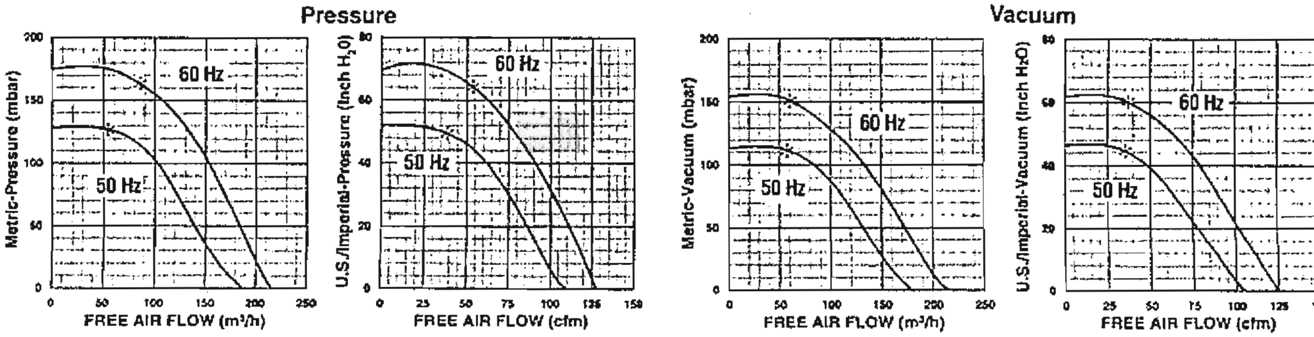


Product Specifications

Model Number	Motor Specs	Full Load Amps	Locked Rotor Amps	HP	RPM	Max Vac "H_2O	Max Vac mbar	Max Pressure "H_2O	Max Pressure mbar	Max Flow cfm	Max Flow m³/h	Net Wt. lbs.	Net Wt. kg
R4P115	110/220-240-50-1	16.0/8.0-9.3	49.0 @ 230V	1.0	2850	45	112	50	125	110	187	61	27,7
	115/208-230-60-1	20.7/11.2-10.4		1.5	3450	60	149	65	162	127	216		
R4P315A	190-220/380-415-50-3	3.9-4.3/1.9-2.0	18.5 @ 460V	1.0	2850	43	107	47	117	110	187	43	24,1
	208-230/460-60-3	5.1-4.9/2.5		1.5	3450	59	147	63	157	127	216		

Product Performance (Metric U.S. Imperial)

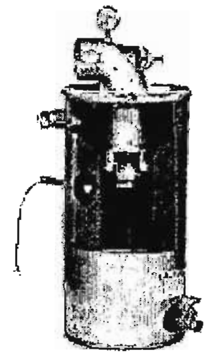
Pressure | Vacuum



*Recommended maximum duty.

Moisture Separator™

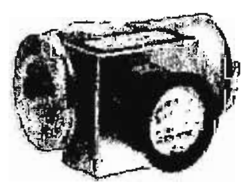
- By separating and containing entrained liquids, Rotron's moisture separator helps protect our regenerative blowers and the end treatment system from corrosion and mineralization damage. Recommended for all soil vacuum extraction applications.


Moisture Separator

Measurement Accessories

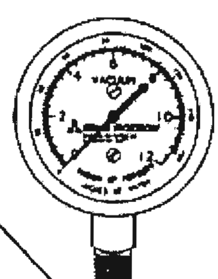
Air Flow Meter
(Analog, 4-20 mA, Digital Readout)

- Measures air flow rates to aid in the balance of multi-pipe systems, detect channeling or plugging of a line and allow system fine tuning for optimal performance. An optional 4-20 mA output can be used to achieve systems with fully automated flow control. Digital readouts in SCFM also available.


Air Flow Meter

Gauges and Relief Valves

- Rotron has a variety of gauges for pressure, vacuum and temperature measurements in various ranges. These gauges are reliable and rugged. The relief valve is installed to prevent excessive system pressure or vacuum that could result from line


Guage

CARBTROL

ACTIVATED CARBON PRODUCTS

CARBON CANISTERS AND ADSORBERS - Low and High Pressure

LIQUID PHASE:

	MODEL	FLOW	CARBON	PRESSURE	SIZE	WEIGHT
CANISTERS	L-1	10 GPM	200 LBS	10 PSI	24"Dx34"H	250 LBS
	HP-90	10 GPM	90 LBS	75 PSI	12"Dx53"H	125 LBS
	HP-200	10 GPM	200 LBS	75 PSI	22"Dx48"H	250 LBS
ADSORBERS	L-4	50 GPM	1000 LBS	11 PSI	4'Dx62"H	1500 LBS
	L-5	50 GPM	1800 LBS	11 PSI	48"Dx75"H	2400 LBS
	L-6	100 GPM	3000 LBS	11 PSI	60"Dx93"H	4000 LBS
	HP-1000	50 GPM	1000 LBS	75 PSI	36"Dx86"H	1500 LBS
	HP-1700	100 GPM	1700 LBS	75 PSI	48"Dx93"H	2300 LBS

VAPOR PHASE:

