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December 18, 2018

VIA PRIVATE CARRIER

Mr. James R. Carroll
Program Administrator
Land Restoration Program
Land Management Administration
Maryland Department of the Environment
1800 Washington Boulevard, Suite 625
Baltimore, Maryland 21230

Subject: Transmittal of the Cow Pen Creek Bank Stabilization and Floodplain Reconstruction Monitoring: 2018 Report
Lockheed Martin Corporation – Middle River Complex
2323 Eastern Boulevard, Middle River, Baltimore County, Maryland

Dear Mr. Carroll:

For your review please find enclosed two hard copies with a CD of the above-referenced document. This report describes the results from the initial site monitoring, per the methods outlined in *Cow Pen Creek Bank Stabilization and Floodplain Reconstruction Monitoring Work Plan*. This report also provides an early assessment of restoration success and, as part of an adaptive management strategy, recommendations for future efforts at Lockheed Martin's Middle River Complex in Middle River, Maryland.

If possible, we respectfully request to receive MDE's document review comments by January 25, 2019.

Sincerely,

Thomas D. Blackman
Project Lead, Environmental Remediation

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COW PEN CREEK
BANK STABILIZATION AND FLOODPLAIN RECONSTRUCTION MONITORING: 2018 REPORT
LOCKHEED MARTIN MIDDLE RIVER COMPLEX
2323 EASTERN BOULEVARD
MIDDLE RIVER, MARYLAND

Prepared for:
Lockheed Martin Corporation

Prepared by:
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December 2018

Revision: 0

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ACRONYMS

BWI	Baltimore/Washington International Airport
CFS	cubic feet per second
CPC	Cow Pen Creek
GPS	global positioning system
Lockheed Martin	Lockheed Martin Corporation
MRC	Middle River Complex
SAV	submerged aquatic vegetation
Tetra Tech	Tetra Tech, Inc.

SECTION 1
INTRODUCTION

On behalf of Lockheed Martin Corporation (Lockheed Martin), Tetra Tech Inc. (Tetra Tech) conducted monitoring during July 2018 of the Cow Pen Creek (CPC) bank stabilization and floodplain reconstruction resulting from completion of the sediment remediation project at the end of 2017. Cow Pen Creek is located adjacent to the Lockheed Martin Middle River Complex (MRC) in Middle River, Maryland.

1.1 PURPOSE OF THE BANK STABLIZATION AND FLOODPLAIN RECONSTRUCTION MONITORING

As part of the sediment remedy at the Middle River Complex, the upper portion of Cow Pen Creek, including both the stream channel and adjacent floodplain area, was excavated to remove contaminated sediment. Subsequent to excavation, the areas were restored as per the approved project design (Tetra Tech, 2016a, 2016b). The restoration included reconstruction of the main channel and floodplains, placement of new channel substrate, streambank stabilization and vegetation, wetlands restoration, and revegetation of areas disturbed by sediment removal. The overall goal of restoration and mitigation was to replace the extent, function, and value for Cow Pen Creek wetlands and waters impacted by the remediation project. Documentation of the sediment removal action is provided in *Season Two Cow Pen Creek Sediment Remedy Completion Report* (Tetra Tech, 2018a).

This monitoring report focuses on bank stabilization and floodplain reconstruction of the upper (non-tidal and inter-tidal) stream portion of Cow Pen Creek. The overall objective of this monitoring is to evaluate whether the channel and its floodplain are remaining stable and maintaining expected vegetative cover during the post-construction period. Results of this first year of annual monitoring will be useful to assess progress toward project goals. The project design report (Tetra Tech, 2016a) called for streambank and floodplain monitoring over a five-year post-

construction period and specified the following performance measures for evaluating the restored channel of Cow Pen Creek during each year of monitoring:

- 85% (minimum) native vegetation cover on banks and floodplains
- 15% (maximum) barren ground on banks and floodplains
- 10% (maximum) unstable banks
- 85% (minimum) streambank length occupied by restoration treatments

1.2 OBJECTIVES

The objectives for the bank stabilization and floodplain reconstruction monitoring are to:

- assess the stability of stream banks along the restored section of Cow Pen Creek
- monitor the establishment of native vegetative cover and other restoration treatments along stream banks
- evaluate vegetation established in the reconstructed floodplain area

SECTION 2
EXISTING SITE CONDITIONS AND BACKGROUND

The Lockheed Martin Middle River Complex, which is part of the Chesapeake Industrial Park, is located at 2323 Eastern Boulevard in Middle River, Maryland, approximately 11.5 miles northeast of downtown Baltimore. The site consists of approximately 161 acres and twelve main buildings. The property also includes an active industrial area and yard, perimeter parking lots, an athletic field, a concrete-covered vacant lot, a trailer and parts storage lot, and numerous grass-covered green spaces along the facility's perimeter. Locked chain-link fences surround all exterior lots and the main industrial area. The site is bounded by Eastern Boulevard (Route 150) to the north, Dark Head Cove to the south, Cow Pen Creek to the west, and Martin State Airport to the east.

Beginning in 2014, Lockheed Martin initiated the removal of sediment contaminated by historical operations in several areas within Dark Head Cove and Cow Pen Creek. Portions of Dark Head Cove and the lower reaches of Cow Pen Creek were dredged and restored by the placement of a six-inch-thick sand layer (residual management layer). During the remedial action in the upstream portion of Cow Pen Creek, the stream channel was essentially removed and reconstructed. An overview of the stream and floodplain reconstruction area within Cow Pen Creek is illustrated in Figure 2-1. The extent of the stream and floodplain reconstruction in the upper portion of Cow Pen Creek is from station 8+00 to 19+00, according to design stationing notation. Using stationing notation established for post-restoration conditions, this restored area extends from station 0+00 to 11+00. All disturbed areas in this segment of the creek were stabilized, restored, and revegetated.

Existing functions and values (e.g., habitat, physical, and chemical conditions, as well as scenic, recreational, and other values) in Cow Pen Creek were restored to the extent practicable following the removal of contaminated sediment. The restoration plan was developed to target the replacement of specific functions and values by designing features to provide aquatic/fisheries habitat, provide moderate flood flow, stabilize the shoreline and retain sediment, remove toxicants,

and provide aesthetic and recreational values. Restored features including installing in-water structures and replanting emergent vegetation to restore/improve fisheries habitat, natural channel meanders were created, and floodplain forest/shrub vegetation was replanted to moderate flood-flow, stabilize shorelines, retain sediment and aid in reducing toxicants. Other features, including replanting of riparian vegetation, were designed to restore visual/aesthetic appeal of the stream corridor.

The design for restoration of Cow Pen Creek included the following elements:

- reconstruction of the main channel and floodplains
- placement of new channel substrate
- streambank stabilization
- revegetation of areas disturbed by the removal

Stream restoration features are detailed in the design documents (Tetra Tech 2016a, 2016b) and are summarized below.

2.1 MAIN CHANNEL AND FLOODPLAIN RECONSTRUCTION

The upper section of Cow Pen Creek was excavated, and the existing channel form was somewhat modified from its original configuration in accordance with the approved design. The restoration approach for this section of the creek was designed to reconstruct the channel and floodplain (as illustrated in Figure 2-2) placing clean fill material within the affected creek section. Newly constructed channel banks were stabilized by temporary erosion-control mats, and subsequently revegetated. Fill material was covered by topsoil suitable to promote establishment of floodplain vegetation. By reconstructing the channel and the floodplain, the project is intended to restore the creek's active channel, providing a more natural stream system that will benefit the resident fish species and improve flood flow functions and values in Cow Pen Creek.

2.2 CHANNEL SUBSTRATE

As part of the sediment remedy, a residuals-management sand layer was placed over all removal areas downstream of Station 19+00. Appropriate bed sediment composition for the non-tidal (Station 8+00 to 13+00) and inter-tidal (Station 13+00 to 19+00) portions of the creek was

determined using a hydraulic model completed for the creek. That analysis indicated that non-native bed material consisting of a graded mixture of silts to cobble-sized material, with a median grain size of 51 millimeters (two inches) and 25 millimeters (one inch) in non-tidal and inter-tidal areas (respectively), would withstand erosive forces while providing a suitable spawning habitat for resident fish. Based on the bed stresses from hydrodynamic modeling, the streambed substrate could transition to a graded sand (less than one-millimeter grain size) in the downstream portion of the inter-tidal area. Using appropriate channel substrate is intended to restore/improve fisheries habitat and flood flow functions/values by creating a more natural streambed.

2.3 STREAMBANK STABILIZATION

Streambanks that were disturbed during excavation, and thus were subject to erosion, were stabilized by grading to gentle slopes to allow for effective vegetative stabilization. Stabilization entailed adding woody structures (i.e., existing logs) and using conventional rigid techniques (e.g., rock toe). An approximately 200-foot segment along the Hawthorne neighborhood side of creek was stabilized and protected with rock toe structures. In the lower portion of the restored stream reach, wetlands were constructed along banks of the creek to allow planting of wetland vegetation and provide vegetative stabilization. Woody vegetative bank-stabilization techniques used living plant materials with the goal of providing a desired ecological benefit per MDE guidelines (MDE, 2000). Physical vegetative coverage on banks reinforces underground soil and protects the surface from scour by establishing a soil–root matrix. These methods have certain limitations as they might not withstand erosive flows (USDA, 2002), and therefore sites treated by vegetative bank-stabilization methods require monitoring to confirm stability.

Bank stabilization techniques used in the restoration included the use of temporary erosion control blankets followed by the installation of vegetation designed to replace the specific wetland types (i.e., emergent, forested, scrub-shrub wetlands), a root-wad revetment, and rock toe and fiber-roll toe protection. The live staking vegetative bank stabilization technique was also employed along certain sections of banks. A root-wad revetment was installed at a scoured location of the creek and was stabilized with other logs and rocks. The revetment is intended to enhance fish rearing habitat by providing scour pool and overhead cover habitat.

Woody debris removed from the creek and floodplains during clearing and excavation was cleaned of all adhering sediment and used in certain locations for restoration, bank stabilization, and toe protection. Useable, large woody debris included debris with structural integrity and of sufficient size to provide bank stabilization and/or stream cover for fish habitat. The preferred use of natural, woody debris and other vegetative stabilization was intended to help to stabilize shorelines, restore visual/aesthetic appeal of the stream corridor, and restore/improve fisheries habitat by creating overhanging vegetation.

2.4 REVEGETATION

The revegetation plan for the upper portion of Cow Pen Creek included measures to restore upland, forested wetland, and scrub-shrub wetland in excavated areas of the creek. Native forest and scrub-shrub plant species typical to streams along the upper Chesapeake Bay were replanted in the areas disturbed and excavated along Cow Pen Creek.

The species list and planting plan was provided as part of the restoration design (Tetra Tech 2016a). Restoring riparian vegetation and shoreline/banks in affected areas is intended to promote shoreline vegetative cover, which will provide bank stabilization and habitat and food for resident fish. Restoration of native vegetative habitats was designed to restore/improve overall habitat, stabilize shorelines, retain and remove sediment and toxicants, and restore visual/aesthetic appeal of the stream corridor.

The restored wetland areas, reconstructed floodplain, and creek channel will be evaluated annually from 2018 – 2020, with optional monitoring in 2021, to determine if the restoration project has met performance standards as specified in the project design report (Tetra Tech, 2016a). These standards for the floodplain and streambanks are listed in Section 5.1. Monitoring will be employed to track conditions annually, with the expectation that performance standards will be met by the end of this multi-year monitoring period.

