Morgan Creek
Stream Restoration Site

Year 5 Final Monitoring Report
Project ID Number: 16-D06027
EEP Project # 92527

Prepared for:
Environmental Banc and Exchange

909 Capability Drive, Suite 3100
Raleigh, NC 27606

Prepared by:
Equinox Environmental Consultation and Design, Inc.

37 Haywood Street, Suite 100
Asheville, NC 28801

Submitted to:
NCDENR - Ecosystem Enhancement Program

1652 Mail Service Center
Raleigh, NC 27699
# TABLE OF CONTENTS

1.0 SUMMARY .................................................................................................................. 1

2.0 INTRODUCTION ........................................................................................................ 2
  2.1 Project Description .................................................................................................. 2
  2.2 Project Purpose ...................................................................................................... 13
  2.3 Project History and Schedule ............................................................................... 13

3.0 STREAM MONITORING ............................................................................................. 16
  3.1 Stream Success Criteria ....................................................................................... 16
  3.2 Stream Morphology Monitoring Plan ................................................................... 16
    3.2.1 Cross-Sections .............................................................................................. 16
    3.2.2 Longitudinal Profile ...................................................................................... 17
    3.2.3 Substrate ........................................................................................................ 17
    3.2.4 Hydrology ....................................................................................................... 17
    3.2.5 Photo Reference Stations ............................................................................. 17
  3.3 Stream Morphology Monitoring Results ................................................................. 17
    3.3.1 Cross-Sections .............................................................................................. 18
    3.3.2 Longitudinal Profile ...................................................................................... 18
    3.3.3 Substrate ........................................................................................................ 19
    3.3.4 Hydrology ....................................................................................................... 19
    3.3.5 Photo Reference Stations ............................................................................. 20
  3.4 Stream Conclusions ............................................................................................... 21

4.0 VEGETATION ............................................................................................................... 24
  4.1 Vegetation Success Criteria .................................................................................... 24
  4.2 Description of Species and Vegetation Monitoring ............................................... 24
  4.3 Results of Vegetation Monitoring .......................................................................... 24
  4.4 Vegetation Observations and Conclusions ............................................................. 28

5.0 CONCLUSIONS AND RECOMMENDATIONS .......................................................... 29

6.0 REFERENCES ............................................................................................................. 30
LIST OF FIGURES

Figure 1. Vicinity Map 3
Figure 2. USGS Map 4
Figure 3. Monitoring Plan View 5

LIST OF TABLES

Table 1. Project Mitigation Structure and Approach 13
Table 2. Project Activity and Reporting History 14
Table 3. Project Contacts 15
Table 4. Crest Gauge Data 20
Table 5. Stream Areas Requiring Observation 20
Table 6. Summary of Morphologic Monitoring Parameters 22
Table 7. Planted Tree Species 24
Table 8. Results of Monitoring Year 5 Vegetation Monitoring by Plot 25
Table 9. Summary of Vegetation Monitoring Results 26
Table 10. Estimated Herbaceous Total Percent Cover 27
Table 11. Volunteer Tree Species 27

APPENDICES

Appendix A. Monitoring Year 5 Current Condition Plan View
Appendix B. Monitoring Year 5 Profile, Cross-Section, and Substrate Data
Appendix C. Monitoring Year 5 Morphologic Monitoring Parameters
Appendix D. Monitoring Year 5 Site Photos
Appendix E. Invasive Exotic Vegetation Control at Morgan Creek Stream Restoration Site Progress Report
1.0 SUMMARY

This Annual Monitoring Report details the activities conducted during 2013 (Year 5) on the Morgan Creek Mitigation Site. Construction of the site, including planting of trees, was completed in July 2008. Due to stream damage associated with several, consecutive tropical storm events in August 2008 stream repairs were required. Additionally, in April 2011 a second supplemental planting of trees occurred within the repaired reaches as well as other areas noted with low stem densities. The 2013 data represent results from the fifth year of stream and vegetation monitoring.

The mitigation design plan for the Morgan Creek Site involved restoration, enhancement, and preservation associated with nine stream reaches. After construction, it was determined that the project included 7,855 linear feet of stream restoration, 1,797 linear feet of stream enhancement level I, 1,629 linear feet of stream enhancement level II, and 7,491 linear feet of stream preservation generating 11,203 stream mitigation units (SMUs). Due to stream bank and bed damage from high flows in August 2008, repairs were deemed necessary for portions of the restored reaches. Repairs were completed in February 2010 and because of restoration pattern changes along Morgan Creek, Unnamed Tributary 4, and Unnamed Tributary 7, the footage of stream restoration was reduced to 7,804 linear feet. Based on the reconstructed pattern, the total combined assets are 11,152 SMUs.

This Annual Report presents the data from 16 cross-sections, 3,163 linear feet of longitudinal profile, three crest gauges, eight vegetation monitoring plots, and 70 photographic reference locations as specified in the approved Mitigation Plan (EBX 2008).

The longitudinal profiles, cross-sections, substrate, and visual assessments indicate bed adjustments have occurred when compared to the as-built conditions. The Year 5 stream channel data indicates that the restored stream reaches are reaching the desired equilibrium that will provide the intended habitat and hydrologic function. The restored stream channel continues to receive significant sediment inputs from upstream sources that are likely driving the bed form changes observed between monitoring years. Since project completion at least four bankfull events have occurred at the project site.

Vegetation plot (VP) monitoring during Year 5 indicates planted stem densities ranged between 324 and 971 stems per acre with an average of 607 planted stems per acre for the entire restoration site; easily meeting the final vegetative success criterion of 260 stems per acre. The increase in percent survival of planted stems since the Year 2 monitoring is the result of a supplemental planting effort that occurred in spring 2011. Overall, planted stems are surviving well at the project site with all plots meeting the final success criteria. When planted and natural stems are combined the average stem density for the entire restoration site is approximately 1,836 stems per acre. Additionally, an intensive exotic invasive plant control effort was initiated in the summer of 2011 with follow up treatments administered in 2012 and 2013.
2.0 INTRODUCTION

2.1 Project Description

The Morgan Creek Stream Mitigation Site was identified and developed through the North Carolina Ecosystem Enhancement Program (NCEEP) full delivery process. The site is located in southern McDowell County approximately eight miles south of Marion, North Carolina (Figure 1). The project streams lie within the Broad River Basin (Hydrologic Unit Code 03050105040040) and the North Carolina Division of Water Quality (NCDWQ) sub-basin 03-08-01.

The Mitigation Site includes portions of Morgan Creek and nine unnamed tributaries encompassing 18,772 linear feet. The nine distinct unnamed tributaries (UT) are identified as UT1, UT2, UT3, UT4, UT5, UT6, UT7, UT8, and UT9. Morgan Creek lies within a relatively flat valley while UT1, UT2, UT3, UT5, UT8, and UT9 originate within the property boundary in the more mountainous area to the south of the Morgan Creek valley. Tributaries UT4, UT6, and UT7 originate off the project property north of Morgan Creek; portions of them on the project property are included in the project easement area. The United States Geological Survey (USGS) Sugar Hill topographic quadrangle (Figure 2) shows the project streams draining to the larger Cove Creek watershed. All reaches drain watersheds consisting of predominately forested and agricultural land. The site is defined by a conservation easement surrounding the streams and adjacent riparian buffers that total approximately 36.58 acres.

Channel restoration (improved pattern, dimension, and longitudinal profile) was completed on all of Morgan Creek and the downstream portions of UT1, UT2, UT3, UT4, UT5, UT6, and UT7 contiguous with Morgan Creek. An additional 163 feet of channel on UT8 was restored by stabilizing the downstream crossing through grading, boulder installation, and elimination of the backwater effect associated with a failed culvert. The middle section of UT1, upstream from the restoration reach was enhanced (enhancement level I) by installing livestock exclusion fencing, a supplemental riparian buffer planting, and stabilizing severely eroding logging roads. The middle sections of UT2, UT3, and UT5, located upstream of the restoration reaches, were enhanced (enhancement level II) by installation of livestock exclusion fencing. The stable headwater reaches and associated riparian buffers of UT1, UT2, UT3, UT5, UT8, and UT9 were protected under preservation criteria.

Prior to restoration, Morgan Creek and the sections of tributaries located within the valley were highly degraded due the presence of livestock, channelization, minimal riparian buffer vegetation, and failed culvert crossings. The enhancement reaches had been previously impacted by livestock access, limited riparian buffer vegetation, and adjacent eroding logging roads.

The 2013 monitoring season represents Year 5 of the monitoring period. Monitoring during 2013 included stream and vegetation monitoring stations (Figure 3, Sheets 1 through 8) as approved in the Mitigation Plan (EBX 2008).
Figure 1
Morgan Creek Mitigation Site
Project Vicinity Map
Figure 2
Morgan Creek Mitigation Site
USGS Map

Mitigation Sites
7.5 Minute Sugar Hill, NC Quadrangle
2.2 Project Purpose

The objective of the project was to provide 11,118 stream mitigation units (SMUs) for the NCEEP full delivery process in the Broad River 03-08-01 Basin. In addition to providing mitigation credits; riparian habitat, aquatic habitat, and water quality improvements are expected to result from the restoration and enhancement of the stream channels at this site.

The Morgan Creek Mitigation Report (EBX 2008) documented 7,855 linear feet of stream restoration, 1,797 linear feet of stream enhancement Level I, 1,629 linear feet of stream enhancement Level II, and 7,491 linear feet of stream preservation resulting in 11,203 SMUs. Due to alignment modifications associated with stream repairs made in 2010, the total linear feet of stream restoration was reduced to 7,804 linear feet (Table 1). Based on the repair as-built conditions, a total of 11,152 SMUs were documented for the site.

Table 1. Project Approach, Mitigation Structure, and SMUs by Stream Reach

<table>
<thead>
<tr>
<th>Reach Name</th>
<th>Stream Restoration (linear feet)</th>
<th>Stream Enhancement Level I (linear feet)</th>
<th>Stream Enhancement Level II (linear feet)</th>
<th>Stream Preservation (linear feet)</th>
<th>Total (linear feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morgan Creek</td>
<td>4,794</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>4,794</td>
</tr>
<tr>
<td>UT1</td>
<td>507</td>
<td>1,797</td>
<td>-</td>
<td>1,569</td>
<td>3,873</td>
</tr>
<tr>
<td>UT2</td>
<td>162</td>
<td>-</td>
<td>120</td>
<td>928</td>
<td>1,210</td>
</tr>
<tr>
<td>UT3</td>
<td>583</td>
<td>-</td>
<td>807</td>
<td>559</td>
<td>1,949</td>
</tr>
<tr>
<td>UT4</td>
<td>171</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>171</td>
</tr>
<tr>
<td>UT5</td>
<td>275</td>
<td>-</td>
<td>702</td>
<td>454</td>
<td>1,431</td>
</tr>
<tr>
<td>UT6</td>
<td>460</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>460</td>
</tr>
<tr>
<td>UT7</td>
<td>689</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>689</td>
</tr>
<tr>
<td>UT8</td>
<td>163</td>
<td>-</td>
<td>-</td>
<td>1,693</td>
<td>1,856</td>
</tr>
<tr>
<td>UT9</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2,288</td>
<td>2,288</td>
</tr>
<tr>
<td>Total Site Linear Feet</td>
<td>7,804</td>
<td>1,797</td>
<td>1,629</td>
<td>7,491</td>
<td>18,721</td>
</tr>
<tr>
<td>Total Site SMUs</td>
<td>7,804</td>
<td>1,198</td>
<td>652</td>
<td>1,498</td>
<td>11,152</td>
</tr>
</tbody>
</table>

Annual monitoring of the site is required to demonstrate successful mitigation based on criteria established in the Restoration Plan (EBX 2007) and through a comparison to as-built and reference conditions. The success criteria components adhere to guidance provided by the United States Army Corps of Engineers (USACE) – Wilmington District (USACE 2003) and recommendations from the NCEEP. Stream and vegetation monitoring are conducted annually for five years or until success criteria have been met. The following sections and Appendix A detail the results of the monitoring efforts for Year 5 at the Morgan Creek Stream Mitigation Site.

2.3 Project History and Schedule

The project was constructed in the spring and summer of 2008. Shortly after completion of the baseline data collection efforts, portions of the restored reaches were degraded due to significant rainfall events. Repairs to the damaged areas were delayed until early 2010, resulting in the
postponement of the Year 1 monitoring efforts. In addition, a supplemental planting occurred in April 2011 not only within the repaired areas, but also in other areas previously noted to have low stem densities. A site wide exotic invasive plant control effort also was initiated in June 2011 with follow up treatments occurring in 2012 and 2013. Year 5 monitoring was completed as originally scheduled (Table 2). Project service providers and contacts are listed in Table 3.