	MODEL	FLOW	CARBON	PRESSURE	SIZE	WEIGHT
CANISTERS	G-1	100 CFM	200 LBS	11 PSI	24"Dx36"H	240 LBS
	G-2	300 CFM	170 LBS	11 PSI	24"Dx36"H	210 LBS
	G-3	500 CFM	140 LBS	11 PSI	24"Dx36"H	180 LBS
ADSORBERS	G-4	600 CFM	1000 LBS	11 PSI	48"Dx36"H	1500 LBS
	G-5	1000 CFM	2000 LBS	2 PSI	4'x4'x75"H	2650 LBS
	G-6	600 CFM	1800 LBS	11 PSI	48"Dx86"H	2500 LBS
	G-7	2500 CFM	1600 LBS	11 PSI	48"Dx93"H	2000 LBS
	G-8	5000 CFM	3000 LBS	11 PSI	60"Dx93"H	4000 LBS
	G-9	2000 CFM	3000 LBS	11 PSI	60"Dx93"H	4000 LBS

LARGER SIZES AVAILABLE

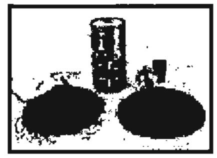
AIR PURIFICATION SYSTEMS

Our systems consist of an activated carbon canister with the blower attached in a factory assembled package complete.

Available capacities are: 75, 125, 300, 450, 1000 and 2000 CFM.

Systems up to 450 CFM are maintained in stock to meet emergency needs.

BULK ACTIVATED CARBON - Virgin or Reactivated



CARBTROL supplies only the highest capacity activated carbons produced to exacting specification.

	MESH SIZE	ACTIVITY	DENSITY	SURFACE AREA
VAPOR PHASE		(Typical)		
CSV (VIRGIN)	4X8	60 CTC	30-32 #/CF	1400-1600 M^2/GR
CSV (REACT)	4X10	55 CTC	30-32 #/CF	1200-1400 M^2/GR
LIQUID PHASE				
CSL (VIRGIN)	8X20	1100 I_2	30-32 #/CF	1200-1400 M^2/GR
CSL (REACT)	8X30	950 I_2	30-32 #/CF	1000-1200 M^2/GR

TECHNICAL SERVICES

CARBTROL is pleased to offer you complete technical assistance in evaluating your adsorption application. Our computerized adsorption performance programs accurately predict carbon system performance for hundreds of air and water contaminants.

CARBTROL also offers complete "Spent Carbon Take-Back" and Reactivation Services including assistance in profiling spent activated carbons. Our documented spent carbon tracking program assures that your carbon handling and reactivation is conducted in accordance with all appropriate regulations.

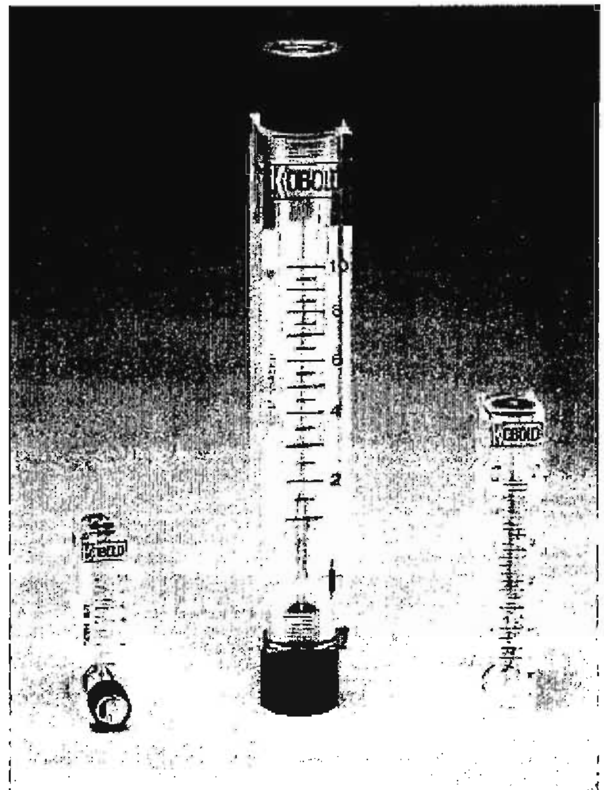
Return To:

CARBTROL Home Page	Packaged Treatment Systems	Remediation Treatment Equipment	Water Treatment Division

Please note: for ordering information, please request a catalog.
Return to flow products
Return to KOBOLD On Line Catalog Index

KFR - ACRYLIC FLOWMETER

Features



* Easy to read scales
* Water range: 0.001 to 20 GPM
* Air range: 0.002 to 100 SCFM
* Durable one-piece construction
* Low cost
* Metric scales on request

The KFR line of flowmeters offers the perfect balance between low-cost, accuracy and range availability. Bridging the micro-flow and large flow ranges, this meter can provide an effective solution to many industrial applications.

The KFR has a one-piece acrylic body with removable PVC or metal fittings for durability. To take the guesswork out of reading the flow, large lettering and extra hash marks make the scale clearly visible. Further enhancing readability, the low flow meters offer an inherently stable float design, while the larger meters feature a float stabilization mechanism. In the larger flow ranges, the stabilization mechanism allows KOBOLD to offer you a smaller installation footprint and a correspondingly lower price.