SECTION 3
STREAMBANK, FLOODPLAIN, AND UPLANDS DATA COLLECTION

3.1 MONITORING

Monitoring was conducted on July 26-27, 2018, and monitoring activities followed the methods detailed in the *Cow Pen Creek Bank Stabilization and Floodplain Reconstruction Monitoring Work Plan* (Tetra Tech, 2018b). The site conditions at the time of monitoring represent the post-two-year or higher rainfall event based on rainfall data and the hydrology/hydraulics of the creek. Year 2018 monitoring represented the first year of post-construction monitoring. Per the monitoring work plan, bank stabilization and floodplain reconstruction monitoring will be conducted once per year (during the summer) from 2018 through 2020 with optional monitoring in 2021.

3.1.1 Weather and Tidal Conditions

Each year, monitoring is to be conducted during the window of June to August, after a two-year or higher flow event. If a two-year flow event does not occur between June and August for a given year, monitoring would instead be conducted in September, preferably after a rain event. Precipitation frequency estimates prepared for the restoration design's hydrology and hydraulics study of the sediment remedy design (Tetra Tech 2016a, Appendix A) indicate that a 24-hour rainfall total of 3.3 inches represents the two-year storm event; the corresponding two-year flow for Cow Pen Creek is estimated at 19.2 cubic feet per second (cfs).

During June–July 2018, field staff tracked weather conditions to select an appropriate qualifying two-year event. Daily rainfall totals for the dates before and during the sampling period are shown in Table 3-1. Rainfall was widespread throughout the Baltimore area on July 21-24, 2018. At Baltimore/Washington International Airport (BWI), 4.77 inches of rain fell on July 21 and 4.07 inches fell on July 24. At Baltimore Inner Harbor, more than two inches of rain fell on July 21 and more than one inch on both July 24 and 25. Based on this rainfall and allowing sufficient time for

water levels to return to a safe level for accessing Cow Pen Creek, monitoring was conducted on July 26-27.

Weather for the two days of monitoring was clear to partly cloudy to cloudy. Rainfall on July 27, 2018 occurred after monitoring was complete.

Monthly precipitation totals for July 2017 to July 2018 are shown in Figure 3-1 and Table 3-2. Baltimore received slightly below-average rainfall during fall 2017. Precipitation totals were above average during February, April, May, and July 2018, with more than twice the average rainfall in May and July 2018.

Observed tidal water levels at NOAA's Fort McHenry station, Patapsco River, were above long-term predicted levels during the July 26-27, 2018, monitoring period, with an average of 0.55 feet above predicted tide levels (Figure 3-2). Tide levels during the days preceding the monitoring were even higher. An examination of Fort McHenry water level data for May-July 2018 showed that higher-than-predicted water levels were common during this period.

3.1.2 Assessment of Streambanks

Visual observations followed the methods detailed in the monitoring plan (Tetra Tech 2018b) and were used to evaluate streambank stability and vegetative cover. Field methods for assessing streambank stability and vegetative cover were derived from guidance by Harris (2006) and Volkman (2006), which provide a quantitative characterization along linear segments of streambank. The data therefore support estimates of the percentage of streambank length in particular classes, for example, the percentage of streambank length with these observed conditions:

1. No vegetation, stable, no erosion
2. No vegetation, unstable, actively eroding
3. Vegetation, stable, no erosion
4. Vegetation, unstable, actively eroding

Conditions observed during this initial post-construction monitoring in 2018 will be compared to future events to assess changes in bank stability over time.

Streambank visual observations were made from the water's edge to the top of the bank. The entire length within the restored reach of Cow Pen Creek (post-construction stations 0+00 to 11+00, the same area designated with original stationing as 8+00 to 19+00) was assessed. Observers worked in a downstream direction beginning at the upstream end of the restored reach (station 0+00) and proceeded downstream to the lower end. Monitored locations, the upper and lower ends of the entire reach, and intermediate points along the bank were recorded by the field team using global positioning system (GPS) instruments. Each bank (right bank and left bank, looking downstream) was assessed separately. Data were recorded electronically using a custom-designed form built within the ArcGIS collector application. Locations of field observation points were recorded at the water's edge using GPS, so that each point will serve as a reference point for recording future observations.

Longitudinal sections of the stream bank were designated by using station notation. Proximity to existing features such as guardrail, stairs, outfalls, or gabion walls was noted. At each section, observations of vegetative cover, bank stability, and erosion were recorded. The upper and lower end of each longitudinal segment was designated (to the nearest foot) using station notation and the distance along the stream thalweg (the line of lowest elevation in the stream) was used to measure and record segment break points (e.g., Segment 0+00 to 0+75, Segment 0+75 to 1+60). After field work was complete, the segment length distances along the thalweg were verified using the as-built channel survey.

To provide additional information on vegetative cover, the field crew also recorded the presence of woody vegetation within three height class categories at each segment: less than three feet, 3-15 feet, and more than 15 feet. The crew recorded the presence of herbaceous cover (if more than 10% vegetated), barren (if less than 10% vegetated), and noted the presence of large woody debris, rock, or other restoration structures where vegetation was not present. Presence of invasive species was also recorded.

Bank conditions were documented by taking digital photographs of each segment at regular intervals along the right and left banks, and by representative photographs looking upstream and downstream. Photographic locations were recorded (GPS point, direction) so that similar views can be photographed during each year of the monitoring survey.

3.1.3 Assessment of Reconstructed Floodplain

The reconstructed floodplains were similarly monitored, and their stability will also be assessed over time (as compared to this initial monitoring) through observations of the establishment of vegetation. The reconstructed floodplain will be monitored for three years after the project construction (2018 through 2020) with optional monitoring in 2021, during the same site visits as the bank assessments.

During July 2018 monitoring, as with the streambank assessments, observations began at the upper end of the restored reach (station 0+00) and extended to the lower end of the restored stream section (station 11+00). To assess vegetation condition, a series of 10 transects was established, leading out from the top of bank to the edge of the floodplain within the reconstructed area. Within each of three sections along the restored reach (0+00 to 3+00, 3+00 to 7+00, and 7+00 to 11+00), sets of three transects were established: at the upstream end, at one-third of the way downstream, and at two-thirds of the way downstream. The downstream end of the last section was also assessed. Depending on their location along the stream, transects crossed through areas of upland, forested wetland, and scrub-shrub wetland that had been planted as part of the restoration project.

For each floodplain transect, locations of the initial field observation point for each side (left and right bank) were recorded at the top of bank using GPS, providing locations that will serve as fixed reference points for future observations. If the bank erodes outward, these points can be used to evaluate the extent of that observed lateral erosion. Along each transect, the field crew ran a measuring tape and recorded (in feet, from the distance at the top of bank) the presence of vegetation in segments. In addition, a GPS point was recorded at the start of each new segment, moving outward from the stream. Segment breaks were made where changes in condition were noted. Break points were also noted at transitions between vegetation community types (upland vs. wetland). After field work was complete, segment distances by vegetation community type were confirmed using the revegetation plan.

Within each segment, coverage was noted as vegetated or not vegetated. “Not vegetated” is defined as having less than 10% vegetative cover along the linear segment assessed. The field crew also recorded the presence of woody vegetation along each segment within three height class categories: less than three feet, 3–15 feet, and more than 15 feet). The crew recorded the presence

of herbaceous cover (if more than 10% vegetated) or noted as barren (if less than 10% vegetated). Presence of invasive species was recorded. Any observed bare spots larger than 10 square feet in the reconstructed floodplain area were also noted.

Vegetative conditions along the floodplain were documented by taking photographs at regular intervals along transects, and by representative photographs looking across the replanted areas. Photographic locations were recorded (GPS point, direction) so that similar views can be photographed during each year of the monitoring survey.

SECTION 4
DATA COLLECTED

4.1 SUMMARY OF DATA COLLECTED

Within the Cow Pen Creek (CPC) study area, data were collected along streambanks and in transects across the floodplain (Figure 4-1). Findings of the field assessments are described below. Locations of representative photographs along the channel and other views are shown on Figure 4-2. Appendix A is a photo log containing representative photographs of the channel (upstream and downstream views at transect locations) and photographs taken from streambank assessments, floodplain transects, and other views. Appendix B lists global positioning system (GPS) coordinates at field assessment points for both the streambank and floodplain assessments.

4.1.1 Streambank Assessment

Streambank assessment data for the individual bank segments are in Table 4-1, including assessments of bank condition according to the following classes:

- Vegetation cover present (yes or no)
- Bank stability (stable or unstable)
- Active erosion (yes or no)

Additional details about vegetation, presence of invasive species, and proximity to structural features are in Table 4-2. Summary indicators were independently assessed and calculated separately for both banks, and as combined overall values for the entire restored stream reach. Summary results are in Table 4-3.

Stable conditions were observed along 92% of total stream bank length (2113 of 2300 total feet). Stable banks without vegetation included several areas with structural stabilization treatments (158 feet total, 6.9% of total bank length), including a 34-foot section of the left bank armored with a rootwad structure (see Figure A-14) and several sections (124 feet total) of unvegetated rip-

rap along the right bank (see example, Figure A-10). A 119-foot portion of the lower right bank lacked vegetation but had matting in place and deposits of fine sediment (Figure A-19). Another two segments (93 feet total) of the lower right bank appeared to be unvegetated yet stable; these sections were near the downstream end of the project and were stabilized with matting, coir log, and wood (Figures A-26 and A-27). Overall, 1770 feet of the total bank length was vegetated, representing 82.6% of the unarmored bank length. Of this vegetated total bank length, 1743 feet were observed to be stable with no evidence of erosion. An example of stable, vegetated bank is shown on Figure A-8.

Bank erosion (Figure 4-3) was observed along 8.1% (187 feet) of total bank length, 7% (160 feet) without vegetation, and 1.2% (27 feet) with vegetation. On the left bank, only one small area (noted as 9 linear feet) was eroding from under matting due to runoff (Figure A-2). On the right bank, erosion was noted in several sections (178 linear feet total), the longest (53 linear feet) of which was associated with a red clay bank, which had matting installed on the lower bank (Figure A-25).

The presence of herbaceous vegetation is one indication of vegetation establishment. Along most of the vegetated streambank, herbaceous vegetation was growing well. Areas that lacked herbaceous vegetation included:

- Along the left bank, the lower part of this streambank and the adjacent floodplain were underwater at the time of sampling and appeared to be frequently inundated (e.g., Figure A-20).

- On the right bank, a few sections of streambank lacked herbaceous cover, and were associated with sediment erosion (e.g., Figure A-4), sediment deposition and elevated water level (e.g., Figure A-19), or clay banks where vegetation did not establish, particularly in areas of elevated water level associated with tidal influence.

Presence of woody vegetation was also recorded. Along streambanks, woody vegetation was present in two height classes, those less than three feet tall and those 3-15 feet tall. Some of the planted woody vegetation, particularly in the lower part of the restored area, showed poor survival (e.g., Figure A-23). In the planted wetland flat areas, woody plants appeared to be subjected to frequent inundation, as evidenced by the presence of submerged aquatic vegetation (SAV).

Phragmites was present along the streambank in some of the uppermost segments (see Figure 4-4); no other invasive plants were noted.

4.1.2 Floodplain Vegetation Assessment

Floodplain assessment data for the 10 transects and for individual segments within transects are summarized in Table 4-4, including: the presence of herbaceous vegetation (yes/no), presence of woody vegetation in three size classes (less than three feet tall, 3-15 feet tall, and more than 15 feet tall), presence of invasive species (yes/no), and notes. Segment breaks were indicated by a change in vegetation type or condition. Transects were subdivided into wetland (floodplain) and upland segments by cross-checking field observations with mapped information on the vegetation type planned for the restoration effort.

Summary values were independently assessed and calculated separately for both banks, and as combined overall values for the entire set of assessed transects. Summary results in Table 4-5 are also broken into the two classes (wetland vs. upland revegetation).