Table 2. Project Activity and Reporting History

<table>
<thead>
<tr>
<th>Month / Year</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>August 2007</td>
<td>Restoration Plan</td>
</tr>
<tr>
<td>June 2008</td>
<td>Construction Completed</td>
</tr>
<tr>
<td>July 2008</td>
<td>Planting Completed</td>
</tr>
<tr>
<td>September 2008</td>
<td>Mitigation Plan / As-Built Report</td>
</tr>
<tr>
<td>December 2008</td>
<td>Supplemental Planting</td>
</tr>
<tr>
<td>February 2010</td>
<td>Repairs Completed</td>
</tr>
<tr>
<td>February - April 2010</td>
<td>Year 1 Morphological Data Collection</td>
</tr>
<tr>
<td>May 2010</td>
<td>Year 1 Annual Monitoring Report</td>
</tr>
<tr>
<td>October 2010</td>
<td>Year 2 Morphological Data Collection</td>
</tr>
<tr>
<td>December 2010</td>
<td>Year 2 Annual Monitoring Report</td>
</tr>
<tr>
<td>April 2011</td>
<td>Supplemental Planting</td>
</tr>
<tr>
<td>April 2011</td>
<td>Year 3 Morphological Data Collection</td>
</tr>
<tr>
<td>June - July 2011</td>
<td>Exotic Invasive Plant Control</td>
</tr>
<tr>
<td>December 2011</td>
<td>Year 3 Annual Monitoring Report</td>
</tr>
<tr>
<td>February and June 2012</td>
<td>Exotic Invasive Plant Control</td>
</tr>
<tr>
<td>December 2012</td>
<td>Year 4 Annual Monitoring Report</td>
</tr>
<tr>
<td>December 2013</td>
<td>Year 5 Annual Monitoring Report</td>
</tr>
</tbody>
</table>
Table 3. Project Contacts

<table>
<thead>
<tr>
<th>Contact</th>
<th>Provider Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Delivery Service Contractor</td>
<td>Environmental Banc &amp; Exchange</td>
</tr>
<tr>
<td>Norton Webster</td>
<td>909 Capability Drive Suite 3100</td>
</tr>
<tr>
<td></td>
<td>Raleigh, North Carolina 27606</td>
</tr>
<tr>
<td></td>
<td>(919) 829-9909</td>
</tr>
<tr>
<td>Designer</td>
<td>Kimley-Horn and Associates, Inc.</td>
</tr>
<tr>
<td>William Wilhelm</td>
<td>4651 Charlotte Park Drive, Suite 300</td>
</tr>
<tr>
<td></td>
<td>Charlotte, North Carolina 28217</td>
</tr>
<tr>
<td></td>
<td>(704) 333-5131</td>
</tr>
<tr>
<td>Construction/Seeding Contractor</td>
<td>RFG Construction Inc.</td>
</tr>
<tr>
<td>Robert Grady</td>
<td>1907 Cambridge Drive</td>
</tr>
<tr>
<td></td>
<td>Kinston, North Carolina 28504</td>
</tr>
<tr>
<td></td>
<td>(252) 523-2405</td>
</tr>
<tr>
<td>Planting Contractor</td>
<td>Superior Wildlife Services</td>
</tr>
<tr>
<td>Robert Cato</td>
<td>2105 Sparre Drive</td>
</tr>
<tr>
<td></td>
<td>Kinston, North Carolina 28504</td>
</tr>
<tr>
<td></td>
<td>(252) 939-0465</td>
</tr>
<tr>
<td>Repair Designer</td>
<td>Stantec Consulting Inc.</td>
</tr>
<tr>
<td>David Bidelspach</td>
<td>801 Jones Frankline Road</td>
</tr>
<tr>
<td></td>
<td>Raleigh, North Carolina 27606</td>
</tr>
<tr>
<td></td>
<td>(919) 851-6866</td>
</tr>
<tr>
<td>Repair Construction Contractor</td>
<td>North State Environmental</td>
</tr>
<tr>
<td>Darrell Westmoreland</td>
<td>2889 Lowery Street</td>
</tr>
<tr>
<td></td>
<td>Winston-Salem, North Carolina 27101</td>
</tr>
<tr>
<td></td>
<td>336-725-2010</td>
</tr>
<tr>
<td>Monitoring Contractor</td>
<td>Equinox Environmental Consultation &amp; Design, Inc.</td>
</tr>
<tr>
<td>Steve Melton</td>
<td>37 Haywood Street, Suite 100</td>
</tr>
<tr>
<td></td>
<td>Asheville, North Carolina 28801</td>
</tr>
<tr>
<td></td>
<td>(828) 253-6856</td>
</tr>
</tbody>
</table>
3.0 STREAM MONITORING

3.1 Stream Success Criteria

As stated in the Mitigation Plan (EBX 2008), the stream restoration will be considered successful if the cross-section geometry, longitudinal profile, and channel sinuosity are stable or reach a dynamic equilibrium within the 5-year monitoring period. While the channels may not adhere to the design or reference ratios of stream geometry, the streams will be considered stable if the following key indicators are present:

- **Stream Type**: Maintenance of the design stream type or progression toward or conversion to a stable stream type such as B, C, or E.
- **Bank Height Ratio**: Bank height ratio between 1.0 and 1.2 will indicate that flood flows have access to the active floodplain and that higher flows do not apply excessive stresses to stream banks.

A minimum of two bankfull events must occur in separate years during the 5-year monitoring period. If two bankfull events do not occur, additional monitoring may be required by the USACE.

3.2 Stream Morphology Monitoring Plan

The stream monitoring program is intended to document trends and progress in achieving the channel success criteria. Monitoring is to occur annually for five years or until the final success criteria are met, whichever is longer. The locations of the individual stream monitoring components are shown in Figure 3.

3.2.1 Cross-Sections

A total of 16 cross-sections were established at the time the as-built conditions were measured. Cross-sections on Morgan Creek include four riffles and two pools within each of the two monitored reaches, Morgan Creek Upper (MC-Upper) and Morgan Creek Lower (MC-Lower). Due to stream and bank repairs within MC-Lower, cross-section locations had to be re-established prior to the Year 1 monitoring efforts. Additionally, the floodplain bench at MC-Upper Riffle 4/Cross-Section 5 was impacted by the repairs, resulting in a change in the apparent bankfull elevation between monitoring years. The Monitoring Plan View (Figure 3) has been updated to reflect these changes in cross-sectional monitoring stations. The UT1 and UT6 restoration reaches each include one riffle and one pool cross-section. All cross-sections were marked on both banks with permanent iron pins to establish known elevations and stationing for comparisons between annual data collection efforts. Cross-sectional survey points include all present breaks in slope; including top of bank, bankfull, inner berm, and thalweg. Photos are taken annually at each cross-section to visually document left and right bank conditions.
3.2.2 Longitudinal Profile

Four permanent longitudinal profile reaches were established during the as-built monitoring efforts. Morgan Creek includes an upper (MC-Upper) and lower reach (MC-Lower), whereas UT1 and UT6 include a portion of the restored reaches. The beginning and end of each longitudinal profile reach were marked on both banks with permanent iron pins to establish benchmarks for annual data comparison and analyses. Longitudinal profile measurements include thalweg, water surface, bankfull, and top of low bank elevations. Thalweg and water surface elevation measurements also are collected annually at the head and tail of each bedform type.

3.2.3 Substrate

Bed substrate assessment sites were established at each permanent cross-section. Pebble counts are collected annually utilizing methods adapted from Harrelson et al. (1994). A minimum of 100 particles are selected and measured from each channel feature type sampled. Sampled materials are placed into size classes using the traditional Wentworth scale classes subdivided based on phi scale. These classes are grouped into broader sediment size categories (e.g. sand, gravel, or cobble) and are utilized to compare substrate changes from as-built conditions.

3.2.4 Hydrology

Crest gauges installed at the lower end of Morgan Creek, UT1, and UT6 are utilized to document bankfull events during the monitoring period. Crest gauges are checked during each site visit to document the highest flow between visits. Gauge height readings are recorded and digital images of floodplain debris lines and sediment deposition are collected to document annual bankfull events.

3.2.5 Photo Reference Stations

A total of 70 representative photo stations were established throughout the site to subjectively evaluate overall trends in project progression and general site conditions over the duration of the monitoring effort. Additionally, the entire site is visually assessed to document any identified areas of concern. Representative photos are collected to document areas of concern identified during the visual site assessment.

3.3 Stream Morphology Monitoring Results

The Year 5 annual stream morphology data were collected between February and September 2013. Reference station photos were collected in January 2013 prior to leaf out to document the general conditions of the site. The Year 5 cross-section, longitudinal profile, and substrate data collection efforts occurred in February 2013. Visual assessments and bankfull documentation were noted during each site visit of the annual monitoring effort. A final site assessment and data collection effort occurred on September 19, 2013.
3.3.1 Cross-Sections

The MC-Upper, MC-Lower, UT1, and UT6 cross-sectional data collected during the Year 5 monitoring effort have been compared with previous data sets (Appendices B and C). Due to stream and bank repairs in 2010 that resulted in the loss of cross-sectional stations within the MC-Lower reach, data for the as-built conditions are not depicted within the cross-sectional profiles in Appendix B. Furthermore, stream and bank repairs impacted bankfull elevation at MC-Upper Riffle 4, Cross-Section 5 and data comparisons between as-built and subsequent monitoring years are only reported in the tables for reference and not for analysis. Lastly, bankfull elevations for the UT6 cross-sections were set at a higher elevation during Year 1 to reflect the floodplain aggradation that occurred between monitoring years.

Overall, the riffle cross-sectional data for MC-Upper indicated narrowing channels with inner berm feature development along the banks between as-built condition and Year 1 monitoring. Additionally, the two constructed riffles (Cross-Sections 1 and 5) within the MC-Upper reach maintained similar maximum depths between the as-built and Year 1; whereas maximum depths for the two non-constructed riffles (Cross-Sections 2 and 4) significantly increased. Based on the two pools monitored within the MC-Upper reach, cross-sectional area decreased significantly between the as-built and Year 1 data collection efforts. Year 4 data for MC-Upper reach indicated that the cross-sectional dimensions were stable when compared to the Year 1 and 2 data sets. Year 5 monitoring indicated some shifts in cross-section dimensions; particularly, in cross-sections 1 and 5 (constructed riffles), while maintaining similar maximum depths saw some scour along the bank and a resulting increase in cross-section area.

Due to the loss of the original cross-sectional stations within the MC-Lower reach, data comparisons with the as-built data are not appropriate. However, with the exception of Cross-Sections 1 and 2, the Year 5 cross-sectional data for MC-Lower indicates minimal changes since the repair as-built data (Year 1) were collected. Cross-section 1 maintained similar depth to Year 4; however, MY5 saw additional scour along the left bank. The pool associated with cross-section 2 cut down approximately 1.4 feet.

Compared to the UT1 as-built data, the Year 5 channel cross-sectional data shows minimal differences between years, indicating that the overall UT1 stream dimensions have remained stable. The riffle cross-section for this reach indicates similar inner berm feature development as seen within the MC-Upper reach.

Stream dimensions for UT6 were impacted from sediment deposition both within the channel and along the floodplain between as-built conditions and Year 1 monitoring. Year 5 monitoring indicated that a large deposit along the left bank of the Riffle cross-section caused a decrease in Cross-Sectional Area, Bankfull Width, and Width/Depth ratio at this particular location.

3.3.2 Longitudinal Profile

Longitudinal profile surveys were conducted along four separate reaches of the restoration project, totaling approximately 3,163 linear feet. The surveys included reach MC-Upper from STA 1005+15 to STA 1019+46 (1,431 linear feet), MC-Lower from STA 1028+20 to STA
1039+25 (1,105 linear feet), UT1 from STA 2000+85 to STA 2004+67 (382 linear feet), and reach UT6 from STA 7002+34 to STA 7004+79 (245 linear feet). Due to design changes resulting from repairs made within the MC-Lower reach, the original as-built data are only reported in the tables for reference and not for analysis. Additionally, data for the MC-Lower as-built conditions are not depicted within the longitudinal profiles in Appendix B. The longitudinal profiles document bed elevations, stream features, and in-stream grade control structures and compare them with the as-built profiles (Appendices B and C).

While the project site continues to experience some changes in morphology, the Year 5 stream profiles and visual observations indicate that the majority of the project has reached a state of equilibrium and is providing the intended habitat and hydrologic function. The MC-Upper has some areas of aggradation, reducing pool depths, along the upper section of the monitoring reach. Tributary UT6 continues to indicate an evolving stream system; however, with an overall trend back towards the designed profile. The restored stream channel continues to receive significant sediment inputs from upstream sources that are likely driving the bed form changes observed between monitoring years.

### 3.3.3 Substrate

Overall, pebble count data for MC-Upper indicate minimal change in substrate size composition between years for both riffles and pools (Appendix B). The MC-Upper pebble count data collected during Year 5 primarily indicate silt/clay and fine sand particles within the pool habitat types and coarser materials within the riffles. As compared to the MC-Upper reach, pebble counts collected for the MC-Lower reach indicate an overall coarser composition within both the pool and riffle habitat types, with pools primarily containing sand and gravel and riffles primarily comprised of gravel. The UT1 pebble count data collected during Year 5 continues to indicate finer substrate material within both pool and riffle habitats, with substrate composition comprised of silt/clay and sand particles. The Year 5 substrate composition within the UT6 riffle habitat is similar to the previous year and was primarily comprised of a wide range of sand and gravel particles. The UT6 pool substrate composition has remained unchanged and was primarily comprised of coarse sand and fine gravel substrate. The pebble count data summary plots are included in Appendix B.

### 3.3.4 Hydrology

Since the Morgan Creek project was completed at least six bankfull events (four documented with crest gauges and two with photos) have occurred at the project site. An initial bankfull event occurred in August 2008, shortly after project completion, which registered 0.15 feet above bankfull on Morgan Creek and 0.02 feet above bankfull on UT6. Owing to damaged crest gauges from this initial event, bankfull events in May 2009 (MY1) and January 2010 (MY2) were documented with photos. During the Year 2 monitoring bankfull events were documented with crest gauges located on the UT1, UT6, and Morgan Creek mainstem restoration reaches (Table 4). One bankfull event occurred during the Year 4 monitoring period. One bankfull event occurred in May of 2013 (Year 5).
### Table 4. Crest Gauge Data, Height above Bankfull

<table>
<thead>
<tr>
<th>Month/Year Recorded</th>
<th>Morgan Creek (feet)</th>
<th>UT1 (feet)</th>
<th>UT6 (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>August 2008</td>
<td>0.15</td>
<td>0.00</td>
<td>0.02</td>
</tr>
<tr>
<td>November 2010</td>
<td>0.56</td>
<td>0.02</td>
<td>0.57</td>
</tr>
<tr>
<td>May 2012</td>
<td>0.66</td>
<td>0.41</td>
<td>0.76</td>
</tr>
<tr>
<td>May 2013</td>
<td>0.93</td>
<td>0.60</td>
<td>0.91</td>
</tr>
</tbody>
</table>

#### 3.3.5 Photo Reference Stations

The Year 5 reference station photos are included in Appendix D. Stream problem areas (SPA) identified through the morphological monitoring and visual assessments include isolated areas of stream bed aggradation and degradation, stream bank erosion, and grade control degradation (Table 5). Representative photos of these areas taken during the Year 5 monitoring are included in Appendix D.

