Fitzgerald Environmental Associates, LLC.

Applied Watershed Science & Ecology

Mill Brook Watershed Report: Phase 1 and 2 Stream Geomorphic Assessment Summary

July 5, 2007

Introduction:

Mill Brook was identified for assessment during 2005 as part of a joint UVM-ANR research project to assess the impacts of stormwater runoff on geomorphic stability in small watersheds in Chittenden County (Fitzgerald, 2007). Due to its rural setting and other established UVM water research sites within the basin, Mill Brook reaches were chosen as reference sites for comparison to reaches in stormwater impaired watersheds in the Burlington area. The assessments for the Mill Brook watershed, which included a total of 15 Phase 1 reaches and 21 Phase 2 reaches/segments, were carried out by Evan Fitzgerald and the UVM field crew in August 2005. Fitzgerald Environmental Associates, LLC. was retained by the ANR River Management Program in 2007 to organize and review the data and produce a summary report of the Phase 1 and 2 assessments.

The following is a documentation of the key geomorphic processes and adjustments occurring in the Mill Brook watershed at the reach scale. The intent of this documentation is twofold: 1) concisely summarize Mill Brook watershed zones and geomorphic processes; 2) highlight for those using the data the key steps containing important or extraordinary information. When used in conjunction with the Phase 1 and 2 data in the DMS, and the SGA watershed mapping, this documentation also provides explanation for questions that may arise concerning discrepancies in the data. At the end of each reach or watershed zone summary is a discussion of potential projects that could protect, sustain, or restore fluvial geomorphic equilibrium conditions, through the implementation of either passive or active stream corridor management strategies. Following the discussion text is Appendix 1, which summarizes QA/QC notes and other relevant information for the Phase 1 and 2 databases. Plots for each channel cross-section measured during the Phase 2 analysis are provided in Appendix 2. Reach summary statistics and maps are found respectively in Appendices 3 and 4.

Mill Brook Watershed Setting:

Mill Brook is drained by an elongated, east to west flowing watershed which spans the towns of Bolton and Jericho. The overall slope of the channel network from headwaters to outlet at the Winooski River is 3.8%, reflecting the high gradient nature of many of the reaches. The surficial geology of the basin oscillates between areas of alluvial deposits and glacial till according to the undulations of topography. Three areas of wide alluvial

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valleys with depositional channel zones are found along the channel network. In between these zones, sediment transport channels are found within confined valley settings. These zones are characterized by steep valley side slopes composed of glacial till and occasionally bedrock substrate. The drainage area of the basin is approximately 16.4 square miles, and land cover is predominately second-growth forest and agriculture with some areas of low density residential development.

During the Phase II field assessments of the Mill Brook watershed, six distinct zones were observed with respect to natural topographic and geologic characteristics, as well as human impacts and the presence of beaver activity. Below is a summary of the reaches assessed for Phase II data during summer 2005 within each of these watershed zones. Stream type departure (STD) information is found within each reach summary, and a project identification discussion is included for those reaches which STD was observed.

Winooski Valley Zone (M01 & M02):

Reaches M01 and M02 are found within the historic Winooski River floodplain which is characterized by alluvial soils and frequent flooding. Both reaches have been impacted by historic agricultural land use. These impacts likely include historic channel straightening (M01), as well as disturbance to the buffer and bank vegetation from the M02-M03 reach break down to the outlet. The degree of historic straightening in reach M01 appears to have been more severe than any (minor) straightening in M02. However, with the exception of the channel conditions at the extreme downstream end of M01 near the confluence with the Winooski River, both channels are in near stable equilibrium or quasi-equilibrium conditions. These conditions have likely recovered since a period of disturbance to the watershed's sediment regime and the channel boundary conditions within this watershed zone.

Reach Descriptions:

Reach M01 is found from the outlet at the Winooski River up approximately 2,200 feet to a change in valley confinement as the channel nears Barber Farm Road. This reach has C-type geometry (Rosgen, 1994) with cobble substrate, riffle-pool bedform (Montgomery and Buffington, 1997) and a channel slope of 1.3 %. Today's channel conditions have resulted from an evolution of channel planform and slope and are now in the latter stages of adjustment and stabilization (stage IV of channel evolution). Significant bank erosion was observed in the lower part of the reach near the outlet (Figure 1) where the channel has cut through the historically aggraded floodplain of the Winooski River. One small waterfall acts as a grade control in the upper part of the reach approximately 150 feet below the reach break.

Reach M02 is found along Barber Farm Road up to the confluence with a large tributary entering from the northeast. This reach has B-type geometry with plane bed morphology and cobble substrate (Figure 2). This reach has been studied by Alex Hackman and the UVM RAN research team, and represents a good reference reach for other coarse bottomed channels in Chittenden County. Two large waterfalls are found within the reach which act as grade controls. Good geomorphic stability and habitat conditions were observed and the reach is in stage I of channel evolution.

Figure 1. M01 bank erosion near outlet

Figure 2. M02 cross section

Preliminary Project Identification:

The farmland surrounding the corridor of Mill Brook in this lower watershed zone has been established in the Winooski floodplain for many decades, and reach M01 has begun to reestablish equilibrium conditions in this setting. Efforts to actively reestablish the depositional floodplain areas associated with the reference conditions of reach M01 are not recommended because of the advanced stage of channel evolution in this reach. Reestablishment of native vegetation in two areas within this watershed zone would help moderate summer stream temperatures and is worth consideration. These areas include: 1) M01 left bank on first meander up from outlet where adjacent cropland abuts stream bank; 2) M02 left bank immediately downstream of Tarbox Road crossing.

Jericho Research Forest Zone (M03 & M04):

Reaches M03 and M04 are found in steep terrain where the landscape transitions from the Winooski Valley to the adjacent foothills of the Green Mountains. Due to the steep slopes of the valley walls, the stream corridor and surrounding landscape within this zone are relatively unimpacted by humans and will likely remain so due to the establishment of the UVM Jericho Research Forest. No significant impacts to the channel boundary conditions or physical stability were noted in either reach, and both were assessed as having reference physical habitat and geomorphic stability (stage I of channel evolution).

Reach Descriptions:

Reach M03 has an overall channel slope of 1.8% which supports a stable plane bed system with cobble substrate (Figure 3). Four natural grade controls were noted within this reach. Reach M04 has an overall channel slope of 3.3% which supports a step-pool system with cobble substrate. Four grade controls were also observed in M04, including a large waterfall located midway up the reach (Figure 4). Because of the reference conditions observed in these reaches, no project identification summary has been included.


Figure 3. M03 cross section


Figure 4. Grade control mid-reach in M04

Tarbox Road Valley (M05):

A sharp change in slope occurs at the reach break between M04 and M05, and the valley widens significantly in reach M05 along Tarbox Road. The three segments assessed within reach M05 have been considered separately due to the valley characteristics and fluvial processes observed. The average slope of the channel through this valley is 0.9%, resulting in depositional reaches with C-type geometry and riffle-pool bedform. Due to the sediment transport limitations of these segments in combination with the higher transport capacity of upstream reaches M06 and M07, the three segments in this valley are actively migrating across a wide corridor. Some large mass failures have occurred where the channel is contiguous with the sandy slopes of the valley walls (Figure 5). Historic straightening in this reach is assumed (not indexed with FIT) due to the shrub vegetation noted along much of the corridor indicating the abandoned agricultural fields. Equilibrium conditions are becoming reestablished in the lower segment of the reach (A) where significant aggradation has occurred, but some incision was still observed in segments B and C.


Figure 5. Large mass failure in M05-A


Figure 6. Aggradation of gravel substrate in M05-A

Reach M05 begins at the break in slope east of Tarbox Road and continues up approximately 1.4 stream miles to the Browns Trace Road crossing at the reach break with M06. The reach was divided into three segments based on changes in depositional features and distinct stages of channel evolution. Segment M05-A has gravel bed substrate and less incised geometry than upstream segments. Fair habitat and geomorphic stability conditions were observed as the segment continues to aggrade coarse material (Figure 6) and regain equilibrium conditions through floodplain redevelopment (stage IV of channel evolution). No corridor encroachments were noted for this segment, but the shrub-sapling vegetation along the banks and buffers indicate that the adjacent floodplain was likely used for agricultural purposes within the last ~50 years. Segment M05-B has a slightly steeper slope than Segment A with cobble substrate, and is currently moving through stage III of channel evolution. Some incision was noted within the segment (see cross section in Appendix 2) and fair geomorphic stability was recorded. The geomorphic conditions of segment M05-C are heavily influenced by two crossings: 1) mid-segment crossing of Fitzsimonds Road; 2) upstream crossing of Browns Trace Road. Downstream of these floodprone-constricting crossings are some degradational features (e.g., incision and bank erosion) which are likely contributing to the transport of gravel substrate to downstream segments A and B.

The habitat conditions vary widely across the three segments of M05. In downstream segment M05-A, significant aggradation and changes in planform have simplified the riffle-pool morphology and reduced available cover features for fish and macroinvertebrates, resulting in fair habitat conditions. Upstream segments B and C have greater variability in riffle-pool features and less substrate embeddedness, resulting in good habitat conditions.

Preliminary Project Identification:

In this depositional zone of the watershed the primary issue of concern should be (in the absence of current encroachment on the corridor) the protection of the corridor from future encroachment. Neither the default corridor developed through SGAT nor the Fluvial Erosion Hazard (FEH) Zone corridor analysis appear to delineate the effective corridor of Segments M05-A and B. In these segments, review of current and historic aerial photography reveals that significant migration has occurred across a corridor as wide as 450 feet. Due to the large aggradational features observed in segments A and B and the channel migration history, a review of the buffer ordinances and/or channel setbacks in the context of Jericho Town Zoning is recommended so that any future encroachment on the effective corridor can be avoided.

Both bridge crossings in segment M05-C are floodprone constricting structures that are causing some channel and bank scour immediately downstream. While these structures are not necessarily in jeopardy due to unstable channel conditions, future project prioritization in the Mill Brook watershed should consider the improvement of the alignment and discharge capacity of both bridges to reduce their impact on the channel.

Nashville Road Zone (M06 & M07):

A moderate change in slope is found in the vicinity of the Browns Trace Road crossing at the reach break between M05-C and M06. Reaches M06 and M07 have been treated separately in this summary because of their similarity in slope, channel form and lack of significant human impacts. The channel slopes in this watershed zone range between 1.5 and 2.0%, resulting in plane bed morphology with B and C-type geometry. Due to the steeper slopes of the valley walls in this zone, few current or historic impacts to the channel boundary conditions (e.g., straightening) were observed. With the exception of one area of minor encroachment in the lower section of reach M06 and a bridge crossing upstream in this reach, the buffer and corridor conditions of this watershed zone are forested by conifers (Eastern Hemlock) and mixed hardwoods.

Reach Descriptions:

Reach M06 is found from the crossing at Browns Trace Road up to approximately 600 feet above the crossing of Fields Road. The channel slope in this reach is 1.7%, and much of the reach exhibits plane bed morphology with some areas of riffle-pool bedform. The channel evolution stage has been assessed as stage I, however there are some isolated areas in the lower reach where aggradation and widening is occurring (Figure 7). One large grade control (waterfall) was noted just below the Fields Road crossing where a diversion and mill once existed. Good geomorphic stability and habitat conditions were noted throughout and many sensitive macroinvertebrates were noted the substrate sampling.

Reach M07 is found from approximately 600 feet above the Fields Road crossing to a sharp break in slope at the western end of the West Bolton Valley. This reach has a channel slope of 1.4%, and is slightly more confined than M06 which results in B-type geometry with plane bedform. No significant corridor encroachments or buffer impacts were observed in this reach. One large grade control (waterfall; Figure 8) was observed in the upper part of the reach. Reference and good conditions were noted for geomorphic stability and habitat respectively, and channel evolution was assessed as stage I.

Figure 7. Aggradation and Widening in lower M06

Figure 8. Grade Control in Upper M07

Preliminary Project Identification:

There is a residence immediately upstream of the Browns Trace Road crossing in lower M06 that is found within the stream corridor. Bank armoring has arrested further erosion on this bend and has protected the property over the years. The consequences of this armoring are evident in the 300 feet of channel downstream where moderate to severe bank erosion is occurring. While this property is not found in an effective depositional zone of the watershed (e.g., wide valley), it may be a fluvial erosion hazard in the future should a large event occur. It is recommended that this property be considered in any future analysis to identify corridor protection sites in the watershed.

West Bolton Valley Zone (M08 – M12)

A large alluvial valley occupies a large portion of the upper Mill Brook basin. This area, herein referred to as the West Bolton Valley, is characterized by a wide valley (as wide as 2000 feet in some areas) made up of coarse alluvial substrate transported from the surrounding steep hillslopes since the last glacial period. The valley is found at an elevation of 800 feet, above the influence of Lake Vermont and the Champlain Sea (Wright, 2003). The channel slopes range in this watershed zone from 0.4 to 0.9%, with reference conditions ranging from E-type to C-type geometry with coarse bed substrate. Due to the depositional nature of this valley, it is likely that all reaches in this valley once had dynamic meandering planform with frequent migrations occurring during large events. Agricultural impacts to the channel boundary conditions (e.g., armoring) and planform (e.g., straightening) have resulted in a departure from reference channel conditions in two of the six reaches found in this valley. Reach descriptions and a project identification summary for this watershed zone are found below.

Reach Descriptions:

Reach M08 is found from the lower end of the West Bolton valley up to the crossing at Snipe Island Road and has a channel length of 2190 feet. The channel slope for this reach is 0.9%, and the surrounding soils are alluvial resulting in a coarse bed channel. Although the upper section of this reach may have been a plane bed system in reference conditions, the lower section of the reach is assumed to have been a riffle-pool system with a floodplain accessing the wide valley. Historic straightening and bank armoring has led to incision and entrenchment of the channel, and a departure from C-type geometry to F-type geometry (Figure 9). One small beaver dam was noted in the lower section of the reach which affected 100 feet of the channel. Fair geomorphic stability and habitat conditions were noted, and the channel evolution was assessed at stage II. The lower section of this reach is considered to be an “extremely” sensitive reach due to its departure from reference conditions. As the channel seeks new equilibrium conditions in the future, significant bank erosion and widening followed by a redevelopment of sinuosity will likely occur.

Reach M09 is a short reach found from the Snipe Island Road crossing up to a confluence with a large tributary entering from the north. The channel length is 970 feet with a slope of 0.5%. This reach has a mixture of sand and fine gravel substrate and E-type geometry. It is impacted in the lower section by berming associated with the adjacent road, and has been assessed at stage II of channel evolution due to the incision resulting from these impacts. Approximately 600 feet of the reach is affected by a large beaver dam found immediately upstream of the Nashville Road crossing (Figure 10). Fair geomorphic stability and habitat conditions were observed in this reach.


Figure 9. Plane bed morphology in reach M08


Figure 10. Large beaver dam in M09

Reach M10 is found to the north of Nashville Road from approximately 700 feet upstream of the road crossing up to the confluence with a large tributary entering from the north. The channel length is 3534 feet and has a slope of 0.4%. The channel is highly sinuous (sinuosity = 1.3) and has likely recovered from a period of historic straightening (not indexed with FIT) which is evident upon review of historic imagery. The current planform supports a channel with C-type geometry and a mixture of sand and gravel substrate (Figure 11). Four beaver dams were observed in the reach which affect approximately 700 feet of the channel. Good geomorphic stability and habitat conditions were observed in the reach, and the channel evolution was assessed at stage V due to the recovery of a meandering planform following historic channel straightening.

Reach M11 is found from approximately 1000 feet downstream of the second Nashville Road crossing up to the confluence with a large tributary entering from the south. The reach has a channel length of 3230 feet and a slope of 0.3%. As in reach M10, the meandering channel planform has likely recovered from historic straightening (not indexed in FIT) and now exhibits E-type geometry with coarse gravel substrate. The presence of many large bar features along with the reestablishment of a new floodplain at a lower elevation indicated that this reach is in stage IV of channel evolution. Good geomorphic stability and habitat conditions were observed in this reach.


Figure 11. Riffle pool morphology in reach M10


Figure 12. Aggradation in segment M12-A

Reach M12 is found from the reach break with M11 up to approximately 600 feet downstream of the third Nashville Road crossing. This reach has an overall slope of 0.4% and a channel length of 5162 feet. The reach was broken into 2 segments to characterize the changes in channel condition resulting from channel straightening. Prior to the historic and recent (within last ~20 years) channel straightening, the reference conditions of this reach were meandering planform with riffle-pool bedform and C-type geometry. Significant straightening, especially in the upper part of the reach, has led to plane bed morphology and a reduction in quality physical habitat. The conditions in the 2 segments are described in further detail below.

Segment M12-A is gravel-bed reach that has still maintained its riffle-pool morphology, but is experiencing significant aggradation of coarse material (Figure 12). This material is being transported from upstream segment M12-B as a result of the severe straightening in that segment. Multiple beaver dams were noted in the extreme lower section of the segment where the channel slope lessens. Geomorphic stability and physical habitat conditions were assessed as fair. Due to the extreme aggradation and subsequent changes in planform observed in this reach, the channel evolution stage has been assessed at stage IIb.