To further increase the value of the KFR product line, the low volume flowmeters (models KFR-1000 through KFR-4000) are available with integral needle valves.

Accuracy, value, low cost. Three not-so-mutually-exclusive attributes made possible by the KOBOLD KFR.

Applications

Specifications

* Air sampling equipment
* Chromatography systems
* Desalinization equipment
* Gas analyzers
* Medical systems
* Photoprocessing equipment
* Water treatment and distribution systems

OEM TARGET PRODUCT

Accuracy

Model 1000/2000: ±5% of full scale
Model 3000/4000: ±3% of full scale
Model 5000/6000: ±2% of full scale

Fittings: Female NPT

Max Pressure: 100 PSIG

Max Temperature: 150°F

Wetted Parts

Body: Clear Acrylic
Fittings: Brass, PVC or SS
Seals
Brass Fittings: Buna-N
PVC Fittings: Buna-N
SS Fittings: Viton

Float: Glass or SS
(See ordering tables)

Model KFR-1000/2000

Water				Air			
Range GPH	Float Material	Fitting Material Brass	Fitting Material SS	Range SCFH	Float Material	Fitting Material Brass	Fitting Material SS
0.2 - 2	Glass	KFR-1118	KFR-1218	0.1 - 1	Glass	KFR-2100	KFR-2200
0.4 - 5	SS	KFR-1119	KFR-1219	0.2 - 2	SS	KFR-2101	KFR-2201
1 - 10	Glass	KFR-1120	KFR-1220	0.4 - 5	Glass	KFR-2102	KFR-2202
2 - 20	SS	KFR-1121	KFR-1221	0.5 - 10	Glass	KFR-2103	KFR-2203
4 - 40	SS	KFR-1122	KFR-1222	2 - 20	SS	KFR-2104	KFR-2204
Options			Order Suffix	3 - 30	SS	KFR-2105	KFR-2205
Brass Inlet Needle Valve			-Y1	4 - 50	Glass	KFR-2106	KFR-2206
Stainless Steel Inlet Needle Valve			-Y2	10 - 100	SS	KFR-2107	KFR-2207
Hose Barb Adapters			-S	20 - 200	SS	KFR-2108	KFR-2208

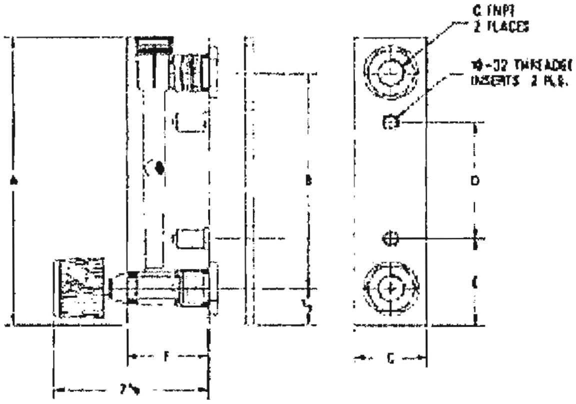
Model KFR-3000/4000

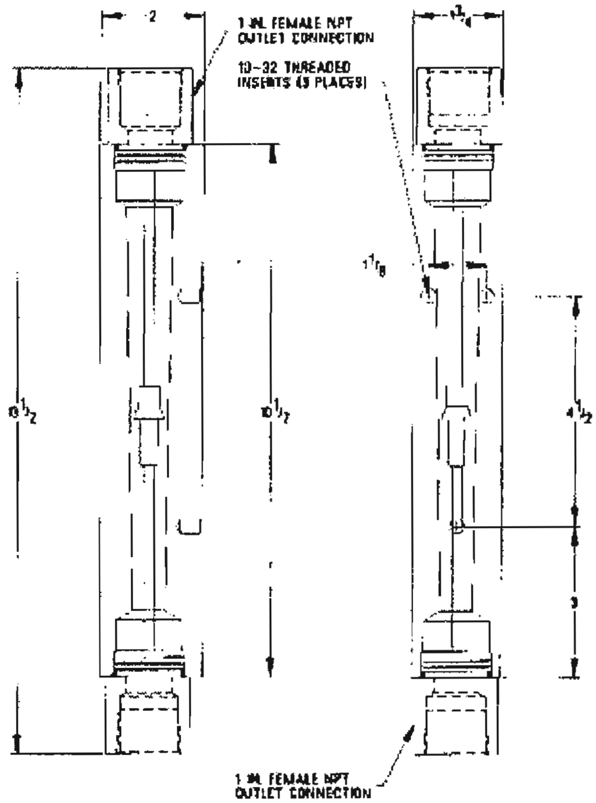
Water				Air			
Range GPH	Float Material	Fitting Material Brass	Fitting Material SS	Range SCFH	Float Material	Fitting Material Brass	Fitting Material SS
1 - 10	Glass	KFR-3145	KFR-3245	0.4 - 5	Glass	KFR-4130	KFR-4230
2 - 25	SS	KFR-3146	KFR-3246	1 - 10	SS	KFR-4131	KFR-4231
4 - 50	SS	KFR-3147	KFR-3247	2 - 20	Glass	KFR-4132	KFR-4232
6 - 60	SS	KFR-3148	KFR-3248	4 - 40	SS	KFR-4133	KFR-4233
				10 - 100	SS	KFR-4134	KFR-4234
Options			Order Suffix	14 - 150	SS	KFR-4135	KFR-4235
Brass Inlet Needle Valve			-Y1	20 - 200	SS	KFR-4136	KFR-4236
Stainless Steel Inlet Needle Valve			-Y2	SCFM			
Hose Barb Adapters			-S	0.3 - 3	SS	KFR-4137-Y1	KFR-4237