### Table 5. Stream Problem Areas Requiring Observation

<table>
<thead>
<tr>
<th>SPA</th>
<th>Feature</th>
<th>Reach</th>
<th>STA</th>
<th>Description</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pool</td>
<td>UT1</td>
<td>2001+10</td>
<td>Reduced pool depth due to aggradation</td>
<td>No action recommended</td>
</tr>
<tr>
<td>2</td>
<td>Pool</td>
<td>UT1</td>
<td>2002+75</td>
<td>Reduced pool depth due to aggradation</td>
<td>No action recommended</td>
</tr>
<tr>
<td>3</td>
<td>Pool</td>
<td>UT1</td>
<td>2003+40</td>
<td>Reduced pool depth due to aggradation</td>
<td>No action recommended</td>
</tr>
<tr>
<td>4</td>
<td>Pool</td>
<td>Morgan Creek</td>
<td>1002+25</td>
<td>Reduced pool depth due to aggradation</td>
<td>No action recommended</td>
</tr>
<tr>
<td>5</td>
<td>Pool/Riffle</td>
<td>UT2</td>
<td>3000+50</td>
<td>Reduced pool depth and riffle fining due to aggradation</td>
<td>No action recommended</td>
</tr>
<tr>
<td>6</td>
<td>Pool</td>
<td>Morgan Creek</td>
<td>1003+25</td>
<td>Reduced pool depth due to aggradation</td>
<td>No action recommended</td>
</tr>
<tr>
<td>7</td>
<td>Pool</td>
<td>Morgan Creek</td>
<td>1005+20</td>
<td>Reduced pool depth due to aggradation</td>
<td>No action recommended</td>
</tr>
<tr>
<td>8</td>
<td>Pool</td>
<td>Morgan Creek</td>
<td>1006+00</td>
<td>Reduced pool depth due to aggradation</td>
<td>No action recommended</td>
</tr>
<tr>
<td>9</td>
<td>Pool</td>
<td>Morgan Creek</td>
<td>1008+00</td>
<td>Reduced pool depth due to aggradation</td>
<td>No action recommended</td>
</tr>
<tr>
<td>10</td>
<td>Riffle</td>
<td>Morgan Creek</td>
<td>1007+75</td>
<td>Riffle down cutting</td>
<td>No action recommended</td>
</tr>
<tr>
<td>11</td>
<td>Riffle</td>
<td>Morgan Creek</td>
<td>1008+75</td>
<td>Riffle down cutting</td>
<td>No action recommended</td>
</tr>
<tr>
<td>12</td>
<td>Pool</td>
<td>UT3</td>
<td>4000+10</td>
<td>Reduced pool depth due to aggradation</td>
<td>No action recommended</td>
</tr>
<tr>
<td>13</td>
<td>Pool</td>
<td>UT3</td>
<td>4001+90</td>
<td>Reduced pool depth due to aggradation</td>
<td>No action recommended</td>
</tr>
<tr>
<td>14</td>
<td>Stream Bank</td>
<td>Morgan Creek</td>
<td>1012+25</td>
<td>Bank erosion</td>
<td>No action recommended</td>
</tr>
<tr>
<td>15</td>
<td>Pool</td>
<td>UT4</td>
<td>5000+90</td>
<td>Reduced pool depth due to aggradation</td>
<td>No action recommended</td>
</tr>
<tr>
<td>16</td>
<td>Pool/Riffle</td>
<td>UT4</td>
<td>5001+50</td>
<td>Reduced pool depth and riffle fining due to aggradation</td>
<td>No action recommended</td>
</tr>
<tr>
<td>17</td>
<td>Riffle</td>
<td>Morgan Creek</td>
<td>1020+75</td>
<td>Riffle down cutting</td>
<td>No action recommended</td>
</tr>
<tr>
<td>18</td>
<td>Pool/Riffle</td>
<td>UT5</td>
<td>6000+50</td>
<td>Reduced pool depth and riffle fining due to aggradation</td>
<td>No action recommended</td>
</tr>
<tr>
<td>19</td>
<td>Stream Channel</td>
<td>Morgan Creek</td>
<td>1025+50</td>
<td>Beaver dam</td>
<td>Beaver management program</td>
</tr>
<tr>
<td>20</td>
<td>Riffle</td>
<td>Morgan Creek</td>
<td>1028+85</td>
<td>Transverse riffle directing thalweg at bank</td>
<td>No action recommended</td>
</tr>
</tbody>
</table>
### SPA  Feature  Reach  STA  Description  Recommendation

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>Stream Bank</td>
<td>Morgan Creek</td>
<td>1029+40</td>
<td>Bank erosion due to thalweg directed at bank</td>
<td>No action recommended</td>
</tr>
<tr>
<td>22</td>
<td>Pool</td>
<td>Morgan Creek</td>
<td>1033+80</td>
<td>Reduced pool depth due to aggradation</td>
<td>No action recommended</td>
</tr>
<tr>
<td>23</td>
<td>Riffle</td>
<td>Morgan Creek</td>
<td>1038+50</td>
<td>Mid channel bar</td>
<td>No action recommended</td>
</tr>
<tr>
<td>24</td>
<td>Pool</td>
<td>Morgan Creek</td>
<td>1047+00</td>
<td>Reduced pool depth due to aggradation</td>
<td>No action recommended</td>
</tr>
<tr>
<td>25</td>
<td>Pool/Riffle  UT7</td>
<td>8000+40</td>
<td>Reduced pool depth and riffle fining due to aggradation</td>
<td>No action recommended</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>Pool/Riffle  UT7</td>
<td>8006+00</td>
<td>Reduced pool depth and riffle fining due to aggradation</td>
<td>No action recommended</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Pool</td>
<td>Morgan Creek</td>
<td>1009+50</td>
<td>Reduced pool depth due to aggradation</td>
<td>No action recommended</td>
</tr>
<tr>
<td>28</td>
<td>Pool</td>
<td>Morgan Creek</td>
<td>1008+50</td>
<td>Reduced pool depth due to aggradation</td>
<td>No action recommended</td>
</tr>
<tr>
<td>29</td>
<td>Pool</td>
<td>Morgan Creek</td>
<td>1007+25</td>
<td>Reduced pool depth due to aggradation</td>
<td>No action recommended</td>
</tr>
<tr>
<td>30</td>
<td>Stream Bank</td>
<td>Morgan Creek</td>
<td>1044+00</td>
<td>Bank erosion</td>
<td>No action recommended</td>
</tr>
<tr>
<td>31</td>
<td>Stream Bank</td>
<td>Morgan Creek</td>
<td>1041+00</td>
<td>Bank erosion</td>
<td>No action recommended</td>
</tr>
<tr>
<td>32</td>
<td>Stream Bank</td>
<td>Morgan Creek</td>
<td>1040+00</td>
<td>Bank erosion</td>
<td>No action recommended</td>
</tr>
<tr>
<td>33</td>
<td>Stream Bank</td>
<td>Morgan Creek</td>
<td>1037+50</td>
<td>Bank Erosion</td>
<td>No action recommended</td>
</tr>
<tr>
<td>34</td>
<td>Stream Bank</td>
<td>Morgan Creek</td>
<td>1014+50</td>
<td>Bank Erosion</td>
<td>No action recommended</td>
</tr>
<tr>
<td>35</td>
<td>Riffle</td>
<td>Morgan Creek</td>
<td>1044+50</td>
<td>Riffle cutting down</td>
<td>No action recommended</td>
</tr>
<tr>
<td>36</td>
<td>Riffle</td>
<td>Morgan Creek</td>
<td>1043+50</td>
<td>Riffle cutting down</td>
<td>No action recommended</td>
</tr>
<tr>
<td>37</td>
<td>Riffle</td>
<td>Morgan Creek</td>
<td>1041+60</td>
<td>Riffle cutting down</td>
<td>No action recommended</td>
</tr>
<tr>
<td>38</td>
<td>Beaver</td>
<td>Morgan Creek</td>
<td>1027+50</td>
<td>Dam obstructing channel</td>
<td>Beaver removal program</td>
</tr>
</tbody>
</table>

### 3.4 Stream Conclusions

The Year 5 morphological monitoring and visual assessments continue to indicate an evolving stream system in which the restoration areas continue to progress towards stability. Areas of concern identified during Year 5 were primarily associated with pool aggradation and riffle degradation. Upstream sediment sources, in conjunction with on-site riffle down-cutting, appear to be the primary influences associated with bed profile changes between years. Additionally, these areas are relatively minor and are not unexpected in natural stream systems. Table 6 summarizes the riffle morphologic parameters since the as-built conditions were measured. Details of the morphologic parameters are provided in Appendices B and C. The MC-Lower as-built and Year 1 parameters in Table 6 are presented for the purpose of comparing the original as-built conditions to conditions following completion of the repairs.
Table 6. Summary of Morphologic Monitoring Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Morgan Creek – Upper Reach</th>
<th>Morgan Creek – Lower Reach</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>As-Built</td>
<td>Year 1</td>
</tr>
<tr>
<td>Average Bankfull Cross-Section Area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abkf (square feet)</td>
<td>28.4</td>
<td>25.0</td>
</tr>
<tr>
<td>Average Bankfull Width</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wbkf (ft)</td>
<td>20.8</td>
<td>19.7</td>
</tr>
<tr>
<td>Average Bankfull Width/Depth Ratio</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>15.5</td>
<td>15.6</td>
</tr>
<tr>
<td>Average Bankfull Mean Depth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dbkf (feet)</td>
<td>1.4</td>
<td>1.3</td>
</tr>
<tr>
<td>Average Bankfull Max Depth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dmax (feet)</td>
<td>2.4</td>
<td>3.0</td>
</tr>
</tbody>
</table>

1 Based on Riffle values
2 Morgan Creek – Lower as-built data are presented for the purpose of comparing the original measures to those of the repair as-built conditions (Year 1) and not for morphological analysis.
Table 6 Continued. Summary of Morphologic Monitoring Parameters\(^1\)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Morgan Creek – UT1</th>
<th>Morgan Creek – UT6</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>As-Built</td>
<td>Year 1</td>
</tr>
<tr>
<td>Average Bankfull Cross-Section Area Abkf (square feet)</td>
<td>4.1</td>
<td>4.2</td>
</tr>
<tr>
<td>Average Bankfull Width Wbkf (feet)</td>
<td>9.1</td>
<td>9.0</td>
</tr>
<tr>
<td>Average Bankfull Width/Depth Ratio</td>
<td>19.9</td>
<td>19.4</td>
</tr>
<tr>
<td>Average Bankfull Mean Depth Dbkf (feet)</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Average Bankfull Max Depth Dmax (feet)</td>
<td>1.2</td>
<td>1.3</td>
</tr>
</tbody>
</table>

\(^1\) Based on Riffle values
4.0 VEGETATION

4.1 Vegetation Success Criteria

Successful establishment of vegetation for the Morgan Creek Stream Restoration Project should be an average of 320 planted stems per acre by the end of Year 3 such that the site will meet the final requirement of 260 planted stems per acre by Year 5.

4.2 Description of Species and Vegetation Monitoring

Eight vegetation plots (VP), or approximately 1% of the restoration site were established within the project easement area: seven standard (10 m x 10 m) plots and one non-standard (5 m x 20 m) plot (Figure 3). These plots were established in accordance with the CVS-EEP Level II monitoring protocol (Lee et al. 2008) within the planted restoration areas. Approximately 0.025-acre in size, vegetation plots were monitored to determine the success of planted vegetation and the overall trajectory of woody plant restoration and natural plant regeneration at the project site. Plots were placed within the applicable planting zones to capture the heterogeneity of the restored vegetative communities. However, given that several planting zones were too narrow to accommodate the standard or non-standard plots, all vegetation plots were placed to include riparian and upland planting zones. Due to the stream repairs completed in early 2010, VP8 had to be re-established and replanted prior to the Year 2 monitoring efforts. An additional supplemental planting effort occurred in April 2011 within the repair areas and other areas previously noted with low stem densities. A total of 11 tree species were planted on the site (Table 7). Taxonomic nomenclature follows Weakley (2008).

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Willow Oak</td>
<td>Quercus phellos</td>
</tr>
<tr>
<td>Water Oak</td>
<td>Quercus nigra</td>
</tr>
<tr>
<td>Swamp Chestnut Oak</td>
<td>Quercus michauxii</td>
</tr>
<tr>
<td>Black Willow</td>
<td>Salix nigra</td>
</tr>
<tr>
<td>River Birch</td>
<td>Betula nigra</td>
</tr>
<tr>
<td>Yellow Poplar</td>
<td>Liriodendron tulipifera var. tulipifera</td>
</tr>
<tr>
<td>American Sycamore</td>
<td>Platanus occidentalis var. occidentalis</td>
</tr>
<tr>
<td>Green Ash</td>
<td>Fraxinus pennsylvanica</td>
</tr>
<tr>
<td>Buttonbush</td>
<td>Cephalanthus occidentalis</td>
</tr>
<tr>
<td>Black Willow</td>
<td>Salix nigra</td>
</tr>
<tr>
<td>Silky Dogwood</td>
<td>Cornus amomum</td>
</tr>
</tbody>
</table>

4.3 Results of Vegetation Monitoring

Planted stem counts for each of the eight vegetation monitoring plots were recorded by species (Table 8). Low stem densities reported for the as-built conditions resulted in a supplemental planting that occurred in December 2008. Additionally, in April 2011 a follow up supplemental planting occurred within the repaired areas and other areas noted with low stem densities.
Results from the Year 5 vegetation monitoring documented planted stem densities ranging from 324 to 971 stems per acre (Table 9) with an average planted stem density of 607 planted stems per acre for the entire restoration site.

