Millbury Dam Removal

Millbury, MA

Feasibility Study Report

Massachusetts Riverways Program

Boston, MA

March 2007

FUSS & O'NEILL
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MILLBURY DAM REMOVAL
Massachusetts Riverways Program

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I. OPINION OF COST

1.0 EXECUTIVE SUMMARY

Millbury Dam is being considered as a candidate for dam removal based on its deteriorated condition and the potential to restore this reach of the Blackstone River. This feasibility study has completed the following tasks to define the alternatives for dam removal:

- Topographic survey of the dam and hydraulic sections of the river channel
- Hydrologic analysis of base and flood flows
- Conceptual design of 4 restoration alternatives:
    - Complete removal of dam and impounded sediments
    - Full dam removal with riffle grade controls
    - Partial dam removal with rock ramp
    - Partial dam removal with step pools
- Hydraulic analysis of restoration alternatives for base and flood flow conditions
- Sediment sampling for volume, gradation, and quality

This feasibility study has produced the following conclusions:

- All 4 restorations alternatives are capable of providing passage for resident fish species and recreational boaters
- Total volume of sediment within the channel behind dam is approximately 8,600 CY
- Majority of sediment in the channel and floodplain has high levels of contamination, including heavy metals and PAHs, some of which have the potential to be considered hazardous waste if dredged
- The sediment poses a threat of release of oil and hazardous material (OHM) to the environment if disturbed
- Constituents of Potential Concern (COPCs) in sediment were detected at concentrations that may pose a risk of harm to aquatic organisms including metals, PAHs and PCBs
- Twenty-three COPCs exceeded their respective ecological screening criteria
- Complete removal of dam and channel sediment will expose bank sediment (legacy sediments) to erosion and require significant stabilization
- Management options for this sediment are:
    - Stabilization in-place
    - Re-use on-site
    - Disposal at licensed disposal facility (recycle or landfill)
- Riverlin Street Bridge will only be impacted by the complete dam removal alternative if the mid-channel bar just downstream headcuts
- No impacts to Providence Road Bridge anticipated for any alternative
- Dorothy Brook may be subject to headcutting for complete removal alternative, RGC at confluence recommended
- Sewer force main and gravity main between Riverlin and Providence Bridges will not be impacted
- National Grid substation will not experience significant slope erosion due to any alternative

- Regulatory requirements necessitate obtaining up to 12 local, state, and federal permits. MCP compliance could be invoked since a sheen could be generated during sediment dredging activities. Pre-emptive MCP communication as part of 401 Water Quality Certification permitting is recommended.
- The least expensive alternative is the rock ramp, order of magnitude range of potential construction cost estimated at $390,000 to $840,000. There could be long term maintenance costs which are estimated to be equivalent to an additional capital expenditure today of between $130,000 and $260,000.
- The most expensive alternative is the complete dam removal (including sediment removal), order of magnitude range of construction cost estimated at $2.2 million to $4.8 million. Substantial portion of costs due to potential that sediments could be hazardous wastes upon dredging.

This feasibility study has produced the following recommendations:

- Perform detailed scour analysis of Riverlin St. Bridge for complete removal option
- Perform revised flow analysis with additional gage daily flow values
- Identify potential re-use alternatives for sediment on National Grid property
- Obtain tailwater measurements for FC/SPs or RGCs alternatives
- Perform gradually varied flow modeling for RGC alternative
- Perform detailed geomorphic survey
- Additional sediment sampling
    - TCLP testing for hazardous waste determination
    - Total Petroleum Hydrocarbons (TPH)
    - Vertical profile of floodplain sediment quality

2.0 INTRODUCTION

2.1 Millbury Dam

The Millbury Dam (also known as the Worcester Consolidated Street Car Company Dam and the Mass Electric Dam) is located on the Blackstone River in Millbury, Massachusetts. Development along the Blackstone River occurred rapidly during the industrial revolution. During that era a dam was built on nearly every mile of the river. Most such dams still exist today, although many are dilapidated and no longer in use. A dam at the site of the present day Millbury Dam was constructed c. 1830. Subsequent modifications included reconstruction in 1917 which is the last known major rehabilitation of the structure.

Enhancement of the Blackstone River and specifically the removal of the Millbury Dam have been awarded priority project status by Massachusetts Riverways Program. The objective of the removal or partial removal of this dam is to improve natural stream conditions. Priority has been placed on the enhancement of navigation for paddlers (recreational boats such as kayaks and canoes). Other goals of the project include facilitating fish passage for resident species and improving water quality. The owner of Millbury Dam, National Grid, has expressed an interest in the removal of the dam.

Figure 1: Existing Conditions – Millbury Dam

The Millbury Dam is located in an 82.8 square mile developed watershed that is largely residential with commercial properties intermixed. The dam is partially breached and has carried cobble boulders downstream. Upstream of the dam there is a former mill race that carries water around the dam during high flows. The diversion and dam were once used for cooling water and power generation but are now inactive. The impoundment area is approximately 45 ft wider than the normal channel width downstream of the dam and extends to the Riverlin Street Bridge. There is a large point bar that has formed along the right bank

downstream of the dam, and flows are concentrated along the outside of the meander. The thalweg meanders within the width of the stream and the banks appear to be well vegetated and fairly stable.

Figure 2: Point Bar and Channel looking downstream of Millbury Dam

Four design alternatives are discussed as potential methods for the removal of the dam: full dam removal, full dam removal with riffle grade control structures, partial dam breaching with a roughened rock ramp, and partial dam breaching with a step pool structure. In both cases the partial dam breach also involves dam lowering. Three design constraints to be considered for each option are the presence of contaminated sediments, thus sediment management, water depth and water velocity. To facilitate boaters the minimum baseflow depth in the waterway must be approximately two feet (average spring baseflow), and the velocities must not exceed the physical swimming capabilities of native resident fish. Based on field sampling completed by Massachusetts Fish and Wildlife, there are twenty-four different species found in the Blackstone River (see Table 1). Four fish of noted concern for the project are the white sucker (*Catostomus commersonii*), common shiner (*Luxilus cornutus*), fallfish (*Semotilus corporalis*), and tessellated darter (*Etheostoma olmstedi*).

Table 1: Blackstone River Fish Species

BLACKSTONE RIVER FISH SPECIES	
Common Name	**Scientific Name**
Black crappie	*Pomoxis nigromaculatus*
Blacknosed dace	*Rhinichthys atratulus*
Bluegill	*Lepomis macrochirus*
Brook trout	*Salvelinus fontinalis*
Brown bullhead	*Ameiurus nebulosus*
Brown trout	*Salmo trutta*
Chain pickerel	*Esox niger*
Common carp	*Cyprinus carpio*
Common shiner	*Luxilus cornutus*
Fallfish	*Semotilus corporalis*
Golden shiner	*Notemigonus crysoleucas*
Goldfish	*Carassius auratus*
Hybrid Bluegill/Pumpkinseed	*Lepomis gibbosus x L. macrochirus*
Largemouth bass	*Micropterus salmoides*
Longnose dace	*Rhinichthys cataractae*
Northern pike	*Esox lucius*
Pumpkinseed	*Lepomis gibbosus*
Rock bass	*Ambloplites rupestris*
Smallmouth bass	*Micropterus dolomieu*
Tesselated darter	*Etheostoma olmstedi*
White catfish	*Ameiurus catus*
White sucker	*Catostomus commersoni*
Yellow bullhead	*Ameiurus natalis*
Yellow perch	*Perca flavescens*

2.2 Fish Passage

Restoring fish passage has received significant attention by regulatory agencies, elected officials, and the public as a growing issue regarding many public works and land development projects. For the restoration engineer, fish passage is accomplished by using either engineered structures (i.e., pool-weirs or fish ladders) or natural channel designs (partial or total stream restoration). Engineered structures are used to provide passage over or through obstructions such as dams and culverts. Natural designs generally focus on restoring channel geomorphology by providing stable dominant-discharge geometry to properly transport sediments and pass flood flows (100-year events). Many of the natural design methods used for restoring channel geomorphology can also be applied to situations where restoring or maintaining designated stream uses, such as recreational boating, are important.

Natural fish passage structures such as flow constrictors/step pools (FC/SP), roughened rock ramps (RRR), and riffle grade controls (RGC) are used to restore passage over relatively low-profile blockages such as weirs, utility lines, culverts, and low-head dams. They are design alternatives often used in conjunction with partial dam removal (lowering) to restore fish passage and a natural hydrology to systems. In addition to promoting fish passage, these structures can eliminate safety concerns, provide additional aquatic habitat and can be designed to provide the water depth necessary for recreational boating.

Natural fish passage designs are developed sequentially with hydraulic criteria, by assessing the hydrology and designing the structure. Essential components of the hydraulic criteria are documentation of the species of concern and evaluations of swimming and migrating behaviors for such species. Hydrologic evaluations for designs should result in a complete understanding of present and past watershed conditions, future development plans, flood flow trends and frequencies, and base flow trends and frequencies. The shared hydrologic and hydraulic considerations allow the designs to function. However, some of the differences in designs are critical to understanding the purpose of nature-like design.

Figure 3: Millbury Dam Project Aerial

3.0 HISTORIC DATA & REPORTS

The Millbury Dam has been the subject of numerous previous studies. This feasibility study included a review of available and relevant data pertaining to the dam, its impoundment, and downstream dams. Historic maps and aerial photography of the dam area were obtained and reviewed to assess the changes which have occurred in the size of the impoundment. It is evident that the impoundment has significantly reduced in surface area from the time of the dam's construction in 1917. These historic images are included in Appendix C.

A study entitled "Final Removal Recommendations: Worcester Consolidated Street Car Co. Dam, Millbury, MA" was prepared by students of Tufts University (Weingram, *et al*, 2001). The conclusions of this report include:

- Impoundment area was heavily sedimented and subsequently covered with fill, possibly to eliminate mosquito habitat or an oily odor during low flow periods
- Sediment behind Millbury Dam is contaminated with a wide range of pollutants
- Three remediation techniques reviewed
    - Thermal Desorption
    - Soil Washing
    - Slurry-Phase Biological Treatment followed by Acid Extraction
- Cost for removal approximated at $500,000 plus environmental remediation cost of $1,000,000 to $7,000,000

Two sources of sediment quality data were reviewed. Provisional USGS data was made available by Riverways and included samples from behind Millbury Dam and Singing Pond Dam, the first dam downstream. Sediment data was also reviewed for Fisherville Pond Dam, the first dam downstream of Singing Pond Dam, as published in the "Blackstone River Feasibility Study Task D: Ecological Risk Assessment" (Battelle, 2002).

4.0 RESTORATION ALTERNATIVES

4.1 Complete Removal

Complete removal of the Millbury Dam and restoration to pre-development conditions is the most desirable alternative based on ecological considerations, recreational use, and public safety. This option would include removal of the masonry dam structure and therefore all sediment impounded behind it. In concept, this would allow the Blackstone River to reclaim its natural profile, thalweg, and point bars. However, sedimentation has significantly altered the natural floodplains in the reach immediately upstream of Millbury Dam. Further sections of this report will discuss the ramifications of full dam removal and costs associated with it.

4.2 Removal with Riffle Grade Control

Riffle Grade Controls (RGCs) are at-grade rock structures that mimic riffle sections of streams and are designed to stabilize streambeds and to create backwater conditions for pool features. RGCs are constructed in three sections: upstream glide section, riffle section, and a downstream run section. Glide surfaces provide an upstream transition from the stream channel to the riffle section and, depending on construction, may provide an upstream pool for improved habitat. Riffle sections are designed with varying cross sections and slopes for purposes such as transporting sediment, passing fish, or improving boating conditions. Runs transition the riffle into a downstream pool or an existing straight reach. The three sections are designed to dissipate energy and reduce stresses, scour, and degradadation of the stream bed. RGCs can be constructed with a central nested channel to concentrate low flows, while storm flows would spread onto the overbank area. This alternative would eliminate the masonry dam structure but utilize a RCG to stabilize much of the impounded sediment in-place.

Figure 4: Riffle Grade Control Example, Main Stem White Marsh Run, Maryland

4.3 Partial Removal with Roughened Rock Ramp

Roughened Rock Ramp (RRR) structures are similar to RGCs in that they are rock structures that mimic steep riffle sections of streams. RRRs can be used in cases where there is a low barrier acting as a flow control spillway that can not be removed due to constraints such as contaminated soils or potential impacts to utilities, structures or adjoining tributaries and can only be lowered but must remain in place. RRRs can be built directly against the blockage such as a dam or built with the glide elevated to create a backwater condition thus submerging the existing blockage. Generally, RRRs are built with resting habitat such as boulder gardens to make it easier for fish to transverse the structure. Large boulders, logs, and other materials are used to increase the roughness of the ramp in order to decrease flow rates and allow for fish passage. RRR sections are designed with varying cross sections and slopes for purposes such as transporting sediment, passing fish, or improving boating conditions. Runs transition the riffle into a downstream pool or an existing straight reach. RRRs, like RGCs, can be constructed with a central nested channel to concentrate low flows, while storm flows would spread onto the overbank. The majority of the sediment behind the dam could be stabilized in-place by this option.

Figure 5: Rock Ramp Example, Northwest Branch, Maryland

4.4 Partial Removal with Step Pools

Flow Constrictors/Step Pools (FC/SPs) are rock structures designed to concentrate flow so that the necessary water depth and velocity to traverse blockages are achieved. In its basic form, FC/SPs are linear structures with multiple rock weirs set at different elevations to promote fish passage at different flows. Multiple structures are installed in the stream with the weirs in horizontally offsetting positions, allowing pools to form in the interstitial space between the structures. Weir elevations sequentially decrease at 0.5 feet increments or more under certain circumstances from the blockage to the last downstream FC/SP, and all the weirs are submerged a minimum of 0.5 feet to ensure streaming flow. The small steps and weir submergence provides a smooth transition, and the pools provide resting places and habitat. The steps also dissipate energy and prevent scour created by large drops. FC/SPs are best suited for streams with low sediment loads. Similar to the RRR alternative, the majority of the sediment behind the dam would be stabilized in-place by this option.

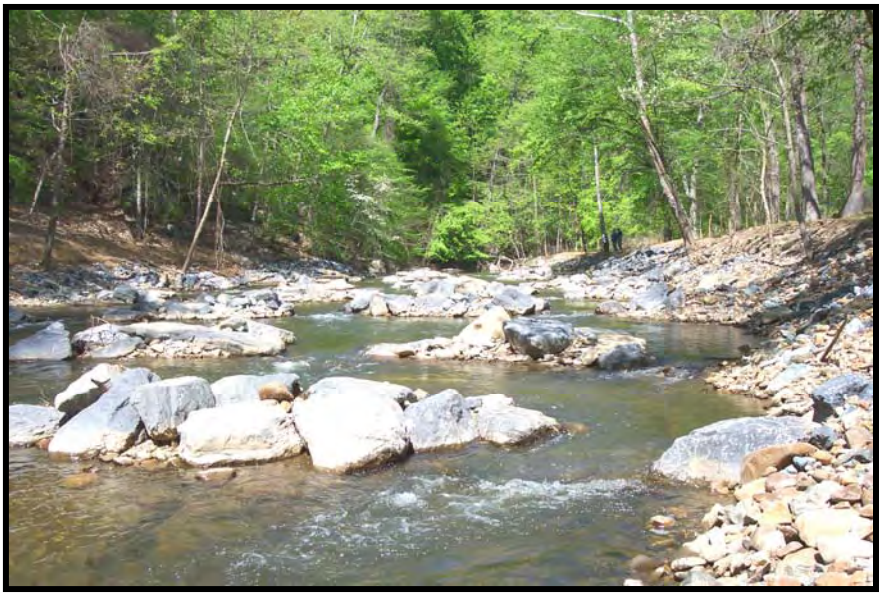

Figure 6: Step Pool Example, Rock Creek Park, Washington, D.C.

5.0 HYDROLOGIC ANALYSIS

5.1 Baseflow Hydrology for Natural Fish Passage

In gaged streams, deriving baseflows first requires hydrograph separation from a gage record. Any hydrograph analysis requires that the designer select the applicable portion of the gage record and the applicable timeframe generally corresponding to a migration season or other targeted timeframe. Since baseflows in urban watersheds likely experienced a reduction over time, statistical analyses are required to identify the applicable length of record that is most representative of current conditions. This may be accomplished by a double mass curve analysis, regression analysis, or t-tests. Limiting the analysis to a particular migration season (i.e., March 1 through June 30 of each year) ensures that the final design flows will be artificially biased toward the hydrology that fish use for upstream migration.

After compiling the baseflow data, average baseflows are calculated for each month for each year and the entire data set is regrouped by month. A frequency analysis is performed for each month using the Log-Pearson III distribution for specific exceedance probabilities. However, resulting flows are reported as annual non-exceedance probabilities, which are the 10 (Drought), 50 (Average), and 90 (Maximum) percentile flows or operational flows. These probabilities are selected based on recommendations from fisheries experts. Designers can select any probability deemed applicable; however, the usual non-exceedance probabilities would be 0.10, 0.50, and 0.90.

If the stream is ungaged then baseflows must be calculated for multiple gages in similar watersheds of varying sizes. A regression analysis is then performed creating curves for the 10, 50, and 90 percent flows with watershed area as the independent variable. Baseflows for the project's watershed can then be estimated using the regression equations.

In order to define low flow conditions for minimum depth requirements an analysis of baseflow hydrology was performed. U.S. Geological Survey gage data was used for hydrologic calculations in this study. The gage located in the direct vicinity of Millbury Dam had discharge records beginning in July of 2002. Due to the short historical record, the Blackstone River at the site location was treated as an ungauged stream for the purpose of estimating baseflows. Three gages in the Blackstone River Basin were chosen to create regression equations for each return period of concern (non-exceedance probability) using watershed area as a predictor variable. The chosen gages were of varying watershed size and all had extensive historical records. Gage 01110000 has a watershed of 25.6 mi^2, gage 1111200 is 27.9 mi^2, and gage 1112500 is 416 mi^2 compared to Millbury Dam's watershed of 82.8 mi^2.

An additional gage existed on the Blackstone River four miles downstream from the Millbury Dam. USGS Gage 0110500 has a drainage area of 139 mi2 and discharge records from October of 1939 to September 1977, and from October 1995 to September 2003. The link to the daily discharge gage data has been malfunctioning and USGS personnel are working to correct the error. Due to this problem, gage 0110500 could not be used for the baseflow estimations but should be included in the analysis during the final design process.

Average annual mean discharge was examined for the entire historical record of each gage. Based on consistency of discharge data in the watershed, the portion of data from 1966 to present was used for analysis. Baseflow calculations were based on mean daily discharge data during the period of February 1st to June 30th and September 15th to November 30th of each year. Using these time periods, representing the spring and fall fish migration seasons and boating seasons, ensures that the final design flows will be representative of the hydrology that fish use for upstream migration.

The hydrologic design for removal and partial removal of the Millbury dam is based on three common baseflow conditions. These conditions are the 10 (Drought), 50 (Average), and 90 (Maximum) percent baseflow of annual non-exceedance values for the period of interest. In this case, the period of interest was from February 1st to June 30th and September 15th to November 30th. Flow conditions below 10 percent are considered to be draught conditions, and those above 90 percent are considered to be stormflows. The 50 percent value is used as a general gauging of the likely average fish passage conditions. However, the design of each particular alternative is established to allow fish passage and boating at all baseflow discharge values.

Each of the flow conditions was found for the three gages using the fixed interval method for baseflow separation developed by Pettyjohn and Henning (1979). The first step in the procedure is to calculate the duration of surface runoff using the empirical relationship:

$$N = A^{0.2} \tag{9}$$

where N is the number of days after which surface runoff ceases and A is the watershed area, in square miles, draining the site. The fixed interval is then found by multiplying N by 2, and using the nearest odd integer to the value of the product. This value is the interval, in days, used for baseflow separation from the hydrograph for the period of record used. The minimum daily baseflow of each interval is assigned to all days within that interval. This is continued until all

days considered have been assigned an interval value. Information on the individual gages, along with their fixed interval is shown in the Table 2.

Table 2: USGS Gages in Blackstone River Watershed

	QUINSIGAMOND RIVER AT NORTH GRAFTON, MA	WEST RIVER BELOW WEST HILL DAM, NR UXBRIDGE, MA	BLACKSTONE RIVER AT WOONSOCKET, RI
U.S. Geological Survey Gage Number	1110000	1111200	1112500
Watershed Area mi^2	25.6	27.9	416
Period of Record	October 1939-present	March 1962- present	Feb 1929-present
Fixed interval	3	3	7

The baseflow values assigned with the fixed interval method were then used in an exceedance probability analysis. The first step in the analysis is to rank all of the interval base flow values. The lowest base flow value is assigned the rank of 1. Data from each watershed is ranked separately. After ranking the discharge values, the probability is found using the Weibull equation:

$$P_i = i/(n+1) \tag{10}$$

Where n is the number of baseflows ranked and *i* is the rank of each baseflow. A probability of 10 percent indicates there is a 10 percent chance that the discharge will not exceed this value, hence it is referred to as the non-exceedance value of 10. The 10 percent exceedance value was found by averaging discharge values with probabilities between 9.8 and 10.2 percent. The 50 and 90 percent exceedance values were found in a similar manner.

The 10, 50, and 90 percent baseflow value for each gage were then plotted against the watershed area (Figure 7). Microsoft Excel® was then used to generate regression lines through the values creating individual equations for each exceedance value. The watershed area for the Millbury Dam, 82.8 mi^2, was then plugged into each regression equation to find the expected 10, 50, and 90 percent exceedance baseflows for the critical migration period at Millbury Dam. The 10, 50, and 90 percent exceedance values are 49 cfs, 139 cfs, and 304 cfs respectively.

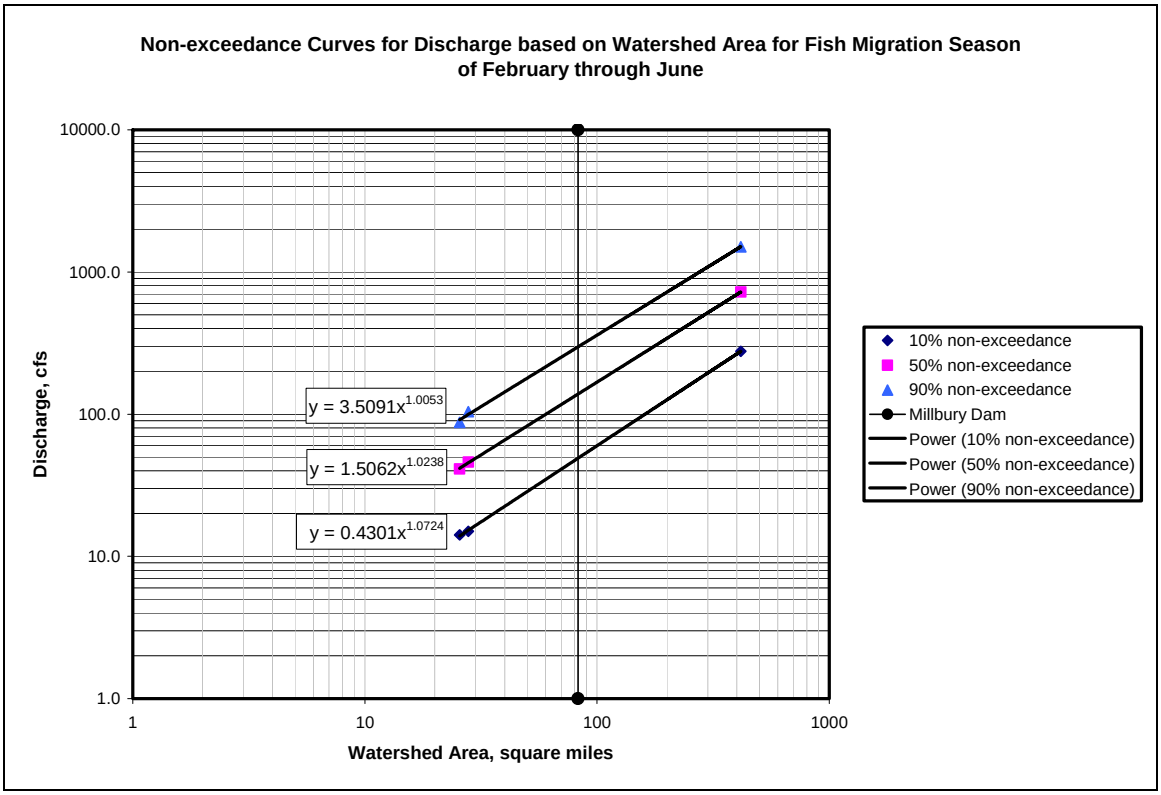

Figure 7: Regression analysis for baseflow non-exceedance values

5.2 Flood Hydrology

Estimations of stormflows were necessary for the design of the future channel. U.S. Geological Survey gage data was again used for the purpose of regression analysis. The three gages in Table 2 were used along with another gage along the Blackstone River. The additional gage (0110500 Blackstone River at Northbridge, MA) is located four miles downstream from Millbury Dam and has a watershed area of 139 square miles.

The peak annual discharge data was used for each of the four sites. The data was ranked with the highest discharge having a rank of 1. The probability was then calculated with the Weibull equation in the same manner as discussed in the previous section. The return year was then calculated by taking the inverse of the probability. Values for the 1, 2, 5, and 10 year recurrence interval were then recorded for each gage. The values were plotted against their corresponding watershed area, and a regression analysis was performed for each return year. The regression graph and equations are shown in Figure 8.

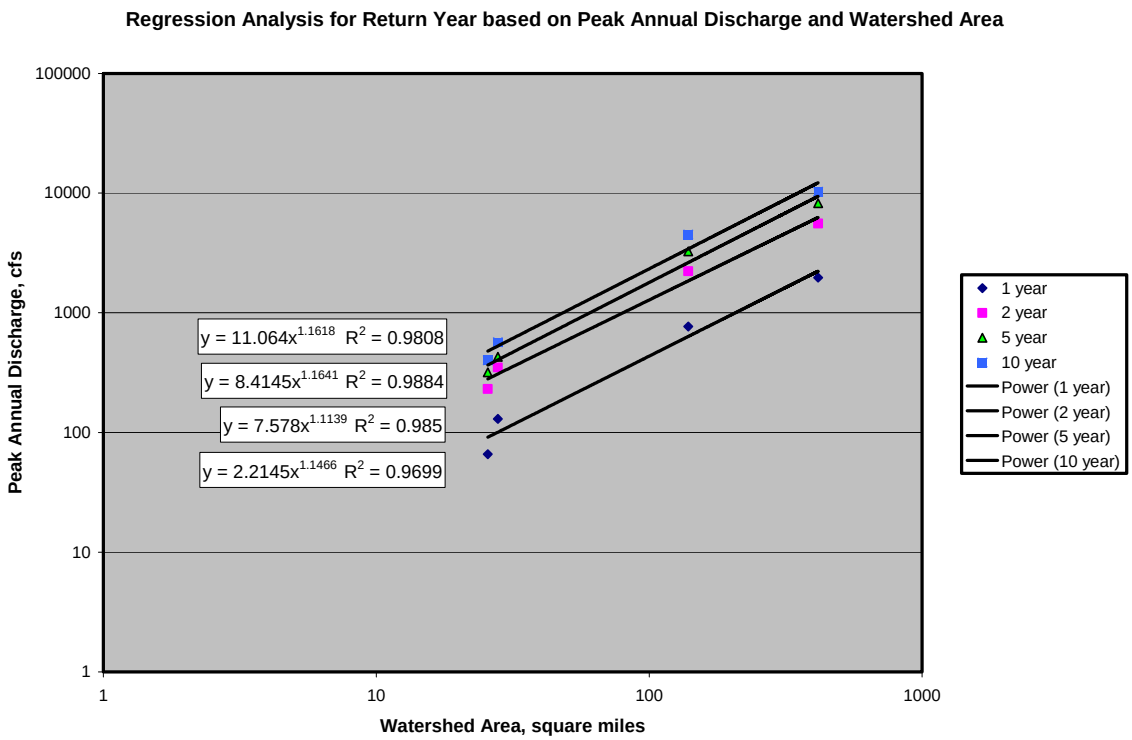

Figure 8: Regression analysis for return year based on annual peak discharge for four USGS gages in the Blackstone River basin.

The Millbury Dam watershed area of 82.8 mi^2 was then plugged into the equations in Figure 8 to obtain estimates for discharge. For return intervals of 1, 2, 5, and 10 years the discharges were calculated to be 350 cfs, 1038 cfs, 1438 cfs, and 1872 cfs respectively.

Additional stormflow discharges were provided for the site by FEMA. These values are for the 10, 50, and 100 year storm, and are 3200 cfs, 5800 cfs, and 7300 cfs respectively. A plot was constructed, Figure 9, using these values. A regression was performed to find an equation for discharge with return year as the input variable. This was done in order to check the estimates found in Table 3. Using the regression relationship shown in Figure 8, the discharge for the 2-year storm was estimated to be 1799 cfs.

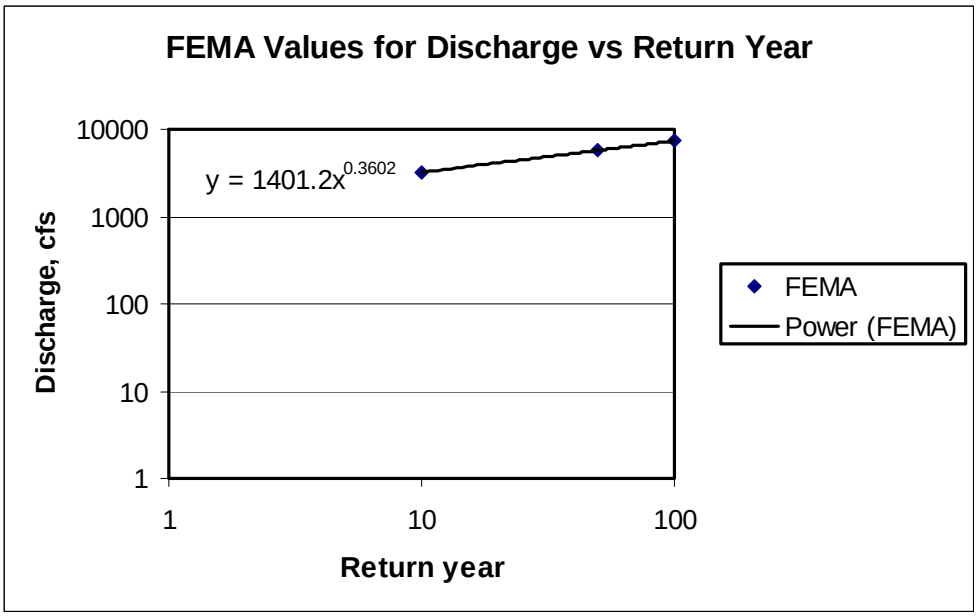

Figure 9: Regression performed on FEMA values for 10, 50, and 100 year storms for the Blackstone River at the Millbury Dam.

The 10, 50, and 90 percent exceedance values will be used for the fish passage design flows. Based on the regressions done using the FEMA and annual peak discharge data from the USGS gages, the discharges in Table 3 were chosen for the basic channel design. The value for the two year storm is in between the values estimated from the two regressions.

Table 3: Selected Design Flow for Millbury Dam

Selected Design Flows		
Non-exceedance	Discharge (cfs)	Downstream Boundary Condition
10 (Drought)	49	NWSE
50 (Average)	139	NWSE
90 (Maximum)	304	NWSE
Return year	Discharge (cfs)	
1	350	NWSE
2	1,350	NWSE
10	3,200	342.3 (NAVD88)
50	5,800	343.5 (NAVD88)
100	7,300	344.3 (NAVD88)
500	12,200	346.3 (NAVD88)

* NSWE: Normal water surface elevation, S=0.004

6.0 HYDRAULIC ANALYSIS

6.1 Topographic Surveys

The detailed topographic survey of Millbury Dam involved locating and measuring elevations of floodplains, bank features and streambed features. The survey of the immediate dam area extended approximately 175 ft. downstream and 75 ft. upstream of the dam crest. Vertical control was established by transferring the elevation from an existing benchmark on Riverlin Street to a new benchmark on the crest of the dam.

Over-bank topography developed from LIDAR aerial survey was merged with the dam survey. The LIDAR survey was performed by The Sanborn Map Company as part of the FEMA restudy of the Blackstone River. This data was obtained from Camp Dresser & McKee, Inc. (CDM), the FEMA contractor for this restudy. The combined detailed survey and overbank topography was used to generate 4 cross sections immediately surrounding the dam (Figure B, Sections C, D, E, F).

The channel profile and wet-sections upstream and downstream of the dam site were developed by combining survey data from various sources. Field survey was conducted to obtain 5 wet cross sections of the channel, three located upstream and two located downstream (Figure B, Sections A, B, G, H, I). Additional data obtained from CDM included bridge cross sections for the Riverlin Street and Providence Road Bridges. Fuss & O'Neill surveyed average channel elevation at 5 points between Riverlin Street and Providence Road Bridges and 5 points downstream of Riverlin Street Bridge to further define the extent of the Millbury Dam impoundment. Channel elevations from the FEMA profile were used to complete the upstream limits (Sections S & T) of the Millbury Dam profile. The section locations, channel profile and wet cross sections are included in Figure B, Figure 10, and Appendix A, respectively.

6.2 HEC-RAS Model

Consideration of the effects of dam removal almost always requires the use of a hydraulic model. A one-dimensional model is suitable to evaluate changes in water surface elevation, channel and bank shear forces, and bridge scour. The USACE HEC-RAS (version 3.1.3) model was selected for this effort based on its ability to model both subcritical and supercritical flow and easily analyze various conceptual design options. Communication with CDM revealed that the hydraulic model developed by FEMA for publication of the existing Flood Insurance Study was not available for use.

Cross sections were developed based on the topographic survey discussed in Section 6.1. The cross section views (including floodplains) are included in Appendix D. Manning's roughness values were based on field observations and range from 0.03 in the channel to 0.07 to 0.10 in the floodplains. The HEC-RAS levee feature was used at Sections C through K to prevent artificial conveyance of flow in the low-lying wetland area to the north of Millbury Dam.

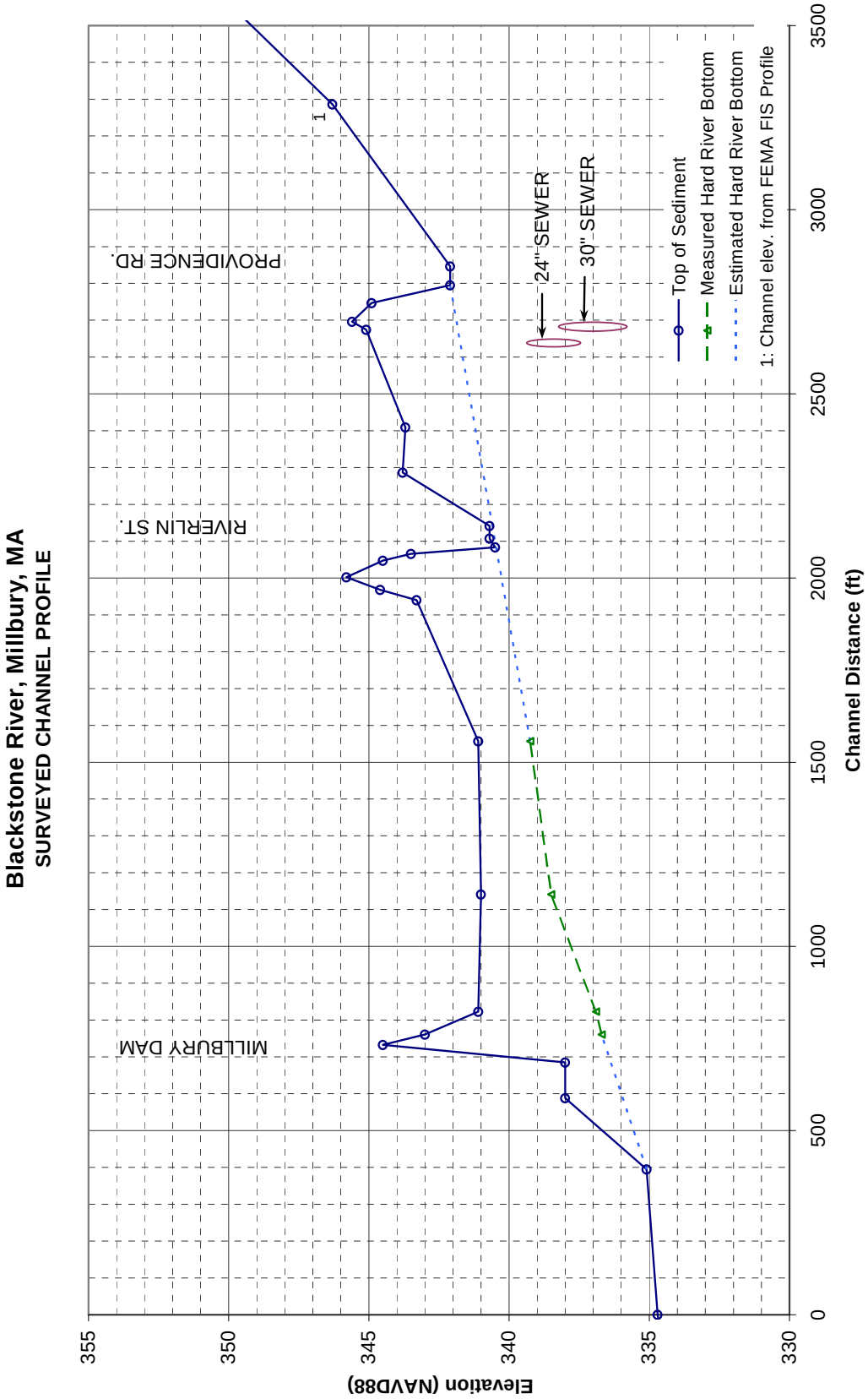

Figure 10: Surveyed Channel Profile

6.3 Natural Fish Passage Analysis

The hydraulic design criteria begin with identifying the migratory and/or resident species of concern, their physiological aspects and the limiting factors or inhibitors to their movement. While significant research has been conducted for the highly valuable commercial migratory fish species, very limited amount of research and data exists for the resident species commonly found in our river systems. However, as more interest is placed on the full range of aquatic organism passage (AOP), more research is being conducted. This has not been compiled into a single technical resource yet and would require a tremendous effort which is beyond the scope of this study. However, some basic information has been compiled to-date in FishXing 3.0tm developed by USDA Forest Service. Based on available information in the model, resident species have a lower swimming range than anadromous migratory species. Information available indicates maximum swim speeds as low as 1.5 ft/sec for the Blacknose dace (*Rhinichthys atratulus*) to the upper end of 4.6 ft/sec for the Common carp (*Cyprinus carpio*). Documentation of burst speeds for resident species was very limited and four were identified as having leaping abilities. The physiological characteristics that need to be considered for the full spectrum of river species are:

- **Cruising and burst swimming speeds.** Used to set the stream velocity limits through the natural structure. More than one species will likely be addressed by a fish passage structure; therefore, the velocities should be set to accommodate the weakest species where possible.
- **Duration of cruising or burst speeds.** Measure of the distance a fish can swim before resting. This criterion is used to judge whether a structure is too long for a fish to successfully traverse. If this were the case, resting places such as pools or boulder clusters would be required.
- **Leaping ability.** Leaping ability could affect the slope of some structures or the size of steps.
- **Size of fish.** Fish size will help determine the slope of the structure and the minimum depth of flow required for fish passage and general size of the pools.
- **Months of migration.** The period of migration is necessary to define the scope of the hydrologic study and design flow calculations.
- **Water Movement**. Considers turbulence and velocity. Velocity barriers occur in areas of abrupt change from slow or moderate flowing water to fast flow, and can greatly affect fish that do not leap. Excessive turbulence will also create a barrier because fish do not get useful information regarding current direction. Turbulence in step pool or ladder pool design is quantified by a parameter known as the Energy Dissipation Factor (EDF) (Washington Department of Fish and Wildlife 1999).

6.4 Boating Passage Analysis

One of the targeted goals for the Millbury Dam removal was to develop a design approach that would allow safe boat passage. Velocities were not a concern in the conceptual design process primarily for the reasoning that velocities were targeted for the lowest constraint factor which was upstream fish passage for resident species fish (1.5 ft/sec to 4.6 ft/sec). Based on concept baseflow analysis for all options, the velocities don't exceed 4 ft/sec at 90 percent (Maximum) baseflow at the deepest portion and decrease in the shallow fringes. The primary concern in

developing the concepts was providing adequate depths for boating. Based on the modeling, the RGC/RRR at 10 percent (Drought) baseflow condition has nearly 2 feet of water while the FC/SP structure has about 1.5 feet at the same flow condition. While navigation of the RGC/RRR will be easier, the boater will still need to have the skill to avoid the installed boulder garden structures which will be required as part of the fish resting habitat. For the FC/SP structure the pool distances are spaced approximately 10 feet apart with weir opening being 10 feet wide at the 10 percent (Draught) baseflow. However, weir spacing can be further a part is desired to allow more pool area. The weir opening increases to a total of 52 feet at the 50 percent (Average) baseflow. At 90 percent (Maximum) baseflow the entire weir structure is submerged and completely navigable. At this flow condition the maximum velocity is just over 3 ft/sec at the deepest section of the weir and drops to 2.5 ft/sec in the more shallow section.

7.0 RESTORATION DESIGN

7.1 Designing Flow Constrictor/Step Pools

FC/SPs are rock structures designed to concentrate flow to provide necessary water depth and velocity for traversing blockages. In their basic form, FC/SPs are linear structures with multiple rock weirs set at different elevations to provide fish passage for varying flows and stages. Multiple weir openings also provide redundancy to account for debris and the range of design flows. Multiple steps are installed in series with the gaps in these step horizontally offset to force lateral flow through the intermediate pools.

For FC/SP design, the hydraulic model for baseflow conditions must be based on rapidly varied flow equations. FC/SP design begins with determining the hydraulic drop between the headwater and tailwater elevations using the low end of the design flow range (i.e., 10-percentile non-exceedance) as the basis for the tailwater elevation. The hydraulic drop is then divided by 6 inches to obtain the number of steps for smooth transitions. A six-inch drop from step to step reduces the flow velocities and submerges the weirs, which provides streaming flow over these steps (Chow 1959). Smooth streaming flow step transitions are required for resident species since they are non-leaping, relatively weak swimmers.

Modeling FC/SPs is primarily a function of solving rapidly varied flow equations. A spreadsheet model of the entire structure is built to evaluate the widths of each weir opening and the height of each step.

$$\frac{Q}{Q_1} = \left[1 - \left(\frac{H_2}{H_1}\right)^{1.5}\right]^{0.385} \qquad \text{Villemonte Submerged Weir} \qquad (1)$$

$$Q_1 = CL_W H_1^{1.5} \qquad \text{Weir Equation } (m^3/s) \qquad (2)$$

Pool design is based on the Energy Dissipation Factor (EDF) (Equation 3) (Washington Department of Fish & Wildlife, 1999) and is generally limited by the 90-percentile flow.

$$EDF = \gamma \frac{QD_S}{V_P} \qquad \text{Energy Dissipation Factor (Pa/s)} \qquad (3)$$

The EDF is a measure of turbulence and the resulting bubble formation. EDF values greater than 4 lb/ft^{2}s indicate that flow in a pool is turbulent enough to disorient and fatigue individual fish. In the above equation, Q is the flow through individual openings; D_s is the hydraulic drop of the step (H_2-H_1); V_p is the volume of the pool; and γ is the unit weight of water.

Pool volume greatly impacts EDF; however there are limitations on sizing pools. Pool length (for the calculation only) is limited to 10 ft or less; the average width of the pool (for the calculation only) is limited by a 4:1 side expansion from the weir opening; and the depth should be at least 3 D_s and sufficiently deep to submerge any hydraulic jump. (Chow 1959). While pools are generally designed longer for aesthetic reasons, the additional length doesn't provide any further reductions of EDF which can only be achieved through increasing the depth or width of the pool. While this practice has been used regularly for structural fishways, allowable EDF values for nature-like fishways are unknown. Studies done by the project team have found *in-situ* EDF is consistently higher than what is predicted by standard calculations. In researching the history of EDF, the project team has learned there is a great need for more field research on the EDF concept in natural systems and nature-like fishways. Ken Bates, formerly of Washington Fish and Wildlife, has suggested that allowable EDF for natural systems be set much higher than that established for structural fishways (personal communication). This point made by Bates, and based on limited field studies on similar structures and construction issues associated with low EDF (very deep pools), indicate a higher allowable EDF be used in the design of nature-like fish passage in the range of 5 to 6 lb/ft^{2}s. Computation tables for the concept FC/SP design are included in Appendix E.

7.2 Designing Riffle Grade Controls/ Roughened Rock Ramp Structures

7.2.1 Hydraulic Design

Riffle Grade Controls (RGCs) are rock structures that mimic riffle sections of streams and are designed to stabilize streambeds. RGCs are constructed in four sections: an upstream glide section, a crest transition, a long riffle section, and a downstream run section. Glide sections transition flow from an upstream pool to the crest. The crest is provided to reduce stresses on the upstream end of the riffle. Riffle sections are designed to pass sediment and fish while providing channel stability. Runs are transitions into a downstream pool or an existing run and are designed to prevent scour hole formation.

Where baseflows are low, RGCs should be constructed with an armored nested channel to concentrate baseflows for improved depth. This nested channel would pass some light storm flows, while larger storm flows would spread onto a stone or vegetated bench area. Dividing flow in this manner allows coarser sediments to pass down the nested channel, while some fines are deposited on the adjacent bench. Initial hydraulic baseflow design consists of spreadsheet solutions to Manning's equation for flow (Equation 4) (King 1986).

$$Q = \frac{R^{2/3} S^{1/2} A}{n} \qquad \text{Manning's Equation (m}^3\text{/s)} \qquad (4)$$

Where R is the hydraulic radius; S is the bed slope (uniform flow assumed); A is the cross section area; and n is assumed from an estimate of bed stone sizes.

Concept design computations were performed for a RRR (Appendix E). Due to the similarity in design parameters between a RRR and RGC, detailed computations were not performed for the RGC alternative. The determination that the RRR alternative meets the project objectives (fish and boating passage) indicates that the RGC alternative would likewise perform satisfactorily.

7.2.2 Resting Places

As previously stated, fish exhibit varying degrees of swimming abilities and the abilities of the weakest fish must be accounted for in natural fish passage design. This is especially true for RGCs since these structures tend to be relatively long posing potential endurance barrier problems. Therefore, fisheries documents from research (Katopodis 1994) and agencies such as the U.S. Fish and Wildlife Service and state natural resource agencies should be consulted to determine the need for and the appropriate distance between resting places. The spacing of the boulders within a particular boulder garden is based on recent flume studies. (Acharya 2000) From their recommendations, spacing of boulders within a garden or cluster is 4D cross channel and 6D longitudinally are chosen where D is the size of the exposed boulder.

8.0 SEDIMENT ANALYSIS

8.1 Sediment Gradation

Sediment samples were obtained for gradation analysis on June 1, 2006 and June 2, 2006. Sampling was performed by use of a Plexiglas coring tube and a sediment auger both driven by hand while wading in the river or from a boat. Sediment samples for gradation analysis were taken in locations as shown in Figure A, Sediment Core Locations. A summary of the samples is included in the Table 4. Gradation analysis is included in Appendix G.

Table 4: Sediment Gradation Sample Summary

Location	Sample Label	Sample Depth	Collected With	Description
Core #1	1A	7"	Core tube	Dark olive gray sand with gravel
	1B	21"	Core tube	Very dark gray sandy silt
	1C	60"	Auger	Very dark gray clayey sand
Core #2 *	2A	3"	Auger	Very dark gray/brown gravel with sand
	2B	26"	Auger	Very dark gray gravel with sand
Core #3	3A	24"	Auger	Dark olive brown silty sand
	3B **	75"	Auger	Dark olive brown silty sand

* River bottom covered with stones 6"-12" diameter that were moved to penetrate the sediment

** Sample similar to 3A, not submitted to lab for analysis

During the sediment sampling of the head pond, a bulk sample of approximately 50lbs was taken from the point bar feature just below Millbury Dam (Figure 11). The sample was dried,

weighted and sieved by KCI Technologies, Inc. materials laboratory. The results of the sample can be found in Appendix G (Bulk Sample).

Figure 11: Point bar below Millbury Dam, looking upstream

In general the material was a very coarse sample with minimal fines. The sample consisted of a D_{16}=2.5mm (very coarse sand/very find gravel), D_{50}=20mm (course gravel) and D_{84}=55mm (very coarse gravel) of natural material. However, numerous bricks were also transported and deposited on the point bar. The bed material was not sampled but should be completed as part of the final design to further refine and calibrate bankfull or dominant discharge flows. The purpose of the sample was to evaluate the type and size of material being transported and deposited by the river and to further understand the geomorphic tendencies of the Blackstone River. This sample also is necessary to determine the potential reuse options for the point bar material under the various restoration alternatives. The material could be used as a wash material for the voids of the RGC/RRR or as pool material for FC/SP structures.

8.2 Sediment Quantity

Sediment depth measurements were performed in the stream channel at cross sections F, G, H, and I with a hand driven auger at multiple points along the section line. Auguring was terminated upon reaching hard river bottom, or refusal of approximately 75 lbs of downward pressure and a twisting motion. These depth measurements were plotted along with the sediment surface as obtained by the wet section topographic survey (Appendix A). The area between the top of sediment and hard river bottom lines was calculated (also in Appendix A). Note that this area is only the portion of sediment within the stream channel and does not include sediment deposited in the floodplain. The total sediment volume was computed using the average end area technique between sections. The total volume of sediment within the existing channel between sections I and E is estimated to be 8,600 CY. Computations of sediment volume are included in Appendix E.

8.3 Sediment Quality

Three sediment samples were collected from behind the Millbury Dam by the U.S. Geologic Service on behalf of the Massachusetts Riverways Program(date of collection unknown). On December 19, 2006, Fuss & O'Neill collected five sediment samples for chemical analysis. Figure A shows the locations of these eight sample sites. Fuss & O'Neill sampling was performed with a hand driven auger while wading. All Fuss & O'Neill samples were obtained as composite samples, or a blend of material from throughout the sediment column.

The three sediment samples collected by USGS were originally analyzed for 32 inorganic metals. In addition, one sediment sample was analyzed for 88 organic compounds including VOCs, SVOCs, PAHs, and PCBs. The five Fuss & O'Neill samples were analyzed for 12 inorganic metals and 26 organic compounds, specifically, PAHs and PCBs.

Fuss & O'Neill compared constituents of potential concern (COPC) to MADEP Freshwater Sediment Screening Values (MADEP, 2006) (Tables A & B). In the absence of MADEP-published screening values, equivalent published screening values were used. The purpose of this analysis was to determine if a potential risk of harm is associated with sediments impounded behind the Millbury Dam. The use of ecological screening criteria provides a means of identifying potential risk and does not provide conclusive evidence that there is or is not risk associated with these sediments. Rather, this information identifies whether additional analysis and assessment may be necessary.

Twenty-three COPCs exceeded their respective ecological screening criteria. These compounds included 7 inorganic metals and 15 PAHs and PCBs. The exceedance of multiple compounds of their respective screening values indicates that there may be a significant risk of harm associated with the sediments impounded behind the Millbury Dam.

Based on the data collected in December 2006 the highest quantity of compounds that exceeded their respective ecological screening criteria were taken from sample locations #1, #3 and#4 for metals and #1 through #4 for PAHs. At Sample Location #5 all but one PAH compound were reported as non-detects. However, the detection limits of these compounds exceeded their respective ecological screening values and, therefore, can not by complete ruled out as posing a potential risk of harm to ecological receptors.

We requested our laboratory to report sample concentrations at or as close to the ecological screening criteria used to evaluate the data. In many cases however, matrix interference and limitations of laboratory equipment precluded the reporting of data to such low limits. However, several compounds, notably PAHs and PCBs, were reported well above ecological screening criteria.

Basic statistics, specifically the median and maximum concentrations, were calculated for all COPCs for samples collected behind Millbury Dam and the Singing Dam by USGS and Fuss & O'Neill (Table B). The median and maximum concentrations from behind the Singing Dam were used as an estimate of local concentrations. The median and maximum concentration from behind the Millbury Dam were then compared to concentration from behind Singing Dam to determine if there is a relative risk of harm associated with sediments. The method by

which these statistics were compared is defined in MCP guidance (MADEP BWSC/ORS-95-141) and, for brevity, is not outlined here.

The data collected in December 2006 together with the limited data available from Weingram, et al. (2001) and Battelle (2002), indicates that the sediment contamination is a widespread issue and is not limited to sediments behind the Millbury Dam but is observed at other impoundments along the Blackstone River as well. Metal concentrations from sediments impounded behind the Millbury Dam were generally elevated compared to local conditions (Singing Pond sediment). In contrast, PAHs and PCBs concentrations compared to local conditions were variable. Six PAHs were elevated when compared to local conditions while ten PAHs plus PCBs were less than or equal to local conditions.

9.0 SEDIMENT MANAGEMENT

9.1 Sediment Mobility

The full dam removal alternative would expose all of the impounded sediment behind Millbury Dam to erosion and transport downstream. The sediment within the stream channel from the dam crest to Section I would likely become re-suspended based on the sediment gradation, the channel profile, and limited riverbed armoring. Based on communication with DEP 401 Water Quality Certification Program, sediment with high contaminant concentration (the majority of the sediment) will not be allowed to redistribute downstream. Dredging and disposal is therefore necessary for some or all of the sediment.

The full dam removal alternative would also pose a problem with exposing the legacy sediments associated with the head pond. Legacy sediments are those that have been deposited in the adjacent floodplain due the effects of the dam and effectively raise the elevation of the floodplain. In an ideal world, the full dam removal scenario would include reconnecting the river system to the historical organic-rich floodplains and groundwater conditions by the removal of the legacy sediments (Franklin and Marshall College).

If these legacy sediments are left in place, removal of the dam and associated riverbed sediment would expose bank heights upstream of the dam in the neighborhood of 8 feet high. This would increase the channel entrenchment and thus overall bed and bank shear conditions. As indicated previously, these floodplain sediments were tested and were found to be contaminated in a similar fashion as the sediments within the channel.

Recent research completed by Franklin and Marshall College has found that over the past ~100 years, breaching or removal of defunct mill dams has caused widespread channel entrenchment, even in un-urbanized and forested areas. Millions of tons of remobilized legacy sediment contribute >50% of the current suspended sediment load in some watersheds. Field work and radiocarbon dating in the Appalachian Piedmont indicate that pre-settlement streams had low, stable bank heights for up to ten thousand years prior to European settlement, and modern "floodplains" often are reservoir fill terraces.

The study concluded that the best approach and target goal of restoration should be to move bankfull discharge down by removing legacy sediments to expose pre-settlement gravel and the

original floodplain. Removing legacy sediments will reduce sediment and nutrient enrichment to our coastal receiving waters and reconnect the groundwater and baseflow interface. This approach also allows for a more robust natural plant community to occur reducing potential for invasive species. While the legacy sediment approach can't be used every where due to site constraints, it is one that should be added to the available restoration options in the future.

However, because of the contamination and the forest and wetlands which have developed on top of the sediments in the Millbury Dam floodplain, the approach of removing the legacy sediments would be cost prohibitive and likely too radical to be easily permitted. As a result, if the full dam removal option is selected, considerable effort will be required to stabilize the banks, primarily the outer meanders, to avoid excessive erosion due to increased channel entrenchment and shear stresses.

The RGC alternative would require excavation of a sediment wedge immediately behind the dam for construction of the RGC. Section 12.2 provides further detail on this alternative. The RRR and FC/SP alternatives would largely maintain the existing state of sediment behind Millbury Dam. These two alternatives nearly maintain the crest elevation of the existing structure, closely replicating hydraulic conditions and therefore minimizing additional sediment mobility. Further detail is included in Sections 12.3 and 12.4.

9.2 Disposal Alternatives

Four alternatives for the management of sediment impounded behind Millbury Dam have been considered. The alternatives include: redistribution, on-site disposal, recycling, and disposal (landfill).

- Redistribution – Removal of the existing dam and controlled release of sediment downstream
- On-site disposal – Dredging and dewatering of sediment and placing it in an appropriate upland area on site.
- Recycling – Reuse of the material (i.e. as landfill cover material or as general fill) or use in a particular function or application as an effective substitute for a commercial product or commodity
- Disposal (Landfill) - Disposal of dredged and dewatered sediment at a Class D or Class C landfill based on its chemical composition.

Although stabilizing the sediment in-place is a viable option, it does not have regulatory implications with regard to disposal of the sediments impounded behind the dam and, therefore, is not discussed in this section. Permits for this alternative will likely require documentation to show that contaminated sediments will be reasonably stable and not move downstream.

Redistribution as indicated previously would not be allowed by the 401 Water Quality Certification program in this case. Some movement of small amounts of sediment downstream is inevitable, however the planned release of substantial quantities of sediments would not be proposed.

The removal of sediment from behind Millbury Dam could potentially be regulated by three bureaus of the Department of Environmental Protection: Resource Protection – Wetlands and Waterways (BRPWW), Solid Waste Management (BSWM), and Waste Site Cleanup (BWSC). These bureaus administer the following regulations and guidance:

- BRPWW: 401 Water Quality Certification (314 CMR 9.00)
- BSWM: Solid Waste Management (310 CMR 19.000) including Beneficial Use of Solid Wastes (310 CMR 19.060); Sampling, Analysis, Handling & Tracking Requirements for Dredged Sediment Reused or Disposed at Massachusetts Permitted Landfills (COMM-94-007)
- BWSC: Massachusetts Contingency Plan (MCP) (310 CMR 40.0000)

The following sections describe these regulations and their application to sediment management at this site. Table 5 summarizes the disposal options under consideration, the agencies which would likely become involved, and the regulation limiting the contaminant concentration for each option.

Table 5: Sediment Management Regulating Agencies & Regulatory Limits

OPTION	REGULATING AGENCY			REGULATORY LIMITS
	BRPWW	BSWM	BWSC	
Redistribution	X			401 WQC, not acceptable, however minor quantities considered on case-by-case basis
On-site re-use	X	X	X	Beneficial Use Determination
Off-Site Disposal (Recycle or Landfill)	X	X		COMM 94, Individual landfill permit

9.2.1 401 Water Quality Certification

Data collected from sediment impounded behind the Millbury Dam were evaluated relative to 314 CMR 9.00: 401 Water Quality Certification for Discharge of Dredged or Fill Material, Dredging, and Dredged Material Disposal in Waters of the United States within the Commonwealth (401 WQC). The 401 WQC regulations have recently been revised. Under the revised 401 WQC (314 CMR 9.07(3)(e) the performance standard for dredge material is described as follows:

> "In evaluating the potential effects of suspension of contaminated sediment on aquatic organisms, the Department may compare the bulk sediment chemistry with recognized guideline values (e.g., Long *et al.* (1995), Ingersoll *et al.* (2000), etc.). The Department reserves the right to request additional sampling and analyses to evaluate the effects of suspension of contaminated sediment on aquatic organisms and/or water quality."

Since there is no specific testing or reporting requirement for sediment in Massachusetts, one can potentially refer to MCP Method 3 evaluation of site-specific risk characterization for general sediment contaminant benchmarks. DEP has recently accepted as final the Technical Update entitled "Freshwater Sediment Screening Benchmarks" (MADEP, 2006) that were developed to be used during MCP Disposal Site Risk Characterization for assessing Environmental Risk. While the 401 WQC regulations currently cite works published by Long et al. and Ingersoll et al., MADEP currently recognizes guideline values for sediment quality originally published by MacDonald et al. (2000). These screening values were used in the following evaluation of the data in accordance with the MCP.

9.2.2 Environmental Risk Characterization

Data collected from sediments impounded behind the Millbury Dam were evaluated in a manner consistent with The Massachusetts Contingency Plan Procedures and Standards for the Characterization of the Risk of Harm to Health, Safety, Public Welfare, and the Environment (310 CMR 40.0900 *et seq.*) and supporting Massachusetts Department of Environmental Protection (MADEP) Guidance for Disposal Site Risk Characterization (BWCS/ORS-95-141). The MCP and supporting guidance were promulgated to address waste and disposal sites where there are known or expected oil and/or hazardous materials (OHM).

Exceedance of sediment screening criteria does not necessarily require conformance with the MCP. Sediment screening criteria are not considered reportable concentrations under the current MCP. However, the exceedance of sediment screening criteria by several COPCs are indicative that a potential risk of harm to ecological receptors currently exists despite only being slightly elevated concentrations compared to local conditions.

The potentially contaminated sediments impounded behind the Millbury Dam have not been identified as a disposal site and therefore are not subject to the MCP. Nevertheless, the MCP guidance provides an established framework for conducting an environmental risk. Therefore, to evaluate the potential environmental risk based on the data currently available, a preliminary Stage I Environmental Risk Assessment (screening) has been conducted. As part of this preliminary Stage I screening the following activities were conducted:

1. Identified potential exposure pathways
2. Determined whether risk of harm is readily apparent
3. Determined whether complete exposure pathways exist
4. Conducted an effect-based screening for complete exposure pathways

The objective of any Stage I screening is to determine the potential risk of environmental harm associated with OHM. Specifically, for the sediment behind the Millbury Dam, this preliminary Stage I screening was conducted to evaluate the potential risk associated with the removal of the dam and resultant re-suspension and re-deposition of sediments downstream. The following documentation was made available to conduct this preliminary Stage I screening:

- USGS data made available by Massachusetts Riverways Program

- Final Removal Recommendations: Worcester Consolidated Street Car Co. Dam (Weingram et al., 2001)
- Blackstone River Feasibility Study Task D: Ecological Risk Assessment (Battelle, 2002)
- Additional sediment data collected by Fuss & O'Neill in December 2006

This preliminary Stage I screening considers sediments impounded behind the Millbury Dam. However, consideration was also given for potentially contaminated sediment impounded behind the Singing Dam (Singing Pond), which is located downstream of the Millbury Dam.