Model KFR-5000/6000

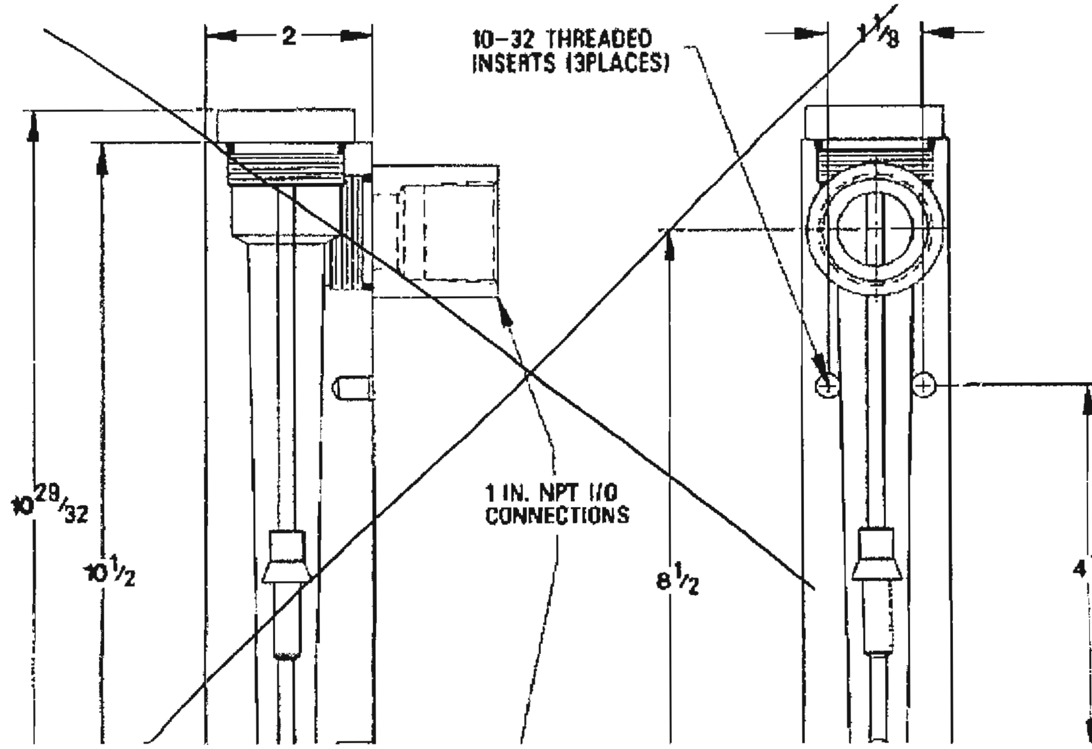
Water				Air			
Range GPM	Float Material	Fitting Material PVC		Range SCFH	Float Material	Fitting Material PVC	
0.4 - 5	SS	KFR-5356		3 - 25	SS	KFR-6350	

1 - 10	SS	KFR-5357	4 - 50	SS	KFR-6351
2 - 20	SS	KFR-5358	10 - 100	SS	KFR-6352
Options			**Order Suffix**		
Panel Mount Version with Rear Inlet/Outlet Fittings			- PM		





Dimensions in Inches							
Model	A	B	C	D	E	F	G
1000/ 2000	4	3	1	1-5/8	1-3/16	1-1/8	1/8
3000/ 4000	6-1/2	5-1/2	1-3/8	3-1/2	1-1/2	1-1/8	1/8



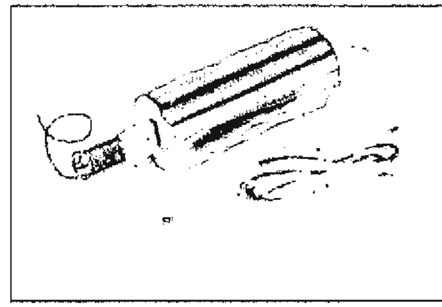
OMEGA
1-888-TC-OMEGA USA and CANADA
1-203-359-1660 INTERNATIONAL

OMJ Series

Smart Transducers for Remote Measurements Via Phone Lines

1 YEAR WARRANTY · OMEGA CARE · MADE IN USA

$ **595.00**
OMJ-PDI420



Click **here** for larger image.