Segment M12-B has had significant alterations to the planform, and the channel is beginning to aggrade material and redevelop limited sinuosity following years of straightening and armoring. Figure 13 depicts the extent of the straightening to maximize surrounding farmland. These alterations have severely reduced the channel stability and quality of the physical habitat throughout this reach. While some areas of the reach continue to incise where armoring has recently been added, much of the reach is beginning to widen and aggrade material, indicating stage III of channel evolution.

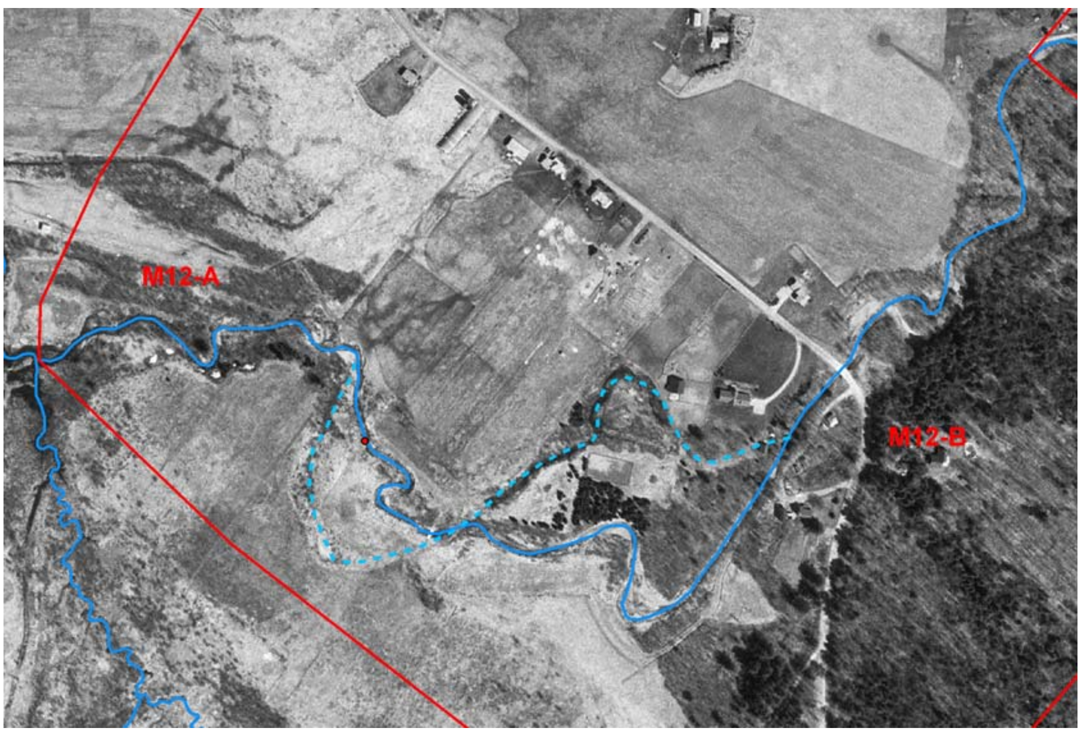


Figure 13. Current channel location (solid blue) and pre-straightened channel location (dashed blue) in reach M12.

Preliminary Project Identification:

Two areas of this watershed zone should be considered in future efforts to identify equilibrium restoration sites. Reach M08, which has maintained an incised channel geometry following straightening, continues to be a sediment transport reach in a depositional zone of the watershed. The adjacent land use appears to be primarily for hay, which may present an opportunity for floodplain restoration given limited infrastructure encroachments. Similarly, the depositional zone of segment M12-B which has been converted to a transport zone will be of particular interest in future restoration efforts. There are properties within the corridor of this segment which could be in danger of erosion hazards should the channel continue to adjust its planform during a large event. If corridor property owners in the lower part of the segment were willing to cooperate in a floodplain restoration project, removal of the large amount of bank armoring found there would further induce the recover of a meandering planform and equilibrium conditions.

A further note of caution should be taken with respect to future development in the West Bolton valley. The alluvial conditions of this valley and the flat terrain (and soils suitable for septic systems) could make properties along Nashville Road desirable for residential development. Planners in the Town of Bolton would be wise to consider the inherent dynamic nature of the stream types found throughout this valley, and plan adequate setbacks from the current channel location. Figure 13 provides evidence of the scale of meander migration that the channel is capable of within the valley.

Headwaters Zone (M13 – M15):

Above the third channel crossing of Nashville Road there is a significant change in valley slope and confinement. Upstream of this slope change, reference channel conditions begin to change from depositional reaches to transport reaches in a confined valley setting. The first segment, M13-A, is the only depositional reach described in this watershed zone. Channel slopes in the headwaters zone range from 3% to 15%, with the steepest slopes found in the final upslope reach. With the exception of road encroachment and berming in segment M13-A, the human impacts in this zone are limited to a single road crossing and legacy impacts from historic forestry practices. B-type channel geometry and step-pool and cascade morphologies are common throughout the reaches.

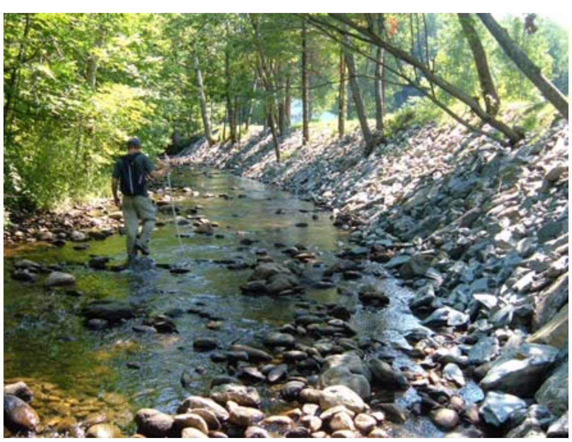


Figure 14. Armoring along reach M13-A


Figure 16. Cross section in M15

Reach M13 has a length of 4744 feet and an overall channel slope of 3%. The reach has been divided into three segments to account for the changes in channel geometry and bedform resulting from natural changes in grade. Lowermost Segment A has C-type geometry with riffle-pool bedform and a cobble substrate. This segment is impacted by encroachment from Nashville Road approximately 600 feet upstream from the road crossing. Recent berming and armoring along the left bank has narrowed the channel and impacted the buffer vegetation (Figure 14). The lower section of segment A is experiencing significant aggradation (likely as a result of upstream armoring) and therefore has been assessed in stage IIb of channel evolution. Fair geomorphic stability and good habitat conditions were noted for Segment A. Segment B is found from this encroachment upstream to a second area of encroachment just above the confluence with a large tributary entering from the north. Segment B has B-type geometry and plane bedform. Limited human impacts in this segment make it an appropriate reference reach for other plane bed stream types. Segment C is found from just upstream of the confluence of a small tributary entering from the south to approximately 350 feet above the crossing of Cemetery Road. This segment also has few human impacts and reference conditions of B-type geometry with step-pool morphology. Reference stability and habitat conditions were noted for Segments B and C.

Reach M14 has length of 5147 feet and an overall channel slope of 9%. A-type channel geometry typical of headwaters channels was observed along the entire reach; however the reach was divided into two segments to account for changes in bedform. Segment A is found from just upstream of the Cemetery Road crossing to a natural change in slope approximately 1000 feet downstream of the confluence with a small tributary entering from the north. This segment is found in a confined valley setting and has step-pool morphology. Segment B is found within a very steep and confined setting with numerous waterfalls and cascades. The change in slope at the segment break results in a cascade bedform throughout much of the segment.

Reach M15 is an extremely steep headwaters channel with a slope of 15% and cascading bedform throughout. It is found from the confluence with a large tributary entering from the south up to the source of Mill Brook just west of Bolton Mountain. A-type geometry and reference conditions were observed in the absence of significant human impacts.

Preliminary Project Identification:

There is one area of corridor encroachment in the lower section of M13-A which should be monitored carefully in the future. Just upstream of the M12/M13 reach break there is a sharp bend that is armored on the right bank to protect the property within the corridor. As noted above, an unnatural degree of aggradation of coarse substrate was observed in this segment due to the encroachment-induced transport conditions found immediately upslope. While the armoring may currently be stable, there is potential for the channel to become dynamic during a large flood event. Future corridor planning effort should consider the hazard these structures pose considering their location in a transitional zone from sediment transport to deposition.

Conclusions:

The largely rural land use conditions of the Mill Brook watershed support many stream reaches in good to reference conditions. Three of the lower reaches (M02, M03 and M04) represent a wide range of channel slope and valley conditions at lower elevations (~300 feet) that can be compared to a diverse array of stream types within the larger stormwater impaired watersheds in Chittenden County. Although some encroachments (e.g., houses in the corridor) and historic impacts to the channel boundary conditions (e.g., straightening) have affected the geomorphic stability and habitat conditions of these reaches, the large scale stressors of altered hydrology are nearly absent. Therefore, these reaches are recommended for comparison with stormwater impaired reaches with drainage areas greater than five square miles.

Historic impacts to the Mill Brook channel conditions from agricultural land uses are still pervasive in many reaches. These impacts were particularly severe in reaches M05, M08, M11, and M12. Although there has been limited direct encroachment and alterations to hydrology upslope of these reaches, channel straightening has had the effect of initiating channel evolution processes that are similar to those observed in stormwater impaired reaches in the Burlington area. Incision, followed by widening and a redevelopment of sinuosity are the processes occurring in these reaches. Due to their altered conditions, these reaches are not recommended for comparison (as reference channels) with stormwater impaired reaches in Chittenden County.

Literature Cited:

Fitzgerald, E. P., 2007, Linking Urban Land Use to Stream Geomorphology and Biotic Integrity in the Lake Champlain Basin, Vermont [M.S. Thesis]: Burlington, Vermont, University of Vermont, 121 p.

Montgomery, D. R., & Buffington, J. M., 1997, Channel-reach morphology in mountain drainage basins, *Geological Society of America Bulletin*, 109(5), 596-611.

Rosgen, D. L., 1994, A classification of natural rivers, *Catena*, 22(3), 169 - 199.

Wright, S., 2003, Glacial Geology of the Burlington and Colchester 7.5 minute Quadrangles, Vermont Geological Survey, Waterbury, VT

Appendix 1

QA Notes For: **Mill Brook**
Data checked by Jared Carrano (5/29/07)

The questions raised in this Quality Assurance assessment are meant to address potential discrepancies within the data set, uncover data entry errors, or otherwise clarify and confirm those observations that might not have been expected. It is important to take into consideration how data might be viewed or interpreted by the myriad of users who are familiar with the science and protocols but may be unfamiliar with the assessed reaches. While providing notes and comments, try to anticipate the types of questions that may arise due to outliers and exceptions observed within the reach or segment. While attempting to clarify the data for those users wishing to utilize it years after collected, it's better to err on the side of making excessive comments than it is for them to be insufficient.

After reviewing the information noted, the consultant should update this document (preferably in a second color) with what steps, if any, were taken to address the comments/questions.

General:

When you update a project from "Old" status with the new FIT extension you should delete the older data so that there is only one set of data. When both old and new data exists simultaneously, an error will get generated in the QA step X.1. The easiest way to delete the old data is to hit the "Delete" button on the QA page. Please go back through for all the reaches where you noted "See new FIT data" and delete the old data.
Completed by Evan Fitzgerald (6/5/07).

Flow regulation should not be left blank in Ph1. If you know that there were no impoundments or withdrawals you should indicate "None". **Reaches: M01 and M03**
Completed by Evan Fitzgerald (6/5/07).

Channel Evolution Model: This has been left blank for **Reaches: M02, M03, M04, M06, M13, M14 and M15**
Completed by Evan Fitzgerald (6/5/07).

Ph1 6.3 Channel Bars and 6.4 Meander Migration: These have been left blank for the entire project.
Completed by Evan Fitzgerald (6/5/07).

Groundwater: This field has been labeled as "No Data" for all of Ph1. Once a phase 2 assessment has been completed, there typically should not be any fields left as "No data", as all fields should then be evaluated. Please update the Ph1 information with groundwater data to the best of your ability.
Completed by Evan Fitzgerald (6/5/07).
Erosion Height and Beaver Dams: You have noted in the QC Comment report the actual heights and lengths for these fields for various reaches where the location was indexed but the associated height or length was not given. Was there a reason you did not go back and add these values into FIT?
Field sheets reviewed by Evan Fitzgerald and data added to FIT for Reaches M01, M08, M09, M11, M12-A, M12-B, M13-A, M13-C. Re-uploaded (6/5/07).

Riffle/Step Spacing: Should not be 0 if the riffle type is complete.
Completed by Evan Fitzgerald (6/5/07).

Reference Channel Width: If you are confident that the channel width you observed in the field is the reference width for that channel, and this width does not agree with the SGAT estimated Ph1 channel width, you should manually update the Ph1 channel width. Please re-evaluate for the following **Reaches: M03, M04, M10 & M15**
Completed by Evan Fitzgerald (6/5/07).

If you know that the Ph1 is likely incorrect but are not confident of the reference channel width (i.e. because the channel is in stage II or III, rather than stage I) than you should note in the comments that the predicted width does not seem to be accurate. **Reaches: M08, M09, M11**
Completed by Evan Fitzgerald (6/5/07).

Steep Riffles and Head Cuts: It appears that no steep riffles or head cuts have been indexed. If this is because the spatial location is not known you will have to provide a best guess location with FIT. This is the only way we can capture this information in the DMS. In the comments space in FIT you should note that this was a best guess as well as in the Step 5 comments.
Field sheets reviewed by Evan Fitzgerald and 3 steep riffles added to FIT for reaches M01, M03, M05-B, M06, M07, M11, M12-A, M12-B. Re-uploaded (6/5/07)

No cross-sections have been uploaded to the DMS. This used to be something that was strongly encouraged, but it is now a requirement. If you can upload these to the DMS it would be very helpful.
Cross sections for all reaches uploaded in M01 and M02 locations on DMS (6/5/07).

Reach By Reach

M01	Ph1 Step 3.2 notes a dam as a grade control. If a dam was not actually present, the Ph1 data should be updated. **Reviewed by Evan Fitzgerald (6/5/07).**
M03	The slope for this channel is %1.8, which falls into the C-channel range (% 0.10 – 2.0). Since this is a B channel there should be a sub-class slope, however, you indicated “None” for sub-class slope. **Reviewed and revised by Evan Fitzgerald (6/5/07).**
M05	Please re-evaluate the valley widths and confinement types for all segments in this reach. You have noted the same valley width for each segment (529’), which is the same as the Ph1 valley width. However, you call segments A and B “Broad” and segment C “Semi-Confined” when all segments should really be “Very Broad”. Keep in mind that the confinement ratio is based on the “reference” channel width where over widened. **Reviewed and revised by Evan Fitzgerald (6/5/07).**
M05 C	Your comment indicates that Rip-rap was not indexed correctly for this segment. You say there is “…a fair amount of riprap…” in addition to 160’ of rip rap along Fitzsimons Rd, suggesting significantly more than 160’. You have only indexed 139’ and only on the right bank.

You've noted 2 bridges, but Phase1 has only 1 bridge indexed.
FIT revised and uploaded by Evan Fitzgerald (6/5/07).

M06 Your comments call this a "Narrowly confined…" valley, but it is actually a "narrow" valley. They are different, and we should try to keep them straight for accuracy and to avoid confusion.
Reviewed and revised by Evan Fitzgerald (6/5/07).

M07 Sub-class slope: This should be "C" with a slope of %1.4.
Reviewed and revised by Evan Fitzgerald (6/5/07).

M08 You have called Step 7 Planform "Historic". If this is because of the historic straightening, it is not correct. The use of "historic" here means "no longer active". If planform will change – i.e. the straightened channel will start to meander – this should not be called "historic".
Reviewed and revised by Evan Fitzgerald (6/5/07).

M12 A Comments indicate multiple beaver ponds, but only 1 was indexed.
One additional beaver dam added to FIT (6/5/07).

Narrative comments say there were many steep riffles, but none have been indexed.
FIT revised and uploaded by Evan Fitzgerald (6/5/07).

M12 B Comments say "channel has many diagonal riffles…" but only 2 were entered. Is this correct?
Reviewed and revised by Evan Fitzgerald (6/5/07).

Also, only about %6 of this reach has had straightening indexed. It sounds like there should be more from the comments. Also, the narrative comments say there was dredging but this has not been indexed.
Additional straightening missed in FIT has been added (6/5/07)

M13 B You note a Human Caused Changed Valley Width (HCC), but only about %16 of the reach has a road within the corridor and your comments say that there are "…little direct impacts apparent" from this road. You also say that this is a good reference B channel, suggesting the change is not human caused.
HCC notation has been reviewed and removed (6/5/07).