Potential Exposure Pathways

In their 2001 report, Weingram, et al. reported on the general ecological character of the Blackstone River and adjacent environment. The authors characterized the northeast bank of the river, between the Millbury and Singing dams, as consisting of mixed hardwoods and open and abandoned pastures. In addition the authors observed evidence of wildlife, including beaver and crayfish; animal tracks and paths; and many small amphibians. Battelle (2002) reported similar conditions in and adjacent to Singing Pond.

Although no specific observations or descriptions of fishes along this segment of the Blackstone River, including downstream to Singing Pond, were made by Weingram et al. (2001), Battelle (2002) reported that shallow water and poor water quality may impede the development of healthy fish populations. Nevertheless, for the purposes of this screening, it is assumed that there is a local fish community that may be affected potentially by OHM found in sediments behind the Millbury Dam.

Potential exposure mechanisms include ingestion of and contact with sediments by on site ecological receptors including benthic macroinvertebrates, finfish, piscivorous wildlife, and omnivorous waterfowl. These potential exposure mechanisms and ecological receptors were determined based on the information provided in Weingram et al. (2001), Battelle (2002), observation made by Fuss & O'Neill staff, an understanding of this reach of the Blackstone River, and the current land use in the area.

Readily Apparent Harm

There is no conclusive indication of a risk of readily apparent harm along this reach of the Blackstone River or at adjacent environmental areas. Risk of readily apparent harm is defined as:

- Visual evidence of stressed biota including fish kills or abiotic conditions.
- OHM concentrations that exceed the MA Surface Water Quality Standards/USEPA Ambient Water Quality Criteria.
- Visible presence of oil, tar, or other non-aqueous phase hazardous material in sediment over an area equal to or greater than 1,000 square feet

The risk of readily apparent harm is based on observation made and site photographs taken during site visits conducted by Fuss & O'Neill staff on multiple dates between April and December 2006. However, it is important to note that during sampling of sediments for

physical and chemical analysis, Fuss & O'Neill noted a petroleum odor and slight sheen associated with the disturbed sediments.

Weingram et al. (2001) also conducted petroleum hydrocarbon screenings using PetroFLAG® Hydrocarbon Analysis System. There screening was limited to ten depths collected from a single sediment core. The results of their PetroFLAG® screening showed very high concentrations of petroleum hydrocarbons, ranging from 300 to 2500 mg/kg. It is unknown at this time the concentrations and aerial extent to which petroleum hydrocarbons are entrained in sediments impounded behind the Millbury Dam, but should nonetheless be considered with due diligence in future planning stages.

Complete Exposure Pathways

Complete exposure pathways were evaluated for the potential ecological receptors identified above. Complete exposure pathways consist of four parts:

1. A source of contamination,
2. A mechanism for transport of a substance from the source to a contaminated media (e.g sediment)
3. A point where an organism or community of organisms come in contact with contaminated media, and
4. A route of entry into the organism or community of organisms.

These complete exposure pathways were evaluated on a qualitative scale of likelihood of exposure to OHM. The values applied are Low, Medium or High. Table 6 summarizes the complete exposure pathways.

Table 6: Summary of Complete Exposure Pathways

Potential Receptors	**Exposure Pathways**		**Complete Exposure Pathway?** (Yes/No)
	Dermal Contact	*Ingestion*	
Benthic macroinvertebrates	High	High	Yes
Fish	High	High	Yes
Picivorous wildlife	Low	Moderate	Yes
Omniverous waterfowl	Low	Moderate	Yes

Based on our review of potential receptors and exposure pathways, complete exposure pathways exist where organisms may ingest or come in contact with sediments impounded behind the Millbury Dam.

Effects Based Screening

As discussed in Section 8.3 and based on comparison to ecological screening criteris, the data collected in December 2006 together with the limited data available form Weingram, et al. (2001) and Battelle (2002) indicates that COPCs in sediment were detected at concentrations that may pose a risk of harm to aquatic organisms. COPCs that potentially pose a risk of harm

include metals, PAHs and PCBs (Table A). However, sediment contamination is a widespread issue and is not limited to sediments behind the Millbury Dam but includes other impoundments along the Blackstone River as well(Table B). Therefore, as part of the overall sediment management plan, the effects associated with sediment released from behind the Millbury Dam must be considered in light of the overall quality of sediments throughout the Blackstone River.

Hazardous Waste

Dredged contaminated sediment is classified as either non-hazardous or hazardous based on the mobility of the COPCs. This determination is based on the results of a Toxicity Concentration Leachate Procedure (TCLP). Dredged sediment with COPC TCLP values over a certain threshold are considered hazardous waste and must be either demobilized, treated with an innovative technology, or disposed of at a hazardous waste facility. Demobilization can be accomplished through a process known as cement stabilization in which the sediment is blended with a cement product. Innovative technologies are beyond the scope of this feasibility assessment but were discussed in detail in the Tufts study (Weingram et al., 2001). The mass concentrations of Pb and Hg were found in Fuss & O'Neill's sampling to have levels high enough that some of this sediment, if dredged, could potentially be a hazardous waste. TCLP testing would be required as part of any dredging and disposal program to properly characterize and dispose of these sediments.

Uncertainty

Uncertainty exists for the data obtained from other sources as part of this review. The data for sediment impounded behind the Millbury Dam was provided by the Massachusetts Riverways Program and was not published. Furthermore, the data, provided in electronic format, prominently included the statement "Provisional…Do Not Cite."

The data for sediment impounded behind the Singing Dam was provided by Battelle (2002) and, though published, was not accompanied by the raw data or other supporting information. In all cases, the data is very limited, providing only the concentrations of metals, VOCs, SVOCs pesticides, and/or PCBs in sediment. The methods by which these compounds were analyzed as well as information regarding the date or time at which the samples were collected; the depth at which the samples were collected; sample collection and handling methods; or other field parameters were not provided. Therefore, this data is being examined at face value with a substantial amount of uncertainty.

9.2.3 Beneficial Use Determination

The Beneficial Use Determination, regulated by the Bureau of Solid Waste Management, would determine whether the dredged sediment could be re-used on-site. This type of re-use might include fill under a parking lot. Such a re-use alternative would need to be approved by the land owner, National Grid, but might include a site within the floodplain or other upland area. BSWM would likely consider the existing site contamination, potential public access, mobility of the contamination, and other factors in this decision. It is less likely that disposal on-site would be a viable alternative if National Grid does not have a potential use for the sediment. The placement of material on-site without a re-use option would likely be required to comply with

landfill regulations, including the landfill siting process. Only non-hazardous material would be suitable for the beneficial use or on-site disposal alternative.

9.2.4 Sediment Management Conclusions

Sediment dredging is regulated primarily by the MADEP and US Army Corps of Engineers. Typically dredging activities are regulated under 314 CRM 9.00 and the 401 Water Quality Certification process. In addition, based on final placement of the dredged sediments additional permits may be required including Reuse and Disposal of Dredged Sediment at Permitted Landfills (COMM-97-001) and Sampling, Analysis, Handling & Tracking Requirements for Dredged Sediment Reused or Disposed at Massachusetts Permitted Landfills (COMM-94-007).

The MCP does not strictly apply to sediment dredging specifically, although sediment quality (or dredging performance standards for the 401 Water Quality Certification) does rely on similar numerical criteria for evaluation. The MCP regulates disposal sites where a known release of OHM has occurred. Furthermore, MCP regulates based upon contaminant concentrations in soil, groundwater and surface water, and not sediment. If a release or threats of release of OHM to the environment occurs upon dredging of contaminated sediments, as defined in 410 CMR 0300 et seq., then the MCP becomes an applicable regulation for the sediments being dredged. A determination as to whether the release or threat of release poses an Imminent Hazard to health, safety, public welfare or the environment would be required.

The MA DEP's Bureau of Waste Site Cleanup is charged with promulgation of the Massachusetts Contingency Plan (MCP, 310 CMR 40.0000) regualtions. These are the primary regulations in the Commonwealth that outline requirements and procedures for notifying the MA DEP of releases and threats of release of oil and hazardous material. The MCP also sets the regulatory standards for the assessment and remediation of such releases after notification. 310 CMR 40.0300 has clear notification criteria (i.e., "Reportable Concentrations") for contaminant levels found in soil and groundwater. However, there are no Reportable Concentrations for contaminant levels measured in sediment samples. The MA DEP generally recognizes media collected beneath a surface water body to be "sediments." They have also indicated that samples collected from a floodplain could be considered sediment if the area is regularly under water for at least part of the year.

In addition to exceeding a Reportable Concentration, there are multiple other criteria that could trigger notification to the MA DEP under 310 CMR 40.0000. Of interest is 310 CMR 40.0311, which covers "Releases Which Require Notification Within Two Hours." Paragraph (5) of the section states:

"…a sudden, continuous or intermittent release to the environment of any quantity of oil or waste oil that is listed at 310 CMR 40.1600 that results in the appearance of a sheen on surface water…"

If site conditions are such that an oil sheen is apparent on surface water, then the owner is obligated to report the site within 2 hours of obtaining that knowledge. The site would then be regulated pursuant to the MCP. Anticipating that the potential exists for a sheen to be generated during construction activities based upon the slight sheen created during sediment sampling, it would be adviseable to notify DEP MCP of the potential for a sheen to be created as part of

the 401 Water Quality certification permitting. The measures to minimize the potential for environmental impact will be the same, however there may be additional paper work to complete as part of the MCP process.

The quality of the sediments behind the Millbury Dam appears similar to or slightly more degraded compared to sediments located downstream behind the Singing Dam. It is likely that, due to the industrial history of the Blackstone River, sediment quality is very similar at other impoundments along the River. However, current regulatory policy will likely preclude the release of contaminated sediments from a philosophical perspective. The opportunity to remove a discrete quantity of contaminated sediment from the river system to reduce the overall mass loading to downstream reaches will likely compel the permitting agencies to require that action. More specifically, current 401 WQC regulations 314 CMR 9.07(3)(e) state: "In evaluating the potential effects of suspension of contaminated sediment on aquatic organisms, the Department may compare the bulk sediment chemistry with recognized guideline values." These values are the sediment screening criteria used in this report.

Although the elevated concentrations of certain constituents in sediments impounded behind the Millbury Dam are not substantially different from downstream sediments, the concentrations of constituents in sediments impounded behind the Millbury Dam exceed both the 401 WQC criteria as well as MADEP Freshwater Sediment Screening Values. In addition, observations by Fuss & O'Neill during sampling exercises indicate that there is the potential threat of release of OHM to the environment.

The extent of contamination extends upgradient of the Millbury Dam approximately 600 feet (to sample location #5) and includes most of the sediment impounded behind the Millbury Dam. Based on the historical and current data, it appears that the sediments impounded behind the Millbury Dam pose a threat of release of OHM to the environment.

9.3 Bank Stabilization

As part of the various alternatives investigated, bank stabilization is a critical element to minimize bank erosion and improve habitat. Table 7 summarizes the flow events for which flow overtops the channel bank and begins to utilize the floodplain for conveyance. By deepening the channel under the complete removal alternative, more flow is contained within the channel and thus greater shear stresses are experienced at the banks and the channel bed. The other alternatives more closely mimic existing conditions and therefore do not significantly change shear stresses in the upstream channel.

Table 7: Out-of-bank Flow Event for Various Scenarios

Scenario	Out-of-bank Flow Event (Section I)
Existing Conditions	10-Year
Full Removal	50-Year
Removal with RGC	10-Year
Partial Removal with Rock Ramp	10-Year
Partial Removal with Step Pool	10-Year

For all alternatives, bioengineering techniques and scour/toe protection will be utilized at varying degrees. For the alternatives that maintain or reduce the overall bank height, the robustness of the treatments will be less. However, as expressed previously, the full dam removal option will require a more robust bank stabilization measure due to the channel entrenchment and the soil characteristics of the existing banks. To avoid considerable slumping and erosion from increased bank shear stresses, a stone scour/toe protection system will be required up to approximately the new 2 year flow elevation. Matting and live staking will be required from approximately the 2 to 5 year flow events. Above the 5 year event, shrubs and trees can be installed or seeded with a woody shrub mix material to reduce overall planting costs.

10.0 SCOUR IMPACTS

10.1 Upstream Bridges

Two bridges upstream of Millbury Dam could potentially be affected by its removal or alteration. Riverlin Street Bridge is a single span reinforced concrete deck and was reconstructed in 2001. The existing abutments are founded on piles and are located just outside the original spread footing abutments. According to the design plans, steel sheeting was driven to a depth of 319.0, or 21 ft. below the channel. The sheeting is shown to be adjacent to the original abutment footing along the entire length of the abutment. No as-built plans were available to confirm the presence of the sheeting. A visual field inspection did not reveal evidence of local scour at the bridge abutments. A 3 ft. deep contraction scour hole is visible in the channel profile (Figure 10).

Figure 12: Upstream face of Riverlin Street Bridge

Providence Road Bridge is a single span reinforced concrete deck and was constructed in 1917. The substructure consists of vertical abutments on spread footings. A visual inspection of this bridge revealed an exposed right abutment which may be indicative of scour. However, the exposed right abutment appears to be founded on bedrock. The left abutment was not visible due to the water level at the time of the inspection. A similar 3 ft. deep contraction scour hole exists in the center of the channel.

Figure 13: Upstream face of Providence Road Bridge

The hydraulic analysis indicates that both Riverlin Street and Providence Road Bridges are overtopped for the 100-year flood. During such an event, the bridges are subjected to pressure flow and high velocities. This flow condition enables boulder size material to be moved through the opening and deposited on the downstream side of the bridge past the expansion zone where velocities decrease. This deposition pattern can be clearly observed in the detailed channel survey (Figure 10).

The impact of the RGC, RRR, or FC/SP on potential scour at these two bridges would be negligible. Because the bridges still flow under pressure for each of these removal options, the change in velocity through the opening is small. Additionally, the selection of any of these three alternatives will have negligible impact to the overall channel slope therefore not altering the sediment transport capacity of the river system. Thus the mid channel/lateral bars at both bridge structures will continue to persist.

The complete removal alternative will only affect the Riverlin Street Bridge in the event that the downstream mid-channel bar is eroded by headcutting. If this does occur, velocity through the bridge opening will increase from 9.6 ft/sec to 11.1 ft/sec (see HEC-RAS results, Appendix D). This could increase the total potential scour depth at Riverlin Street Bridge. However, the depth of sheeting around the bridge abutments would likely prevent undermining of the bridge substructure. A detailed scour analysis can easily be performed during final design utilizing the

HEC-RAS model. This analysis will allow for a comparison of the maximum theoretical scour depth to the reported sheeting depth. The HEC-RAS results indicate that no changes will occur in hydraulics at the Providence Road Bridge.

10.2 Dorothy Brook

Dorothy Brook flows into the Blackstone River approximately 450 ft. downstream of the Riverlin Street Bridge. No significant impact is expected for the 3 alternatives which would maintain the channel profile upstream of Section H. For the full removal alternative, the channel could potentially drop 2' to 3' at the point of confluence and headcut up the tributary to reach a new channel slope. To prevent a headcut from migrating upstream towards the Canal Street Bridge potentially impacting other infrastructure or utilities and causing bank erosion, a RGC structure is recommended at the mouth of Dorothy Brook. Since the confluence occurs in a straight run of the Blackstone River, lateral erosion of the RGC is not likely.

Figure 14: Mouth of Dorothy Brook

10.3 Utilities

Fuss & O'Neill visited the Millbury Town Hall and spoke with Joseph Chase, director of the Department of Public Works. Mr. Chase indicated that he knew of only 2 pipes crossing underneath the Blackstone River in the vicinity of the Millbury Dam. At his direction, Fuss & O'Neill visited the sewage pump station on Providence Road where plans were obtained of these utilities.

Two sewer lines exist under the channel between Riverlin Street and Providence Road Bridges. The location of these utilities can be seen in relation to the profile of the Blackstone River in Figure 10. The sewer lines consist of one 30" gravity sewer and one 24" force main positioned

within 10 ft. of each other horizontally. The 30" gravity line is part of the original sewer network dating back at least 50 years and is slightly lower than the 24" force main. The 24" force main was installed in 2004 and the portion under the channel bed is encased in concrete. Record plans of the 24" force main installation are included in Appendix C. The datum of these plans was confirmed by surveying manhole elevations in the Goretti's Supermarket parking lot relative to the channel profile datum.

No significant impact to these two sewer lines is likely due to modification or removal of Millbury Dam. As indicated in Section 10.1, the deposit of material between Providence Road and Riverlin Street Bridges is considered stable under flood flow conditions. Even if this deposit was mobilized during a massive flood, the profile (Figure 10) indicates that the pipes are located 3 ft. below the estimated hard channel bottom. Additionally, the higher of the two pipes, the 24" force main, is encased in concrete should therefore be protected from damage in the event of exposure.

An 8 inch gas main is supported between the deck beams of the Riverlin Street Bridge. This line is above the hydraulic opening and would not be affected by downstream alterations. No other cross-channel utilities were discovered during discussions with Town personnel and review of existing plans.

10.4 Downstream Channel

The left channel bank adjacent to the National Grid Substation (between Sections A & B) is a 1.6H : 1V slope armored with 2 – 3 ft diameter stone. National Grid has expressed concern that modifications to the Millbury Dam could destabilize this slope and jeopardize the substation infrastructure.

Figure 15: National Grid substation, left downstream bank

The results of the HEC-RAS analysis (Appendix D) indicate that shear stresses on the left bank and channel at Section B do not increase for any of the restoration alternatives. Flow depth (and shear stress) calculated at Section A cannot be compared since this section is the downstream boundary condition and does not vary between scenarios. The partial removal with RGC alternative results in channel modifications furthest downstream from the existing dam structure (300', or nearly to Section B). This alternative does have the potential to alter minor local bank velocities beyond the precision of a one-dimensional hydraulic model (HEC-RAS). However, each alternative, including the RGC, calls for stone bank armoring along the outer meander to minimize erosion of the existing slope.

11.0 DAM REPAIR

11.1 Condition of Dam

The Millbury dam is currently in poor condition. This condition assessment is characterized by the following major deficiencies:

- *Deteriorated condition of spillway masonry*
  The cut stone masonry spillway has lost a number of capstones resulting in a partial breach of the crest. This breach appears relatively stable however since historical documents indicate that this damage occurred in 1955 when the original 12 inch high stop log was washed away, followed by several capstones.

- *Deteriorated condition of earthen embankment and abutments*
  The earthen embankment, located to the right of the spillway and extending to the outlet works, has a heavy growth of vegetation including trees and brush. Similar vegetation growth occurs on the earthen spillway abutments. Burrowing animal activity has been reported in the past.

- *Deteriorated condition of the stone masonry training walls*
  The stone masonry training walls have been partially undermined due to erosive flood flow. They have tree growth through some portions of the masonry and some stone is missing.

- *Deteriorated condition of the outlet works*
  The two 4 foot by 4 foot outlet gates are non functional and in a condition of disrepair. They could fail and result in the unintended draining of the pond through the tail race canal.

The failure of this dam would not be expected to cause instantaneous damage to downstream improvements due to the small size of the impoundment relative to the size of the downstream river channel. Long term the failure of the dam would likely result in the release of impounded sediments which are known to be contaminated.

The dam is characterized as a Low hazard classification, Intermediate Size dam based on a recent inspection report produced for National Grid. The impoundment volume is reported to

be approximately 5 acre feet at normal pool level. We estimate the pond area at approximately 3 acres. The freeboard height from spillway crest to top of spillway training wall is roughly 5 feet. This puts the volume of the impoundment at maximum pool at somewhat in excess of the 15 acre feet jurisdictional volume. The implication therefore is that this dam is likely still jurisdictional, however should be considered a Small Size dam since it is less than 15 feet high.

11.2 Repairs

Since the dam poses a low hazard, there is no compelling reason to undertake repairs other than to minimize the uncontrolled release of water through outlet gates if they were to fail, or the uncontrolled release of sediments if the dam were to fail.

If repairs were to be undertaken to prevent the dam from failing and releasing sediment, they would consist of the following:

- Remove trees, brush and grub roots and stumps from embankments and abutment areas.
- Regrade and reconstruct embankments and abutments and stabilize with turf
- Reconstruct damaged stone masonry training walls
- Repair damaged spillway crest
- Repair or permanently block the 4 foot by 4 foot gates.

The opinion of order of magnitude range of construction costs for these repairs is $175,000 to $375,000. Additional costs for design, permitting and engineering services could be in the range of $50,000 to $80,000.

12.0 RESTORATION ALTERNATIVES ANALYSIS

12.1 Complete Removal

When attempting full restoration of a river, complete dam removal is often the best design alternative. Removing the dam restores ecological connectivity and natural flow conditions to the system, allowing fish, aquatic organisms, sediment, and debris to pass freely up and downstream. Removing the dam impoundment also eliminates the potential increase in water temperature. With a lack of structures, continued maintenance would not be necessary at the site. Also, removing the dam eliminates the potential for damage downstream due to dam failure.

However, numerous challenges accompany the complete dam removal option. Due to the large amount of contaminated sediment present, the removal of such sediment will be expensive. While the river attempts to restore its natural hydrology and planform, it may actively downcut the currently stable mid channel bar at Riverlin Street and potentially into Dorothy Brook. Also, the channel banks must be properly armored to minimize the potential for lateral migration through legacy sediments.

12.2 Removal with Riffle Grade Control Structures

The removal with RGCs alternative offers the benefits of full dam removal while lessening some of the problems associated with hydraulics and sediment management. Contaminated sediment is still an issue in that a strict management and removal plan must be developed and that slight channel adjustments are to be expected as the system over time evolves. Additionally, while this approach is a controlled modification of a full dam removal, this alternative is more complex and costly to construct. However, it provides the best long term approach to achieving a geomorphically correct and stable channel capable of managing or reducing contaminated sediment release.

The existing Millbury Dam structure is located on the natural meander of the river. The left side of the dam (looking downstream) which would normally be the outer meander of the channel has lost a number of the top stones, pushing the thalweg to this side and promoting the development of a larger, deeper and extended pool below the dam. Below the dam, the channel is showing geomorphic tendencies towards achieving some form of equilibrium through the development of a sizable point bar on the inner meander and a stable cross-sectional area. The point bar, which is 3 feet lower in elevation than the dam (elevation 340 to 341 feet), consists of a gravel mix (D_{50}=20mm/D_{84}=55mm) with the channel below being more cobble in nature. Based on our preliminary hydrology and hydraulics, the point bar and channel indicators below the dam correspond closely with the baseflow (304.3 cfs) and bankfull (1037 cfs) flow calculated. The 90 percent baseflow width is estimated to be approximately 58 to 60 feet at 3 to 3.5 feet depth with the bankfull flow being approximately 85 to 100 feet and an elevation of between 342 to 343 feet. The banks of the downstream channel are well vegetated and stable.

The technical aspects of this alternative involve the complete removal of the dam, the construction of two RGC structures, the excavation and removal of the contaminated sediments in the location of the RGC's, the construction of the pool and point bar, and channel bank stabilization/re-vegetation. The upper RGC is proposed to have a maximum slope of 1 percent and designed to hold much of the existing contaminated sediments in place. The length of the structure will need to be determined during final design. The lower RGC would have a maximum slope of 2 percent and extend down past the existing high flow bypass channel (former mill race). The top end of the lower RGC will be placed at approximately elevation 339 feet to hold the pool elevation. It is recommended that the high flow bypass channel be closed off at both the upper and lower ends to allow natural filling and to serve as an oxbow/habitat area. Once the construction is completed, the banks and other graded areas other than the point bar will be vegetated using bioengineering techniques.

12.3 Partial Removal with Roughened Rock Ramp

Millbury Dam is located on the outer meander of the river which, without the implementation of complete removal or removal with RGC, limits the ability of allowing the channel to naturally form the desired pool-glide-riffle-run process being demonstrated in the field. However, the implementation of the RRR alternative will meet the project objectives by containing a significant portion of the contaminated sediments, yet allowing for natural transport during dominant discharge events and allowing for passage for both fish and boaters. The placement of the RRR along the left bank (looking downstream) with a constructed point bar on the right bank tying into the upstream inner meander while not creating a natural

sequence of pool-glide-riffle-run will provide a transition of a riffle to run at the dam section. To help with velocities and provide resting habitat, boulder clusters will be used. One challenge will be the need to provide the spacing that will allow for proper resting habitat while not creating an unsafe condition for recreational boaters. Additionally, the determination of the primary type of boating to be designed for is critical as the requirements and constraints of the river conditions for canoes versus kayaks are very different.

Based on the preliminary conceptual design work for the Millbury Dam RRR, the proposed structure would be approximately 200 feet long and 65 feet wide with a maximum slope of 2 percent. While many RRR's have been built greater than 2.5 percent in our region, it is not recommended to go steeper as the depths and velocities generally will become excessive and beyond the physiological limits of most fish and boaters alike. It also becomes more complex and difficult to build as larger stone will be required and the challenge of maintaining a consistent bed slope where super-critical flow regimes can be of a concern.

Figure 16: Rock ramp with boulder garden on Indian Creek, Maryland

The right bank of the RRR would tie into the point bar up to an elevation of 344 meeting the crest of the lowered dam. The low flow channel of the RRR would be set at the crest of the dam at approximately elevation 340.6 feet which would require the removal of some sediment. If sediment removal is to be avoided, during final design the concepts could be further refined to look at increasing the low flow elevation to elevation 341 or 342. This would potentially reduce the effectiveness of the RRR at the 50 or 90 percent baseflow conditions as the system would need to be wider, lengthened or steeper. However, the point of the concept is to show that the RRR alternative is capable based on preliminary analysis of providing both fish and boater passage. It is recommended that the high flow bypass channel be closed off at both the upper and lower ends to allow natural filling and to serve as an oxbow/habitat area. Once the construction is completed, the banks and other graded areas other than the point bar will be vegetated using bioengineering techniques.

12.4 Partial Removal with Step Pool Structure

The conceptual design for the FC/SP alternative at Millbury Dam would involve a structure that is approximately 200 feet long or less. Unlike the RRR, the FC/SP can be reduced in length by increasing step heights for the proposed 0.5 foot lift and by reducing the pool lengths

to as small as 10 foot in length, the maximum included in the EDF calculations. Although these extra short pools would be acceptable for fish passage, they would pose a difficulty in navigating the structure for canoes more so than kayaks. The current concept is based on 25

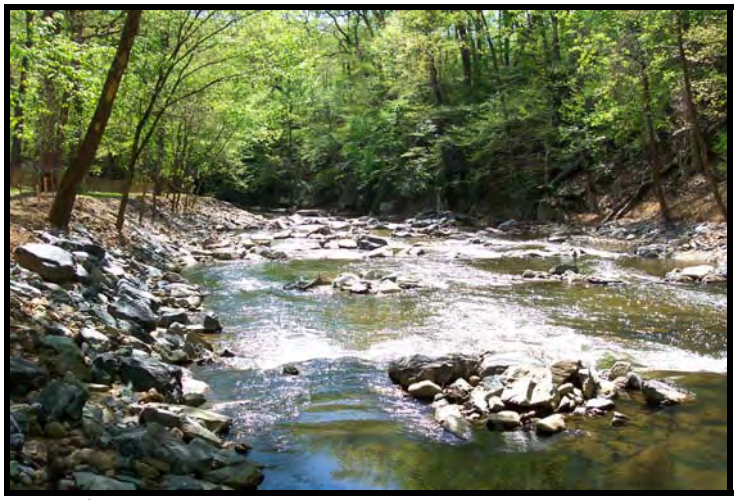

Figure 17: FC/SP structure in the Rock Creek National Park, Washington D.C.

foot pool lengths and it is recommended not to reduce to below 15 foot (more for constructability facts such as equipment operations). The current concept proposes between 6 and 7 weirs with sizable pools that vary in depth from 3 to 5 feet using an EDF of 5. The velocities for this alternative are generally in the acceptable range for both fish and boating passage. As with the RRR, the FC/SP will crest the dam at an elevation of approximately 340.2 feet and therefore will require that a small amount of sediment be removed. If the elevation has to be increased to 341 or 342 feet, the structure will have to be wider at the top end, less efficient, and shallower for a short distance. As with the RRR, the right bank would tie into the current point bar after lowering the dam to elevation 343. As with the other alternatives, it is recommended that the high flow bypass channel be closed off at both the upper and lower ends to allow natural filling and to serve as an oxbow/habitat area. Once the construction is completed, the banks and other graded areas other than the point bar will be vegetated using bioengineering techniques.

This design alternative is likely the most expensive and complex to construct. The boulders used to create the steps are large, particularly with the flood flows experienced in this channel, and specific in shape and size. Likewise, with canoeing and kayaking being a primary goal, stone will have to be round and smooth to avoid injury during the recreational activity. They must be handpicked from a quarry and require intensive installation practices. Also, this option would be navigable for kayaks and passable for targeted fish species but extremely difficult for canoeing. The final disadvantage of this alternative involves the sediment load in the Blackstone River. Based on the size of the point bar downstream of the Millbury Dam, this river could be classified as a high bed load system. This could have the effect of filling in the constructed step pools, thereby reducing flow depths and altering hydraulics.

13.0 PERMITTING

The proposed Millbury Dam project will require permits from various Federal, State and Local regulatory agencies. Following is a brief discussion of the various permits likely to be required:

13.1 Army Corps of Engineers Section 404 of the Clean Water Act

The 404 permit program in Massachusetts has three levels of permitting: the Programmatic General Permit (PGP) Category 1 & 2, and the Individual Permit. The most recent permit modification dated December 18, 2006 allows for the coverage of "Projects with proactive restoration as a primary purpose" to be covered under the PGP Category 2 provided that the "Corps in consultation with the State and Federal agencies, must determine that the net adverse effects are not more than minimal". There is no further guidance in the regulations regarding what would be considered minimal. Discussions with the Corps revealed if there is any potential for more than minimal impact during or after construction that this will likely go to an Individual Permit category.

13.2 NPDES Permit Program

Activities which could impact greater than one acre may require a NPDES Stormwater Discharge permit. This would require the filing of a Notice of Intent (NOI) and the preparation of a Stormwater plan to protect water quality from proposed construction activities.

13.3 Massachusetts 401 Water Quality Certification

The 401 permit program is administered on the State level and would require a permit for any activity requiring a Corps 404 Category 2 permit. Specifically an individual 401 permit would be required for activities resulting in disturbance of more than 5,000 square feet of isolated bordering vegetated wetlands or land under water, or in the dredging of more than 100 cubic yards of sediment. It is likely that most of the alternatives being considered will require an individual 401 WQC. Typically this will require a "Major Project Certification". For dredge projects of more than 5,000 cubic yards a Major Dredge Project Certification is typically required. Both of these certifications may be required if both types of activities are undertaken. See Section 9.2 for further details on the 401 Water Quality Certification as relates to sediment management.

13.4 Massachusetts Chapter 91 Waterways License

A permit may be required to modify an existing dam by placing fill in the waterways. To determine if a permit is required a Request for a Determination of Applicability should be submitted. If a permit is required, it will require the review and certification of the Town Planning Board. Recent communication from Riverways indicates that Chapter 91 will likely require a simplified dredging license not a full license.

13.5 Massachusetts Chapter 253 Dam Safety Permit

The removal of or modification to a dam will require a Chapter 253 permit to be submitted to the Department of Conservation & Recreation (DCR) Office of Dam Safety. Based upon the

size of the dam and maximum impoundment behind the dam, the dam would currently be considered a jurisdictional dam. The DCR has the discretion to determine a dam non-jurisdictional and there may be that opportunity here with the Millbury Dam.

13.6 Massachusetts Environmental Policy Act (MEPA)

MEPA requires certain compliance actions be taken if a project exceeds certain regulatory thresholds. An Environmental Notification Form and a mandatory Environmental Impact Report are required if a project involves "structural alteration of an existing dam that causes an expansion of 20 percent or any decrease in impoundment capacity." Based on this threshold it would appear likely that most of the alternatives would require an ENF and an EIR under MEPA. Recent communications of Riverways with the MEPA director confirmed that the ENF/EIR mandatory threshold for dam removals, are only for "jurisdictional dams" as defined by Chapter 253. The Millbury Dam is currently of a size to be considered jurisdictional. There may be an opportunity under current regulation to petition DCR to consider the Millbury Dam non-jurisdictional.

13.7 Massachusetts Historical Commission (MHC)

A project requiring a Corps 404 permit will need to submit a Project Notification Form (PNF) to the MHC. The MHC will determine if the site is listed on the national or State Register of Historic Places or if there are significant historic or cultural resources which could be impacted (for example areas of known or suspected native American activities). Further archaeological research may be required if deemed appropriate by MHC.

13.8 Massachusetts DEP Beneficial Re-use Permit

A Beneficial Re-use permit will be required if material from the dam is used on site for activities such as scour protection, water diversion, etc. Specifically if stone masonry from the dam is re-used onsite then an application form for a Major or minor category permit will be required. The Major category is for re-use of more than 20 tons of material, while the minor is for less than 20 tons of material. See Section 9.2 for further details on the Beneficial Re-use Permit as relates to sediment management.

13.9 Massachusetts Wetlands Protection Act (Millbury Conservation Commission)

An Order of Conditions must be obtained from the Conservation Commission for the removal or modification to a dam. This requires that a Notice of Intent (NOI) be submitted by the applicant. In some cases fish passage, dam modifications or removals can be considered pro-active restoration which may make these projects eligible for "Limited Project" status. This still requires the filing of an NOI which typically requires the following information: Resource area boundaries including Land Under Water, Inland Bank, Bordering Vegetated Wetlands, and Land Subject to Flooding.

13.10 Town of Millbury Permits/Approvals

The following permits or approvals will be required from the Town of Millbury:

Flood Plain Permit – Zoning Board of Appeals
This will require the submission of documentation showing how the proposed actions will affect the flood levels and flood flow velocities in the Blackstone River. It is anticipated that the flood levels will be reduced, however there still needs to be demonstrated that no adverse affects will result to other structures within the flood plains, which includes bridges, banks, etc. This will require submittal of a flood zone application with accompanying mapping of water surface elevations and aerial flood extents. The Town will require that a conditional letter of Map Revision (CLOMR) be prepared to reflect the permanent changes to the flood plain that will result from the proposed actions. This CLOMR is to be submitted to FEMA for review and approval under the National Flood Insurance Program.

Earth Removal Permit – Earth Removal Board
A permit will be required for removal of 500 cubic yards or more of material from a site. Major focus will be on dust/erosion control, stockpiling areas, traffic routes and hours of operation and ultimate destination for the removed earth. Permit application can be obtained from the Town Clerk.

Demolition Permit – Building Inspector
A demolition permit will be required for the proposed dam removal activities. Major concerns will be similar to earth removal permit.

14.0 OPINION OF COST

Order of magnitude opinions of cost were prepare for each of the 4 restoration alternatives. The assumption for sediment disposal is that all or a portion of the dredged sediment must be disposed of as hazardous waste with the remainder at American Reclamation Corporation (AMREC), a recycling facility in Charlton, MA. Costs may vary considerably based on results of further sediment testing if all of the sediment can be considered non-hazardous (see Section 15.2). These opinions of cost are anticipated to be accurate within plus 50% or minus 30% and this range is reflected in Table 8. It is also assumed that no scour countermeasures will be necessary at the Riverlin Street Bridge, although further analysis is recommended to confirm this (see Section 15.2). Quantities and unit prices used in these opinions of cost are included in Appendix F. Engineering and permitting costs are not included in these opinions of construction cost. Engineering fees, including the items listed in Section 15.2, could range from $75,000 to $85,000 regardless of the alternative selected. Permitting costs could vary greatly depending on the alternative selected and could range from $20,000 to $40,000.

15.0 SUMMARY & RECOMMENDATIONS

15.1 Restoration Alternative Summary

The advantages and disadvantages of each of the four restoration alternatives are summarized in Table 8. The least costly alternative is the Roughened Rock Ramp and the most costly alternative is Complete Dam Removal.

The management of the contaminated sediment is clearly one of the most critical aspects of the removal of Millbury Dam. Early coordination with the regulating agencies is recommended to avoid conflicts during sediment removal operations.

Table 8: Summary of Alternatives

Alternative	Advantages	Disadvantages	Order of Magnitude Opinion of Cost
Complete Dam Removal	▪ Most natural restoration alternative ▪ Provides best fish and boat passage	▪ Extensive armoring required to stabilize legacy sediment ▪ Most expensive due to removal of all channel sediment	$2,200,000 – $4,800,000
Removal with RGC	▪ Complete removal of dam structure while stabilizing most of sediment in-place	▪ Requires removal of 1,000 CY of sediment	$760,000 – $1,600,000
Roughened Rock Ramp	▪ Least costly option ▪ Minimal sediment removal	▪ Dam structure remains	$390,000 – $840,000
Step Pool	▪ Smallest footprint of disturbance ▪ Minimal sediment removal	▪ May be affected by sediment load of Blackstone River ▪ Difficult navigation for canoes ▪ Dam structure remains	$420,000 – $900,000

15.2 Recommended Analysis for Final Design

The following studies and analysis should be considered during the final design process:

Tailwater Measurements

Tailwater measurements provide the basis for calculating the hydraulic drop, which governs the number of FC/SPs or guide the length of RGCs. These measurements replace hydraulic modeling for the baseflow condition, as traditional one-dimensional stepped hydraulic models such as HEC-RAS are not sensitive enough to accurately model targeted conditions. For final design of RGC, RRR, or FC/SP alternatives, staff gages or automated transducers/data loggers should be installed downstream of the proposed structure and outside the influence of construction. Stream stages are read for flows ranging from baseflow to low storm flow. A minimum of three flow and stage measurements are required to produce a rating curve of stage versus discharge. If pressure transducers are used, frequency analyses can be performed to

estimate the dominant tailwater elevation. For concept development, tailwater measurements are taken from the planning stage HEC-RAS analysis as starting points only and are refined as the project moves into final design.

Gradually Varied Flow Modeling

Due to the very shallow depths of the target baseflow conditions, the traditional one-dimensional models can not effectively adjust for channel roughness and submerged multi-opening weir structures. Although HEC-RAS is used to model river flow conditions, HEC-RAS is a flood flow model, not a baseflow model. The HEC-RAS model is unable to do gradually varied flow for RGCs/RRR and rapidly varied flow for FC/SP structures. When modeling in HEC-RAS, Manning's roughness remains consistent and is averaged across the section for RGCs/RRR. For FC/SP, HEC-RAS averages the velocities and depths across a single weir section. In order to accurately model targeted baseflow conditions, a proprietary 2-dimensional (2D) model is used for the design of RGCs to accurately estimate velocities and depths for various flow conditions. A 2D model for RGCs is able to vary the Manning's roughness for all the flow conditions based on specific bed mix across the section. The advantage is that bed mixes can vary across a section as necessary to achieve desired flow depths and velocities conditions. However, to determine average shears stresses, HEC-RAS can be used to determine stone sizing at either top of bank or flood flows.

A major concern in hydraulic modeling is defining roughness in RGC designs. For top of bank and flood flow conditions, standard methods of determining Manning's n can be used. At these deeper flow depths, roughness is primarily based on the channel geometry and general surface materials. However at baseflow levels, the flow is so shallow that the roughness can be based on flow around and over individual rock. This relative roughness condition requires different methods of predicting and using Manning's n.

As a final step in boulder selection, the initial assumptions concerning roughness are verified. The Manning's n value used in the hydraulic models is estimated using equations developed from relative roughness and natural stream studies. Relative roughness is classified into small-scale, intermediate-scale, and large-scale roughness based on relative submergence as follows: (Bathurst 1978, Shea 2000).

Small-Scale Roughness	Intermediate-Scale Roughness	Large-Scale Roughness
$\frac{d}{D_{50}} > 7.5$	$7.5 > \frac{d}{D_{50}} > 2$	$2 > \frac{d}{D_{50}}$
$\frac{d}{D_{84}} > 4$	$4 > \frac{d}{D_{84}} > 1.2$	$1.2 > \frac{d}{D_{84}}$

Where d is the flow depth; D_{50} is the median particle size; and D_{84} is the 84-percent size of the median axis length.

Since the design flow depths are shallow during migration periods, the large-scale roughness criteria generally applies. A regression-fitted relationship was developed based on measurements of flow in mountain streams composed of boulders and cobbles where the relative submergence in the data ranged between 0.2 and 4 (Mussetter 1989). This relationship is:

$$\sqrt{\frac{8}{f}} = 1.11\left(\frac{d}{D_{84}}\right)^{0.46}\left(\frac{D_{84}}{D_{50}}\right)^{-0.85} S^{-0.39} \tag{5}$$

Where S is the friction slope; and *f* is the Darcy-Weisbach friction factor. The Darcy-Weisbach friction factor can be related to Manning's n by:

$$n = \frac{R^{1/6}}{\sqrt{g}\sqrt{\frac{8}{f}}} \tag{6}$$

Where R is the hydraulic radius; and g is the gravitational acceleration.

For small-scale roughness, the Manning's n is estimated using traditional methods. In the hydraulic models, Manning's n can vary with depth. The roughness values for corresponding depths are compared to the original roughness assumptions. If significant differences are found, the hydraulic models are adjusted, re-run, and the shear stresses are re-evaluated. Because of site-specific hydraulic issues due to bridges, levees or channel types, each riffle grade control has the potential for needing a unique design. However after evaluating the extremes in site geometry and flow conditions, generalizations and interpolations in between these extremes can be made based on the results of a HEC-RAS model.

Results of further modeling during final design may show that several areas of higher shear stresses are localized on the initially proposed channel geometry. For example, a high flow stress zone may be identified at the crest of the RGCs or at the boundaries between natural materials and the structure, which has been identified by others (Ayers 1998, Thorncraft 1996, Wildman 2001). To solve this particular problem, a class of stone could be used to compensate for these higher flow stresses. This modeling may also indicate that the edges of any nested channel feature will receive high flow stresses. Larger stone and robust vegetative cover could be used to stabilize these areas.

Sizing Structural Materials

The selection of the stone for use in constructing natural fish passage structures is based on a standard channel design method. Stone for RGCs should be well graded to provide for better compaction and a degree of impermeability that will prevent low flows from flowing through the structure instead of over it. Boulders for FC/SPs should be large enough to remain stationary during flood flows and should be well sorted.

The tractive force, or tractive shear stress, method is utilized to determine from calculations or graphs the size particle that corresponds to a particular shear stress that represents the flood stage of highest impact on the structure. Care should be taken when selecting the material sizes because these structures cannot be allowed to mobilize during flood (Johnson 1999). The selection process is iterative and based on assumptions of stone size and roughness, which must be verified and refined with hydraulic modeling.

Proposed RGCs are modeled using HEC-RAS and the 2-D hydraulic software to determine the tractive shear stresses on the fishway. The 2-D model considers 10-, 50- and 90-percent of base

flow and the top of bank flow conditions. The actual shear stress values are compared to the upper limit of incipient motion from field and laboratory studies. (Leopold 1964) For comparison, a computation of stone size is performed using critical shear stress methods. Conservative values are selected for a computation of dimensionless critical shear stress from cobble - gravel river studies (Equation 7) (Andrews 1983). The incipient stone size is computed from equation 8 (Shields 1936). Additionally, the coefficient of curvature ($C_z = D_{30}^2/(D_{60}*D_{10})$) should range between 1 and 3, suggesting a well-graded material (Craig 1993). Based on this criterion, the stone for the riffle grade control structures are sized.

$$\tau_{ci}^{*} = 0.0375\left(\frac{d_i}{d_{s50}}\right)^{-0.872} \qquad \text{Dimensionless Critical Shear Stress} \qquad (7)$$

$$\tau_{ci} = \tau_{ci}^{*}(\rho_s - \rho)gd_i \qquad \text{Critical Shear Stress} \qquad (8)$$

Where ρ is the density of water; ρ_s is the density of the rock; g is gravity; d_{s50} is the median rock size; d_i is the size of the stone for incipient motion.

The sizes of stone used for boulder clusters, boulder gardens and steps are based on field studies of existing, exposed grade control structures and includes foundation boulders. (Rosgen 2001). The advantage of using field studies for boulder sizing is that these studies inherently include the effects of such hazards as debris and ice impact.

Detailed Geomorphic Survey

Geomorphic surveys provide valuable information regarding dominant discharge shear stresses and the size of the sediment being transported and deposited in the study reach. Careful analysis of the sediment is important because the median particle size (D_{50}) will determine whether the RGC or the FC/SP will be used for fish passage. Geomorphic surveys would consist of pebble counts in the streambed and bar sampling of side, point, and mid-channel bars. Procedures for conducting these surveys may be found in Rosgen, 1996. If the median particle size is sand or gravel, an RGC would likely be the structure of choice. FC/SPs would be the preferred structure if the median particle size were cobbles or boulders. Under normal design conditions RGCs are designed for less than 1 percent with RRR being designed up to 2 percent. Any slope greater than 2 percent, the FC/SP structure would be used. Within the Millbury Dam project reach the natural channel slope is less than 1 percent so the RGC would be more conducive to the existing conditions.

Additional Sediment Sampling

- Final design sediment sampling should include TCLP testing to determine what portion, if any, of the material is considered hazardous waste. TCLP values will assist in determining the mobility of the contaminants and therefore the allowable disposal alternatives. This will assist in segregating zones of contamination. For example, further analysis of sediment between samples #3 and #5 would allow the zone of high lead contamination to be tightened. These additional data points will help to minimize the amount of sediment destined for the more costly hazardous waste disposal alternatives.
- Total Petroleum Hydrocarbons (TPH) should be added to the analysis parameter list based on pervasive petroleum contamination.

- If justified by the final design alternative, samples should be obtained from the legacy sediment in the floodplain at discrete depths to classify the quality of the reported "cap" material.

Other

- Perform detailed scour analysis of Riverlin St. Bridge using HEC-RAS for complete removal option where mid-channel bar is eroded
- Perform revised flow analysis with additional gage daily flow values. The website used to obtain this data was malfunctioning at the time of this analysis.
- Identify potential re-use options on National Grid property

16.0 REFERENCES

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TABLES

FUSS & O'NEILL

Table A: Comparison of Sediments Impounded behind the Millbury Dam
and Singing Dam to MADEP Freshwater Sediment Screening Criteria

			Millbury Dam (Mass Riverways, 2005)			Millbury Dam (Fuss & O'Neill, 2006)					Singing Pond (Battelle, 2002)		
Compound	Units	Screening Criteria	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	SP1	SP2	SP3
METALS (6010/7471)													
Arsenic	mg/kg	33 [a]	22	23	22	57.9	15.8	45.6	71.6	5.61	4.6	36.3	11.6
Barium	mg/kg	NE	84	85	86	251	51.3	120	169	30.8			
Cadmium	mg/kg	5 [a]	8	9	9	3.33	0.507	1.99	2.77	2.44	1.02	14.4	0.912
Chromium	mg/kg	110 [a]	361	527	278	140	49.2	92.1	94	111	52.3	159	56.9
Copper	mg/kg	150 [a]	397	447	469	2480	91.4	2400	3730	74.5	62	979	56.2
Lead	mg/kg	130 [a]	154	152	158	447	112	356	822	34.8	50.9	425	50.1
Mercury	mg/kg	0.18 [a]				4.3	1.29	2.8	3.46	<0.10	0.19	1.39	0.0814
Nickel	mg/kg	49 [a]	33	37	32	26.8	11.6	18.4	28	20.9	14.7	76.4	14.6
Selenium	mg/kg	NE				<2.5	<2.5	<2.5	<2.5	<2.5			
Silver	mg/kg	500 [b]	0.8	0.8	0.8	0.7	<0.5	<0.5	1.18	<0.5	1.89	3.11	0.266
Zinc	mg/kg	460 [a]	274	275	308	1170	134	519	702	84.4	58.2	701	62.1
PAHs (8270)													
2-Methylnaphthalene	ug/kg					820	<550	1800	1900	<390			
Acenaphthene	ug/kg	6.71 [b]	620			780	890	1400	1200	<390	84.9	1042.92	61.06
Acenaphthylene	ug/kg	5.87 [b]	620			<660	<550	720	1900	<390	110.19	383.34	93.35
Anthracene	ug/kg	57 [a]	860			1000	1000	3300	3700	<390	228.32	1842.32	139.35
Benzo[a]anthracene	ug/kg	110 [a]	1500			1800	1400	5000	8000	<390	1033.3	4105.68	801.22
Benzo[a]pyrene	ug/kg	150 [a]	1400			1500	900	3800	7100	400	1127.83	4386.89	937.98
Benzo[b]fluoranthene	ug/kg	10400 [b]	1100			1300	1100	3300	8100	<390	747.57	3562.14	640
Benzo[ghi]perylene	ug/kg	170 [b]	890			1100	<550	2200	5600	<390	737.57	3010.34	648.61
Benzo[k]fluoranthene	ug/kg	240 [b]	1000			<660	<550	1100	2400	<390	881.6	3846.05	737.99
Carbazole	ug/kg	NE	140										
Chrysene	ug/kg	170 [a]	1600			1800	1300	5000	8800	<390	1217.75	4885.02	929.26
Dibenzo[a,h]anthracene	ug/kg	33 [a]	330			<660	<550	<600	1500	<390	232.09	895.2	200.61
Fluoranthene	ug/kg	420 [a]	2400			2200	2600	5500	7400	<390	1253.65	7198.96	929.31
Fluorene	ug/kg	77 [a]	670			<660	900	1500	1900	<390	122.68	1212.08	84.46
Indeno[1,2,3-cd]pyrene	ug/kg	200 [b]	890			770	<550	1800	5000	<390	717.02	2999.62	644.24
Naphthalene	ug/kg	180 [a]	950			1900	1400	2800	3800	<390	414.76	1378.34	220.17
Phenanthrene	ug/kg	200 [a]	2500			3300	3700	9200	9200	<390	988.43	6949.68	533.01
Pyrene	ug/kg	200 [a]	3000			3200	2100	7500	8700	400	1943.12	7147.99	1214.31

Table A: Comparison of Sediments Impounded behind the Millbury Dam
and Singing Dam to MADEP Freshwater Sediment Screening Criteria

			Millbury Dam (Mass Riverways, 2005)			Millbury Dam (Fuss & O'Neill, 2006)					Singing Pond (Battelle, 2002)		
Compound	Units	Screening Criteria	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	SP1	SP2	SP3
PCBs (8082)													
Total PCB	ug/kg	29.8 [a]	100								1262.78	3755.99	1045.1
PCB-1016	ug/kg	29.8 [a]				<780	<650	<720	<700	<470			
PCB-1221	ug/kg	29.8 [a]				<780	<650	<720	<700	<470			
PCB-1232	ug/kg	29.8 [a]				<780	<650	<720	<700	<470			
PCB-1242	ug/kg	29.8 [a]				<780	<650	<720	<700	<470			
PCB-1248	ug/kg	29.8 [a]				<780	<650	<720	<700	<470			
PCB-1254	ug/kg	29.8 [a]				<780	<650	<720	<700	<470			
PCB-1260	ug/kg	29.8 [a]				<780	<650	<720	<700	<470			
PCB-1262	ug/kg	29.8 [a]				<780	<650	<720	<700	<470			
PCB-1268	ug/kg	29.8 [a]				<780	<650	<720	<700	<470			

NOTES:

N/A = Not Applicable - comparison to screening criteria no applied
NE = No screening criteria established
Empty Cells = Sample not analyzed for that compound
Highlighted Cells = Compound exceeds screening criteria for that sample

[a] MADEP Bureau of Waste Site Cleanup and Office of Research and Standards. 2006. Freshwater Sediment Screening Benchmarks for Use Under the Massachusetts Contingency Plan.

[b] USEPA Region 5, 2003, Ecological Screening Levels (ESLs) for RCRA Appendix IX Hazardous Constituents. August 2003 Available Online: http://www.epa.gov/reg5rcra/ca/ESL.pdf

[c] Persaud,D., R. Jaagumag, and A. Hayton. 1993. Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario. Queen's Printer for Ontario. Reprinted 1994

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Table B: Comparison of Sediments Impounded behind the Millbury Dam
to Sediments Impounded behind the Singing Dam and to MADEP Freshwater Sediment Screening Criteria

			Millbury Dam			Singing Dam			
Compound	Units	Ecologcial Screening Criteria	Median	Maximum	95%UCL	Median	Maximum	Exceeds Local Conditions?	Exceed Screening Criteria?
METALS (6010/7471)									
Arsenic	mg/kg	33 [a]	22.5	71.6	49	11.6	36.3	Yes	Yes
Barium	mg/kg	NE	85.5	251	159	N/A	N/A	N/A	N/A
Cadmium	mg/kg	5 [a]	3.05	9	7	1.02	14.4	Yes	Yes
Chromium	mg/kg	110 [a]	125.5	527	322	56.9	159	Yes	Yes
Copper	mg/kg	150 [a]	458	3730	2230	62	979	Yes	Yes
Lead	mg/kg	130 [a]	156	822	458	50.9	425	Yes	Yes
Mercury	mg/kg	0.18 [a]	2.8	4.3	4	0.19	1.39	Yes	Yes
Nickel	mg/kg	49 [a]	27.4	37	32	14.7	76.4	Yes	No
Selenium	mg/kg		2.5	2.5		N/A	N/A	N/A	N/A
Silver	mg/kg	500 [b]	0.75	1.18	1	1.89	3.11	No	No
Zinc	mg/kg	460 [a]	291.5	1170	682	62.1	701	Yes	Yes
PAHs (8270)									
2-Methylnaphthalene	ug/kg	20.2 [b]	357	826	1714	N/A	N/A	N/A	N/A
Acenaphthene	ug/kg	6.71 [b]	363	609	1177	85	1043	Yes	Yes
Acenaphthylene	ug/kg	5.87 [b]	278	826	1245	110	383	Yes	Yes
Anthracene	ug/kg	57 [a]	435	1609	2838	228	1842	Yes	Yes
Benzo[a]anthracene	ug/kg	110 [a]	717	3478	5336	1033	4106	No	Yes !
Benzo[a]pyrene	ug/kg	150 [a]	630	3087	4542	1128	4387	No	Yes !
Benzo[b]fluoranthene	ug/kg	10400 [b]	522	3522	4862	748	3562	No	No
Benzo[ghi]perylene	ug/kg	170 [b]	433	2435	3367	738	3010	No	Yes !
Benzo[k]fluoranthene	ug/kg	240 [b]	361	1043	1600	882	3846	No	Yes !
Chrysene	ug/kg	170 [a]	739	3826	5694	1218	4885	No	Yes !
Dibenzo[a,h]anthracene	ug/kg	33 [a]	250	652	1012	232	895	No	Yes !
Fluoranthene	ug/kg	420 [a]	1087	3217	5457	1254	7199	No	Yes !
Fluorene	ug/kg	77 [a]	341	826	1465	123	1212	Yes	Yes
Indeno[1,2,3-cd]pyrene	ug/kg	200 [b]	361	2174	2969	717	3000	No	Yes !
Naphthalene	ug/kg	180 [a]	717	1652	2876	415	1378	Yes	Yes
Phenanthrene	ug/kg	200 [a]	1522	4000	7641	988	6950	Yes	Yes
Pyrene	ug/kg	200 [a]	1348	3783	6741	1943	7148	No	Yes !

Table B: Comparison of Sediments Impounded behind the Millbury Dam
to Sediments Impounded behind the Singing Dam and to MADEP Freshwater Sediment Screening Criteria

			Millbury Dam			Singing Dam		Exceeds Local Conditions?	Exceed Screening Criteria?
Compound	Units	Ecologcial Screening Criteria	Median	Maximum	95%UCL	Median	Maximum		
PCBs (8082)									
PCBs	ug/kg	29.8 [a]				1263	3756	No	No
PCB-1016	ug/kg	29.8 [a]	700	780	767				
PCB-1221	ug/kg	29.8 [a]	700	780	767				
PCB-1232	ug/kg	29.8 [a]	700	780	767				
PCB-1242	ug/kg	29.8 [a]	700	780	767				
PCB-1248	ug/kg	29.8 [a]	700	780	767				
PCB-1254	ug/kg	29.8 [a]	700	780	767				
PCB-1260	ug/kg	29.8 [a]	700	780	767				
PCB-1262	ug/kg	29.8 [a]	700	780	767				
PCB-1268	ug/kg	29.8 [a]	700	780	767				

NOTES:

N/A = Not Applicable - value could not be calculated

Empty Cells = Sample not analyzed for that compound

Highlighted Cells Compound exceeds screening criteria for that sample

! Compound exceeds screening criteria for that sample but does not exceed background conditions

For sample where ND was reported median and maximum calculated based on reporting limit

a MADEP Bureau of Waste Site Cleanup and Office of Research and Standards. 2006. Freshwater Sediment Screening Benchmarks for Use Under th Contingency Plan.

b USEPA Region 5, 2003, Ecological Screening Levels (ESLs) for RCRA Appendix IX Hazardous Constituents. August 2003 Available Online: http://www.epa.gov/reg5rcra/ca/ESL.pdf

c Persaud,D., R. Jaagumag, and A. Hayton. 1993. Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario. Queen's Pr Reprinted 1994

d Jones, D.S., G.W. Suter, and R.N. Hull. 1997. Toxicological benchmarks for screening contaminants of potential concern for effects on sediment-as revision. Oak Ridge National Laboritories. ES/ER/TM-93/R4

FUSS & O'NEILL

Table C: Comparison of Sediments Impounded behind the Millbury Dam to Published Criteria[a]

Compound	Units	Freshwater Sediment Benchmarks[b]	Threshold Effects Level	Probable Effects Level	Probable Effects Concentration	Background "Native" Soil	MCP S1-GW1	MCP S2-GW3	Lined Landfill	Unlined Landfill	Millbury Dam Median	Millbury Dam Maximum
METALS (6010/7471)												
Arsenic	mg/kg	33	5.9	17	33	20	30	30	40	40	22.5	71.6
Barium	mg/kg	NE	--	--	--	--	--	--	--	--	85.5	251
Cadmium	mg/kg	5	0.6	3.53	4.98	2	30	80	80	30	3.05	9
Chromium	mg/kg	110	37.3	90	111	30	1000	2500	1000	1000	125.5	527
Copper	mg/kg	150	35.7	197	149	40	--	--	--	--	458	3730
Lead	mg/kg	130	35	91.3	128	100	300	600	2000	1000	156	822
Mercury	mg/kg	0.18	0.17	0.49	--	0.3	20	60	10	10	2.8	4.3
Nickel	mg/kg	49	18	35.9	48.6	20	300	1000	--	--	27.4	37
Selenium	mg/kg		--	--	--	0.5	400	2500	--	--	2.5	2.5
Silver	mg/kg	500	--	--	--	0.6	100	200	--	--	0.75	1.18
Zinc	mg/kg	460	123	315	459	100	2500	2500	--	--	291.5	1170
PAHs (8270)												
2-Methylnaphthalene	ug/kg	20.2[b]	--	--	--	--	--	--	--	--	357	826
Acenaphthene	ug/kg	6.71[b]	--	--	--	--	--	--	--	--	363	609
Acenaphthylene	ug/kg	5.87[b]	--	--	--	--	--	--	--	--	278	826
Anthracene	ug/kg	57	--	--	--	1,000	1,000,000	2,500,000	--	--	435	1,609
Benzo[a]anthracene	ug/kg	110	31.7	385	--	2,000	700	1,000	--	--	717	3,478
Benzo[a]pyrene	ug/kg	150	31.9	782	--	2,000	700	700	--	--	630	3,087
Benzo[b]fluoranthene	ug/kg	10400[b]	--	--	--	--	--	--	--	--	522	3,522
Benzo[ghi]perylene	ug/kg	170[b]	--	--	--	--	--	--	--	--	433	2,435
Benzo[k]fluoranthene	ug/kg	240[b]	--	--	--	--	--	--	--	--	361	1,043
Chrysene	ug/kg	170	57.1	862	--	2,000	700	10,000	--	--	739	3,826
Dibenzo[a,h]anthracene	ug/kg	33			--	500	700	700	--	--	250	652
Fluoranthene	ug/kg	420	111	2355	--	4,000	1,000,000	1,000,000	--	--	1,087	3,217
Fluorene	ug/kg	77	--	--	--	1,000	400,000	2,000,000	--	--	341	826
Indeno[1,2,3-cd]pyrene	ug/kg	200[b]	--	--	--	--	--	--	--	--	361	2,174
Naphthalene	ug/kg	180	--	--	--	500	4,000	1,000,000	--	--	717	1,652
Phenanthrene	ug/kg	200	41.9	515	--	3,000	700,000	100,000	--	--	1,522	4,000
Pyrene	ug/kg	200	53	875	--	4,000	700,000	2,000,000	--	--	1,348	3,783
Total PAHs	ug/kg	1,610	--	--	22,800	--	--	--	100,000		10,522	37,626
Total PCBs (8082)	ug/kg	29.8	34.1	277	676	--	2000	2000	2000	--	700	780

NOTES:

N/A = Not Applicable - value could not be calculated

Empty Cells = Sample not analyzed for that compound

Highlighted Cells Compound exceeds screening criteria for that sample

! Compound exceeds screening criteria for that sample but does not exceed background conditions

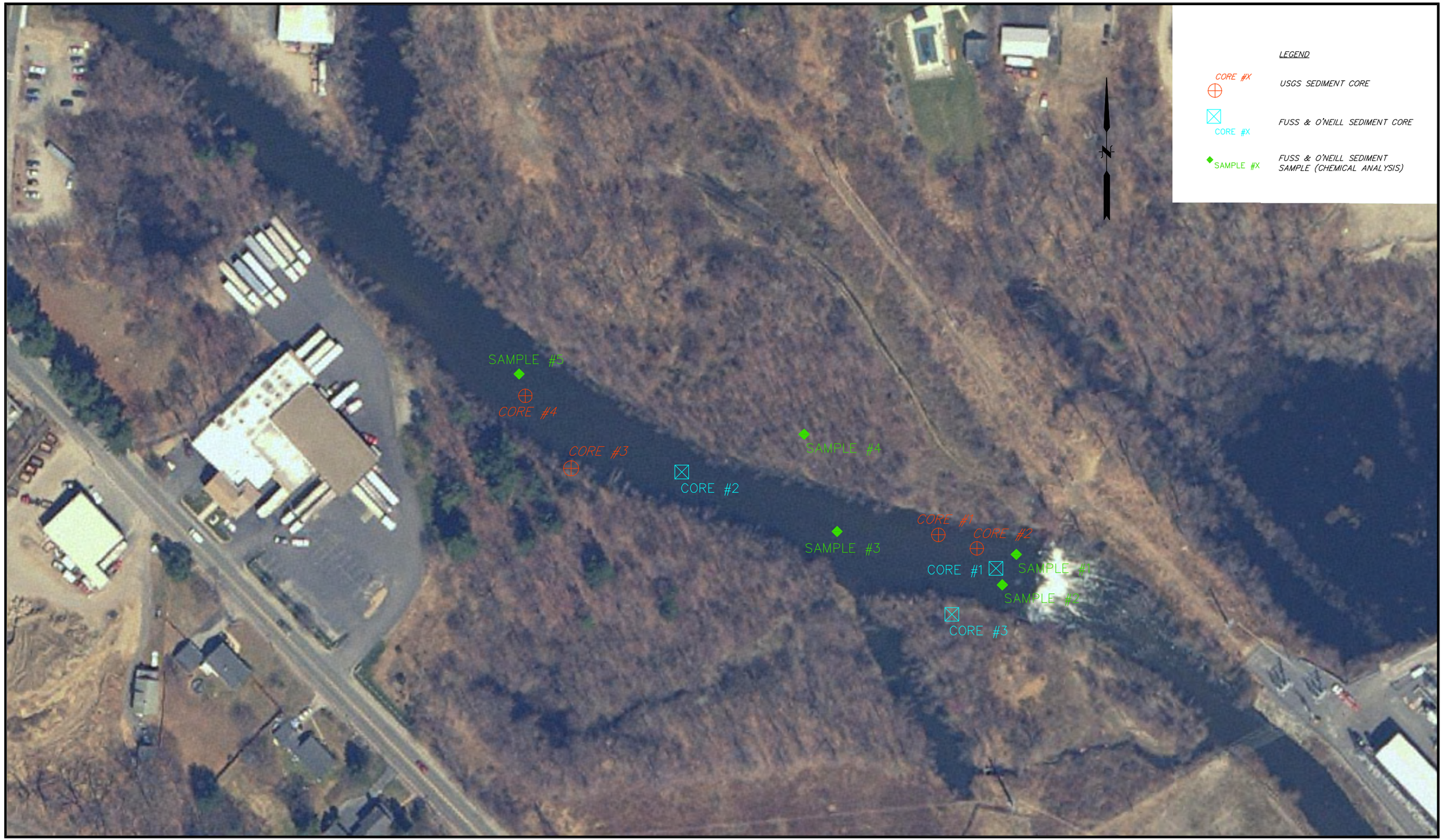
For sample where ND was reported median and maximum calculated based on reporting limit

a Except as noted, criteria used from various sources and published collectively in Massachusetts Riverway Program document entitled "Impounded Sediment and Dam Removal in Massachusetts: A Decision Making Framework Regarding Dam Removal and Sediment Management Options"

b MADEP Bureau of Waste Site Cleanup and Office of Research and Standards. 2006. Freshwater Sediment Screening Benchmarks for Use Under the Massachusetts Contingency Plan.

c USEPA Region 5, 2003, Ecological Screening Levels (ESLs) for RCRA Appendix IX Hazardous Constituents. August 2003 Available Online: http://www.epa.gov/reg5rcra/ca/ESL.pdf

FIGURES



No.	DATE	DESCRIPTION	BY
1.	2/16/2007	ADD CHEMICAL ANALYSIS SAMPLE LOCATIONS	JAZ

REVISIONS

PROJ. MANAGER:
CHIEF DESIGNER:
REVIEWED BY: DATE

SCALE:
HORZ.: 1" = 100'
VERT.:
DATUM:
HORZ.:
VERT.:
0 50 100
GRAPHIC SCALE

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COMMONWEALTH OF MASSACHUSETTS RIVERWAYS PROGRAM

SEDIMENT CORE LOCATIONS

MASS ELECTRIC DAM REMOVAL FEASIBILITY STUDY

MILLBURY MASSACHUSETTS

PROJ. No.: 20051066.C10
DATE: JUNE 2006

FIG. A

File Path: J:\DWG\P20051066\C10\Plan\051066C10SAM001.dwg, Layout: SED CORES Fri, Mar 16, 2007 - 10:26 AM User: JZahner
CTB: FO_COLOR.ctb
LMAN: SED CORE
MS VIEW: MVIEW_CORE-100
UCS:

LEGEND

SOIL BORING	PROPERTY LINE
EXISTING IRON PIPE	EDGE OF WATER
EXISTING I.ROD OR I.PIN	EXISTING CONTOUR
CONTROL POINT	INDEX CONTOUR
	LIDAR CONTOUR

MAP REFERENCE:

1. DETAILED DAM AND CHANNEL MAPPING FROM SURVEY BY FUSS & O'NEILL, INC. 6/1/2006

2. OVERBANK TOPOGRAPHY FROM LIDAR SURVEY BY SANBORN 5/2005; PROVIDED BY CDM 5/2006

No.	DATE	DESCRIPTION	BY
1.			