Across all transects, 10% (80 feet) of the assessed segment length lacked herbaceous vegetation. The longest area (48 feet) was in the lower right bank, where a wetland mudflat was present (transect at 8+33, Figure A-50). The other two areas without herbaceous vegetation (20 and 12 feet long) were both on the right bank under existing tree canopy.

Overall, 10% (89 feet) of the assessed segment length lacked woody vegetation in surveyed transects. Much of this total length (35 feet) was in four streamside areas, which were planted only in grasses, and where woody vegetation was not expected. A large fallen tree was within one 14-foot segment on the right bank (transect at 7+00). There was also a 40-foot section of upland vegetation on the left bank near the downstream end of the project area (transect at 11+00), where vegetation was sparse and lacked woody vegetation.

A substantial number of trees, particularly within the forested wetlands planted at the lower end of the project area, were dead at the time of monitoring. These forested wetland areas had signs of longer than anticipated inundation, and SAV was growing between the planted trees. On July 26, 2018, approximately 40 dead trees were noted in the wetland area outside of tree tubes, and 50 trees within the wetland area inside tree tubes were also dead. The field team observed additional dead trees in the upland area. Coincidentally, construction field staff were onsite on July 27 removing tree tubes from trees throughout much of the project area.

During floodplain transect assessment, invasive plants (phragmites) were noted within or near the uppermost transects, on both sides of the stream. No other invasive plants were noted.

Eight bare patches greater than 10 square feet were noted and photographed (Table 4-6), seven in wetland areas and one in the upland area. In addition to these areas, additional patches were noted where planted vegetation was sparse, and netting was visible (see example, Figure A-45). These areas of sparse vegetation were noted but not counted as individual bare patches since they were not completely bare.

Locations of particular areas with notes about erosion or vegetation cover concerns are shown on the map in Figure 4-5.

Start points of floodplain monitoring transects, which had been field-placed at the top of bank on both sides of the stream, corresponded well with as-built survey contours, as illustrated in Figure 4-6. These benchmarks can be used in future years to check for lateral erosion of the banks.

4.2 COMPARISON OF DATA TO OTHER EVENT DATA

This section is reserved for future monitoring reports in which data will be compared across years, including comparison of future years' findings to the (initial) 2018 data herein.

SECTION 5
CONCLUSIONS AND RECOMMENDATIONS

5.1 COMPARISON TO PERFORMANCE MEASURES

The project design report (Tetra Tech, 2016a) specified four performance measures for evaluating the restored channel of Cow Pen Creek during each year of monitoring. This section lists those measures and provides supporting summary information from the 2018 monitoring.

- 10% (maximum) unstable banks
    - Streambank was unstable/eroding along 8% of its length (187 of 2300 feet).
    - Streambank was stable, with no erosion, along 92% of its length (2113 of 2300 feet)
- 85% (minimum) streambank length occupied by restoration treatments:
    - Approximately 93% (2140 of 2300 feet) of total streambank length was occupied by restoration treatments
    - Vegetation was present on 1770 of 2140 feet, and 370 of 2140 feet were covered by other treatments (rootwad, rip-rap, and stable matting/coir).
- 85% (minimum) native vegetation cover on banks and floodplains
    - Vegetation covers 83% (1770 feet) of the unarmored bank length (2142 feet)
    - Invasive vegetation (phragmites) was being actively treated in the several limited small areas of banks and floodplain in the upper portion of stream. Spraying for control for phragmites in the floodplain was observed on July 27, 2018 during monitoring. Follow-up inspections for invasive species along the streambank should be conducted, and spraying applied, if warranted.
- 15% (maximum) barren ground on banks and floodplains
    - Nearly 7% of the total bank length (160 of 2300 feet) was barren (without vegetation or other bank treatments).
    - Approximately 25% of floodplain wetland area was documented as bare, based on observations obtained during the October 2018 field inspection (see Figure 4-1 in the wetland restoration monitoring report [Tetra Tech, Inc., 2018c])

- Bare areas in the upland area of the creek were minimal.

The influence of tidal water levels on the vegetated area should be considered. During the 2-day monitoring period in July 2018, water levels at NOAA's Fort McHenry station were on average 0.55 feet above predicted tide levels and had been even higher during the preceding days. Higher-than-predicted water levels were also common during the preceding months (May-July).

In the floodplain area, it is possible that some settling has occurred post-construction, in comparison with elevations at time of construction. However, data were not collected to specifically confirm whether settling has occurred.

5.2 FUTURE MONITORING/MAINTENANCE EVENTS

The next monitoring event for the streambank stabilization and floodplain assessment is planned for summer 2019. During or prior to 2019 monitoring, areas with sparse vegetation in 2018 should be re-assessed to determine whether plant growth is adequately filling in those areas, or whether further plantings and/or seeding are needed to augment and fill in those areas.

Recommended maintenance activities for fall 2018 or spring 2019 are as follows:

- Revisit areas noted with phragmites, determine whether treatments to date have effectively controlled growth of phragmites, and spray as needed to eliminate spreading.
- Address bare patches identified along streambank and in floodplain areas by replanting or reseeding.
- Address tree mortality, particularly in wet areas near the lower end of project area. Revise stabilization approach and species list, as this area is likely wetter than was originally anticipated. See the wetlands monitoring report for further discussion of tree mortality.

5.3 OTHER RECOMMENDATIONS

Other recommendations include an evaluation of current and anticipated future hydrologic conditions. Since the time of construction, the site is experiencing wetter conditions than were characterized in the design stage hydrology/hydraulic study, which may explain the challenges of establishing wetland vegetation. This new assessment of hydrologic conditions may be needed to better represent the higher water levels that have been observed and that may continue to persist.

SECTION 6
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United States Department of Agriculture (USDA), 2002. *A Soil Bioengineering Guide for Streambank and Lakeshore Stabilization*, FS-683. United States Department of Agriculture Forest Service Technology and Development program. San Dimas, California.

Volkman, J., 2006. Effectiveness Monitoring in Habitat Enhancement Areas. Umatilla Tribe.

FIGURES

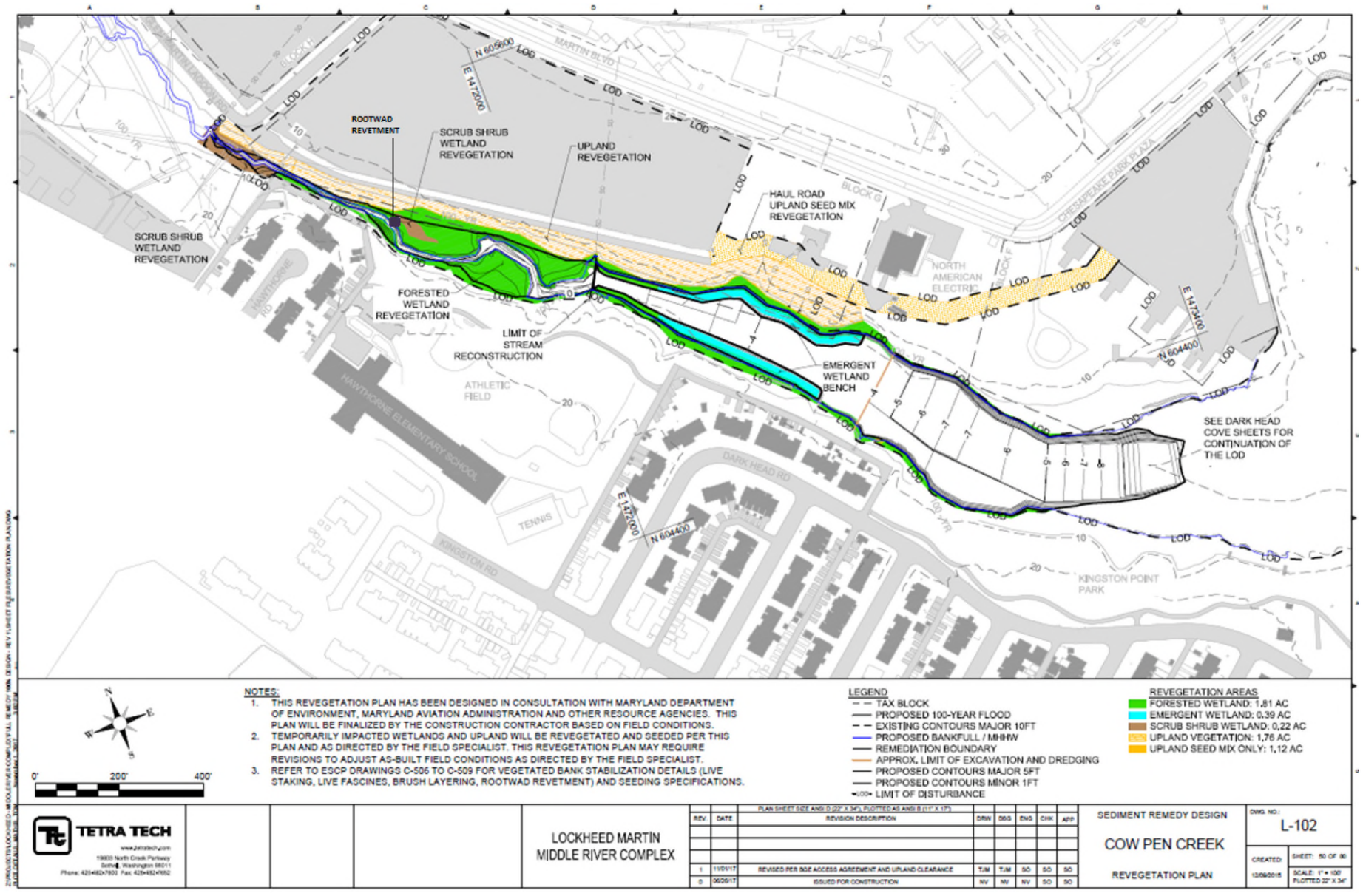
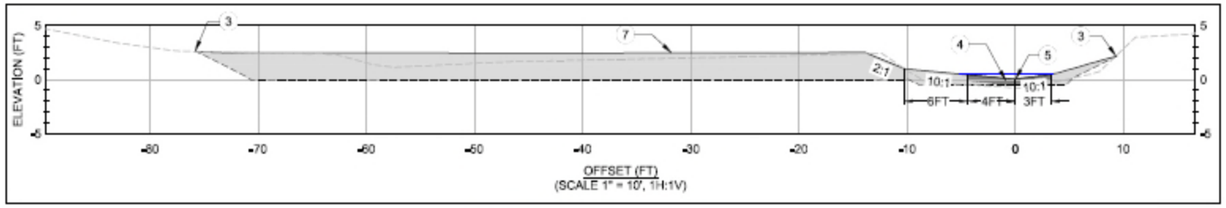


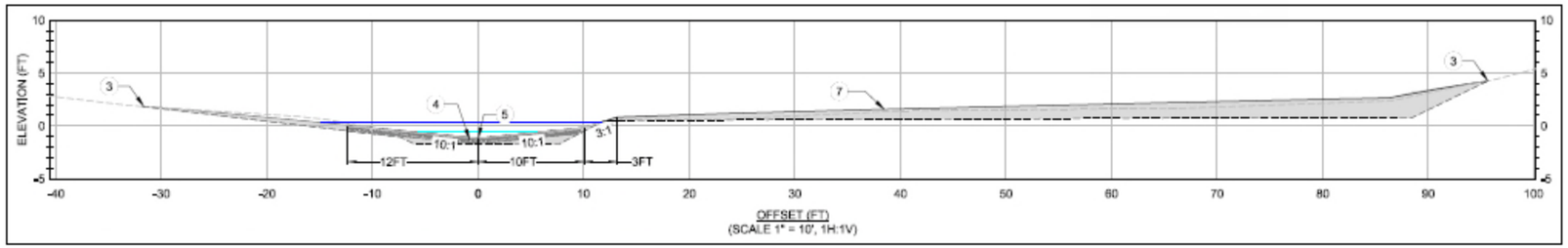
Figure 2-1 Extent of Cow Pen Creek Stream Channel and Floodplain Reconstruction