Also, if the reach has a confined or semi-confined valley type because of a HCC, than you must still use the "Unconfined" RGA form. If the segment has a different natural valley type than the other segments, it would be helpful to note this in the comments.

M14 A You called the confinement type "Broad" but used the confined RGA. Data entry error?
Revised to semi-confined (6/5/07).

Phase II Notes and Updates to Phase I Data:
General updates are reviewed below for each DMS Phase II step to which noteworthy revisions were made to the Mill Brook dataset, after the automated DMS QC and the subsequent QC from DEC staff. Common parameter themes across reaches are summarized with **reach names in bold text**. References to Phase I data are summarized and discussed in red text.

- *Step 1 - Valley and Floodplain Corridor:*
  - Adjacent Terrace or Hillside (1.4)
    - Phase II side-slopes have been reviewed but have **NOT** been updated in the Phase I database. Therefore, database user should refer to Phase II for correct valley side-slope data.
  - Valley Features (1.5)
    - Where better estimated or measured values were taken for valley width in Phase II surveys, Phase I data has been updated. Otherwise, Phase I valley width has been used and entered in Phase II database.
  - Grade Controls (1.6)
    - Phase II grade controls have been reviewed but have **NOT** been updated in the Phase I database. Therefore, database user should refer to Phase II for correct grade control data.
    - Despite the abundance of beaver dams in some reaches and their ability to control stream grade on a short-term basis, these features have been removed as grade controls in the database.
- *Step 2 - Stream Channel:*
  - Stream Channel (2.1 – 2.9)
    - Efforts were made to get 1 to 2 cross-sections per reach; 2 for the longer reaches. Sometimes representative cross-sections selected for DMS data entry disagrees with stream type or adjustment type, or suggests a higher/lower degradation adjustment than that observed.
  - Riffle Data (2.10 – 2.11)
    - Riffle data has not been collected for “dune-ripple” or “plane” bedforms. All observed riffle/pool spacings have been included for “riffle-pool” and “step-pool” bedforms.
  - Substrate Data (2.12 – 2.13)
    - Percent Detritus has been estimated and tends to be higher on lower gradient reaches (E-types). Note that this data is more qualitative than quantitative.
    - For “Dune-Ripple” bedforms, average largest particles on both the bed and bar are sand, which often appear as “0” values in the DMS.
  - Stream Type (2.14)
    - In heterogeneous reaches, dominant bedform has been selected even though reach may contain multiple bedforms throughout (e.g., B3 step-pool may also have significant portions of plane bedform). Those reaches with altered bedform from reference conditions are listed below:
      1. Plane bed reaches that were likely riffle-pool include: **M08 & M12-B**

    - Determination of stream type may be based on data from more than one cross-section measurement. - Please refer to all cross section data (see appendix 2) to confirm chosen stream type. Reference condition stream types have been updated in the Phase I database where a type different from Phase I estimate was observed in the field.

- *Step 3 - Riparian Banks, Buffers, and Corridors:*
  - Stream Banks (3.1)
    - Bank textures observations during Phase II assessments focused more on material type more than cohesiveness. Therefore, "cohesive" versus "non-cohesive" values have been updated during the QA process and are now considered accurate.
    - Observed bank erosion values in many cases represent best possible estimations of length for each bank. For reaches with higher percentages in particular, estimated values are likely more qualitative than quantitative.
    - Phase II bank erosion data have **NOT** been updated in the Phase I database. Therefore, database user should refer to Phase II for correct data.
  - Stream Buffer (3.2)
    - Phase II buffer width and vegetation data have been reviewed but have **NOT** been updated in the Phase I database. Therefore, database user should refer to Phase II for correct data.
  - Stream Corridor (3.3)
    - Phase II corridor land use data have been reviewed but have **NOT** been updated in the Phase I database. Therefore, database user should refer to Phase II for correct data.
- *Step 4 – Flow and Flow Modifiers:*
  - Springs, Seeps, & Tributaries (4.1)
    - In addition to seeps and springs, tributaries of any size were considered to provide water storage capacity at the reach scale during the Phase II assessments. GIS mapping using orthophotography and VHD layers were also used to determine the abundance of tributaries for each reach.
  - Adjacent Wetlands/GW Inputs; Impoundments/Flow Regs; Constrictions (4.2, 4.5, 4.7, 4.8)
    - Phase II inputs for above-described data have been reviewed but have **NOT** been updated in the Phase I database. Therefore, database user should refer to Phase II for correct data.
  - Flow Regulating Impoundments (4.5 & 4.7)
    - Aside from beaver ponding, only one on-stream impoundment was noted for Reach M04.
  - Stormwater Inputs (4.6)
    - Stormwater inputs include those outfalls discharging directly to the channel, as well as those ditches and other features conveying concentrated runoff directly to channel.
- *Step 5 – Channel Bed and Planform Changes:*
  - Bar Types (5.1)
    - Phase II bar type and abundance data have been reviewed but have **NOT** been updated in the Phase I database. Therefore, database user should refer to Phase II for correct data.
  - Planform Changes (5.2 – 5.3)
    - Alterations to the hydrologic and sediment regimes in the Mill Bk. watershed are caused primarily by: 1) historic agricultural impacts, and 2) beaver

modifications to channel and floodplain. It is often difficult to tease apart the relative impacts of each of these factors during Phase II assessments when both are present in a reach or segment. Noteworthy planform changes relative to each impact are listed below:

1. Reaches where significant alterations to planform have resulted from **historic agricultural impacts** include the following reaches: **M01, M05-B, M08, M12-A & M12-B**
2. Reaches where alterations to planform have resulted from **beaver activity** include: **M09, M10, M11 & M12-A**

- o Channel Alterations (5.5)
  - Phase II channel alteration data have been reviewed but have **NOT** been updated in the Phase I database. Therefore, database user should refer to Phase II for correct data. Channel alterations are described in further detail in the commentary section at the end of step 5.

• *Step 6 – RHA:*

- o Bank Stability (6.8)
  - Bank stability measurements reflect estimated bank erosion values entered in step 3.1. In some cases RHA scores for bank stability may appear slightly higher or lower than the expected ranges/values entered in step 3.1. Best judgment was used in these cases when evaluating bank stability from a habitat perspective.
- o Overall Rating (6.11)
  - Confidence in integrity of overall RHA scores is high for Mill Brook.
  - Overall habitat assessment in E-type channels is difficult due to general lack of quality habitat associated with these sand-bottomed reaches, and alterations from beaver activity.

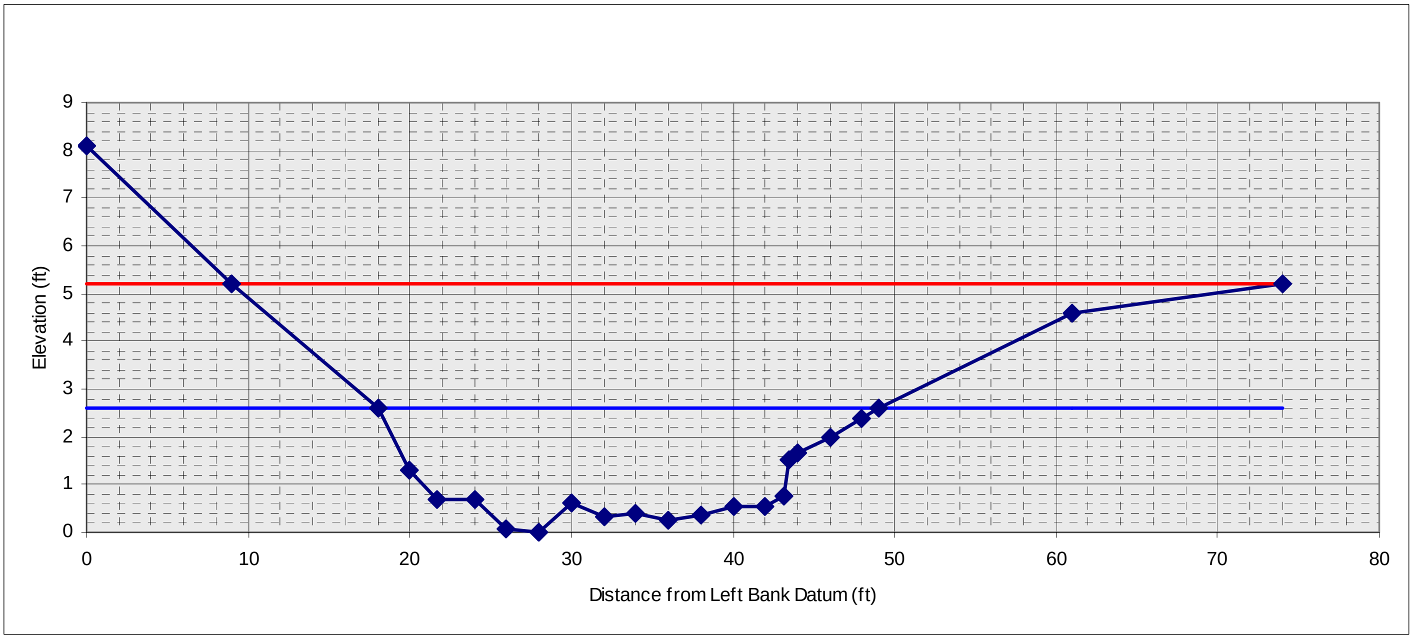
• *Step 7 – RGA:*

- o Channel Degradation (7.1)
  - Incision values and entrenchment ratios were reviewed for ALL reach cross-section measurements and field observations in order to determine scores in 7.1 (row 2) and 7.3 (row 3). Certain reaches may appear to have RGA scores for these rows which do not agree with reported DMS cross section geometry, in which case database user should refer to additional cross-sections and/or DMS narrative in step 5.
- o Channel Widening (7.3)
  - Aggradation and widening are the predominant adjustment processes occurring in the impacted reaches of Mill Brook. This can be explained by the historic alterations to the channel planform (e.g., straightening) and subsequent readjustment of channel width and slope as these reaches move through stages III and IV of channel evolution. Channel widths were compared with hydraulic geometry curves developed for Chittenden County in order to make adjustments to scores in 7.3 (row 1). For this parameter, width to depth ratio is not always adequate at capturing the degree of widening. Also, certain reaches may appear to have RGA scores for these rows which do not agree with reported DMS cross section geometry, in which case the database user should refer to additional cross sections.
- o Overall Rating (7.6)
  - Confidence in integrity of overall RGA scores is high for Mill Brook.

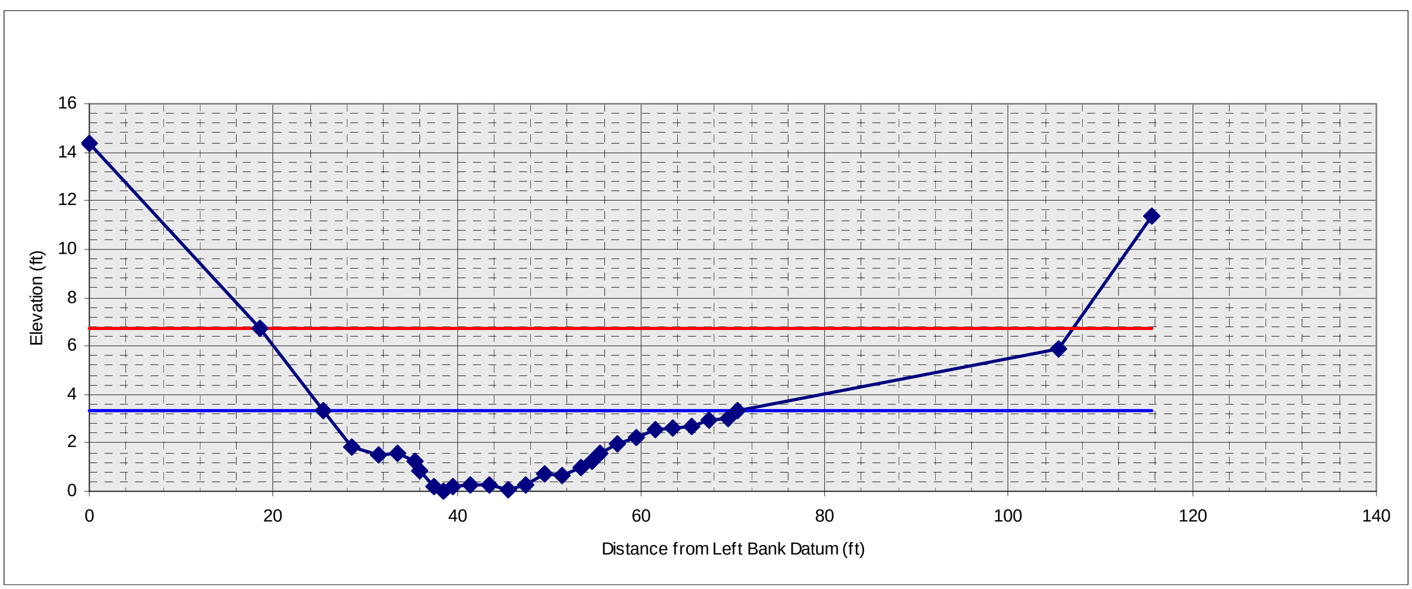
Appendix 2

Cross-sectional plots for Mill Brook reaches and segments are found below. The horizontal **blue line** represents the bankfull width and depth, and the **red line** represents the field-estimated floodprone depth and width (if visible on plot). Reaches/segments with multiple cross sections are denoted by X1, X2, etc.