REVISIONS

PROJ. MANAGER:
CHIEF DESIGNER:
REVIEWED BY: DATE

SEAL

SEAL

SCALE:
HORZ.: 1" = 100'
VERT.:
DATUM:
HORZ.: NAVD88
VERT.: ASSUMED
100 50 0 100
GRAPHIC SCALE

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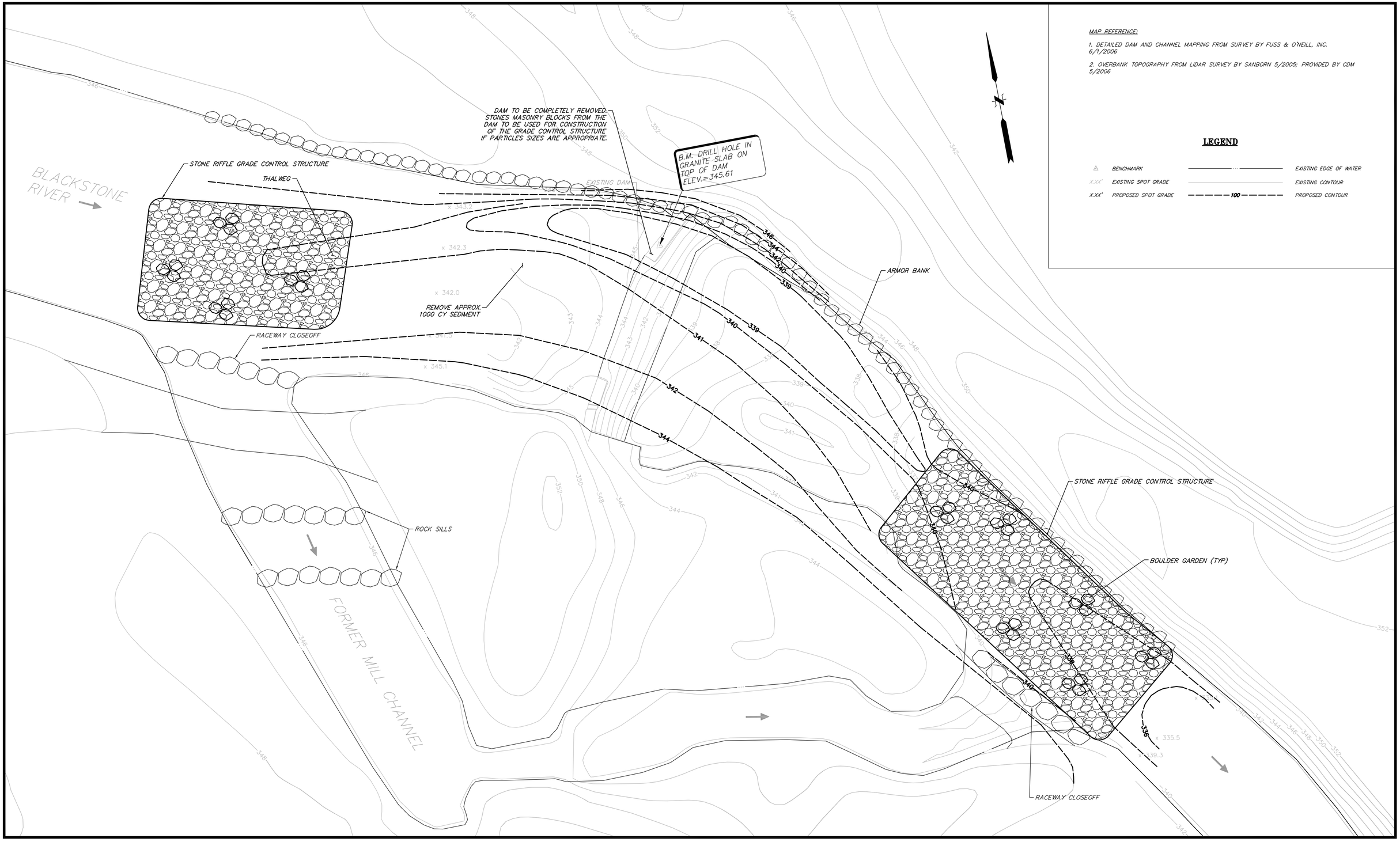
MASSACHUSETTS RIVERWAYS PROGRAM
CROSS-SECTION LOCATIONS
HYDRAULIC ANALYSIS
MILLBURY DAM REMOVAL FEASIBILITY STUDY
MILLBURY MASSACHUSETTS

PROJ. No.: 20051066.C10
DATE: MARCH 2007

FIG. B

File Path: J:\DWG\P2005\1066\C10\Plan\051066C10STP002.dwg, Layout: 100 Scale Fri, Mar 16, 2007 - 10:20 AM User: JZahner
CTB: FO_STANDARD
LMAN: 100 SCALE
MS VIEW: MVIEW_100 SCALE
UCS:



No.	DATE	DESCRIPTION	BY
1.			

REVISIONS

PROJ. MANAGER:
CHIEF DESIGNER:
REVIEWED BY: DATE

SEAL

SEAL

SCALE:
HORZ.: 1" = 20'
VERT.:
DATUM:
HORZ.: NAVD88
VERT.: ASSUMED
20 10 0 20
GRAPHIC SCALE

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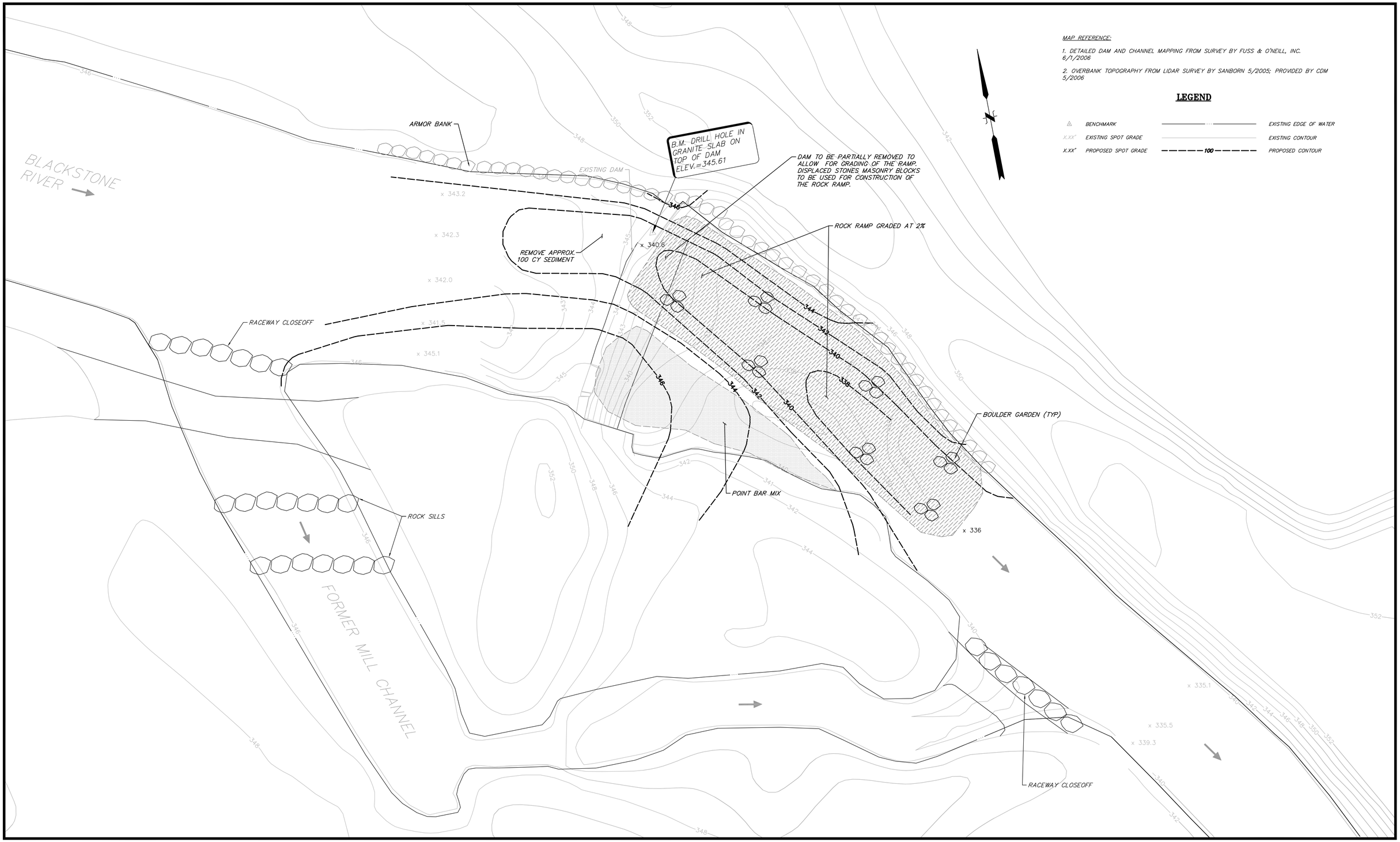
MASSACHUSETTS RIVERWAYS PROGRAM
CONCEPTUAL SITE PLAN
DAM REMOVAL WITH RIFFLE GRADE CONTROL
MILLBURY DAM REMOVAL FEASIBILITY STUDY
MILLBURY MASSACHUSETTS

PROJ. No.: 20051066.C10
DATE: MARCH 2007

FIG. C

UCS: | MS VIEW: MVIEW_20_OPT 2 | LMAN: GRADE CONTROL | CTB: FO_STANDARD | File Path: J:\DWG\P2005\1066\C10\Plan\05\1066C10STP002.dwg, Layout: OPT_2_GRADE CONT. Fri, Mar 16, 2007 - 10:09 AM User: JZahner



No.	DATE	DESCRIPTION	BY
1.			

REVISIONS

PROJ. MANAGER:
CHIEF DESIGNER:
REVIEWED BY: DATE

SEAL

SEAL

SCALE:
HORZ.: 1" = 20'
VERT.:
DATUM:
HORZ.: NAVD88
VERT.: ASSUMED
20 10 0 20
GRAPHIC SCALE

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MASSACHUSETTS RIVERWAYS PROGRAM
CONCEPTUAL SITE PLAN
PARTIAL DAM REMOVAL WITH ROCK RAMP
MILLBURY DAM REMOVAL FEASIBILITY STUDY
MILLBURY MASSACHUSETTS

PROJ. No.: 20051066.C10
DATE: MARCH 2007

FIG. D

File Path: J:\DWG\P2005\1066\C10\Plan\051066C10STP002.dwg, Layout: OPT_3_RAMP Fri, Mar 16, 2007 - 10:07 AM User: JZahner
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LMAN: ROCK RAMP
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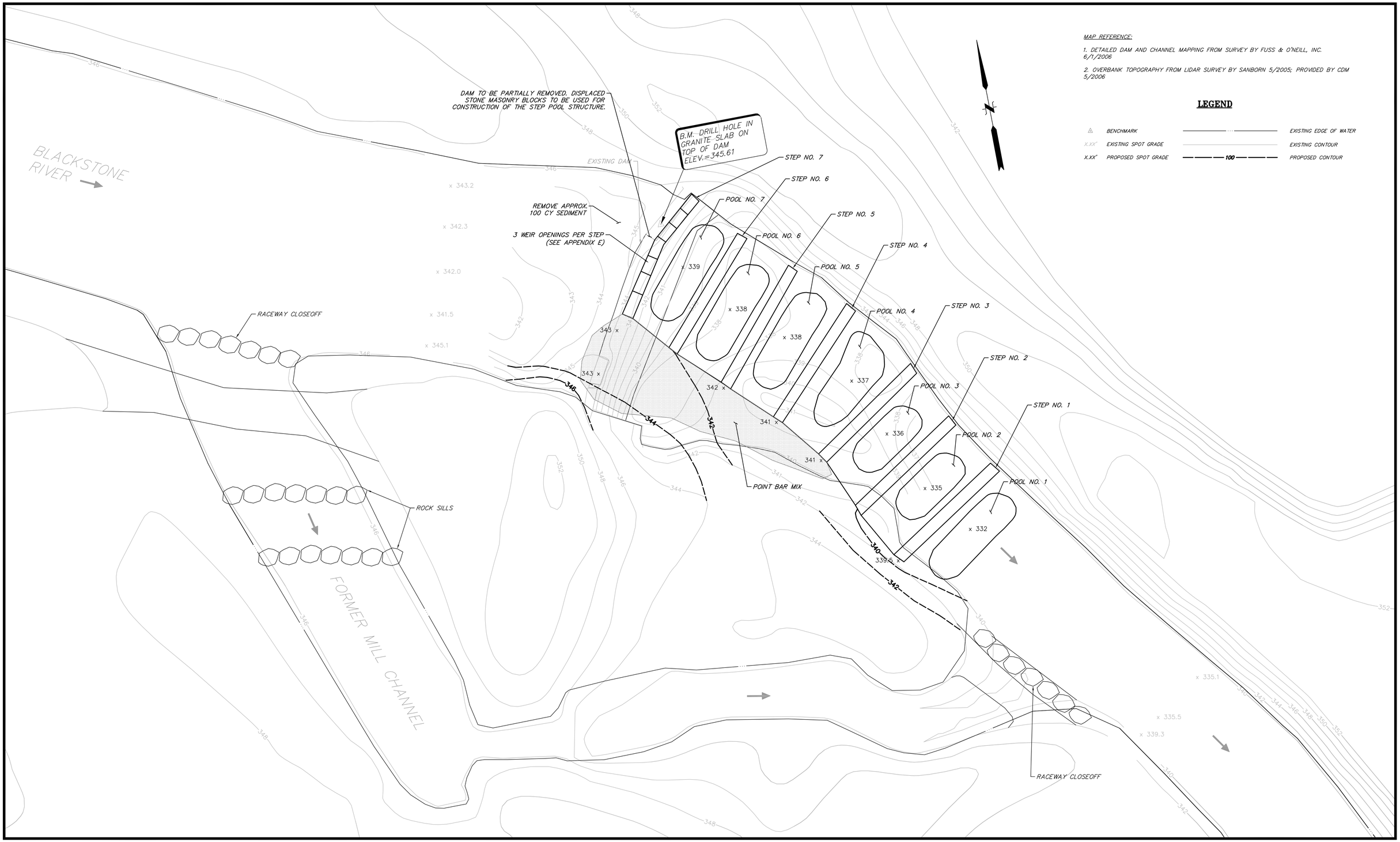
UCS:



No.	DATE	DESCRIPTION	BY
1.			

REVISIONS

PROJ. MANAGER:
CHIEF DESIGNER:
REVIEWED BY: DATE

SEAL

SEAL

SCALE:
HORZ.: 1" = 20'
VERT.:
DATUM:
HORZ.: NAVD88
VERT.: ASSUMED
20 10 0 20
GRAPHIC SCALE

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MASSACHUSETTS RIVERWAYS PROGRAM
CONCEPTUAL SITE PLAN
PARTIAL DAM REMOVAL WITH STEP POOLS
MILLBURY DAM REMOVAL FEASIBILITY STUDY
MILLBURY MASSACHUSETTS

PROJ. No.: 20051066.C10
DATE: MARCH 2007

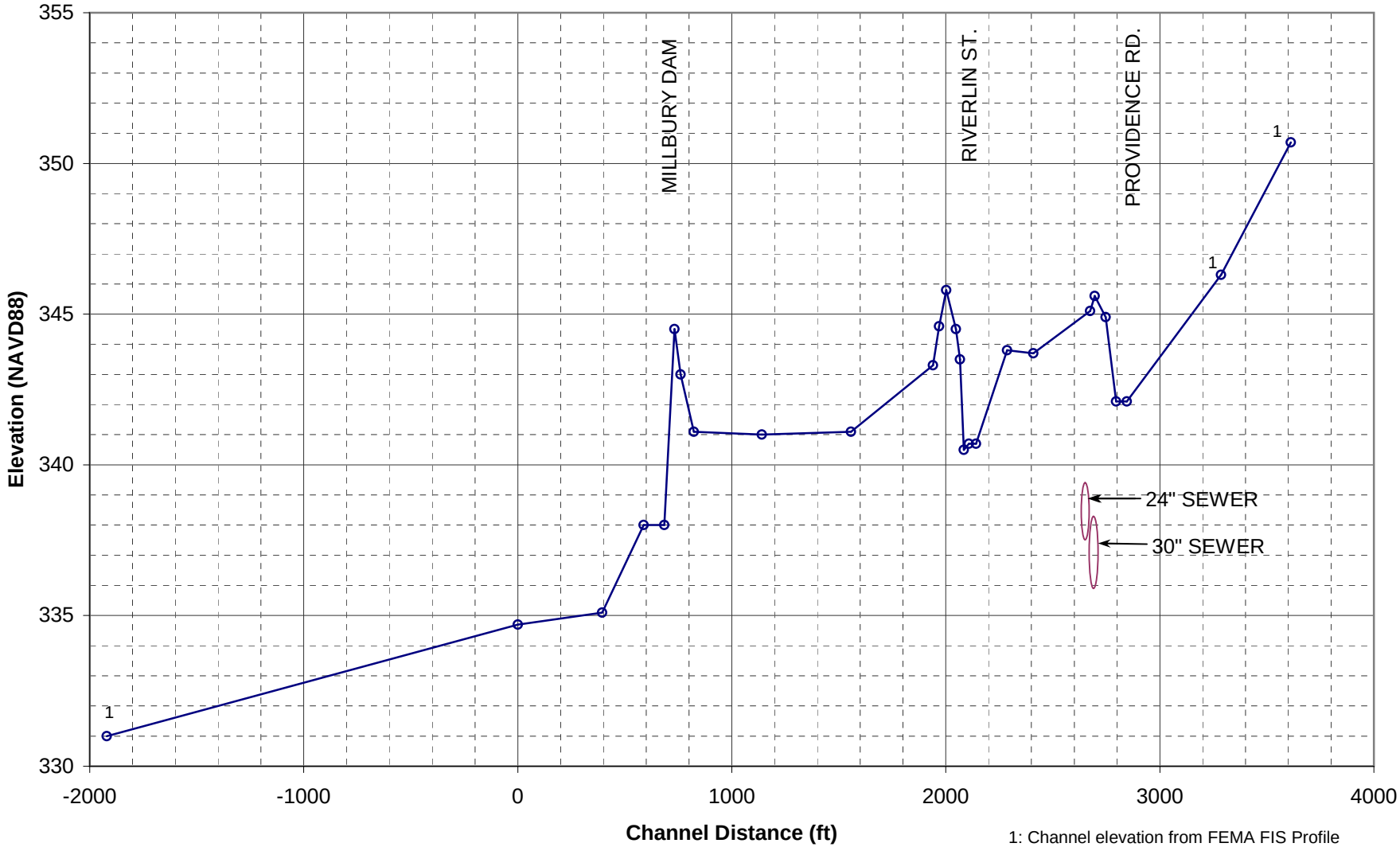
FIG. E

File Path: J:\DWG\P2005\1066\C10\Plan\051066C10STP002.dwg, Layout: OPT_4_STEP POOLS Fri, Mar 16, 2007 - 10:05 AM User: JZahner
CTB: FO_STANDARD
LMAN: ROCK RAMP
MS VIEW: MVEIW_20
UCS:

APPENDIX A

CHANNEL SURVEY DATA

Blackstone River, Millbury, MA
SURVEYED CHANNEL PROFILE



1: Channel elevation from FEMA FIS Profile

Blackstone River, Millbury, MA
SURVEYED CHANNEL PROFILE

HEC-RAS SECTION	CHANNEL STATION (ft)	CHANNEL LOW POINT (ft NGVD)	DESCRIPTION	DATA SOURCE	HARD RIVER BOTTOM (ft NGVD)
	-1920	331		FEMA	
A	0	334.7		6/2/2006	
B	394.5	335.1		6/2/2006	335.1
C	587.8	338		6/1/2006	
D	684.8	338		6/1/2006	
E	732.8	344.5	Millbury Dam	6/1/2006	
F	760.8	343		6/1/2006	336.7
G	822.9	341.1		6/2/2006	336.9
H	1141	341		6/2/2006	338.5
I	1557	341.1		6/2/2006	339.25
	1940	343.3		12/19/2006	
	1968.3	344.6		12/19/2006	
J	2002.4	345.8		12/19/2006	
	2047.6	344.5		12/19/2006	
	2065.8	343.5		12/19/2006	
	2083.8	340.5		CDM	340.5
K	2107.8	340.7	DS Face Riverlin	CDM	
M	2141.8	340.7	US Face Riverlin	CDM	
N	2286.7	343.8		12/19/2006	
	2409.1	343.7		12/19/2006	
	2674.3	345.1		12/19/2006	
O	2696.3	345.6		12/19/2006	
	2746.7	344.9		12/19/2006	
P	2795.2	342.1	DS Face Providence	CDM	342.1
R	2846.2	342.1	US Face Providence	CDM	
S	3286.2	346.3		FEMA	
T	3612	350.7		FEMA	

Notes:
1: 6/1/2006, 6/2/2006, 12/19/2006 survey by Fuss & O'Neill, Inc.
2: CDM data surveyed by Green International Affiliates, Inc. 8/31/05 for FEMA restudy
3: FEMA data from Town of Millbury FIS, Revised 1/7/2000

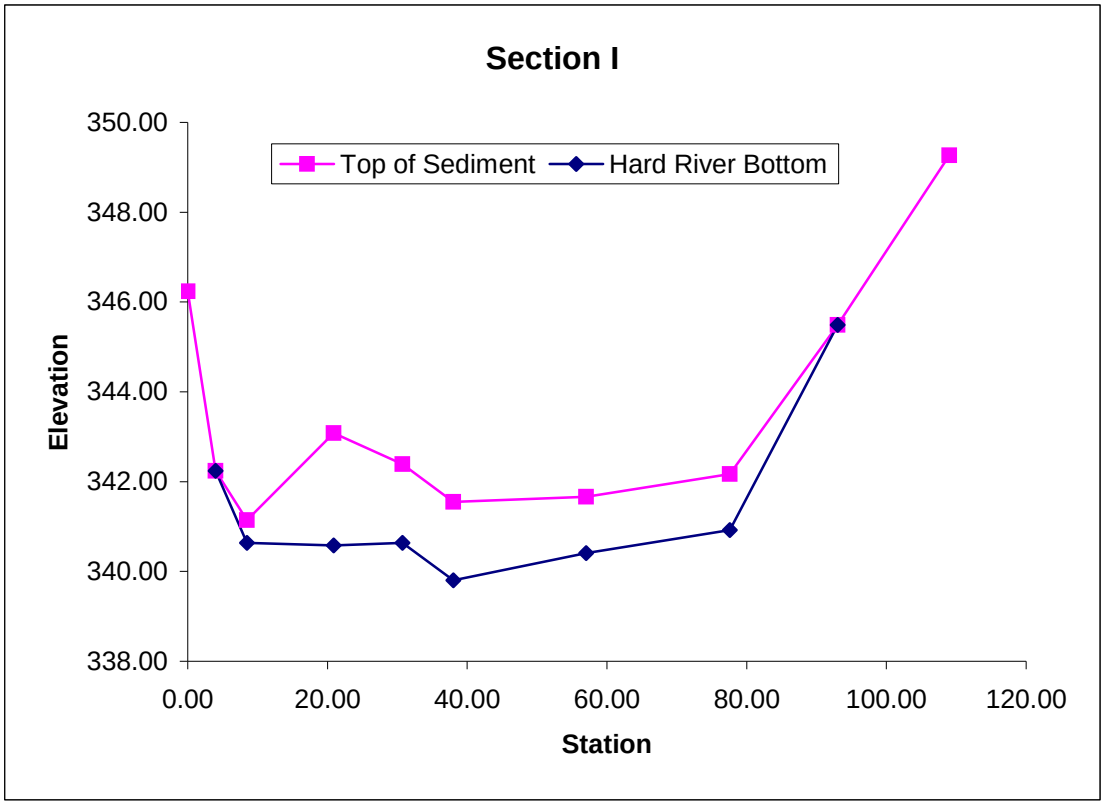
MILLBURY DAM

FIELD SURVEYED CROSS SECTION DATA

Section I HI= 5.38 HR= 8.40

(Survey Section #1) **bold** indicates actual depth measurements vs. estimated

Station	Vertical Dist.	Elevation	Description	Sediment Depth (ft)	HRB	Area between surfaces (sq ft)
0.00	3.91	**350.15**	BM 1: Nail/Tree			
0.00	0.00	346.24	TBL			
4.00	-4.00	342.24	BBL	0	342.24	
8.46	-5.10	341.14	CHAN	0.5	340.64	1.1
20.88	-3.16	343.08	CHAN	2.5	340.58	18.6
30.73	-3.85	342.39	CHAN	**1.75**	**340.64**	20.9
38.00	-4.69	341.55	CHAN	1.75	339.80	12.7
57.03	-4.58	341.66	CHAN	**1.25**	**340.41**	28.5
77.57	-4.07	342.17	CHAN	1.25	340.92	25.7
93.04	-0.75	345.49	WSE	0	345.49	
109.00		349.27	Instrument, TBR			
					Total Area	107.6



MILLBURY DAM

FIELD SURVEYED CROSS SECTION DATA

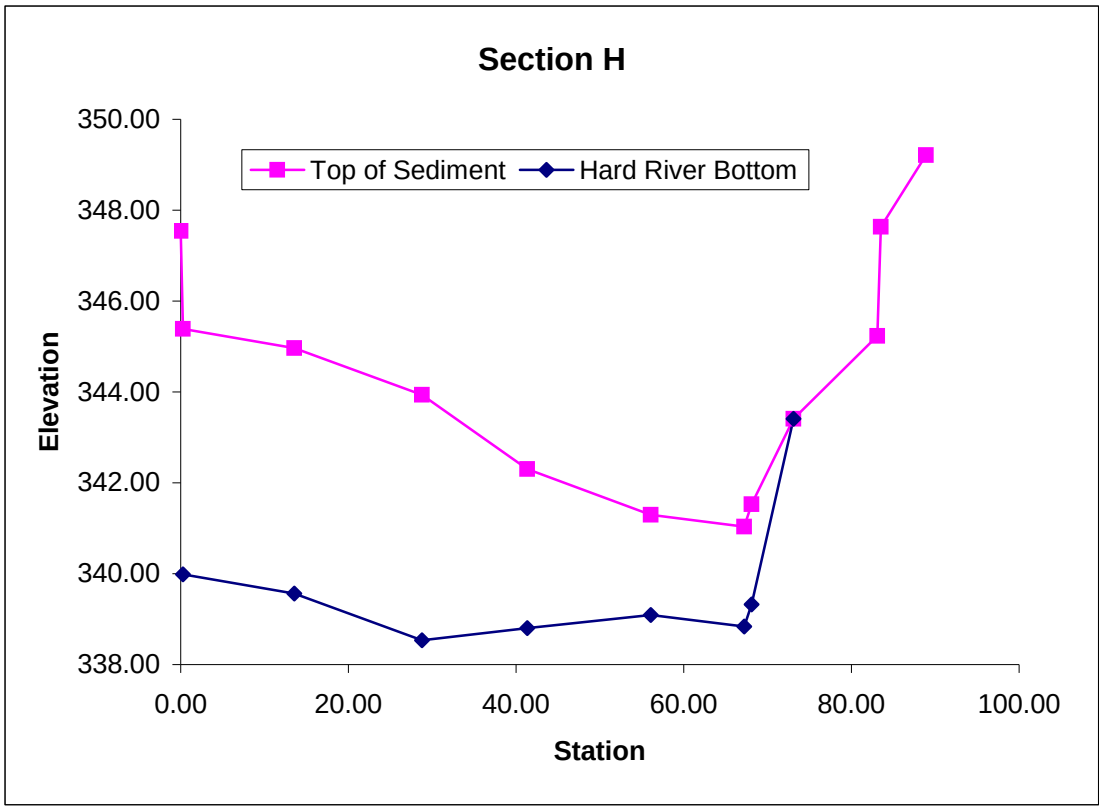
Section H

HI= 5.58 HR= 8.40

(Survey Section #2)

bold indicates actual depth measurements vs. estimated

Station	Vertical Dist.	Elevation	Description	Sediment Depth (ft)	HRB	Area between surfaces (sq ft)
-39.96	4.13	**350.53**	BM 2: Nail/Tree			
0.00	1.15	347.55	TBL			
0.28	-1.01	345.39	BBL	5.4	339.99	
13.56	-1.43	344.97	CHAN	5.4	339.57	71.7
28.76	-2.46	343.94	CHAN	**5.4**	**338.54**	82.1
41.32	-4.09	342.31	CHAN	3.5	338.81	55.9
56.07	-5.10	341.30	CHAN	2.2	339.10	42.0
67.21	-5.36	341.04	CHAN	**2.2**	**338.84**	24.5
68.11	-4.87	341.53	CHAN	2.2	339.33	2.0
73.11	-2.99	343.41	CHAN	**0**	**343.41**	5.5
83.08	-1.16	345.24	BBR			
83.53	1.24	347.64	TBR			
88.90		349.21	Instrument, TBR			
					Total area	283.7



MILLBURY DAM

FIELD SURVEYED CROSS SECTION DATA

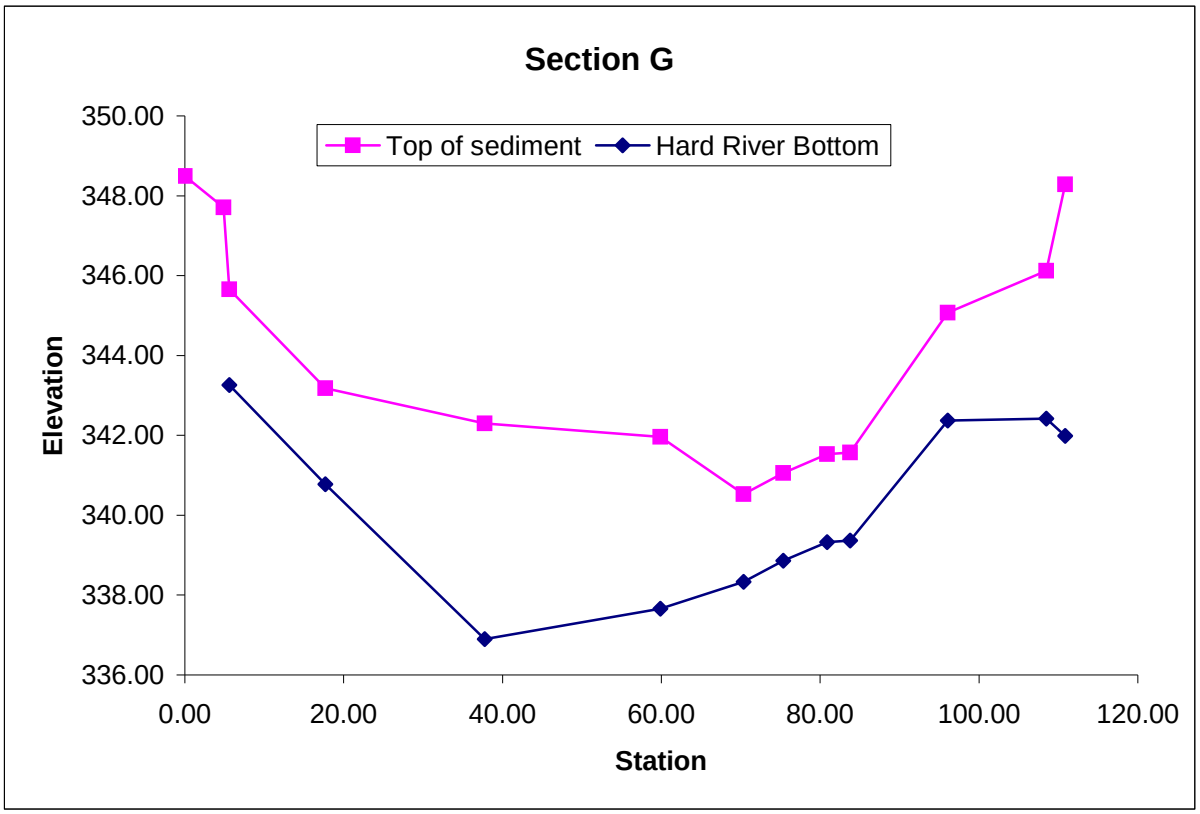
* New setup to set elevation of pin

	HI*=	5.40	HR*=	5.30
Section G	HI=	5.53	HR=	8.40

(Survey Section #3)

bold indicates actual depth measurements vs. estimated

Station	Vertical Dist.	Elevation	Description	Sediment Depth (ft)	HRB	Area between surfaces (sq ft)
152.22	0.03	**348.63**	BM 3: Nail/Tree			
0.00		348.50	Instrument, TBL			
4.87	2.08	347.71	TBL			
5.61	0.03	345.66	BBL	**2.4**	**343.26**	
17.67	-2.45	343.18	CHAN	2.4	340.78	28.9
37.74	-3.33	342.30	CHAN	**5.4**	**336.90**	78.3
59.87	-3.67	341.96	CHAN	**4.3**	**337.66**	107.3
70.35	-5.10	340.53	CHAN	**2.2**	**338.33**	34.1
75.36	-4.57	341.06	CHAN	2.2	338.86	11.0
80.89	-4.10	341.53	CHAN	2.2	339.33	12.2
83.79	-4.06	341.57	CHAN	2.2	339.37	6.4
96.05	-0.56	345.07	CHAN	**2.7**	**342.37**	30.0
108.46	0.49	346.12	BBR	3.7	342.42	39.7
110.84	2.66	348.29	TBR	**6.3**	**341.99**	11.9
					Total Area	359.8



MILLBURY DAM

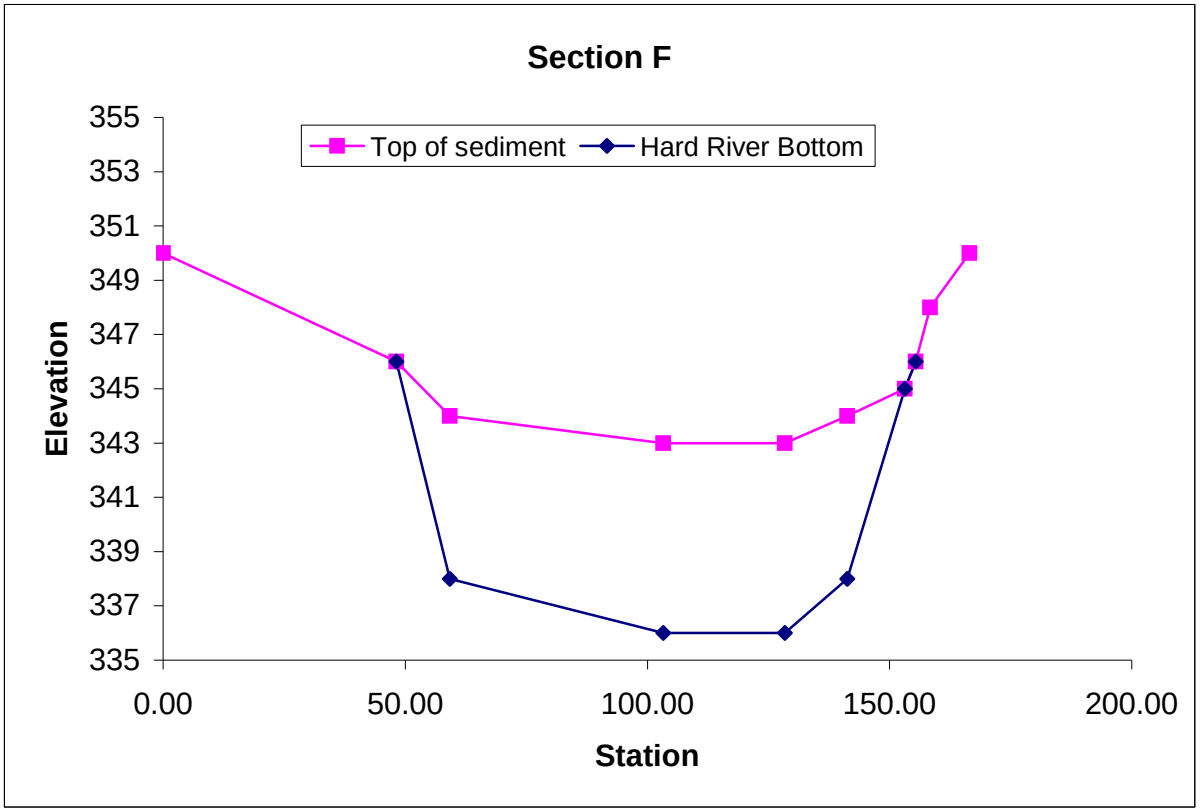
FIELD SURVEYED CROSS SECTION DATA

Section F

(Data from dam survey)

bold indicates actual depth measurements vs. estimated

Station	Vertical Dist.	Elevation	Description	Sediment Depth (ft)	HRB	Area between surfaces (sq ft)
0.00	N/A	350				
48.16	N/A	346	TBL		346.00	
59.20	N/A	344	BBL	6	338.00	33.1
103.26	N/A	343	CHAN	**7**	**336.00**	286.4
128.41	N/A	343	CHAN	**7**	**336.00**	176.1
141.23	N/A	344	CHAN	6	338.00	83.3
153.16	N/A	345	CHAN		345.00	35.8
155.43	N/A	346	BBR		346.00	0.0
158.35	N/A	348	TBR			0.0
166.50	N/A	350				0.0
					Total Area	614.7



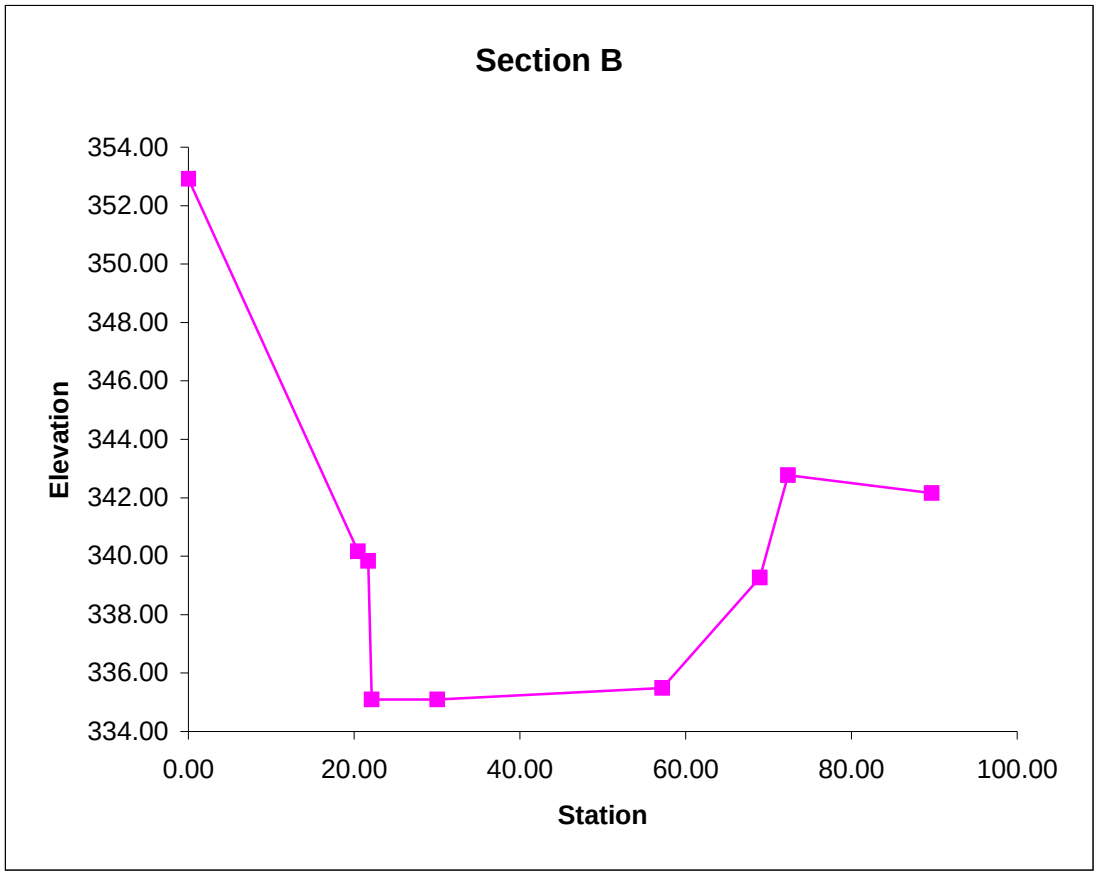
MILLBURY DAM

FIELD SURVEYED CROSS SECTION DATA

Section B

(Survey Section #4)

Station	Vertical Dist.	Elevation	Description	HI	HR
137.97	12.93	**358.35**	BM 4: Nail/Tree	5.54	5.30
-4.00		345.18	Instrument, #1	5.54	5.30
0.00	*8.43*	*352.91*	*TBL*	*5.23*	*5.30*
20.48	*-4.32*	*340.16*	*BANK*	*5.23*	*5.30*
21.70	-1.55	*339.83*	*WSE*	*5.23*	*8.40*
22.12	*-5.10*	*335.10*	*BBL*	*5.23*	*12.00*
30.02		*335.10*	*EST. CHAN*		
57.17	-6.82	335.50	CHAN	5.54	8.40
68.94	-3.05	339.27	BBR	5.54	8.40
72.36	0.46	342.78	TBR	5.54	8.40
89.70	*-0.86*	*342.16*	*Instrument, #2*	*5.54*	*5.30*



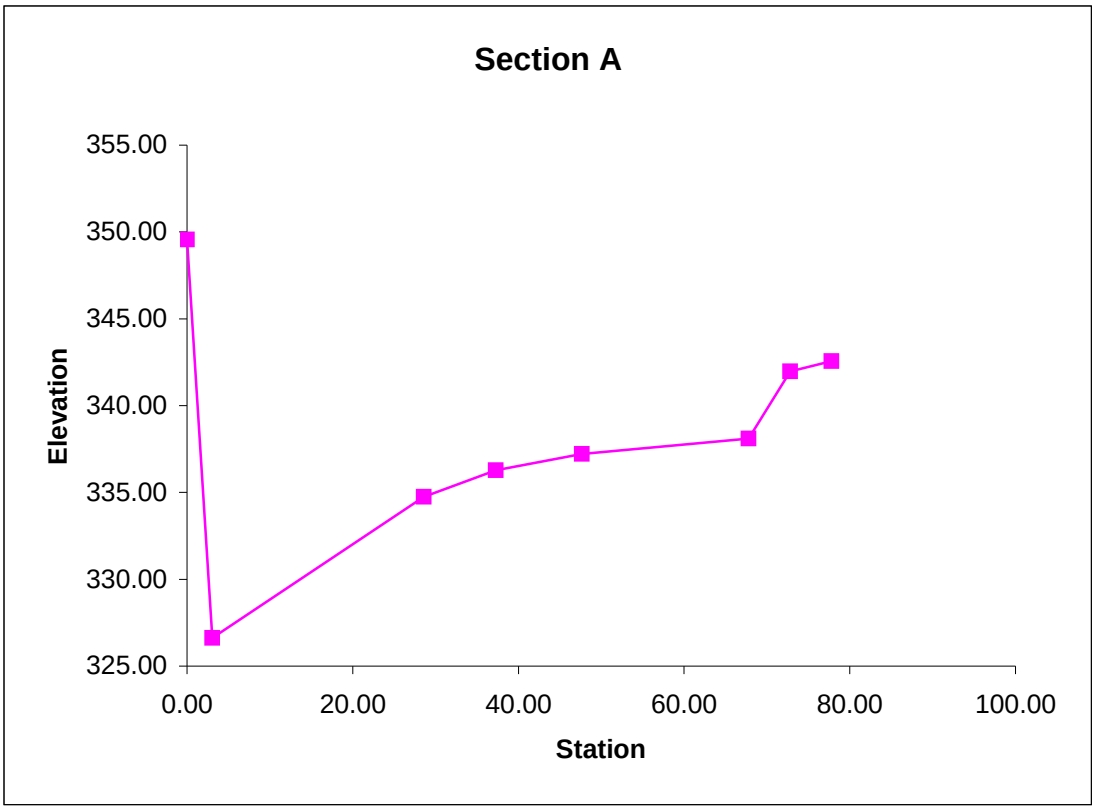
MILLBURY DAM

FIELD SURVEYED CROSS SECTION DATA

Section A

(Survey Section #5)

Station	Vertical Dist.	Elevation	Description	HI	HR
137.97	12.93	**358.35**	BM 4: Nail/Tree	5.54	5.30
0.00	7.54	349.56	TBL	5.35	5.30
3.05	-5.10	326.62	BBL	5.35	15.60
28.59	-4.18	334.74	CHAN	5.35	8.40
37.28	-3.23	336.28	CHAN	5.35	8.40
47.65	-2.29	337.22	CHAN	5.35	8.40
67.80	-1.41	338.10	BBR	5.35	8.40
72.79	-0.64	341.97	TBR	5.35	5.30
77.80	-2.86	342.56	Instrument	5.54	5.30

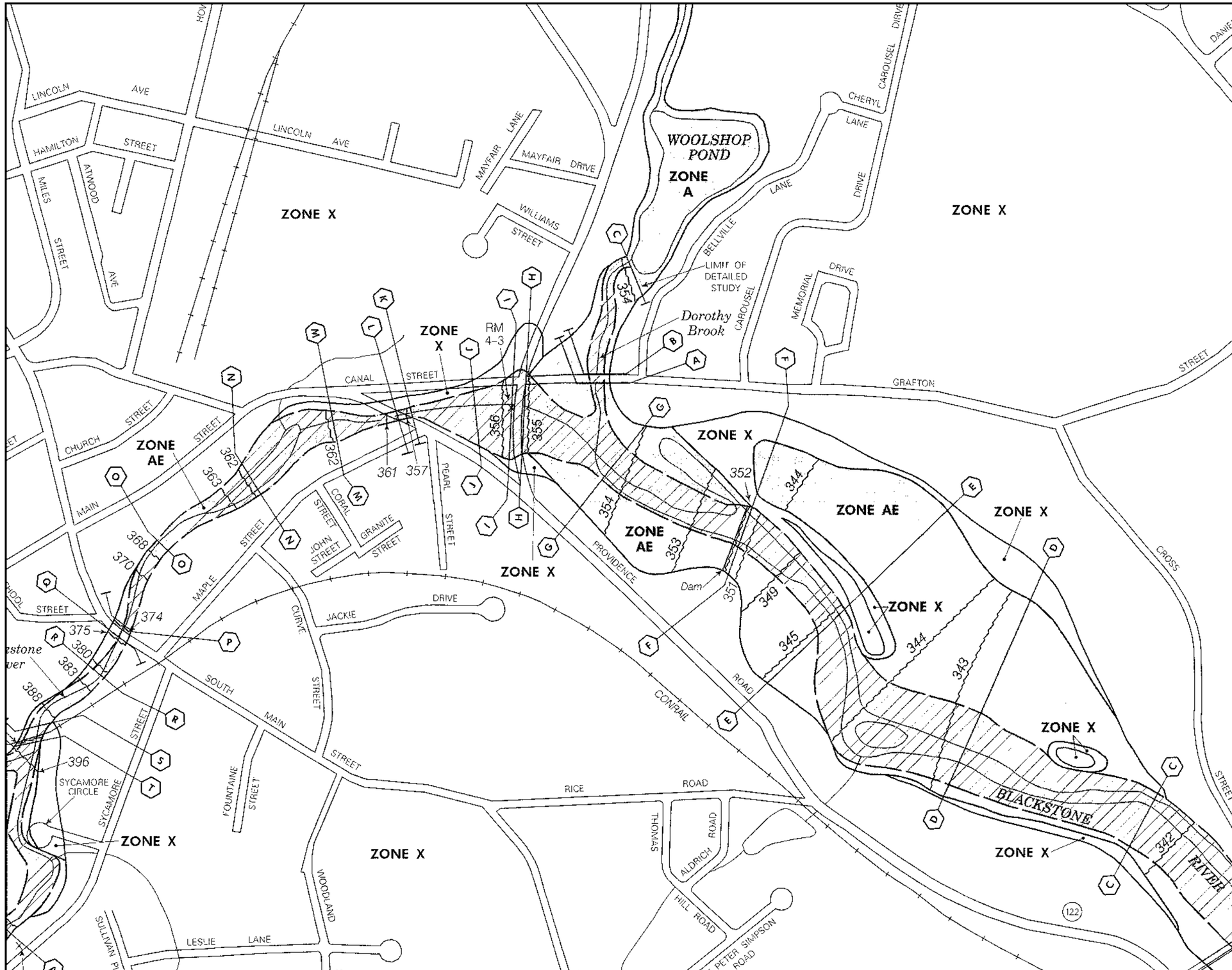


APPENDIX B

FEMA DATA

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

APPROXIMATE SCALE
500 0 500 FEET



NATIONAL FLOOD INSURANCE PROGRAM

FIRM
FLOOD INSURANCE RATE MAP

TOWN OF
MILLBURY,
MASSACHUSETTS
WORCESTER COUNTY

PANEL 4 OF 6

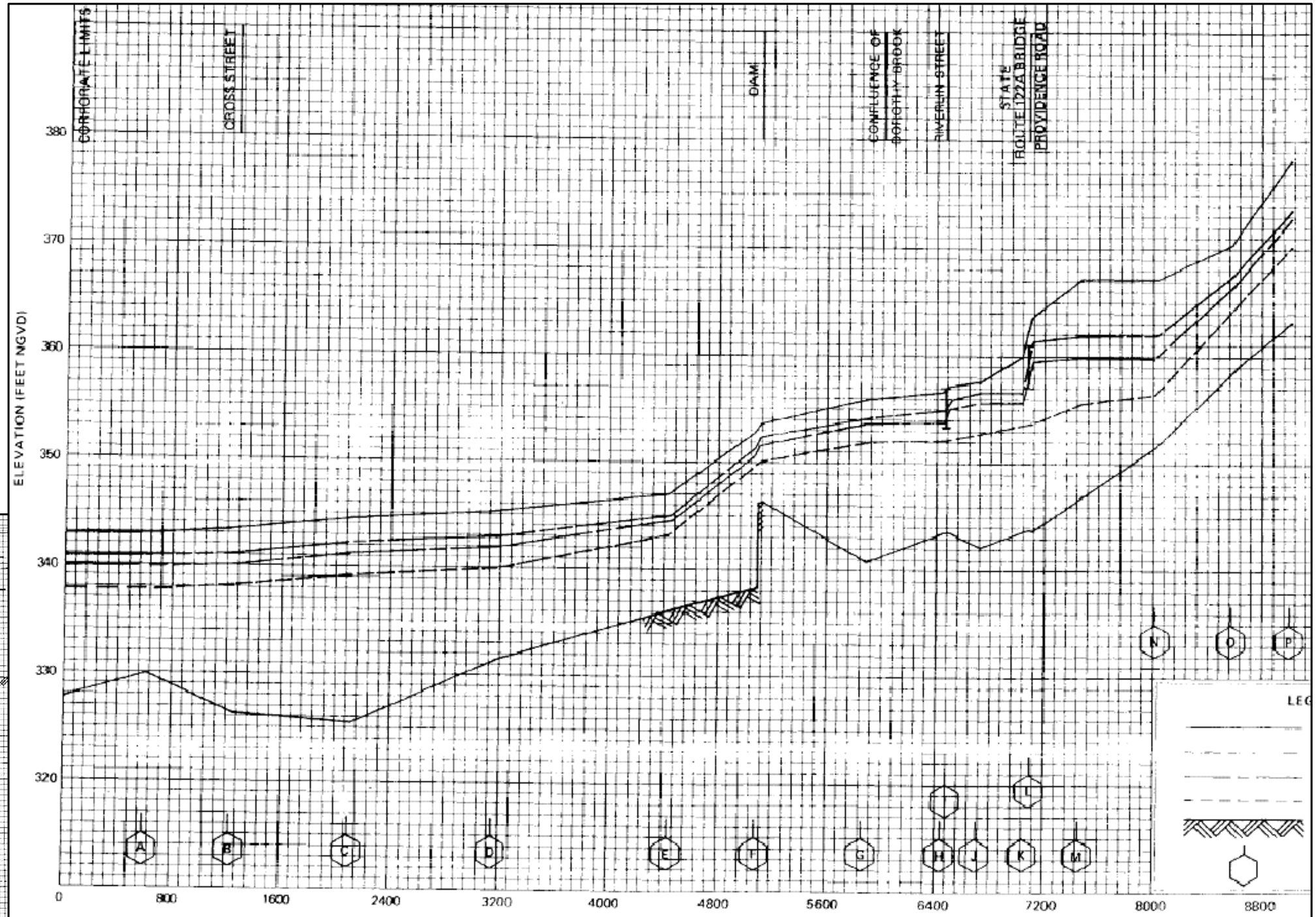
(SEE MAP INDEX FOR PANELS NOT PRINTED)

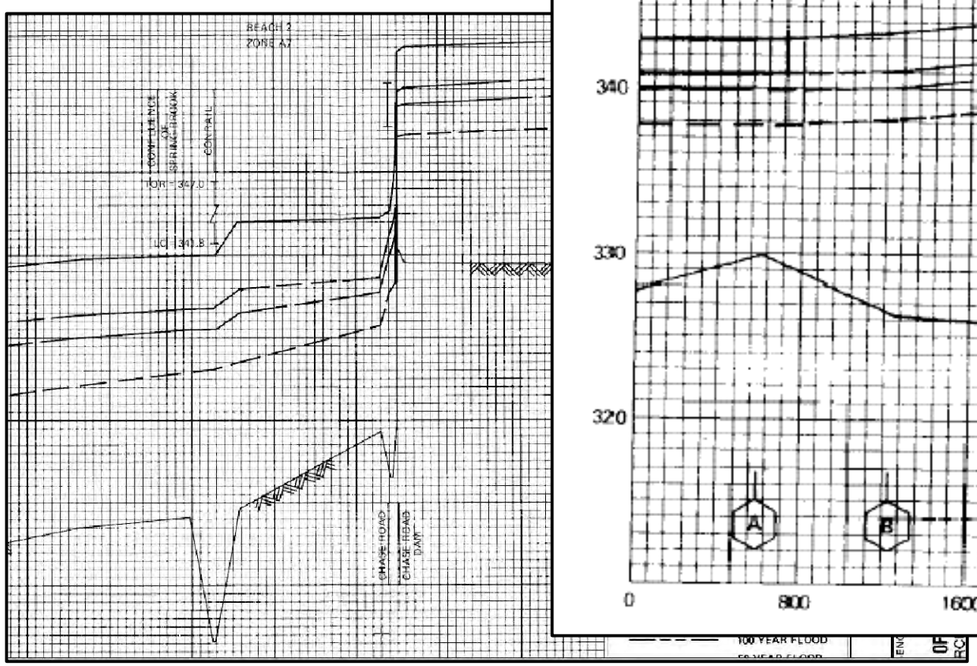
COMMUNITY - PANEL NUMBER
250318 0004 C

MAP REVISED:
JANUARY 7, 2000

Federal Emergency Management Agency

This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov


ELEVATION (FEET NGVD)
380
370
360
350
340
330
320
0
800
1600
2400
3200
4000
4800
5600
6400
7200
8000
8800
CORPORATE LIMITS
CROSS STREET
DAM
CONFLUENCE OF
DORCHIN BROOK
DIVERLIN STREET
STATE
ROUTE 122A BRIDGE
PROVIDENCE ROAD
A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P
LEG

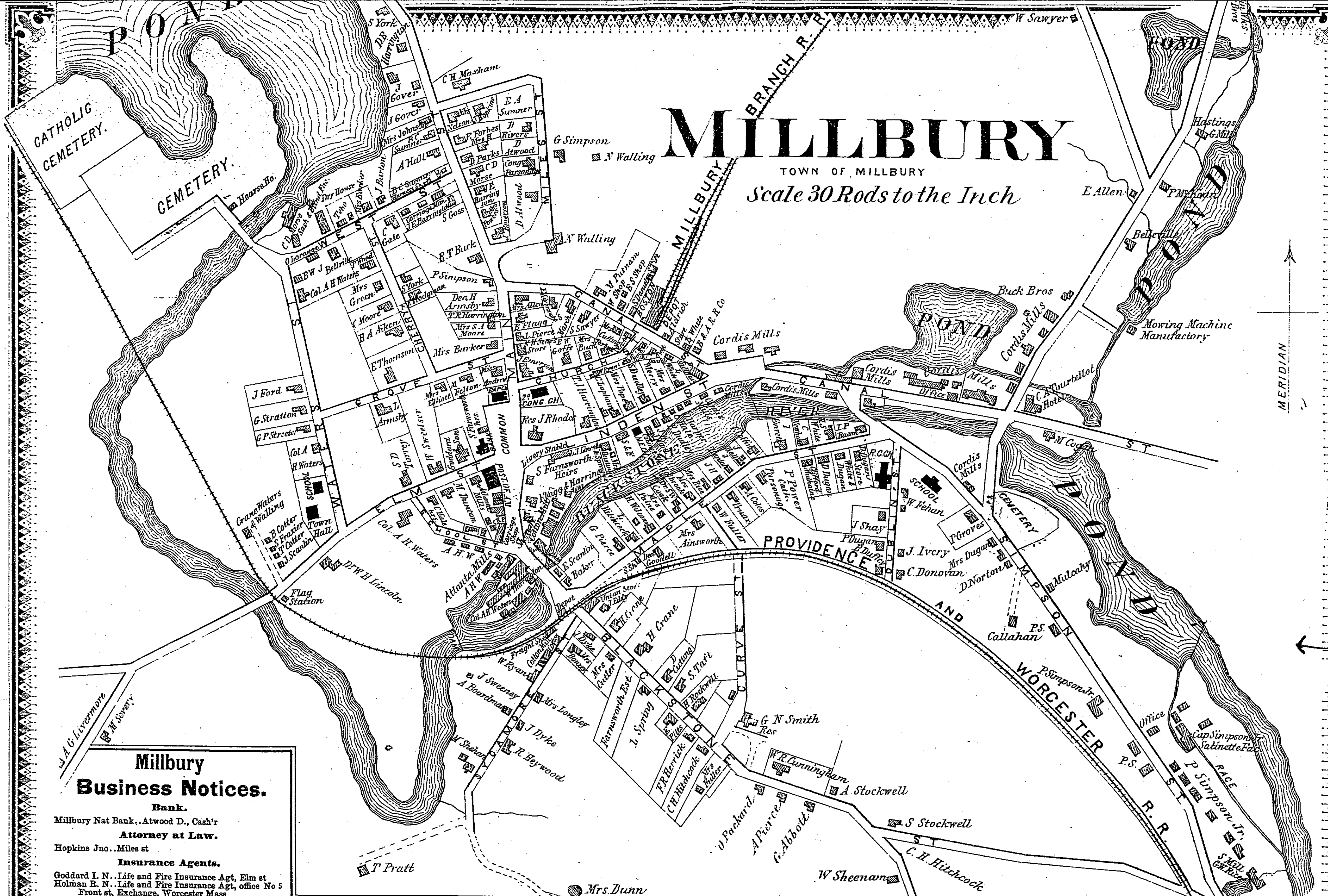

BEACH 2
ZONE A2
CONFLUENCE
OF
SPRING BROOK
CONTROL
TOP 347.0
DD 341.5
CHASE ROAD
CHASE ROAD
DAM
100 YEAR FLOOD

APPENDIX C

OTHER PLANS

1870 MAP
1917 MAP
MILLBURY FORCE MAIN
RIVERLIN STREET BRIDGE
PROVIDENCE STREET BRIDGE

FROM: 1870 DeBeer's Worcester County MAP Book



*Original Mill and DAM built in 1830 by Sheperd; Ridgeway. The Peter Simpson Satinette Mill

Millbury Business Notices.