Table 8. Results of Monitoring Year 5 Vegetation Monitoring by Plot

<table>
<thead>
<tr>
<th>Species</th>
<th>VP1</th>
<th>VP2</th>
<th>VP3</th>
<th>VP4</th>
<th>VP5</th>
<th>VP6</th>
<th>VP7</th>
<th>VP8</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Betula nigra</strong></td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>11</td>
<td>8</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td><strong>Cephalanthus occidentalis</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td><strong>Fagus grandifolia</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td><strong>Fraxinus pennsylvanica</strong></td>
<td>4</td>
<td>4</td>
<td>6</td>
<td></td>
<td>10</td>
<td>4</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td><strong>Liriodendron tulipifera</strong> var. tulipifera</td>
<td>1</td>
<td></td>
<td></td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td>5</td>
</tr>
<tr>
<td><strong>Platanus occidentalis</strong> var. occidentalis</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Quercus michauxii</strong></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td><strong>Quercus nigra</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td><strong>Quercus phellos</strong></td>
<td>2</td>
<td></td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td><strong>Quercus species</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td><strong>Salix nigra</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td>13</td>
<td>11</td>
<td>8</td>
<td>12</td>
<td>19</td>
<td>21</td>
<td>24</td>
<td>12</td>
</tr>
</tbody>
</table>
### Table 9. Summary of Vegetation Monitoring Results

<table>
<thead>
<tr>
<th>Plot ID</th>
<th>Stems Planted (Original Baseline Conditions)</th>
<th>Baseline Stems + Initial Supplemental Planting Stems (Revised Baseline Conditions)</th>
<th>2013 Planted Stems</th>
<th>Percent Survival as Compared to Revised Baseline Conditions</th>
<th>Stems per Acre</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>VP1</td>
<td>7</td>
<td>10</td>
<td>13</td>
<td>130%</td>
<td>283</td>
<td>405</td>
<td>405</td>
<td>486</td>
<td>486</td>
<td>526</td>
</tr>
<tr>
<td>VP2</td>
<td>3</td>
<td>5</td>
<td>11</td>
<td>220%</td>
<td>122</td>
<td>162</td>
<td>283</td>
<td>445</td>
<td>405</td>
<td>445</td>
</tr>
<tr>
<td>VP3</td>
<td>5</td>
<td>7</td>
<td>8</td>
<td>114%</td>
<td>202</td>
<td>283</td>
<td>283</td>
<td>364</td>
<td>324</td>
<td>324</td>
</tr>
<tr>
<td>VP4</td>
<td>7</td>
<td>10</td>
<td>12</td>
<td>120%</td>
<td>283</td>
<td>405</td>
<td>445</td>
<td>526</td>
<td>526</td>
<td>486</td>
</tr>
<tr>
<td>VP5</td>
<td>10</td>
<td>17</td>
<td>19</td>
<td>112%</td>
<td>405</td>
<td>688</td>
<td>728</td>
<td>890</td>
<td>809</td>
<td>769</td>
</tr>
<tr>
<td>VP6</td>
<td>14</td>
<td>23</td>
<td>21</td>
<td>91%</td>
<td>567</td>
<td>931</td>
<td>850</td>
<td>890</td>
<td>890</td>
<td>850</td>
</tr>
<tr>
<td>VP7</td>
<td>16</td>
<td>22</td>
<td>24</td>
<td>109%</td>
<td>648</td>
<td>891</td>
<td>809</td>
<td>890</td>
<td>850</td>
<td>971</td>
</tr>
<tr>
<td>VP8</td>
<td>9</td>
<td>21</td>
<td>11</td>
<td>N/A</td>
<td>364</td>
<td>850</td>
<td>486</td>
<td>567</td>
<td>486</td>
<td>486</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>359</td>
<td>576</td>
<td>536</td>
<td>632</td>
<td>597</td>
<td>607</td>
</tr>
</tbody>
</table>

Average stems per acre: 607
Range of stems per acre: 324 – 971
*Increases since revised baseline conditions are the result of an additional supplemental planting effort in April 2011.
**Includes supplemental planting data
N/A – Plot re-established in Year 2 and percent survival is not applicable between monitoring years.

A visual estimate of herbaceous vegetation cover within the monitoring plots is provided to assess the overall stability of the restoration site (Table 10). On average, herbaceous vegetation coverage is 93% within the plots ranging from 80% to 100%. Observations of herbaceous cover throughout the project area were noted during the visual assessment and are documented in Appendix A; representative photos are included in Appendix D. Herbaceous cover typically consists of dogfennel (*Eupatorium capillifolium*), hollow-stem Joe-pye weed (*Eutrochium fistulosum*), narrow-leaved sunflower (*Helianthus angustifolius*), goldenrod (*Solidago sp.*), rice cutgrass (*Leersia oryzoides*), honesnettle (*Solanum carolinensis*), soft rush (*Juncus effusus*), daisy fleabane (*Erigeron annuus*), Queen Anne’s lace (*Daucus carota*), arrowleaf tearthumb (*Polygonum sagittatum*) and blackberry (*Rubus sp.*). Overall, herbaceous cover has increased between years and is expected to continue as a result of natural recruitment from adjacent vegetated areas and due to previous remedial actions undertaken by EBX to improve vegetative cover in the bare areas.
Table 10. Estimated Herbaceous Total Percent Cover

<table>
<thead>
<tr>
<th>Plot ID</th>
<th>Estimated Herbaceous Cover (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VP1</td>
<td>100</td>
</tr>
<tr>
<td>VP2</td>
<td>95</td>
</tr>
<tr>
<td>VP3</td>
<td>100</td>
</tr>
<tr>
<td>VP4</td>
<td>90</td>
</tr>
<tr>
<td>VP5</td>
<td>80</td>
</tr>
<tr>
<td>VP6</td>
<td>100</td>
</tr>
<tr>
<td>VP7</td>
<td>85</td>
</tr>
<tr>
<td>VP8</td>
<td>90</td>
</tr>
<tr>
<td>Mean</td>
<td>93</td>
</tr>
</tbody>
</table>

Commonly encountered woody volunteer or natural species also have been documented throughout the five-year monitoring period (Table 11). Mean recruitment density of volunteer stems rose to 1229 stems per acre between Year 4 and Year 5.

Table 11. Volunteer Tree Species

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>American Persimmon</td>
<td>Diospyros virginiana</td>
</tr>
<tr>
<td>American Hornbeam</td>
<td>Carpinus caroliniana</td>
</tr>
<tr>
<td>Black Willow</td>
<td>Salix nigra</td>
</tr>
<tr>
<td>Tag Alder</td>
<td>Alnus serrulata</td>
</tr>
<tr>
<td>Buttonbush*</td>
<td>Cepalanthus occidentalis</td>
</tr>
<tr>
<td>Willow Oak*</td>
<td>Quercus phellos</td>
</tr>
<tr>
<td>Green Ash*</td>
<td>Fraxinus pennsylvanica</td>
</tr>
<tr>
<td>American Sycamore*</td>
<td>Platanus occidentalis var. occidentalis</td>
</tr>
<tr>
<td>Swamp Chestnut Oak*</td>
<td>Quercus michauxii</td>
</tr>
<tr>
<td>River Birch*</td>
<td>Betula nigra</td>
</tr>
<tr>
<td>Red Maple</td>
<td>Acer rubrum</td>
</tr>
<tr>
<td>Black Cherry</td>
<td>Prunus serotina</td>
</tr>
<tr>
<td>Shortleaf Pine</td>
<td>Pinus echinata</td>
</tr>
<tr>
<td>Smooth Sumac</td>
<td>Rhus glabra</td>
</tr>
<tr>
<td>Silky Dogwood</td>
<td>Cornus amomum</td>
</tr>
<tr>
<td>Elderberry</td>
<td>Sambucus canadensis</td>
</tr>
</tbody>
</table>

*Likely planted during the earlier repair efforts.
4.4 Vegetation Observations and Conclusions

Overall, planted stems are surviving well at the Morgan Creek Stream Restoration Site. Only 3% of planted stems were found to be dead or missing during Year 5 monitoring; mortality was highest at VP6. 81% of all stems had a vigor score of good or excellent. All vegetation monitoring are meeting the final success criterion of 260 stems per acre. The average stem density across the whole site for planted and volunteers combined is approximately 1,836 stems per acre, which is well above the final success criterion of 260 stems per acre at the end of Year 5. Additionally, herbaceous cover is well established and relatively high in the majority of the vegetation monitoring plots.

Invasive exotic plants such as multiflora rose (*Rosa multiflora*), Japanese stiltgrass (*Microstegium vimineum*), Japanese honeysuckle (*Lonicera japonica*), and privet (*Ligustrum sp.*) were generally abundant throughout the easement area. Japanese knotweed (*Reynoutria japonica*), tree of heaven (*Ailanthus altissima*), princess tree (*Paulownia tomentosa*), Oriental bittersweet (*Celastrus orbiculatus*), kudzu (*Pueraria montana var. lobata*), Japanese barberry (*Berberis thunbergii*), and olive species (*Elaeagnus sp.*) were also documented in dense isolated patches within the easement boundary. Control of the kudzu, knotweed, and other high-priority species began prior to Year 4 monitoring and appears to have eliminated the Japanese knotweed from the site. Additional intensive control efforts were administered in Year 4 with follow up treatments completed in Year 5. The current condition plan views (CCPV) in Appendix A depict those areas treated for invasive exotic plants during Year 5. Appendix E contains the baseline report and contains a summary of the invasive exotic management activities conducted during this period.
5.0 CONCLUSIONS AND RECOMMENDATIONS

- The morphological data and observations of stream conditions indicate the restored reaches are reaching a desired state of stability. Areas of concern identified during Year 5 monitoring were primarily associated with pool and riffle degradation; likely caused by upstream disturbance. Problem areas identified are relatively minor and do not exceed expectations associated with sediment transport in natural stream systems. Beaver activity has been observed on Morgan Creek and current trapping is ongoing through the USDA Animal and Plant Health Inspection Service.

- Vegetation monitoring efforts have documented the average density planted stems to be 607 stems per acre for the 2013 monitoring year. All vegetation plots meeting the final success criterion of 260 stems per acre. Likewise, individuals classified as volunteer species were similar between years. Lastly, monitoring final invasive exotic plant control treatment was administered in 2013. No remedial action is recommended.
6.0 REFERENCES


APPENDIX A

Monitoring Year 4
Current Condition Plan View
Date: September 2013

Notes:
1. Coordinate System is State Plane Feet NAD 83
2. Base map information provided by Kimley Horn & Stantec. Dwg title(s): ACAD-018336000-BASE.dwg & 171300323_ASBUILT_BASE_corrected.dwg respectively
3. Aerial photography is NC One Map 2010

Prepared by:

LEGEND
- Vegetation Monitoring Plots
- Easement Boundary
- Stream
- Longitudinal Profile Reach
- Longitudinal Profile Begin/End
- Control Point
- Cross Section
- Crest Gauge
- Photo Point
- Constructed Riffle
- A-Vane
- Cross Vane
- J-Hook
- Log Sill
- Root Wad
- Rock Leg Riffle
- Double Rock Drop Cross Vane
- Double Log Sill
LEGEND

Vegetation Monitoring Plots
Easement Boundary
Stream
Longitudinal Profile Reach
Longitudinal Profile Begin/End
Control Point
Cross Section
Crest Gauge
Photo Point
Constructed Riffle
A-Vane
Cross Vane
J-Hooks
Log Sill
Root Wad
Rock Log Riffle
Double Rock Drop Cross Vane
Double Leg Sill

Morgan Creek
McDowell County, NC

Current Condition Plan View
Draft Year 5 Monitoring 2013

Date: September 2013

Prepared for: Morgan Creek
Prepared by: Morgan Creek

Notes:
1. Coordinate System is State Plane Feet NAD 83
2. Base map information provided by Kimley Horn & Stantec. Dwg title(s): ACAD-018336000-BASE.dwg & 171300323_ASBUILT_BASE_corrected.dwg respectively
3. Aerial photography is NC One Map 2010

Sheet: 2 of 8
Morgan Creek
McDowell County, NC

Current Condition Plan View
Year 5 Monitoring-2013
Draft
Date: September 2013

Prepared for:
Prepared by:

Notes:
1. Coordinate System is State Plane Feet NAD 83
2. Base map information provided by Kimley Horn & Stantec. .DWG title(s): ACAD-018336000-BASE.dwg & 171300323_ASBUILT_BASE_corrected.dwg respectively
3. Aerial photography is NC One Map 2010

LEGEND
Vegetation Monitoring Plots
Easement Boundary
Stream
Longitudinal Profile Reach
Longitudinal Profile Begin/End
Control Point
Cross Section
Crest Gauge
Photo Point
Constructed Riffle
A-Vane
Cross Vane
J-Hook
Log Sill
Root Wad
Rock Log Riffle
Double Rock Drop Cross Vane
Double Log Sill

YEAR 5 CONDITIONS
Bank/Bed Conditions
- Bank Stressed
- Bed Aggradation
- Bed Scour
Vegetation Plots
- Criteria Met MY5
Vegetation Problem Areas
- Invasive Population Treated
Beaver Activity
- Dam

SCALE 1" = 0
300 200 100 250 50
200'
SCALE 1" = 0 250 500 750 1000 1500 2000'  

YEAR 5 CONDITIONS  
Bank/Bed Conditions  
- Bank Stressed  
- Bed Aggradation  
- Bed Scour  
Vegetation Plots  
- Criteria Met MY5  
- Vegetation Problem Areas  
- Invasive Population Treated  
Beaver Activity  
- Dam  

LEGEND  
Vegetation Monitoring Plots  
Easement Boundary  
Stream  
Longitudinal Profile Reach  
Longitudinal Profile Begin/End  
Control Point  
Cross Section  
Crest Gauge  
Photo Point  
Constructed Riffle  
A-Vane  
Cross Vane  
J-Hook  
Log Sill  
Root Wad  
Rock Log Riffle  
Double Rock Drop Cross Vane  
Double Log Sill  

Prepared for:  
Prepared by:  
Notes:  
1. Coordinate System is State Plane Feet NAD 83  
2. Base map information provided by Kimley Horn & Stantec.  