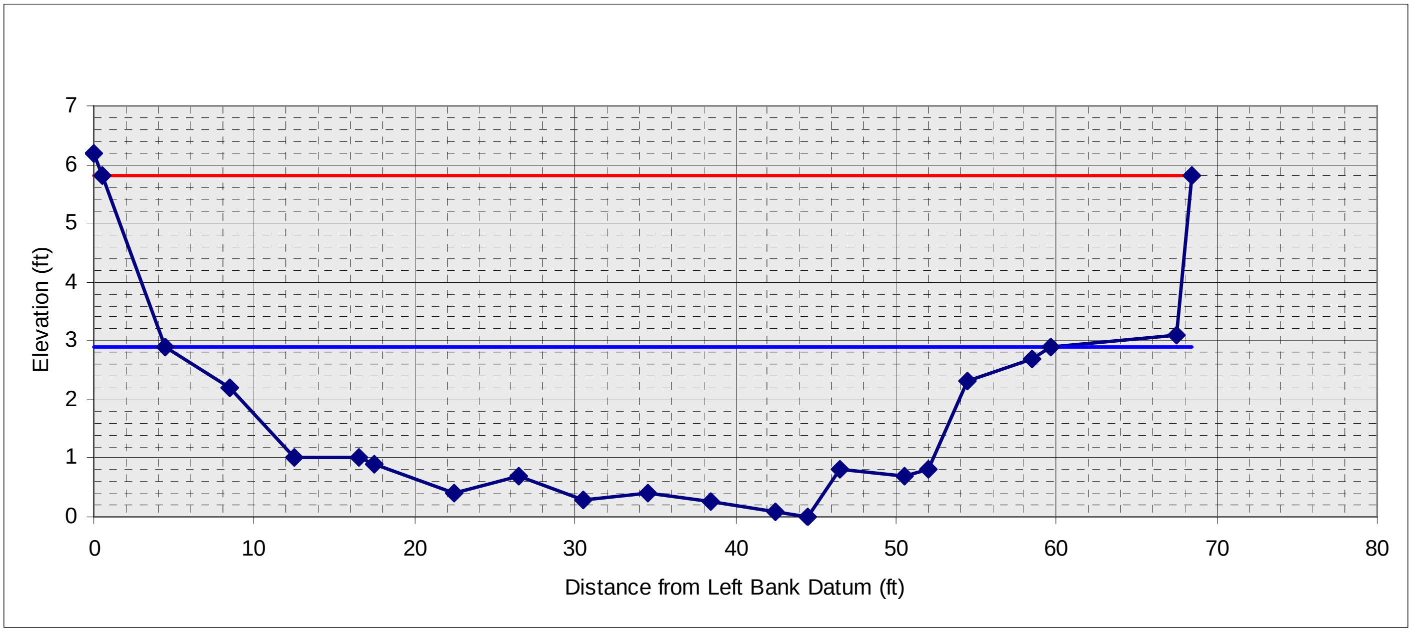
Reach M01



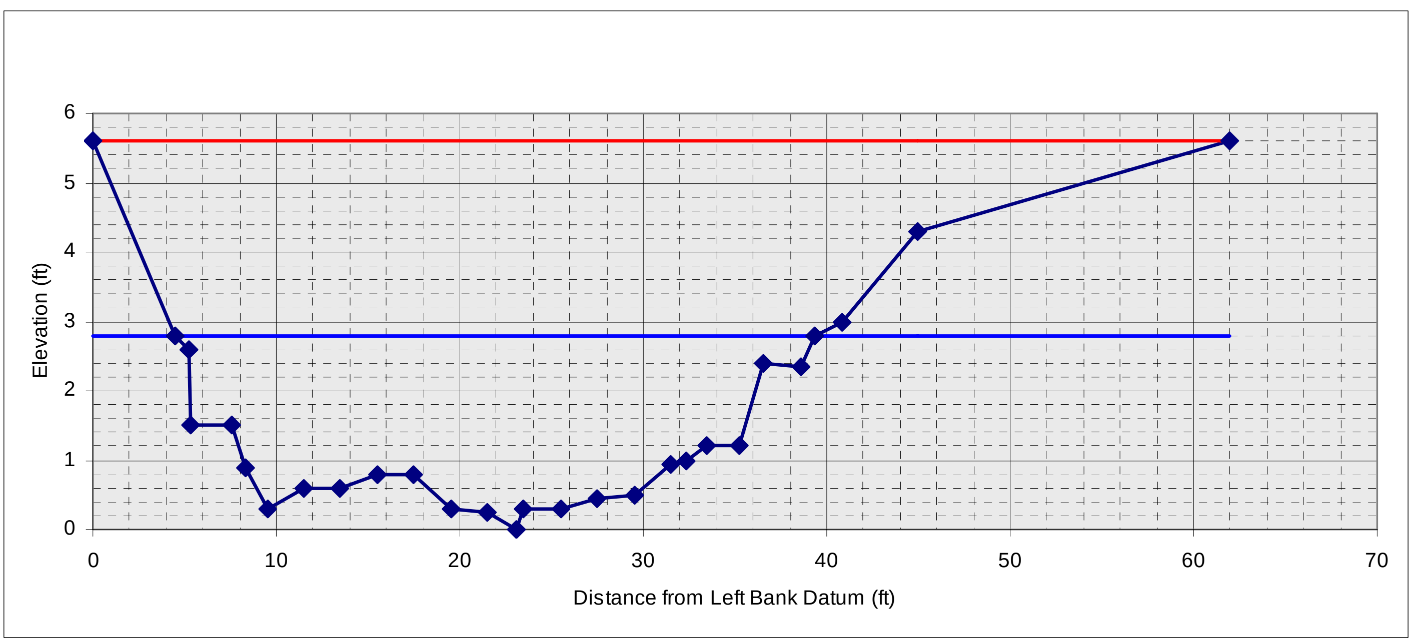
Reach M02



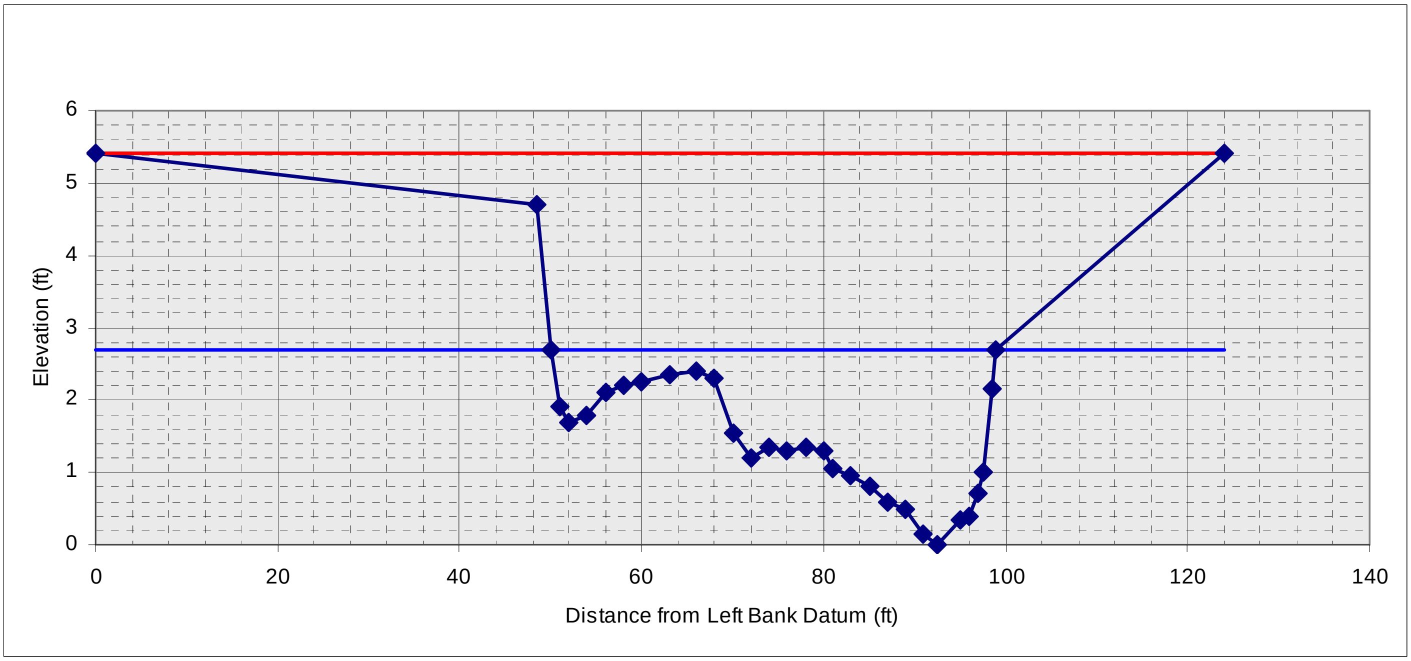
Reach M03



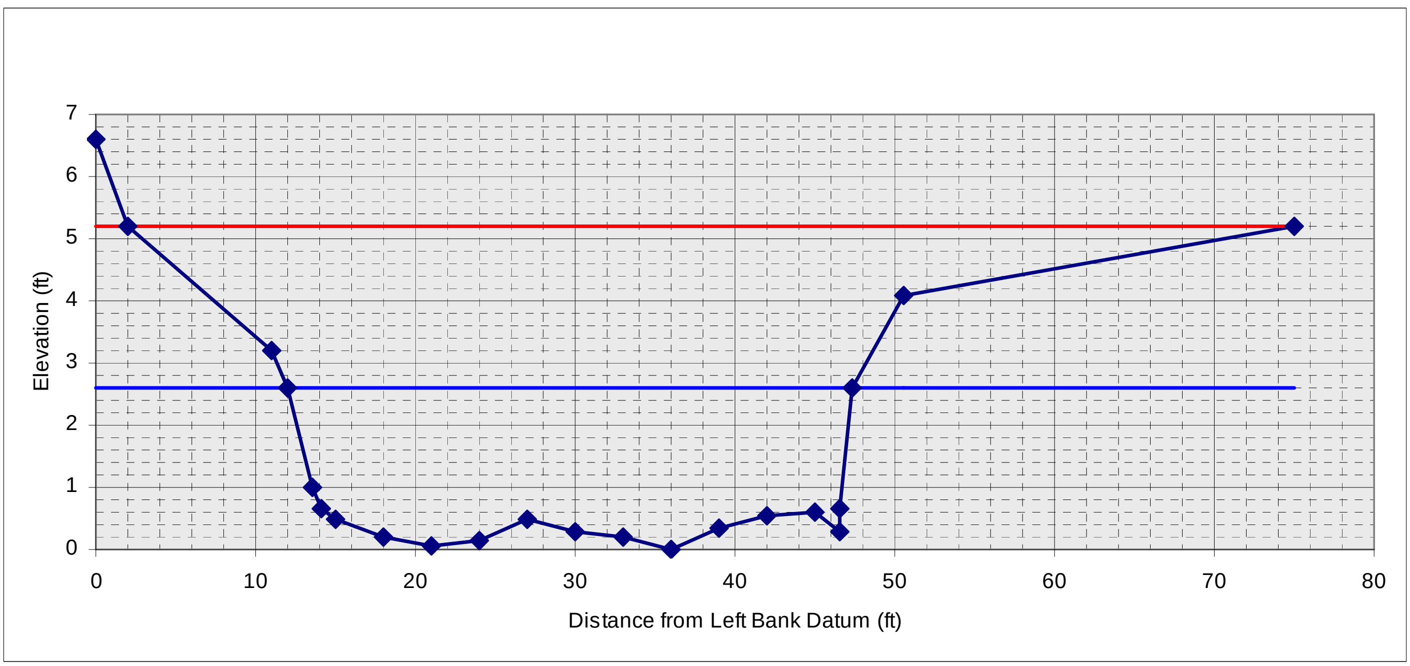
Reach M04



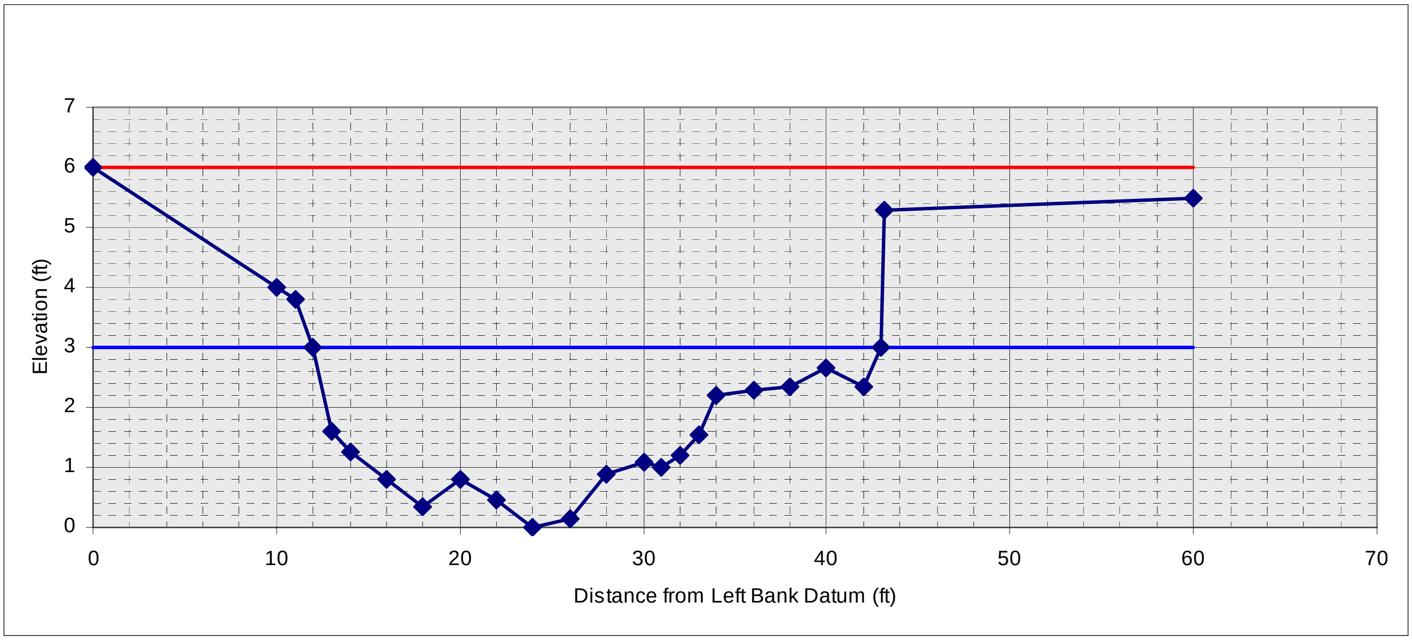
Segment M05-A



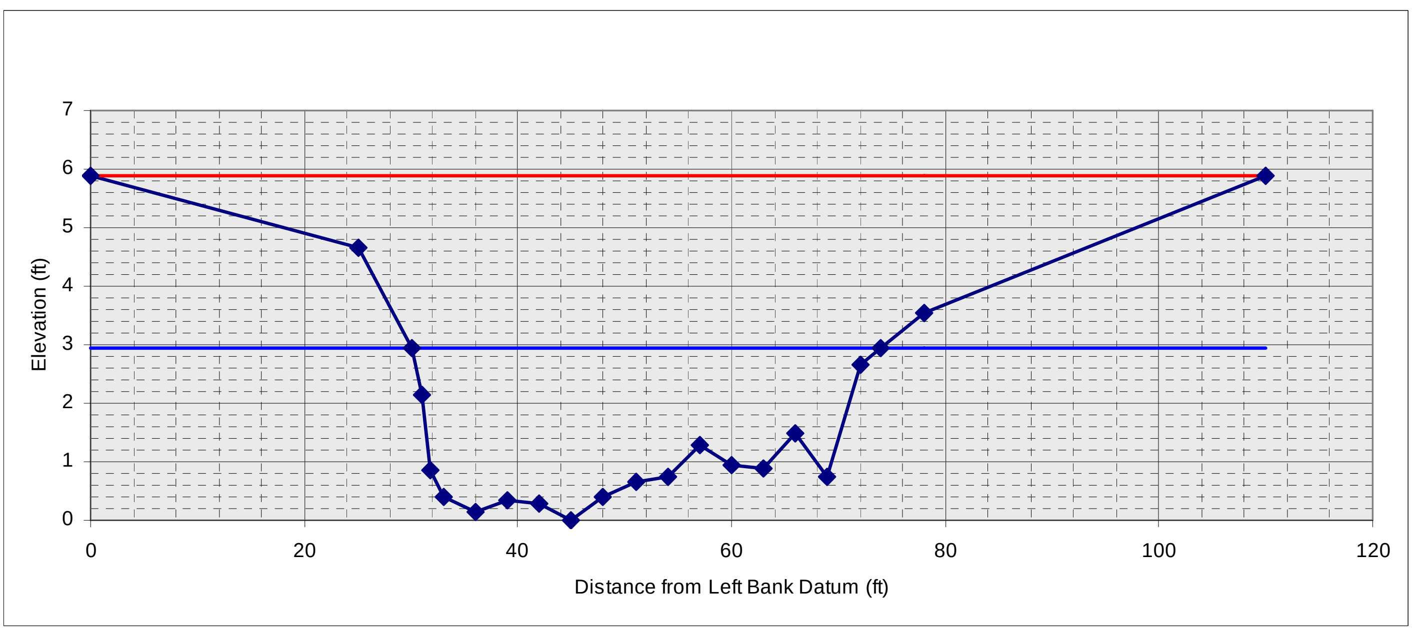
Segment M05-B



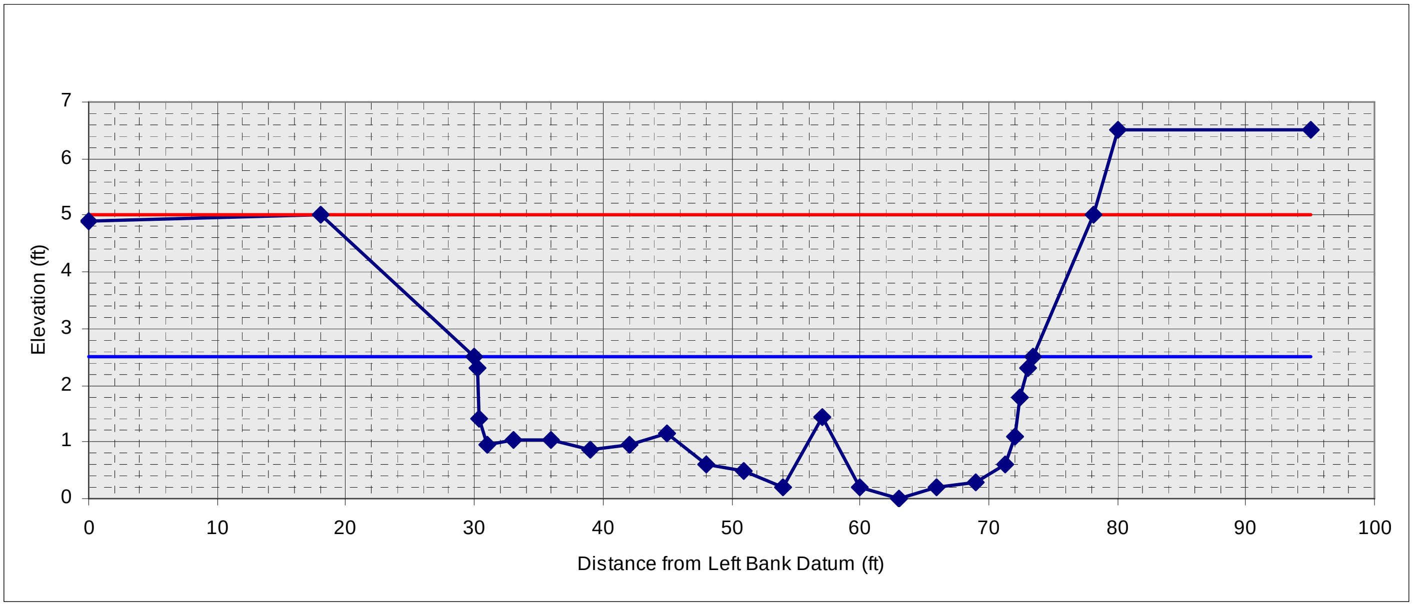
Segment M05-C



Reach M06 X1

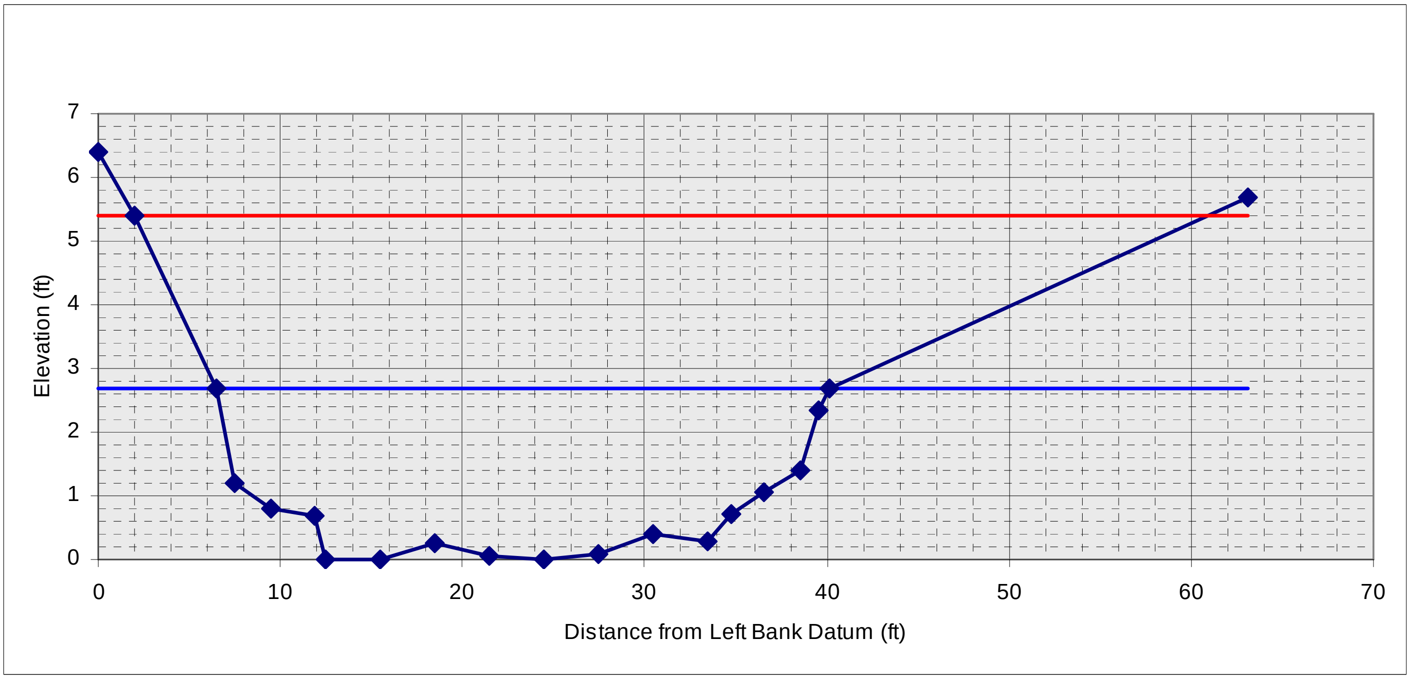


Reach M06 – X2

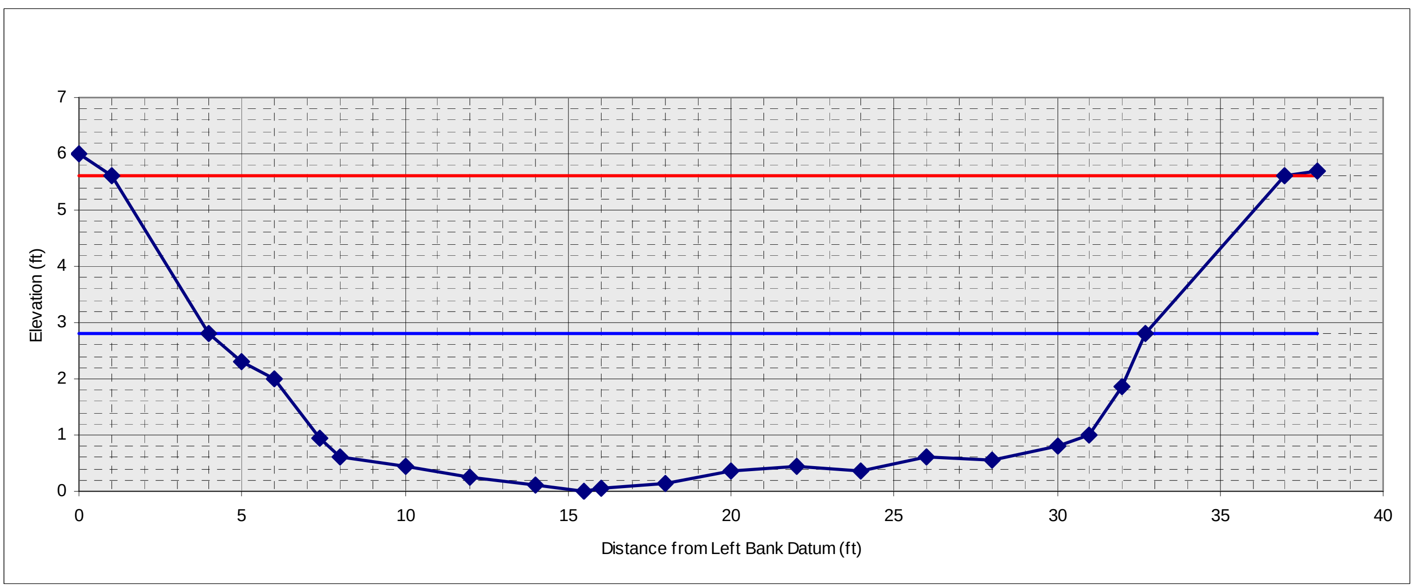


Reach M07 X1

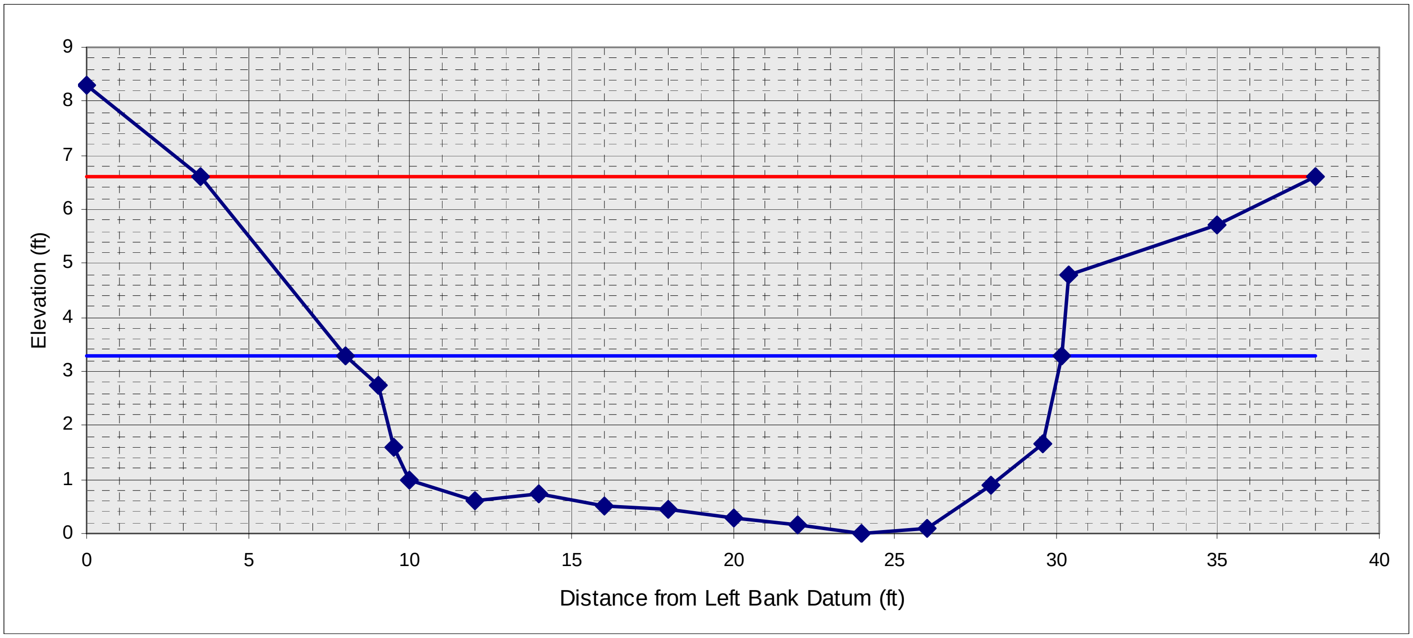
Reach M07 X2



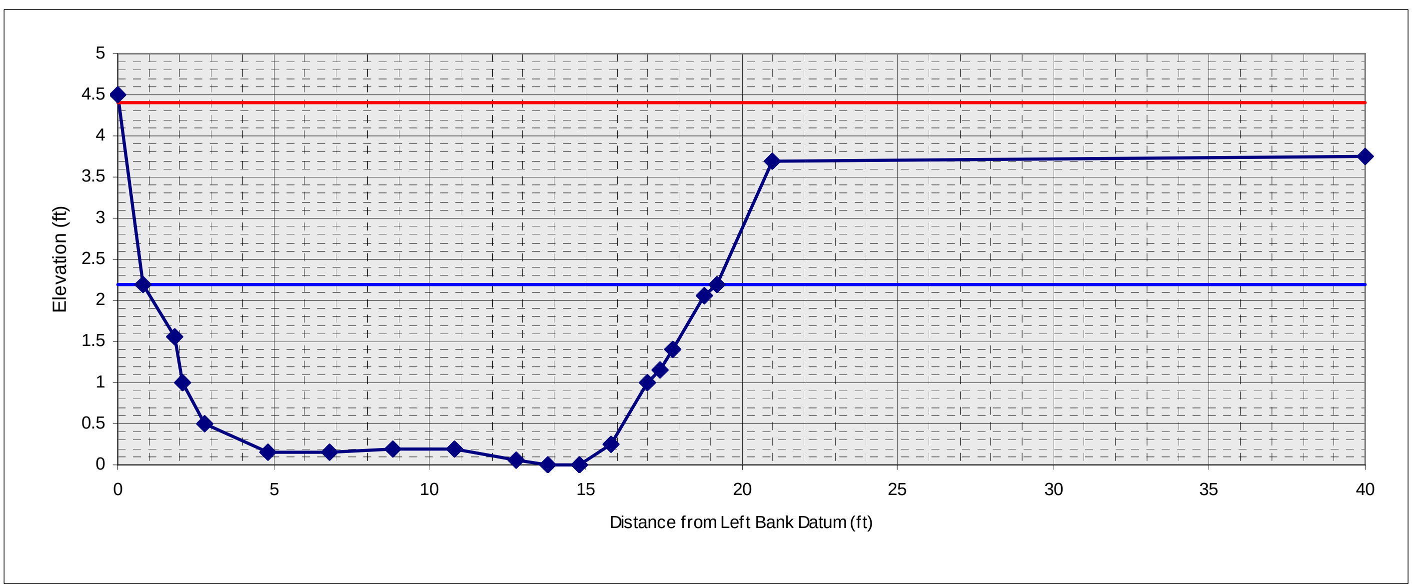
Reach M08



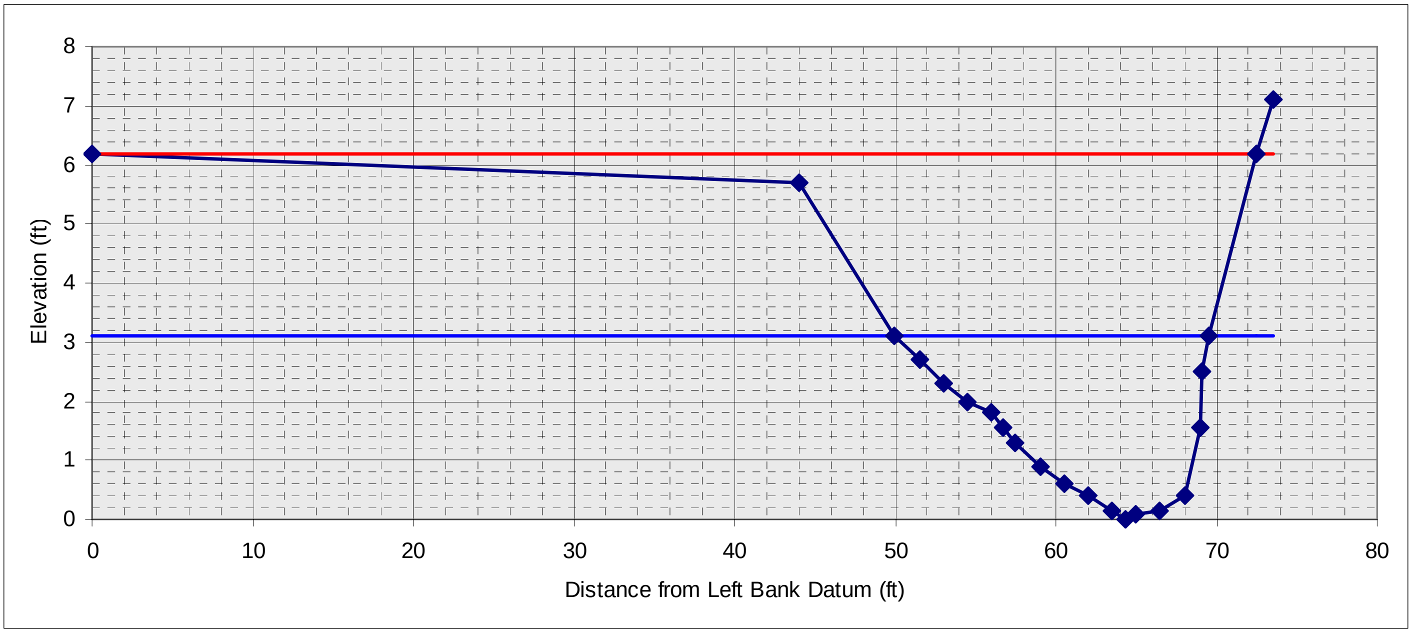
Reach M09



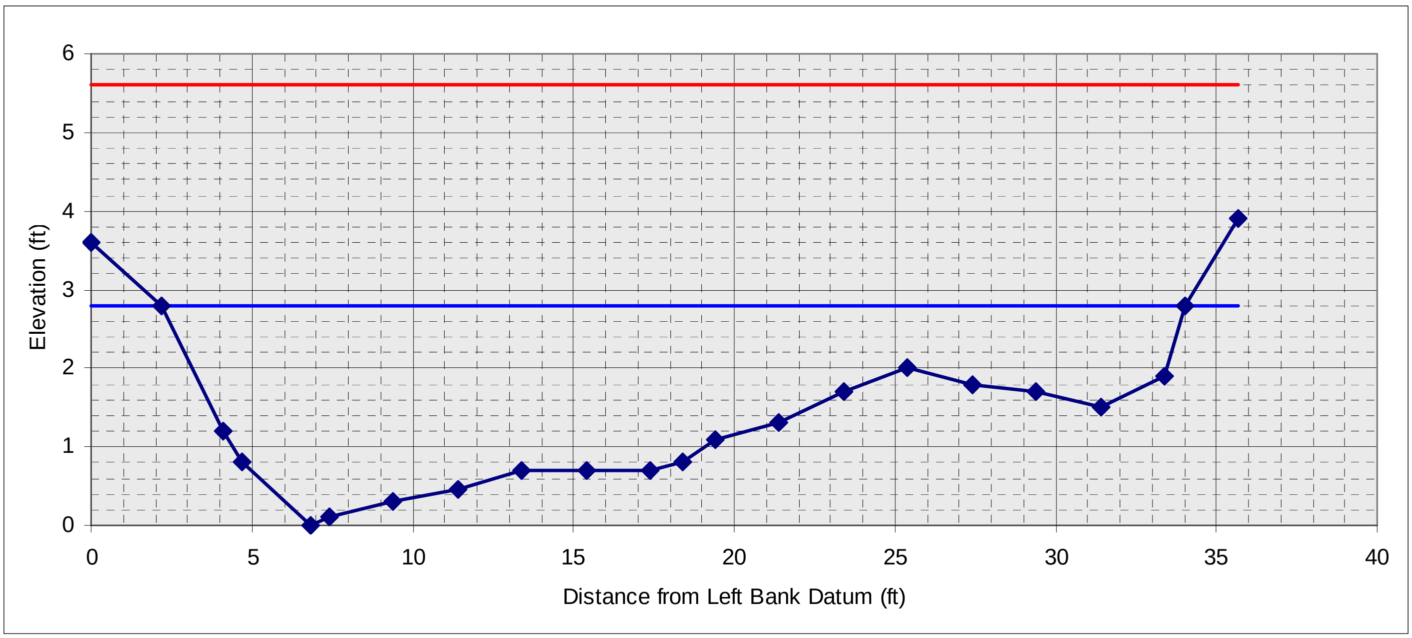
Reach M10



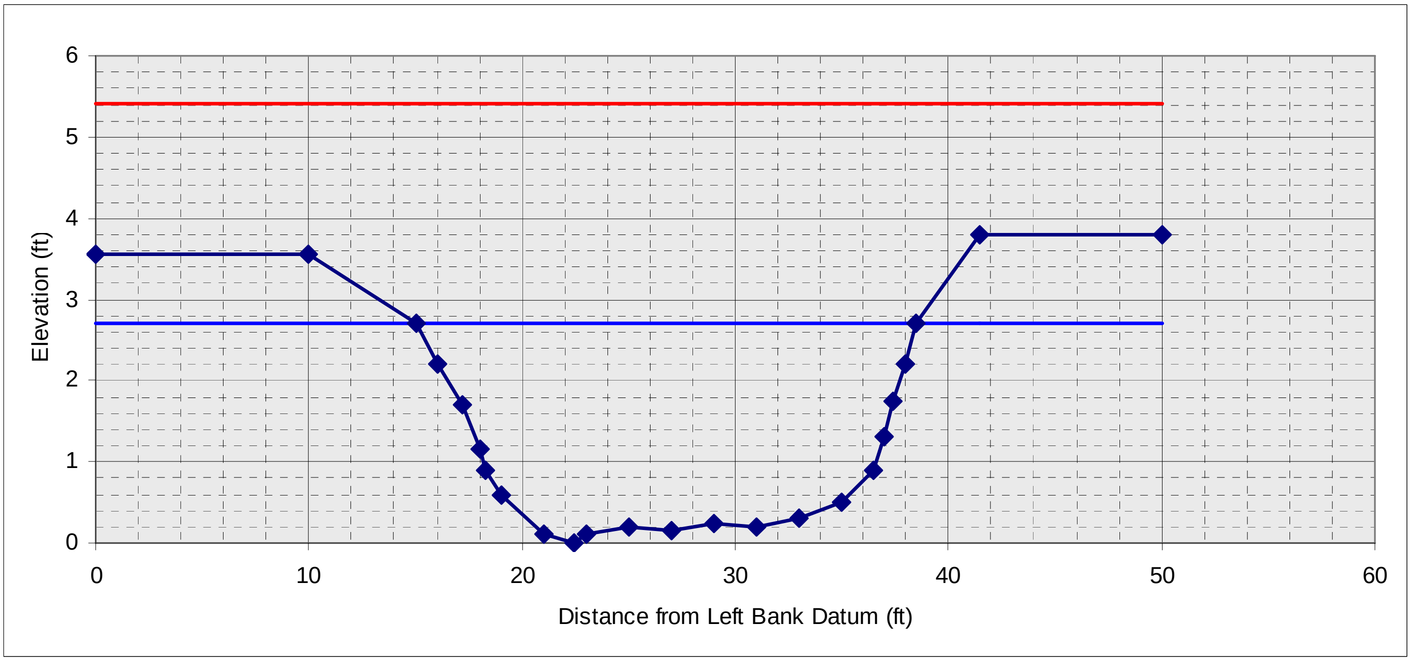
Reach M11