Bank.

Millbury Nat Bank..Atwood D., Cash'r

Attorney at Law.

Hopkins Jno..Miles st

Insurance Agents.

Goddard I. N..Life and Fire Insurance Agt, Elm st
Holman R. N..Life and Fire Insurance Agt, office No 5 Front st, Exchange, Worcester Mass

Physicians and Surgeons.

Lincoln W. H..Elm st
Spaulding L..Bramanville

Manufacturers.

Buck Bros..Chisel Manufrs
Brierly Jas..Manufr of Print Cloths
Emerson J..Manufr of Print Cloths
Flagg B..Cotton Manufr
Howard B. B..Agt "Cordis' Mills," Manufrs of Ticks, Stripes and Denims
Harrington J. E..Manufr of Carriages
Lovell W. A..Supt "Atlanta Mills"
Lapham M..Woolen Manufr, Bramanville
Morse C. D. & Co..Manufrs and Dealers in Doors, Sash, Blinds, &c. Building finish of all kinds constantly on hand
Putnam M..Manufr of Carriages, also the "Hathaway Regulator," Canal st
Rhodes Jno..Manufr Satinet Warps and Print Cloth
Ward J..Cabinet Maker, Linden st
Waters A. H..Manufr, res Elm st
Walling N..Manufr of Cassimeres, Bramanville
Waters O. H..Manufr firm of Crane & Waters, Bramanville
Wood J. G..Manufr of Boots and Shoes, also Farmer and Dealer in Fine Stock, West Millbury
Wheeler Cotton Mills..Manufrs of Cotton Sheetings, Bramanville

Merchants.

Bancroft H. L. & Co..Dealers in Dry Goods, Groceries, Hardware, Crockery, Paper Hangings, Boots, Shoes, and all articles usually found in a Country Store, Bramanville
Briggs & Co..Cotton Waste and Paper Stock Dealers, Canal st
Goddard & Son Dealers in Boots and Shoes, Elm st, Millbury
Handy E..Dealer in Groceries, Fish, Oysters, Fruits, Confectionery and Fancy Goods, Bramanville
Hitchcock C. H..Agt "Union store," Millbury
Lumbard C. O..Miller and Dealer in Grain and Meal, West Millbury
Lovell A. B..Dealer in Boots, Shoes, Hats, Caps and Yankee Notions, Bramanville
Rice Geo. W..Dealer in all kinds Wood and Lumber, Millbury
Sears N. H..Apothecary, Main st, Millbury
Winter A. S..Agt Bramanville "Union Store," Dealer in Dry Goods, Crockery, Groceries, Flour, Feed, &c
White Levi..Dealer in Groceries and Provisions, Canal st, Millbury

Hotel.

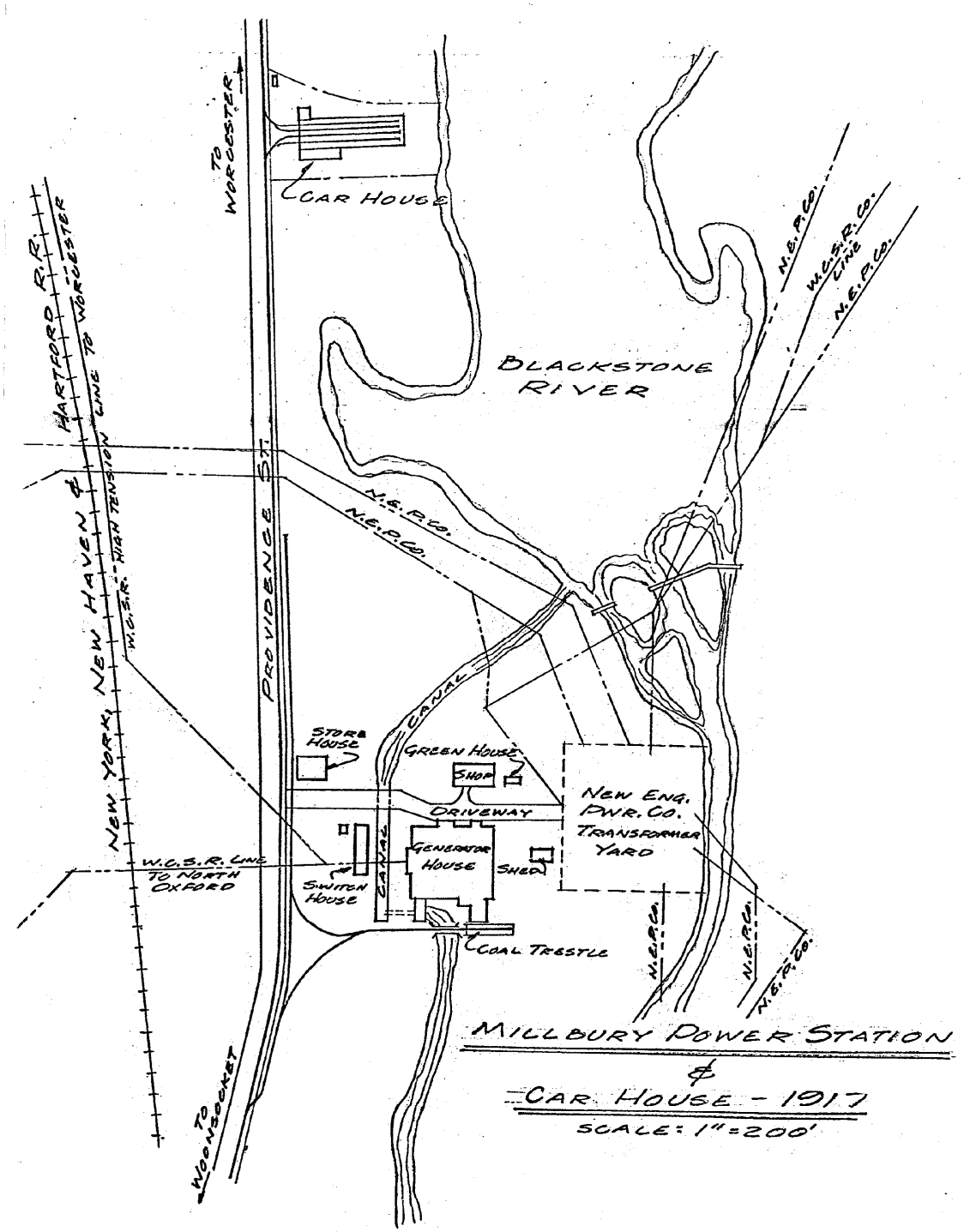
Tourtellot C. A..Propt of Hotel, Millbury

Livery Stables.

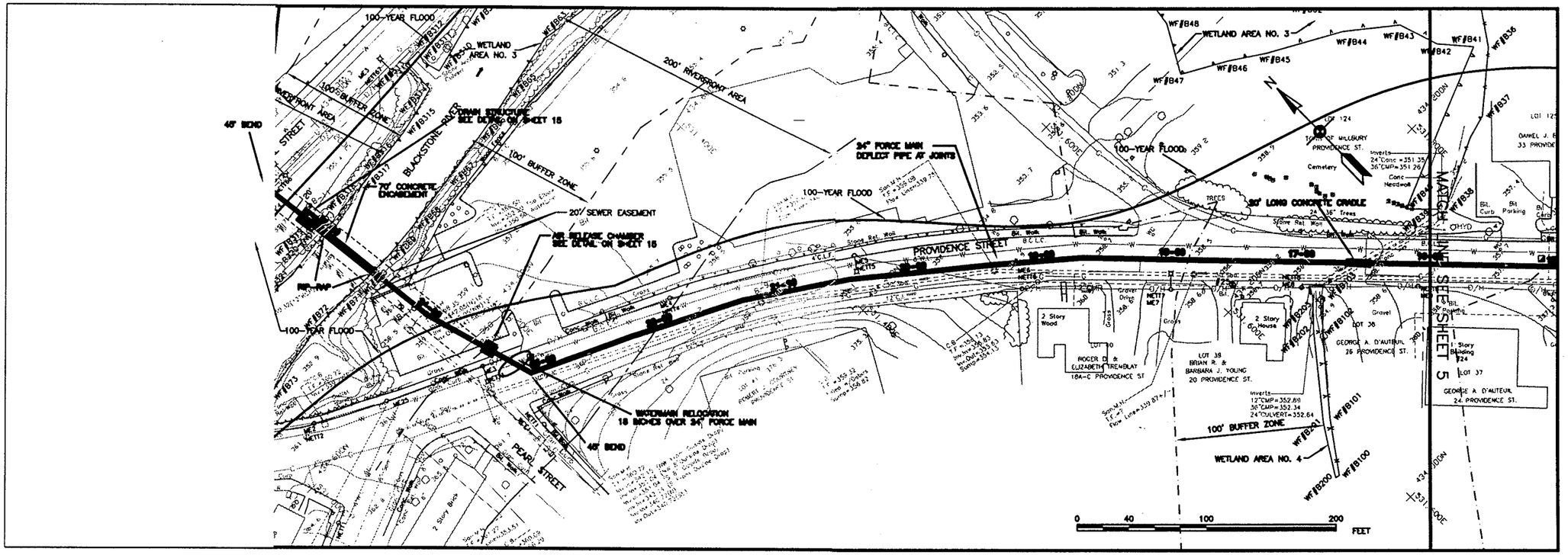
Lovell W. F..Propt, Bramanville
Lincoln L. J..Propt, Linden st, Millbury

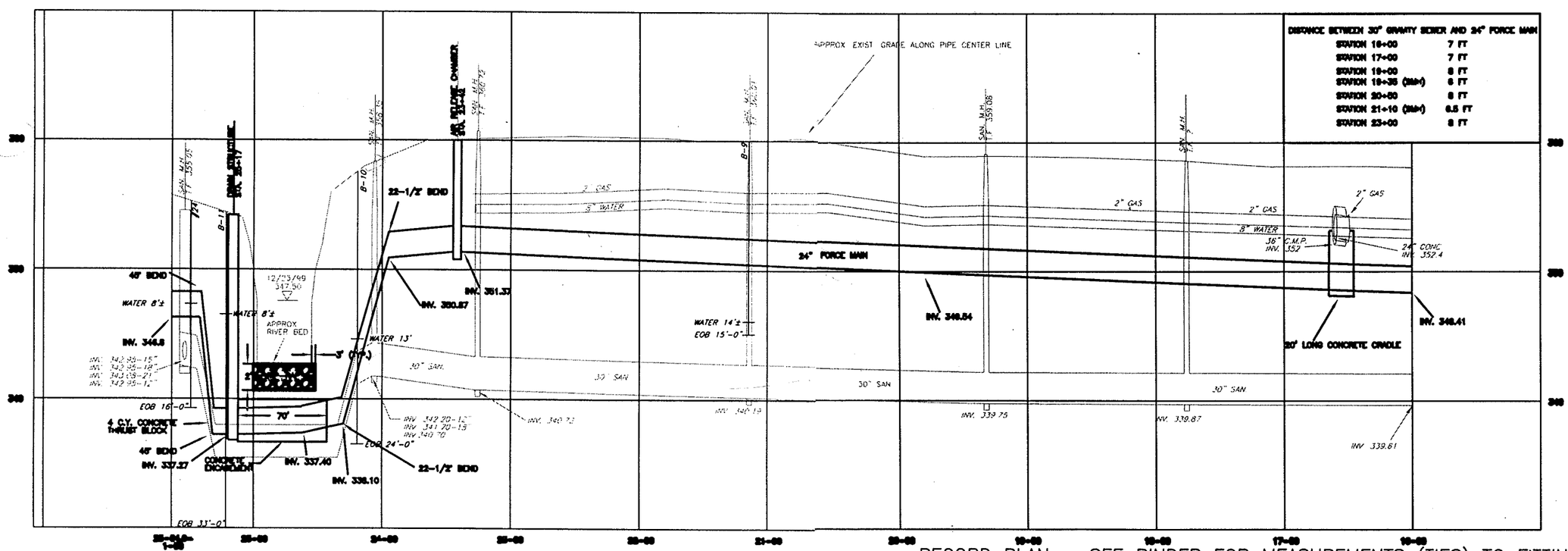
Miscellaneous.

Armsby H..Res Main st
Bowen R. E..Post Master, Millbury
Burminghaus R..Barber, Linden st, Millbury
Bancroft S..Carpenter and Joiner, Bramanville
Crane R. R..Res Blackstone st
Dwinell L..Farmer
Doherty M. J..Pastor Catholic Church
Everett I..Gardener, Maple st



WORCESTER CONSOLIDATED ST. RWY. COMPANY





RECORD PLAN – SEE BINDER FOR MEASUREMENTS (TIES) TO FITTINGS

EARTH TECH
655 Winding Brook Drive Glastonbury, CT (860) 657-1200

FULL SIZE DRAWING – 4"

1	ISSUED WITH REVISIONS 30%-PLAN	MJB	CBB	11-1-99	BWC
0	ISSUED TO REVIEWED PLAN				BWC
NO.	REVISIONS				

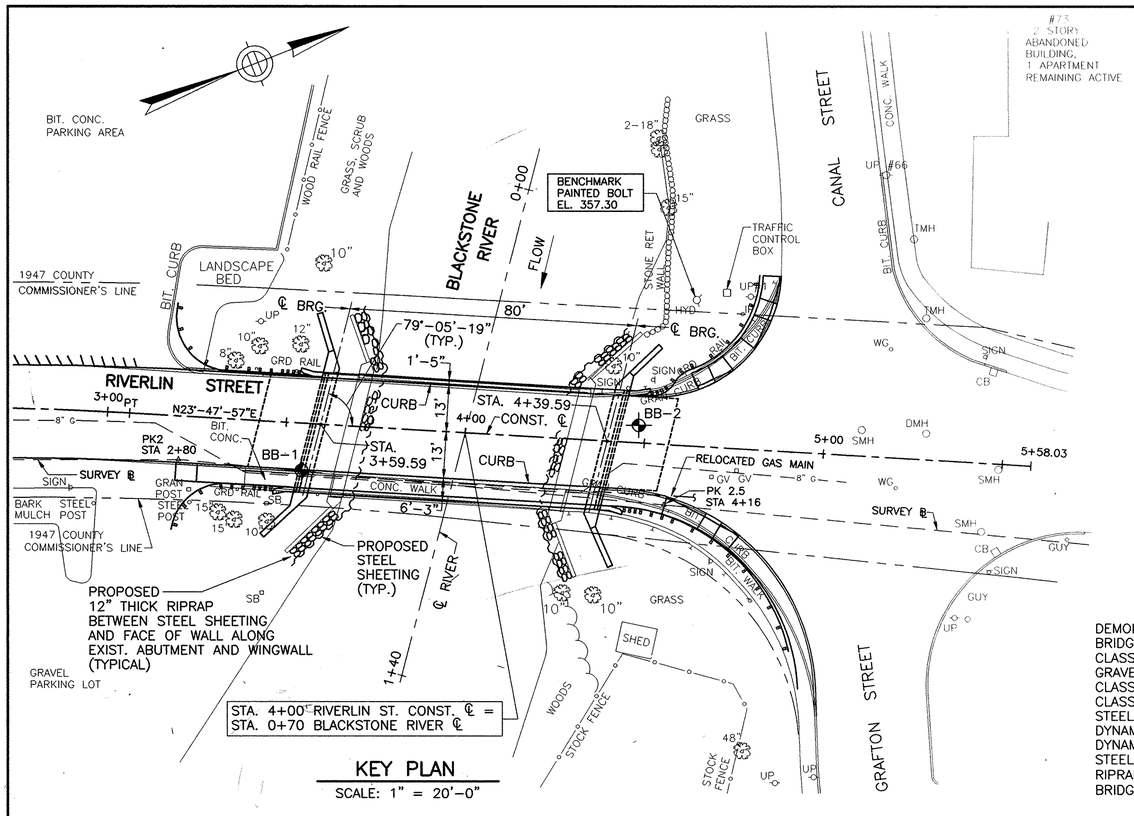
MILLBURY, MA.
MILLBURY FORCE MAIN
PROVIDENCE STREET
STA. 16+00 TO STA. 25+64.0

DESIGNED BY MJB	DWG SCALE 1"=20' HOR. 1"=5' VERT.
DRAWN BY WF	CONTRACT NO 22
CHECKED BY BWC	BWC OCT 2001

6

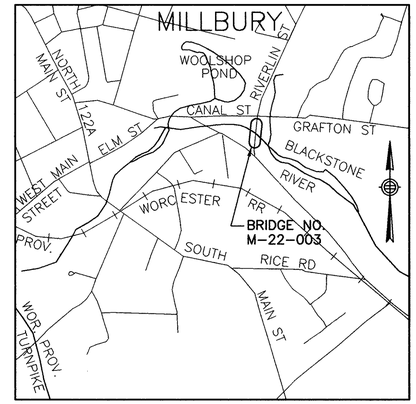
SHEET 6 OF 15

STATE	FED. AID PROJ. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
MASS.		2001	17	33
PROJECT FILE NO. 600340				



KEY PLAN

SCALE: 1" = 20'-0"



LOCUS PLAN

500 0 1000 2000

SCALE 1 INCH = 1000 FEET

ESTIMATED QUANTITIES

(NOT GUARANTEED)

DEMOLITION OF BRIDGE, BRIDGE NO. M-22-003	1	L.S.
BRIDGE EXCAVATION	350	C.Y.
CLASS B ROCK EXCAVATION	20	C.Y.
GRAVEL BORROW	140	C.Y.
CLASS I BIT. CONCRETE PAVEMENT (TYPE I-1)	21	TONS
CLASS I DENSE BINDER COURSE FOR BRIDGE	21	TONS
STEEL PILE HP 14 IN 89 LB	1,310	L.F.
DYNAMIC LOAD TEST PREPARATION	2	EA.
DYNAMIC LOAD TEST BY CONTRACTOR	2	EA.
STEEL SHEETING	92,500	LB
RIPRAP	35	TONS
BRIDGE STRUCTURE, BRIDGE NO. M-22-003	1	L.S.

GENERAL NOTES

DESIGN:
IN ACCORDANCE WITH THE 1996 AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO) STANDARD SPECIFICATIONS FOR HIGHWAY BRIDGES, 16TH EDITION WITH CURRENT INTERIM SPECIFICATIONS THROUGH 1999, FOR HS20-44 LOADING.

BENCH MARK:
PAINTED BOLT ON HYDRANT BONNET.
CONSTRUCTION ℄ 4+62, 42 FEET LEFT
EL. 357.30 NAVD, 1988

ELEVATIONS:
ELEVATIONS ARE BASED ON THE NORTH AMERICAN VERTICAL DATUM (NAVD) OF 1988

SURVEY:
UNIVERSAL ENGINEERING CORPORATION
100 BOYLSTON STREET - BOSTON, MASS. - JUNE, 1995.

SCALES:
SCALES NOTED ON THE PLANS ARE NOT APPLICABLE TO REDUCED SIZE PRINTS. DIVIDE SCALES BY 2 FOR HALF-SIZE PRINTS (A3).

FOUNDATIONS:
FOUNDATIONS MAY BE ALTERED, IF NECESSARY, TO SUIT CONDITIONS ENCOUNTERED DURING CONSTRUCTION, WITH THE APPROVAL OF THE ENGINEER.

UNSUITABLE MATERIAL:
ALL UNSUITABLE MATERIAL SHALL BE REMOVED WITHIN THE LIMITS OF THE EXCAVATIONS OF THE STRUCTURE, AS DIRECTED BY THE ENGINEER.

REINFORCEMENT:
REINFORCING STEEL SHALL CONFORM TO THE REQUIREMENTS OF ASTM DESIGNATION A615 GRADE 60 AND SHALL BE EPOXY COATED. ALL #4 BARS SHALL BE LAPPED 24" AND ALL #5 BARS SHALL BE LAPPED 30". FOR HORIZONTAL BARS WITH 12" OR MORE OF CONCRETE BELOW THE BAR, THE LAP LENGTHS SHALL BE 33" FOR #4 BARS AND 42" FOR #5 BARS. IF THE ABOVE BARS ARE SPACED 6" OR MORE ON CENTER, THE LAP LENGTH SHALL BE 80% OF THE LAP LENGTH GIVEN ABOVE. ALL OTHER BARS SHALL BE LAPPED AS SHOWN ON THE PLANS.

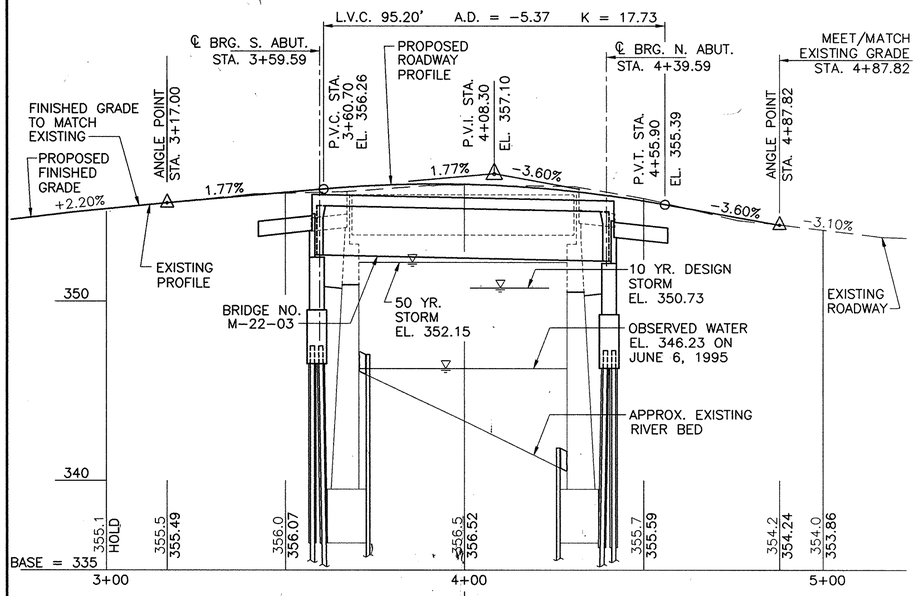
CONCRETE MIXES:
CEMENT CONCRETE IS DESIGNATED ON THE DRAWINGS BY STRENGTH, COARSE AGGREGATE SIZE, AND CEMENT CONTENT.
EXAMPLE: 4000, 3/4", 610

28-DAY COMPRESSIVE STRENGTH	= 4000 PSI
MAXIMUM AGGREGATE SIZE	= 3/4 INCHES
CEMENT CONTENT	= 610 LB/CU. YD.

TRAFFIC:
ROADWAY MUST BE KEPT CLOSED TO TRAFFIC AT ALL TIMES DURING THE DEMOLITION AND RECONSTRUCTION PHASES.

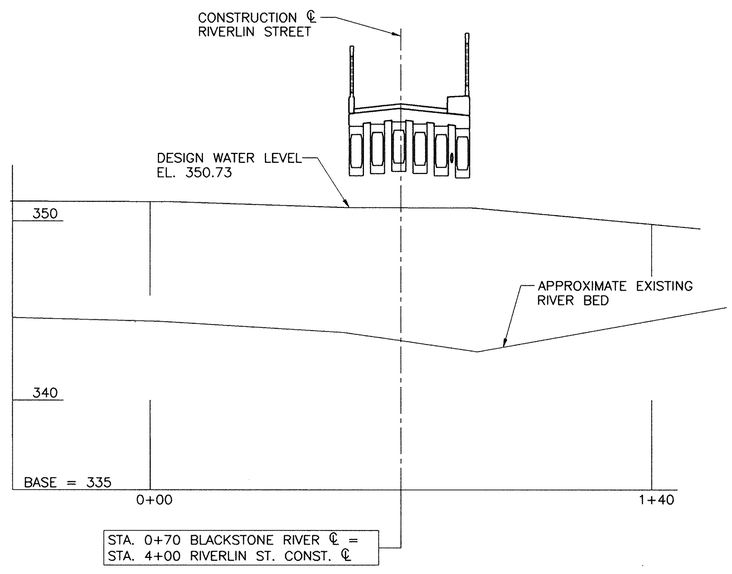
DATE:
TO BE PLACED ON THE INSIDE FACE OF THE NORTHWEST AND SOUTHEAST END POSTS. A SHEET SHOWING SIZE AND CHARACTER OF NUMERALS WILL BE FURNISHED. THE DATE USED SHALL BE THE LATEST YEAR OF CONTRACT COMPLETION AS OF THE DATE THE FIRST END POST IS CONSTRUCTED. ALL END POSTS SHALL FEATURE THE SAME DATE.

PILES:
PILES SHALL BE AASHTO M270 (ASTM A709) GRADE 36.
NO SPLICES SHALL BE FURNISHED IN THE PILES.



PROFILE ALONG CONSTRUCTION ℄ RIVERLIN STREET

SCALE: HOR. 1" = 20'-0"
VERT. 1" = 4'-0"



PROFILE ALONG BLACKSTONE RIVER ℄

SCALE: HOR. 1" = 20'-0"
VERT. 1" = 4'-0"

MAR. 26, 2004	⚠ SHEETS 4 & 5 REVISED - SHEETS 4A & 5A ADDED
MAR. 26, 2004	⚠ REMOVE PILES SW WING - ADD SPREAD FOOTING
JUL. 26, 2002	⚠ SHEET 5 REVISED -
9/1/01	ISSUED FOR CONSTRUCTION

COMMONWEALTH OF MASSACHUSETTS
STANLEY D. ELKERTON
No. 27678
REGISTERED PROFESSIONAL ENGINEER

UNIVERSAL ENGINEERING

100 BOYLSTON STREET
BOSTON, MA 02116-4693
TEL: (617) 542-8216
FAX: (617) 423-0373

MASS HIGHWAY

PROPOSED BRIDGE
MILLBURY

RIVERLIN STREET
OVER BLACKSTONE RIVER

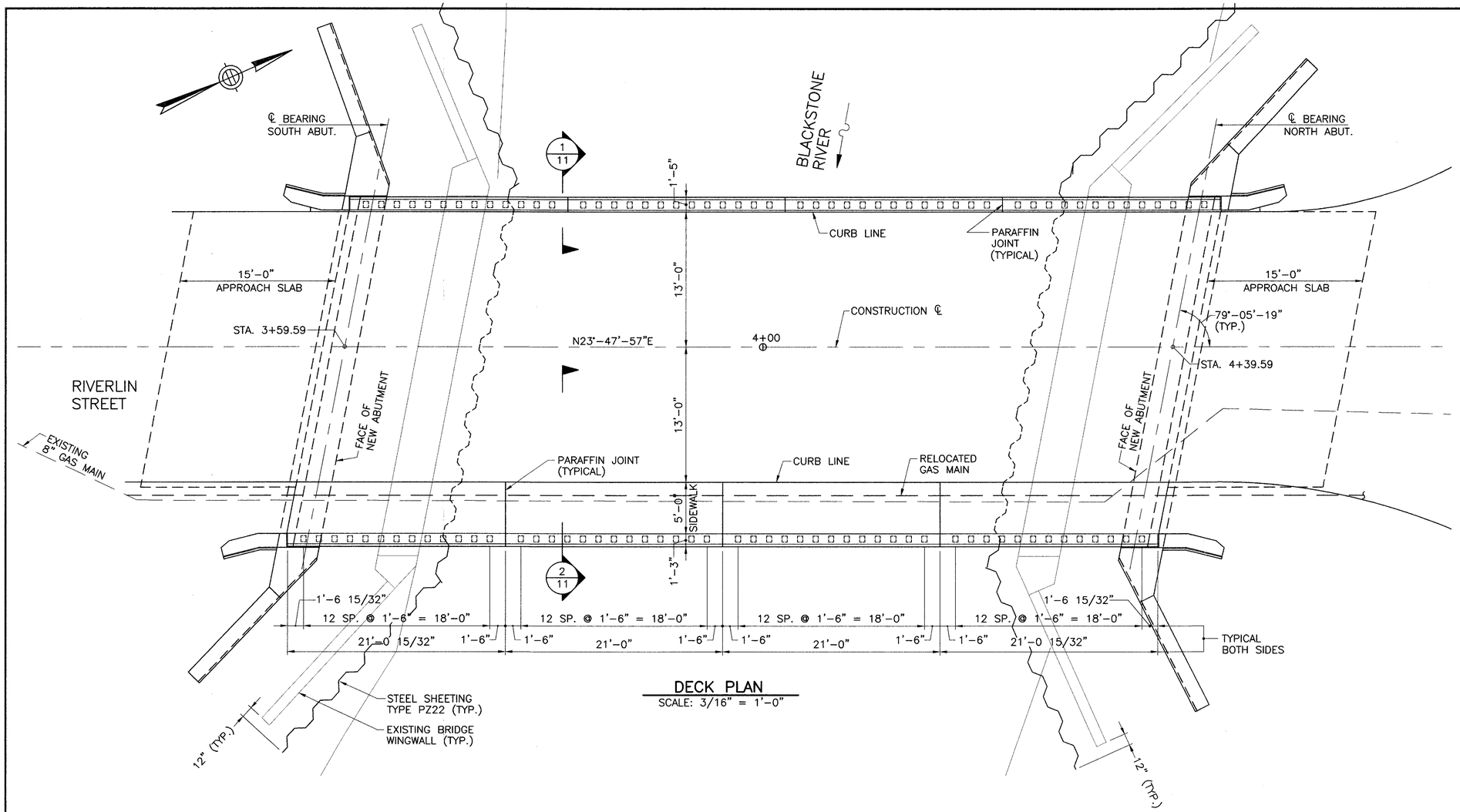
THE COMMONWEALTH OF MASSACHUSETTS
MASSACHUSETTS HIGHWAY DEPARTMENT
10 PARK PLAZA BOSTON, MASS

BRIDGE ENGINEER — CHIEF ENGINEER

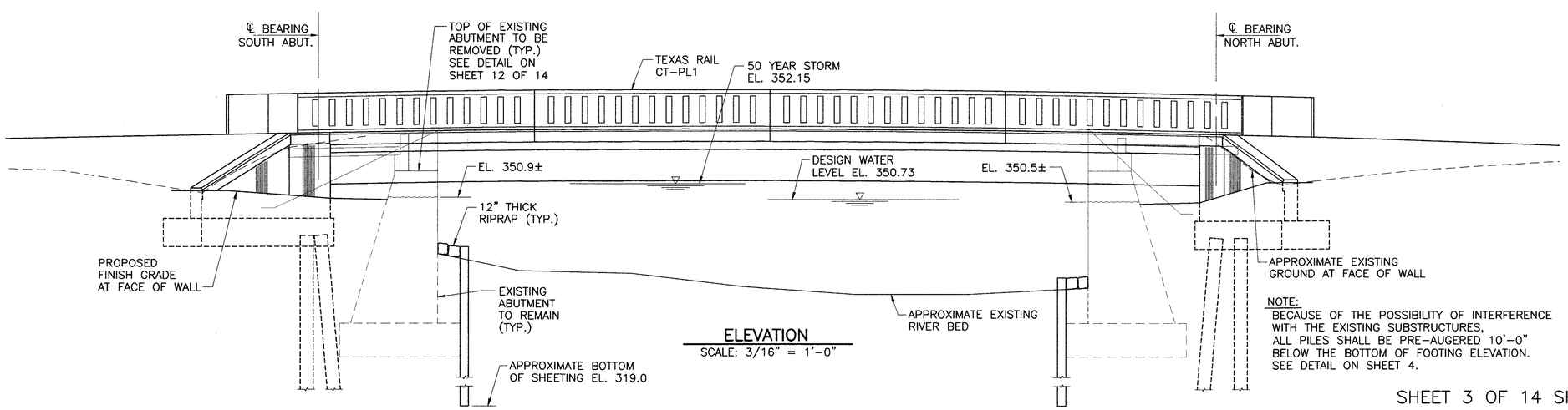
SHEET 1 OF 14 SHEETS BRIDGE NO. M-22-003 (AW4)

I:\9700105\FINAL PLANS\FINAL PLAN & PROFILE

STATE	FED. AID PROJ. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
MASS.		2001	19	33
PROJECT FILE NO. 600340				



DECK PLAN
SCALE: 3/16" = 1'-0"



ELEVATION
SCALE: 3/16" = 1'-0"

NOTE:
BECAUSE OF THE POSSIBILITY OF INTERFERENCE WITH THE EXISTING SUBSTRUCTURES, ALL PILES SHALL BE PRE-AUGERED 10'-0" BELOW THE BOTTOM OF FOOTING ELEVATION. SEE DETAIL ON SHEET 4.

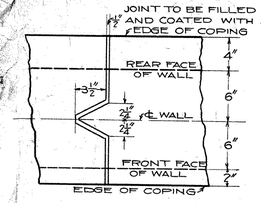
DATE	DESCRIPTION
9/1/01	ISSUED FOR CONSTRUCTION
USE ONLY PRINTS OF LATEST DATE	

SHEET 3 OF 14 SHEETS BRIDGE NO. M-22-003 (AW4)

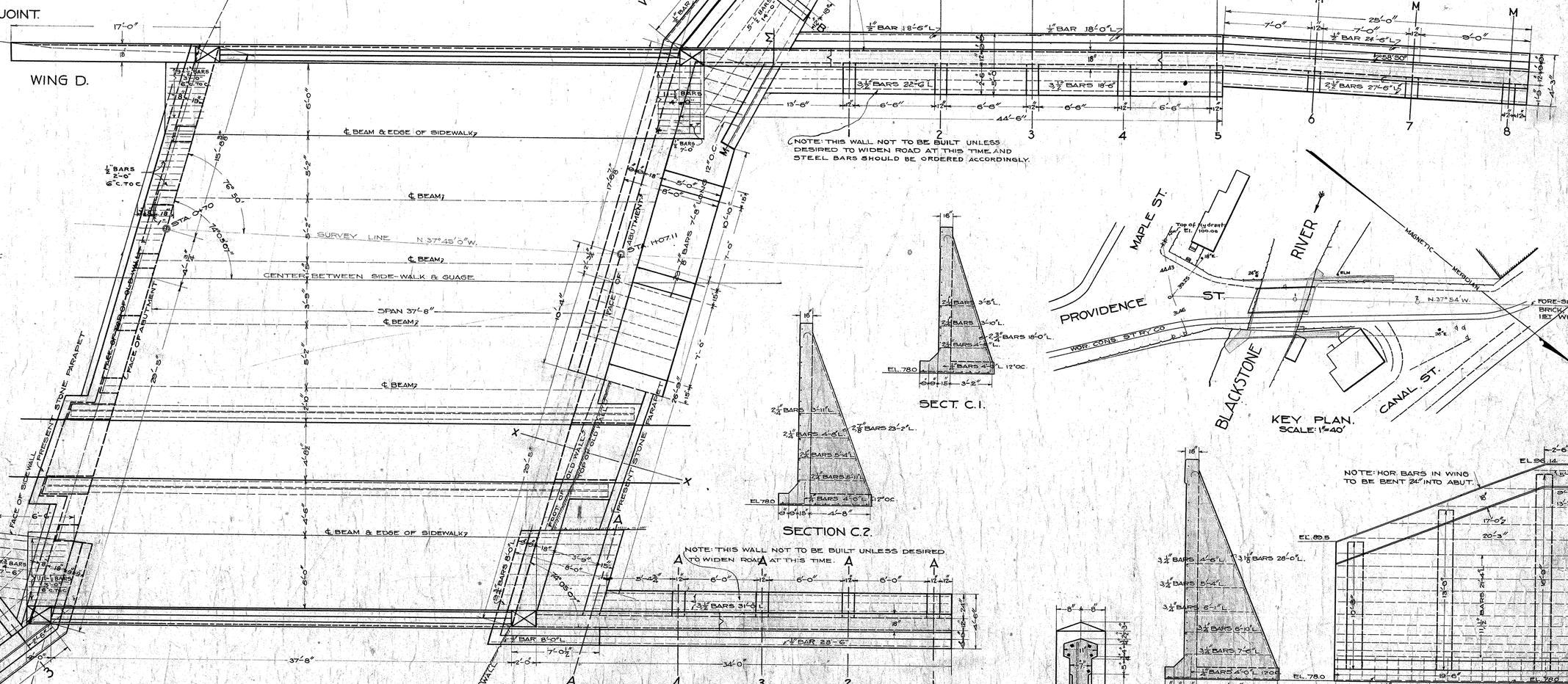
I:\9700105\FINAL PLANS\DECKPLN

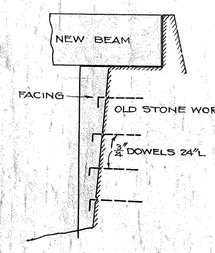
FINISH: ALL EXPOSED SURFACES TO BE RUBBED SMOOTH WITH CORUNDUM BRICK AND LEFT FREE FROM ALL FORM MARKS & IMPERFECTIONS.

DATE: TO BE PLACED IN MIDDLE OF PANEL ON INSIDE OF FENCE. FOR SIZE & CHARACTER SEE ANOTHER SHEET.



DETAIL OF EXPANSION JOINT.
SCALE: $1\frac{1}{2}$"=1 FT.

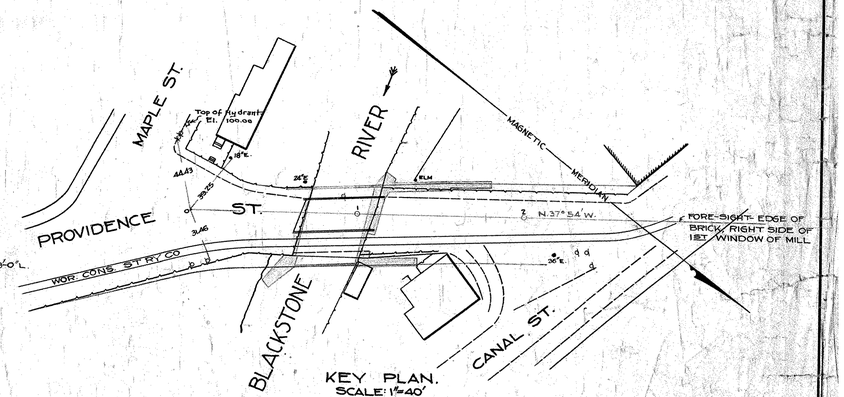




SECTION X-X

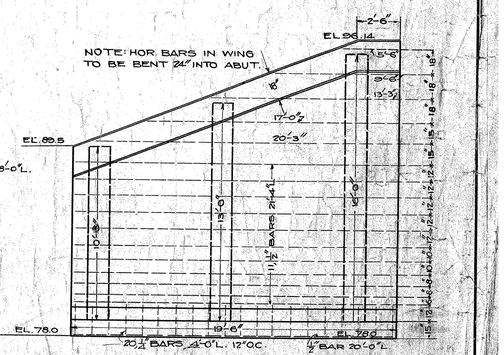
SECT. C.1.

SECTION C.2.

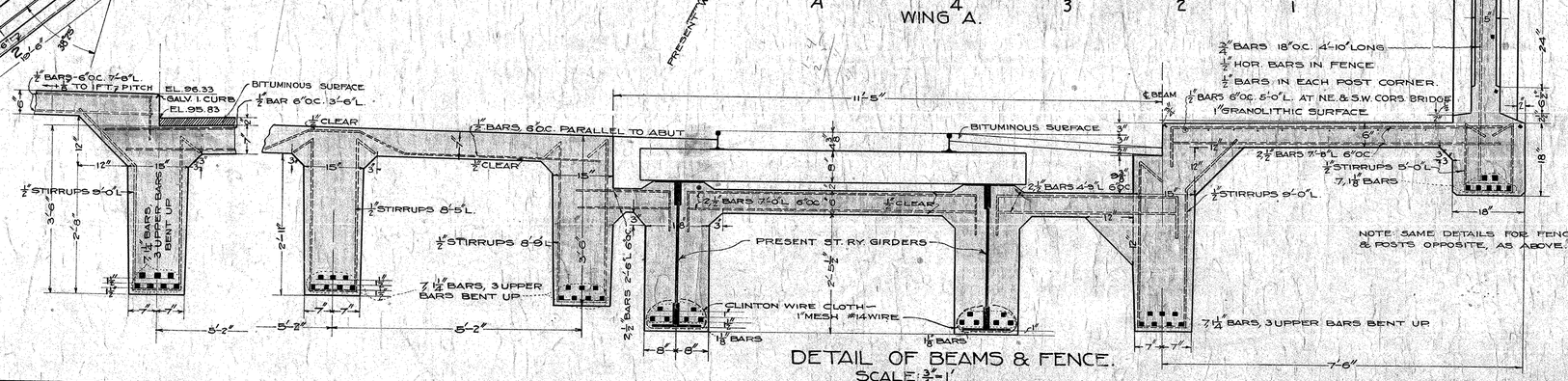


KEY PLAN.
SCALE: 1"=40'

SECTION C.3.



ELEVATION WING C.



DETAIL OF BEAMS & FENCE.
SCALE: $\frac{3}{4}$"=1'

PLAN OF
PROPOSED REINFORCED CONCRETE BRIDGE
OVER BLACKSTONE RIVER IN THE

TOWN OF MILLBURY

SCALE: FOUR FEET TO THE INCH UNLESS OTHERWISE NOTED.
OFFICE OF THE MASSACHUSETTS HIGHWAY COMMISSION.
STATE HOUSE, BOSTON, MASS.
OCT. 1917.

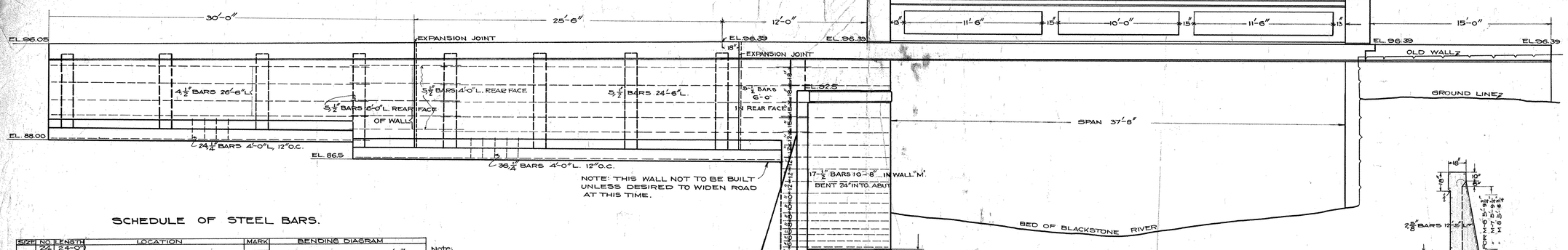
CHIEF ENGINEER.

MADE BY [illegible]
CHECKED " C.J.R.

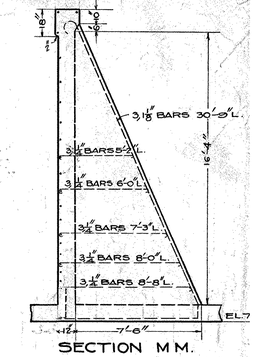
179-330-013

M-22-5

BRIDGE



EASTERLY EL. & EL. WING M.



SECTION M M.

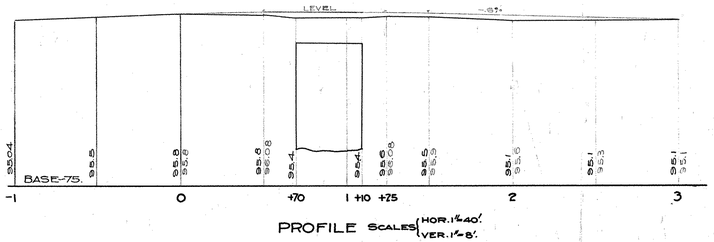
SCHEDULE OF STEEL BARS.

SIZE	NO	LENGTH	LOCATION	MARK
5/8"	24	24'-0"		
	24	20'-6"	LOWER BARS IN INTER. BEAMS (STRAIGHT)	B1
	6	16'-4"		
	6	18'-6"	UPPER " " " (lap 4'-7")	B2
	6	18'-6"		
	12	27'-6"	(STRAIGHT)	
	12	17'-10"	" BARS IN INTER. " "	B3
	12	12'-3"	" " " " "	B3
	24	25'-0"	" " GIRDER " (lap 4'-0")	B4
7/8"	28	27'-0"	" " OUTER " " "	B5
	3	28'-0"	" " COUNTER C3	C4
	3	30'-9"	" " " MM	C2
	3	30'-2"	" " " AA	C3
1"	2	23'-1"	" " " BB	C6
7/8"	42	18'-2"	VERT " " NO ABUT.	A1
	28	21'-8"	" " " FTG.	F
	2	23'-2"	" " COUNTER C2	C1
	7	7'-6"	" " S. ABUT. FTG.	F
	2	18'-0"	" " " C1	C5
3/4"	50	8'-0"	VERT " " FENCES	F2
	3	8'-0"	" " N. ABUT. FTG.	F14
	8	12'-6"	" " COUNTERS M6,7,8	C7
5/8"	10	15'-1"	" " " M1,2,3,4,5	C8
	8	14'-0"	" " " A1,2,3,4	C9
	164	12'-1"	" " MAIN FLOOR	F3
	16	5'-0"	VERT " " POST CORS.	P
	312	9'-8"	" " SIDEWALK FLOOR	F4
	156	4'-9"	" " FLOOR UNDER TK	F5
	184	7'-0"		F5
	184	9'-8"		F4
	78	3'-8"	FLOOR BAR OVER E. CURB BEAM	F6
	78	22'-0"	HOR " " IN FENCE & COPING	F7
	268	22'-0"	STIRRUP " " OUTER BEAMS	S1
	68	8'-0"	" " " CURB "	S2
	34	8'-9"	" " " 1ST BEAM E. OF TRK	S3
	102	8'-5"	" " " INTER. BEAMS	S4
	11	31'-0"	" " " WING B FTG	F8
	5	14'-0"		
	11	12'-6"	HOR " " " "	W1
	1	18'-6"		
	1	20'-6"		
	1	21'-6"	" " " C "	F9
	1	23'-0"		
	1	21'-0"		
	1	22'-0"		
	11	21'-4"	" " " " "	W2
	1	20'-3"		
	1	17'-0"		
	1	13'-3"		
	1	9'-6"		
	1	5'-6"		
	1	18'-6"	" " " M "	F11
	3	22'-6"		F10
	3	27'-6"	" " " " "	F10
	5	34'-6"	" " " " "	W9
	1	19'-0"		
	3	18'-0"	" " " "	F11
	3	6'-0"	" " " " (rear)	W4
	4	26'-6"	" " " " "	W5
	1	18'-6"	" " " A FTG	F13
	3	31'-0"		F12
	4	12'-0"	" " " " "	W6
	1	8'-0"		W6
	8	8'-0"	" " " "	W7
	4	16'-0"	" " " " "	W8
	2	16'-6"	" " " " COPING	G1
	2	18'-6"		
	2	39'-0"	" " " M "	G2
	2	26'-0"		
	2	18'-0"	" " " "	
	5	4'-0"	" " " M (rear)	W4
	7	10'-0"	GALV. I. CURB	
	1	11'-0"		
	1	3'-0"		
	65	2'-0"	BARS IN END OF FLOOR	F15
1/2"	17	10'-8"	HOR BARS IN WING M	W3
	18	5'-0"	" " " " " (rear face)	W10
	2	7'-0"	TRANS. " " SIDEWALK END	F16
	20	3'-0"	BARS IN END OF SIDEWALKS	F16
	11	4'-0"	" " " " "	F16

BENDING DIAGRAM

Note: All bars not shown here are straight.

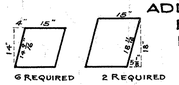
#5 BARS NO	LENGTH	LOCATION	MARK
3	5'-2"		
3	6'-0"		
3	7'-3"	HOR. IN COUNTER MM	H1
3	8'-0"		
3	8'-9"		
3	5'-5"		
3	6'-4"	" " " AA	H2
3	7'-5"		
3	8'-1"		
3	4'-6"		
2	5'-4"		
2	6'-1"	" " " C3	H3
2	6'-10"		
2	7'-6"		
2	3'-11"		
2	4'-8"	" " " C2	H4
2	5'-4"		
2	5'-11"		
2	3'-5"		
2	3'-10"	" " " C1	H5
2	4'-5"		
2	3'-10"		
2	4'-8"	" " " B8	H6
2	5'-3"		
2	5'-7"		
125	4'-0"	FOUNDATION TIES	T1
225	5 SQ. FT.- 1" MESH, #14 WIRE		
	CLINTON CLOTH		
30	4"x11 1/2"	METAL SEPARATORS	
100	3/4"x2'-0"	ABUTMENT DOWELS	D1



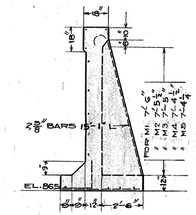
PROFILE SCALES {HOR. 1"=40' VER. 1"=8'}

APPROXIMATE QUANTITIES.

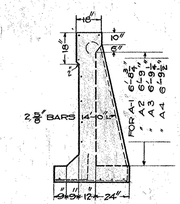
EXCAVATION	250 C.Y.
1:2 1/2:5 CONCRETE	145 "
1:2:4 "	105 "
ROCK EMBANKMENT	20 "
GRANOLITHIC SURFACE	500 S.FT.
2" BITUMINOUS "	158 S.YDS.
STEEL	
ADDITIONAL FOR RETAINING WALLS	
EXCAVATION	85 C.Y.
1:2 1/2:5 CONCRETE	45 "



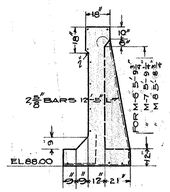
DETAIL OF 1/2" ZINC BEARING PLATES



SECTS. M1,2,3,4 & 5.

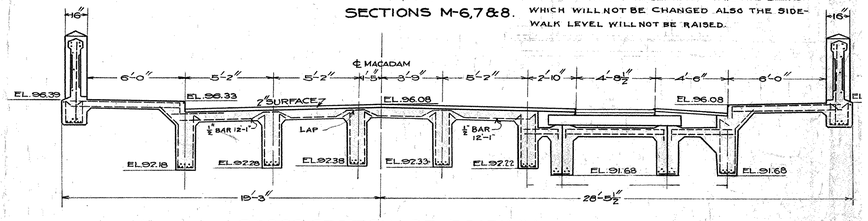


SECTS. A-1,2,3 & 4.

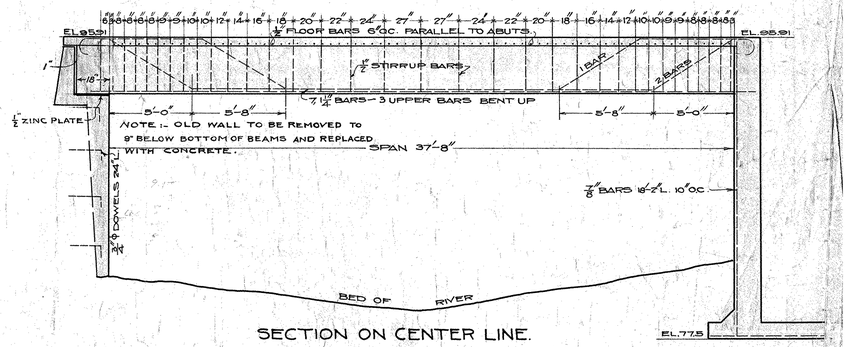


SECTIONS M-6,7 & 8.

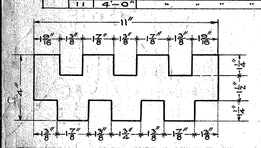
NOTE:- IF BITUMINOUS SURFACE IS NOT USED ALL THE BEAMS AND SLAB MUST BE RAISED 2 INCHES EXCEPT THE RAILROAD BEAMS WHICH WILL NOT BE CHANGED ALSO THE SIDEWALK LEVEL WILL NOT BE RAISED.



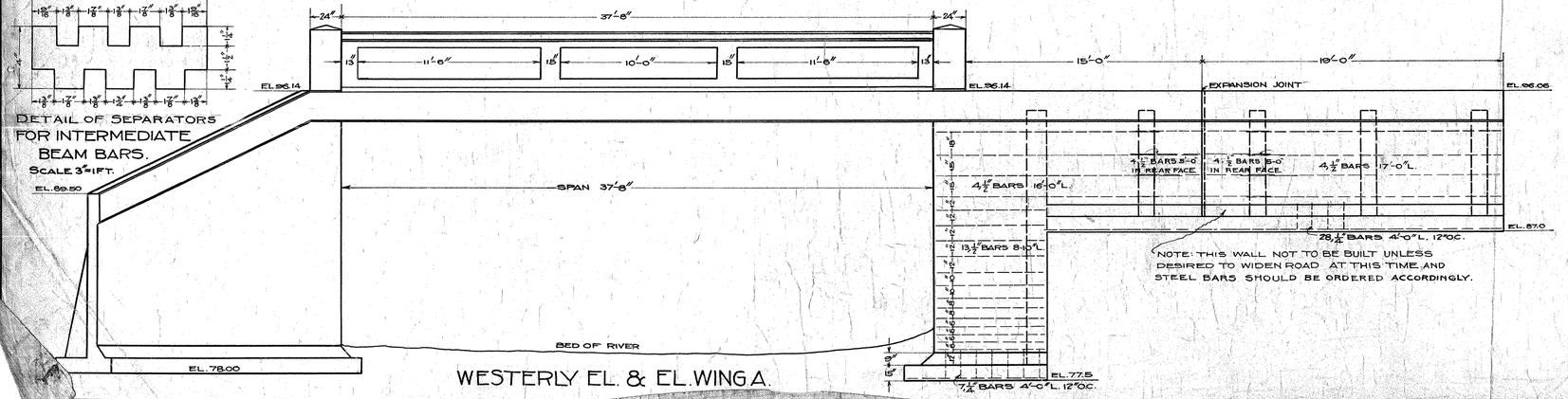
CROSS-SECTION OF ROADWAY.



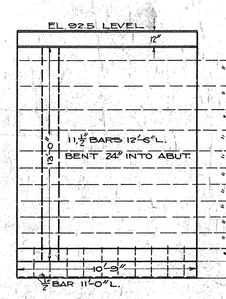
SECTION ON CENTER LINE.



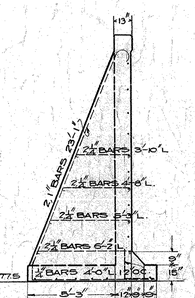
DETAIL OF SEPARATORS FOR INTERMEDIATE BEAM BARS.
SCALE 3"=1FT.



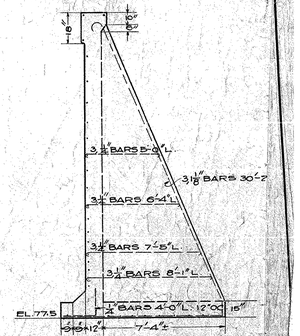
WESTERLY EL. & EL. WING A.



ELEVATION WING B.



SECTION B-B



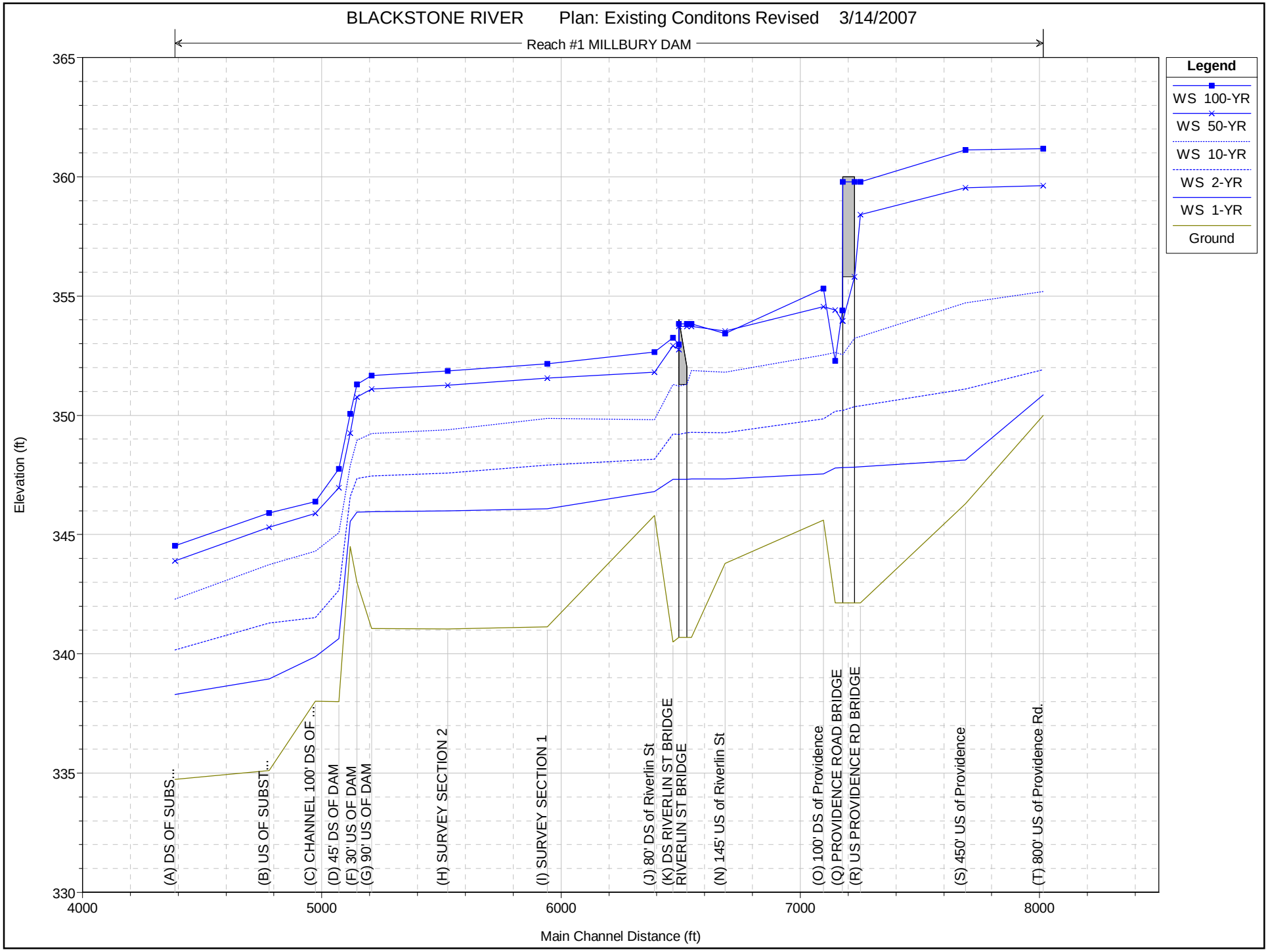
SECTION A-A.