Source: Tetra Tech, Revegetation Plan, Nov. 20, 2017

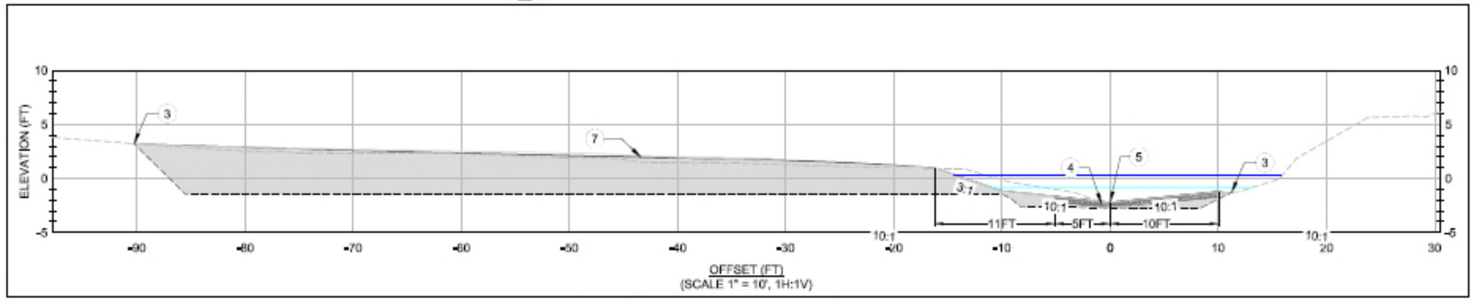


H C-225 CROSS SECTION AT STATION 6+72

NOTES:
3 EXISTING GRADE MATCH POINT.
4 STREAMBED MIX WILL BE PLACED ALONG BOTTOM OF CHANNEL AT 6IN MINIMUM DEPTH.
5 PROPOSED THALWEG.
7 PLACE TEMPORARY EROSION CONTROL MAT ALONG EXCAVATED AND BACKFILLED SLOPES.



I C-226 CROSS SECTION AT STATION 8+66



J C-226 CROSS SECTION AT STATION 9+75

LEGEND:
EXISTING GRADE
PROPOSED GRADE
REMEDIATION GRADE
BACKFILL
TOE ROCK
STREAM BED MIX
PROPOSED BANKFULL/MHHW
PROPOSED BASEFLOW/MLLW

TETRA TECH
www.tetratech.com
19803 North Creek Parkway
Bothell, Washington 98011
Phone: 425-483-7600 Fax: 425-483-7662

PROFESSIONAL CERTIFICATION: I HEREBY CERTIFY THAT THESE DOCUMENTS WERE PREPARED OR APPROVED BY ME, AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MARYLAND, LICENSE NO. 45103, EXPIRATION DATE: 03-24-2019

LOCKHEED MARTIN
MIDDLE RIVER COMPLEX

REV.	DATE	REVISION DESCRIPTION	DRW	DSG	ENG	CHK	APP
0	09/12/18	ISSUED FOR CONSTRUCTION	NV	NV	NV	SO	SO

PLAN SHEET SIZE ANSI D (22" X 34"), PLOTTED AS ANSI B (11" X 17")

SEDIMENT REMEDY DESIGN
COW PEN CREEK
STREAM RESTORATION SECTIONS

DWG. NO.: C-231
CREATED: 12/28/2015
SHEET: 46 OF 80
SCALE: 1" = 5'
PLOTTED 22" X 34"

Figure 2-2 Example Stream and Floodplain Cross-sections, Cow Pen Creek Restoration

Source: Tetra Tech, 2016b

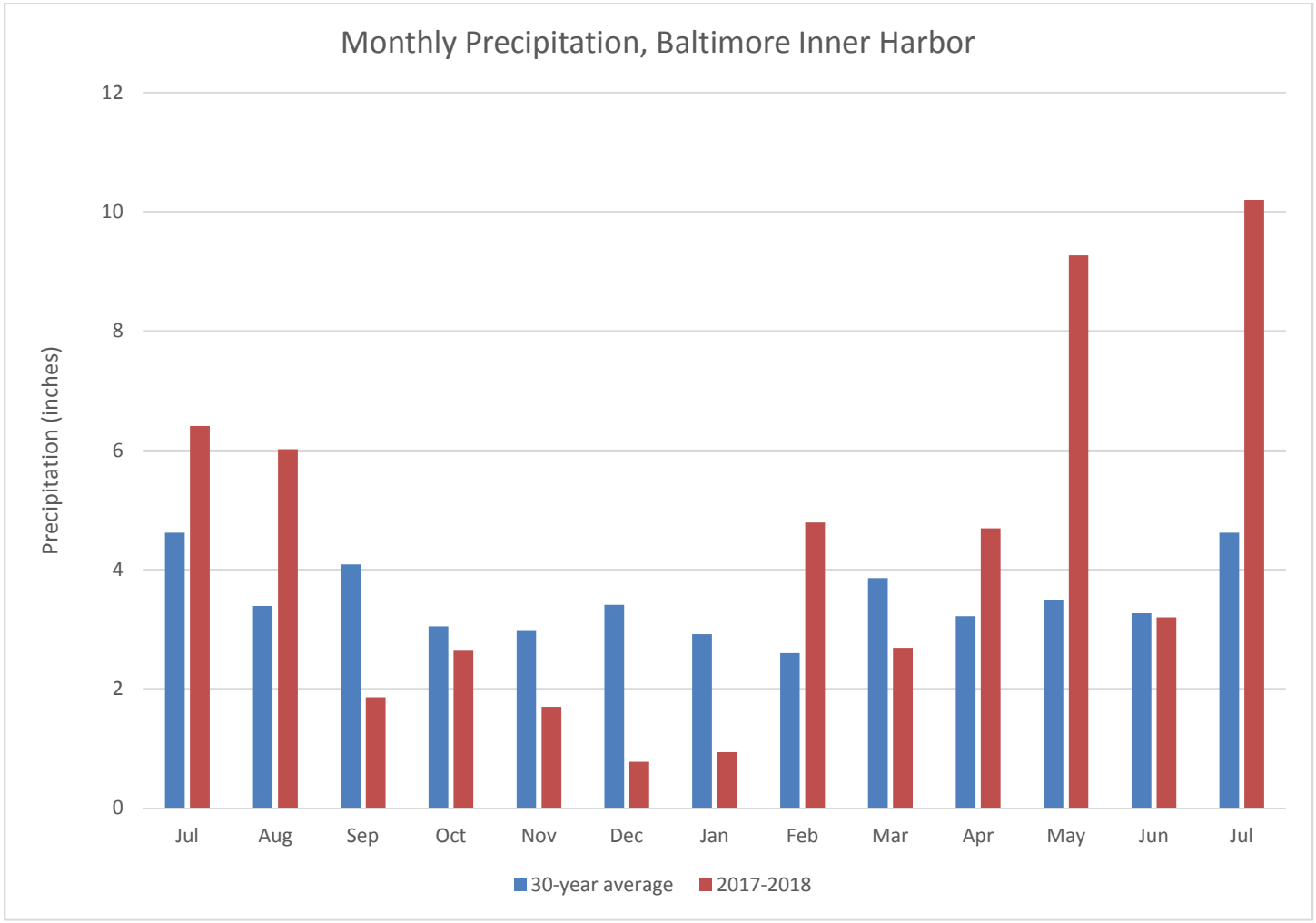


Figure 3-1 Monthly Precipitation Totals July 2017 to July 2018, Baltimore Inner Harbor

Based on data from National Weather Service, summarized by Iowa State University, https://mesonet.agron.iastate.edu

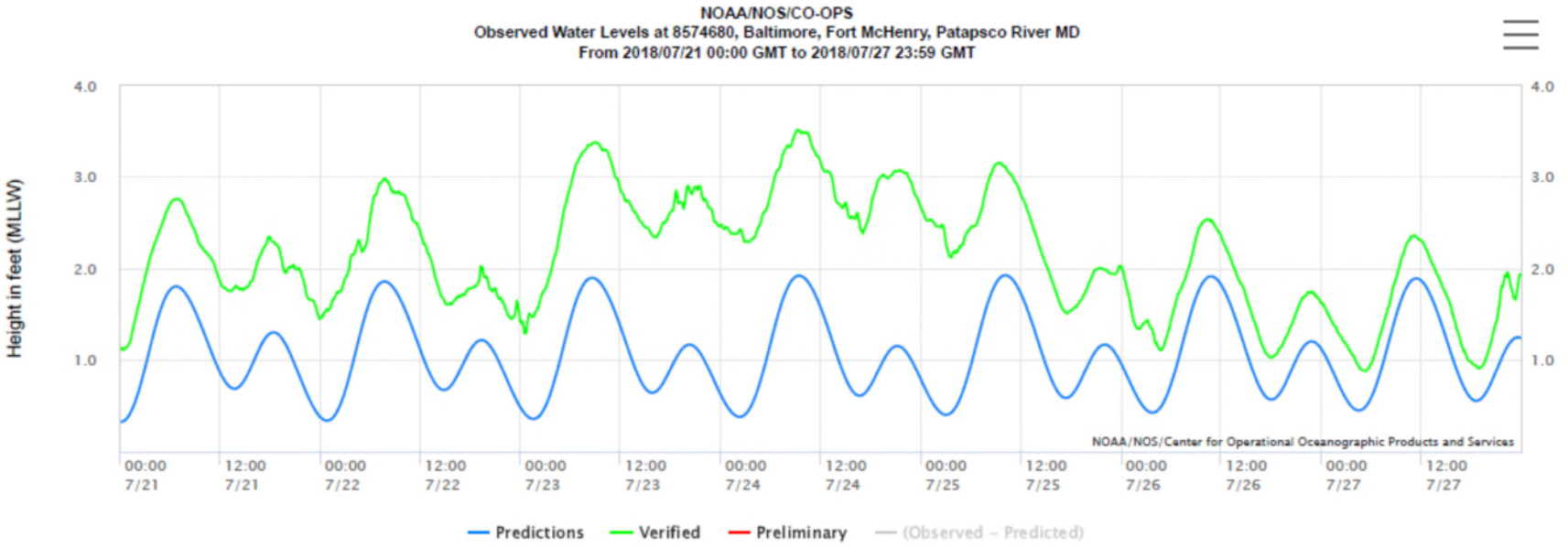


Figure 3-2 Observed water levels at NOAA's tidal observation station at Baltimore, Fort McHenry, Patapsco River July 21-27, 2018. Observed values (green line) are compared with long-term predicted levels (blue line). NOAA data from https://tidesandcurrents.noaa.gov/waterlevels.html?id=8574680&units=standard&bdate=20180721&edate=20180727&timezone=GMT&datum=MLLW&interval=6&action=

Figure 4-1 Map of Cow Pen Creek study area showing bank stabilization segment endpoints along both streambanks (blue) and floodplain survey points (yellow) along 10 floodplain transects.
Upland and wetland vegetation types are from revegetation plan, Nov. 20, 2017.

Figure 4-2 Map of Cow Pen Creek study area showing locations of representative photographs along the stream channel (upstream and downstream views at each transect) and photographs of other features of note (map points 1-17, with photograph descriptions). For photographs, see Appendix A, Figures A-60 to A-97. Upland and wetland vegetation types are from revegetation plan, Nov. 20, 2017.