Sheet: 4 of 8  
Date: September 2013
YEAR 5 CONDITIONS

Bank/Bed Conditions
- Bank Stressed
- Bed Aggradation
- Bed Scour

Vegetation Plots
- Criteria Met MY5
- Vegetation Problem Areas
- Invasive Population Treated

Beaver Activity
- Dam

LEGEND
- Vegetation Monitoring Plots
- Easement Boundary
- Stream
- Longitudinal Profile Reach
- Longitudinal Profile Begin/End
- Control Point
- Cross Section
- Crest Gauge
- Photo Point
- Constructed Riffle
- A-Vane
- Cross Vane
- J-Hook
- Log Sill
- Root Wad
- Rock Log Riffle
- Double Rock Drop Cross Vane
- Double Log Sill

SCALE 1" = 150'
SCALE 1" = 150 100 50 25 ft

YEAR 5 CONDITIONS
Bank/Bed Conditions
- Bank Stressed
- Bed Aggradation
- Bed Scour
Vegetation Plots
- Criteria Met MV3
Vegetation Problem Areas
- Invasive Population Treated
- Beaver Activity
- Dam

LEGEND
- Vegetation Monitoring Plots
- Easement Boundary
- Stream
- Longitudinal Profile Reach
- Longitudinal Profile Begin/End
- Control Point
- Cross Section
- Crest Gauge
- Photo Point
- Constructed Riffle
- A-Vane
- Cross Vane
- J-Hook
- Log Sill
- Root Wad
- Rock Log Riffle
- Double Rock Drop Cross Vane
- Double Log Sill

Notes:
1. Coordinate System is State Plane Feet NAD 83
2. Base map information provided by Kimley Horn & Stantec. DWG title(s): ACAD-018336000-BASE.dwg & 171300323_ASBUILT_BASE_corrected.dwg respectively
3. Aerial photography is NC One Map 2010

Prepared for: Prepared by:

Date:
September 2013

Sheet: 7 of 8

Morgan Creek
MC Dispatch Map
McDowell County, NC

Current Condition Plan View
Year 5 Monitoring-2013
Draft
APPENDIX B

Monitoring Year 5
Longitudinal Profile, Cross-Section, and Substrate Data
Morgan Creek - Lower
Longitudinal Profile

Station (feet)

Elevation (feet)

MY1
MY2
MY3 4/21/11
MY4 3/14/12
MY5 2/14/13
Bkf
WS
Structures - MY2
Linear (Bkf)
Morgan Creek Upper – Riffle 2
Cross-Section 2

Looking at Left Bank

Looking at Right Bank

Morgan Creek Upper
Riffle 2

1221
1220
1219
1218
1217
1216
1215
1214
1213
0+00 0+05 0+10 0+15 0+20 0+25 0+30 0+35
Elevation (feet)
Station (feet)
Morgan Creek Lower – Riffle 1
Cross-Section 1

Looking at Left Bank

Looking at Right Bank

Morgan Creek Lower
Riffle 1

Station (feet)

Elevation (feet)
Morgan Creek Lower – Pool 1
Cross-Section 2

Looking at Left Bank

Looking at Right Bank

Morgan Creek Lower
Pool 1
Morgan Creek Lower – Riffle 2
Cross-Section 3

Looking at Left Bank
Looking at Right Bank

Morgan Creek Lower
Riffle 2

Elevation (feet)
Station (feet)
Morgan Creek Lower – Riffle 3
Cross-Section 4

Looking at Left Bank

Looking at Right Bank

Morgan Creek Lower
Riffle 3

[Graph showing elevation changes along the cross-section with stations marked as MY1 to MY5 and Bkf.]
Morgan Creek Lower – Riffle 4
Cross-Section 6

Looking at Left Bank

Looking at Right Bank

Morgan Creek Lower
Riffle 4

<table>
<thead>
<tr>
<th>Station (feet)</th>
<th>Elevation (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0+00</td>
<td>1202</td>
</tr>
<tr>
<td>0+05</td>
<td>1202</td>
</tr>
<tr>
<td>0+10</td>
<td>1202</td>
</tr>
<tr>
<td>0+15</td>
<td>1202</td>
</tr>
<tr>
<td>0+20</td>
<td>1202</td>
</tr>
<tr>
<td>0+25</td>
<td>1202</td>
</tr>
<tr>
<td>0+30</td>
<td>1202</td>
</tr>
<tr>
<td>0+35</td>
<td>1202</td>
</tr>
<tr>
<td>0+40</td>
<td>1202</td>
</tr>
<tr>
<td>0+45</td>
<td>1202</td>
</tr>
</tbody>
</table>

- MY1
- MY2
- MY3
- MY4
- MY5
- Bkf

Equinox Environmental Consultation and Design, Inc.
Annual Monitoring Report 2013 (Year 5)
Appendix B

Monitoring Year 5 Cross-Sections

Unnamed Tributary 1 – Riffle
Cross-Section 1

Looking at Left Bank

Looking at Right Bank

Unnamed Tributary 1
Riffle

Elevation (feet)

Station (feet)
Appendix B

Monitoring Year 5 Cross-Sections

Unnamed Tributary 1 – Pool
Cross-Section 2

Looking at Left Bank

Looking at Right Bank

Unnamed Tributary 1 Pool

Elevation (feet)
Station (feet)

MY0 MY1 MY2 MY3 MY4 MY5 Bkf

Station (feet)
Appendix B

Monitoring Year 5 Cross-Sections

Unnamed Tributary 6 – Pool
Cross-Section 1

Looking at Left Bank

Looking at Right Bank

Elevation (feet)
Station (feet)

Unnamed Tributary 6 Pool

Morgan Creek Site
Equinox Environmental Consultation and Design, Inc.

Project ID No. 16-D06027
Annual Monitoring Report 2013 (Year 5)
Appendix B                                                                                  Monitoring Year 5 Cross-Sections

Morgan Creek Site                                                  Equinox Environmental Consultation and Design, Inc.
Project ID No.  16-D06027              B-20                                                Annual Monitoring Report 2013 (Year 5)

Unamed Tributary 6 – Riffle
Cross-Section 2

Looking at Left Bank

Looking at Right Bank

Unamed Tributary 6
Riffle

- MY0
- MY1
- MY2
- MY3
- MY4
- MY5
- Bkf
Morgan Creek Upper – Riffle 1
Pebble Count

Particle Size (mm)

0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%

0 - 0.062
0.062 - 0.125
0.125 - 0.25
0.25 - 0.5
0.5 - 1.0
1 - 2
2 - 4
4 - 8
8 - 16
16 - 32
32 - 64
64 - 128
128 - 256
256 - 512
512 - 1024
1024 - 2048
2048 - 4096
Bedrock

MY0 % Individual
MY1 % Individual
MY2 % Individual
MY3 % Individual
MY4 % Individual
MY5 % Individual
MY0 Cumulative % Finer Than
MY1 Cumulative % Finer Than
MY2 Cumulative % Finer Than
MY3 Cumulative % Finer Than
MY4 Cumulative % Finer Than
MY5 Cumulative % Finer Than
Morgan Creek Upper – Riffle 2
Pebble Count

Particle Size (mm)
Morgan Creek Upper – Riffle 3
Pebble Count

Particle Size (mm)

Bedrock
Morgan Creek Upper – Riffle 4
Pebble Count

Appendix B
Monitoring Year 5 Substrate Data
Morgan Creek Lower – Pool 1
Pebble Count

Morgan Creek Site
Project ID No. 16-D06027
Equinox Environmental Consultation and Design, Inc.
B-28
Annual Monitoring Report 2013 (Year 5)
### Morgan Creek Lower – Riffle 3

#### Pebble Count

<table>
<thead>
<tr>
<th>Particle Size (mm)</th>
<th>MY0 % Individual</th>
<th>MY1 % Individual</th>
<th>MY2 % Individual</th>
<th>MY3 % Individual</th>
<th>MY4 % Individual</th>
<th>MY5 % Individual</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 0.062</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.062 - 0.125</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.125 - 0.25</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.25 - 0.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.5 - 1.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 - 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 - 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 - 8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 - 16</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 - 32</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32 - 64</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>64 - 128</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>128 - 256</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>256 - 512</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>512 - 1024</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1024 - 2048</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2048 - 4096</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bedrock</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Legend:**
- MY0 Cumulative % Finer Than
- MY1 Cumulative % Finer Than
- MY2 Cumulative % Finer Than
- MY3 Cumulative % Finer Than
- MY4 Cumulative % Finer Than
- MY5 Cumulative % Finer Than
Morgan Creek Lower – Riffle 4
Pebble Count

[Graph showing substrate data with chart and legend for different particle sizes and cumulative % finer than each size.]
# Appendix B

## Monitoring Year 5 Substrate Data

**Morgan Creek Site**

**Equinox Environmental Consultation and Design, Inc.**

**Project ID No. 16-D06027**

**Annual Monitoring Report 2013 (Year 5)**

### Unnamed Tributary 1 – Pool Pebble Count

<table>
<thead>
<tr>
<th>Particle Size (mm)</th>
<th>MY0 % Individual</th>
<th>MY1 % Individual</th>
<th>MY2 % Individual</th>
<th>MY3 % Individual</th>
<th>MY4 % Individual</th>
<th>MY5 % Individual</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 0.062</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.062 - 0.125</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.125 - 0.25</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.25 - 0.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.5 - 1.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 - 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 - 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 - 8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 - 16</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 - 32</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32 - 64</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>64 - 128</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>128 - 256</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>256 - 512</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>512 - 1024</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1024 - 2048</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2048 - 4096</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bedrock</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### MY0 Cumulative % Finer Than

- 0%
- 10%
- 20%
- 30%
- 40%
- 50%
- 60%
- 70%
- 80%
- 90%
- 100%

### MY1 Cumulative % Finer Than

- 0 - 0.062
- 0.062 - 0.125
- 0.125 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1 - 2
- 2 - 4
- 4 - 8
- 8 - 16
- 16 - 32
- 32 - 64
- 64 - 128
- 128 - 256
- 256 - 512
- 512 - 1024
- 1024 - 2048
- 2048 - 4096
- Bedrock

### MY2 Cumulative % Finer Than

- MY3 Cumulative % Finer Than

- MY4 Cumulative % Finer Than

- MY5 Cumulative % Finer Than
Unnamed Tributary 6 – Pool
Pebble Count

Particle Size (mm)

- 0%
- 10%
- 20%
- 30%
- 40%
- 50%
- 60%
- 70%
- 80%
- 90%
- 100%
- 0 - 0.062
- 0.062 - 0.125
- 0.125 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- 1 - 2
- 2 - 4
- 4 - 8
- 8 - 16
- 16 - 32
- 32 - 64
- 64 - 128
- 128 - 256
- 256 - 512
- 512 - 1024
- 1024 - 2048
- 2048 - 4096
- Bedrock

- MY0 % Individual
- MY1 % Individual
- MY2 % Individual
- MY3 % Individual
- MY4 % Individual
- MY5 % Individual
- MY0 Cumulative % Finer Than
- MY1 Cumulative % Finer Than
- MY2 Cumulative % Finer Than
- MY3 Cumulative % Finer Than
- MY4 Cumulative % Finer Than
- MY5 Cumulative % Finer Than
APPENDIX C

Monitoring Year 5
Morphologic Monitoring Parameters
### Morgan Creek – Upper Reach