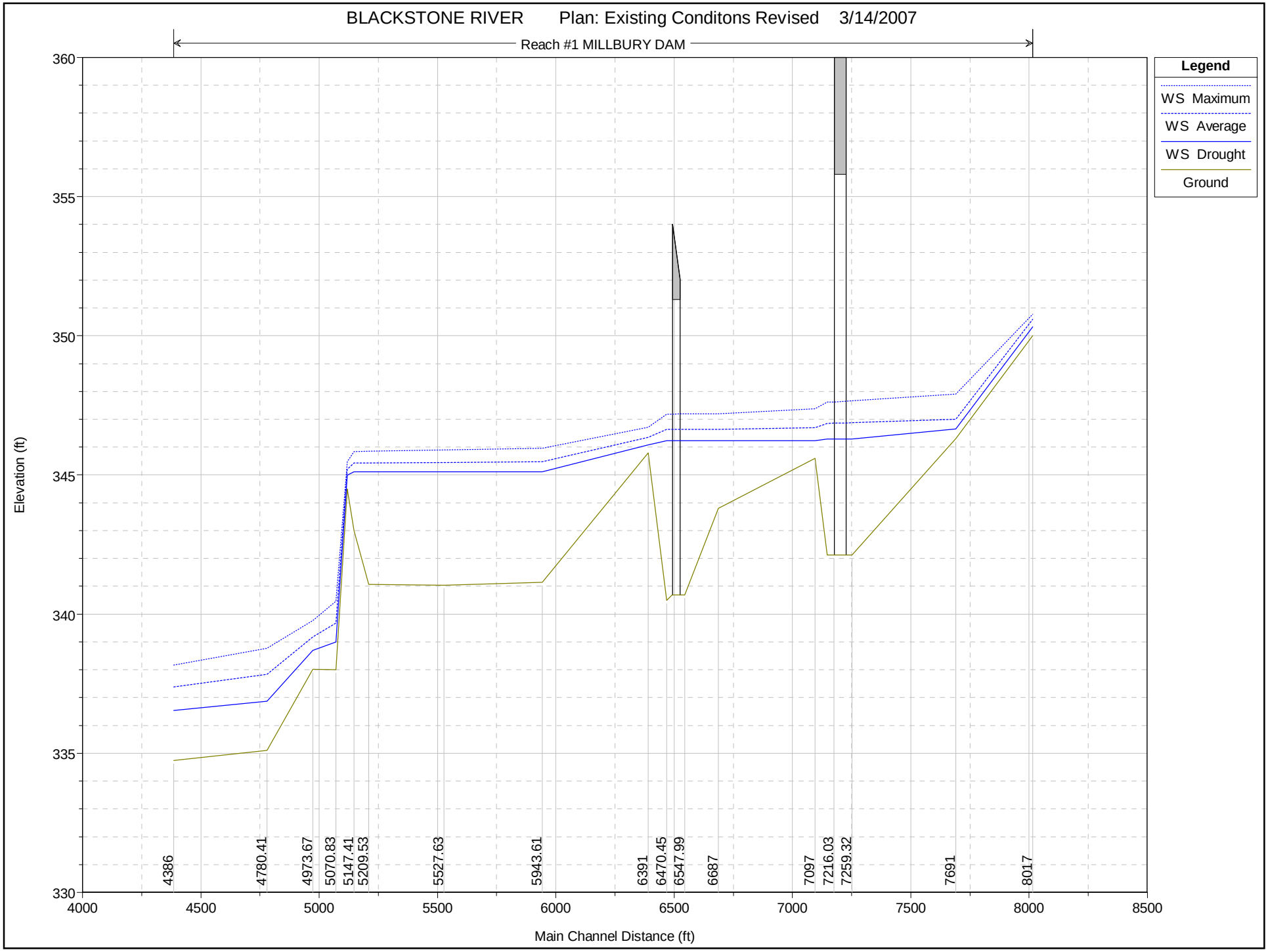
M-22-5

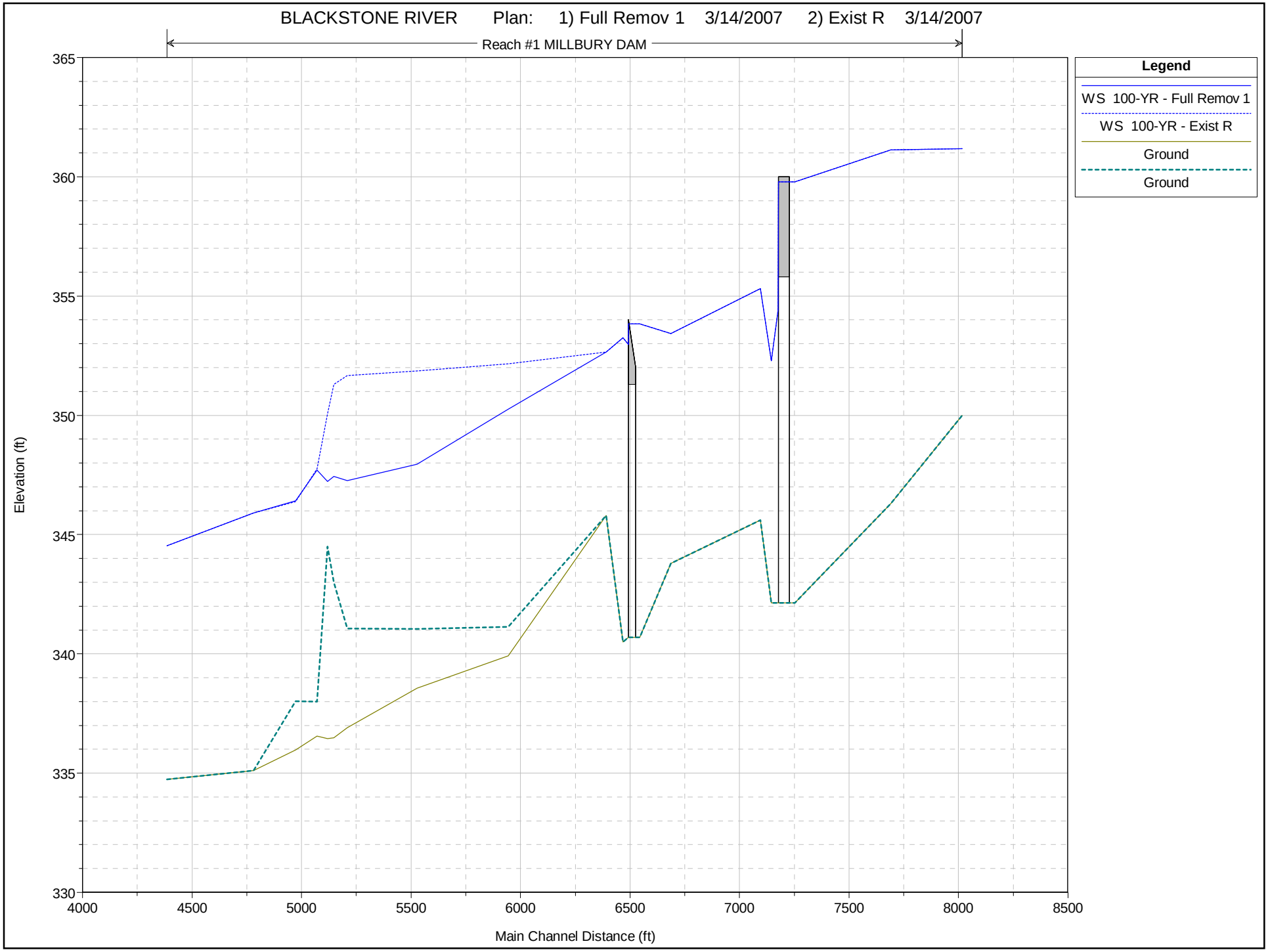
APPENDIX D

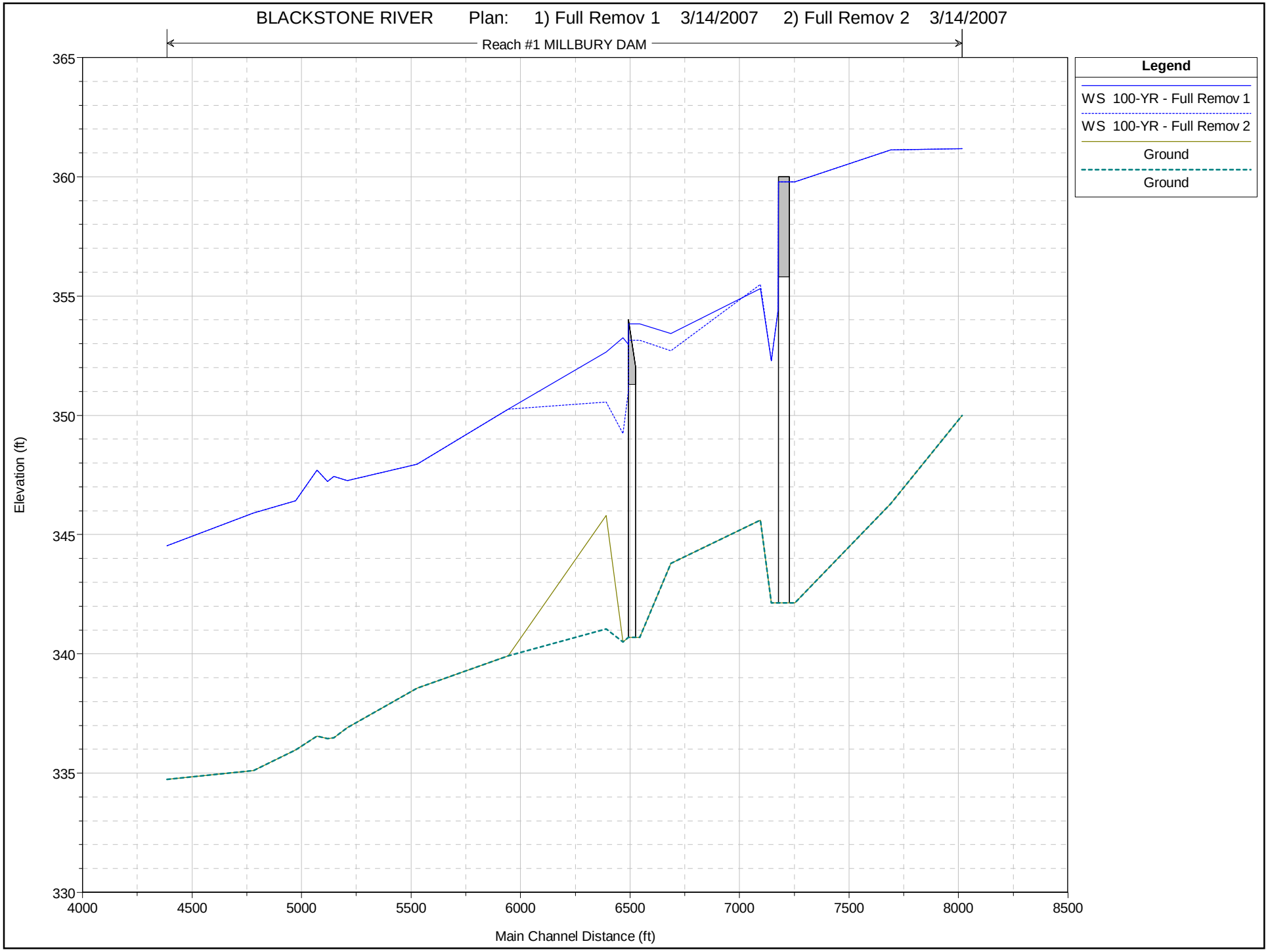
HEC-RAS MODEL

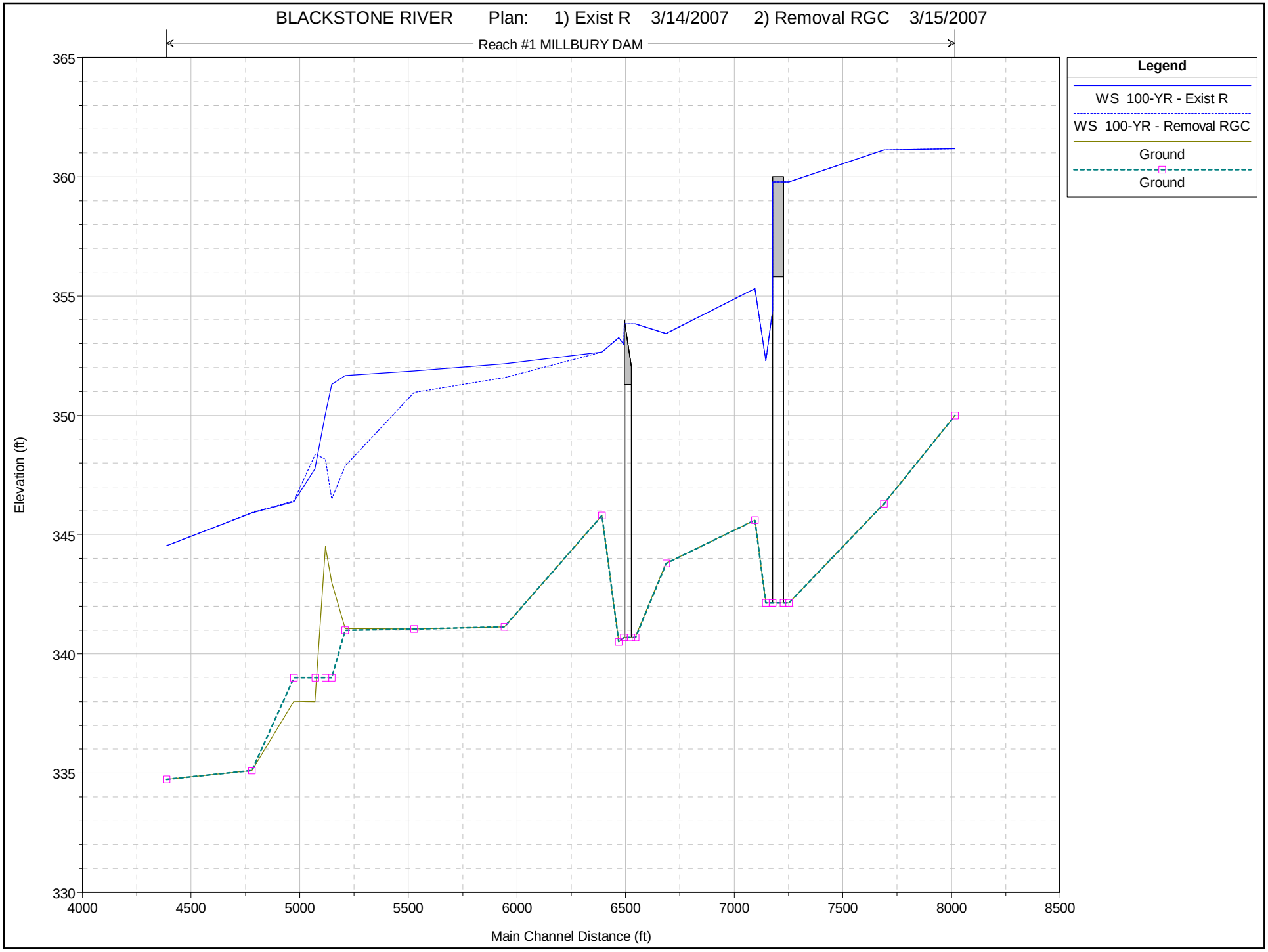
PROFILES, CROSS SECTIONS, SUMMARY TABLES

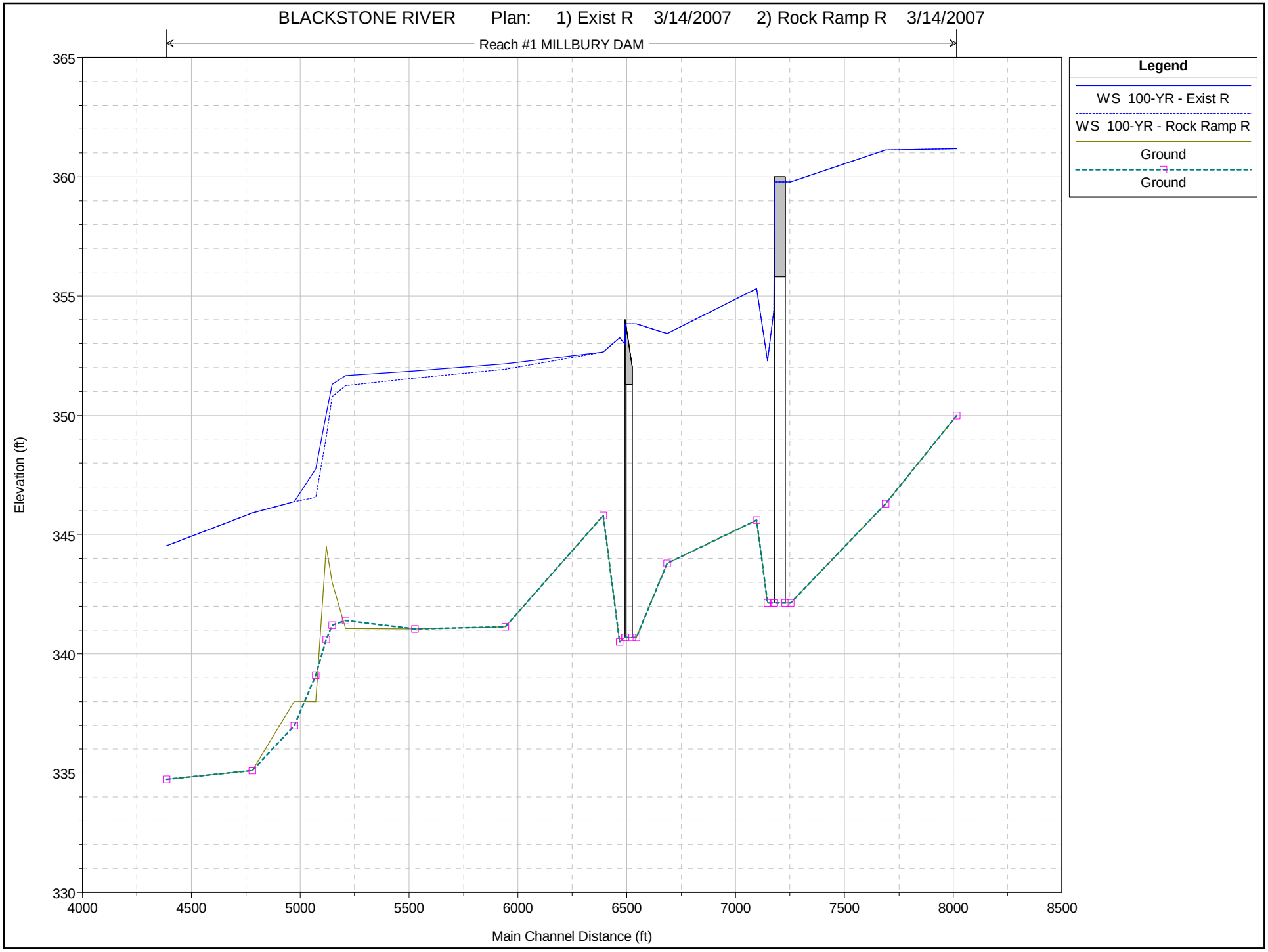

BLACKSTONE RIVER Plan: Existing Conditons Revised 3/14/2007
Reach #1 MILLBURY DAM
Legend
WS 100-YR
WS 50-YR
WS 10-YR
WS 2-YR
WS 1-YR
Ground
Elevation (ft)
365
360
355
350
345
340
335
330
4000
5000
6000
7000
8000
Main Channel Distance (ft)
(A) DS OF SUBS...
(B) US OF SUBST...
(C) CHANNEL 100' DS OF ...
(D) 45' DS OF DAM
(F) 30' US OF DAM
(G) 90' US OF DAM
(H) SURVEY SECTION 2
(I) SURVEY SECTION 1
(J) 80' DS of Riverlin St
(K) DS RIVERLIN ST BRIDGE
RIVERLIN ST BRIDGE
(N) 145' US of Riverlin St
(O) 100' DS of Providence
(Q) PROVIDENCE ROAD BRIDGE
(R) US PROVIDENCE RD BRIDGE
(S) 450' US of Providence
(T) 800' US of Providence Rd.


BLACKSTONE RIVER Plan: Existing Conditons Revised 3/14/2007
Reach #1 MILLBURY DAM
Legend
WS Maximum
WS Average
WS Drought
Ground
Elevation (ft)
Main Channel Distance (ft)
360
355
350
345
340
335
330
4000
4500
5000
5500
6000
6500
7000
7500
8000
8500
4386
4780.41
4973.67
5070.83
5147.41
5209.53
5527.63
5943.61
6391
6470.45
6547.99
6687
7097
7216.03
7259.32
7691
8017


BLACKSTONE RIVER Plan: 1) Full Remov 1 3/14/2007 2) Exist R 3/14/2007
Reach #1 MILLBURY DAM
Legend
WS 100-YR - Full Remov 1
WS 100-YR - Exist R
Ground
Ground
Elevation (ft)
365
360
355
350
345
340
335
330
4000
4500
5000
5500
6000
6500
7000
7500
8000
8500
Main Channel Distance (ft)

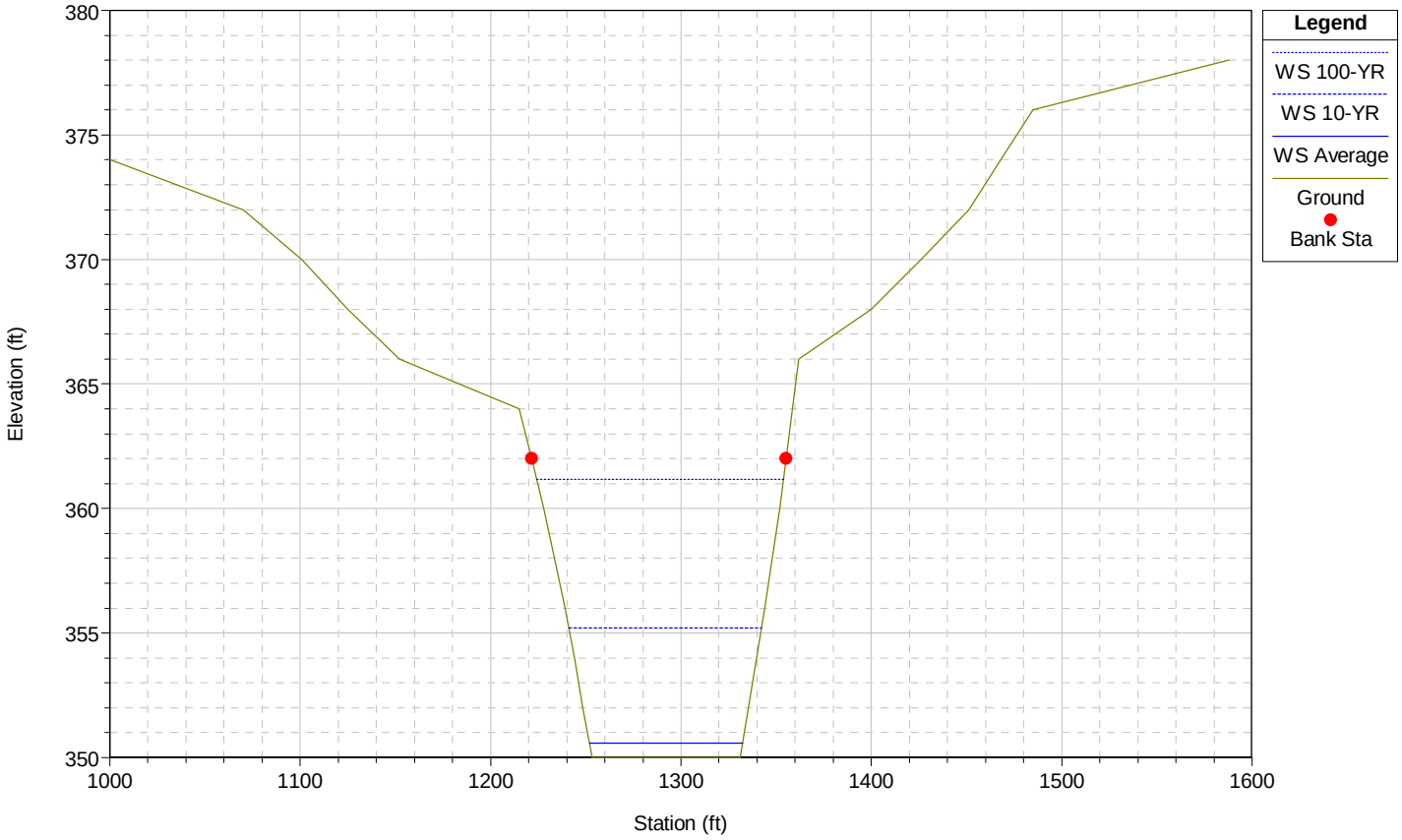

BLACKSTONE RIVER Plan: 1) Full Remov 1 3/14/2007 2) Full Remov 2 3/14/2007
Reach #1 MILLBURY DAM
Legend
WS 100-YR - Full Remov 1
WS 100-YR - Full Remov 2
Ground
Ground
Elevation (ft)
365
360
355
350
345
340
335
330
4000
4500
5000
5500
6000
6500
7000
7500
8000
8500
Main Channel Distance (ft)


BLACKSTONE RIVER Plan: 1) Exist R 3/14/2007 2) Removal RGC 3/15/2007
Reach #1 MILLBURY DAM
Legend
WS 100-YR - Exist R
WS 100-YR - Removal RGC
Ground
Ground
Elevation (ft)
365
360
355
350
345
340
335
330
4000
4500
5000
5500
6000
6500
7000
7500
8000
8500
Main Channel Distance (ft)


BLACKSTONE RIVER Plan: 1) Exist R 3/14/2007 2) Rock Ramp R 3/14/2007
Reach #1 MILLBURY DAM
Legend
WS 100-YR - Exist R
WS 100-YR - Rock Ramp R
Ground
Ground
Elevation (ft)
365
360
355
350
345
340
335
330
4000
4500
5000
5500
6000
6500
7000
7500
8000
8500
Main Channel Distance (ft)

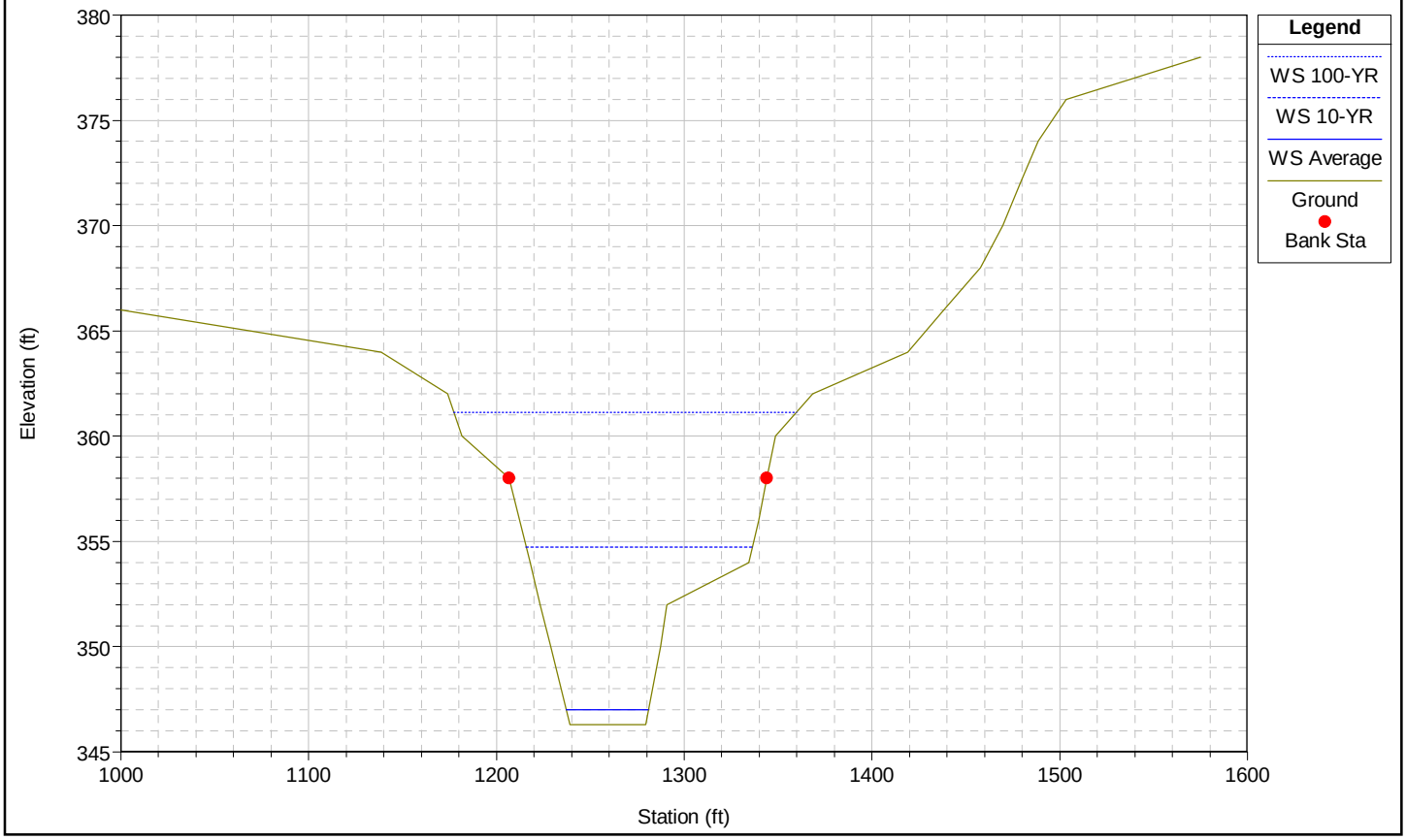
BLACKSTONE RIVER Plan: Existing Conditons Revised 3/14/2007

RS = 8017 (T) 800' US of Providence Rd.



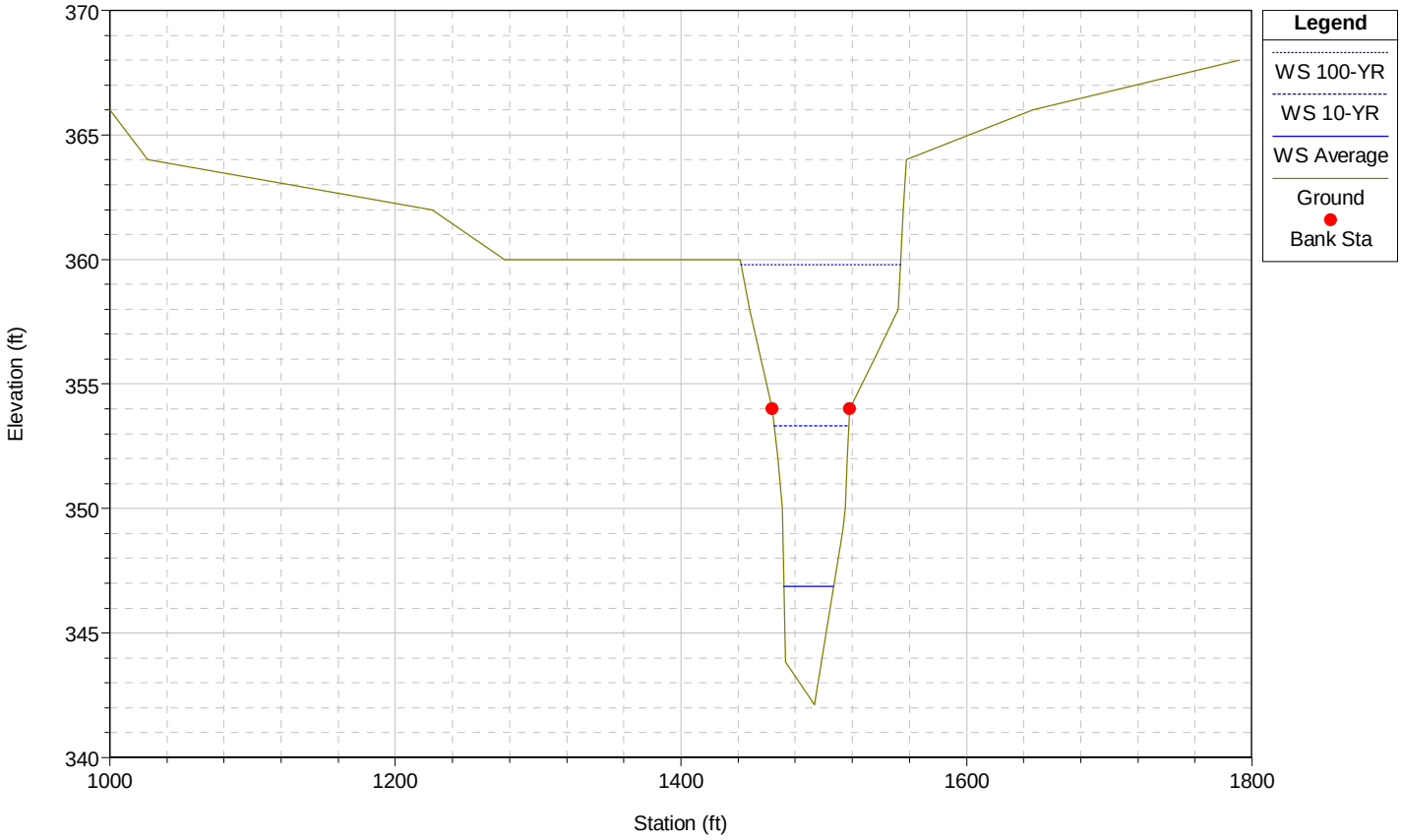
BLACKSTONE RIVER Plan: Existing Conditons Revised 3/14/2007

RS = 7691 (S) 450' US of Providence



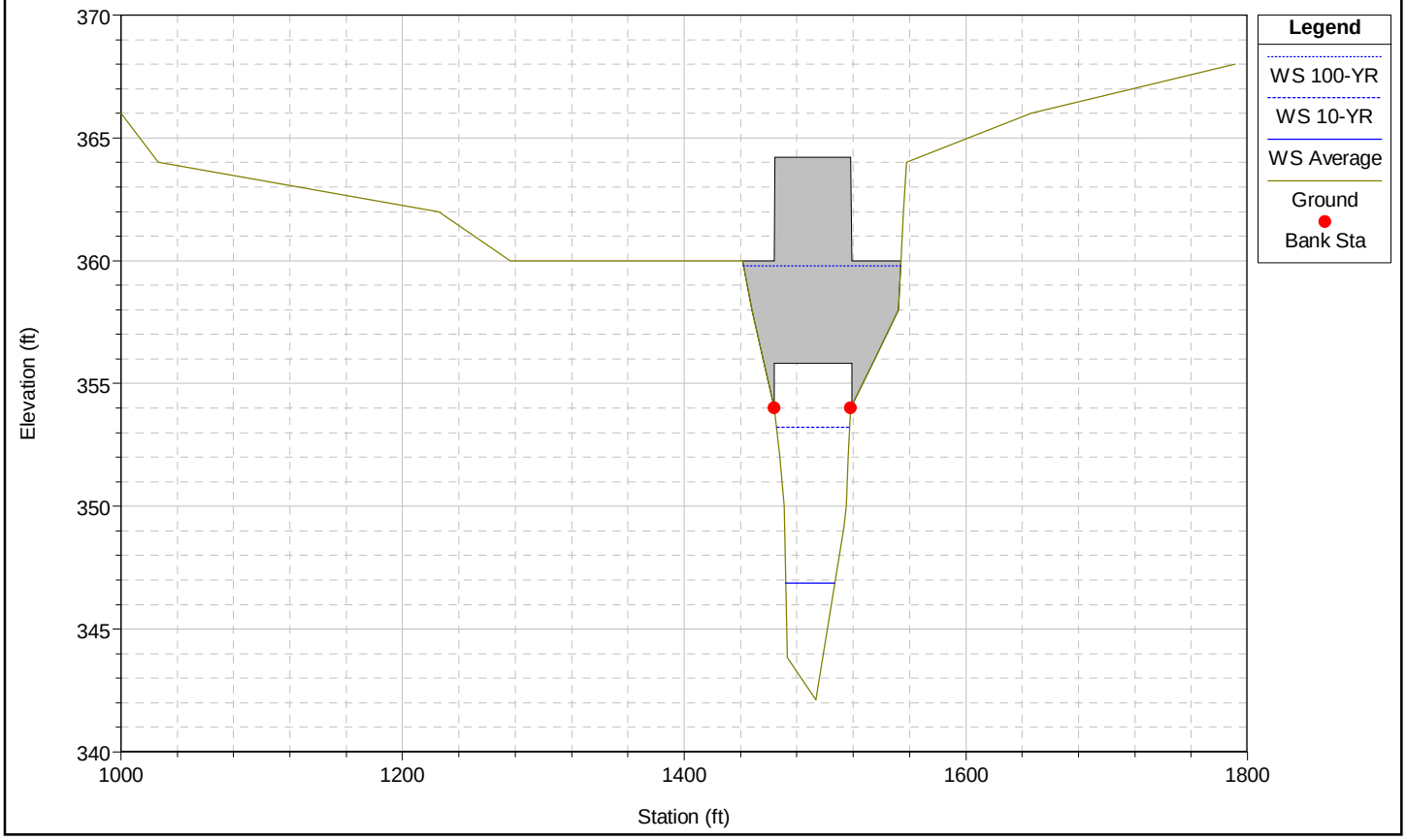
BLACKSTONE RIVER Plan: Existing Conditons Revised 3/14/2007

RS = 7259.32 (R) US PROVIDENCE RD BRIDGE



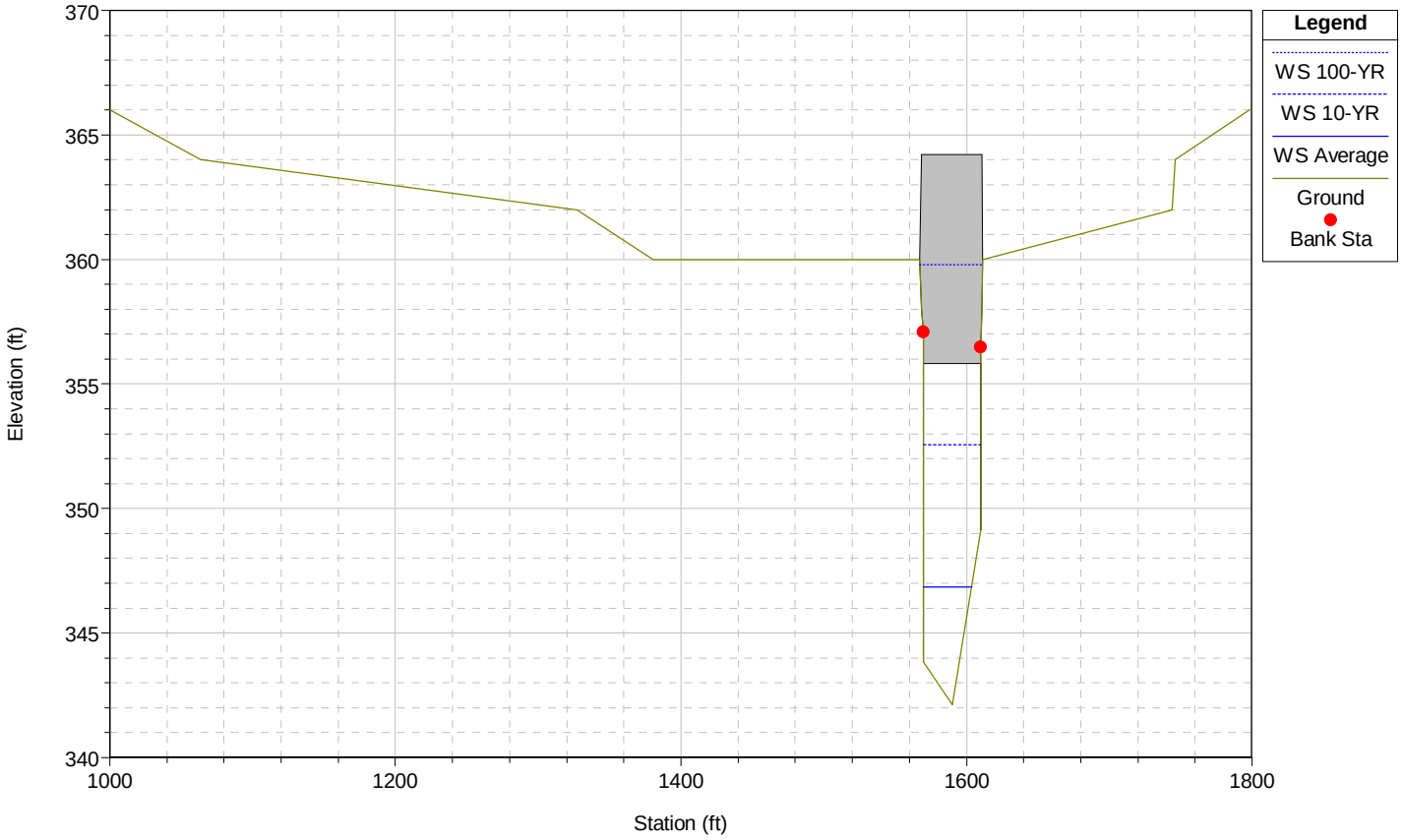
BLACKSTONE RIVER Plan: Existing Conditons Revised 3/14/2007

RS = 7218 BR PROVIDENCE RD BRIDGE



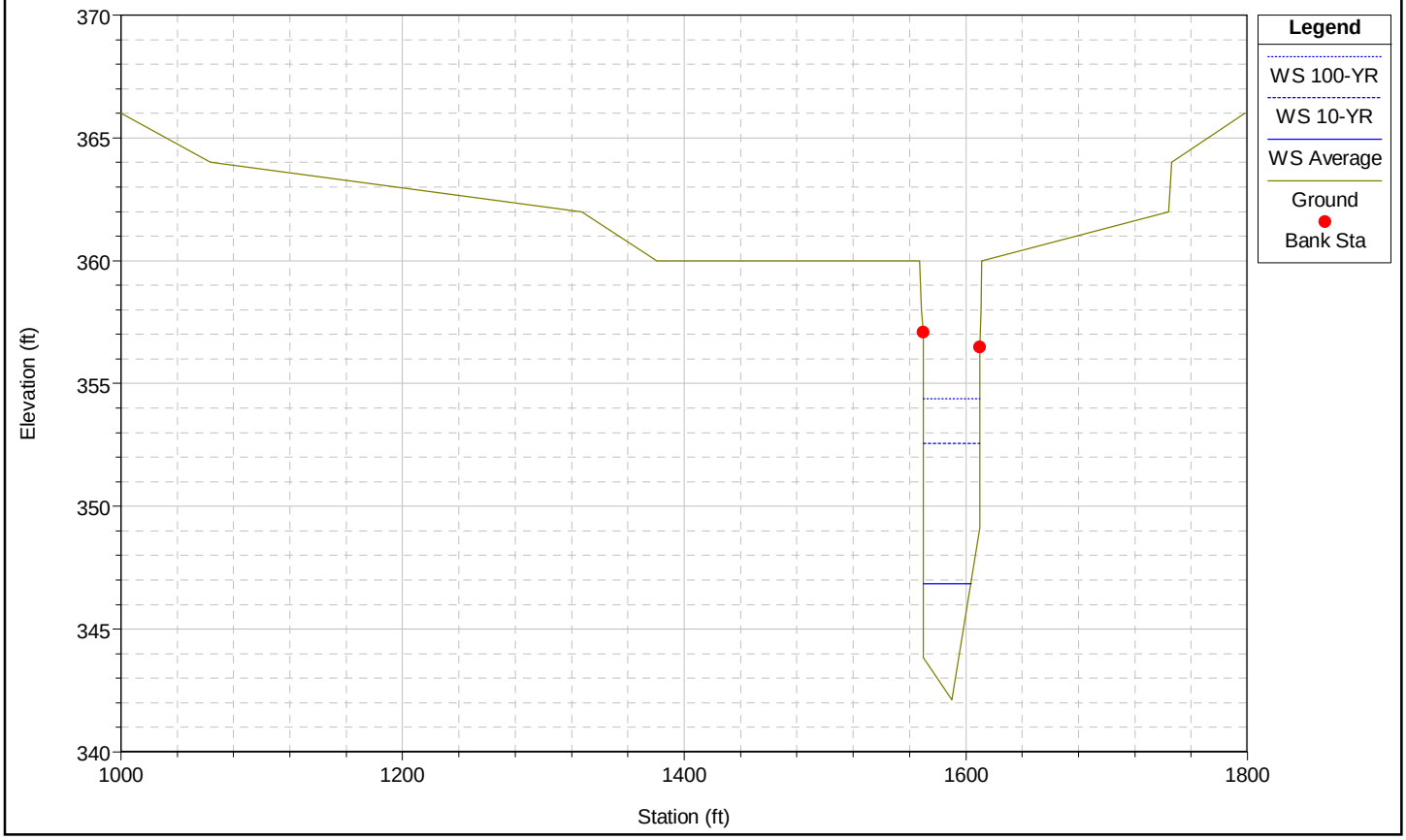
BLACKSTONE RIVER Plan: Existing Conditons Revised 3/14/2007

RS = 7218 BR PROVIDENCE RD BRIDGE



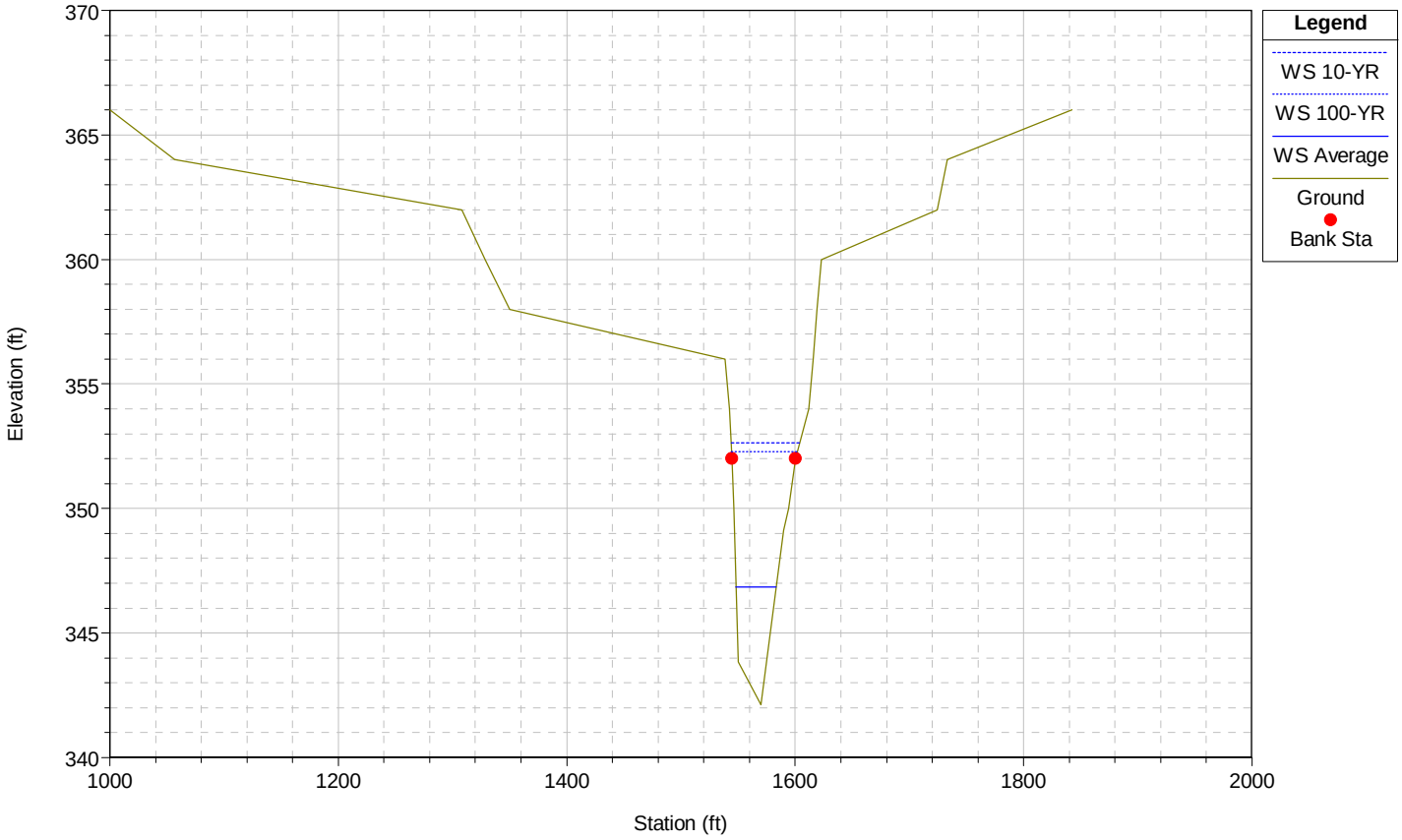
BLACKSTONE RIVER Plan: Existing Conditons Revised 3/14/2007

RS = 7216.03 (Q) PROVIDENCE ROAD BRIDGE



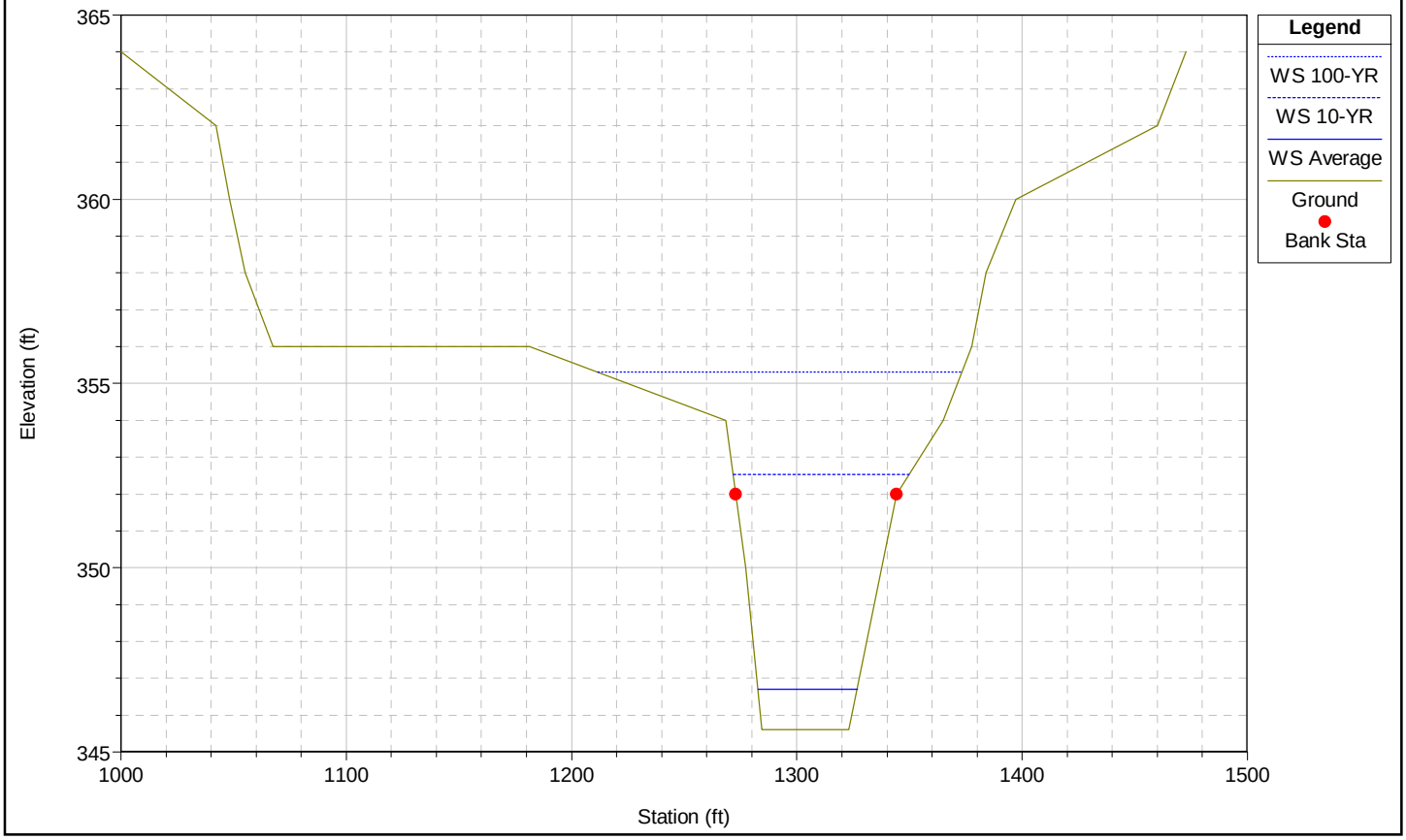
BLACKSTONE RIVER Plan: Existing Conditons Revised 3/14/2007

RS = 7152.43 (P) DS PROVIDENCE RD BRIDGE



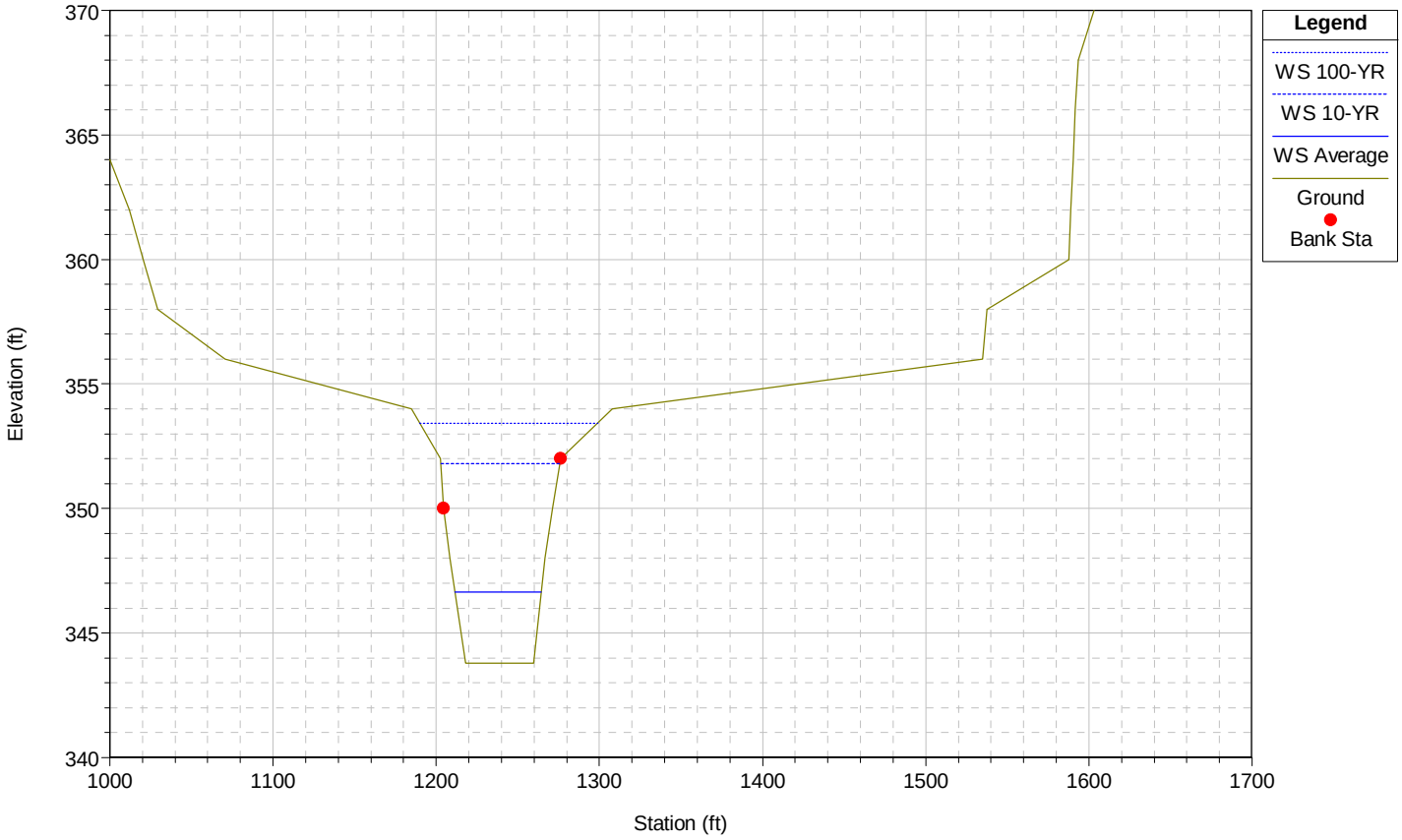
BLACKSTONE RIVER Plan: Existing Conditons Revised 3/14/2007

RS = 7097 (O) 100' DS of Providence



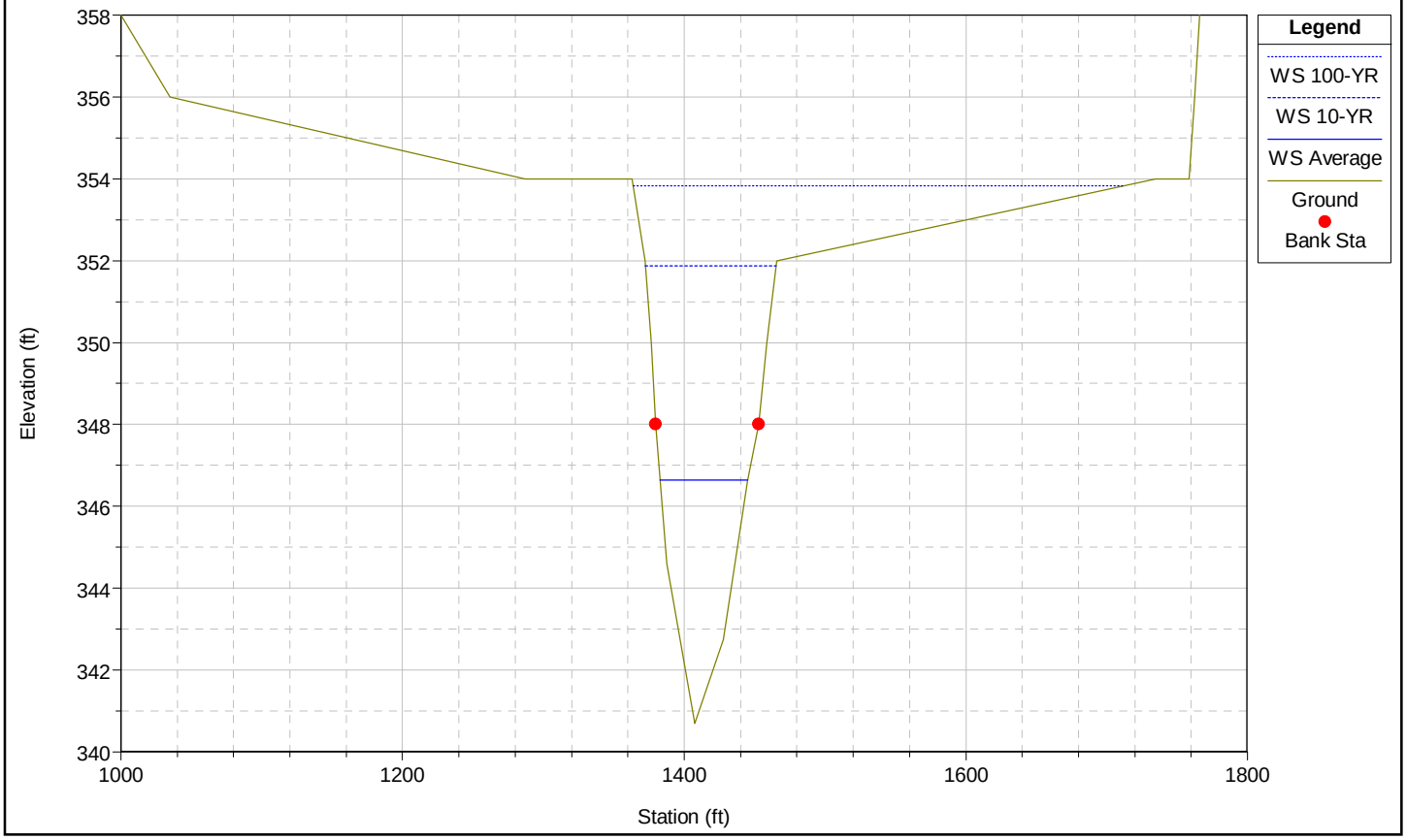
BLACKSTONE RIVER Plan: Existing Conditons Revised 3/14/2007