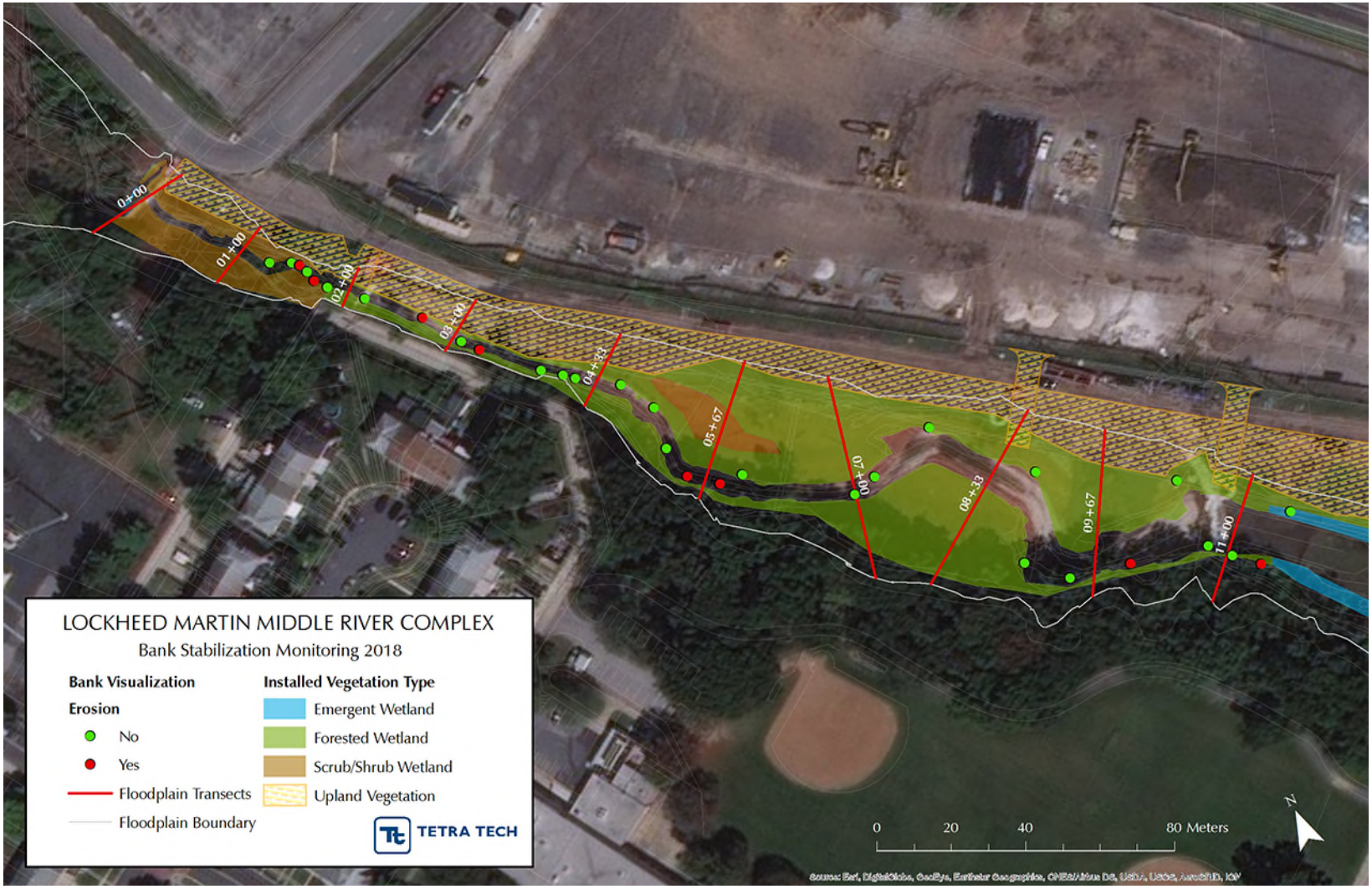


Figure 4-3 Map of Cow Pen Creek study area showing locations of bank erosion, noted as lower endpoints of segments assessed along both streambanks. Upland and wetland vegetation types are from revegetation plan, Nov. 20, 2017

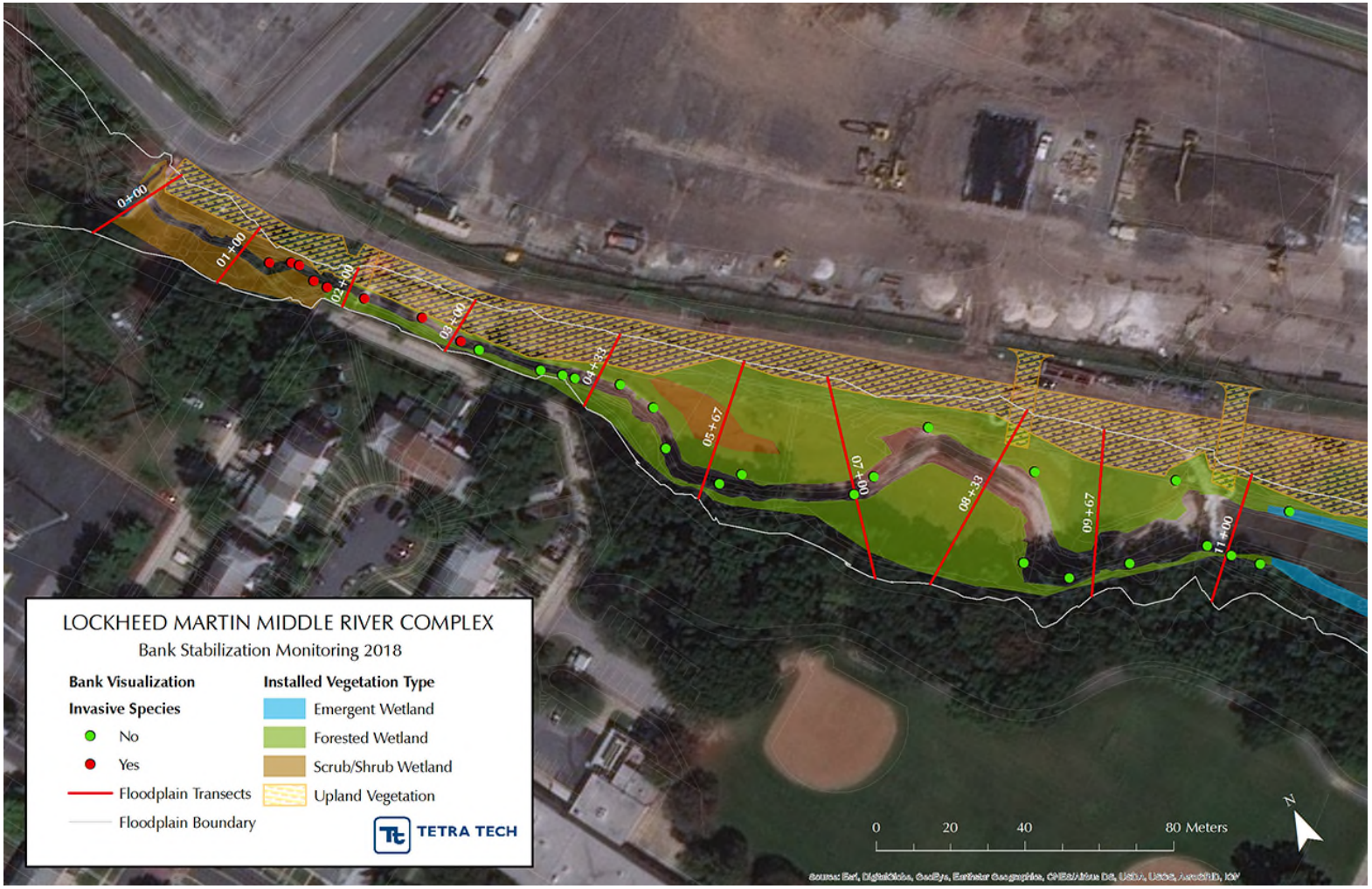


Figure 4-4 Map of Cow Pen Creek study area showing locations of invasive plant species, noted as lower endpoints of segments assessed along both streambanks. Upland and wetland vegetation types are from revegetation plan, Nov. 20, 2017

Map Point	Notes on Vegetation and Erosion
A	Soil eroding under matting due to runoff
B	Minor erosion near stone walkway
C	Most of the bank under water and appears to not be vegetated. Trees in the nearby tubes mostly dead.
D	Bare spot, approximately 15x15 ft
E	Roughly half of trees in tubes in this segment dead
F	Most of bank under water and barren
G	Soil eroding under matting, bare spot
H	Minor erosion below vegetative cover

Map Point	Notes on Vegetation and Erosion
I	Sediment washing out from mats, no plant growth, bare spot
J	Erosion of red clay bank
K	Fine sediments deposited on top of the matting
L	Mud flat with fine sediments depositing on the wetland, SAV growing on bank
M	Some herbaceous vegetation rooted along top of bank, barren below
N	Erosion of red clay bank
O	Some herbaceous vegetation in matting along top of bank, bare near waterline
P	Coir logs at waterline; bank stable with matting but mostly unvegetated; small patch of pickerelweed

Map Point	Notes on Vegetation and Erosion
Q	Stakes underwater
R	Small, sparse/bare spots on bank
S	Several sparse/bare spots present near floodplain transect
T	Sparse/bare spots present near floodplain transect
U	Bare spot near bank; other sparse/bare areas present near floodplain transect
V	Area along stream planned as forested wetland is mudflat with mostly herbaceous vegetation; lowest part under water
W	Area near road has numerous bare/sparse patches
X	Mudflat with sparse woody vegetation, bare spot
Y	Barren area, red clay
Z	Bare spot
AA	Bare spot
BB	Bare spot

Figure 4-5 Map of Cow Pen Creek study area showing locations of areas noted based on concerns for erosion or vegetative cover condition. Upland and wetland vegetation types are from revegetation plan, Nov. 20, 2017.

Figure 4-6 Map of Cow Pen Creek study area showing streambank and floodplain field survey points, along with as-built survey topography. Floodplain transect start points (yellow points closest to stream along transect) were field-placed at top of bank on both sides of stream. As-built survey is from Dec. 27, 2017. Upland and wetland vegetation types are from revegetation plan, Nov. 20, 2017.