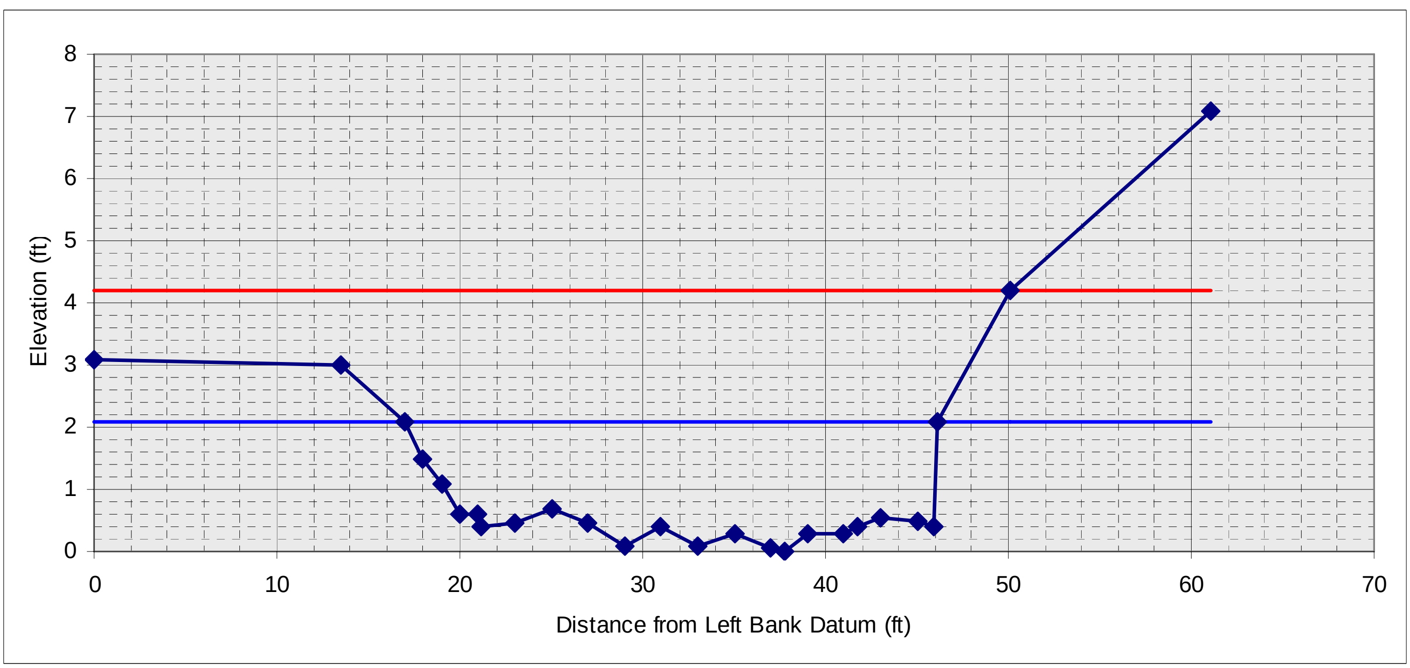
Segment M12-A



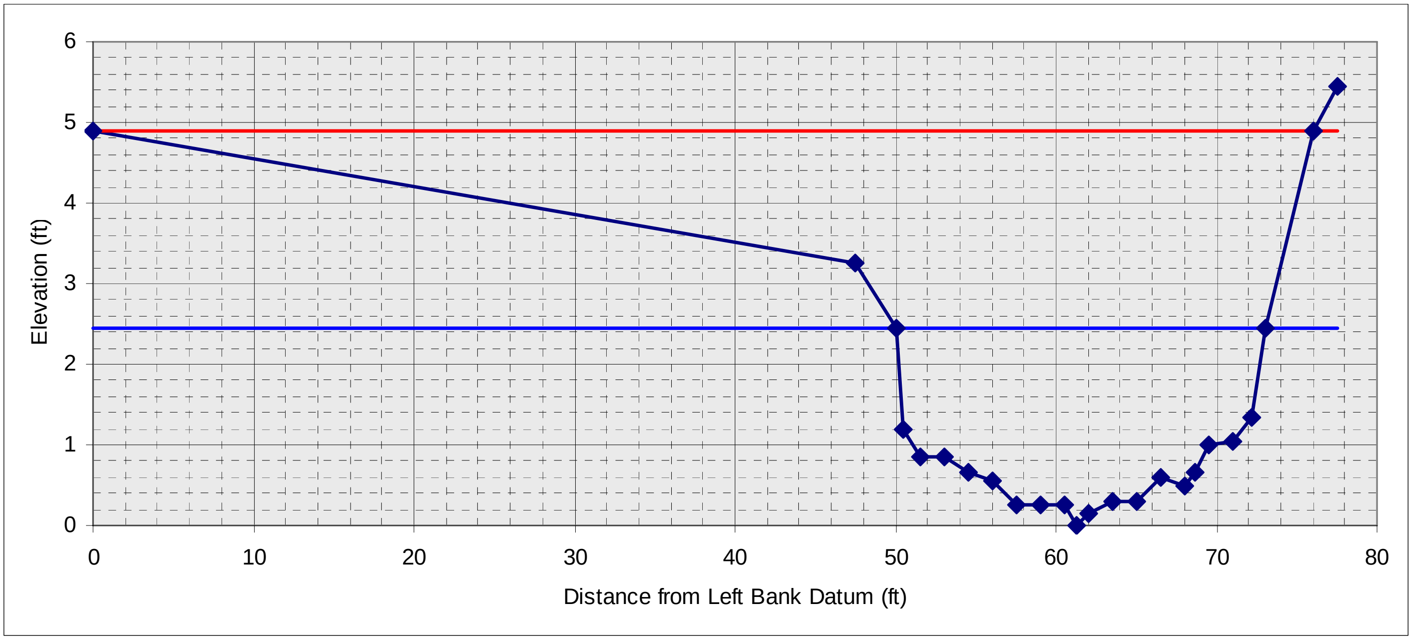
Segment M12-B



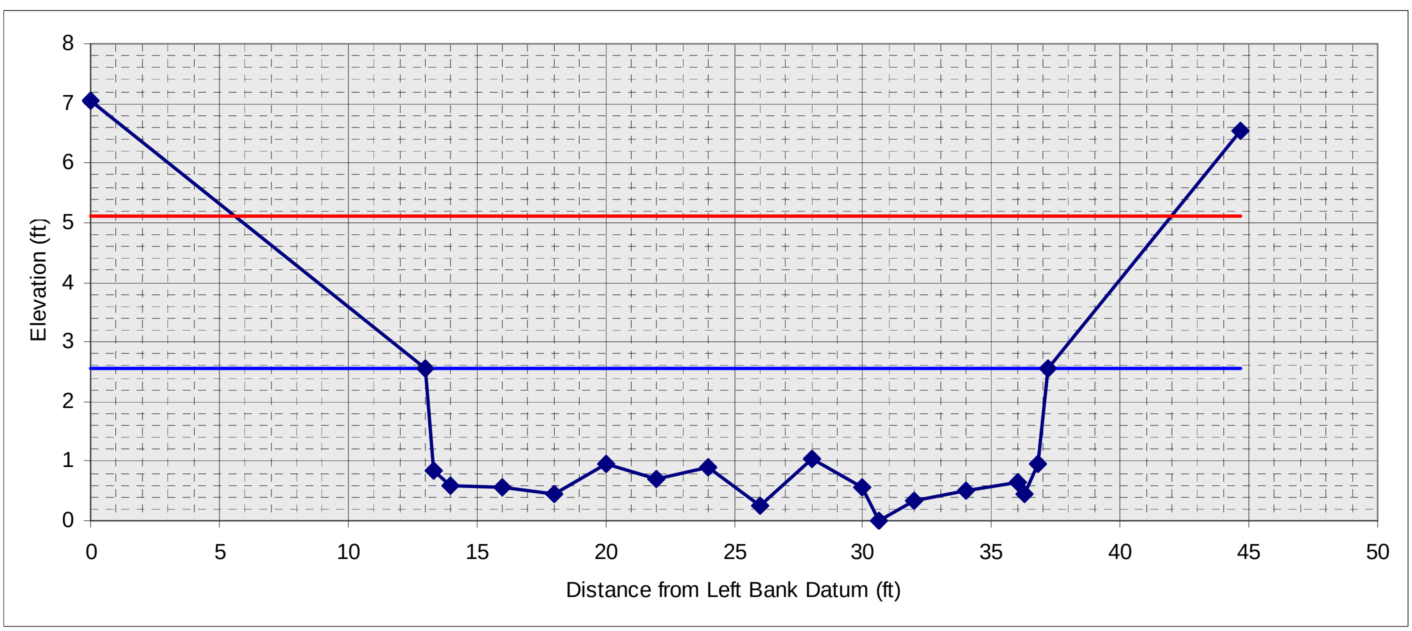
Segment M13-A



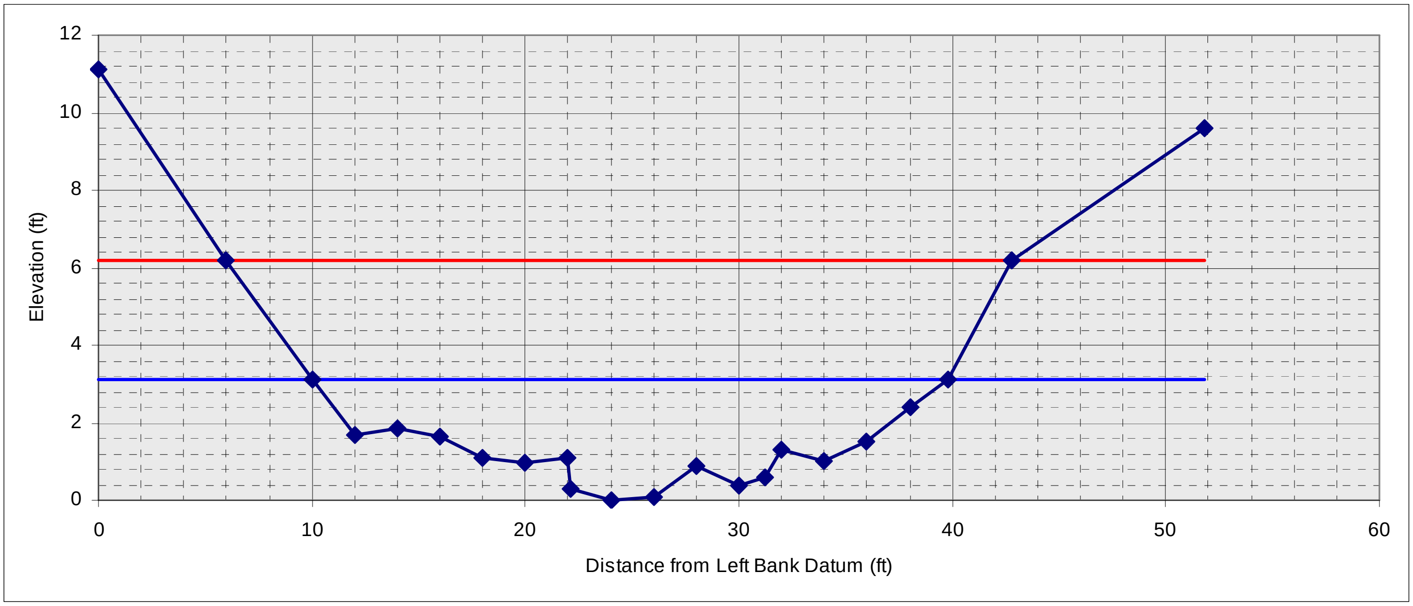
Segment M13-B



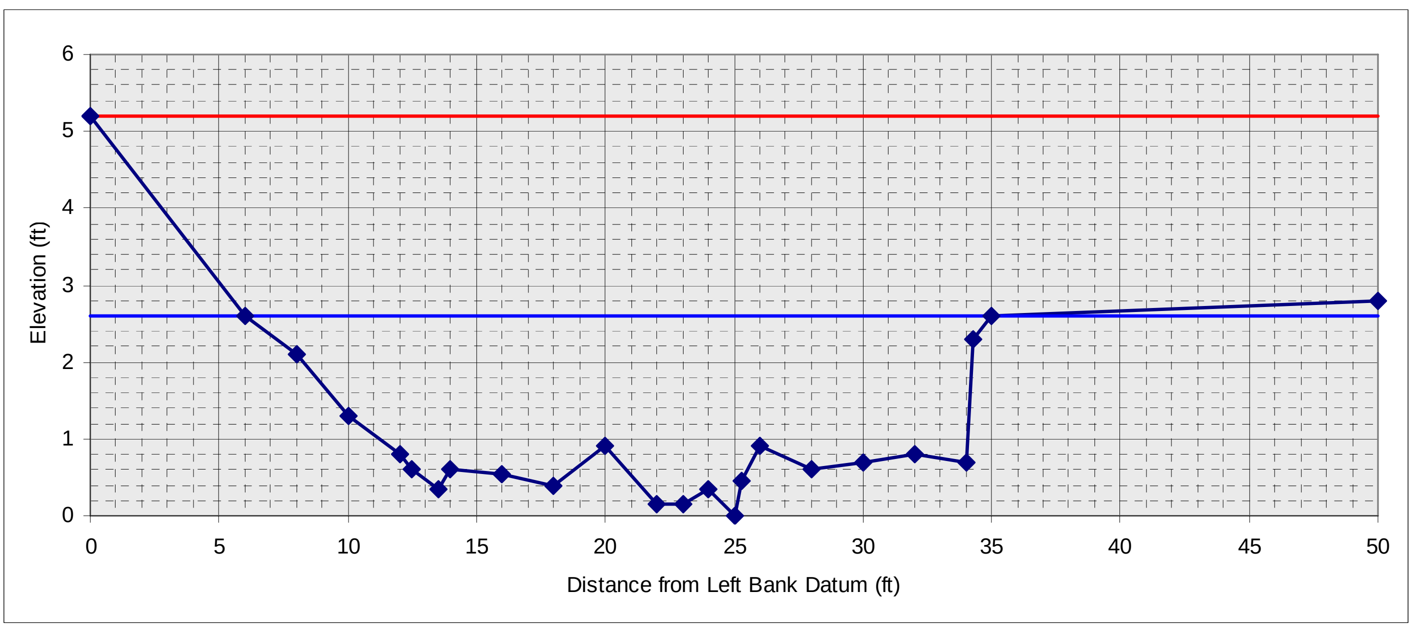
Segment M13-C



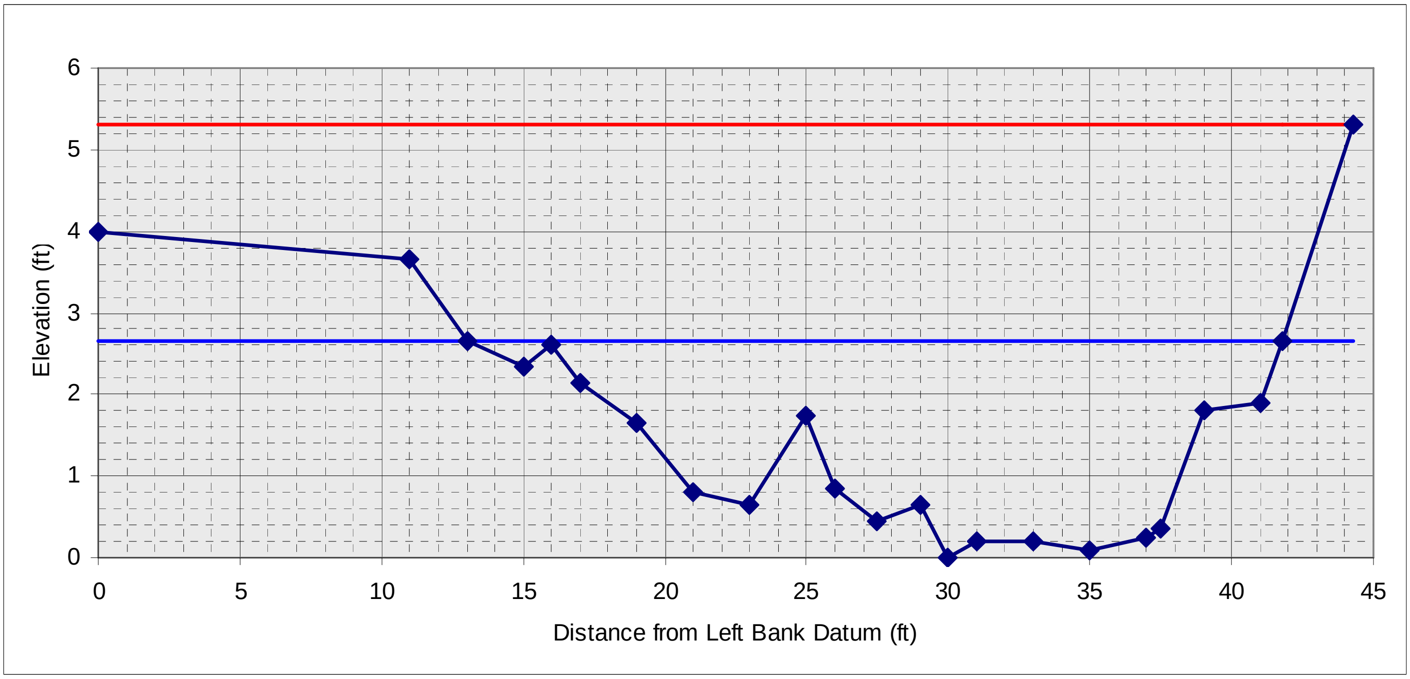
Segment M14-A



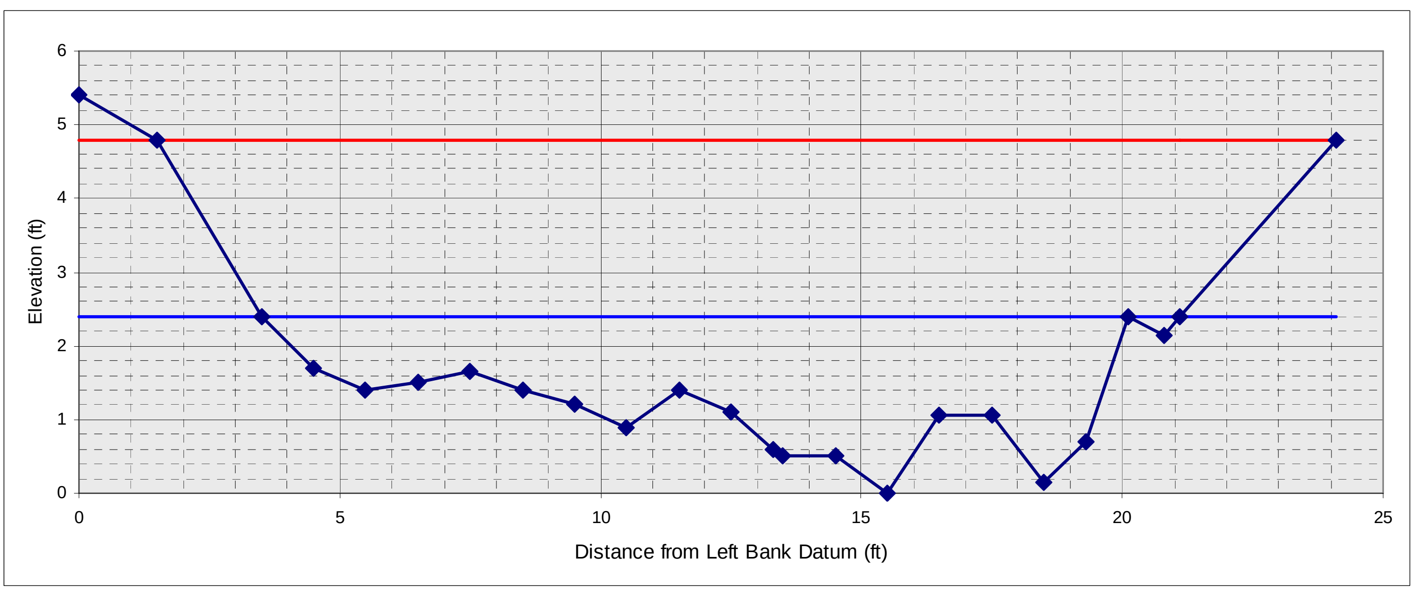
Segment M14-B



Reach M15 X1



Reach M15 X2



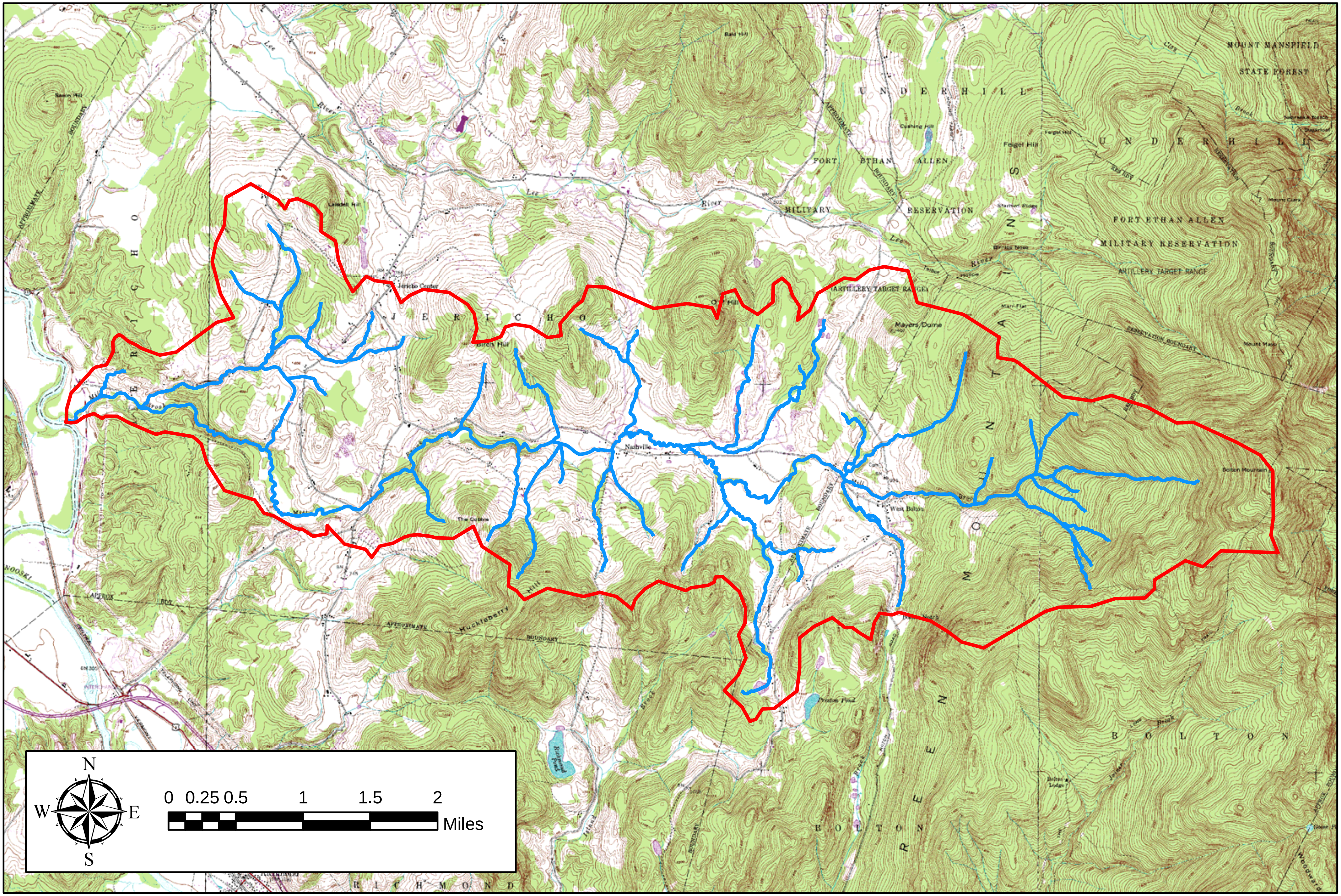
Appendix 3 - Phase 2 Reach Summary Statistics														
Reach/ Segment	Stream Type	Dominant Bed Material	Bedform	STD*	Reference Stream Type†	Reference Bed Material†	Reference Bedform†	RHA Score	RHA Condition	RGA Score	RGA Condition	Reach Sensitivity	CEM**	CEM** Stage
M01	C	Cobble	Riffle-Pool	No				0.51	Fair	0.55	Fair	High	F	IV