RS = 6687 (N) 145' US of Riverlin St



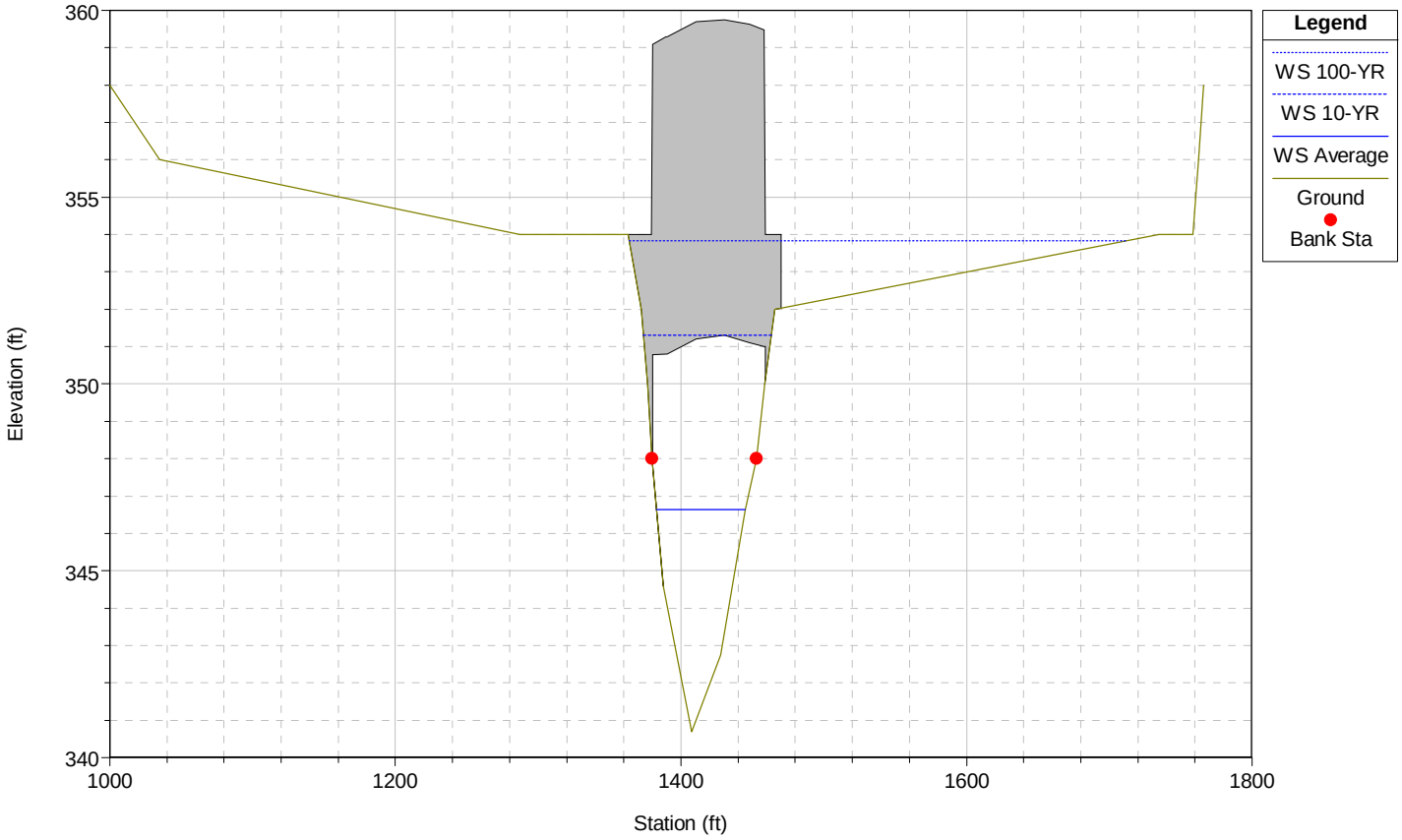
BLACKSTONE RIVER Plan: Existing Conditons Revised 3/14/2007

RS = 6547.99 (M) US RIVERLIN ST BRIDGE



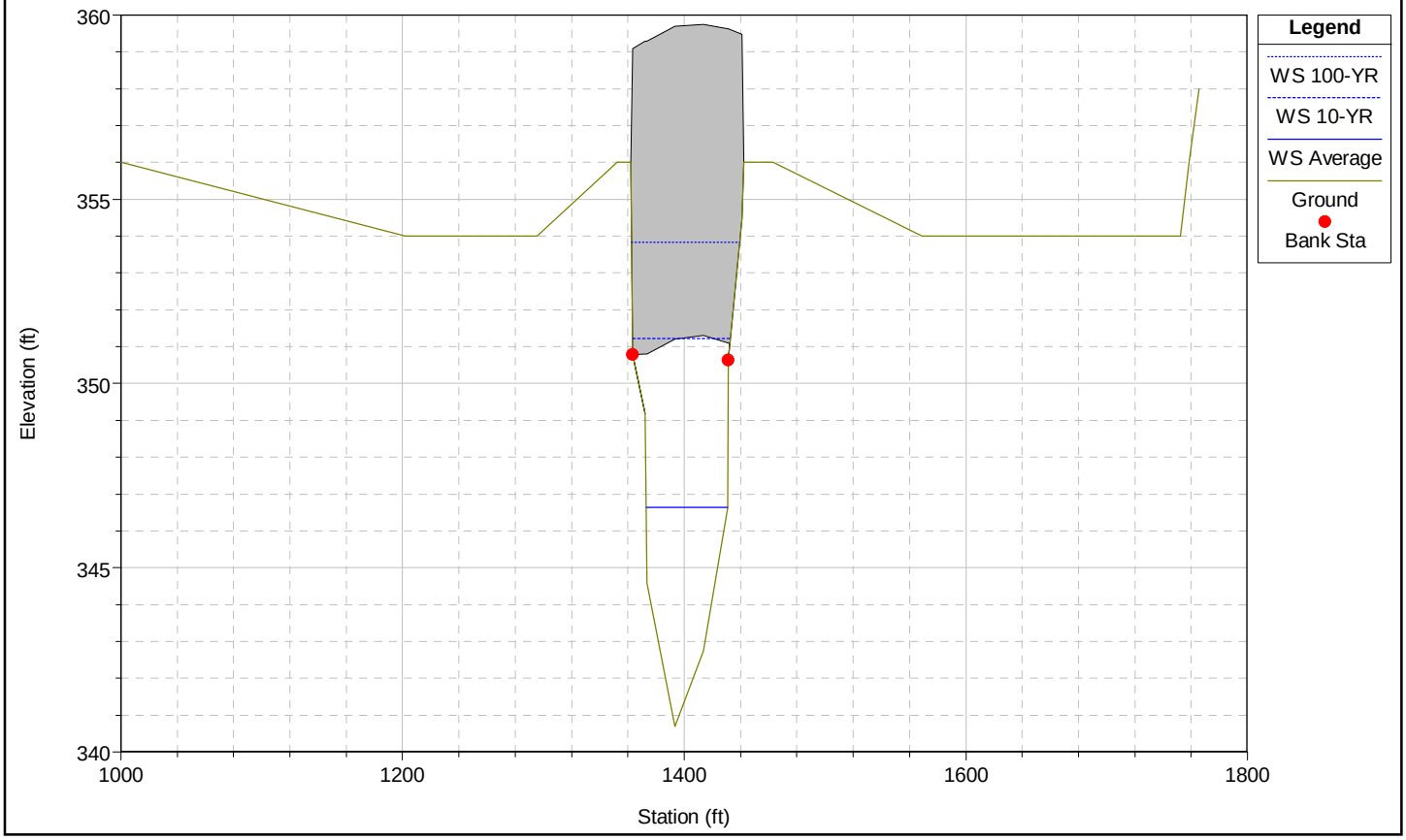
BLACKSTONE RIVER Plan: Existing Conditons Revised 3/14/2007

RS = 6529.47 BR RIVERLIN ST BRIDGE



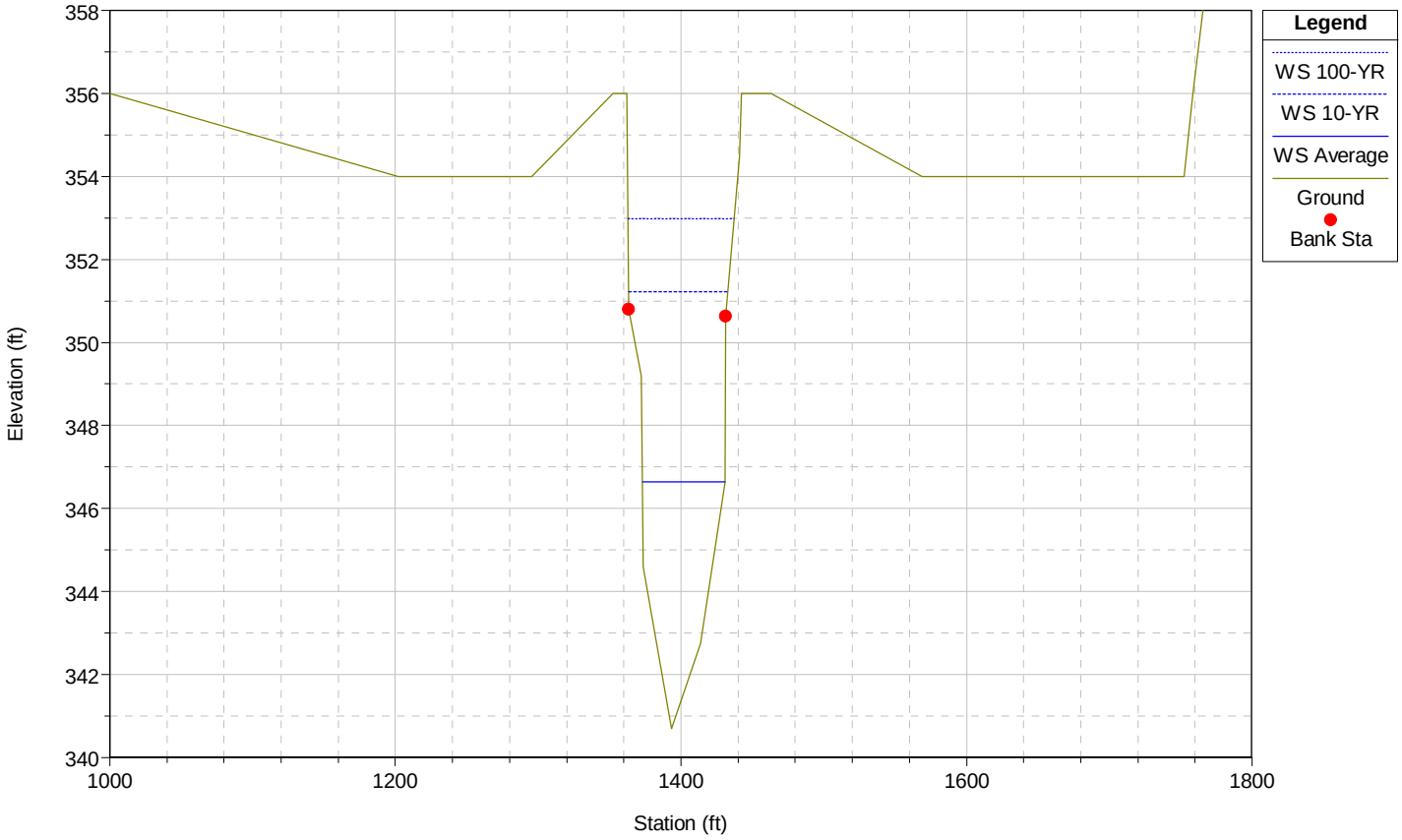
BLACKSTONE RIVER Plan: Existing Conditons Revised 3/14/2007

RS = 6529.47 BR RIVERLIN ST BRIDGE



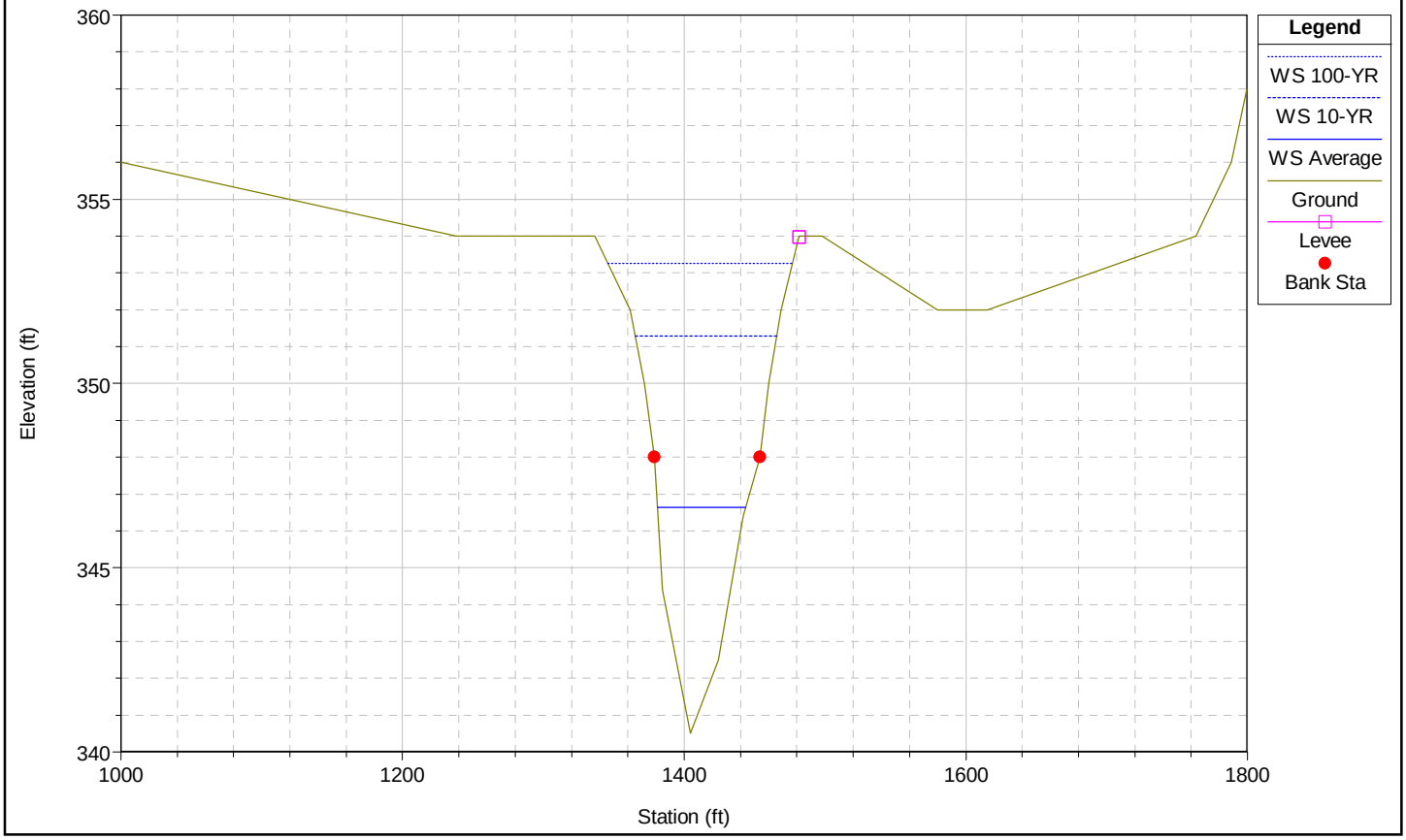
BLACKSTONE RIVER Plan: Existing Conditons Revised 3/14/2007

RS = 6510.94 (L) RIVERLIN ST BRIDGE



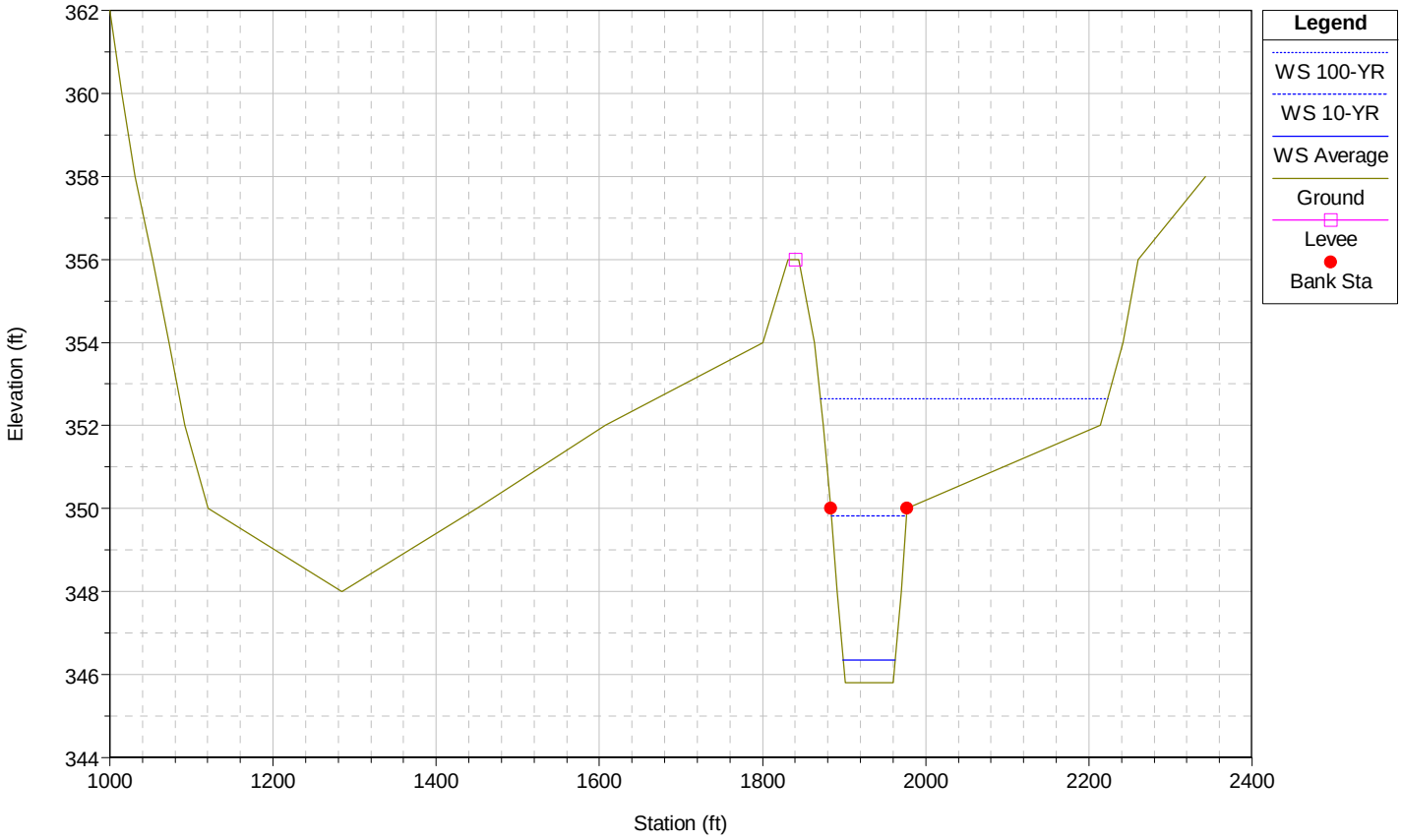
BLACKSTONE RIVER Plan: Existing Conditons Revised 3/14/2007

RS = 6470.45 (K) DS RIVERLIN ST BRIDGE



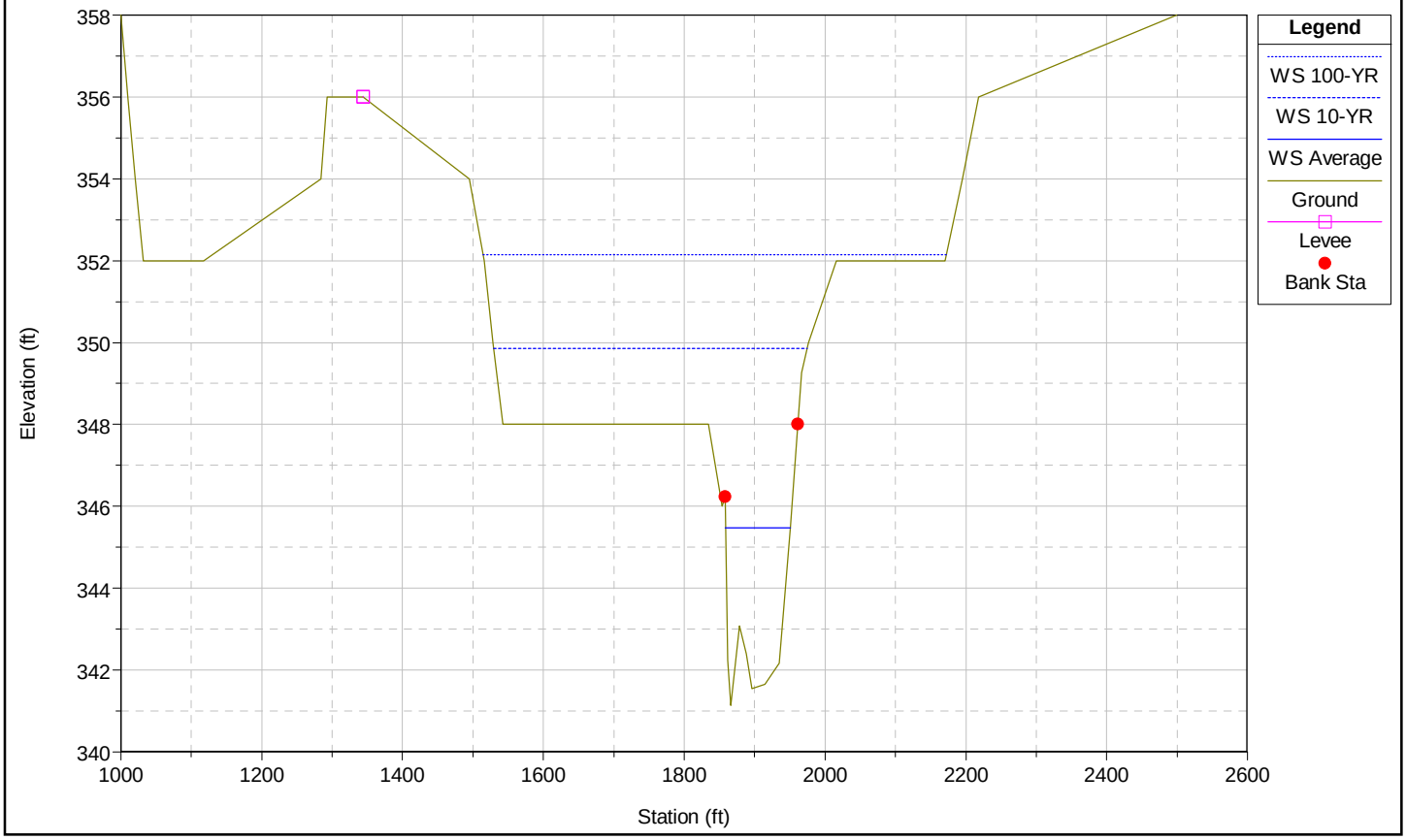
BLACKSTONE RIVER Plan: Existing Conditons Revised 3/14/2007

RS = 6391 (J) 80' DS of Riverlin St



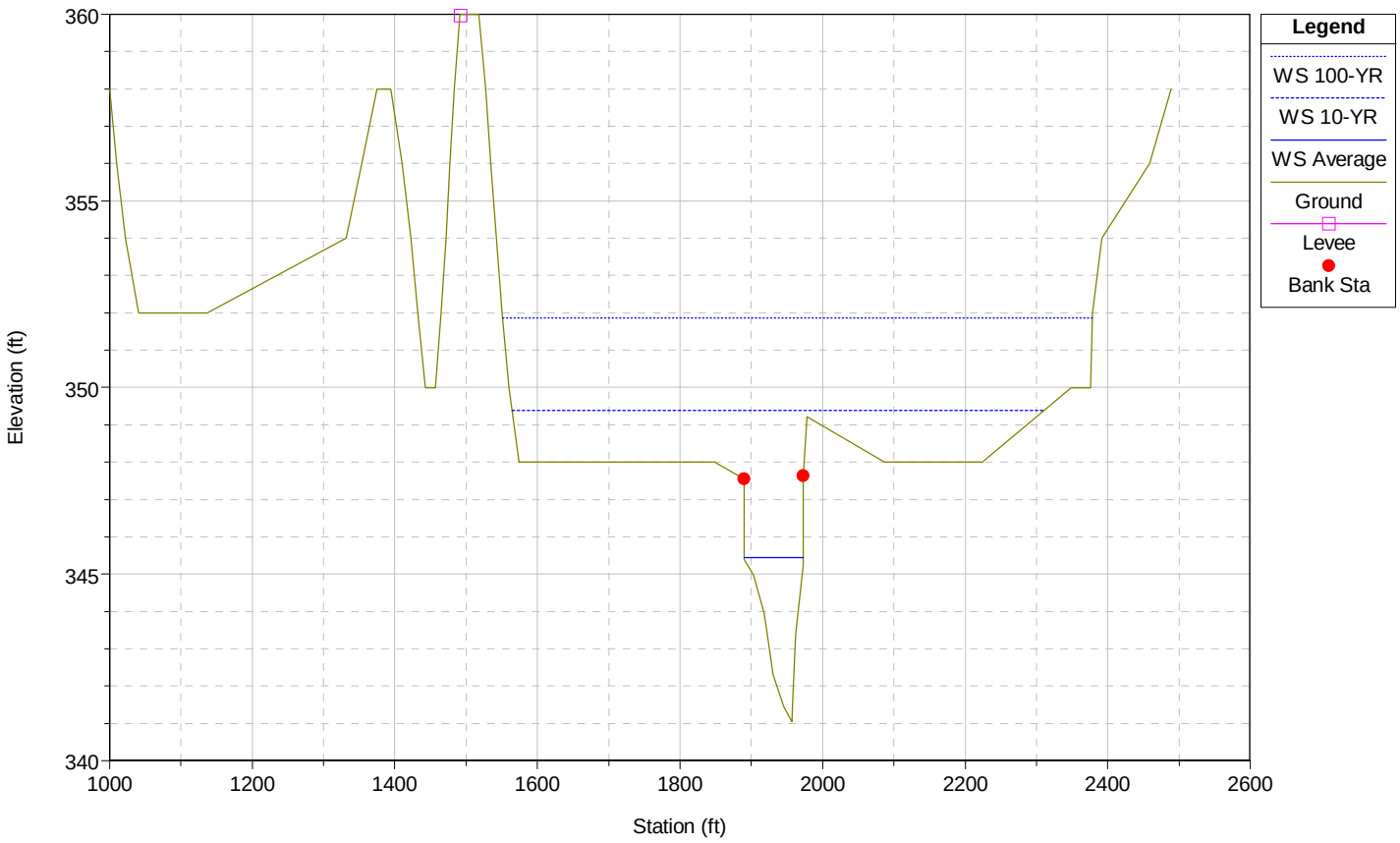
BLACKSTONE RIVER Plan: Existing Conditons Revised 3/14/2007

RS = 5943.61 (I) SURVEY SECTION 1



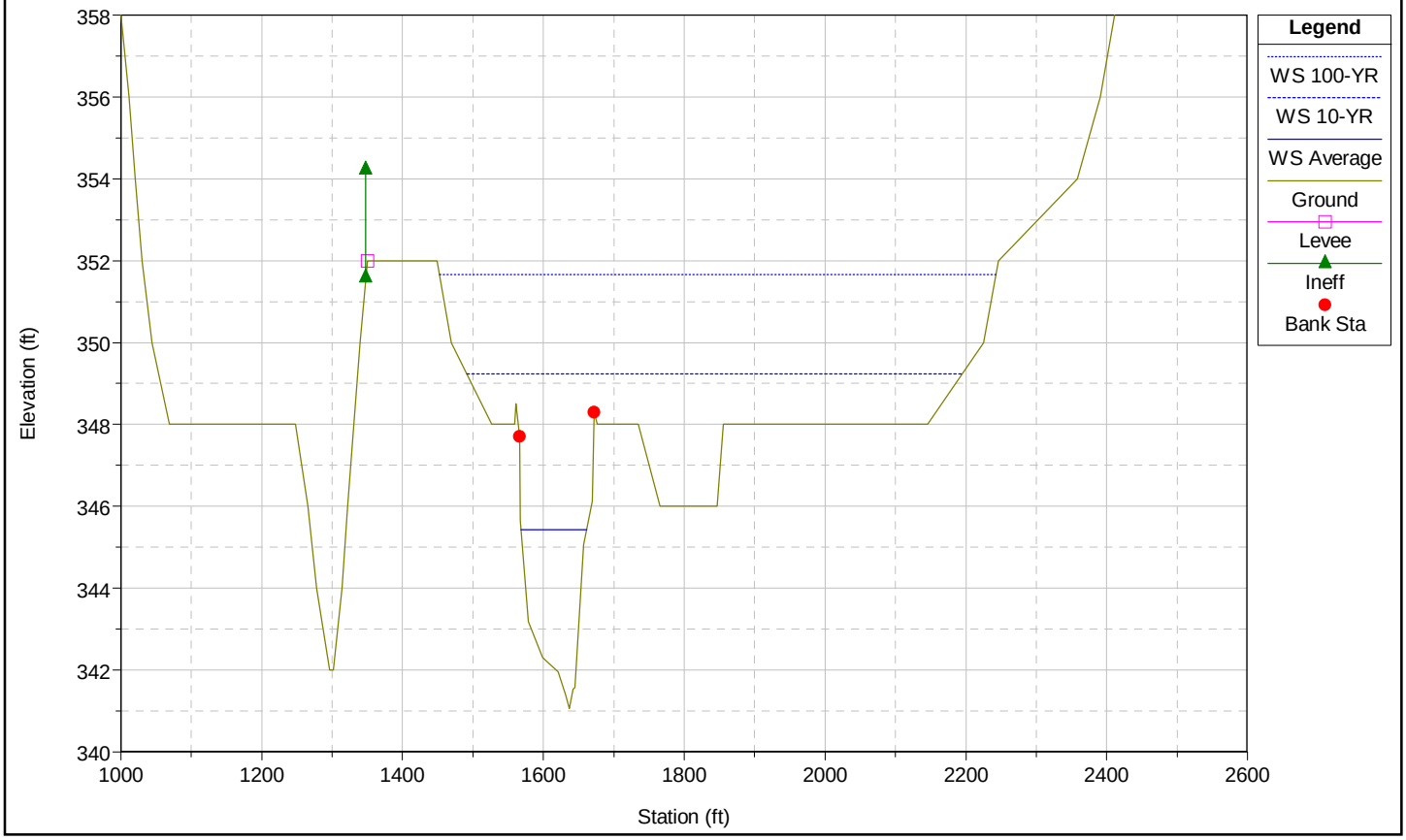
BLACKSTONE RIVER Plan: Existing Conditons Revised 3/14/2007

RS = 5527.63 (H) SURVEY SECTION 2



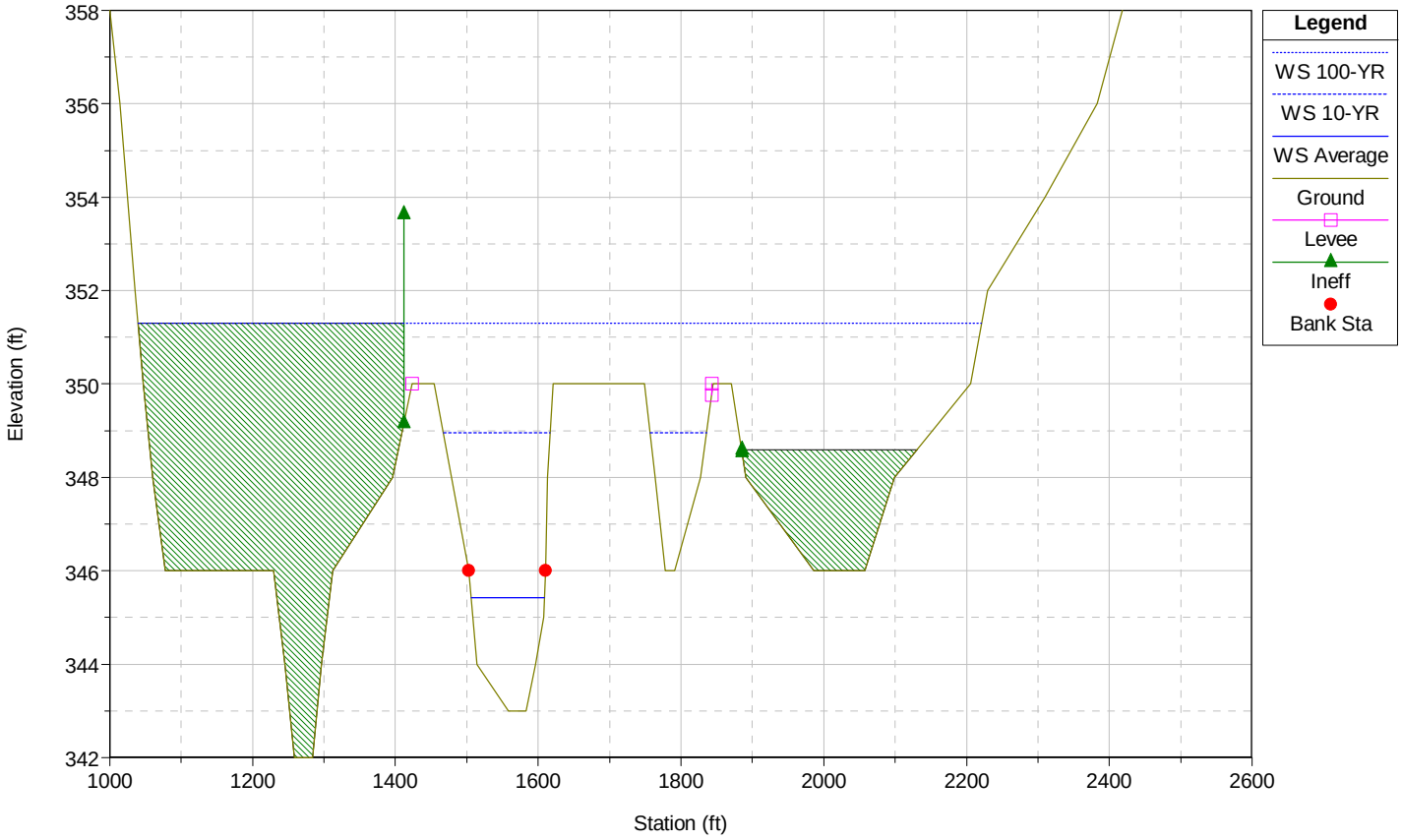
BLACKSTONE RIVER Plan: Existing Conditons Revised 3/14/2007

RS = 5209.53 (G) 90' US OF DAM



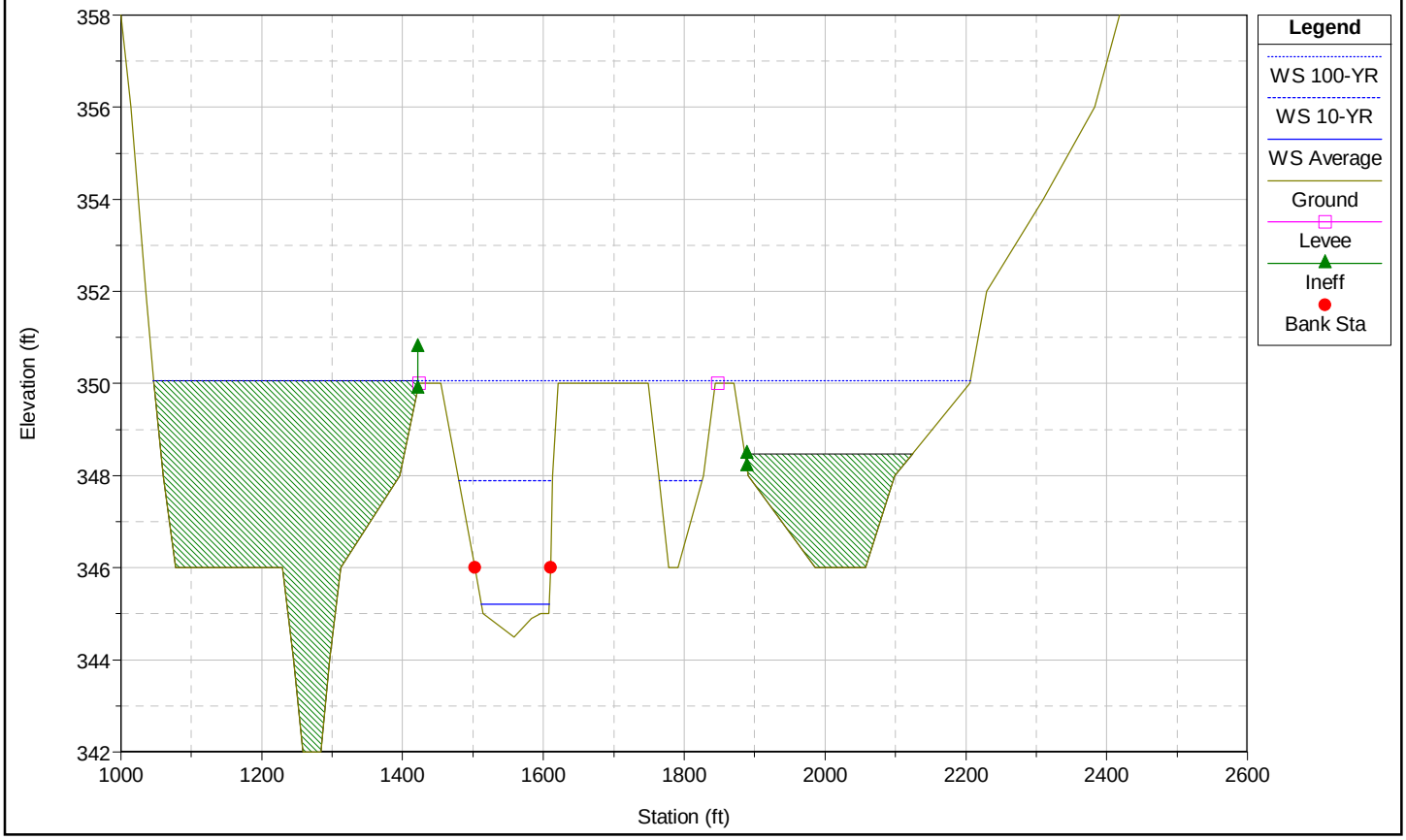
BLACKSTONE RIVER Plan: Existing Conditons Revised 3/14/2007

RS = 5147.41 (F) 30' US OF DAM



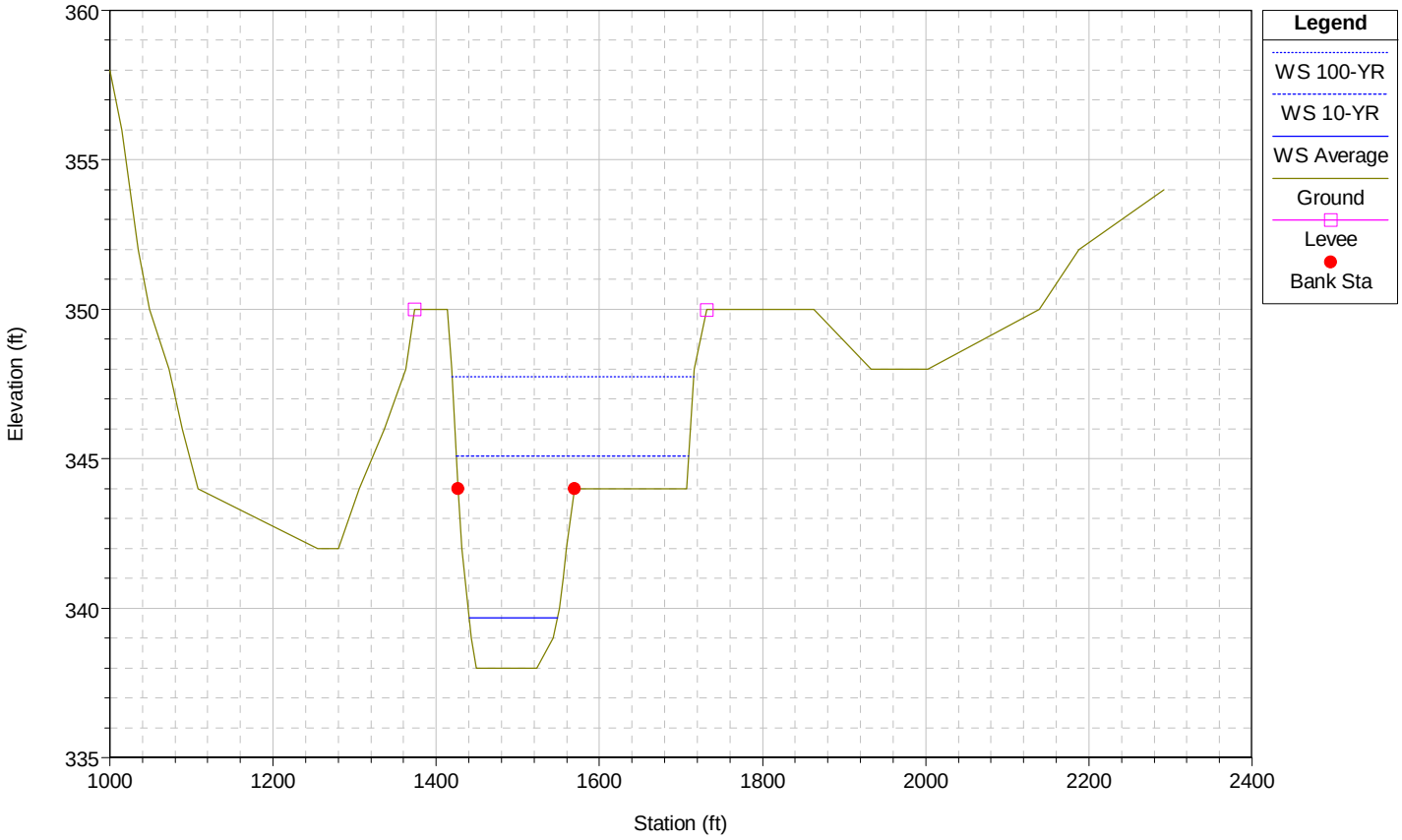
BLACKSTONE RIVER Plan: Existing Conditons Revised 3/14/2007

RS = 5117 (E) DAM CREST



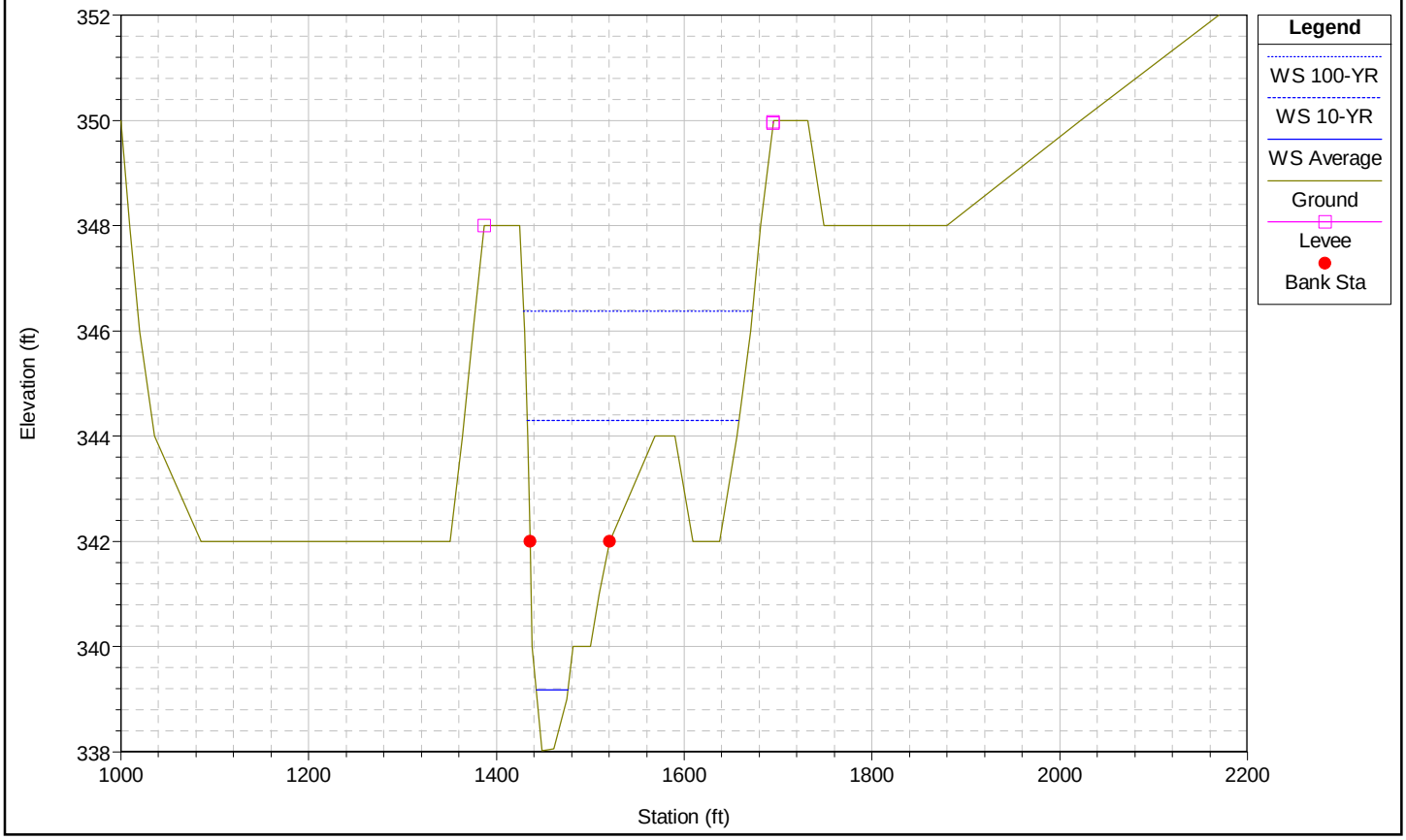
BLACKSTONE RIVER Plan: Existing Conditons Revised 3/14/2007

RS = 5070.83 (D) 45' DS OF DAM



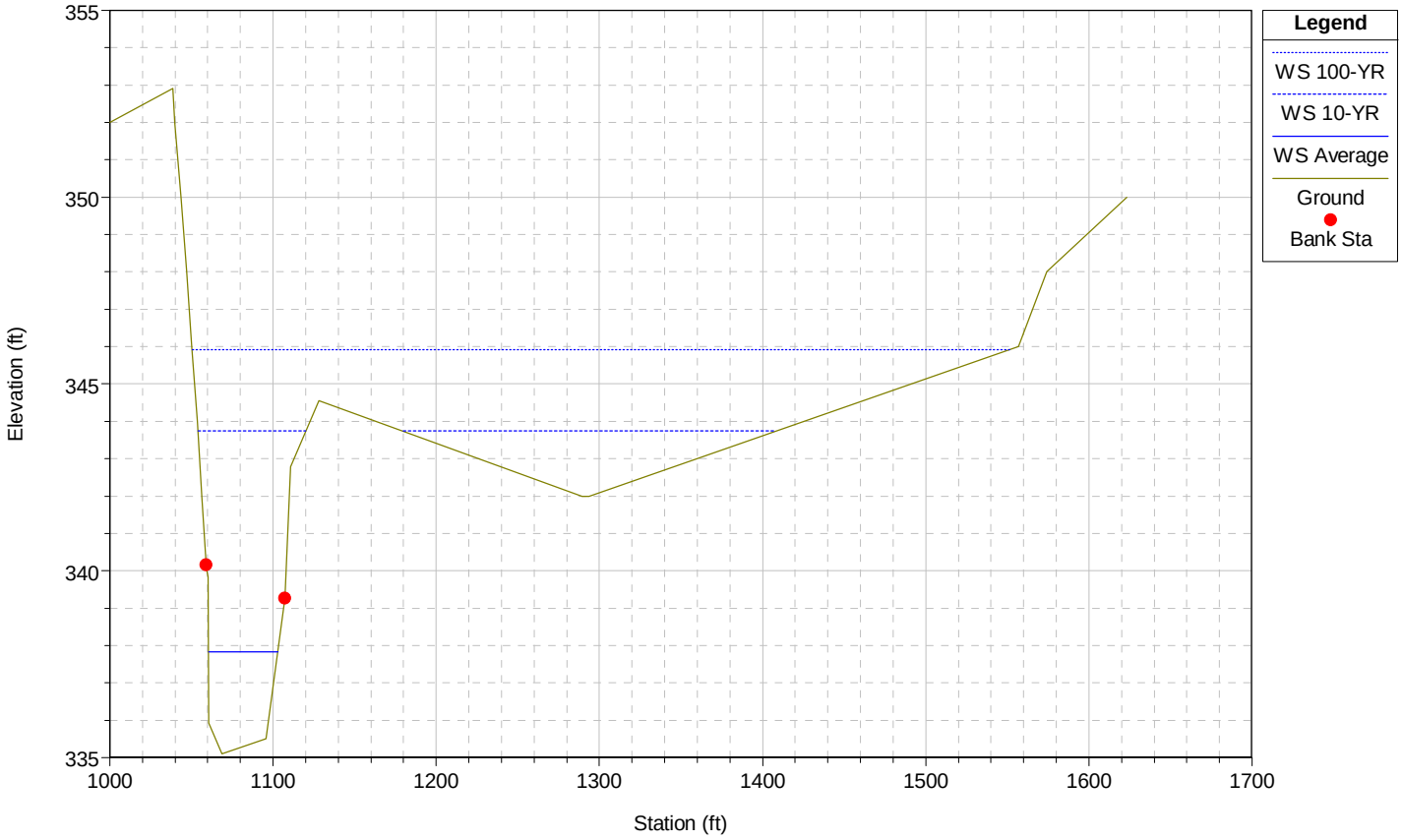
BLACKSTONE RIVER Plan: Existing Conditons Revised 3/14/2007

RS = 4973.67 (C) CHANNEL 100' DS OF DAM



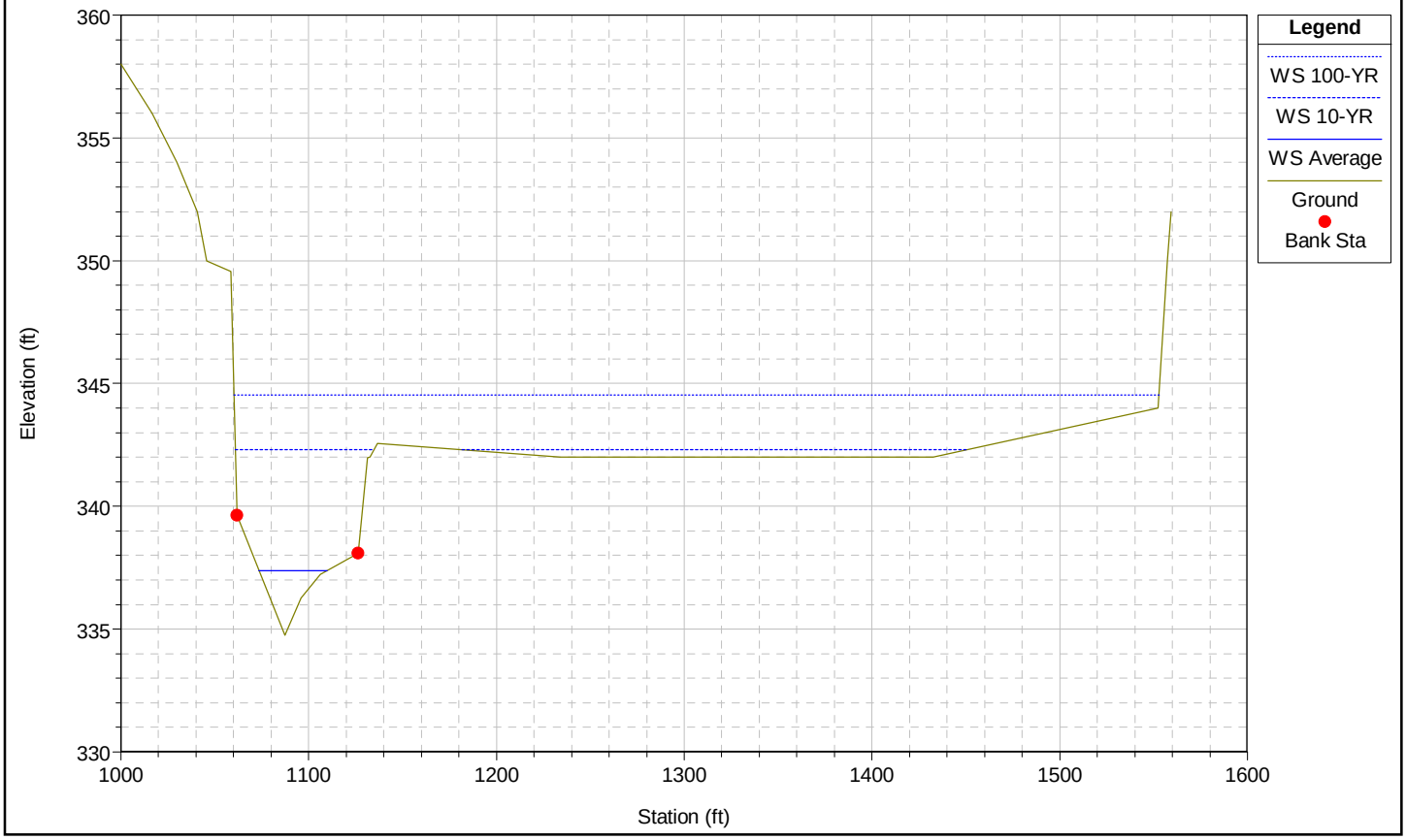
BLACKSTONE RIVER Plan: Existing Conditons Revised 3/14/2007

RS = 4780.41 (B) US OF SUBSTATION



BLACKSTONE RIVER Plan: Existing Conditons Revised 3/14/2007

RS = 4386 (A) DS OF SUBSTATION



HEC-RAS River: Reach #1 Reach: MILLBURY DAM

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan	Shear LOB	Shear ROB
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)	(lb/sq ft)	(lb/sq ft)
MILLBURY DAM	8017	Drought	Full Remov 2	49.00	350.00	350.32	350.23	350.38	0.007055	1.94	25.25	79.12	0.61	0.14		
MILLBURY DAM	8017	Drought	Full Remov 1	49.00	350.00	350.32	350.23	350.38	0.007055	1.94	25.25	79.12	0.61	0.14		
MILLBURY DAM	8017	Drought	Removal RGC	49.00	350.00	350.32	350.23	350.38	0.007055	1.94	25.25	79.12	0.61	0.14		
MILLBURY DAM	8017	Drought	Rock Ramp R	49.00	350.00	350.32	350.23	350.38	0.007055	1.94	25.25	79.12	0.61	0.14		
MILLBURY DAM	8017	Drought	Exist R	49.00	350.00	350.32	350.23	350.38	0.007055	1.94	25.25	79.12	0.61	0.14		
MILLBURY DAM	8017	Average	Full Remov 2	139.00	350.00	350.59	350.46	350.73	0.007497	2.98	46.66	80.35	0.69	0.27		
MILLBURY DAM	8017	Average	Full Remov 1	139.00	350.00	350.59	350.46	350.73	0.007497	2.98	46.66	80.35	0.69	0.27		
MILLBURY DAM	8017	Average	Removal RGC	139.00	350.00	350.59	350.46	350.73	0.007497	2.98	46.66	80.35	0.69	0.27		
MILLBURY DAM	8017	Average	Rock Ramp R	139.00	350.00	350.59	350.46	350.73	0.007497	2.98	46.66	80.35	0.69	0.27		
MILLBURY DAM	8017	Average	Exist R	139.00	350.00	350.59	350.46	350.73	0.007497	2.98	46.66	80.35	0.69	0.27		
MILLBURY DAM	8017	Maximum	Full Remov 2	304.00	350.00	350.77	350.77	351.15	0.014651	4.96	61.31	81.18	1.01	0.69		
MILLBURY DAM	8017	Maximum	Full Remov 1	304.00	350.00	350.77	350.77	351.15	0.014634	4.96	61.33	81.18	1.01	0.69		
MILLBURY DAM	8017	Maximum	Removal RGC	304.00	350.00	350.77	350.77	351.15	0.014634	4.96	61.33	81.18	1.01	0.69		
MILLBURY DAM	8017	Maximum	Rock Ramp R	304.00	350.00	350.77	350.77	351.15	0.014634	4.96	61.33	81.18	1.01	0.69		
MILLBURY DAM	8017	Maximum	Exist R	304.00	350.00	350.77	350.77	351.15	0.014634	4.96	61.33	81.18	1.01	0.69		
MILLBURY DAM	8017	1-YR	Full Remov 2	350.00	350.00	350.85	350.85	351.27	0.014202	5.19	67.46	81.52	1.00	0.73		
MILLBURY DAM	8017	1-YR	Full Remov 1	350.00	350.00	350.85	350.85	351.27	0.014216	5.19	67.45	81.52	1.01	0.73		
MILLBURY DAM	8017	1-YR	Removal RGC	350.00	350.00	350.85	350.85	351.27	0.014216	5.19	67.45	81.52	1.01	0.73		
MILLBURY DAM	8017	1-YR	Rock Ramp R	350.00	350.00	350.85	350.85	351.27	0.014216	5.19	67.45	81.52	1.01	0.73		
MILLBURY DAM	8017	1-YR	Exist R	350.00	350.00	350.85	350.85	351.27	0.014216	5.19	67.45	81.52	1.01	0.73		
MILLBURY DAM	8017	2-YR	Full Remov 2	1350.00	350.00	351.90	352.06	353.06	0.014007	8.65	156.13	86.36	1.13	1.57		
MILLBURY DAM	8017	2-YR	Full Remov 1	1350.00	350.00	351.90	352.06	353.06	0.014007	8.65	156.13	86.36	1.13	1.57		
MILLBURY DAM	8017	2-YR	Removal RGC	1350.00	350.00	351.90	352.06	353.06	0.014007	8.65	156.13	86.36	1.13	1.57		
MILLBURY DAM	8017	2-YR	Rock Ramp R	1350.00	350.00	351.90	352.06	353.06	0.014007	8.65	156.13	86.36	1.13	1.57		
MILLBURY DAM	8017	2-YR	Exist R	1350.00	350.00	351.90	352.06	353.06	0.014007	8.65	156.13	86.36	1.13	1.57		
MILLBURY DAM	8017	10-YR	Full Remov 2	3200.00	350.00	355.12	353.60	355.88	0.002743	7.00	457.02	100.89	0.58	0.76		
MILLBURY DAM	8017	10-YR	Full Remov 1	3200.00	350.00	355.19	353.60	355.93	0.002609	6.89	464.61	101.24	0.57	0.73		
MILLBURY DAM	8017	10-YR	Removal RGC	3200.00	350.00	355.19	353.60	355.93	0.002609	6.89	464.61	101.24	0.57	0.73		
MILLBURY DAM	8017	10-YR	Rock Ramp R	3200.00	350.00	355.19	353.60	355.93	0.002609	6.89	464.61	101.24	0.57	0.73		
MILLBURY DAM	8017	10-YR	Exist R	3200.00	350.00	355.19	353.60	355.93	0.002609	6.89	464.61	101.24	0.57	0.73		
MILLBURY DAM	8017	50-YR	Full Remov 2	5800.00	350.00	359.62	355.27	360.19	0.000998	6.05	958.89	122.16	0.38	0.47		
MILLBURY DAM	8017	50-YR	Full Remov 1	5800.00	350.00	359.63	355.27	360.19	0.000997	6.05	959.15	122.17	0.38	0.47		
MILLBURY DAM	8017	50-YR	Removal RGC	5800.00	350.00	359.63	355.27	360.19	0.000997	6.05	959.15	122.17	0.38	0.47		
MILLBURY DAM	8017	50-YR	Rock Ramp R	5800.00	350.00	359.63	355.27	360.19	0.000997	6.05	959.15	122.17	0.38	0.47		
MILLBURY DAM	8017	50-YR	Exist R	5800.00	350.00	359.63	355.27	360.19	0.000997	6.05	959.15	122.17	0.38	0.47		
MILLBURY DAM	8017	100-YR	Full Remov 2	7300.00	350.00	361.18	356.09	361.80	0.000926	6.32	1155.10	129.81	0.37	0.50		
MILLBURY DAM	8017	100-YR	Full Remov 1	7300.00	350.00	361.18	356.09	361.80	0.000926	6.32	1155.10	129.81	0.37	0.50		
MILLBURY DAM	8017	100-YR	Removal RGC	7300.00	350.00	361.18	356.09	361.80	0.000926	6.32	1155.10	129.81	0.37	0.50		
MILLBURY DAM	8017	100-YR	Rock Ramp R	7300.00	350.00	361.18	356.09	361.80	0.000926	6.32	1155.10	129.81	0.37	0.50		
MILLBURY DAM	8017	100-YR	Exist R	7300.00	350.00	361.18	356.09	361.80	0.000926	6.32	1155.10	129.81	0.37	0.50		
MILLBURY DAM	7691	Drought	Full Remov 2	49.00	346.30	346.66	346.66	346.83	0.018763	3.35	14.64	42.08	1.00	0.41		
MILLBURY DAM	7691	Drought	Full Remov 1	49.00	346.30	346.66	346.66	346.83	0.018763	3.35	14.64	42.08	1.00	0.41		
MILLBURY DAM	7691	Drought	Removal RGC	49.00	346.30	346.66	346.66	346.83	0.018763	3.35	14.64	42.08	1.00	0.41		
MILLBURY DAM	7691	Drought	Rock Ramp R	49.00	346.30	346.66	346.66	346.83	0.018763	3.35	14.64	42.08	1.00	0.41		
MILLBURY DAM	7691	Drought	Exist R	49.00	346.30	346.66	346.66	346.83	0.018763	3.35	14.64	42.08	1.00	0.41		
MILLBURY DAM	7691	Average	Full Remov 2	139.00	346.30	347.01	347.01	347.35	0.015052	4.67	29.74	43.80	1.00	0.63		
MILLBURY DAM	7691	Average	Full Remov 1	139.00	346.30	347.01	347.01	347.35	0.015052	4.67	29.74	43.80	1.00	0.63		
MILLBURY DAM	7691	Average	Removal RGC	139.00	346.30	347.01	347.01	347.35	0.015052	4.67	29.74	43.80	1.00	0.63		
MILLBURY DAM	7691	Average	Rock Ramp R	139.00	346.30	347.01	347.01	347.35	0.015052	4.67	29.74	43.80	1.00	0.63		
MILLBURY DAM	7691	Average	Exist R	139.00	346.30	347.01	347.01	347.35	0.015052	4.67	29.74	43.80	1.00	0.63		
MILLBURY DAM	7691	Maximum	Full Remov 2	304.00	346.30	347.96	347.47	348.23	0.004005	4.11	73.89	48.47	0.59	0.38		
MILLBURY DAM	7691	Maximum	Full Remov 1	304.00	346.30	347.90	347.47	348.19	0.004526	4.28	71.04	48.18	0.62	0.41		
MILLBURY DAM	7691	Maximum	Removal RGC	304.00	346.30	347.90	347.47	348.19	0.004526	4.28	71.04	48.18	0.62	0.41		
MILLBURY DAM	7691	Maximum	Rock Ramp R	304.00	346.30	347.90	347.47	348.19	0.004526	4.28	71.04	48.18	0.62	0.41		
MILLBURY DAM	7691	Maximum	Exist R	304.00	346.30	347.90	347.47	348.19	0.004526	4.28	71.04	48.18	0.62	0.41		