#### Monitoring Year 5 Morphologic Monitoring Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Cross-Section 1</th>
<th>Cross-Section 2</th>
<th>Cross-Section 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Riffle 1</td>
<td>Riffle 2</td>
<td>Pool 1</td>
</tr>
<tr>
<td>Dimension</td>
<td>Base MY1 MY2 MY3 MY4 MY5</td>
<td>Base MY1 MY2 MY3 MY4 MY5</td>
<td>Base MY1 MY2 MY3 MY4 MY5</td>
</tr>
<tr>
<td>BF Width (ft)</td>
<td>20.5 21.4 21.2 20.8 20.7</td>
<td>19.6 18.8 18.4 18.3 17.8</td>
<td>32.9 28.3 27.3 27.8 27.9</td>
</tr>
<tr>
<td>Floodprone Width (ft)</td>
<td>&gt;100 &gt;100 &gt;100 &gt;100 &gt;100</td>
<td>&gt;100 &gt;100 &gt;100 &gt;100 &gt;100</td>
<td>&gt;100 &gt;100 &gt;100 &gt;100 &gt;100</td>
</tr>
<tr>
<td>BF Cross Sectional Area (ft²)</td>
<td>29.4 25.2 24.4 23.1 23.0</td>
<td>26.6 28.1 29.1 29.7 30.3</td>
<td>65.7 38.3 38.0 38.9 34.4</td>
</tr>
<tr>
<td>BF Mean Depth (ft)</td>
<td>1.4 1.2 1.2 1.1 1.1</td>
<td>1.4 1.5 1.6 1.6 1.7</td>
<td>2.0 1.4 1.4 1.4 1.2</td>
</tr>
<tr>
<td>BF Max Depth (ft)</td>
<td>2.5 2.6 2.7 2.7 2.5</td>
<td>2.3 3.8 3.8 4.0 4.0</td>
<td>4.5 3.7 3.6 3.2 3.1</td>
</tr>
<tr>
<td>BF Mean Diameter (ft)</td>
<td>14.3 18.1 18.4 18.7 18.7</td>
<td>14.5 12.6 11.6 11.3 10.5</td>
<td>16.4 20.9 19.6 19.9</td>
</tr>
<tr>
<td>BF Width/Depth Ratio</td>
<td>14.3 18.1 18.4 18.7 18.7</td>
<td>14.5 12.6 11.6 11.3 10.5</td>
<td>16.4 20.9 19.6 19.9</td>
</tr>
<tr>
<td>BF Mean Depth (ft)</td>
<td>21.3 23.4 23.1 22.5 22.5</td>
<td>20.3 22.9 21.8 22.2 21.7</td>
<td>34.4 30.2 29.0 30.0 29.8</td>
</tr>
<tr>
<td>BF Mean Diameter (ft)</td>
<td>1.4 1.1 1.1 1.0 1.0</td>
<td>1.3 1.2 1.3 1.3 1.4</td>
<td>1.9 1.3 1.3 1.3 1.2</td>
</tr>
<tr>
<td>BF Width/Depth Ratio</td>
<td>13.0 15.2 15.6 15.0 14.6</td>
<td>20.0 16.6 18.4 14.3 14.4</td>
<td>30.8 22.1 17.1 10.1</td>
</tr>
<tr>
<td>BF Mean Diameter (ft)</td>
<td>32.7 25.7 25.1 24.4 24.0</td>
<td>24.7 21.0 20.9 19.7 19.1</td>
<td>49.2 23.4 24.8 23.3 21.9</td>
</tr>
<tr>
<td>BF Mean Diameter (ft)</td>
<td>4.9 5.1 5.0 5.2 5.3</td>
<td>&gt;5.4 &gt;5.4 &gt;5.1 &gt;6.0 &gt;6.1</td>
<td>&gt;2.6 &gt;4.4 &gt;4.9 &gt;6.5 &gt;7.0</td>
</tr>
<tr>
<td>BF Mean Diameter (ft)</td>
<td>21.4 21.9 22.0 21.6 21.1</td>
<td>22.8 19.9 20.6 18.0 17.6</td>
<td>40.9 25.0 23.3 18.4 16.8</td>
</tr>
<tr>
<td>BF Mean Diameter (ft)</td>
<td>1.5 1.2 1.1 1.1 1.1</td>
<td>1.1 1.1 1.0 1.1 1.1</td>
<td>1.2 0.9 1.1 1.3 1.3</td>
</tr>
</tbody>
</table>

---

Morgan Creek Site  
Project ID No. 16-D06027  
Equinox Environmental Consultation and Design, Inc.  
Annual Monitoring Report 2013 (Year 5)
# Morgan Creek – Lower Reach*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Cross-Section 1</th>
<th>Cross-Section 2</th>
<th>Cross-Section 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rifle 1</td>
<td>Pool 1</td>
<td>Riffle 2</td>
</tr>
<tr>
<td>Dimension</td>
<td>Base</td>
<td>MY1</td>
<td>MY2</td>
</tr>
<tr>
<td>BF Width (ft)</td>
<td>18.7</td>
<td>24.8</td>
<td>24.3</td>
</tr>
<tr>
<td>Floodprone Width (ft)</td>
<td>&gt;100</td>
<td>&gt;100</td>
<td>&gt;100</td>
</tr>
<tr>
<td>BF Cross Sectional Area (ft²)</td>
<td>22.5</td>
<td>45.3</td>
<td>47.7</td>
</tr>
<tr>
<td>BF Mean Depth (ft)</td>
<td>1.2</td>
<td>1.8</td>
<td>2.0</td>
</tr>
<tr>
<td>BF Max Depth (ft)</td>
<td>2.3</td>
<td>3.4</td>
<td>4.0</td>
</tr>
<tr>
<td>BF Cross Sectional Area (ft²)</td>
<td>15.5</td>
<td>13.6</td>
<td>12.3</td>
</tr>
<tr>
<td>BF Mean Depth (ft)</td>
<td>&gt;5.3</td>
<td>&gt;4.0</td>
<td>&gt;4.1</td>
</tr>
<tr>
<td>BF Max Depth (ft)</td>
<td>19.3</td>
<td>26.5</td>
<td>26.2</td>
</tr>
<tr>
<td>BF Cross Sectional Area (ft²)</td>
<td>1.2</td>
<td>1.7</td>
<td>1.8</td>
</tr>
</tbody>
</table>

*Morgan Creek Lower As-built data (Base) are presented for the purpose of comparing the original to those of the repair As-built conditions (MY1) and not for morphological analysis.

# Morgan Creek – Lower Reach*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Cross-Section 4</th>
<th>Cross-Section 5</th>
<th>Cross-Section 6</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rifle 3</td>
<td>Pool 2</td>
<td>Riffle 4</td>
</tr>
<tr>
<td>Dimension</td>
<td>Base</td>
<td>MY1</td>
<td>MY2</td>
</tr>
<tr>
<td>BF Width (ft)</td>
<td>24.9</td>
<td>25.1</td>
<td>27.4</td>
</tr>
<tr>
<td>Floodprone Width (ft)</td>
<td>&gt;100</td>
<td>&gt;100</td>
<td>&gt;100</td>
</tr>
<tr>
<td>BF Cross Sectional Area (ft²)</td>
<td>31.0</td>
<td>37.7</td>
<td>38.5</td>
</tr>
<tr>
<td>BF Mean Depth (ft)</td>
<td>1.2</td>
<td>1.5</td>
<td>1.4</td>
</tr>
<tr>
<td>BF Max Depth (ft)</td>
<td>2.3</td>
<td>2.6</td>
<td>2.6</td>
</tr>
<tr>
<td>BF Cross Sectional Area (ft²)</td>
<td>20.0</td>
<td>16.7</td>
<td>19.5</td>
</tr>
<tr>
<td>BF Mean Depth (ft)</td>
<td>&gt;4.0</td>
<td>&gt;4.0</td>
<td>&gt;3.6</td>
</tr>
<tr>
<td>BF Max Depth (ft)</td>
<td>25.6</td>
<td>26.3</td>
<td>28.6</td>
</tr>
<tr>
<td>BF Cross Sectional Area (ft²)</td>
<td>1.2</td>
<td>1.4</td>
<td>1.3</td>
</tr>
</tbody>
</table>

*Morgan Creek Lower As-built data (Base) are presented for the purpose of comparing the original to those of the repair As-built conditions (MY1) and not for morphological analysis.
### Unnamed Tributary 1

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Cross-Section 1</th>
<th></th>
<th>Cross-Section 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cross-Section</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dimension</td>
<td>My1</td>
<td>My2</td>
<td>My3</td>
</tr>
<tr>
<td>BF Width (ft)</td>
<td>9.1</td>
<td>9.0</td>
<td>9.2</td>
</tr>
<tr>
<td>Floodprone Width (ft)</td>
<td>&gt;50.0</td>
<td>&gt;50.0</td>
<td>&gt;50.0</td>
</tr>
<tr>
<td>BF Cross Sectional Area (ft²)</td>
<td>4.1</td>
<td>4.2</td>
<td>4.2</td>
</tr>
<tr>
<td>BF Mean Depth (ft)</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>BF Max Depth (ft)</td>
<td>1.2</td>
<td>1.3</td>
<td>1.4</td>
</tr>
<tr>
<td>Width/Depth Ratio</td>
<td>19.9</td>
<td>19.4</td>
<td>22.7</td>
</tr>
<tr>
<td>Entrenchment Ratio</td>
<td>&gt;5.5</td>
<td>&gt;5.6</td>
<td>&gt;5.2</td>
</tr>
<tr>
<td>Wetted Perimeter (ft)</td>
<td>9.5</td>
<td>10.0</td>
<td>10.7</td>
</tr>
<tr>
<td>Hydraulic Radius (ft)</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
</tr>
</tbody>
</table>

### Unnamed Tributary 6

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Cross-Section 1</th>
<th></th>
<th>Cross-Section 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cross-Section</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dimension</td>
<td>My1</td>
<td>My2</td>
<td>My3</td>
</tr>
<tr>
<td>BF Width (ft)</td>
<td>24.3</td>
<td>19.9</td>
<td>22.2</td>
</tr>
<tr>
<td>Floodprone Width (ft)</td>
<td>&gt;50.0</td>
<td>&gt;50.0</td>
<td>&gt;50.0</td>
</tr>
<tr>
<td>BF Cross Sectional Area (ft²)</td>
<td>29.4</td>
<td>14.6</td>
<td>14.8</td>
</tr>
<tr>
<td>BF Mean Depth (ft)</td>
<td>1.2</td>
<td>0.7</td>
<td>0.7</td>
</tr>
<tr>
<td>BF Max Depth (ft)</td>
<td>3.0</td>
<td>1.6</td>
<td>1.6</td>
</tr>
<tr>
<td>Width/Depth Ratio</td>
<td>20.2</td>
<td>27.1</td>
<td>33.2</td>
</tr>
<tr>
<td>Entrenchment Ratio</td>
<td>&gt;2.1</td>
<td>&gt;2.5</td>
<td>&gt;2.3</td>
</tr>
<tr>
<td>Wetted Perimeter (ft)</td>
<td>25.3</td>
<td>20.7</td>
<td>22.8</td>
</tr>
<tr>
<td>Hydraulic Radius (ft)</td>
<td>1.2</td>
<td>0.7</td>
<td>0.7</td>
</tr>
</tbody>
</table>
### Morgan Creek – Upper Reach

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Baseline</th>
<th>MY1</th>
<th>MY2</th>
<th>MY3</th>
<th>MY4</th>
<th>MY5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pattern</strong></td>
<td>Min</td>
<td>Max</td>
<td>Med</td>
<td>Min</td>
<td>Max</td>
<td>Med</td>
</tr>
<tr>
<td>Channel Beltwidth (ft)</td>
<td>60.0</td>
<td>92.7</td>
<td>81.2</td>
<td>62.5</td>
<td>95.5</td>
<td>87.6</td>
</tr>
<tr>
<td>Radius of Curvature (ft)</td>
<td>42.3</td>
<td>55.6</td>
<td>49.7</td>
<td>34.6</td>
<td>56.6</td>
<td>48.9</td>
</tr>
<tr>
<td>Meander Wavelength (ft)</td>
<td>141.4</td>
<td>215.2</td>
<td>200.3</td>
<td>153.7</td>
<td>219.3</td>
<td>199.6</td>
</tr>
<tr>
<td>Meander Width Ratio</td>
<td>3.68</td>
<td>3.87</td>
<td>3.70</td>
<td>4.28</td>
<td>4.87</td>
<td>4.65</td>
</tr>
<tr>
<td><strong>Profile</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Riffle Length (ft)</td>
<td>16.93</td>
<td>43.38</td>
<td>26.51</td>
<td>14.13</td>
<td>68.47</td>
<td>27.23</td>
</tr>
<tr>
<td>Riffle Slope (ft/ft)</td>
<td>0.0018</td>
<td>0.0197</td>
<td>0.0053</td>
<td>0.0001</td>
<td>0.0209</td>
<td>0.0079</td>
</tr>
<tr>
<td>Pool Length (ft)</td>
<td>13.27</td>
<td>80.84</td>
<td>44.42</td>
<td>15.25</td>
<td>68.17</td>
<td>33.69</td>
</tr>
<tr>
<td>Pool Spacing (ft)</td>
<td>51.77</td>
<td>138.88</td>
<td>102.18</td>
<td>58.30</td>
<td>170.24</td>
<td>106.81</td>
</tr>
<tr>
<td><strong>Additional Reach Parameters</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valley Length (ft)</td>
<td>1181.5</td>
<td></td>
<td></td>
<td>1181.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Channel Length (ft)</td>
<td>1424.7</td>
<td></td>
<td></td>
<td>1465.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sinuosity</td>
<td>1.21</td>
<td>1.24</td>
<td></td>
<td>1.24</td>
<td></td>
<td>1.24</td>
</tr>
<tr>
<td>Water Surface Slope (ft/ft)</td>
<td>0.008</td>
<td>0.007</td>
<td></td>
<td>0.008</td>
<td></td>
<td>0.007</td>
</tr>
<tr>
<td>BF Slope (ft/ft)</td>
<td>0.009</td>
<td>0.007</td>
<td></td>
<td>0.008</td>
<td></td>
<td>0.007</td>
</tr>
<tr>
<td>Rosgen Classification</td>
<td>C4</td>
<td>C4</td>
<td></td>
<td>C4</td>
<td></td>
<td>C4</td>
</tr>
</tbody>
</table>

*Morgan Creek Lower As-built data (Baseline) are presented for the purpose of comparing the original to those of the repair As-built conditions (MY1) and not for morphological analysis.*