TABLES

Table 3-1

Daily Rainfall Totals Prior To and Including the Summer 2018 Monitoring Period (National Weather Service data, summarized by Iowa State University, https://mesonet.agron.iastate.edu)

Date	Baltimore/Washington International Airport (inches)	Baltimore Inner Harbor (inches)
7/21/2018	4.79	2.77
7/22/2018	0.50	0.96
7/23/2018	1.42	0.81
7/24/2018	4.07	1.77
7/25/2018	0.39	1.16
7/26/2018	0.00	0.00
7/27/2018	0.97	1.51

Table 3-2

Monthly Precipitation Totals for July 2017 to July 2018 (National Weather Service data, summarized by Iowa State University, https://mesonet.agron.iastate.edu)

Month	Monthly Precipitation, Baltimore/Washington International Airport (inches)		Monthly Precipitation, Baltimore Inner Harbor (inches)	
	30-Year Average	Observed Monthly Total	30-Year Average	Observed Monthly Total
Jul 2017	4.07	7.11	4.62	6.41
Aug 2017	3.29	4.60	3.39	6.02
Sep 2017	4.03	1.95	4.09	1.86
Oct 2017	3.33	2.99	3.05	2.64
Nov 2017	3.30	2.14	2.97	1.70
Dec 2017	3.37	0.95	3.41	0.78
Jan 2018	3.05	1.02	2.92	0.94
Feb 2018	2.90	5.28	2.60	4.79
Mar 2018	3.90	2.20	3.86	2.69
Apr 2018	3.19	3.20	3.22	4.69
May 2018	3.99	8.17	3.49	9.27
Jun 2018	3.46	4.77	3.27	3.20
Jul 2018	4.07	16.73	4.62	10.20

Table 4-1

Conditions Observed by Streambank Segment, Cow Pen Creek
Lockheed Martin Middle River Complex, July 26-27, 2018, Monitoring Event
Page 1 of 2

Bank Segment			Condition			Segment Length by Vegetation and Stability Class			
Stream Bank	Approximate Station Location, Segment Endpoint (feet)	Bank Segment Length (feet) as Measured Along GIS Thalweg	Vegetation	Bank Stability	Erosion	No Vegetation, Stable, No Erosion (feet)	No Vegetation, Unstable, Actively Eroding (feet)	Vegetation, Stable, No Erosion (feet)	Vegetation, Unstable, Actively Eroding (feet)
left	01+25	125	yes	stable	no	0	0	125	0
left	01+38	24	yes	stable	no	0	0	24	0
left	01+48	9	yes	unstable	yes	0	0	0	9
left	02+64	118	yes	stable	no	0	0	118	0
left	04+55	185	yes	stable	no	0	0	185	0
left	04+88	34	no	stable	no	34	0	0	0
left	05+93	112	yes	stable	no	0	0	112	0
left	07+10	123	yes	stable	no	0	0	123	0
left	07+71	60	yes	stable	no	0	0	60	0
left	08+75	91	yes	stable	no	0	0	91	0
left	10+68	196	yes	stable	no	0	0	196	0
left	11+80	77	yes	stable	no	0	0	77	0
right	01+56	166	yes	stable	no	0	0	166	0
right	01+67	14	no	unstable	yes	0	14	0	0
right	01+78	8	yes	stable	no	0	0	8	0

Table 4-1

Conditions Observed by Streambank Segment, Cow Pen Creek
Lockheed Martin Middle River Complex, July 26-27, 2018, Monitoring Event
Page 2 of 2

Bank Segment			Condition			Segment Length by Vegetation and Stability Class			
Stream Bank	Approximate Station Location, Segment Endpoint (feet)	Bank Segment Length (feet) as Measured Along GIS Thalweg	Vegetation	Bank Stability	Erosion	No Vegetation, Stable, No Erosion (feet)	No Vegetation, Unstable, Actively Eroding (feet)	Vegetation, Stable, No Erosion (feet)	Vegetation, Unstable, Actively Eroding (feet)
right	02+12	36	no	stable	no	36	0	0	0
right	03+05	92	yes	stable	no	0	0	92	0
right	03+22	18	yes	unstable	yes	0	0	0	18
right	03+60	57	no	stable	no	57	0	0	0
right	03+79	19	no	stable	no	19	0	0	0
right	03+90	12	no	stable	no	12	0	0	0
right	04+98	111	yes	stable	no	0	0	111	0
right	05+30	31	no	unstable	yes	0	31	0	0
right	05+58	27	no	unstable	yes	0	27	0	0
right	07+00	119	no	stable	no	119	0	0	0
right	09+09	232	yes	stable	no	0	0	232	0
right	09+42	23	yes	stable	no	0	0	23	0
right	09+93	53	no	unstable	yes	0	53	0	0
right	10+70	68	no	stable	no	68	0	0	0
right	11+10	25	no	stable	no	25	0	0	0
right	11+35	35	no	unstable	yes	0	35	0	0

Table 4-2

Notes on Specific Conditions Observed by Streambank Segment, Cow Pen Creek Lockheed Martin Middle River Complex, July 26-27, 2018, Monitoring Event

Bank Segment			Herbaceous Vegetation Present (>10% cover)	Woody Vegetation by Height Class			Vegetative Cover Notes	Invasive Species Present	Invasive Species Notes	Proximity to Structural Features
Stream Bank	Approximate Station Location, Segment Endpoint (feet)	Bank Segment Length (feet) as Measured Along GIS Thalweg		Woody Vegetation Present (<3 feet)	Woody Vegetation Present (3–15 feet)	Woody Vegetation Present (>15 feet)				
left	01+25	125	herbaceous cover	Yes	No	No		yes	Phragmites	
left	01+38	24	herbaceous cover	No	No	No		yes	Phragmites	
left	01+48	9	herbaceous cover	No	Yes	No	Soil eroding under matting due to runoff	yes	Phragmites	
left	02+64	118	herbaceous cover	Yes	Yes	No	Some erosion near stone walkway	yes	Phragmites	Stone walkway
left	04+55	185	herbaceous cover	Yes	Yes	No		no		
left	04+88	34	herbaceous layer <10% cover	Yes	Yes	No		no		Rootwad feature with vegetation cover behind rootwad
left	05+93	112	herbaceous cover	Yes	Yes	No		no		

Table 4-2

Notes on Specific Conditions Observed by Streambank Segment, Cow Pen Creek
Lockheed Martin Middle River Complex, July 26-27, 2018, Monitoring Event
Page 2 of 5

Bank Segment			Herbaceous Vegetation Present (>10% cover)	Woody Vegetation by Height Class			Vegetative Cover Notes	Invasive Species Present	Invasive Species Notes	Proximity to Structural Features
Stream Bank	Approximate Station Location, Segment Endpoint (feet)	Bank Segment Length (feet) as Measured Along GIS Thalweg		Woody Vegetation Present (<3 feet)	Woody Vegetation Present, (3–15 feet)	Woody Vegetation Present, (>15 feet)				
left	07+10	123	herbaceous layer <10% cover	Yes	Yes	No	Most of the lower bank is under water and appears to not be vegetated. Trees in the nearby tubes are mostly dead. Upper bank has woody vegetation.	no		
left	07+71	60	herbaceous cover	Yes	Yes	No	Nearby barren section approximately 15x15 ft.	no		
left	08+75	91	herbaceous cover	Yes	Yes	No	Roughly half of trees in tubes dead	no		Outfall
left	10+68	196	herbaceous cover	Yes	Yes	No		no		
left	11+80	77	herbaceous cover	Yes	Yes	No	Lower part of bank is under water. Upper bank has vegetation.	no		Outfall

Table 4-2

Notes on Specific Conditions Observed by Streambank Segment, Cow Pen Creek
Lockheed Martin Middle River Complex, July 26-27, 2018, Monitoring Event
Page 3 of 5

Bank Segment			Herbaceous Vegetation Present (>10% cover)	Woody Vegetation by Height Class			Vegetative Cover Notes	Invasive Species Present	Invasive Species Notes	Proximity to Structural Features
Stream Bank	Approximate Station Location, Segment Endpoint (feet)	Bank Segment Length (feet) as Measured Along GIS Thalweg		Woody Vegetation Present (<3 feet)	Woody Vegetation Present (3–15 feet)	Woody Vegetation Present (>15 feet)				
right	01+56	166	herbaceous cover	Yes	Yes	No		no		
right	01+67	14	herbaceous layer <10% cover	Yes	No	No	Soil eroding under matting	yes	Phragmites	
right	01+78	8	herbaceous cover	Yes	No	No		yes	Phragmites	Guardrail
right	02+12	36	herbaceous layer <10% cover	Yes	No	No		yes	Phragmites	Guardrail, rip-rap, outfall
right	03+05	92	herbaceous cover	No	Yes	No		yes	Phragmites	Rip-rap on part of bank
right	03+22	18	herbaceous cover	Yes	No	No	Minor erosion below vegetative cover	no		
right	03+60	57	herbaceous layer <10% cover	No	No	No		no		Rip-rap
right	03+79	19	herbaceous layer <10% cover	No	No	No		no		Log and rip-rap, old bridge

Table 4-2

Notes on Specific Conditions Observed by Streambank Segment, Cow Pen Creek Lockheed Martin Middle River Complex, July 26-27, 2018, Monitoring Event Page 4 of 5

Bank Segment			Herbaceous Vegetation Present (>10% cover)	Woody Vegetation by Height Class			Vegetative Cover Notes	Invasive Species Present	Invasive Species Notes	Proximity to Structural Features
Stream Bank	Approximate Station Location, Segment Endpoint (feet)	Bank Segment Length (feet) as Measured Along GIS Thalweg		Woody Vegetation Present, < 3 feet	Woody Vegetation Present, 3–15 feet	Woody Vegetation Present, > 15 feet				
right	03+90	12	herbaceous layer <10% cover	No	No	No		no		Rip-rap
right	04+98	111	herbaceous cover	Yes	No	No	Gravel bar	no		
right	05+30	31	herbaceous layer <10% cover	No	No	No	Sediment washing out from mats. No plant growth.	no		
right	05+58	27	herbaceous layer <10% cover	No	No	No	One tree in bank, >15ft. Red clay bank.	no		
right	07+00	119	herbaceous layer <10% cover	No	No	No	Fine sediments deposited on top of the matting	no		
right	09+09	232	herbaceous cover	Yes	Yes	No	Mud flat with fine sediments depositing on the wetland, SAV growing on bank	no		

Table 4-2

Notes on Specific Conditions Observed by Streambank Segment, Cow Pen Creek
Lockheed Martin Middle River Complex, July 26-27, 2018, Monitoring Event
Page 5 of 5

Bank Segment			Herbaceous Vegetation Present (>10% cover)	Woody Vegetation by Height Class			Vegetative Cover Notes	Invasive Species Present	Invasive Species Notes	Proximity to Structural Features
Stream Bank	Approximate Station Location, Segment Endpoint (feet)	Bank Segment Length (feet) as Measured Along GIS Thalweg		Woody Vegetation Present, < 3 feet	Woody Vegetation Present, 3–15 feet	Woody Vegetation Present, > 15 feet				
right	09+42	23	herbaceous layer <10% cover	No	No	No	Some herbaceous vegetation rooted along top of bank, bare below	no		
right	09+93	53	herbaceous layer <10% cover	No	No	No	Red clay bank	no		
right	10+70	68	herbaceous layer <10% cover	No	No	No	Some herbaceous vegetation in matting along top of bank, bare near waterline	no		
right	11+10	25	herbaceous layer <10% cover	No	No	No	Coir logs at waterline; bank stable with matting but mostly unvegetated; small patch of pickerelweed	no		
right	11+35	35	herbaceous layer <10% cover	No	No	No	Stakes underwater	no		

Table 4-3

Summary of Streambank Conditions, Cow Pen Creek
Lockheed Martin Middle River Complex, July 26-27, 2018 Monitoring Event

Total Streambank Length by Vegetation and Stability Class						
Bank	**No Vegetation, Stable, No Erosion (feet)**		**No Vegetation, Unstable, Actively Eroding (feet)**	**Vegetation, Stable, No Erosion (feet)**	**Vegetation, Unstable, Actively Eroding (feet)**	**Total (feet)**
	Armored with structures	**Unarmored, Stabilized with Other Treatments (Coir Log, Matting)**				
Total length, left bank	34	0	0	1,111	9	1,154
Total length, right bank	124	212	160	632	18	1,146
Total length, both banks	158	212	160	1,743	27	2,300

Table 4-4

Conditions Observed Within Floodplain Transect Segments, Cow Pen Creek Lockheed Martin Middle River Complex, July 26-27, 2018, Monitoring Event