HEC-RAS River: Reach #1 Reach: MILLBURY DAM (Continued)

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan	Shear LOB	Shear ROB
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)	(lb/sq ft)	(lb/sq ft)
MILLBURY DAM	7691	1-YR	Full Remov 2	350.00	346.30	348.18	347.59	348.44	0.003520	4.15	84.34	49.51	0.56	0.37		
MILLBURY DAM	7691	1-YR	Full Remov 1	350.00	346.30	348.13	347.59	348.41	0.003853	4.27	81.92	49.27	0.58	0.39		
MILLBURY DAM	7691	1-YR	Removal RGC	350.00	346.30	348.13	347.59	348.41	0.003853	4.27	81.92	49.27	0.58	0.39		
MILLBURY DAM	7691	1-YR	Rock Ramp R	350.00	346.30	348.13	347.59	348.41	0.003853	4.27	81.92	49.27	0.58	0.39		
MILLBURY DAM	7691	1-YR	Exist R	350.00	346.30	348.13	347.59	348.41	0.003853	4.27	81.92	49.27	0.58	0.39		
MILLBURY DAM	7691	2-YR	Full Remov 2	1350.00	346.30	351.05	349.35	351.52	0.002066	5.47	246.63	63.11	0.49	0.49		
MILLBURY DAM	7691	2-YR	Full Remov 1	1350.00	346.30	351.10	349.35	351.55	0.001996	5.41	249.57	63.32	0.48	0.48		
MILLBURY DAM	7691	2-YR	Removal RGC	1350.00	346.30	351.10	349.35	351.55	0.001996	5.41	249.57	63.32	0.48	0.48		
MILLBURY DAM	7691	2-YR	Rock Ramp R	1350.00	346.30	351.10	349.35	351.55	0.001996	5.41	249.57	63.32	0.48	0.48		
MILLBURY DAM	7691	2-YR	Exist R	1350.00	346.30	351.10	349.35	351.55	0.001996	5.41	249.57	63.32	0.48	0.48		
MILLBURY DAM	7691	10-YR	Full Remov 2	3200.00	346.30	354.60		355.10	0.001722	5.67	563.89	119.94	0.46	0.49		
MILLBURY DAM	7691	10-YR	Full Remov 1	3200.00	346.30	354.72		355.20	0.001597	5.54	578.13	120.58	0.45	0.47		
MILLBURY DAM	7691	10-YR	Removal RGC	3200.00	346.30	354.72		355.20	0.001597	5.54	578.13	120.58	0.45	0.47		
MILLBURY DAM	7691	10-YR	Rock Ramp R	3200.00	346.30	354.72		355.20	0.001597	5.54	578.13	120.58	0.45	0.47		
MILLBURY DAM	7691	10-YR	Exist R	3200.00	346.30	354.72		355.20	0.001597	5.54	578.13	120.58	0.45	0.47		
MILLBURY DAM	7691	50-YR	Full Remov 2	5800.00	346.30	359.54		359.90	0.000530	4.77	1231.17	160.35	0.28	0.28	0.03	0.02
MILLBURY DAM	7691	50-YR	Full Remov 1	5800.00	346.30	359.54		359.90	0.000530	4.77	1231.52	160.39	0.28	0.28	0.03	0.02
MILLBURY DAM	7691	50-YR	Removal RGC	5800.00	346.30	359.54		359.90	0.000530	4.77	1231.52	160.39	0.28	0.28	0.03	0.02
MILLBURY DAM	7691	50-YR	Rock Ramp R	5800.00	346.30	359.54		359.90	0.000530	4.77	1231.52	160.39	0.28	0.28	0.03	0.02
MILLBURY DAM	7691	50-YR	Exist R	5800.00	346.30	359.54		359.90	0.000530	4.77	1231.52	160.39	0.28	0.28	0.03	0.02
MILLBURY DAM	7691	100-YR	Full Remov 2	7300.00	346.30	361.13		361.52	0.000480	5.07	1502.87	182.50	0.28	0.30	0.06	0.03
MILLBURY DAM	7691	100-YR	Full Remov 1	7300.00	346.30	361.13		361.52	0.000480	5.07	1502.87	182.50	0.28	0.30	0.06	0.03
MILLBURY DAM	7691	100-YR	Removal RGC	7300.00	346.30	361.13		361.52	0.000480	5.07	1502.87	182.50	0.28	0.30	0.06	0.03
MILLBURY DAM	7691	100-YR	Rock Ramp R	7300.00	346.30	361.13		361.52	0.000480	5.07	1502.87	182.50	0.28	0.30	0.06	0.03
MILLBURY DAM	7691	100-YR	Exist R	7300.00	346.30	361.13		361.52	0.000480	5.07	1502.87	182.50	0.28	0.30	0.06	0.03
MILLBURY DAM	7259.32	Drought	Full Remov 2	49.00	342.13	346.35	343.35	346.35	0.000030	0.52	94.00	33.09	0.05	0.01		
MILLBURY DAM	7259.32	Drought	Full Remov 1	49.00	342.13	346.29	343.35	346.30	0.000032	0.53	92.17	32.91	0.06	0.01		
MILLBURY DAM	7259.32	Drought	Removal RGC	49.00	342.13	346.29	343.35	346.30	0.000032	0.53	92.17	32.91	0.06	0.01		
MILLBURY DAM	7259.32	Drought	Rock Ramp R	49.00	342.13	346.29	343.35	346.30	0.000032	0.53	92.17	32.91	0.06	0.01		
MILLBURY DAM	7259.32	Drought	Exist R	49.00	342.13	346.29	343.35	346.30	0.000032	0.53	92.17	32.91	0.06	0.01		
MILLBURY DAM	7259.32	Average	Full Remov 2	139.00	342.13	346.97	343.97	346.99	0.000136	1.21	115.09	35.11	0.12	0.03		
MILLBURY DAM	7259.32	Average	Full Remov 1	139.00	342.13	346.87	343.97	346.90	0.000148	1.24	111.83	34.80	0.12	0.03		
MILLBURY DAM	7259.32	Average	Removal RGC	139.00	342.13	346.87	343.97	346.90	0.000148	1.24	111.83	34.80	0.12	0.03		
MILLBURY DAM	7259.32	Average	Rock Ramp R	139.00	342.13	346.87	343.97	346.90	0.000148	1.24	111.83	34.80	0.12	0.03		
MILLBURY DAM	7259.32	Average	Exist R	139.00	342.13	346.87	343.97	346.90	0.000148	1.24	111.83	34.80	0.12	0.03		
MILLBURY DAM	7259.32	Maximum	Full Remov 2	304.00	342.13	347.73	344.65	347.80	0.000352	2.13	142.89	37.61	0.19	0.08		
MILLBURY DAM	7259.32	Maximum	Full Remov 1	304.00	342.13	347.66	344.66	347.73	0.000372	2.17	140.18	37.37	0.20	0.08		
MILLBURY DAM	7259.32	Maximum	Removal RGC	304.00	342.13	347.66	344.66	347.73	0.000372	2.17	140.18	37.37	0.20	0.08		
MILLBURY DAM	7259.32	Maximum	Rock Ramp R	304.00	342.13	347.66	344.66	347.73	0.000372	2.17	140.18	37.37	0.20	0.08		
MILLBURY DAM	7259.32	Maximum	Exist R	304.00	342.13	347.66	344.66	347.73	0.000372	2.17	140.18	37.37	0.20	0.08		
MILLBURY DAM	7259.32	1-YR	Full Remov 2	350.00	342.13	347.90	344.82	347.99	0.000411	2.34	149.45	38.17	0.21	0.09		
MILLBURY DAM	7259.32	1-YR	Full Remov 1	350.00	342.13	347.84	344.82	347.93	0.000430	2.38	147.04	37.96	0.21	0.09		
MILLBURY DAM	7259.32	1-YR	Removal RGC	350.00	342.13	347.84	344.82	347.93	0.000430	2.38	147.04	37.96	0.21	0.09		
MILLBURY DAM	7259.32	1-YR	Rock Ramp R	350.00	342.13	347.84	344.82	347.93	0.000430	2.38	147.04	37.96	0.21	0.09		
MILLBURY DAM	7259.32	1-YR	Exist R	350.00	342.13	347.84	344.82	347.93	0.000430	2.38	147.04	37.96	0.21	0.09		
MILLBURY DAM	7259.32	2-YR	Full Remov 2	1350.00	342.13	350.32	347.28	350.77	0.001409	5.39	250.58	44.91	0.40	0.43		
MILLBURY DAM	7259.32	2-YR	Full Remov 1	1350.00	342.13	350.40	347.28	350.84	0.001355	5.32	253.95	45.07	0.39	0.42		
MILLBURY DAM	7259.32	2-YR	Removal RGC	1350.00	342.13	350.40	347.28	350.84	0.001355	5.32	253.95	45.07	0.39	0.42		
MILLBURY DAM	7259.32	2-YR	Rock Ramp R	1350.00	342.13	350.40	347.28	350.84	0.001355	5.32	253.95	45.07	0.39	0.42		
MILLBURY DAM	7259.32	2-YR	Exist R	1350.00	342.13	350.40	347.28	350.84	0.001355	5.32	253.95	45.07	0.39	0.42		
MILLBURY DAM	7259.32	10-YR	Full Remov 2	3200.00	342.13	353.08	350.12	354.16	0.002382	8.35	383.18	51.70	0.54	0.95		
MILLBURY DAM	7259.32	10-YR	Full Remov 1	3200.00	342.13	353.31	350.11	354.33	0.002189	8.10	395.19	52.38	0.52	0.89		
MILLBURY DAM	7259.32	10-YR	Removal RGC	3200.00	342.13	353.31	350.11	354.33	0.002189	8.10	395.19	52.38	0.52	0.89		
MILLBURY DAM	7259.32	10-YR	Rock Ramp R	3200.00	342.13	353.31	350.11	354.33	0.002189	8.10	395.19	52.38	0.52	0.89		
MILLBURY DAM	7259.32	10-YR	Exist R	3200.00	342.13	353.31	350.11	354.33	0.002189	8.10	395.19	52.38	0.52	0.89		

HEC-RAS River: Reach #1 Reach: MILLBURY DAM (Continued)

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan	Shear LOB	Shear ROB
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)	(lb/sq ft)	(lb/sq ft)
MILLBURY DAM	7259.32	50-YR	Full Remov 2	5800.00	342.13	358.41	352.94	359.48	0.001235	8.43	791.80	105.73	0.42	0.82	0.17	0.18
MILLBURY DAM	7259.32	50-YR	Full Remov 1	5800.00	342.13	358.41	352.94	359.49	0.001234	8.43	792.12	105.74	0.42	0.82	0.17	0.18
MILLBURY DAM	7259.32	50-YR	Removal RGC	5800.00	342.13	358.41	352.94	359.49	0.001234	8.43	792.12	105.74	0.42	0.82	0.17	0.18
MILLBURY DAM	7259.32	50-YR	Rock Ramp R	5800.00	342.13	358.41	352.94	359.49	0.001234	8.43	792.12	105.74	0.42	0.82	0.17	0.18
MILLBURY DAM	7259.32	50-YR	Exist R	5800.00	342.13	358.41	352.94	359.49	0.001234	8.43	792.12	105.74	0.42	0.82	0.17	0.18
MILLBURY DAM	7259.32	100-YR	Full Remov 2	7300.00	342.13	359.79	354.27	361.10	0.001326	9.38	942.55	111.80	0.45	0.98	0.24	0.30
MILLBURY DAM	7259.32	100-YR	Full Remov 1	7300.00	342.13	359.79	354.27	361.10	0.001326	9.38	942.55	111.80	0.45	0.98	0.24	0.30
MILLBURY DAM	7259.32	100-YR	Removal RGC	7300.00	342.13	359.79	354.27	361.10	0.001326	9.38	942.55	111.80	0.45	0.98	0.24	0.30
MILLBURY DAM	7259.32	100-YR	Rock Ramp R	7300.00	342.13	359.79	354.27	361.10	0.001326	9.38	942.55	111.80	0.45	0.98	0.24	0.30
MILLBURY DAM	7259.32	100-YR	Exist R	7300.00	342.13	359.79	354.27	361.10	0.001326	9.38	942.55	111.80	0.45	0.98	0.24	0.30
MILLBURY DAM	7218			Bridge												
MILLBURY DAM	7216.03	Drought	Full Remov 2	49.00	342.13	346.35		346.35	0.000031	0.53	92.75	32.11	0.05	0.01		
MILLBURY DAM	7216.03	Drought	Full Remov 1	49.00	342.13	346.29		346.29	0.000033	0.54	90.97	31.95	0.06	0.01		
MILLBURY DAM	7216.03	Drought	Removal RGC	49.00	342.13	346.29		346.29	0.000033	0.54	90.97	31.95	0.06	0.01		
MILLBURY DAM	7216.03	Drought	Rock Ramp R	49.00	342.13	346.29		346.29	0.000033	0.54	90.97	31.95	0.06	0.01		
MILLBURY DAM	7216.03	Drought	Exist R	49.00	342.13	346.29		346.29	0.000033	0.54	90.97	31.95	0.06	0.01		
MILLBURY DAM	7216.03	Average	Full Remov 2	139.00	342.13	346.96		346.98	0.000144	1.23	112.84	33.86	0.12	0.03		
MILLBURY DAM	7216.03	Average	Full Remov 1	139.00	342.13	346.86		346.89	0.000156	1.27	109.67	33.59	0.12	0.03		
MILLBURY DAM	7216.03	Average	Removal RGC	139.00	342.13	346.86		346.89	0.000156	1.27	109.66	33.59	0.12	0.03		
MILLBURY DAM	7216.03	Average	Rock Ramp R	139.00	342.13	346.86		346.89	0.000156	1.27	109.66	33.59	0.12	0.03		
MILLBURY DAM	7216.03	Average	Exist R	139.00	342.13	346.86		346.89	0.000156	1.27	109.66	33.59	0.12	0.03		
MILLBURY DAM	7216.03	Maximum	Full Remov 2	304.00	342.13	347.70		347.77	0.000383	2.19	138.80	35.99	0.20	0.08		
MILLBURY DAM	7216.03	Maximum	Full Remov 1	304.00	342.13	347.62		347.70	0.000404	2.23	136.15	35.78	0.20	0.08		
MILLBURY DAM	7216.03	Maximum	Removal RGC	304.00	342.13	347.62		347.70	0.000404	2.23	136.15	35.78	0.20	0.08		
MILLBURY DAM	7216.03	Maximum	Rock Ramp R	304.00	342.13	347.62		347.70	0.000404	2.23	136.15	35.78	0.20	0.08		
MILLBURY DAM	7216.03	Maximum	Exist R	304.00	342.13	347.62		347.70	0.000404	2.23	136.15	35.78	0.20	0.08		
MILLBURY DAM	7216.03	1-YR	Full Remov 2	350.00	342.13	347.87		347.96	0.000450	2.42	144.85	36.47	0.21	0.10		
MILLBURY DAM	7216.03	1-YR	Full Remov 1	350.00	342.13	347.80		347.89	0.000471	2.46	142.48	36.28	0.22	0.10		
MILLBURY DAM	7216.03	1-YR	Removal RGC	350.00	342.13	347.80		347.89	0.000471	2.46	142.48	36.28	0.22	0.10		
MILLBURY DAM	7216.03	1-YR	Rock Ramp R	350.00	342.13	347.80		347.89	0.000471	2.46	142.48	36.28	0.22	0.10		
MILLBURY DAM	7216.03	1-YR	Exist R	350.00	342.13	347.80		347.89	0.000471	2.46	142.48	36.28	0.22	0.10		
MILLBURY DAM	7216.03	2-YR	Full Remov 2	1350.00	342.13	350.11		350.64	0.001698	5.80	232.69	40.09	0.42	0.51		
MILLBURY DAM	7216.03	2-YR	Full Remov 1	1350.00	342.13	350.20		350.70	0.001627	5.72	236.02	40.09	0.42	0.49		
MILLBURY DAM	7216.03	2-YR	Removal RGC	1350.00	342.13	350.20		350.70	0.001627	5.72	236.02	40.09	0.42	0.49		
MILLBURY DAM	7216.03	2-YR	Rock Ramp R	1350.00	342.13	350.20		350.70	0.001627	5.72	236.02	40.09	0.42	0.49		
MILLBURY DAM	7216.03	2-YR	Exist R	1350.00	342.13	350.20		350.70	0.001627	5.72	236.02	40.09	0.42	0.49		
MILLBURY DAM	7216.03	10-YR	Full Remov 2	3200.00	342.13	352.23		353.80	0.003789	10.08	317.38	40.14	0.63	1.42		
MILLBURY DAM	7216.03	10-YR	Full Remov 1	3200.00	342.13	352.55		354.01	0.003369	9.69	330.37	40.14	0.60	1.30		
MILLBURY DAM	7216.03	10-YR	Removal RGC	3200.00	342.13	352.55		354.01	0.003369	9.69	330.37	40.14	0.60	1.30		
MILLBURY DAM	7216.03	10-YR	Rock Ramp R	3200.00	342.13	352.55		354.01	0.003369	9.69	330.37	40.14	0.60	1.30		
MILLBURY DAM	7216.03	10-YR	Exist R	3200.00	342.13	352.55		354.01	0.003369	9.69	330.37	40.14	0.60	1.30		
MILLBURY DAM	7216.03	50-YR	Full Remov 2	5800.00	342.13	353.68	352.94	357.38	0.007605	15.43	375.92	40.17	0.89	3.21		
MILLBURY DAM	7216.03	50-YR	Full Remov 1	5800.00	342.13	353.95	352.94	357.44	0.007010	15.00	386.72	40.17	0.85	3.01		
MILLBURY DAM	7216.03	50-YR	Removal RGC	5800.00	342.13	353.95	352.94	357.44	0.007010	15.00	386.72	40.17	0.85	3.01		
MILLBURY DAM	7216.03	50-YR	Rock Ramp R	5800.00	342.13	353.95	352.94	357.44	0.007010	15.00	386.72	40.17	0.85	3.01		
MILLBURY DAM	7216.03	50-YR	Exist R	5800.00	342.13	353.95	352.94	357.44	0.007010	15.00	386.72	40.17	0.85	3.01		
MILLBURY DAM	7216.03	100-YR	Full Remov 2	7300.00	342.13	354.39	354.39	359.45	0.009768	18.05	404.39	40.18	1.00	4.32		
MILLBURY DAM	7216.03	100-YR	Full Remov 1	7300.00	342.13	354.39	354.39	359.45	0.009768	18.05	404.39	40.18	1.00	4.32		
MILLBURY DAM	7216.03	100-YR	Removal RGC	7300.00	342.13	354.39	354.39	359.45	0.009768	18.05	404.39	40.18	1.00	4.32		
MILLBURY DAM	7216.03	100-YR	Rock Ramp R	7300.00	342.13	354.39	354.39	359.45	0.009768	18.05	404.39	40.18	1.00	4.32		
MILLBURY DAM	7216.03	100-YR	Exist R	7300.00	342.13	354.39	354.39	359.45	0.009768	18.05	404.39	40.18	1.00	4.32		
MILLBURY DAM	7152.43	Drought	Full Remov 2	49.00	342.13	346.34		346.35	0.000030	0.52	94.38	33.47	0.05	0.00		
MILLBURY DAM	7152.43	Drought	Full Remov 1	49.00	342.13	346.29		346.29	0.000032	0.53	92.52	33.28	0.06	0.01		

HEC-RAS River: Reach #1 Reach: MILLBURY DAM (Continued)

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan	Shear LOB	Shear ROB
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)	(lb/sq ft)	(lb/sq ft)
MILLBURY DAM	7152.43	Drought	Removal RGC	49.00	342.13	346.29		346.29	0.000032	0.53	92.52	33.28	0.06	0.01		
MILLBURY DAM	7152.43	Drought	Rock Ramp R	49.00	342.13	346.29		346.29	0.000032	0.53	92.52	33.28	0.06	0.01		
MILLBURY DAM	7152.43	Drought	Exist R	49.00	342.13	346.29		346.29	0.000032	0.53	92.52	33.28	0.06	0.01		
MILLBURY DAM	7152.43	Average	Full Remov 2	139.00	342.13	346.95		346.97	0.000136	1.21	115.30	35.55	0.12	0.03		
MILLBURY DAM	7152.43	Average	Full Remov 1	139.00	342.13	346.86		346.88	0.000148	1.24	111.96	35.22	0.12	0.03		
MILLBURY DAM	7152.43	Average	Removal RGC	139.00	342.13	346.86		346.88	0.000148	1.24	111.96	35.22	0.12	0.03		
MILLBURY DAM	7152.43	Average	Rock Ramp R	139.00	342.13	346.86		346.88	0.000148	1.24	111.96	35.22	0.12	0.03		
MILLBURY DAM	7152.43	Average	Exist R	139.00	342.13	346.86		346.88	0.000148	1.24	111.96	35.22	0.12	0.03		
MILLBURY DAM	7152.43	Maximum	Full Remov 2	304.00	342.13	347.69		347.76	0.000357	2.13	142.47	38.07	0.19	0.08		
MILLBURY DAM	7152.43	Maximum	Full Remov 1	304.00	342.13	347.61		347.69	0.000377	2.18	139.64	37.82	0.20	0.08		
MILLBURY DAM	7152.43	Maximum	Removal RGC	304.00	342.13	347.61		347.69	0.000377	2.18	139.64	37.82	0.20	0.08		
MILLBURY DAM	7152.43	Maximum	Rock Ramp R	304.00	342.13	347.61		347.69	0.000377	2.18	139.64	37.82	0.20	0.08		
MILLBURY DAM	7152.43	Maximum	Exist R	304.00	342.13	347.61		347.69	0.000377	2.18	139.64	37.82	0.20	0.08		
MILLBURY DAM	7152.43	1-YR	Full Remov 2	350.00	342.13	347.85		347.94	0.000418	2.35	148.81	38.64	0.21	0.09		
MILLBURY DAM	7152.43	1-YR	Full Remov 1	350.00	342.13	347.79		347.88	0.000439	2.39	146.28	38.42	0.22	0.10		
MILLBURY DAM	7152.43	1-YR	Removal RGC	350.00	342.13	347.79		347.88	0.000439	2.39	146.28	38.42	0.22	0.10		
MILLBURY DAM	7152.43	1-YR	Rock Ramp R	350.00	342.13	347.79		347.88	0.000439	2.39	146.28	38.42	0.22	0.10		
MILLBURY DAM	7152.43	1-YR	Exist R	350.00	342.13	347.79		347.88	0.000439	2.39	146.28	38.42	0.22	0.10		
MILLBURY DAM	7152.43	2-YR	Full Remov 2	1350.00	342.13	350.09		350.56	0.001616	5.52	244.54	47.96	0.43	0.47		
MILLBURY DAM	7152.43	2-YR	Full Remov 1	1350.00	342.13	350.17		350.63	0.001544	5.43	248.66	48.31	0.42	0.45		
MILLBURY DAM	7152.43	2-YR	Removal RGC	1350.00	342.13	350.17		350.63	0.001544	5.43	248.66	48.31	0.42	0.45		
MILLBURY DAM	7152.43	2-YR	Rock Ramp R	1350.00	342.13	350.17		350.63	0.001544	5.43	248.66	48.31	0.42	0.45		
MILLBURY DAM	7152.43	2-YR	Exist R	1350.00	342.13	350.17		350.63	0.001544	5.43	248.66	48.31	0.42	0.45		
MILLBURY DAM	7152.43	10-YR	Full Remov 2	3200.00	342.13	352.30		353.52	0.003069	8.88	360.74	57.85	0.62	1.12	0.02	0.03
MILLBURY DAM	7152.43	10-YR	Full Remov 1	3200.00	342.13	352.64		353.74	0.002592	8.44	380.55	60.16	0.57	0.99	0.04	0.05
MILLBURY DAM	7152.43	10-YR	Removal RGC	3200.00	342.13	352.64		353.74	0.002592	8.44	380.55	60.16	0.57	0.99	0.04	0.05
MILLBURY DAM	7152.43	10-YR	Rock Ramp R	3200.00	342.13	352.64		353.74	0.002592	8.44	380.55	60.16	0.57	0.99	0.04	0.05
MILLBURY DAM	7152.43	10-YR	Exist R	3200.00	342.13	352.64		353.74	0.002592	8.44	380.55	60.16	0.57	0.99	0.04	0.05
MILLBURY DAM	7152.43	50-YR	Full Remov 2	5800.00	342.13	354.16		356.56	0.004310	12.45	480.15	70.16	0.76	2.02	0.22	0.30
MILLBURY DAM	7152.43	50-YR	Full Remov 1	5800.00	342.13	354.42		356.67	0.003885	12.07	498.37	71.13	0.73	1.87	0.22	0.32
MILLBURY DAM	7152.43	50-YR	Removal RGC	5800.00	342.13	354.42		356.67	0.003885	12.07	498.37	71.13	0.73	1.87	0.22	0.32
MILLBURY DAM	7152.43	50-YR	Rock Ramp R	5800.00	342.13	354.42		356.67	0.003885	12.07	498.37	71.13	0.73	1.87	0.22	0.32
MILLBURY DAM	7152.43	50-YR	Exist R	5800.00	342.13	354.42		356.67	0.003885	12.07	498.37	71.13	0.73	1.87	0.22	0.32
MILLBURY DAM	7152.43	100-YR	Full Remov 2	7300.00	342.13	352.29	354.02	358.68	0.016091	20.30	359.92	57.75	1.41	5.83	0.11	0.14
MILLBURY DAM	7152.43	100-YR	Full Remov 1	7300.00	342.13	352.29	354.02	358.68	0.016091	20.30	359.92	57.75	1.41	5.83	0.11	0.14
MILLBURY DAM	7152.43	100-YR	Removal RGC	7300.00	342.13	352.29	354.02	358.68	0.016091	20.30	359.92	57.75	1.41	5.83	0.11	0.14
MILLBURY DAM	7152.43	100-YR	Rock Ramp R	7300.00	342.13	352.29	354.02	358.68	0.016091	20.30	359.92	57.75	1.41	5.83	0.11	0.14
MILLBURY DAM	7152.43	100-YR	Exist R	7300.00	342.13	352.29	354.02	358.68	0.016091	20.30	359.92	57.75	1.41	5.83	0.11	0.14
MILLBURY DAM	7097	Drought	Full Remov 2	49.00	345.60	346.29	345.96	346.34	0.002198	1.76	27.87	41.99	0.38	0.09		
MILLBURY DAM	7097	Drought	Full Remov 1	49.00	345.60	346.22		346.28	0.003123	1.96	24.99	41.65	0.45	0.12		
MILLBURY DAM	7097	Drought	Removal RGC	49.00	345.60	346.22		346.28	0.003123	1.96	24.99	41.65	0.45	0.12		
MILLBURY DAM	7097	Drought	Rock Ramp R	49.00	345.60	346.22		346.28	0.003123	1.96	24.99	41.65	0.45	0.12		
MILLBURY DAM	7097	Drought	Exist R	49.00	345.60	346.22		346.28	0.003123	1.96	24.99	41.65	0.45	0.12		
MILLBURY DAM	7097	Average	Full Remov 2	139.00	345.60	346.83	346.33	346.95	0.002527	2.71	51.30	44.67	0.45	0.18		
MILLBURY DAM	7097	Average	Full Remov 1	139.00	345.60	346.70		346.85	0.003671	3.05	45.59	44.04	0.53	0.23		
MILLBURY DAM	7097	Average	Removal RGC	139.00	345.60	346.70		346.85	0.003671	3.05	45.58	44.03	0.53	0.23		
MILLBURY DAM	7097	Average	Rock Ramp R	139.00	345.60	346.70		346.85	0.003671	3.05	45.58	44.03	0.53	0.23		
MILLBURY DAM	7097	Average	Exist R	139.00	345.60	346.70		346.85	0.003671	3.05	45.58	44.03	0.53	0.23		
MILLBURY DAM	7097	Maximum	Full Remov 2	304.00	345.60	347.49	346.81	347.71	0.002816	3.71	81.87	47.95	0.50	0.30		
MILLBURY DAM	7097	Maximum	Full Remov 1	304.00	345.60	347.38		347.63	0.003442	3.96	76.72	47.41	0.55	0.34		
MILLBURY DAM	7097	Maximum	Removal RGC	304.00	345.60	347.38		347.63	0.003442	3.96	76.72	47.41	0.55	0.34		
MILLBURY DAM	7097	Maximum	Rock Ramp R	304.00	345.60	347.38		347.63	0.003442	3.96	76.72	47.41	0.55	0.34		
MILLBURY DAM	7097	Maximum	Exist R	304.00	345.60	347.38		347.63	0.003442	3.96	76.72	47.41	0.55	0.34		
MILLBURY DAM	7097	1-YR	Full Remov 2	350.00	345.60	347.64	346.92	347.88	0.002882	3.93	89.05	48.69	0.51	0.32		
MILLBURY DAM	7097	1-YR	Full Remov 1	350.00	345.60	347.55		347.81	0.003398	4.15	84.40	48.21	0.55	0.37		

HEC-RAS River: Reach #1 Reach: MILLBURY DAM (Continued)

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan	Shear LOB	Shear ROB
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)	(lb/sq ft)	(lb/sq ft)
MILLBURY DAM	7097	1-YR	Removal RGC	350.00	345.60	347.55		347.81	0.003398	4.15	84.40	48.21	0.55	0.37		
MILLBURY DAM	7097	1-YR	Rock Ramp R	350.00	345.60	347.55		347.81	0.003398	4.15	84.40	48.21	0.55	0.37		
MILLBURY DAM	7097	1-YR	Exist R	350.00	345.60	347.55		347.81	0.003398	4.15	84.40	48.21	0.55	0.37		
MILLBURY DAM	7097	2-YR	Full Remov 2	1350.00	345.60	349.72	348.72	350.42	0.003727	6.71	201.06	59.00	0.64	0.77		
MILLBURY DAM	7097	2-YR	Full Remov 1	1350.00	345.60	349.86		350.50	0.003326	6.46	209.02	59.67	0.61	0.71		
MILLBURY DAM	7097	2-YR	Removal RGC	1350.00	345.60	349.86		350.50	0.003326	6.46	209.02	59.67	0.61	0.71		
MILLBURY DAM	7097	2-YR	Rock Ramp R	1350.00	345.60	349.86		350.50	0.003326	6.46	209.02	59.67	0.61	0.71		
MILLBURY DAM	7097	2-YR	Exist R	1350.00	345.60	349.86		350.50	0.003326	6.46	209.02	59.67	0.61	0.71		
MILLBURY DAM	7097	10-YR	Full Remov 2	3200.00	345.60	352.09		353.35	0.004061	8.99	355.90	72.52	0.71	1.22	0.01	0.01
MILLBURY DAM	7097	10-YR	Full Remov 1	3200.00	345.60	352.53		353.59	0.003069	8.27	388.72	78.00	0.63	1.00	0.05	0.05
MILLBURY DAM	7097	10-YR	Removal RGC	3200.00	345.60	352.53		353.59	0.003069	8.27	388.72	78.00	0.63	1.00	0.05	0.05
MILLBURY DAM	7097	10-YR	Rock Ramp R	3200.00	345.60	352.53		353.59	0.003069	8.27	388.72	78.00	0.63	1.00	0.05	0.05
MILLBURY DAM	7097	10-YR	Exist R	3200.00	345.60	352.53		353.59	0.003069	8.27	388.72	78.00	0.63	1.00	0.05	0.05
MILLBURY DAM	7097	50-YR	Full Remov 2	5800.00	345.60	354.26		356.22	0.003950	11.28	543.87	109.34	0.74	1.70	0.11	0.29
MILLBURY DAM	7097	50-YR	Full Remov 1	5800.00	345.60	354.55		356.35	0.003439	10.81	577.98	123.91	0.70	1.54	0.10	0.29
MILLBURY DAM	7097	50-YR	Removal RGC	5800.00	345.60	354.55		356.35	0.003439	10.81	577.98	123.91	0.70	1.54	0.10	0.29
MILLBURY DAM	7097	50-YR	Rock Ramp R	5800.00	345.60	354.55		356.35	0.003439	10.81	577.97	123.91	0.70	1.54	0.10	0.29
MILLBURY DAM	7097	50-YR	Exist R	5800.00	345.60	354.55		356.35	0.003439	10.81	577.97	123.91	0.70	1.54	0.10	0.29
MILLBURY DAM	7097	100-YR	Full Remov 2	7300.00	345.60	355.50	354.04	357.65	0.003560	11.92	717.66	171.10	0.72	1.80	0.19	0.43
MILLBURY DAM	7097	100-YR	Full Remov 1	7300.00	345.60	355.31	354.04	357.59	0.003869	12.23	685.91	161.59	0.75	1.91	0.19	0.44
MILLBURY DAM	7097	100-YR	Removal RGC	7300.00	345.60	355.31	354.04	357.59	0.003869	12.23	685.93	161.60	0.75	1.91	0.19	0.44
MILLBURY DAM	7097	100-YR	Rock Ramp R	7300.00	345.60	355.31	354.04	357.59	0.003870	12.23	685.88	161.58	0.75	1.91	0.19	0.44
MILLBURY DAM	7097	100-YR	Exist R	7300.00	345.60	355.31	354.04	357.59	0.003870	12.23	685.89	161.58	0.75	1.91	0.19	0.44
MILLBURY DAM	6687	Drought	Full Remov 2	49.00	343.80	344.15	344.15	344.32	0.018978	3.33	14.73	43.10	1.00	0.40		
MILLBURY DAM	6687	Drought	Full Remov 1	49.00	343.80	346.22		346.23	0.000028	0.43	112.67	51.18	0.05	0.00		
MILLBURY DAM	6687	Drought	Removal RGC	49.00	343.80	346.22		346.23	0.000028	0.43	112.67	51.18	0.05	0.00		
MILLBURY DAM	6687	Drought	Rock Ramp R	49.00	343.80	346.22		346.23	0.000028	0.43	112.67	51.18	0.05	0.00		
MILLBURY DAM	6687	Drought	Exist R	49.00	343.80	346.22		346.23	0.000028	0.43	112.67	51.18	0.05	0.00		
MILLBURY DAM	6687	Average	Full Remov 2	139.00	343.80	344.49	344.49	344.83	0.015283	4.67	29.79	44.44	1.00	0.63		
MILLBURY DAM	6687	Average	Full Remov 1	139.00	343.80	346.64		346.66	0.000130	1.03	134.37	52.81	0.11	0.02		
MILLBURY DAM	6687	Average	Removal RGC	139.00	343.80	346.64		346.66	0.000130	1.03	134.37	52.81	0.11	0.02		
MILLBURY DAM	6687	Average	Rock Ramp R	139.00	343.80	346.64		346.66	0.000130	1.03	134.37	52.81	0.11	0.02		
MILLBURY DAM	6687	Average	Exist R	139.00	343.80	346.64		346.66	0.000130	1.03	134.37	52.81	0.11	0.02		
MILLBURY DAM	6687	Maximum	Full Remov 2	304.00	343.80	344.95	344.95	345.51	0.013085	5.98	50.81	46.24	1.01	0.89		
MILLBURY DAM	6687	Maximum	Full Remov 1	304.00	343.80	347.20		347.25	0.000337	1.85	164.28	54.97	0.19	0.06		
MILLBURY DAM	6687	Maximum	Removal RGC	304.00	343.80	347.20		347.25	0.000337	1.85	164.28	54.97	0.19	0.06		
MILLBURY DAM	6687	Maximum	Rock Ramp R	304.00	343.80	347.20		347.25	0.000337	1.85	164.28	54.97	0.19	0.06		
MILLBURY DAM	6687	Maximum	Exist R	304.00	343.80	347.20		347.25	0.000337	1.85	164.28	54.97	0.19	0.06		
MILLBURY DAM	6687	1-YR	Full Remov 2	350.00	343.80	345.07	345.07	345.67	0.012714	6.25	56.00	46.68	1.01	0.94		
MILLBURY DAM	6687	1-YR	Full Remov 1	350.00	343.80	347.33		347.39	0.000393	2.04	171.53	55.48	0.20	0.07		
MILLBURY DAM	6687	1-YR	Removal RGC	350.00	343.80	347.33		347.39	0.000393	2.04	171.53	55.48	0.20	0.07		
MILLBURY DAM	6687	1-YR	Rock Ramp R	350.00	343.80	347.33		347.39	0.000393	2.04	171.53	55.48	0.20	0.07		
MILLBURY DAM	6687	1-YR	Exist R	350.00	343.80	347.33		347.39	0.000393	2.04	171.53	55.48	0.20	0.07		
MILLBURY DAM	6687	2-YR	Full Remov 2	1350.00	343.80	347.01	346.83	348.20	0.008100	8.77	153.97	54.23	0.92	1.39		
MILLBURY DAM	6687	2-YR	Full Remov 1	1350.00	343.80	349.27		349.61	0.001277	4.70	286.93	63.57	0.39	0.35		
MILLBURY DAM	6687	2-YR	Removal RGC	1350.00	343.80	349.27		349.61	0.001277	4.70	286.93	63.57	0.39	0.35		
MILLBURY DAM	6687	2-YR	Rock Ramp R	1350.00	343.80	349.27		349.61	0.001277	4.70	286.93	63.57	0.39	0.35		
MILLBURY DAM	6687	2-YR	Exist R	1350.00	343.80	349.27		349.61	0.001277	4.70	286.93	63.57	0.39	0.35		
MILLBURY DAM	6687	10-YR	Full Remov 2	3200.00	343.80	349.47	349.01	351.24	0.006332	10.68	299.58	64.42	0.87	1.76		
MILLBURY DAM	6687	10-YR	Full Remov 1	3200.00	343.80	351.81		352.56	0.001751	6.97	460.67	72.82	0.48	0.67	0.07	
MILLBURY DAM	6687	10-YR	Removal RGC	3200.00	343.80	351.81		352.56	0.001751	6.97	460.67	72.82	0.48	0.67	0.07	
MILLBURY DAM	6687	10-YR	Rock Ramp R	3200.00	343.80	351.81		352.56	0.001751	6.97	460.67	72.82	0.48	0.67	0.07	
MILLBURY DAM	6687	10-YR	Exist R	3200.00	343.80	351.81		352.56	0.001751	6.97	460.67	72.82	0.48	0.67	0.07	
MILLBURY DAM	6687	50-YR	Full Remov 2	5800.00	343.80	352.78		354.64	0.003616	10.95	539.76	92.87	0.71	1.59	0.14	0.09
MILLBURY DAM	6687	50-YR	Full Remov 1	5800.00	343.80	353.52		355.04	0.002609	9.91	615.50	111.27	0.61	1.26	0.15	0.12

HEC-RAS River: Reach #1 Reach: MILLBURY DAM (Continued)

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan	Shear LOB	Shear ROB
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)	(lb/sq ft)	(lb/sq ft)
MILLBURY DAM	6687	50-YR	Removal RGC	5800.00	343.80	353.52		355.04	0.002609	9.91	615.50	111.27	0.61	1.26	0.15	0.12
MILLBURY DAM	6687	50-YR	Rock Ramp R	5800.00	343.80	353.52		355.04	0.002609	9.91	615.49	111.27	0.61	1.26	0.15	0.12
MILLBURY DAM	6687	50-YR	Exist R	5800.00	343.80	353.52		355.04	0.002609	9.91	615.49	111.27	0.61	1.26	0.15	0.12
MILLBURY DAM	6687	100-YR	Full Remov 2	7300.00	343.80	352.70	352.24	355.71	0.005948	13.94	532.21	90.84	0.91	2.59	0.22	0.13
MILLBURY DAM	6687	100-YR	Full Remov 1	7300.00	343.80	353.43	352.24	355.90	0.004308	12.64	604.76	108.85	0.79	2.06	0.23	0.19
MILLBURY DAM	6687	100-YR	Removal RGC	7300.00	343.80	353.43	352.24	355.90	0.004309	12.64	604.69	108.83	0.79	2.06	0.23	0.19
MILLBURY DAM	6687	100-YR	Rock Ramp R	7300.00	343.80	353.43	352.24	355.90	0.004305	12.64	604.90	108.88	0.79	2.06	0.23	0.19
MILLBURY DAM	6687	100-YR	Exist R	7300.00	343.80	353.43	352.24	355.90	0.004305	12.64	604.92	108.88	0.79	2.06	0.23	0.19
MILLBURY DAM	6547.99	Drought	Full Remov 2	49.00	340.69	342.75	341.90	342.79	0.000949	1.55	31.63	30.61	0.27	0.06		
MILLBURY DAM	6547.99	Drought	Full Remov 1	49.00	340.69	346.22	341.90	346.23	0.000006	0.26	192.07	59.42	0.03	0.00		
MILLBURY DAM	6547.99	Drought	Removal RGC	49.00	340.69	346.22	341.90	346.23	0.000006	0.26	192.07	59.42	0.03	0.00		
MILLBURY DAM	6547.99	Drought	Rock Ramp R	49.00	340.69	346.22	341.90	346.23	0.000006	0.26	192.07	59.42	0.03	0.00		
MILLBURY DAM	6547.99	Drought	Exist R	49.00	340.69	346.22	341.90	346.23	0.000006	0.26	192.07	59.42	0.03	0.00		
MILLBURY DAM	6547.99	Average	Full Remov 2	139.00	340.69	343.43	342.53	343.54	0.001601	2.54	54.66	37.16	0.37	0.15		
MILLBURY DAM	6547.99	Average	Full Remov 1	139.00	340.69	346.64	342.53	346.65	0.000032	0.64	217.42	62.27	0.06	0.01		
MILLBURY DAM	6547.99	Average	Removal RGC	139.00	340.69	346.64	342.53	346.65	0.000032	0.64	217.42	62.27	0.06	0.01		
MILLBURY DAM	6547.99	Average	Rock Ramp R	139.00	340.69	346.64	342.53	346.65	0.000032	0.64	217.42	62.27	0.06	0.01		
MILLBURY DAM	6547.99	Average	Exist R	139.00	340.69	346.64	342.53	346.65	0.000032	0.64	217.42	62.27	0.06	0.01		
MILLBURY DAM	6547.99	Maximum	Full Remov 2	304.00	340.69	344.25	343.19	344.44	0.002002	3.44	88.36	45.06	0.43	0.24		
MILLBURY DAM	6547.99	Maximum	Full Remov 1	304.00	340.69	347.19	343.21	347.22	0.000102	1.20	253.10	66.69	0.11	0.02		
MILLBURY DAM	6547.99	Maximum	Removal RGC	304.00	340.69	347.19	343.21	347.22	0.000102	1.20	253.10	66.69	0.11	0.02		
MILLBURY DAM	6547.99	Maximum	Rock Ramp R	304.00	340.69	347.19	343.21	347.22	0.000102	1.20	253.10	66.69	0.11	0.02		
MILLBURY DAM	6547.99	Maximum	Exist R	304.00	340.69	347.19	343.21	347.22	0.000102	1.20	253.10	66.69	0.11	0.02		
MILLBURY DAM	6547.99	1-YR	Full Remov 2	350.00	340.69	344.43	343.35	344.64	0.002073	3.62	96.61	46.79	0.44	0.26		
MILLBURY DAM	6547.99	1-YR	Full Remov 1	350.00	340.69	347.33	343.35	347.35	0.000124	1.34	261.91	67.73	0.12	0.03		
MILLBURY DAM	6547.99	1-YR	Removal RGC	350.00	340.69	347.33	343.35	347.35	0.000124	1.34	261.91	67.73	0.12	0.03		
MILLBURY DAM	6547.99	1-YR	Rock Ramp R	350.00	340.69	347.33	343.35	347.35	0.000124	1.34	261.91	67.73	0.12	0.03		
MILLBURY DAM	6547.99	1-YR	Exist R	350.00	340.69	347.33	343.35	347.35	0.000124	1.34	261.91	67.73	0.12	0.03		
MILLBURY DAM	6547.99	2-YR	Full Remov 2	1350.00	340.69	346.90	345.39	347.41	0.002511	5.78	233.56	64.31	0.53	0.56		
MILLBURY DAM	6547.99	2-YR	Full Remov 1	1350.00	340.69	349.28	345.39	349.46	0.000483	3.34	406.94	78.71	0.25	0.16	0.02	0.02
MILLBURY DAM	6547.99	2-YR	Removal RGC	1350.00	340.69	349.28	345.39	349.46	0.000483	3.34	406.94	78.71	0.25	0.16	0.02	0.02
MILLBURY DAM	6547.99	2-YR	Rock Ramp R	1350.00	340.69	349.28	345.39	349.46	0.000483	3.34	406.94	78.71	0.25	0.16	0.02	0.02
MILLBURY DAM	6547.99	2-YR	Exist R	1350.00	340.69	349.28	345.39	349.46	0.000483	3.34	406.94	78.71	0.25	0.16	0.02	0.02
MILLBURY DAM	6547.99	10-YR	Full Remov 2	3200.00	340.69	349.60	347.61	350.47	0.002252	7.50	431.88	80.07	0.55	0.80	0.09	0.11
MILLBURY DAM	6547.99	10-YR	Full Remov 1	3200.00	340.69	351.87	347.61	352.32	0.000742	5.36	627.99	92.95	0.33	0.37	0.07	0.08
MILLBURY DAM	6547.99	10-YR	Removal RGC	3200.00	340.69	351.87	347.61	352.32	0.000742	5.36	627.99	92.95	0.33	0.37	0.07	0.08
MILLBURY DAM	6547.99	10-YR	Rock Ramp R	3200.00	340.69	351.87	347.61	352.32	0.000742	5.36	627.99	92.95	0.33	0.37	0.07	0.08
MILLBURY DAM	6547.99	10-YR	Exist R	3200.00	340.69	351.87	347.61	352.32	0.000742	5.36	627.99	92.95	0.33	0.37	0.07	0.08
MILLBURY DAM	6547.99	50-YR	Full Remov 2	5800.00	340.69	353.00	349.56	354.09	0.001559	8.47	802.22	232.29	0.49	0.88	0.17	0.07
MILLBURY DAM	6547.99	50-YR	Full Remov 1	5800.00	340.69	353.73	349.56	354.62	0.001163	7.70	1010.10	334.37	0.43	0.71	0.15	0.07
MILLBURY DAM	6547.99	50-YR	Removal RGC	5800.00	340.69	353.73	349.56	354.62	0.001163	7.70	1010.09	334.36	0.43	0.71	0.15	0.07
MILLBURY DAM	6547.99	50-YR	Rock Ramp R	5800.00	340.69	353.73	349.56	354.62	0.001163	7.70	1010.07	334.36	0.43	0.71	0.15	0.07
MILLBURY DAM	6547.99	50-YR	Exist R	5800.00	340.69	353.73	349.56	354.62	0.001163	7.70	1010.07	334.36	0.43	0.71	0.15	0.07
MILLBURY DAM	6547.99	100-YR	Full Remov 2	7300.00	340.69	353.14	350.56	354.81	0.002328	10.46	838.28	252.97	0.60	1.33	0.26	0.11
MILLBURY DAM	6547.99	100-YR	Full Remov 1	7300.00	340.69	353.83	350.56	355.20	0.001773	9.57	1042.81	347.71	0.53	1.09	0.23	0.12
MILLBURY DAM	6547.99	100-YR	Removal RGC	7300.00	340.69	353.83	350.56	355.20	0.001774	9.57	1042.56	347.62	0.53	1.09	0.23	0.12
MILLBURY DAM	6547.99	100-YR	Rock Ramp R	7300.00	340.69	353.83	350.56	355.20	0.001773	9.57	1043.24	347.89	0.53	1.09	0.23	0.12
MILLBURY DAM	6547.99	100-YR	Exist R	7300.00	340.69	353.83	350.56	355.20	0.001772	9.57	1043.30	347.91	0.53	1.09	0.23	0.12
MILLBURY DAM	6529.47			Bridge												
MILLBURY DAM	6510.94	Drought	Full Remov 2	49.00	340.69	342.70		342.74	0.001103	1.64	29.94	29.86	0.29	0.07		
MILLBURY DAM	6510.94	Drought	Full Remov 1	49.00	340.69	346.22		346.23	0.000006	0.26	189.99	56.24	0.02	0.00		
MILLBURY DAM	6510.94	Drought	Removal RGC	49.00	340.69	346.22		346.23	0.000006	0.26	189.99	56.24	0.02	0.00		
MILLBURY DAM	6510.94	Drought	Rock Ramp R	49.00	340.69	346.22		346.23	0.000006	0.26	189.99	56.24	0.02	0.00		

HEC-RAS River: Reach #1 Reach: MILLBURY DAM (Continued)

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan	Shear LOB	Shear ROB
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)	(lb/sq ft)	(lb/sq ft)
MILLBURY DAM	6510.94	Drought	Exist R	49.00	340.69	346.22		346.23	0.000006	0.26	189.99	56.24	0.02	0.00		
MILLBURY DAM	6510.94	Average	Full Remov 2	139.00	340.69	343.32		343.44	0.001989	2.74	50.67	36.20	0.41	0.17		
MILLBURY DAM	6510.94	Average	Full Remov 1	139.00	340.69	346.64		346.65	0.000032	0.65	213.74	58.17	0.06	0.01		
MILLBURY DAM	6510.94	Average	Removal RGC	139.00	340.69	346.64		346.65	0.000032	0.65	213.74	58.17	0.06	0.01		
MILLBURY DAM	6510.94	Average	Rock Ramp R	139.00	340.69	346.64		346.65	0.000032	0.65	213.74	58.17	0.06	0.01		
MILLBURY DAM	6510.94	Average	Exist R	139.00	340.69	346.64		346.65	0.000032	0.65	213.74	58.17	0.06	0.01		
MILLBURY DAM	6510.94	Maximum	Full Remov 2	304.00	340.69	344.10		344.31	0.002485	3.72	81.82	43.74	0.48	0.29		
MILLBURY DAM	6510.94	Maximum	Full Remov 1	304.00	340.69	347.19		347.21	0.000099	1.24	245.67	58.30	0.11	0.02		
MILLBURY DAM	6510.94	Maximum	Removal RGC	304.00	340.69	347.19		347.21	0.000099	1.24	245.67	58.30	0.11	0.02		
MILLBURY DAM	6510.94	Maximum	Rock Ramp R	304.00	340.69	347.19		347.21	0.000099	1.24	245.67	58.30	0.11	0.02		
MILLBURY DAM	6510.94	Maximum	Exist R	304.00	340.69	347.19		347.21	0.000099	1.24	245.67	58.30	0.11	0.02		
MILLBURY DAM	6510.94	1-YR	Full Remov 2	350.00	340.69	344.27		344.51	0.002569	3.91	89.49	45.40	0.49	0.31		
MILLBURY DAM	6510.94	1-YR	Full Remov 1	350.00	340.69	347.32		347.35	0.000120	1.38	253.20	58.34	0.12	0.03		
MILLBURY DAM	6510.94	1-YR	Removal RGC	350.00	340.69	347.32		347.35	0.000120	1.38	253.20	58.34	0.12	0.03		
MILLBURY DAM	6510.94	1-YR	Rock Ramp R	350.00	340.69	347.32		347.35	0.000120	1.38	253.20	58.34	0.12	0.03		
MILLBURY DAM	6510.94	1-YR	Exist R	350.00	340.69	347.32		347.35	0.000120	1.38	253.20	58.34	0.12	0.03		
MILLBURY DAM	6510.94	2-YR	Full Remov 2	1350.00	340.69	346.61		347.24	0.003115	6.37	211.94	58.06	0.59	0.68		
MILLBURY DAM	6510.94	2-YR	Full Remov 1	1350.00	340.69	349.21		349.42	0.000576	3.71	363.81	58.88	0.26	0.20		
MILLBURY DAM	6510.94	2-YR	Removal RGC	1350.00	340.69	349.21		349.42	0.000576	3.71	363.81	58.88	0.26	0.20		
MILLBURY DAM	6510.94	2-YR	Rock Ramp R	1350.00	340.69	349.21		349.42	0.000576	3.71	363.81	58.88	0.26	0.20		
MILLBURY DAM	6510.94	2-YR	Exist R	1350.00	340.69	349.21		349.42	0.000576	3.71	363.81	58.88	0.26	0.20		
MILLBURY DAM	6510.94	10-YR	Full Remov 2	3200.00	340.69	348.80		350.18	0.003980	9.41	340.14	58.70	0.69	1.30		
MILLBURY DAM	6510.94	10-YR	Full Remov 1	3200.00	340.69	351.23		351.88	0.001422	6.48	494.47	69.50	0.42	0.57	0.00	0.02
MILLBURY DAM	6510.94	10-YR	Removal RGC	3200.00	340.69	351.23		351.88	0.001422	6.48	494.47	69.50	0.42	0.57	0.00	0.02
MILLBURY DAM	6510.94	10-YR	Rock Ramp R	3200.00	340.69	351.23		351.88	0.001422	6.48	494.47	69.50	0.42	0.57	0.00	0.02
MILLBURY DAM	6510.94	10-YR	Exist R	3200.00	340.69	351.23		351.88	0.001422	6.48	494.47	69.50	0.42	0.57	0.00	0.02
MILLBURY DAM	6510.94	50-YR	Full Remov 2	5800.00	340.69	350.37	349.84	353.11	0.006752	13.30	436.08	65.47	0.91	2.49		
MILLBURY DAM	6510.94	50-YR	Full Remov 1	5800.00	340.69	352.75		354.21	0.002477	9.70	603.50	73.76	0.58	1.21	0.03	0.15
MILLBURY DAM	6510.94	50-YR	Removal RGC	5800.00	340.69	352.75		354.21	0.002477	9.70	603.50	73.76	0.58	1.21	0.03	0.15
MILLBURY DAM	6510.94	50-YR	Rock Ramp R	5800.00	340.69	352.75		354.21	0.002477	9.70	603.50	73.76	0.58	1.21	0.03	0.15
MILLBURY DAM	6510.94	50-YR	Exist R	5800.00	340.69	352.75		354.21	0.002477	9.70	603.50	73.76	0.58	1.21	0.03	0.15
MILLBURY DAM	6510.94	100-YR	Full Remov 2	7300.00	340.69	351.04	351.04	354.61	0.008097	15.18	481.10	68.96	1.00	3.18	0.01	0.10
MILLBURY DAM	6510.94	100-YR	Full Remov 1	7300.00	340.69	352.97		355.17	0.003608	11.91	620.05	74.39	0.70	1.80	0.05	0.25
MILLBURY DAM	6510.94	100-YR	Removal RGC	7300.00	340.69	352.97		355.17	0.003609	11.91	620.01	74.39	0.70	1.80	0.05	0.25
MILLBURY DAM	6510.94	100-YR	Rock Ramp R	7300.00	340.69	352.97		355.17	0.003607	11.90	620.11	74.39	0.70	1.80	0.05	0.25
MILLBURY DAM	6510.94	100-YR	Exist R	7300.00	340.69	352.97		355.17	0.003607	11.90	620.13	74.39	0.70	1.80	0.05	0.25
MILLBURY DAM	6470.45	Drought	Full Remov 2	49.00	340.50	342.68	341.71	342.71	0.000660	1.36	35.90	32.00	0.23	0.05		
MILLBURY DAM	6470.45	Drought	Full Remov 1	49.00	340.50	346.22	341.71	346.23	0.000005	0.24	203.63	59.50	0.02	0.00		
MILLBURY DAM	6470.45	Drought	Removal RGC	49.00	340.50	346.22	341.71	346.23	0.000005	0.24	203.63	59.50	0.02	0.00		
MILLBURY DAM	6470.45	Drought	Rock Ramp R	49.00	340.50	346.22	341.71	346.23	0.000005	0.24	203.63	59.50	0.02	0.00		
MILLBURY DAM	6470.45	Drought	Exist R	49.00	340.50	346.22	341.71	346.23	0.000005	0.24	203.63	59.50	0.02	0.00		
MILLBURY DAM	6470.45	Average	Full Remov 2	139.00	340.50	343.29	342.34	343.38	0.001405	2.43	57.29	37.88	0.35	0.13		
MILLBURY DAM	6470.45	Average	Full Remov 1	139.00	340.50	346.64	342.34	346.64	0.000028	0.61	228.91	62.73	0.06	0.01		
MILLBURY DAM	6470.45	Average	Removal RGC	139.00	340.50	346.64	342.34	346.64	0.000028	0.61	228.91	62.73	0.06	0.01		
MILLBURY DAM	6470.45	Average	Rock Ramp R	139.00	340.50	346.64	342.34	346.64	0.000028	0.61	228.91	62.73	0.06	0.01		
MILLBURY DAM	6470.45	Average	Exist R	139.00	340.50	346.64	342.34	346.64	0.000028	0.61	228.91	62.73	0.06	0.01		
MILLBURY DAM	6470.45	Maximum	Full Remov 2	304.00	340.50	344.06	343.00	344.24	0.001941	3.40	89.36	45.30	0.43	0.24		
MILLBURY DAM	6470.45	Maximum	Full Remov 1	304.00	340.50	347.19	343.00	347.21	0.000090	1.15	264.65	67.71	0.10	0.02		
MILLBURY DAM	6470.45	Maximum	Removal RGC	304.00	340.50	347.19	343.00	347.21	0.000090	1.15	264.65	67.71	0.10	0.02		
MILLBURY DAM	6470.45	Maximum	Rock Ramp R	304.00	340.50	347.19	343.00	347.21	0.000090	1.15	264.65	67.71	0.10	0.02		
MILLBURY DAM	6470.45	Maximum	Exist R	304.00	340.50	347.19	343.00	347.21	0.000090	1.15	264.65	67.71	0.10	0.02		
MILLBURY DAM	6470.45	1-YR	Full Remov 2	350.00	340.50	344.24	343.14	344.44	0.002037	3.60	97.24	46.94	0.44	0.26		
MILLBURY DAM	6470.45	1-YR	Full Remov 1	350.00	340.50	347.32	343.14	347.34	0.000110	1.28	273.47	68.88	0.11	0.03		
MILLBURY DAM	6470.45	1-YR	Removal RGC	350.00	340.50	347.32	343.14	347.34	0.000110	1.28	273.47	68.88	0.11	0.03		
MILLBURY DAM	6470.45	1-YR	Rock Ramp R	350.00	340.50	347.32	343.14	347.34	0.000110	1.28	273.47	68.88	0.11	0.03		

HEC-RAS River: Reach #1 Reach: MILLBURY DAM (Continued)