- **Easy to Install Smart Transducers**
- **Compact Size**
- **Use Your PC to Collect and Analyze Data**
- **Conditioned Data is Transmitted Over Phone Lines**
- **Compatible with Windows Spreadsheets**
- **Transducer is Self-Powered Through Phone Line**

The OMJ Series is a family of smart transducers that send formatted data over standard phone lines.Transducer models are available to measure temperature, pressure, 4-20 mA current loops, and also tank level. The transducer converts the raw analog or digital information obtained from its sensor to a modulated data form that is transmitted over telephone lines, via a built-in modem. A personal computer can be programmed to contact multiple OMJ Series transducers in different remote locations. The remote interrogation ability of the OMJ Series allows cost-effective centralized data acquisition for applications ranging from remote locations anywhere in the world. OMJ Series transducers include all of the required electronics as well as the sensing element. No other signal conditioning or data gathering devices are required. OMJ Series transducers are self-powered by virtue of the phone line. There is no need for expensive power lines, backup systems, or batteries. Simply connect the unit as a normal transducer and plug in a phone line. OMJ Series transducers are FCC approved. Using the optional OMJ-SOFT data acquisition software and a PC with Windows, the information from multiple remote locations can be linked or pasted into a spreadsheet or other user-generated software. Once the information has been obtained from the transducer and entered into the PC, historical records can be generated and process control charts can be monitored. Since OMJ Series transducers communicate using a simple ASCII format, you may also connect to them with any PC running a standard communication or terminal emulation program. With the OMJ Series, it is possible to conduct state-of-the-art data acquisition at a very attractive cost per point. To use an OMJ Series transducer, simply connect it to the point of measurement in the manner of any typical transducer and plug it into a phone line. The unit is now fully operational. No power line hassles or expensive backup systems are required. In addition to the measurement/conditioning circuitry, each unit contains a 1200 baud auto answer modem connected to an RJ-11 phone jack. Each OMJ Series transducer is temperature profiled and calibrated at the factory. OMJ Series transducers are sealed in stainless steel and are highly resistant to water and corrosive atmospheres. When an OMJ Series transducer is called by a PC modem, the unit will respond on the first ring and report the current value of the measured parameter. The OMJ Series transducers will continue to issue updated readings every 10 sec until the dialing modem hangs up. The transmitted data is ASCII, 8 bit, no parity.

To Order (Specify Model Number) ?

Part Number	†Price	Description	Qty

OMJ-TPJ460	$495.00	Type J thermocouple input transducer (-40 to 860°F) -40 to 460°C	0
OMJ-TPK460	$495.00	Type K thermocouple input transducer (-40 to 860°F)-40 to 460°C	0
OMJ-PDI420	$595.00	Current loop transducer 0-25 mA	0
OMJ-TG0030	$695.00	Tank Gauge pressure transducer 0-30 PSI	0
OMJ-TG0300	$695.00	Tank Gauge pressure transducer 0-300 PSI	0
OMJ-DP0040	$695.00	Differential pressure transducer 0-40" H2O D	0
OMJ-DP0150	$695.00	Differential pressure transducer 0-15 PSID	0
OMJ-DP0400	$695.00	Differential pressure transducer 0-400" H2O D	0
OMJ-LPP040	$595.00	Gauge pressure transducer 0-40" H2O Gauge	0
OMJ-PP0015	$595.00	Gauge pressure transducer 0-15 PSIG	0
OMJ-PP0030	$595.00	Gauge pressure transducer 0-30 PSIG	0
OMJ-PP0300	$595.00	Gauge pressure transducer 0-300 PSIG	0
SWD-OMJ	$125.00	OMJ Series Windows software	0

Add to Cart View Cart Empty Cart Checkout

† *All dollar amounts on this site are shown in US currency.*
Note: Temperature models supplied with beaded wire thermocouple probe terminated with male subminiature thermocouple connector. All models include complete operator's manual.

Related Links

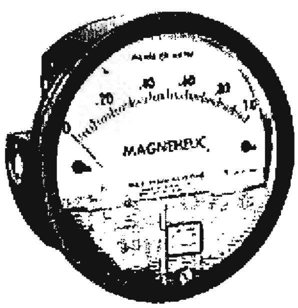
Literature

Download complete Product Specifications in PDF format.

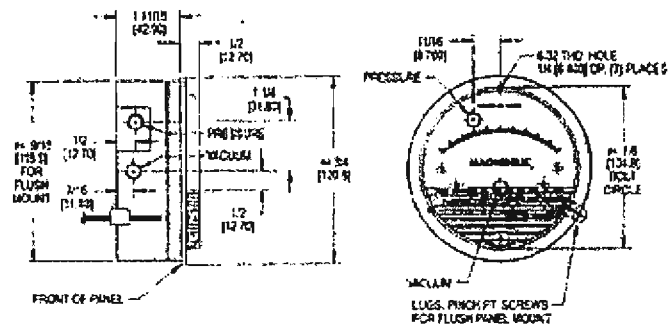
1-888-TC-OMEGA USA and CANADA
1-203-359-1660 INTERNATIONAL

Series 2000 Magnehelic® Differential Pressure Gages

Indicate low air or gas pressures-positive, negative or differential. Accurate within 2%. 81 Ranges.