Stream Bank	Station	Segment Start and End Points (ft), as Distance from Top of Bank		Upland or Wetland Revegetation Area	Herbaceous Vegetation Cover Present	Woody Vegetation by Height Class			Vegetative Cover Notes	Invasive Species Present	Invasive Notes
		Start Point (feet)	End Point (feet)			Woody Vegetation Present < 3 feet	Woody Vegetation Present 3–15 feet	Woody Vegetation Present >15 feet			
left	00+00	0	10	Wetland	Yes	Yes	No	No		yes	Phragmites
		10	43	Upland	Yes	Yes	No	No			
left	01+00	0	17	Wetland	Yes	Yes	No	No		yes	Phragmites
		17	38	Upland	Yes	Yes	No	No			
left	02+00	0	4	Wetland	Yes	No	No	No	Streamside area planted as grass only (0 to 4 ft)	no	
		4	16	Upland	Yes	Yes	Yes	No			
		16	35	Upland	Yes	Yes	Yes	No			
left	03+00	0	28	Wetland	Yes	No	Yes	No	Bare patch < 10 sq ft present	no	
		28	34	Upland	Yes	No	Yes	No			
left	04+33	0	12	Wetland	Yes	Yes	Yes	No	Small, sparse/bare spots on bank	no	
		12	50	Upland	Yes	Yes	Yes	No			
left	05+67	0	59	Wetland	Yes	Yes	Yes	No	Several sparse/bare spots present near transect	no	
		59	97	Wetland	Yes	Yes	Yes	No			
		97	107	Upland	Yes	Yes	Yes	No			
left	07+00	0	54	Wetland	Yes	Yes	Yes	No	Sparse/bare spots present near transect	no	
		54	80	Wetland	Yes	Yes	Yes	No			

Table 4-4

Conditions Observed Within Floodplain Transect Segments, Cow Pen Creek Lockheed Martin Middle River Complex, July 26-27, 2018, Monitoring Event

Stream Bank	Station	Segment Start and End Points (ft), as Distance from Top of Bank		Upland or Wetland Revegetation Area	Herbaceous Vegetation Cover Present	Woody Vegetation by Height Class			Vegetative Cover Notes	Invasive Species Present	Invasive Notes
		Start Point (feet)	End Point (feet)			Woody Vegetation Present < 3 feet	Woody Vegetation Present 3–15 feet	Woody Vegetation Present >15 feet			
left	08+33	0	5	Wetland	Yes	No	No	No	Streamside area grass only (0 to 5 ft); sparse/bare spots present near transect	no	
		5	30	Upland	Yes	Yes	Yes	No			
		30	49	Upland	Yes	Yes	Yes	No			
left	09+67	0	33	Wetland	Yes	Yes	Yes	No	Area along stream planned as forested wetland is mudflat with mostly herbaceous vegetation; lowest part under water	no	
		33	81	Upland	Yes	Yes	Yes	No			
left	11+00	0	17	Wetland	Yes	No	No	No	Streamside area grass only (0 to 15 ft). Area further from stream and near road has numerous bare/sparse patches. Near downstream end of project area.	no	
		17	57	Upland	Yes	No	No	No			

Table 4-4

Conditions Observed Within Floodplain Transect Segments, Cow Pen Creek Lockheed Martin Middle River Complex, July 26-27, 2018, Monitoring Event

Stream Bank	Station	Segment Start and End Points (ft), as Distance from Top of Bank		Upland or Wetland Revegetation Area	Herbaceous Vegetation Cover Present	Woody Vegetation by Height Class			Vegetative Cover Notes	Invasive Species Present	Invasive Notes
		Start Point (feet)	End Point (feet)			Woody Vegetation Present < 3 feet	Woody Vegetation Present 3–15 feet	Woody Vegetation Present >15 feet			
left	07+00	80	112	Upland	Yes	Yes	Yes	No	Sparse/bare spots present near transect	no	
right	00+00	0	9	Wetland	Yes	Yes	No	No	Creek in transect (at 9-29 ft), small bare section (1 ft x 4 ft)	yes	Phragmites
		9	29	Wetland	Yes	Yes	No	No			
		29	42	Wetland	Yes	Yes	Yes	No			
right	01+00	0	9	Wetland	Yes	No	No	No	Streamside area has herbaceous vegetation only (0 to 9 ft). Large tree providing canopy along transect (9 to 29 ft).	yes	Phragmites
		9	29	Wetland	No	Yes	Yes	No			
right	02+00	0	16	Wetland	Yes	No	Yes	Yes	Guardrail at 10 ft	no	
right	03+00	0	7	Wetland	Yes	No	Yes	No		no	

Table 4-4

Conditions Observed Within Floodplain Transect Segments, Cow Pen Creek
Lockheed Martin Middle River Complex, July 26-27, 2018, Monitoring Event
Page 4 of 5

Stream Bank	Station	Segment Start and End Points (ft), as Distance from Top of Bank		Upland or Wetland Revegetation Area	Herbaceous Vegetation Cover Present	Woody Vegetation by Height Class			Vegetative Cover Notes	Invasive Species Present	Invasive Notes
		Start Point (feet)	End Point (feet)			Woody Vegetation Present < 3 feet	Woody Vegetation Present 3–15 feet	Woody Vegetation Present >15 feet			
right	04+33	0	6	Wetland	Yes	Yes	No	No	Rip-rap on bank	no	
		6	17	Wetland	Yes	Yes	Yes	Yes			
right	05+67	0	5	Wetland	Yes	Yes	Yes	No		no	
right	07+00	0	14	Wetland	Yes	No	No	No	Streamside area has herbaceous vegetation only (0 to 14 ft). Large tree down in transect.	no	
		14	33	Wetland	Yes	Yes	Yes	Yes			

Table 4-4

Conditions Observed Within Floodplain Transect Segments, Cow Pen Creek Lockheed Martin Middle River Complex, July 26-27, 2018, Monitoring Event

Stream Bank	Station	Segment Start and End Points (ft), as Distance from Top of Bank		Upland or Wetland Revegetation Area	Herbaceous Vegetation Cover Present	Woody Vegetation by Height Class			Vegetative Cover Notes	Invasive Species Present	Invasive Notes
		Start Point (feet)	End Point (feet)			Woody Vegetation Present < 3 feet	Woody Vegetation Present 3–15 feet	Woody Vegetation Present >15 feet			
right	08+33	0	48	Wetland	No	Yes	Yes	No	Mud flat with sparse woody vegetation (0 to 48 ft from stream bank), hiking trail in outer section (78 to 81 ft) near edge of restored area	no	
		48	78	Wetland	Yes	Yes	Yes	No			
		78	87	Wetland	No	Yes	Yes	Yes			
right	09+67	0	12	Wetland	No	No	No	Yes	Barren area; red clay; under tree canopy	no	
right	11+00	0	4	N/A	No	Yes	No	No	Outside of restoration area; under tree canopy; hiking trails in transect.	no	

Table 4-5

Summary of Floodplain Transect Vegetation Assessments, Cow Pen Creek Lockheed Martin Middle River Complex, July 26-27, 2018 Monitoring Event

Length of Assessed Segments in Revegetated Area (feet)			
	Length of Assessed Segments – Floodplain / Wetland	**Length of Assessed Segments–Upland**	**Total Length**
Total length, left bank	275	331	606
Total length, right bank	248	0	248
Total length, both banks	523	331	854
Segments Without Vegetation (feet)			
	Wetland Segment Length Without Herbaceous Vegetation	**Upland Segment Length Without Herbaceous Vegetation**	**Total Length**
Total length, left bank)	0	0	0
Total length, right bank)	80	0	80
Total length, both banks)	80	0	80
	Wetland Segment Length Without Woody Vegetation	**Upland Segment Length Without Woody Vegetation**	**Total Length**
Total length, left bank	26	40	63
Total length, right bank	23	0	23
Total length, both banks	49	40	89

Table 4-6

Bare Spots Greater than 10 Square Feet Observed during Streambank and Floodplain Assessment, Cow Pen Creek Lockheed Martin Middle River Complex, July 26-27, 2018 Monitoring Event

Side	Approximate Station Location	Upland or Wetland	Map Point (Figure 4-5)	Photo (Appx A)
Right	00+05	Wetland	Z	Figure A-62
Right	01+67	Wetland	G	Figure A-4
Left	04+15	Upland	AA	Figure A-77
Right	05+25	Wetland	I	Figure A-78
Right	05+69	Wetland	BB	Figure A-79
Left	07+71	Wetland	D	Figure A-85
Left	08+32	Wetland	U	Figure A-88
Right	08+41	Wetland	X	Figure A-89

APPENDICES

Appendix A—Photo Log

Appendix B—GPS Coordinates for Field Assessment Points

APPENDIX A—PHOTO LOG

Figure A-1. Left streambank, upstream view at station 01+38.

Figure A-2. Left streambank at station 01+48.

Figure A-3. Right streambank, upstream view at station 01+56.

Figure A-4. Right streambank, upstream view at station 01+67.

Figure A-5. Right streambank, upstream view at station 01+78.

Figure A-6. Right streambank, upstream view at station 02+12.

Figure A-7. Left streambank, upstream view at station 02+64.

Figure A-8. Right streambank, upstream view at station 03+05.

Figure A-9. Right streambank, upstream view at station 03+22.

Figure A-10. Right streambank, upstream view at station 03+60.

Figure A-11. Right streambank, upstream view at station 03+79.

Figure A-12. Right streambank, upstream view at station 03+90.

Figure A-13. Left streambank, upstream view at station 04+55.

Figure A-14. Left streambank, upstream view at station 04+88.

Figure A-15. Right streambank, upstream view at station 04+98.

Figure A-16. Right streambank, upstream view at station 05+30.

Figure A-17. Right streambank, upstream view at station 05+58.

Figure A-18. Left streambank, upstream view at station 05+93.

Figure A-19. Right streambank, upstream view at station 07+00.

Figure A-20. Left streambank, upstream view at station 07+10.

Figure A-21. Left streambank, upstream view at station 07+71.

Figure A-22. Left streambank, upstream view at station 08+75.

Figure A-23. Right streambank, upstream view at station 09+09.

Figure A-24. Right streambank, upstream view at station 09+42.

Figure A-25. Right streambank, upstream view at station 09+93.

Figure A-26. Right streambank, upstream view at station 10+70.

Figure A-27. Right streambank, upstream view at station 11+10.

Figure A-28. Right streambank, upstream view at station 11+35.

Figure A-29. Left streambank, upstream view at station 11+80.

Figure A-30. Floodplain transect at station 01+00, left bank, 0 feet to 38 feet from top of bank.

Figure A-31. Floodplain transect at station 01+00, right bank, 0 feet to 9 feet from top of bank.

Figure A-32. Floodplain transect at station 01+00, 9 feet to 29 feet from top of bank.

Figure A-33. Floodplain transect at station 02+00, left bank, 0 feet to 4 feet from top of bank.

Figure A-34. Floodplain transect at station 02+00, left bank, 4 feet to 35 feet from top of bank.

Figure A-35. Floodplain transect at station 02+00, right bank, 0 feet to 10 feet from top of bank.

Figure A-36. Floodplain transect at station 03+00, left bank, 0 feet to 34 feet from top of bank.

Figure A-37. Floodplain transect at station 03+00, right bank, 0 feet to 7 feet from top of bank.

Figure A-38. Floodplain transect at station 04+33, left bank, 0 feet to 50 feet from top of bank.

Figure A-39. Floodplain transect at station 04+33, right bank, 0 feet to 6 feet from top of bank.

Figure A-40. Floodplain transect at station 04+33, right bank, 6 feet to 17 feet from top of bank.

Figure A-41. Floodplain transect at station 05+67, left bank, 0 feet to 59 feet from top of bank.

Figure A-42. Floodplain transect at station 05+67, left bank, 59 feet to 113 feet from top of bank.

Figure A-43. Floodplain transect at station 05+67, right bank, 0 feet to 5 feet from top of bank.

Figure A-44. Floodplain transect at station 07+00, left bank, 0 feet to 54 feet from top of bank.

Figure A-45. Floodplain transect at station 07+00, left bank, 54 feet to 112 feet from top of bank.