### Morgan Creek – Lower Reach*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Baseline</th>
<th>MY1</th>
<th>MY2</th>
<th>MY3</th>
<th>MY4</th>
<th>MY5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pattern</strong></td>
<td>Min</td>
<td>Max</td>
<td>Med</td>
<td>Min</td>
<td>Max</td>
<td>Med</td>
</tr>
<tr>
<td>Channel Beltwidth (ft)</td>
<td>57.5</td>
<td>84.9</td>
<td>70.4</td>
<td>62.5</td>
<td>85.5</td>
<td>70.2</td>
</tr>
<tr>
<td>Radius of Curvature (ft)</td>
<td>30.7</td>
<td>53.7</td>
<td>34.1</td>
<td>30.2</td>
<td>55.8</td>
<td>36.8</td>
</tr>
<tr>
<td>Meander Wavelength (ft)</td>
<td>170.2</td>
<td>200.3</td>
<td>181.2</td>
<td>172.1</td>
<td>203.9</td>
<td>180.3</td>
</tr>
<tr>
<td>Meander Width Ratio</td>
<td>2.83</td>
<td>3.76</td>
<td>3.17</td>
<td>2.76</td>
<td>2.95</td>
<td>2.80</td>
</tr>
<tr>
<td><strong>Profile</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Riffle Length (ft)</td>
<td>14.76</td>
<td>53.25</td>
<td>44.15</td>
<td>30.46</td>
<td>91.11</td>
<td>47.28</td>
</tr>
<tr>
<td>Riffle Slope (ft/ft)</td>
<td>0.0016</td>
<td>0.0201</td>
<td>0.0076</td>
<td>0.0037</td>
<td>0.0206</td>
<td>0.0013</td>
</tr>
<tr>
<td>Pool Length (ft)</td>
<td>38.51</td>
<td>80.98</td>
<td>60.72</td>
<td>15.40</td>
<td>38.70</td>
<td>30.03</td>
</tr>
<tr>
<td>Pool Spacing (ft)</td>
<td>92.14</td>
<td>157.68</td>
<td>109.52</td>
<td>40.56</td>
<td>234.10</td>
<td>109.20</td>
</tr>
<tr>
<td><strong>Additional Reach Parameters</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valley Length (ft)</td>
<td>865</td>
<td></td>
<td></td>
<td>865</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Channel Length (ft)</td>
<td>1054.4</td>
<td></td>
<td></td>
<td>1083.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sinuosity</td>
<td>1.21</td>
<td>1.25</td>
<td></td>
<td>1.29</td>
<td></td>
<td>1.30</td>
</tr>
<tr>
<td>Water Surface Slope (ft/ft)</td>
<td>0.007</td>
<td>0.006</td>
<td></td>
<td>0.008</td>
<td></td>
<td>0.005</td>
</tr>
<tr>
<td>BF Slope (ft/ft)</td>
<td>0.007</td>
<td>0.005</td>
<td></td>
<td>0.007</td>
<td></td>
<td>0.004</td>
</tr>
<tr>
<td>Rosgen Classification</td>
<td>C4</td>
<td>C4</td>
<td></td>
<td>C4</td>
<td></td>
<td>C4</td>
</tr>
</tbody>
</table>

*Equinox Environmental Consultation and Design, Inc.*

Annual Monitoring Report 2013 (Year 5)
### Unnamed Tributary 1

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Baseline</th>
<th>MY1</th>
<th>MY2</th>
<th>MY3</th>
<th>MY4</th>
<th>MY5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pattern</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Channel Beltwidth (ft)</td>
<td>36.6</td>
<td>650</td>
<td>39.6</td>
<td>32.0</td>
<td>65.4</td>
<td>44.1</td>
</tr>
<tr>
<td>- Radius of Curvature (ft)</td>
<td>22.1</td>
<td>29.9</td>
<td>26.7</td>
<td>13.3</td>
<td>25.9</td>
<td>23.1</td>
</tr>
<tr>
<td>- Meander Wavelength (ft)</td>
<td>95.6</td>
<td>109.3</td>
<td>101.4</td>
<td>94.6</td>
<td>103.4</td>
<td>103.0</td>
</tr>
<tr>
<td>- Meander Width Ratio</td>
<td>4.35</td>
<td>4.89</td>
<td>4.54</td>
<td>4.54</td>
<td>4.54</td>
<td>4.54</td>
</tr>
<tr>
<td><strong>Profile</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Riffle Length (ft)</td>
<td>13.18</td>
<td>25.73</td>
<td>23.34</td>
<td>9.24</td>
<td>26.68</td>
<td>17.52</td>
</tr>
<tr>
<td>- Riffle Slope (ft/ft)</td>
<td>0.0084</td>
<td>0.0467</td>
<td>0.0222</td>
<td>0.0062</td>
<td>0.0324</td>
<td>0.0155</td>
</tr>
<tr>
<td>- Pool Length (ft)</td>
<td>4.34</td>
<td>30.99</td>
<td>20.78</td>
<td>4.12</td>
<td>38.54</td>
<td>21.86</td>
</tr>
<tr>
<td>- Pool Spacing (ft)</td>
<td>17.63</td>
<td>77.03</td>
<td>36.48</td>
<td>22.69</td>
<td>91.52</td>
<td>37.28</td>
</tr>
<tr>
<td><strong>Additional Reach Parameters</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Valley Length (ft)</td>
<td>310.3</td>
<td>310.3</td>
<td>310.3</td>
<td>310.3</td>
<td>310.3</td>
<td>310.3</td>
</tr>
<tr>
<td>- Channel Length (ft)</td>
<td>378.1</td>
<td>386.4</td>
<td>386.4</td>
<td>386.4</td>
<td>387.0</td>
<td>388.0</td>
</tr>
<tr>
<td>- Sinuosity</td>
<td>1.22</td>
<td>1.25</td>
<td>1.24</td>
<td>1.25</td>
<td>1.25</td>
<td>1.25</td>
</tr>
<tr>
<td>- Water Surface Slope (ft/ft)</td>
<td>0.011</td>
<td>0.012</td>
<td>0.012</td>
<td>0.011</td>
<td>0.012</td>
<td>0.011</td>
</tr>
<tr>
<td>- BF Slope (ft/ft)</td>
<td>0.013</td>
<td>0.013</td>
<td>0.013</td>
<td>0.012</td>
<td>0.011</td>
<td>0.011</td>
</tr>
<tr>
<td>- Rosgen Classification</td>
<td>C5</td>
<td>C5</td>
<td>C5</td>
<td>C5</td>
<td>C5</td>
<td>C5</td>
</tr>
</tbody>
</table>

### Unnamed Tributary 6

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Baseline</th>
<th>MY1</th>
<th>MY2</th>
<th>MY3</th>
<th>MY4</th>
<th>MY5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pattern</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Channel Beltwidth (ft)</td>
<td>28.7</td>
<td>43.5</td>
<td>42.3</td>
<td>29.6</td>
<td>45.4</td>
<td>45.0</td>
</tr>
<tr>
<td>- Radius of Curvature (ft)</td>
<td>27.7</td>
<td>31.7</td>
<td>30.2</td>
<td>21.7</td>
<td>32.1</td>
<td>22.5</td>
</tr>
<tr>
<td>- Meander Wavelength (ft)</td>
<td>114.0</td>
<td>123.1</td>
<td>120.1</td>
<td>100.9</td>
<td>120.3</td>
<td>119.5</td>
</tr>
<tr>
<td>- Meander Width Ratio</td>
<td>3.16</td>
<td>3.85</td>
<td>3.64</td>
<td>3.64</td>
<td>3.64</td>
<td>3.64</td>
</tr>
<tr>
<td><strong>Profile</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Riffle Length (ft)</td>
<td>14.86</td>
<td>30.95</td>
<td>28.19</td>
<td>7.28</td>
<td>25.67</td>
<td>16.29</td>
</tr>
<tr>
<td>- Riffle Slope (ft/ft)</td>
<td>0.0013</td>
<td>0.0110</td>
<td>0.0042</td>
<td>0.0014</td>
<td>0.0237</td>
<td>0.0108</td>
</tr>
<tr>
<td>- Pool Length (ft)</td>
<td>2.38</td>
<td>18.09</td>
<td>14.64</td>
<td>4.02</td>
<td>15.59</td>
<td>8.70</td>
</tr>
<tr>
<td>- Pool Spacing (ft)</td>
<td>5.90</td>
<td>66.37</td>
<td>54.03</td>
<td>14.52</td>
<td>54.28</td>
<td>28.32</td>
</tr>
<tr>
<td><strong>Additional Reach Parameters</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Valley Length (ft)</td>
<td>222.5</td>
<td>222.5</td>
<td>222.5</td>
<td>222.5</td>
<td>222.5</td>
<td>222.5</td>
</tr>
<tr>
<td>- Channel Length (ft)</td>
<td>252.4</td>
<td>258.9</td>
<td>254.5</td>
<td>254.5</td>
<td>255.1</td>
<td>251.0</td>
</tr>
<tr>
<td>- Sinuosity</td>
<td>1.13</td>
<td>1.16</td>
<td>1.14</td>
<td>1.15</td>
<td>1.13</td>
<td>1.11</td>
</tr>
<tr>
<td>- Water Surface Slope (ft/ft)</td>
<td>0.008</td>
<td>0.010</td>
<td>0.017</td>
<td>0.016</td>
<td>0.016</td>
<td>0.013</td>
</tr>
<tr>
<td>- BF Slope (ft/ft)</td>
<td>0.014</td>
<td>0.010</td>
<td>0.013</td>
<td>0.016</td>
<td>0.010</td>
<td>0.008</td>
</tr>
<tr>
<td>- Rosgen Classification</td>
<td>C4</td>
<td>C5</td>
<td>C5</td>
<td>C5</td>
<td>C4</td>
<td>C4</td>
</tr>
</tbody>
</table>
APPENDIX D

Monitoring Year 5
Site Photos
Permanent Photo Point 1 – Unnamed Tributary 7
Looking Upstream
January 4, 2013

Permanent Photo Point 2 – Unnamed Tributary 7
Looking Upstream
January 4, 2013
Permanent Photo Point 3 – Unnamed Tributary 7
Looking Upstream
January 4, 2013

Permanent Photo Point 4 – Unnamed Tributary 7
Looking Upstream
January 4, 2013
Permanent Photo Point 5 – Unnamed Tributary 7
Looking Upstream
January 4, 2013

Permanent Photo Point 6 – Unnamed Tributary 7
Looking Upstream
January 4, 2013
Permanent Photo Point 7 – Unnamed Tributary 7
Looking Upstream
January 4, 2013

Permanent Photo Point 8 – Morgan Creek
Looking Upstream
January 4, 2013
Permanent Photo Point 9 – Morgan Creek  
Looking Upstream  
January 4, 2013

Permanent Photo Point 10 – Morgan Creek  
Looking Upstream  
January 4, 2013
Permanent Photo Point 11 – Morgan Creek
Looking Upstream
January 4, 2013

Permanent Photo Point 12 – Morgan Creek
Looking Upstream
January 4, 2013
Permanent Photo Point 13 – Morgan Creek
Looking Upstream
January 4, 2013

Permanent Photo Point 14 – Morgan Creek
Looking Upstream
January 4, 2013
Permanent Photo Point 15 – Morgan Creek
Looking Upstream
January 4, 2013

Permanent Photo Point 16 – Morgan Creek
Looking Upstream
January 4, 2013
Permanent Photo Point 17 – Morgan Creek
Looking Upstream
January 4, 2013

Permanent Photo Point 18 – Morgan Creek
Looking Upstream
January 4, 2013
Appendix D
Monitoring Year 5 Site Photos

Permanent Photo Point 19 – Morgan Creek
Looking Upstream
January 4, 2013

Permanent Photo Point 20 – Morgan Creek
Looking Upstream
January 4, 2013
Appendix D
Monitoring Year 5 Site Photos

Permanent Photo Point 21 – Morgan Creek
Looking Upstream
January 4, 2013

Permanent Photo Point 22 – Unnamed Tributary 6
Looking Upstream
January 4, 2013
Permanent Photo Point 23 – Unnamed Tributary 6
Looking Upstream
January 4, 2013

Permanent Photo Point 24 – Unnamed Tributary 6
Looking Upstream
January 4, 2013
Permanent Photo Point 25 – Unnamed Tributary 6
Looking Upstream
January 4, 2013

Permanent Photo Point 26 – Unnamed Tributary 6
Looking Upstream
January 4, 2013
Permanent Photo Point 27 – Morgan Creek
Looking Upstream
January 4, 2013

Permanent Photo Point 28 – Morgan Creek
Looking Upstream
January 4, 2013
Permanent Photo Point 29 – Morgan Creek
Looking Upstream
January 4, 2013

Permanent Photo Point 30 – Morgan Creek
Looking Upstream
January 4, 2013
Permanent Photo Point 30 – Unnamed Tributary 5
Looking Upstream
January 4, 2013

Permanent Photo Point 31 – Unnamed Tributary 5
Looking Upstream
January 4, 2013
Permanent Photo Point 32 – Unnamed Tributary 5
Looking Downstream
January 4, 2013

Permanent Photo Point 32 – Unnamed Tributary 5
Looking Upstream
January 4, 2013
Permanent Photo Point 34 – Unnamed Tributary 5
Looking Upstream
January 4, 2013

Permanent Photo Point 35 – Unnamed Tributary 5
Looking Downstream
January 4, 2013
Permanent Photo Point 35 – Unnamed Tributary 5
Looking 115 Degrees
January 4, 2013

Permanent Photo Point 35 – Unnamed Tributary 5
Looking Upstream
January 4, 2013
Appendix D  Monitoring Year 5 Site Photos

Morgan Creek Site
Project ID No. 16-D06027

Permanent Photo Point 35 – Unnamed Tributary 5
Looking 358 Degrees
January 4, 2013

Permanent Photo Point 36 – Morgan Creek
Looking Upstream
January 4, 2013

Equinox Environmental Consultation and Design, Inc.
Annual Monitoring Report 2013 (Year 5)
Permanent Photo Point 37 – Morgan Creek
Looking Upstream
January 4, 2013

Permanent Photo Point 38 – Morgan Creek
Looking Upstream
January 4, 2013
Permanent Photo Point 39 – Unnamed Tributary 4
Looking Downstream
January 4, 2013

Permanent Photo Point 39 – Unnamed Tributary 4
Looking Upstream
January 4, 2013
Appendix D

Monitoring Year 5 Site Photos

Permanent Photo Point 40 – Morgan Creek
Looking Upstream
January 4, 2013

Permanent Photo Point 41 – Morgan Creek
Looking Upstream
January 4, 2013
Permanent Photo Point 42 – Morgan Creek
Looking Downstream
January 4, 2013

Permanent Photo Point 42 – Morgan Creek
Looking Upstream
January 4, 2013
Permanent Photo Point 43 – Unnamed Tributary 3
Looking Upstream
January 4, 2013

Permanent Photo Point 44 – Unnamed Tributary 3
Looking Upstream
January 4, 2013
Permanent Photo Point 45 –Unnamed Tributary 3
Looking Upstream
January 4, 2013

Permanent Photo Point 46 – Unnamed Tributary 3
Looking Upstream
January 4, 2013
Permanent Photo Point 47 – Unnamed Tributary 3  
Looking Upstream  
January 4, 2013

Permanent Photo Point 48 – Unnamed Tributary 3  
Looking Upstream  
January 4, 2013
Permanent Photo Point 49 – Unnamed Tributary 3
Looking Upstream
January 4, 2013

Permanent Photo Point 50 – Unnamed Tributary 3
Looking Upstream
January 4, 2013
Permanent Photo Point 51 – Unnamed Tributary 3
Looking Downstream
January 4, 2013

Permanent Photo Point 51 – Unnamed Tributary 3
Looking Upstream
January 4, 2013
Permanent Photo Point 52 – Unnamed Tributary 3
Looking Downstream
January 4, 2013

Permanent Photo Point 52 – Unnamed Tributary 3
Looking 110 Degrees
January 4, 2013
Appendix D

Morgan Creek Site

Project ID No. 16-D06027

Equinox Environmental Consultation and Design, Inc.