Service Manual



Dimensional Enlargement

Select the Dwyer Magnehelic gage for high accuracy--guaranteed within 2% of full scale--and for the wide choice of 81 ranges available to suit your needs precisely. Using Dwyer's simple, frictionless Magnehelic movement, it quickly indicates low air or non-corrosive gas pressures--either positive, negative (vacuum) or differential. The design resists shock, vibration and over-pressures. No manometer fluid to evaporate, freeze or cause toxic or leveling problems. It's inexpensive, too.

Widely used to measure fan and blower pressures, filter resistance, air velocity, furnace draft, pressure drop across orifice plates, liquid levels with bubbler systems and pressures in fluid amplifier or fluidic systems. It also checks gas-air ratio controls and automatic valves, and monitors blood and respiratory pressures in medical care equipment.

Mounting. A single case size is used for most ranges of Magnehelic gages. They can be flush or surface mounted with standard hardware supplied. With the optional A-610 Pipe Mounting Kit they may be conveniently installed on horizontal or vertical 1 1/4" - 2" pipe. Although calibrated for vertical position, many ranges above 1 inch may be used at any angle by simply re-zeroing. However, for maximum accuracy, they must be calibrated in the same position in which they are used. These characteristics make Magnehelic gages ideal for both stationary and portable applications. A 4 9/16" hole is required for flush panel mounting. Complete mounting and connection fittings plus instructions are furnished with each instrument.

Vent valves

In applications where pressure is continuous and the Magnehelic gage is connected by metal or plastic tubing which cannot be easily removed, we suggest using Dwyer A-310A vent valves to connect gage. Pressure can then be removed to check or re-zero the gage.

HIGH AND MEDIUM PRESSURE MODELS

Installation is similar to standard gages except that a 4 13/16" hole is needed for flush mounting. The medium pressure construction is rated for internal pressures up to 35 psig and the high pressure up to 80 psig. Available in all ranges. Because of larger case, will not fit in portable case. Weight 1 lb., 10 oz. (Installation of the A-321 safety relief valve on standard Magnehelic gages often provides adequate protection against infrequent overpressure; see Bulletin S-101).

TO ORDER

PHYSICAL DATA

Ambient temperature range: 20° to 140° F.*
Rated total pressure: -20" Hg. to 15 psig.+
Overpressure: Relief plug opens at approximately 25 psig
Connections: 1/8'" NPT female high and low pressure taps duplicated - one pair side and one pair back.
Housing: Die cast aluminum. Case and aluminum parts Iridite-dipped to withstand 168 hour salt spray test. Exterior finish is baked dark gray hammerloid.
Accuracy: Plus or minus 2% of full scale (3% on - 0 and 4% on - 00 ranges), throughout range at 70°F.
Standard accessories: Two 1/8" NPT plugs for duplicate pressure taps, two 1/8" pipe thread to rubber tubing adapter and three flush mounting adapters with screws. (Mounting and snap ring retainer substituted for 3 adapters in MP & HP gage accessories.)
Weight: 1 lb. 2 OZ.

* Low temperature models available as special option.
+ For applications with high cycle rate within gage total pressure rating next higher rating is recommended. See Medium and High pressure options lower left.

OPTIONS AND ACCESSORIES

Transparent overlays

Furnished in red and green to highlight and emphasize critical pressures.

Adjustable signal flag

Integral with plastic gage cover; has external reset screw. Available for most ranges except those with medium or high pressure construction. Can be ordered with gage or separately.

LED Setpoint Indicator

Bright red LED on right of scale shows when setpoint is reached. Field adjustable from gage face, unit operates on 12 - 24 VDC Requires MP or HP style cover and bezel.

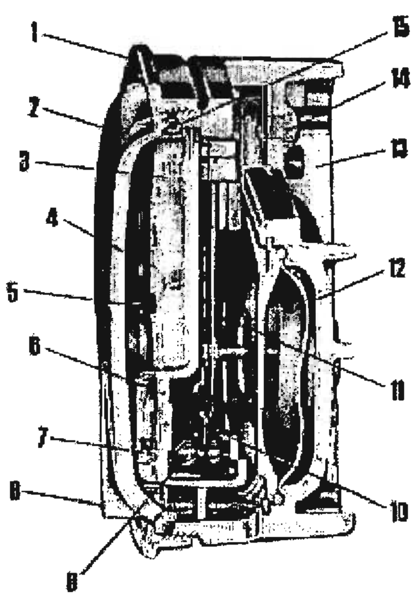
Portable units

Combine carrying case with any Magnehelic gage of standard range (not high pressure) includes 9 ft. of 3/16" I.D. rubber tubing, stand- hang bracket, and terminal tube with holder.

Air filter gage accessory package

Adapts any standard Magnehelic for use as an air filter gage. Includes aluminum surface mounting bracket with screws, two 5 ft lengths of 1/4" aluminum tubing, two static pressure tips and two molded plastic vent valves, integral compression fittings on both tips and valves.