Figure A-46. Floodplain transect at station 07+00, right bank, 0 feet to 14 feet from top of bank.

Figure A-47. Floodplain transect at station 07+00, right bank, 14 feet to 33 feet from top of bank.

Figure A-48. Floodplain transect at station 08+33, left bank, 0 feet to 5 feet from top of bank.

Figure A-49. Floodplain transect at station 08+33, left bank, 5 feet to 49 feet from top of bank.

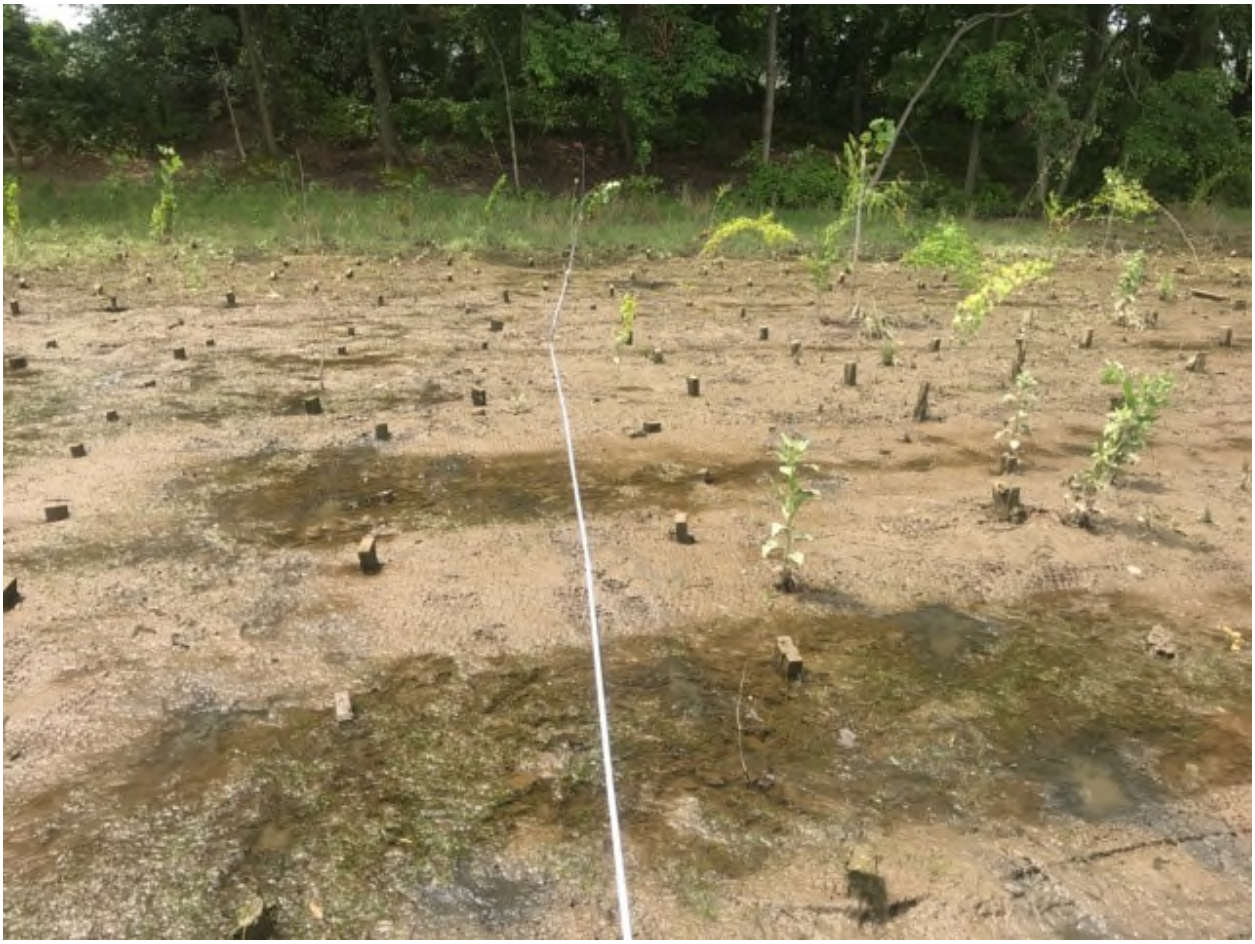


Figure A-50. Floodplain transect at station 08+33, right bank, 0 feet to 48 feet from top of bank.

Figure A-51. Floodplain transect at station 08+33, right bank, 48 feet to 78 feet from top of bank.

Figure A-52. Floodplain transect at station 08+33, right bank, 78 feet to 87 feet from top of bank.

Figure A-53. Floodplain transect at station 09+67, left bank, 0 feet to 33 feet from top of bank.

Figure A-54. Floodplain transect at station 09+67, left bank, 33 feet to 81 feet from top of bank.

Figure A-55. Floodplain transect at station 09+67, right bank, 0 feet to 12 feet from top of bank.

Figure A-56. Floodplain transect at station 11+00, left bank, 0 feet to 17 feet from top of bank.

Figure A-57. Floodplain transect at station 11+00, left bank, 17 feet to 57 feet from top of bank.

Figure A-58. Floodplain transect at station 11+00, right bank, 0 feet to 4 feet from top of bank.

Figure A-59. Floodplain transect at station 11+00, right bank, 4 feet to 26 feet from top of bank.

Figure A-60. Downstream view from thalweg at station 00+00.

Figure A-61. Upstream view from thalweg at station 00+00.

Figure A-62. Bare spot on the right streambank at station 00+05.

Figure A-63. Downstream view from thalweg at station 01+00.

Figure A-64. Upstream view from thalweg at station 01+00.

Figure A-65. Soil eroding from under the matting on the lower left bank at station 01+55.

Figure A-66. Soil eroding from under the matting on the right bank at station 01+67.

Figure A-67. Outfall and guard rail on the right bank at station 01+99.

Figure A-68. Downstream view from thalweg at station 02+00.

Figure A-69. Upstream view from thalweg at station 02+00.

Figure A-70. Upstream view of both streambanks at station 02+01.

Figure A-71. Downstream view from thalweg at station 03+00.

Figure A-72. Upstream view from thalweg at station 03+00.

Figure A-73. Right streambank at station 03+20.

Figure A-74. Downstream view from thalweg at station 04+33.

Figure A-75. Upstream view from the thalweg at station 04+33.

Figure A-76. View of root wad and left bank from station 04+50.

Figure A-77. Barren floodplain area on the left streambank at station 04+15.

Figure A-78. Barren area on the right streambank at station 05+25.

Figure A-79. Barren right streambank at station 05+69.

Figure A-80. Downstream view from thalweg at station 05+67.

Figure A-81. Upstream view from thalweg at station 05+67.

Figure A-82. Barren right streambank and new tree fall at station 06+07.

Figure A-83. Downstream view from thalweg at station 07+00.

Figure A-84. Upstream view from thalweg at station 07+00.

Figure A-85. Barren floodplain area on the left streambank at station 07+71.

Figure A-86. Downstream view from thalweg at station 08+33.

Figure A-87. Upstream view from thalweg at station 08+33.

Figure A-88. Outfall and barren area on left streambank at station 08+32.

Figure A-89. Barren wetland area on the right streambank at station 08+41.

Figure A-90. Downstream view from thalweg at station 09+67.

Figure A-91. Upstream view from thalweg at station 09+67.

Figure A-92. Inundated tree tubes on the right streambank at station 09+09.

Figure A-93. Upstream view of wetland area at station 10+00.

Figure A-94. Downstream view from thalweg at station 11+00.

Figure A-95. Upstream view from thalweg at station 11+00.

Figure A-96. View from top of floodplain, left streambank at station 01+30.

Figure A-97. Upstream view from top of floodplain, left streambank at station 10+70.

APPENDIX B—GPS COORDINATES FOR FIELD ASSESSMENT POINTS

Table B-1. GPS Coordinates for Streambank Assessment Segment End Points			
Approximate Station Location, Segment End Point	**Stream Bank**	**Latitude (decimal degrees)**	**Longitude (decimal degrees)**
01+25	left	39.32805945	-76.43757453
01+38	left	39.32803824	-76.43751032
01+48	left	39.32802417	-76.43749153
02+64	left	39.32778604	-76.43720827
04+55	left	39.32744288	-76.43672891
04+88	left	39.32735891	-76.43666332
05+93	left	39.32712318	-76.43649747
07+10	left	39.32698836	-76.43612279
07+71	left	39.32704243	-76.43590582
08+75	left	39.32683994	-76.43565922
10+68	left	39.32668088	-76.43526631
11+80	left	39.32649977	-76.43498392
01+56	right	39.32800191	-76.43747875
01+67	right	39.32797489	-76.43746981
01+78	right	39.32794746	-76.43743987
02+12	right	39.32788661	-76.43734745
03+05	right	39.32769574	-76.43712868
03+22	right	39.32765913	-76.4370867
03+60	right	39.32755278	-76.43693809
03+79	right	39.3275211	-76.43688173
03+90	right	39.32750221	-76.43685038
04+98	right	39.32725653	-76.43668024
05+30	right	39.32717492	-76.43665703
05+58	right	39.32712596	-76.43657258
07+00	right	39.32696839	-76.43620208
09+09	right	39.32664972	-76.43580695
09+42	right	39.32657164	-76.43569628
09+93	right	39.32654319	-76.4355053
10+70	right	39.32650552	-76.43526257
11+10	right	39.3264603	-76.43520634
11+35	right	39.32641238	-76.4351342

Table B-2. GPS Coordinates for Floodplain Transect Locations. Coordinates listed are for start point of field-assessed segment.

Station	Stream Bank	Approximate Location of Transect Start (ft), as Distance from Top of Bank	Approximate Location of Transect End (ft), as Distance from Top of Bank	Latitude (decimal degrees)	Longitude (decimal degrees)
00+00	left	0	43	39.32832101	-76.43780533
01+00	left	0	38	39.3281118	-76.43762388
02+00	left	0	4	39.32792956	-76.43736539
02+00	left	4	35	39.32793457	-76.43735399
03+00	left	0	34	39.32772479	-76.43711486
04+33	left	0	50	39.32748373	-76.43678264
05+67	left	0	59	39.32717466	-76.43658438
05+67	left	59	113	39.32729764	-76.43644428
07+00	left	0	54	39.32701752	-76.43618656
07+00	left	54	112	39.32716346	-76.43614878
08+33	left	0	5	39.32693326	-76.43568858
08+33	left	5	49	39.32694056	-76.43567333
09+67	left	0	33	39.32670472	-76.43551738
09+67	left	33	81	39.32678517	-76.43546558
11+00	left	0	17	39.3265887	-76.43507907
11+00	left	17	57	39.32662116	-76.43503966
00+00	right	0	9	39.32832483	-76.43784294
00+00	right	9	29	39.32831805	-76.43788409
00+00	right	29	42	39.32831856	-76.43795238
01+00	right	0	9	39.32808954	-76.43767885
01+00	right	9	29	39.32808936	-76.43768018
02+00	right	0	10	39.32811097	-76.43765489
03+00	right	0	7	39.32769945	-76.43717015
04+33	right	0	6	39.32746753	-76.43681399
04+33	right	6	17	39.3274544	-76.43683035
05+67	right	0	5	39.32713547	-76.43662788
07+00	right	0	14	39.32694816	-76.43622954
07+00	right	14	33	39.32690906	-76.43625661
08+33	right	0	48	39.32685006	-76.43583683
08+33	right	48	78	39.3267693	-76.43596625
08+33	right	78	87	39.32672503	-76.43605887
09+67	right	0	12	39.32654735	-76.43561067
11+00	right	0	4	39.32643668	-76.43523064
11+00	right	4	26	39.3264367	-76.43523817