Annual Monitoring Report 2013 (Year 5)

Permanent Photo Point 52 – Unnamed Tributary 3
Looking Upstream
January 4, 2013

Permanent Photo Point 52 – Unnamed Tributary 3
Looking 355 Degrees
January 4, 2013
Appendix D

Morgan Creek Site
Project ID No. 16-D06027

Monitoring Year 5 Site Photos

Permanent Photo Point 53 – Morgan Creek
Looking Upstream
January 4, 2013

Permanent Photo Point 54 – Morgan Creek
Looking Upstream
January 4, 2013
Permanent Photo Point 55 – Morgan Creek
Looking Upstream
January 4, 2013

Permanent Photo Point 56 – Unnamed Tributary 2
Looking Upstream
January 4, 2013
Permanent Photo Point 57 – Unnamed Tributary 2
Looking Upstream
January 4, 2013

Permanent Photo Point 58 – Unnamed Tributary 2
Looking Downstream
January 4, 2013
Permanent Photo Point 58 – Unnamed Tributary 2
Looking Upstream
January 4, 2013

Permanent Photo Point 59 – Unnamed Tributary 2
Looking Downstream
January 4, 2013
Permanent Photo Point 59 – Unnamed Tributary 2
Looking Upstream
January 4, 2013

Permanent Photo Point 60 – Unnamed Tributary 2
Looking Downstream
January 4, 2013
<table>
<thead>
<tr>
<th>Image 1</th>
<th>Image 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Permanent Photo Point 60 – Unnamed Tributary 2</strong></td>
<td><strong>Permanent Photo Point 61 – Morgan Creek</strong></td>
</tr>
<tr>
<td>Looking Upstream</td>
<td>Looking Upstream</td>
</tr>
<tr>
<td><strong>January 4, 2013</strong></td>
<td><strong>January 4, 2013</strong></td>
</tr>
<tr>
<td>Permanent Photo Point</td>
<td>Location</td>
</tr>
<tr>
<td>-----------------------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td>62</td>
<td>Unnamed Tributary 1 Looking Upstream</td>
</tr>
<tr>
<td>63</td>
<td>Unnamed Tributary 1 Looking Upstream</td>
</tr>
</tbody>
</table>
Permanent Photo Point 64 – Unnamed Tributary 1
Looking Upstream
January 4, 2013

Permanent Photo Point 65 – Unnamed Tributary 1
Looking Upstream
January 4, 2013
Permanent Photo Point 66 – Unnamed Tributary 1
Looking Downstream
January 4, 2013

Permanent Photo Point 66 – Unnamed Tributary 1
Looking Upstream
January 4, 2013
Permanent Photo Point 67 – Unnamed Tributary 1  
Looking Downstream  
January 4, 2013

Permanent Photo Point 67 – Unnamed Tributary 1  
Looking 185 Degrees  
January 4, 2013
Permanent Photo Point 67 – Unnamed Tributary 1
Looking Upstream
January 4, 2013

Permanent Photo Point 67 – Unnamed Tributary 1
Looking 360 Degrees
January 4, 2013
Permanent Photo Point 68 – Unnamed Tributary 1
Looking Downstream
January 4, 2013

Permanent Photo Point 68 – Unnamed Tributary 1
Looking 94 Degrees
January 4, 2013
Permanent Photo Point 68 – Unnamed Tributary 1
Looking Upstream
January 4, 2013

Permanent Photo Point 68 – Unnamed Tributary 1
Looking 327 Degrees
January 4, 2013
Permanent Photo Point 69 – Unnamed Tributary 8  
Looking Downstream  
January 4, 2013

Permanent Photo Point 69 – Unnamed Tributary 8  
Looking 168 Degrees  
January 4, 2013
Appendix D
Monitoring Year 5 Site Photos

Permanent Photo Point 69 – Unnamed Tributary 8
Looking Upstream
January 4, 2013

Permanent Photo Point 69 – Unnamed Tributary 8
Looking 53 Degrees
January 4, 2013
Permanent Photo Point 70 – Unnamed Tributary 9
Looking Downstream
January 4, 2013

Permanent Photo Point 70 – Unnamed Tributary 9
Looking Upstream 196 Degrees
January 4, 2013
Permanent Photo Point 70 – Unnamed Tributary 9
Looking Upstream 248 Degrees
January 4, 2013
Morgan Creek Vegetation Plot Photos

Vegetation Plot 1

Vegetation Plot 2
Appendix D

Morgan Creek Site
Project ID No. 16-D06027

Equinox Environmental Consultation and Design, Inc.
Annual Monitoring Report 2013 (Year 5)

Monitoring Year 5 Site Photos

Vegetation Plot 3

Vegetation Plot 4
Appendix D
Monitoring Year 5 Site Photos

Vegetation Plot 7

Vegetation Plot 8
Morgan Creek Representative Photos of Stream Areas

SPA 4 Morgan Creek Sta. 1003+25 – Reduced pool depth due to aggradation

SPA 21 Morgan Creek Sta. 1029+40 – Bank erosion due to thalweg not centering
SPA 23 Morgan Creek Sta. 1038+50 – Riffle aggradation due to mid-channel bar formation

SPA 24 Morgan Creek Sta. 1038+50 – Reduced pool depth due to aggradation
Appendix D

Morgan Creek Site
Project ID No. 16-D06027

Monitoring Year 5 Site Photos

Unnamed Tributary 1 Representative Photos of Stream Areas

SPA 2 UT1 Sta. 2001+75 – Reduced pool depth due to aggradation

Unnamed Tributary 2 Representative Photo of Stream Areas

SPA 5 UT2 Sta. 3000+50 – Reduced pool depth and riffle fining due to aggradation
Unnamed Tributary 3 Representative Photo of Stream Areas

SPA 13 UT3 Sta. 4001+90 – Reduced pool depth due to aggradation
APPENDIX E

Invasive Exotic Vegetation Control at Morgan Creek Stream Restoration Site Final Report
Purpose
The Morgan Creek Stream Restoration Site was treated for invasive exotic plants to eliminate competition of non-native plants within riparian easement areas. A comprehensive inventory of invasive exotic plants occurring within the easement was performed in 2010. Initial treatments occurred in the summer and fall of 2011 with follow-up treatments occurring in 2012 and final treatments ending in late fall of 2013. This Progress Report provides a summary of management activities occurring in 2013 as well as the status of invasive exotic plant populations on-site.

Site Conditions
Approximately 2.8 acres of invasive exotic plant infestations were treated at Morgan Creek in 2012, which reduced these populations by 30%. In 2013, follow-up treatment occurred within the same areas to verify control and to apply final treatments to observed resprouts. Target species included:

- Privet (Ligustrum sinense)
- Multiflora Rose (Rosa multiflora)
- Japanese Honeysuckle (Lonicera japonica)
- Oriental Bittersweet (Celastrus orbiculatus)
- Autumn Olive (Eleagnus umbellata)
- Tree of Heaven (Ailanthus altissima)
- Princess Tree (Paulownia tomentosa)

Summary of Control Activities
Two days were spent on management activities at the Morgan Creek Stream Restoration Site. On February 14, 2013, foliar applications were applied to semi-evergreen species such as Privet and Japanese Honeysuckle prior to leaf-out of other non-target species. Efforts were focused on UT-1, where infestations of privet were the most severe. Treatments also occurred on UT-6, UT-5, and UT-4; large stems were treated with basal bark, while smaller stems were controlled with foliar methods.

A final control event was held on October 1 to follow up on treatments that occurred mainly along UT-1, UT-5, and UT-7, but all reaches were evaluated. Because infestations within UT-1, UT-5 and UT-7 were originally so dense, resprouting was heavy, but the follow-up foliar treatments will reduce the density and allow native species to succeed and outcompete the NNIS.

All herbicide applications were applied and/or supervised by certified NCDA&CS Pesticide Applicator, License #026-29539. Table 1 summarizes the reaches treated, application method employed, herbicide volume used, herbicide concentrations used, and other relevant information occurring in 2013.

Recommendations
Even though treatments have been quite effective at stopping invasive exotic seed formation and limiting vegetative reproduction by existing plants, factors such as seed banking, root propagation, recruitment, and other means of latent proliferation may occur in future years. Also, infestations of invasive exotic plants currently exist in varying abundance on the lands peripheral to the easement area; these populations will almost certainly continue to volunteer invasive exotic recruits into the easement. We recommend that invasive populations be visually assessed on an annual basis and subsequent management practices be employed as necessary in order to protect the natural resources preserved within the easement area.
Table 1: 2013 Treatment Records

<table>
<thead>
<tr>
<th>Date</th>
<th>Reaches</th>
<th>Description Notes</th>
<th>Target Species</th>
<th>Type of Treatment</th>
<th>Herbicide</th>
<th>Concentration (%)</th>
<th>Volume Herbicide Concentrate Used* (oz)</th>
<th>Volume Mixture Used (gal)</th>
<th>Weather</th>
<th>Temperature (°F)</th>
<th>Wind Speed (mph)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>2/14/2013</td>
<td>Mainstem, UT-7, UT-6, UT-5, UT-4, UT-1;</td>
<td>UT-7: cut stem / foliar on LISI infestation on LBD hillside, foliar on LOJA mats along roadside, cut stem/foliar on LISI at road corner, cut stem/foliar on LOJA/LISI infestations around lower bridge, scattered infestations on LBD as it parallels farm road; UT-6: cut stem/foliar on LISI infestation where it abuts the main road; UT-5: foliar on LOJA/LISI occurring below mature overstory below crossing; UT-4: foliar on LISI/LOJA + ROMU infestation just below crossing, foliar on LISI/LOJA/ROMU occurring below small patch of mature trees on RBD; UT-1: foliar on large, dense LOJA infestation on RBD at SE corner of easement; Privet, Japanese honeysuckle, multiflora rose;</td>
<td>Privet, Japanese honeysuckle, multiflora rose;</td>
<td>foliar</td>
<td>Rodeo (glyphosate)</td>
<td>4%</td>
<td>128</td>
<td>32</td>
<td>Sunny, breezy at times</td>
<td>58</td>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td>2/14/2013</td>
<td>Mainstem, UT-7, UT-6, UT-5, UT-4, UT-1;</td>
<td>(see above)</td>
<td>Privet, Japanese honeysuckle, multiflora rose;</td>
<td>cut stump</td>
<td>Element 3A (triclopyr)</td>
<td>50%</td>
<td>12</td>
<td>0.375</td>
<td>Sunny, breezy at times</td>
<td>58</td>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td>10/1/2013</td>
<td>UT-1, UT-3, UT-4, UT-5, UT-7;</td>
<td>Focus on UT-1: LOJA on RBD adjacent to field; ROMU scattered; worked up UT-1 into preservation reach; UT-3 ROMU LISI at crossing, foliar small privet/rose/LOJA along ground and chest-height; Privet, honeysuckle, bittersweet, rose, tree of heaven, princesstree;</td>
<td>Privet, honeysuckle, bittersweet, rose, tree of heaven, princesstree;</td>
<td>foliar</td>
<td>Garlon 3A</td>
<td>5%</td>
<td>180</td>
<td>45</td>
<td>sunny, warm, slight breeze</td>
<td>70</td>
<td>4</td>
<td>foliar along UT-7 fencrow, hillside; sprayed at UT-5 downstream of preservation; UT-1, hit LOJA/ROMU below crossing hard; LISI and LOJA upstream of crossing sprayed, density greater;</td>
</tr>
<tr>
<td>10/1/2013</td>
<td>UT-1, UT-3, UT-4, UT-5, UT-7;</td>
<td>basal on large privet, cut some stems; - basal on AIAL/PATO up reach towards preservation; UT-7 basal on lots of stems, basal on large CEOR vines;</td>
<td>basal</td>
<td>Garlon 4</td>
<td>25%</td>
<td>192</td>
<td>6</td>
<td>sunny, warm, slight breeze</td>
<td>70</td>
<td>4</td>
<td>basal on LG privet along UT-1; also hit large ROMU and any visible LOJA crowns; hillside of privet on UT-7;</td>
<td></td>
</tr>
</tbody>
</table>