Quality design and construction features



1. **Bezel** provides flange for flush mounting in panel.
2. **Clear plastic face** is highly resistant to breakage. Provides undistorted viewing of pointer and scale.
3. **Precision litho-printed scale** is accurate and easy to read.
4. **Red tipped pointer** of heat treated aluminum tubing is easy to see. It is rigidly mounted on helix shaft.
5. **Pointer stops** of molded rubber prevent pointer over-travel without damage.
6. **"Wishbone" assembly** provides mounting for helix, helix bearings and pointer shaft.
7. **Sapphire bearings** are shock-resistant mounted; provide virtually friction-free motion for helix. Motion damped with high viscosity silicone fluid.
8. **Zero adjustment screw** is conveniently located in plastic cover, accessible without removing cover. "O"

ring seal provides pressure tightness.

9. **Helix** is precision milled from an alloy of high magnetic permeability, deburred and annealed in a hydrogen atmosphere for best. magnetic qualities. Mounted in jeweled bearings, it turns freely to align with magnetic field of magnet to transmit pressure indication.
10. **Alnico magnet** mounted at one end of range spring rotates helix without mechanical linkages.
11. **Calibrated range spring** is a flat leaf of Swedish spring steel in temperature compensated design. Small amplitude of motion assures consistency and long life. It reacts to pressure on diaphragm. Live length adjustable for calibration.
12. **Silicone rubber diaphragm** with integrally molded "O" ring is supported by front and rear plates. It is locked and sealed in position with a sealing plate and retaining ring. Diaphragm motion is restricted to prevent damage due to overpressures.
13. **Die cast aluminum case** is precision made. Iridite-dipped to withstand 168 hour salt spray test. Exterior finished in baked dark gray hammerloid. One case size used for all standard pressure ranges, and for both surface and flush mounting.
14. **Blowout plug** of silicone rubber protects against overpressure on 15 PSIG rated models. Opens at approximately 25 PSIG.
15. **"O" ring seal** for cover assures pressure integrity of case.

SERIES 2000 MAGNEHELIC® GAGES STOCKED MODELS, RANGES

The models listed below will fulfill most requirements. Custom models can be provided for OEM customers. For special units with scales reading in ounces per square inch, inches of mercury, other metric units, etc., contact the factory.

TO ORDER

STOCKED MODELS

Model Number	Range, Inches of Water	Minor Div.
2000-00 +	0- .25	.005
2000-0 +	0- .50	.01
2001	0-1.0	.02
2002	0-2.0	.05
2003	0-3.0	.10
2004	0-4.0	.10
2005	0-5.0	.10
2006	0-6.0	.20
2008	0-8.0	.20
2010	0-10	.20
2015	0-15	.50
2020	0-20	.50
2025	0-25	.50
2030	0-30	1.0
2040	0-40	1.0
2050	0-50	1.0
2060	0-60	2.0
2080	0-80	2.0
2100	0-100	2.0
2150	0-150	50
2300-0 +	.25-0-.25	.01
2301	.5-0-.5	.02

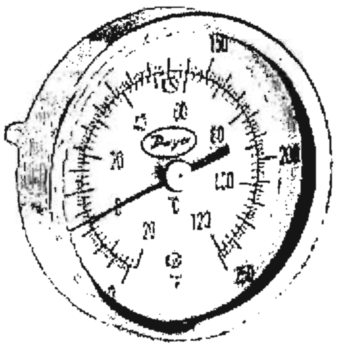
Model Number	Range PSI	Minor Div.
2201	0-1	.02
2202	0-2	.05
2203	0-3	.10
2204	0-4	.10
2205	0-5	.10
2210*	0-10	.20
2215*	0-15	.50
2220*	0-20	.50
2230**	0-30	1.0

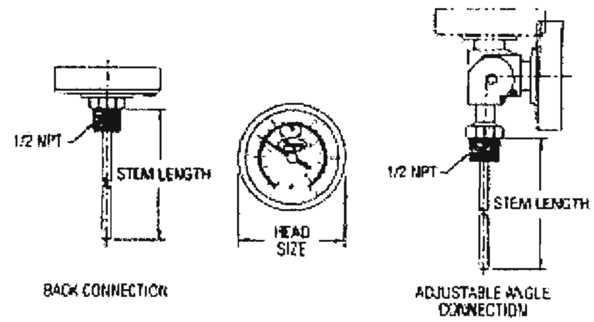
*MP option standard
**HP option standard

Dual Scale Velocity Units

Model Number	Range Inches of Water	Range Air Velocity F.P.M.
2000-00AV +	0-.25	300- 2000
2000-0AV +	0-.50	500- 2800
2001AV	0-1.0	500- 4000
2002AV	0-2.0	1000- 5600
2010AV	0-10	2000-12500

Series BT
Bimetal Thermometers
2", 3" or 5" Dial, Dual Scale, ±1% FS Accuracy, External Reset





Series BT Bimetal Thermometers offer accurate, reliable service even in the toughest environments. These corrosion resistant units are constructed form stainless steel and hermetically sealed to prevent crystal fogging. The bimetal element directly drives pointer, eliminating gears and linkage. An external reset screw allows field calibration and easy-to-read aluminum dial minimizes parallax error. Choose back connection or adjustable angle for easy viewing and installation. NOTE: When using in pressurized applications, use a suitable thermowell.