M02	B	Cobble	Plane Bed	No				0.80	Good	0.79	Good	Moderate	F	I
M03	B	Cobble	Plane Bed	No				0.87	Reference	0.88	Reference	Moderate	F	I
M04	B	Cobble	Step-Pool	No				0.90	Reference	0.90	Reference	Moderate	F	I
M05-A	C	Gravel	Riffle-Pool	No				0.63	Fair	0.64	Fair	Very High	F	IV
M05-B	C	Cobble	Riffle-Pool	No				0.74	Good	0.64	Fair	High	F	III
M05-C	C	Cobble	Riffle-Pool	No				0.68	Good	0.61	Fair	High	F	II
M06	C	Cobble	Plane Bed	No				0.78	Good	0.75	Good	Moderate	F	I
M07	B	Cobble	Plane Bed	No				0.82	Good	0.89	Reference	Moderate	F	I
M08	F	Cobble	Plane Bed	Yes	C	Cobble	Riffle-Pool	0.49	Fair	0.54	Fair	Extreme	F	II
M09	E	Sand	Dune-Ripple	No				0.58	Fair	0.64	Fair	Very High	F	II
M10	C	Gravel	Riffle-Pool	No				0.74	Good	0.68	Good	High	F	V
M11	E	Gravel	Riffle-Pool	No				0.70	Good	0.73	Good	High	F	IV
M12-A	C	Gravel	Riffle-Pool	No				0.54	Fair	0.64	Fair	Very High	D	IIb
M12-B	C	Gravel	Plane Bed	Yes	C	Gravel	Riffle-Pool	0.56	Fair	0.53	Fair	Very High	F	III
M13-A	C	Cobble	Plane Bed	No				0.68	Good	0.64	Fair	High	F	II
M13-B	B	Cobble	Plane Bed	No				0.93	Reference	0.91	Reference	Moderate	F	I
M13-C	B	Cobble	Step-Pool	No				1	Reference	1	Reference	Moderate	F	I
M14-A	A	Cobble	Step-Pool	No				1	Reference	1	Reference	Very Low	F	I
M14-B	A	Cobble	Cascade	No				0.89	Reference	0.84	Good	Very Low	F	I
M15	A	Cobble	Cascade	No				0.94	Reference	0.91	Reference	Very Low	F	I

	RHA	RGA
Mean:	0.74	0.73
Max:	0.94	0.91
Min:	0.49	0.53

* STD = Stream Type Departure
** CEM = Channel Evolution Model
† = Assessed Reference Condition Prior to Stream Type Departure
NE = Not Evaluated