Model Number	Dial Size Stem Length	Temperature Range, °F(°C)	Degree Div., °F(°C)
Back Connection			
BTB2405D	2", 4"	0/250 (-20/120)	2 (2)
BTB2409D	2", 4"	200/1000 (100/500)	10 (5)
BTB3255D	3", 2 ½"	0/250 (-20/120)	2 (2)
BTB3405D	3", 4",	0/250 (-20/120)	2 (2)
BTB3605D	3", 6"	0/250 (-20/120)	2 (2)
BTB3407D	3", 4"	50/500 (10/260)	5 (5)
Adjustable Angle Connection			
BTA5405D	5", 4"	0/250 (-20/120)	2 (2)
BTA5605D	5", 6"	0/250 (-20/120)	2 (2)

TO ORDER

PHYSICAL DATA

Accuracy: ±1% full scale
Response Time: ≤ 40 seconds
Maximum Head Temperature: 200°F (93°C)
Maximum Stem Temperature: Not to exceed 50% over-range or 1000°F (538°C) or 800°F (427°C) continuously
Immersion Depth: Minimum 2" in liquids, 4" in gas
Stem Diameter: ¼" O.D.
Materials of Construction: 304 stainless steel stem, glass crystal, anodized aluminum dial, Series 300 stainless steel head, bezel and mounting bushing
Process Connection: ½" NPT (BTB models: 1/4" NPT)

APPLICATIONS

Temperature measurement in boilers, burners, ducts, air consitioning systems, furnaces, manifolds, stacks, steam generators, ventilation systems, refrigeration systems, piping, grain elevators, tanks, or any process application.

APPENDIX G

PERFORMANCE MONITORING FORMS

Biosparging Remediation Systems
Operation and Maintenance Log
Tank K Area – Former GE Facility
RTN 3-0518

Wilmington, Massachusetts

Date: ________________________ Personnel On Site:________________________________
Time: In__________Out_________ ______________________________
Weather:____

1. Visual Inspection (Circle) Comments

Equip. Enclosure Condition	Good Poor	______________________
Biosparging System Condition	Good Poor	______________________
SVE System Condition	Good Poor	______________________
Control Panel	Good Poor	______________________
Observation Wells	Good Poor	______________________

2. Systems Monitoring Data

Biosparging System: System Operating Upon Arrival: Yes No (Circle One)

Reason for shutdown: ____
____
____

System Re-Started: Yes No

If "No" Reason: ____
____
____

Complete attached Biosparging Monitoring Forms, which include forms for 1) the air compressor and main line and 2) the sparge points for each lateral (total of six forms; one form for each lateral A through E). Also, if applicable, complete attached Repair and Maintenance Forms for the Biosparging System.

SVE System: System Operating Upon Arrival: Yes No (Circle One)

Reason for shutdown: ____
____
____

System Re-Started: Yes No

If "No" Reason: ____

____

____

Complete attached SVE Forms, which include forms for 1) vacuum, pressure and flow measurements for the entire SVE system and 2) PID vapor measurements for the entire SVE system. Also, if applicable, complete attached Repair and Maintenance Forms for the SVE System.

At the end of the site visit, check if the remote monitoring system is operational by dialing the following number (   ) -   with the system "on" and "off " to confirm system status.

3. SVE Moisture Separator

Volume of water in moisture separator:________________gallons (approximate)

Water removed from the moisture separator: Yes No
If "yes", where stored or disposed of:______________________________________

____

____

High Level Switch Tested: Yes No

Secondary Containment (Empty ?) Yes No

If water was removed from the moisture separator, complete attached SVE Moisture Separator Log.

4. SVE GAC Treatment System

Carbon Changeout: Yes No

Carbon Changeout: Primary Secondary Both (Circle One)

If carbon changeout is performed, complete attached Carbon Changeout Log.

5. Waste Storage Inventory

Any drums of waste (spent carbon/separator water etc.) on-site: Yes No
If "yes" complete following section.

Drum Inventory Number	Contents	Volume in Drum	Date Generated

6. Groundwater Performance Monitoring

If "yes" to any below, complete attached performance monitoring forms.

	Water Levels		Field Parameters (pH, DO, etc.)		Laboratory Analytical	
WE-2	Yes	No	Yes	No	Yes	No
WE-4S	Yes	No	Yes	No	Yes	No
WE-4D	Yes	No	Yes	No	Yes	No
WE-7	Yes	No	Yes	No	Yes	No
WE-8	Yes	No	Yes	No	Yes	No
WE-9	Yes	No	Yes	No	Yes	No

Comments: ____

____

____

____

____

____

____

____

7. Pre-Departure Checklist

			Comments:
Biosparging System	On	Off	______________
SVE System	On	Off	______________
Moisture Separator Valve	Open	Closed	______________
Check Remote Monitoring System?	______		______________
Equipment Enclosure Locked?	______		______________
<u>Observation Wells</u> Closed?	______		______________
Site Clean and Neat?	______		______________
Call Office	______		______________