Appendix 4

Watershed and Reach Maps



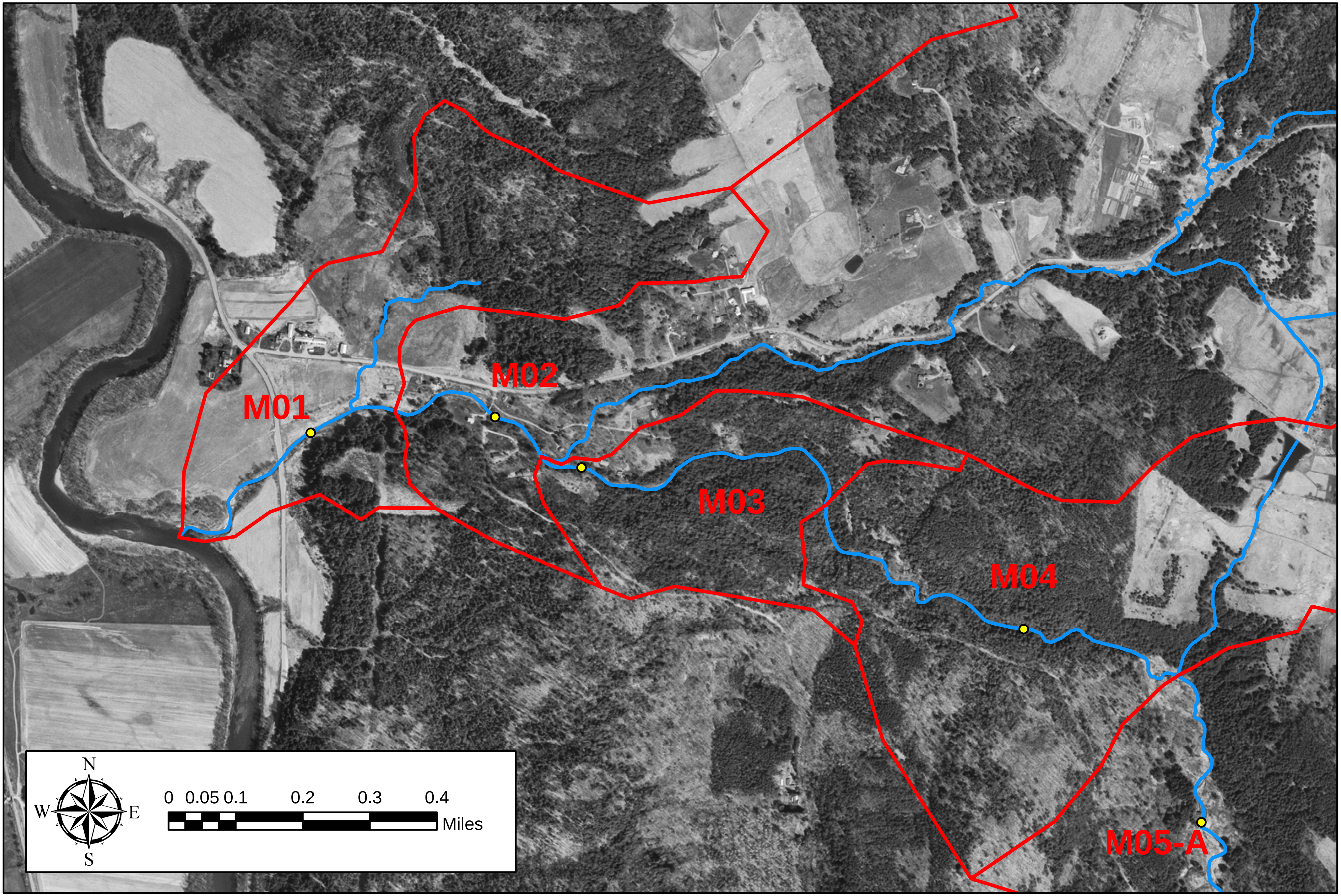
Legend

Mill Bk Watershed

Mill Bk Surface Waters

Mill Brook Watershed Map

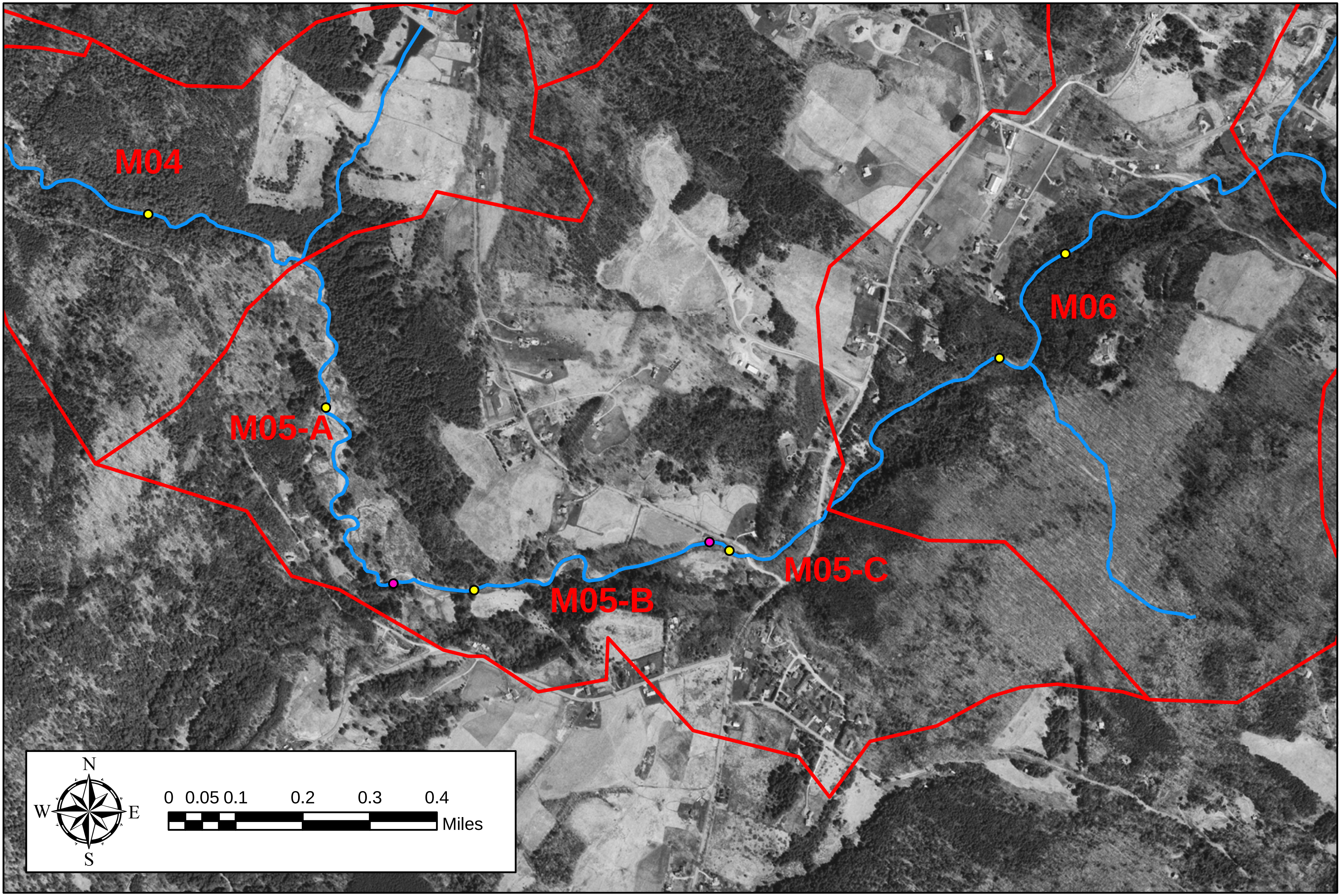
Fitzgerald Environmental Associates, LLC.
316 River Road
Colchester, VT 05446
tel. 802.999.1357 fax. 802.861.7599



Mill Bk Surface Waters
Mill Bk Subwatersheds
Mill Bk Cross Sections
Mill Bk Segment Breaks

Mill Brook Subwatershed Map
Reaches M01 to M05-A

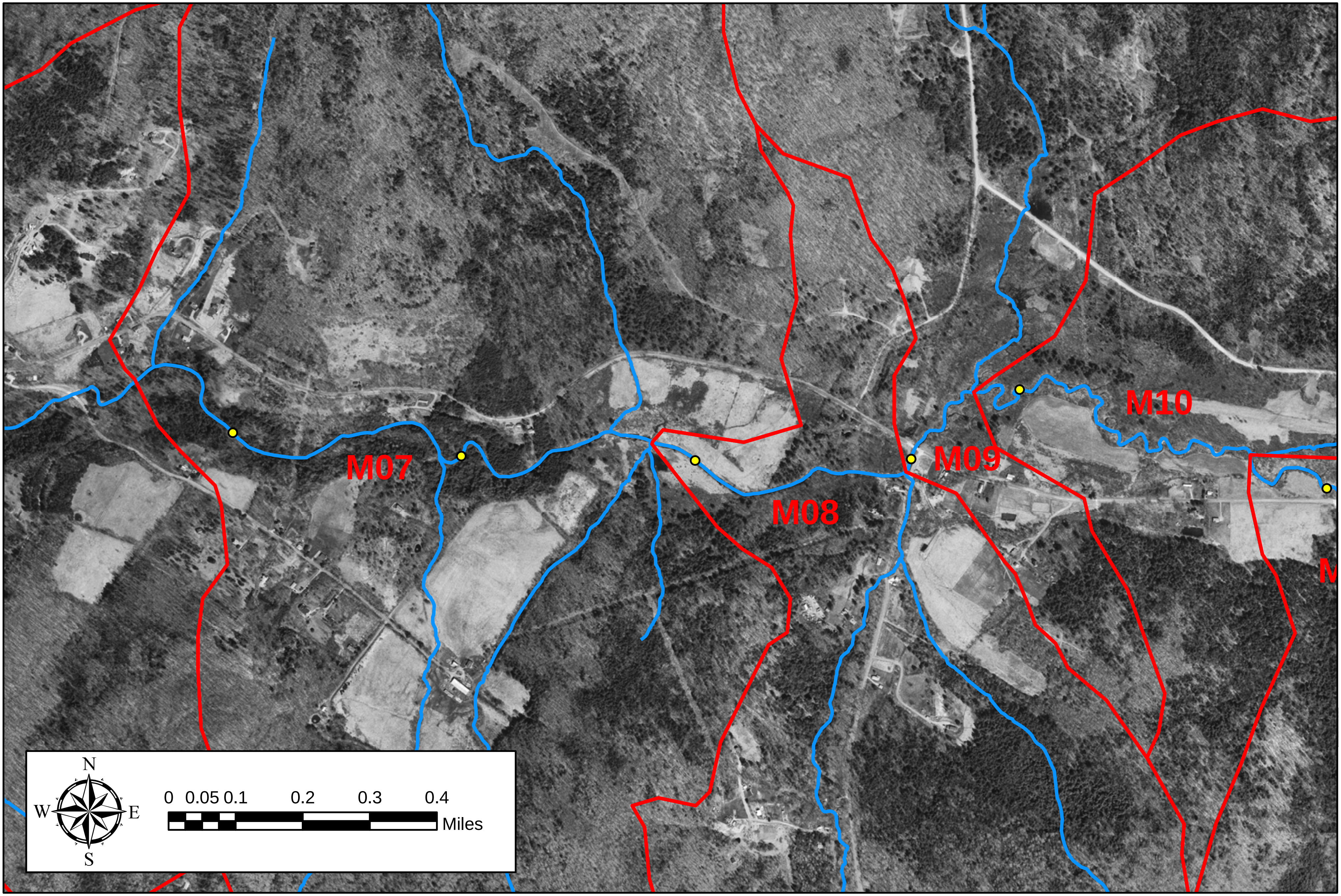
Fitzgerald Environmental Associates, LLC.
316 River Road
Colchester, VT 05446
tel. 802.999.1357 fax. 802.861.7599



Mill Bk Surface Waters
Mill Bk Subwatersheds
Mill Bk Cross Sections
Mill Bk Segment Breaks

Mill Brook Subwatershed Map
Reaches M05-A to M06

Fitzgerald Environmental Associates, LLC.
316 River Road
Colchester, VT 05446
tel. 802.999.1357 fax. 802.861.7599



Mill Bk Surface Waters

Mill Bk Subwatersheds

Mill Bk Cross Sections

Mill Bk Segment Breaks

Mill Brook Subwatershed Map
Reaches M07 to M10

Fitzgerald Environmental Associates, LLC.
316 River Road
Colchester, VT 05446
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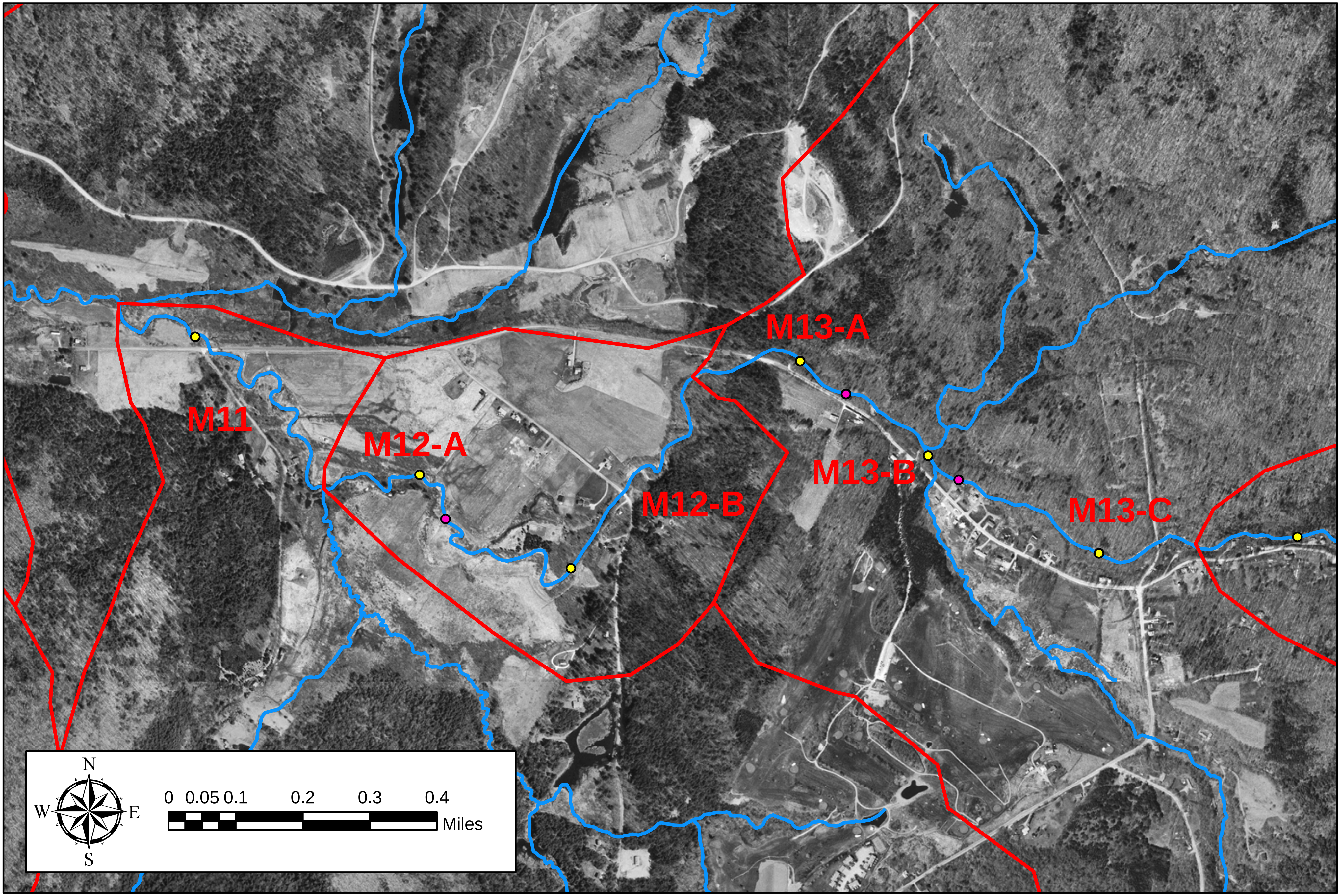
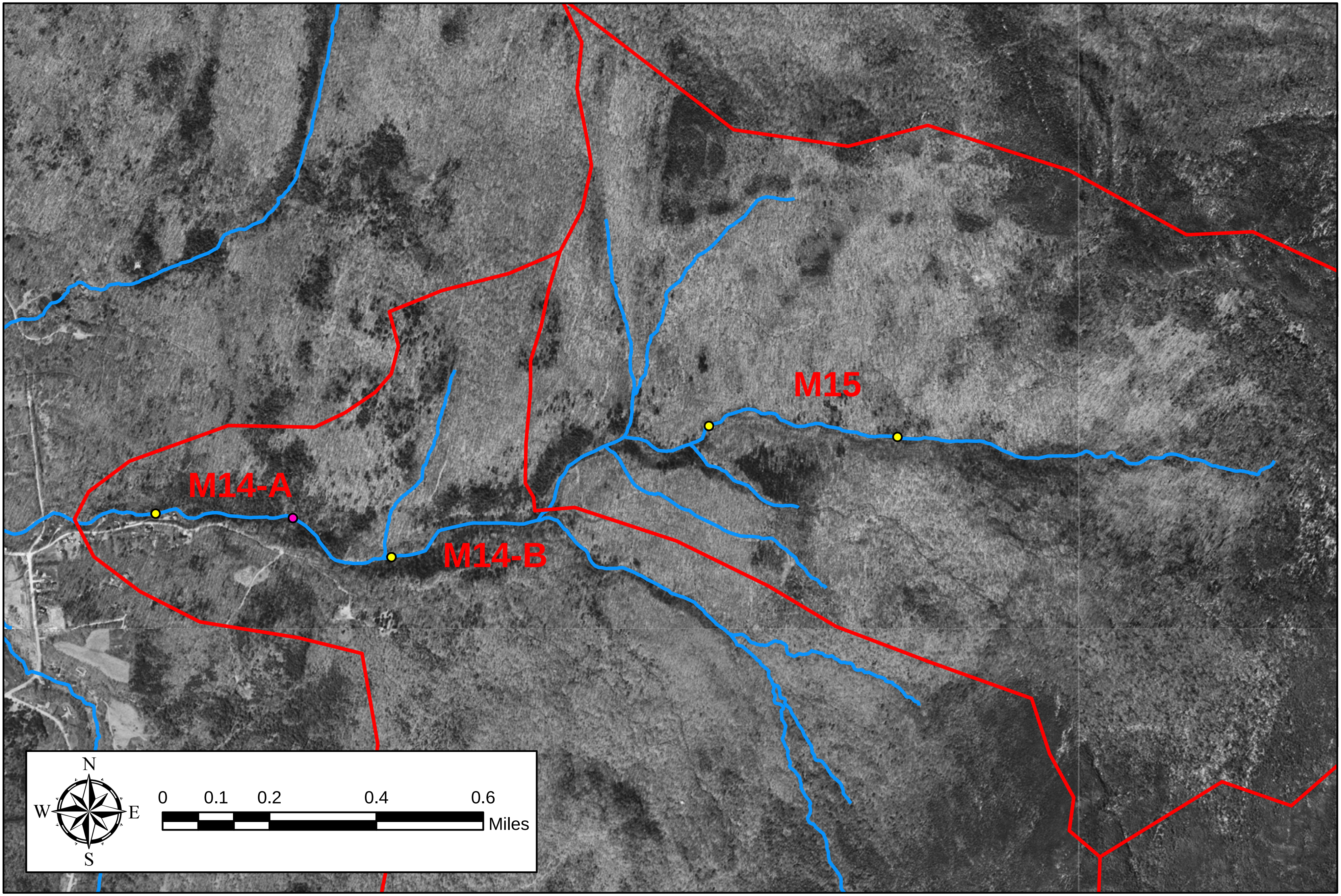


Mill Bk Surface Waters
Mill Bk Subwatersheds
Mill Bk Cross Sections
Mill Bk Segment Breaks

Mill Brook Subwatershed Map
Reaches M11 to M13-C

Fitzgerald Environmental Associates, LLC.
316 River Road
Colchester, VT 05446
tel. 802.999.1357 fax. 802.861.7599



Mill Bk Surface Waters
Mill Bk Subwatersheds
Mill Bk Cross Sections
Mill Bk Segment Breaks

Mill Brook Subwatershed Map
Reaches M14-A to M15

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