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan	Shear LOB	Shear ROB
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)	(lb/sq ft)	(lb/sq ft)
MILLBURY DAM	6470.45	1-YR	Exist R	350.00	340.50	347.32	343.14	347.34	0.000110	1.28	273.47	68.88	0.11	0.03		
MILLBURY DAM	6470.45	2-YR	Full Remov 2	1350.00	340.50	346.57	345.17	347.13	0.002736	6.01	224.81	62.13	0.56	0.60		
MILLBURY DAM	6470.45	2-YR	Full Remov 1	1350.00	340.50	349.22	345.17	349.38	0.000460	3.26	419.03	83.12	0.24	0.15	0.02	0.02
MILLBURY DAM	6470.45	2-YR	Removal RGC	1350.00	340.50	349.22	345.17	349.38	0.000460	3.26	419.03	83.12	0.24	0.15	0.02	0.02
MILLBURY DAM	6470.45	2-YR	Rock Ramp R	1350.00	340.50	349.22	345.17	349.38	0.000460	3.26	419.03	83.12	0.24	0.15	0.02	0.02
MILLBURY DAM	6470.45	2-YR	Exist R	1350.00	340.50	349.22	345.17	349.38	0.000460	3.26	419.03	83.12	0.24	0.15	0.02	0.02
MILLBURY DAM	6470.45	10-YR	Full Remov 2	3200.00	340.50	348.88	347.43	349.93	0.003198	8.23	391.20	80.89	0.64	1.01	0.08	0.08
MILLBURY DAM	6470.45	10-YR	Full Remov 1	3200.00	340.50	351.29	347.43	351.77	0.000880	5.57	607.75	100.52	0.36	0.41	0.08	0.08
MILLBURY DAM	6470.45	10-YR	Removal RGC	3200.00	340.50	351.29	347.43	351.77	0.000880	5.57	607.75	100.52	0.36	0.41	0.08	0.08
MILLBURY DAM	6470.45	10-YR	Rock Ramp R	3200.00	340.50	351.29	347.43	351.77	0.000880	5.57	607.75	100.52	0.36	0.41	0.08	0.08
MILLBURY DAM	6470.45	10-YR	Exist R	3200.00	340.50	351.29	347.43	351.77	0.000880	5.57	607.75	100.52	0.36	0.41	0.08	0.08
MILLBURY DAM	6470.45	50-YR	Full Remov 2	5800.00	340.50	350.68	349.44	352.55	0.003839	11.01	548.53	94.76	0.73	1.63	0.29	0.29
MILLBURY DAM	6470.45	50-YR	Full Remov 1	5800.00	340.50	352.92	349.44	353.95	0.001481	8.23	788.20	124.65	0.48	0.83	0.17	0.19
MILLBURY DAM	6470.45	50-YR	Removal RGC	5800.00	340.50	352.92	349.44	353.95	0.001481	8.23	788.19	124.65	0.48	0.83	0.17	0.19
MILLBURY DAM	6470.45	50-YR	Rock Ramp R	5800.00	340.50	352.92	349.44	353.95	0.001481	8.23	788.19	124.65	0.48	0.83	0.17	0.19
MILLBURY DAM	6470.45	50-YR	Exist R	5800.00	340.50	352.92	349.44	353.95	0.001481	8.23	788.19	124.65	0.48	0.83	0.17	0.19
MILLBURY DAM	6470.45	100-YR	Full Remov 2	7300.00	340.50	349.24	350.41	354.01	0.013243	17.53	421.20	83.30	1.31	4.46	0.49	0.49
MILLBURY DAM	6470.45	100-YR	Full Remov 1	7300.00	340.50	353.25	350.41	354.76	0.002072	9.97	830.83	130.96	0.57	1.20	0.24	0.28
MILLBURY DAM	6470.45	100-YR	Removal RGC	7300.00	340.50	353.25	350.41	354.76	0.002073	9.97	830.77	130.95	0.57	1.20	0.24	0.28
MILLBURY DAM	6470.45	100-YR	Rock Ramp R	7300.00	340.50	353.25	350.41	354.76	0.002072	9.97	830.95	130.98	0.57	1.20	0.24	0.28
MILLBURY DAM	6470.45	100-YR	Exist R	7300.00	340.50	353.25	350.41	354.76	0.002072	9.96	830.97	130.98	0.57	1.20	0.24	0.28
MILLBURY DAM	6391	Drought	Full Remov 2	49.00	341.05	342.52	342.25	342.60	0.003701	2.29	21.38	32.02	0.49	0.15		
MILLBURY DAM	6391	Drought	Full Remov 1	49.00	345.80	346.08	346.08	346.21	0.020196	2.94	16.66	61.65	1.00	0.34		
MILLBURY DAM	6391	Drought	Removal RGC	49.00	345.80	346.08	346.08	346.21	0.020196	2.94	16.66	61.65	1.00	0.34		
MILLBURY DAM	6391	Drought	Rock Ramp R	49.00	345.80	346.08	346.08	346.21	0.020196	2.94	16.66	61.65	1.00	0.34		
MILLBURY DAM	6391	Drought	Exist R	49.00	345.80	346.08	346.08	346.21	0.020196	2.94	16.66	61.65	1.00	0.34		
MILLBURY DAM	6391	Average	Full Remov 2	139.00	341.05	342.90	342.69	343.16	0.007063	4.06	34.21	35.18	0.73	0.43		
MILLBURY DAM	6391	Average	Full Remov 1	139.00	345.80	346.35	346.35	346.61	0.016251	4.11	33.79	64.15	1.00	0.53		
MILLBURY DAM	6391	Average	Removal RGC	139.00	345.80	346.35	346.35	346.61	0.016251	4.11	33.79	64.15	1.00	0.53		
MILLBURY DAM	6391	Average	Rock Ramp R	139.00	345.80	346.35	346.35	346.61	0.016251	4.11	33.79	64.15	1.00	0.53		
MILLBURY DAM	6391	Average	Exist R	139.00	345.80	346.35	346.35	346.61	0.016251	4.11	33.79	64.15	1.00	0.53		
MILLBURY DAM	6391	Maximum	Full Remov 2	304.00	341.05	343.54	343.28	343.97	0.006872	5.21	58.40	40.46	0.76	0.61		
MILLBURY DAM	6391	Maximum	Full Remov 1	304.00	345.80	346.71	346.71	347.14	0.013917	5.26	57.81	67.51	1.00	0.74		
MILLBURY DAM	6391	Maximum	Removal RGC	304.00	345.80	346.71	346.71	347.14	0.013917	5.26	57.81	67.51	1.00	0.74		
MILLBURY DAM	6391	Maximum	Rock Ramp R	304.00	345.80	346.71	346.71	347.14	0.013917	5.26	57.81	67.51	1.00	0.74		
MILLBURY DAM	6391	Maximum	Exist R	304.00	345.80	346.71	346.71	347.14	0.013917	5.26	57.81	67.51	1.00	0.74		
MILLBURY DAM	6391	1-YR	Full Remov 2	350.00	341.05	343.68	343.41	344.15	0.006928	5.46	64.12	41.62	0.77	0.66		
MILLBURY DAM	6391	1-YR	Full Remov 1	350.00	345.80	346.80	346.80	347.27	0.013535	5.49	63.74	68.31	1.00	0.79		
MILLBURY DAM	6391	1-YR	Removal RGC	350.00	345.80	346.80	346.80	347.27	0.013535	5.49	63.74	68.31	1.00	0.79		
MILLBURY DAM	6391	1-YR	Rock Ramp R	350.00	345.80	346.80	346.80	347.27	0.013535	5.49	63.74	68.31	1.00	0.79		
MILLBURY DAM	6391	1-YR	Exist R	350.00	345.80	346.80	346.80	347.27	0.013535	5.49	63.74	68.31	1.00	0.79		
MILLBURY DAM	6391	2-YR	Full Remov 2	1350.00	341.05	345.37	345.37	346.70	0.009764	9.23	146.25	55.59	1.00	1.58		
MILLBURY DAM	6391	2-YR	Full Remov 1	1350.00	345.80	348.17	348.17	349.20	0.010466	8.16	165.51	80.53	1.00	1.33		
MILLBURY DAM	6391	2-YR	Removal RGC	1350.00	345.80	348.17	348.17	349.20	0.010466	8.16	165.51	80.53	1.00	1.33		
MILLBURY DAM	6391	2-YR	Rock Ramp R	1350.00	345.80	348.17	348.17	349.20	0.010466	8.16	165.51	80.53	1.00	1.33		
MILLBURY DAM	6391	2-YR	Exist R	1350.00	345.80	348.17	348.17	349.20	0.010466	8.16	165.51	80.53	1.00	1.33		
MILLBURY DAM	6391	10-YR	Full Remov 2	3200.00	341.05	347.55	347.55	349.46	0.008559	11.09	288.49	75.24	1.00	2.01		
MILLBURY DAM	6391	10-YR	Full Remov 1	3200.00	345.80	349.82	349.82	351.49	0.008892	10.37	308.63	92.33	1.00	1.84		
MILLBURY DAM	6391	10-YR	Removal RGC	3200.00	345.80	349.82	349.82	351.49	0.008892	10.37	308.63	92.33	1.00	1.84		
MILLBURY DAM	6391	10-YR	Rock Ramp R	3200.00	345.80	349.82	349.82	351.49	0.008892	10.37	308.63	92.33	1.00	1.84		
MILLBURY DAM	6391	10-YR	Exist R	3200.00	345.80	349.82	349.82	351.49	0.008892	10.37	308.63	92.33	1.00	1.84		
MILLBURY DAM	6391	50-YR	Full Remov 2	5800.00	341.05	349.56	349.56	352.08	0.007886	12.74	455.23	90.45	1.00	2.43		
MILLBURY DAM	6391	50-YR	Full Remov 1	5800.00	345.80	351.80	351.80	353.67	0.005677	11.22	692.46	314.70	0.86	1.85	0.31	0.32
MILLBURY DAM	6391	50-YR	Removal RGC	5800.00	345.80	351.80	351.80	353.67	0.005677	11.22	692.46	314.70	0.86	1.85	0.31	0.32
MILLBURY DAM	6391	50-YR	Rock Ramp R	5800.00	345.80	351.80	351.80	353.67	0.005677	11.22	692.46	314.70	0.86	1.85	0.31	0.32

HEC-RAS River: Reach #1 Reach: MILLBURY DAM (Continued)

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan	Shear LOB	Shear ROB
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)	(lb/sq ft)	(lb/sq ft)
MILLBURY DAM	6391	50-YR	Exist R	5800.00	345.80	351.80	351.80	353.67	0.005677	11.22	692.46	314.70	0.86	1.85	0.31	0.32
MILLBURY DAM	6391	100-YR	Full Remov 2	7300.00	341.05	350.56	350.56	353.30	0.007011	13.29	567.65	162.45	0.97	2.51	0.12	0.12
MILLBURY DAM	6391	100-YR	Full Remov 1	7300.00	345.80	352.65	352.65	354.50	0.004868	11.48	982.14	352.11	0.82	1.84	0.37	0.49
MILLBURY DAM	6391	100-YR	Removal RGC	7300.00	345.80	352.65	352.65	354.50	0.004855	11.47	983.52	352.19	0.82	1.84	0.37	0.49
MILLBURY DAM	6391	100-YR	Rock Ramp R	7300.00	345.80	352.65	352.65	354.50	0.004868	11.48	982.14	352.11	0.82	1.84	0.37	0.49
MILLBURY DAM	6391	100-YR	Exist R	7300.00	345.80	352.65	352.65	354.50	0.004868	11.48	982.14	352.11	0.82	1.84	0.37	0.49
MILLBURY DAM	5943.61	Drought	Full Remov 2	49.00	339.92	341.21	340.88	341.24	0.002523	1.50	32.77	70.24	0.39	0.07		
MILLBURY DAM	5943.61	Drought	Full Remov 1	49.00	339.92	341.21	340.88	341.24	0.002523	1.50	32.77	70.24	0.39	0.07		
MILLBURY DAM	5943.61	Drought	Removal RGC	49.00	341.14	342.88	342.01	342.89	0.000228	0.71	68.82	73.39	0.13	0.01		
MILLBURY DAM	5943.61	Drought	Rock Ramp R	49.00	341.14	343.15	342.01	343.15	0.000106	0.55	89.20	79.02	0.09	0.01		
MILLBURY DAM	5943.61	Drought	Exist R	49.00	341.14	345.12	342.01	345.12	0.000004	0.19	256.18	90.19	0.02	0.00		
MILLBURY DAM	5943.61	Average	Full Remov 2	139.00	339.92	341.75	341.24	341.81	0.001564	1.91	72.59	74.88	0.34	0.09		
MILLBURY DAM	5943.61	Average	Full Remov 1	139.00	339.92	341.75	341.24	341.81	0.001564	1.91	72.59	74.88	0.34	0.09		
MILLBURY DAM	5943.61	Average	Removal RGC	139.00	341.14	343.67	342.34	343.69	0.000247	1.06	131.43	81.99	0.15	0.02		
MILLBURY DAM	5943.61	Average	Rock Ramp R	139.00	341.14	343.98	342.34	343.99	0.000142	0.89	156.75	83.72	0.11	0.02		
MILLBURY DAM	5943.61	Average	Exist R	139.00	341.14	345.47	342.34	345.47	0.000021	0.48	287.96	92.17	0.05	0.00		
MILLBURY DAM	5943.61	Maximum	Full Remov 2	304.00	339.92	342.24	341.58	342.36	0.002007	2.77	109.80	78.44	0.41	0.17		
MILLBURY DAM	5943.61	Maximum	Full Remov 1	304.00	339.92	342.24	341.58	342.36	0.002007	2.77	109.80	78.44	0.41	0.17		
MILLBURY DAM	5943.61	Maximum	Removal RGC	304.00	341.14	344.55	342.73	344.59	0.000288	1.48	205.89	86.98	0.17	0.04		
MILLBURY DAM	5943.61	Maximum	Rock Ramp R	304.00	341.14	344.89	342.73	344.91	0.000191	1.29	235.18	88.87	0.14	0.03		
MILLBURY DAM	5943.61	Maximum	Exist R	304.00	341.14	345.96	342.73	345.97	0.000065	0.91	333.97	94.82	0.09	0.01		
MILLBURY DAM	5943.61	1-YR	Full Remov 2	350.00	339.92	342.35	341.66	342.48	0.002103	2.96	118.13	78.89	0.43	0.20		
MILLBURY DAM	5943.61	1-YR	Full Remov 1	350.00	339.92	342.35	341.66	342.48	0.002103	2.96	118.13	78.89	0.43	0.20		
MILLBURY DAM	5943.61	1-YR	Removal RGC	350.00	341.14	344.75	342.83	344.78	0.000299	1.57	222.91	88.08	0.17	0.05		
MILLBURY DAM	5943.61	1-YR	Rock Ramp R	350.00	341.14	345.09	342.83	345.12	0.000201	1.38	253.44	90.02	0.15	0.03		
MILLBURY DAM	5943.61	1-YR	Exist R	350.00	341.14	346.08	342.83	346.10	0.000078	1.01	345.42	97.52	0.09	0.02	0.00	
MILLBURY DAM	5943.61	2-YR	Full Remov 2	1350.00	339.92	344.23	342.95	344.60	0.002187	4.93	274.07	86.91	0.49	0.42		
MILLBURY DAM	5943.61	2-YR	Full Remov 1	1350.00	339.92	344.23	342.95	344.60	0.002187	4.93	274.07	86.91	0.49	0.42		
MILLBURY DAM	5943.61	2-YR	Removal RGC	1350.00	341.14	347.07	344.12	347.21	0.000541	3.05	450.95	114.03	0.26	0.15	0.02	
MILLBURY DAM	5943.61	2-YR	Rock Ramp R	1350.00	341.14	347.50	344.12	347.62	0.000404	2.77	501.62	120.06	0.22	0.12	0.02	
MILLBURY DAM	5943.61	2-YR	Exist R	1350.00	341.14	347.92	344.12	348.02	0.000310	2.54	553.61	125.95	0.20	0.10	0.02	
MILLBURY DAM	5943.61	10-YR	Full Remov 2	3200.00	339.92	346.67	344.57	347.30	0.001979	6.40	503.73	108.46	0.50	0.61	0.05	
MILLBURY DAM	5943.61	10-YR	Full Remov 1	3200.00	339.92	346.67	344.57	347.30	0.001979	6.40	503.73	108.46	0.50	0.61	0.05	
MILLBURY DAM	5943.61	10-YR	Removal RGC	3200.00	341.14	349.41	345.71	349.68	0.000646	4.34	1163.75	436.03	0.30	0.26	0.06	0.02
MILLBURY DAM	5943.61	10-YR	Rock Ramp R	3200.00	341.14	349.70	345.71	349.93	0.000539	4.08	1291.02	442.03	0.27	0.23	0.06	0.02
MILLBURY DAM	5943.61	10-YR	Exist R	3200.00	341.14	349.86	345.71	350.08	0.000487	3.94	1364.92	445.48	0.26	0.21	0.06	0.02
MILLBURY DAM	5943.61	50-YR	Full Remov 2	5800.00	339.92	349.07	346.34	349.89	0.001700	7.46	1113.31	430.91	0.49	0.74	0.12	0.05
MILLBURY DAM	5943.61	50-YR	Full Remov 1	5800.00	339.92	349.07	346.34	349.89	0.001700	7.46	1113.31	430.91	0.49	0.74	0.12	0.05
MILLBURY DAM	5943.61	50-YR	Removal RGC	5800.00	341.14	350.90	347.41	351.35	0.000895	5.86	1838.01	471.57	0.36	0.44	0.16	0.05
MILLBURY DAM	5943.61	50-YR	Rock Ramp R	5800.00	341.14	351.16	347.41	351.57	0.000779	5.59	1964.99	478.51	0.34	0.39	0.15	0.05
MILLBURY DAM	5943.61	50-YR	Exist R	5800.00	341.14	351.56	347.41	351.90	0.000641	5.22	2154.91	488.71	0.31	0.34	0.14	0.05
MILLBURY DAM	5943.61	100-YR	Full Remov 2	7300.00	339.92	350.26	347.20	351.06	0.001414	7.54	1642.54	455.17	0.46	0.72	0.20	0.07
MILLBURY DAM	5943.61	100-YR	Full Remov 1	7300.00	339.92	350.26	347.20	351.06	0.001414	7.54	1642.54	455.17	0.46	0.72	0.20	0.07
MILLBURY DAM	5943.61	100-YR	Removal RGC	7300.00	341.14	351.57	348.77	352.12	0.001005	6.55	2164.32	489.21	0.39	0.53	0.22	0.08
MILLBURY DAM	5943.61	100-YR	Rock Ramp R	7300.00	341.14	351.93	348.77	352.41	0.000849	6.18	2339.11	498.40	0.36	0.47	0.20	0.08
MILLBURY DAM	5943.61	100-YR	Exist R	7300.00	341.14	352.15	348.77	352.60	0.000771	5.99	2473.64	657.90	0.35	0.44	0.20	0.03
MILLBURY DAM	5527.63	Drought	Full Remov 2	49.00	338.56	339.87	339.59	339.93	0.004068	1.99	24.63	49.17	0.50	0.13		
MILLBURY DAM	5527.63	Drought	Full Remov 1	49.00	338.56	339.87	339.59	339.93	0.004068	1.99	24.63	49.17	0.50	0.13		
MILLBURY DAM	5527.63	Drought	Removal RGC	49.00	341.04	342.67	342.00	342.71	0.001117	1.59	30.90	32.56	0.29	0.07		
MILLBURY DAM	5527.63	Drought	Rock Ramp R	49.00	341.04	343.05	342.00	343.07	0.000394	1.11	44.26	36.57	0.18	0.03		
MILLBURY DAM	5527.63	Drought	Exist R	49.00	341.04	345.12	342.00	345.12	0.000017	0.32	150.81	73.44	0.04	0.00		
MILLBURY DAM	5527.63	Average	Full Remov 2	139.00	338.56	340.03	340.01	340.30	0.015086	4.21	33.05	57.35	0.98	0.54		
MILLBURY DAM	5527.63	Average	Full Remov 1	139.00	338.56	340.03	340.01	340.30	0.015086	4.21	33.05	57.35	0.98	0.54		
MILLBURY DAM	5527.63	Average	Removal RGC	139.00	341.04	343.38	342.53	343.47	0.001573	2.46	56.59	39.91	0.36	0.14		

HEC-RAS River: Reach #1 Reach: MILLBURY DAM (Continued)

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan	Shear LOB	Shear ROB
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)	(lb/sq ft)	(lb/sq ft)
MILLBURY DAM	5527.63	Average	Rock Ramp R	139.00	341.04	343.82	342.53	343.87	0.000719	1.84	75.50	45.64	0.25	0.07		
MILLBURY DAM	5527.63	Average	Exist R	139.00	341.04	345.45	342.53	345.45	0.000093	0.79	176.89	82.85	0.09	0.01		
MILLBURY DAM	5527.63	Maximum	Full Remov 2	304.00	338.56	340.61	340.41	340.91	0.007169	4.44	68.42	62.35	0.75	0.49		
MILLBURY DAM	5527.63	Maximum	Full Remov 1	304.00	338.56	340.61	340.41	340.91	0.007169	4.44	68.42	62.35	0.75	0.49		
MILLBURY DAM	5527.63	Maximum	Removal RGC	304.00	341.04	344.14	343.14	344.31	0.002149	3.34	91.11	51.32	0.44	0.24		
MILLBURY DAM	5527.63	Maximum	Rock Ramp R	304.00	341.04	344.64	343.14	344.74	0.001107	2.55	119.42	61.46	0.32	0.13		
MILLBURY DAM	5527.63	Maximum	Exist R	304.00	341.04	345.89	343.14	345.92	0.000239	1.42	214.04	82.99	0.16	0.04		
MILLBURY DAM	5527.63	1-YR	Full Remov 2	350.00	338.56	340.76	340.50	341.07	0.006164	4.47	78.33	63.14	0.71	0.47		
MILLBURY DAM	5527.63	1-YR	Full Remov 1	350.00	338.56	340.76	340.50	341.07	0.006164	4.47	78.33	63.14	0.71	0.47		
MILLBURY DAM	5527.63	1-YR	Removal RGC	350.00	341.04	344.31	343.28	344.50	0.002265	3.50	100.14	54.76	0.46	0.26		
MILLBURY DAM	5527.63	1-YR	Rock Ramp R	350.00	341.04	344.83	343.28	344.94	0.001155	2.66	131.46	65.30	0.33	0.14		
MILLBURY DAM	5527.63	1-YR	Exist R	350.00	341.04	346.00	343.28	346.04	0.000278	1.57	222.89	83.02	0.17	0.05		
MILLBURY DAM	5527.63	2-YR	Full Remov 2	1350.00	338.56	342.93	341.96	343.48	0.003307	5.95	226.78	73.67	0.60	0.62		
MILLBURY DAM	5527.63	2-YR	Full Remov 1	1350.00	338.56	342.93	341.96	343.48	0.003307	5.95	226.78	73.67	0.60	0.62		
MILLBURY DAM	5527.63	2-YR	Removal RGC	1350.00	341.04	346.26	345.30	346.73	0.003073	5.53	244.24	83.10	0.57	0.55		
MILLBURY DAM	5527.63	2-YR	Rock Ramp R	1350.00	341.04	347.01	345.30	347.31	0.001468	4.40	307.00	83.34	0.40	0.32		
MILLBURY DAM	5527.63	2-YR	Exist R	1350.00	341.04	347.58	345.30	347.80	0.000927	3.81	354.24	85.98	0.33	0.23	0.00	
MILLBURY DAM	5527.63	10-YR	Full Remov 2	3200.00	338.56	345.40	343.77	346.30	0.002824	7.61	420.56	82.83	0.60	0.87		
MILLBURY DAM	5527.63	10-YR	Full Remov 1	3200.00	338.56	345.40	343.77	346.30	0.002824	7.61	420.56	82.83	0.60	0.87		
MILLBURY DAM	5527.63	10-YR	Removal RGC	3200.00	341.04	348.07	346.91	349.08	0.003600	8.08	436.33	548.45	0.65	1.01	0.02	0.02
MILLBURY DAM	5527.63	10-YR	Rock Ramp R	3200.00	341.04	349.06	346.91	349.56	0.001528	5.98	1062.59	710.21	0.44	0.52	0.10	0.07
MILLBURY DAM	5527.63	10-YR	Exist R	3200.00	341.04	349.39	346.91	349.77	0.001152	5.38	1300.86	746.42	0.39	0.41	0.10	0.07
MILLBURY DAM	5527.63	50-YR	Full Remov 2	5800.00	338.56	347.28	345.68	348.85	0.003440	10.06	576.27	83.43	0.67	1.38		
MILLBURY DAM	5527.63	50-YR	Full Remov 1	5800.00	338.56	347.28	345.68	348.85	0.003440	10.06	576.27	83.43	0.67	1.38		
MILLBURY DAM	5527.63	50-YR	Removal RGC	5800.00	341.04	349.87	349.39	350.74	0.002520	8.38	1671.39	780.13	0.58	0.97	0.29	0.22
MILLBURY DAM	5527.63	50-YR	Rock Ramp R	5800.00	341.04	350.67	349.39	351.15	0.001363	6.65	2314.72	820.09	0.43	0.59	0.22	0.17
MILLBURY DAM	5527.63	50-YR	Exist R	5800.00	341.04	351.27	349.39	351.60	0.000891	5.67	2808.91	823.91	0.35	0.42	0.18	0.15
MILLBURY DAM	5527.63	100-YR	Full Remov 2	7300.00	338.56	347.95	346.56	350.02	0.004022	11.53	640.54	121.50	0.74	1.77	0.05	0.04
MILLBURY DAM	5527.63	100-YR	Full Remov 1	7300.00	338.56	347.95	346.56	350.02	0.004022	11.53	640.54	121.50	0.74	1.77	0.05	0.04
MILLBURY DAM	5527.63	100-YR	Removal RGC	7300.00	341.04	350.95	349.90	351.59	0.001752	7.74	2551.32	821.92	0.49	0.79	0.32	0.26
MILLBURY DAM	5527.63	100-YR	Rock Ramp R	7300.00	341.04	351.56	349.90	352.00	0.001162	6.63	3053.03	825.79	0.41	0.57	0.25	0.21
MILLBURY DAM	5527.63	100-YR	Exist R	7300.00	341.04	351.86	349.90	352.23	0.000964	6.19	3299.68	827.68	0.37	0.49	0.23	0.19
MILLBURY DAM	5209.53	Drought	Full Remov 2	49.00	336.91	338.13	337.93	338.24	0.007266	2.68	18.26	35.89	0.66	0.23		
MILLBURY DAM	5209.53	Drought	Full Remov 1	49.00	336.91	338.13	337.93	338.24	0.007266	2.68	18.26	35.89	0.66	0.23		
MILLBURY DAM	5209.53	Drought	Removal RGC	49.00	341.00	341.58	341.58	341.78	0.017961	3.55	13.80	35.19	1.00	0.44		
MILLBURY DAM	5209.53	Drought	Rock Ramp R	49.00	341.40	342.79	342.39	342.83	0.001914	1.63	29.98	45.15	0.35	0.08		
MILLBURY DAM	5209.53	Drought	Exist R	49.00	341.06	345.11	342.00	345.11	0.000005	0.21	231.63	88.30	0.02	0.00		
MILLBURY DAM	5209.53	Average	Full Remov 2	139.00	336.91	339.11	338.41	339.18	0.001425	2.10	66.23	55.42	0.34	0.11		
MILLBURY DAM	5209.53	Average	Full Remov 1	139.00	336.91	339.11	338.41	339.18	0.001425	2.10	66.23	55.42	0.34	0.11		
MILLBURY DAM	5209.53	Average	Removal RGC	139.00	341.00	341.99	341.99	342.30	0.015406	4.42	31.42	51.35	1.00	0.59		
MILLBURY DAM	5209.53	Average	Rock Ramp R	139.00	341.40	343.48	342.79	343.55	0.001503	2.11	65.83	56.11	0.34	0.11		
MILLBURY DAM	5209.53	Average	Exist R	139.00	341.06	345.43	342.44	345.44	0.000030	0.53	260.74	93.63	0.06	0.01		
MILLBURY DAM	5209.53	Maximum	Full Remov 2	304.00	336.91	340.03	338.87	340.12	0.001112	2.50	121.51	64.67	0.32	0.13		
MILLBURY DAM	5209.53	Maximum	Full Remov 1	304.00	336.91	340.03	338.87	340.12	0.001112	2.50	121.51	64.67	0.32	0.13		
MILLBURY DAM	5209.53	Maximum	Removal RGC	304.00	341.00	342.42	342.42	342.90	0.013402	5.52	55.06	58.09	1.00	0.79		
MILLBURY DAM	5209.53	Maximum	Rock Ramp R	304.00	341.40	344.21	343.27	344.33	0.001550	2.81	108.27	61.38	0.37	0.17		
MILLBURY DAM	5209.53	Maximum	Exist R	304.00	341.06	345.86	342.87	345.87	0.000096	1.01	301.97	99.83	0.10	0.02		
MILLBURY DAM	5209.53	1-YR	Full Remov 2	350.00	336.91	340.22	338.97	340.32	0.001095	2.61	134.16	66.24	0.32	0.14		
MILLBURY DAM	5209.53	1-YR	Full Remov 1	350.00	336.91	340.22	338.97	340.32	0.001095	2.61	134.16	66.24	0.32	0.14		
MILLBURY DAM	5209.53	1-YR	Removal RGC	350.00	341.00	342.52	342.52	343.04	0.013194	5.76	60.81	59.57	1.00	0.84		
MILLBURY DAM	5209.53	1-YR	Rock Ramp R	350.00	341.40	344.39	343.36	344.52	0.001541	2.93	119.50	63.34	0.38	0.18		
MILLBURY DAM	5209.53	1-YR	Exist R	350.00	341.06	345.96	342.98	345.98	0.000116	1.12	312.02	101.05	0.11	0.02		
MILLBURY DAM	5209.53	2-YR	Full Remov 2	1350.00	336.91	342.39	340.56	342.73	0.001535	4.63	291.46	77.67	0.42	0.35		
MILLBURY DAM	5209.53	2-YR	Full Remov 1	1350.00	336.91	342.39	340.56	342.73	0.001535	4.63	291.46	77.67	0.42	0.35		
MILLBURY DAM	5209.53	2-YR	Removal RGC	1350.00	341.00	344.02	344.02	345.03	0.010455	8.09	166.77	82.10	1.00	1.32		

HEC-RAS River: Reach #1 Reach: MILLBURY DAM (Continued)

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan	Shear LOB	Shear ROB
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)	(lb/sq ft)	(lb/sq ft)
MILLBURY DAM	5209.53	2-YR	Rock Ramp R	1350.00	341.40	346.29	344.97	346.71	0.002456	5.17	283.98	169.76	0.51	0.47		0.04
MILLBURY DAM	5209.53	2-YR	Exist R	1350.00	341.06	347.46	344.35	347.57	0.000440	2.77	607.27	215.13	0.23	0.12		0.03
MILLBURY DAM	5209.53	10-YR	Full Remov 2	3200.00	336.91	344.89	342.40	345.53	0.001729	6.41	499.23	88.45	0.48	0.59		
MILLBURY DAM	5209.53	10-YR	Full Remov 1	3200.00	336.91	344.89	342.40	345.53	0.001729	6.41	499.24	88.45	0.48	0.59		
MILLBURY DAM	5209.53	10-YR	Removal RGC	3200.00	341.00	345.65	345.65	347.31	0.008838	10.33	309.87	92.89	1.00	1.82		
MILLBURY DAM	5209.53	10-YR	Rock Ramp R	3200.00	341.40	348.02	346.98	348.82	0.003516	7.35	629.31	607.65	0.64	0.87	0.00	0.10
MILLBURY DAM	5209.53	10-YR	Exist R	3200.00	341.06	349.23	346.10	349.46	0.000643	4.15	1538.65	703.54	0.29	0.24	0.04	0.06
MILLBURY DAM	5209.53	50-YR	Full Remov 2	5800.00	336.91	346.60	344.31	347.76	0.002683	8.66	718.24	196.83	0.60	1.04		0.09
MILLBURY DAM	5209.53	50-YR	Full Remov 1	5800.00	336.91	346.60	344.31	347.76	0.002683	8.66	718.24	196.83	0.60	1.04		0.09
MILLBURY DAM	5209.53	50-YR	Removal RGC	5800.00	341.00	347.51	347.51	349.40	0.006724	11.28	638.25	216.21	0.92	1.94		0.55
MILLBURY DAM	5209.53	50-YR	Rock Ramp R	5800.00	341.40	350.25	347.84	350.69	0.001457	6.25	2185.47	761.43	0.44	0.55	0.15	0.22
MILLBURY DAM	5209.53	50-YR	Exist R	5800.00	341.06	351.10	347.67	351.34	0.000585	4.72	2943.94	778.72	0.29	0.29	0.08	0.12
MILLBURY DAM	5209.53	100-YR	Full Remov 2	7300.00	336.91	347.27	345.29	348.73	0.003051	9.77	854.31	211.06	0.65	1.28		0.21
MILLBURY DAM	5209.53	100-YR	Full Remov 1	7300.00	336.91	347.27	345.29	348.73	0.003051	9.77	854.31	211.06	0.65	1.28		0.21
MILLBURY DAM	5209.53	100-YR	Removal RGC	7300.00	341.00	347.88	347.88	350.36	0.008285	12.97	720.74	226.09	1.03	2.53		0.82
MILLBURY DAM	5209.53	100-YR	Rock Ramp R	7300.00	341.40	351.24	347.84	351.61	0.001144	6.11	2943.17	781.51	0.40	0.50	0.17	0.24
MILLBURY DAM	5209.53	100-YR	Exist R	7300.00	341.06	351.66	347.94	351.95	0.000671	5.29	3383.83	790.18	0.32	0.35	0.11	0.16
MILLBURY DAM	5147.41	Drought	Full Remov 2	49.00	336.48	338.18	337.11	338.19	0.000091	0.55	89.60	71.46	0.09	0.01		
MILLBURY DAM	5147.41	Drought	Full Remov 1	49.00	336.48	338.18	337.11	338.19	0.000091	0.55	89.60	71.46	0.09	0.01		
MILLBURY DAM	5147.41	Drought	Removal RGC	49.00	339.00	340.21	339.69	340.29	0.002242	2.32	21.16	21.03	0.41	0.14		
MILLBURY DAM	5147.41	Drought	Rock Ramp R	49.00	341.20	342.42	342.29	342.59	0.008955	3.36	14.60	23.93	0.76	0.34		
MILLBURY DAM	5147.41	Drought	Exist R	49.00	343.00	345.11	343.41	345.11	0.000023	0.32	155.53	100.35	0.04	0.00		
MILLBURY DAM	5147.41	Average	Full Remov 2	139.00	336.48	339.13	337.40	339.15	0.000116	0.88	158.63	73.88	0.11	0.02		
MILLBURY DAM	5147.41	Average	Full Remov 1	139.00	336.48	339.13	337.40	339.15	0.000116	0.88	158.63	73.88	0.11	0.02		
MILLBURY DAM	5147.41	Average	Removal RGC	139.00	339.00	340.90	340.33	341.12	0.003547	3.75	37.09	25.04	0.54	0.32		
MILLBURY DAM	5147.41	Average	Rock Ramp R	139.00	341.20	343.25	342.85	343.38	0.005337	2.90	47.86	66.31	0.60	0.24		
MILLBURY DAM	5147.41	Average	Exist R	139.00	343.00	345.43	343.74	345.43	0.000101	0.74	187.40	102.80	0.10	0.01		
MILLBURY DAM	5147.41	Maximum	Full Remov 2	304.00	336.48	340.05	337.75	340.08	0.000175	1.34	227.50	76.21	0.14	0.03		
MILLBURY DAM	5147.41	Maximum	Full Remov 1	304.00	336.48	340.05	337.75	340.08	0.000175	1.34	227.50	76.21	0.14	0.03		
MILLBURY DAM	5147.41	Maximum	Removal RGC	304.00	339.00	341.56	341.24	341.95	0.008115	4.99	60.94	50.45	0.80	0.60		
MILLBURY DAM	5147.41	Maximum	Rock Ramp R	304.00	341.20	344.10	343.42	344.22	0.002075	2.73	111.23	83.10	0.42	0.17		
MILLBURY DAM	5147.41	Maximum	Exist R	304.00	343.00	345.84	344.11	345.86	0.000254	1.32	230.33	106.00	0.16	0.03		
MILLBURY DAM	5147.41	1-YR	Full Remov 2	350.00	336.48	340.25	337.83	340.28	0.000190	1.44	242.39	76.71	0.14	0.04		
MILLBURY DAM	5147.41	1-YR	Full Remov 1	350.00	336.48	340.25	337.83	340.28	0.000190	1.44	242.39	76.71	0.14	0.04		
MILLBURY DAM	5147.41	1-YR	Removal RGC	350.00	339.00	341.71	341.45	342.11	0.008379	5.08	68.95	57.05	0.81	0.62		
MILLBURY DAM	5147.41	1-YR	Rock Ramp R	350.00	341.20	344.29	343.49	344.41	0.001845	2.74	127.68	86.93	0.40	0.17		
MILLBURY DAM	5147.41	1-YR	Exist R	350.00	343.00	345.93	344.18	345.97	0.000294	1.45	240.56	106.75	0.17	0.04		
MILLBURY DAM	5147.41	2-YR	Full Remov 2	1350.00	336.48	342.46	339.16	342.62	0.000514	3.23	418.49	82.34	0.25	0.16		
MILLBURY DAM	5147.41	2-YR	Full Remov 1	1350.00	336.48	342.46	339.16	342.62	0.000514	3.23	418.49	82.34	0.25	0.16		
MILLBURY DAM	5147.41	2-YR	Removal RGC	1350.00	339.00	343.56	343.04	344.20	0.005378	6.42	210.22	87.58	0.73	0.79		
MILLBURY DAM	5147.41	2-YR	Rock Ramp R	1350.00	341.20	346.28	344.83	346.54	0.001578	4.10	333.79	131.86	0.41	0.30	0.01	0.02
MILLBURY DAM	5147.41	2-YR	Exist R	1350.00	343.00	347.36	345.35	347.53	0.000829	3.38	446.19	172.56	0.31	0.19	0.03	0.04
MILLBURY DAM	5147.41	10-YR	Full Remov 2	3200.00	336.48	344.99	340.89	345.38	0.000908	5.00	640.20	99.52	0.35	0.35		
MILLBURY DAM	5147.41	10-YR	Full Remov 1	3200.00	336.48	344.99	340.89	345.38	0.000908	5.00	640.20	99.52	0.35	0.35		
MILLBURY DAM	5147.41	10-YR	Removal RGC	3200.00	339.00	345.52	344.70	346.50	0.004463	7.94	402.92	105.65	0.72	1.04		
MILLBURY DAM	5147.41	10-YR	Rock Ramp R	3200.00	341.20	347.96	346.26	348.53	0.001952	6.12	608.94	195.79	0.50	0.57	0.12	0.14
MILLBURY DAM	5147.41	10-YR	Exist R	3200.00	343.00	348.96	346.75	349.38	0.001287	5.36	770.03	228.92	0.41	0.42	0.12	0.14
MILLBURY DAM	5147.41	50-YR	Full Remov 2	5800.00	336.48	346.76	342.76	347.52	0.001404	7.01	847.06	149.61	0.45	0.64	0.03	0.05
MILLBURY DAM	5147.41	50-YR	Full Remov 1	5800.00	336.48	346.76	342.76	347.52	0.001404	7.01	847.06	149.61	0.45	0.64	0.03	0.05
MILLBURY DAM	5147.41	50-YR	Removal RGC	5800.00	339.00	345.58	346.30	348.70	0.013951	14.17	409.33	105.86	1.27	3.28		
MILLBURY DAM	5147.41	50-YR	Rock Ramp R	5800.00	341.20	349.62	347.81	350.53	0.002166	7.89	981.20	250.75	0.55	0.86	0.24	0.28
MILLBURY DAM	5147.41	50-YR	Exist R	5800.00	343.00	350.77	348.26	351.27	0.001172	6.23	2036.19	1172.45	0.41	0.52	0.14	0.13
MILLBURY DAM	5147.41	100-YR	Full Remov 2	7300.00	336.48	347.45	343.67	348.45	0.001661	8.07	958.99	176.09	0.49	0.83	0.07	0.09
MILLBURY DAM	5147.41	100-YR	Full Remov 1	7300.00	336.48	347.45	343.67	348.45	0.001661	8.07	958.99	176.09	0.49	0.83	0.07	0.09
MILLBURY DAM	5147.41	100-YR	Removal RGC	7300.00	339.00	346.50	347.10	349.70	0.011027	14.38	518.12	139.44	1.17	3.17	0.17	0.25

HEC-RAS River: Reach #1 Reach: MILLBURY DAM (Continued)

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan	Shear LOB	Shear ROB
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)	(lb/sq ft)	(lb/sq ft)
MILLBURY DAM	5147.41	100-YR	Rock Ramp R	7300.00	341.20	350.78	348.55	351.50	0.001550	7.45	2090.43	1172.50	0.48	0.72	0.18	0.18
MILLBURY DAM	5147.41	100-YR	Exist R	7300.00	343.00	351.30	348.97	351.87	0.001289	6.86	2464.06	1181.58	0.44	0.61	0.19	0.19
MILLBURY DAM	5117	Drought	Full Remov 2	49.00	336.44	338.18	337.24	338.18	0.000208	0.70	69.53	70.57	0.13	0.01		
MILLBURY DAM	5117	Drought	Full Remov 1	49.00	336.44	338.18	337.24	338.18	0.000208	0.70	69.53	70.57	0.13	0.01		
MILLBURY DAM	5117	Drought	Removal RGC	49.00	339.00	340.22	339.45	340.24	0.000616	1.21	40.54	41.27	0.21	0.04		
MILLBURY DAM	5117	Drought	Rock Ramp R	49.00	340.60	341.93	341.93	342.26	0.015100	4.60	10.66	16.02	0.99	0.62		
MILLBURY DAM	5117	Drought	Exist R	49.00	344.50	344.99	344.99	345.10	0.020483	2.66	18.40	79.88	0.98	0.29		
MILLBURY DAM	5117	Average	Full Remov 2	139.00	336.44	339.13	337.64	339.14	0.000182	1.01	137.60	72.92	0.13	0.02		
MILLBURY DAM	5117	Average	Full Remov 1	139.00	336.44	339.13	337.64	339.14	0.000182	1.01	137.60	72.92	0.13	0.02		
MILLBURY DAM	5117	Average	Removal RGC	139.00	339.00	340.97	339.87	341.02	0.000893	1.77	78.35	59.20	0.27	0.07		
MILLBURY DAM	5117	Average	Rock Ramp R	139.00	340.60	342.61	342.61	343.12	0.013527	5.72	24.28	24.17	1.01	0.84		
MILLBURY DAM	5117	Average	Exist R	139.00	344.50	345.20	345.20	345.40	0.018304	3.62	38.40	96.64	1.01	0.45		
MILLBURY DAM	5117	Maximum	Full Remov 2	304.00	336.44	340.04	338.02	340.07	0.000242	1.48	205.24	75.19	0.16	0.04		
MILLBURY DAM	5117	Maximum	Full Remov 1	304.00	336.44	340.04	338.02	340.07	0.000242	1.48	205.24	75.19	0.16	0.04		
MILLBURY DAM	5117	Maximum	Removal RGC	304.00	339.00	341.70	340.47	341.79	0.001189	2.39	127.42	76.45	0.33	0.12		
MILLBURY DAM	5117	Maximum	Rock Ramp R	304.00	340.60	343.36	343.36	344.04	0.011949	6.64	45.75	33.18	1.00	1.01		
MILLBURY DAM	5117	Maximum	Exist R	304.00	344.50	345.48	345.48	345.81	0.015388	4.63	65.68	100.33	1.01	0.63		
MILLBURY DAM	5117	1-YR	Full Remov 2	350.00	336.44	340.23	338.11	340.27	0.000258	1.59	219.83	75.67	0.16	0.05		
MILLBURY DAM	5117	1-YR	Full Remov 1	350.00	336.44	340.23	338.11	340.27	0.000258	1.59	219.83	75.67	0.16	0.05		
MILLBURY DAM	5117	1-YR	Removal RGC	350.00	339.00	341.85	340.60	341.94	0.001253	2.52	139.00	79.98	0.34	0.13		
MILLBURY DAM	5117	1-YR	Rock Ramp R	350.00	340.60	343.51	343.51	344.24	0.011792	6.85	51.10	35.07	1.00	1.06		
MILLBURY DAM	5117	1-YR	Exist R	350.00	344.50	345.55	345.55	345.91	0.014707	4.81	72.72	101.26	1.00	0.66		
MILLBURY DAM	5117	2-YR	Full Remov 2	1350.00	336.44	342.42	339.44	342.60	0.000629	3.45	391.26	81.10	0.28	0.18		
MILLBURY DAM	5117	2-YR	Full Remov 1	1350.00	336.44	342.42	339.44	342.60	0.000629	3.45	391.26	81.10	0.28	0.18		
MILLBURY DAM	5117	2-YR	Removal RGC	1350.00	339.00	343.73	342.22	344.01	0.001773	4.28	315.26	105.83	0.44	0.33		
MILLBURY DAM	5117	2-YR	Rock Ramp R	1350.00	340.60	345.52	345.52	346.39	0.010954	7.48	180.58	103.42	1.00	1.18		
MILLBURY DAM	5117	2-YR	Exist R	1350.00	344.50	346.60	346.60	347.41	0.010447	7.25	199.12	143.50	0.97	1.12	0.20	0.28
MILLBURY DAM	5117	10-YR	Full Remov 2	3200.00	336.44	344.91	341.16	345.35	0.000994	5.33	600.81	90.19	0.36	0.39		
MILLBURY DAM	5117	10-YR	Full Remov 1	3200.00	336.44	344.91	341.16	345.35	0.000994	5.33	600.81	90.19	0.36	0.39		
MILLBURY DAM	5117	10-YR	Removal RGC	3200.00	339.00	345.77	343.80	346.28	0.002026	5.69	561.91	135.70	0.49	0.52		
MILLBURY DAM	5117	10-YR	Rock Ramp R	3200.00	340.60	346.92	346.92	348.34	0.008552	9.62	357.57	155.57	0.97	1.63	0.24	0.33
MILLBURY DAM	5117	10-YR	Exist R	3200.00	344.50	347.90	347.90	349.22	0.008393	9.45	417.05	193.36	0.96	1.57	0.49	0.59
MILLBURY DAM	5117	50-YR	Full Remov 2	5800.00	336.44	346.60	343.04	347.47	0.001749	7.48	788.94	143.40	0.49	0.75	0.03	0.05
MILLBURY DAM	5117	50-YR	Full Remov 1	5800.00	336.44	346.60	343.04	347.47	0.001749	7.48	788.94	143.40	0.49	0.75	0.03	0.05
MILLBURY DAM	5117	50-YR	Removal RGC	5800.00	339.00	347.35	345.42	348.20	0.002266	7.38	826.66	192.76	0.55	0.78	0.09	0.12
MILLBURY DAM	5117	50-YR	Rock Ramp R	5800.00	340.60	348.40	348.40	350.33	0.007080	11.38	630.29	210.36	0.94	2.00	0.53	0.63
MILLBURY DAM	5117	50-YR	Exist R	5800.00	344.50	349.25	349.25	351.07	0.007313	11.30	710.20	238.10	0.95	1.99	0.74	0.88
MILLBURY DAM	5117	100-YR	Full Remov 2	7300.00	336.44	347.24	343.98	348.39	0.002078	8.63	888.05	167.93	0.54	0.97	0.08	0.10
MILLBURY DAM	5117	100-YR	Full Remov 1	7300.00	336.44	347.24	343.98	348.39	0.002078	8.63	888.05	167.94	0.54	0.97	0.08	0.10
MILLBURY DAM	5117	100-YR	Removal RGC	7300.00	339.00	348.16	346.15	349.16	0.002270	8.08	990.79	216.05	0.56	0.90	0.14	0.18
MILLBURY DAM	5117	100-YR	Rock Ramp R	7300.00	340.60	349.10	349.10	351.27	0.006696	12.18	786.21	233.22	0.94	2.18	0.65	0.77
MILLBURY DAM	5117	100-YR	Exist R	7300.00	344.50	350.06	350.06	351.70	0.005669	11.14	1363.87	1160.15	0.86	1.83	0.44	0.42
MILLBURY DAM	5070.83	Drought	Full Remov 2	49.00	336.55	338.14	337.48	338.16	0.001393	1.20	40.70	77.35	0.29	0.05		
MILLBURY DAM	5070.83	Drought	Full Remov 1	49.00	336.55	338.14	337.48	338.16	0.001393	1.20	40.70	77.35	0.29	0.05		
MILLBURY DAM	5070.83	Drought	Removal RGC	49.00	339.00	340.19	339.45	340.21	0.000671	1.25	39.21	40.49	0.22	0.04		
MILLBURY DAM	5070.83	Drought	Rock Ramp R	49.00	339.10	340.20	340.46	341.02	0.048894	7.26	6.75	12.31	1.73	1.65		
MILLBURY DAM	5070.83	Drought	Exist R	49.00	338.00	339.00	338.23	339.01	0.000155	0.56	87.23	100.20	0.11	0.01		
MILLBURY DAM	5070.83	Average	Full Remov 2	139.00	336.55	339.11	337.97	339.13	0.000351	1.08	128.25	101.48	0.17	0.03		
MILLBURY DAM	5070.83	Average	Full Remov 1	139.00	336.55	339.11	337.97	339.13	0.000351	1.08	128.25	101.48	0.17	0.03		
MILLBURY DAM	5070.83	Average	Removal RGC	139.00	339.00	340.92	339.88	340.98	0.000986	1.84	75.46	58.03	0.28	0.08		
MILLBURY DAM	5070.83	Average	Rock Ramp R	139.00	339.10	340.77	341.17	341.99	0.041612	8.87	15.67	18.76	1.71	2.14		
MILLBURY DAM	5070.83	Average	Exist R	139.00	338.00	339.68	338.47	339.69	0.000194	0.88	157.31	108.20	0.13	0.02		
MILLBURY DAM	5070.83	Maximum	Full Remov 2	304.00	336.55	340.03	338.41	340.06	0.000289	1.34	226.58	112.30	0.17	0.04		
MILLBURY DAM	5070.83	Maximum	Full Remov 1	304.00	336.55	340.03	338.41	340.06	0.000289	1.34	226.58	112.30	0.17	0.04		

HEC-RAS River: Reach #1 Reach: MILLBURY DAM (Continued)

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan	Shear LOB	Shear ROB
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)	(lb/sq ft)	(lb/sq ft)
MILLBURY DAM	5070.83	Maximum	Removal RGC	304.00	339.00	341.63	340.47	341.72	0.001327	2.49	122.22	74.81	0.34	0.13		
MILLBURY DAM	5070.83	Maximum	Rock Ramp R	304.00	339.10	341.40	341.94	343.02	0.036040	10.22	29.74	25.84	1.68	2.55		
MILLBURY DAM	5070.83	Maximum	Exist R	304.00	338.00	340.47	338.77	340.49	0.000228	1.23	246.37	115.85	0.15	0.03		
MILLBURY DAM	5070.83	1-YR	Full Remov 2	350.00	336.55	340.23	338.49	340.26	0.000287	1.41	248.62	113.88	0.17	0.04		
MILLBURY DAM	5070.83	1-YR	Full Remov 1	350.00	336.55	340.23	338.49	340.26	0.000287	1.41	248.62	113.88	0.17	0.04		
MILLBURY DAM	5070.83	1-YR	Removal RGC	350.00	339.00	341.77	340.59	341.88	0.001401	2.63	133.21	78.23	0.35	0.15		
MILLBURY DAM	5070.83	1-YR	Rock Ramp R	350.00	339.10	341.54	342.09	343.24	0.034812	10.45	33.49	27.42	1.67	2.61		
MILLBURY DAM	5070.83	1-YR	Exist R	350.00	338.00	340.65	338.85	340.67	0.000234	1.31	267.29	117.30	0.15	0.03		
MILLBURY DAM	5070.83	2-YR	Full Remov 2	1350.00	336.55	342.45	339.63	342.55	0.000439	2.59	522.22	131.74	0.23	0.11		
MILLBURY DAM	5070.83	2-YR	Full Remov 1	1350.00	336.55	342.45	339.63	342.55	0.000439	2.59	522.22	131.74	0.23	0.11		
MILLBURY DAM	5070.83	2-YR	Removal RGC	1350.00	339.00	343.61	342.21	343.92	0.001983	4.45	303.12	104.34	0.46	0.36		
MILLBURY DAM	5070.83	2-YR	Rock Ramp R	1350.00	339.10	343.78	344.46	345.65	0.016150	10.98	122.95	52.54	1.26	2.32		
MILLBURY DAM	5070.83	2-YR	Exist R	1350.00	338.00	342.67	339.93	342.77	0.000450	2.59	520.51	133.32	0.23	0.11		
MILLBURY DAM	5070.83	10-YR	Full Remov 2	3200.00	336.55	345.05	340.97	345.24	0.000460	3.55	1031.33	284.59	0.25	0.18	0.01	0.03
MILLBURY DAM	5070.83	10-YR	Full Remov 1	3200.00	336.55	345.05	340.97	345.24	0.000460	3.55	1031.35	284.59	0.25	0.18	0.01	0.03
MILLBURY DAM	5070.83	10-YR	Removal RGC	3200.00	339.00	345.80	343.81	346.15	0.001509	4.95	849.38	284.61	0.43	0.39		0.17
MILLBURY DAM	5070.83	10-YR	Rock Ramp R	3200.00	339.10	345.36	345.94	347.66	0.020032	12.54	327.66	195.82	1.42	2.99		1.13
MILLBURY DAM	5070.83	10-YR	Exist R	3200.00	338.00	345.08	341.25	345.28	0.000506	3.66	1009.67	284.71	0.26	0.19	0.02	0.03
MILLBURY DAM	5070.83	50-YR	Full Remov 2	5800.00	336.55	346.93	342.40	347.26	0.000573	4.74	1574.93	292.78	0.29	0.29	0.05	0.10
MILLBURY DAM	5070.83	50-YR	Full Remov 1	5800.00	336.55	346.93	342.40	347.26	0.000573	4.74	1574.93	292.78	0.29	0.29	0.05	0.10
MILLBURY DAM	5070.83	50-YR	Removal RGC	5800.00	339.00	347.51	345.37	348.01	0.001421	6.03	1345.58	294.63	0.44	0.51	0.06	0.30
MILLBURY DAM	5070.83	50-YR	Rock Ramp R	5800.00	339.10	346.22	347.25	349.62	0.025218	15.55	532.88	289.57	1.64	4.37	0.16	1.82
MILLBURY DAM	5070.83	50-YR	Exist R	5800.00	338.00	346.95	342.65	347.30	0.000616	4.84	1551.11	292.88	0.30	0.30	0.05	0.11
MILLBURY DAM	5070.83	100-YR	Full Remov 2	7300.00	336.55	347.70	343.10	348.12	0.000650	5.36	1801.00	296.25	0.32	0.35	0.07	0.14
MILLBURY DAM	5070.83	100-YR	Full Remov 1	7300.00	336.55	347.70	343.10	348.12	0.000650	5.36	1801.01	296.25	0.32	0.35	0.07	0.14
MILLBURY DAM	5070.83	100-YR	Removal RGC	7300.00	339.00	348.37	345.90	348.95	0.001377	6.50	1602.59	301.38	0.44	0.57	0.10	0.36
MILLBURY DAM	5070.83	100-YR	Rock Ramp R	7300.00	339.10	346.56	347.76	350.54	0.026036	17.04	630.44	291.09	1.69	5.06	0.41	2.42
MILLBURY DAM	5070.83	100-YR	Exist R	7300.00	338.00	347.75	343.34	348.18	0.000685	5.44	1786.08	296.49	0.33	0.37	0.07	0.15
MILLBURY DAM	4973.67	Drought	Full Remov 2	49.00	335.97	337.37	337.37	337.81	0.014340	5.33	9.20	10.31	0.99	0.76		
MILLBURY DAM	4973.67	Drought	Full Remov 1	49.00	335.97	337.37	337.37	337.81	0.014340	5.33	9.20	10.31	0.99	0.76		
MILLBURY DAM	4973.67	Drought	Removal RGC	49.00	339.00	339.74	339.74	340.01	0.016584	4.20	11.68	21.76	1.01	0.55		
MILLBURY DAM	4973.67	Drought	Rock Ramp R	49.00	337.00	337.97	337.97	338.22	0.017124	4.00	12.26	25.25	1.01	0.52		
MILLBURY DAM	4973.67	Drought	Exist R	49.00	338.02	338.69	338.69	338.93	0.016514	3.93	12.47	25.60	0.99	0.50		
MILLBURY DAM	4973.67	Average	Full Remov 2	139.00	335.97	338.40	338.40	338.97	0.013164	6.06	22.92	19.91	1.00	0.91		
MILLBURY DAM	4973.67	Average	Full Remov 1	139.00	335.97	338.40	338.40	338.97	0.013164	6.06	22.92	19.91	1.00	0.91		
MILLBURY DAM	4973.67	Average	Removal RGC	139.00	339.00	340.32	340.32	340.70	0.014376	4.98	27.93	36.21	1.00	0.69		
MILLBURY DAM	4973.67	Average	Rock Ramp R	139.00	337.00	338.34	338.47	338.95	0.021992	6.24	22.26	28.22	1.24	1.08		
MILLBURY DAM	4973.67	Average	Exist R	139.00	338.02	339.18	339.18	339.59	0.014334	5.11	27.20	33.85	1.00	0.72		
MILLBURY DAM	4973.67	Maximum	Full Remov 2	304.00	335.97	339.23	339.23	339.91	0.012461	6.59	46.14	34.47	1.00	1.01		
MILLBURY DAM	4973.67	Maximum	Full Remov 1	304.00	335.97	339.23	339.23	339.91	0.012461	6.59	46.14	34.47	1.00	1.01		
MILLBURY DAM	4973.67	Maximum	Removal RGC	304.00	339.00	340.89	340.89	341.39	0.013315	5.65	53.81	54.46	1.00	0.82		
MILLBURY DAM	4973.67	Maximum	Rock Ramp R	304.00	337.00	338.78	339.10	339.93	0.025874	8.61	35.29	31.08	1.42	1.82		
MILLBURY DAM	4973.67	Maximum	Exist R	304.00	338.02	339.76	339.76	340.36	0.012497	6.23	48.79	40.61	1.00	0.93		
MILLBURY DAM	4973.67	1-YR	Full Remov 2	350.00	335.97	339.39	339.39	340.10	0.012180	6.79	51.58	36.26	1.00	1.05		
MILLBURY DAM	4973.67	1-YR	Full Remov 1	350.00	335.97	339.39	339.39	340.10	0.012180	6.79	51.58	36.26	1.00	1.05		
MILLBURY DAM	4973.67	1-YR	Removal RGC	350.00	339.00	341.01	341.01	341.53	0.012982	5.78	60.58	58.16	1.00	0.84		
MILLBURY DAM	4973.67	1-YR	Rock Ramp R	350.00	337.00	338.88	339.25	340.17	0.026554	9.11	38.43	31.73	1.46	1.99		
MILLBURY DAM	4973.67	1-YR	Exist R	350.00	338.02	339.88	339.88	340.54	0.012536	6.51	53.78	42.02	1.01	0.99		
MILLBURY DAM	4973.67	2-YR	Full Remov 2	1350.00	335.97	341.51	341.26	342.37	0.007571	7.43	181.70	78.46	0.86	1.07		
MILLBURY DAM	4973.67	2-YR	Full Remov 1	1350.00	335.97	341.51	341.26	342.37	0.007571	7.43	181.70	78.46	0.86	1.07		
MILLBURY DAM	4973.67	2-YR	Removal RGC	1350.00	339.00	342.51	342.51	343.49	0.009324	7.99	185.00	118.45	0.96	1.26	0.12	0.25
MILLBURY DAM	4973.67	2-YR	Rock Ramp R	1350.00	337.00	340.44	341.43	343.51	0.027971	14.04	96.14	42.77	1.65	3.85		
MILLBURY DAM	4973.67	2-YR	Exist R	1350.00	338.02	341.51	341.51	342.56	0.010358	8.20	164.73	78.48	1.00	1.34		
MILLBURY DAM	4973.67	10-YR	Full Remov 2	3200.00	335.97	344.36	343.03	345.10	0.002517	7.14	616.22	226.12	0.56	0.77	0.14	0.22
MILLBURY DAM	4973.67	10-YR	Full Remov 1	3200.00	335.97	344.36	343.03	345.10	0.002517	7.14	616.24	226.12	0.56	0.76	0.14	0.22

HEC-RAS River: Reach #1 Reach: MILLBURY DAM (Continued)

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan	Shear LOB	Shear ROB
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)	(lb/sq ft)	(lb/sq ft)
MILLBURY DAM	4973.67	10-YR	Removal RGC	3200.00	339.00	343.80	343.80	345.70	0.010203	11.38	357.47	150.77	1.08	2.19	0.45	0.80
MILLBURY DAM	4973.67	10-YR	Rock Ramp R	3200.00	337.00	342.82	343.83	345.77	0.018215	13.90	256.39	118.40	1.40	3.41		0.77
MILLBURY DAM	4973.67	10-YR	Exist R	3200.00	338.02	344.30	343.22	345.12	0.002975	7.53	585.35	225.58	0.61	0.86	0.16	0.25
MILLBURY DAM	4973.67	50-YR	Full Remov 2	5800.00	335.97	345.95	344.78	347.08	0.002828	9.10	988.44	240.47	0.63	1.13	0.27	0.50
MILLBURY DAM	4973.67	50-YR	Full Remov 1	5800.00	335.97	345.95	344.78	347.08	0.002828	9.10	988.45	240.47	0.63	1.13	0.27	0.50
MILLBURY DAM	4973.67	50-YR	Removal RGC	5800.00	339.00	345.75	345.75	347.64	0.006131	11.90	792.61	238.64	0.90	2.06	0.55	0.90
MILLBURY DAM	4973.67	50-YR	Rock Ramp R	5800.00	337.00	345.83	345.33	347.20	0.004679	9.96	848.40	239.40	0.78	1.47	0.23	0.71
MILLBURY DAM	4973.67	50-YR	Exist R	5800.00	338.02	345.88	344.93	347.10	0.003198	9.47	954.04	239.83	0.66	1.24	0.30	0.55
MILLBURY DAM	4973.67	100-YR	Full Remov 2	7300.00	335.97	346.41	345.49	347.89	0.003457	10.53	1099.12	244.18	0.70	1.48	0.36	0.69
MILLBURY DAM	4973.67	100-YR	Full Remov 1	7300.00	335.97	346.41	345.49	347.89	0.003456	10.53	1099.16	244.18	0.70	1.48	0.36	0.69
MILLBURY DAM	4973.67	100-YR	Removal RGC	7300.00	339.00	346.42	346.42	348.56	0.006143	12.88	954.60	244.26	0.92	2.32	0.64	1.13
MILLBURY DAM	4973.67	100-YR	Rock Ramp R	7300.00	337.00	346.37	345.95	348.05	0.005104	11.12	978.74	243.88	0.82	1.78	0.31	0.93
MILLBURY DAM	4973.67	100-YR	Exist R	7300.00	338.02	346.37	345.61	347.94	0.003792	10.84	1073.20	243.89	0.73	1.59	0.39	0.75
MILLBURY DAM	4780.41	Drought	Full Remov 2	49.00	335.10	336.86	335.73	336.88	0.000202	0.87	56.04	39.41	0.13	0.02		
MILLBURY DAM	4780.41	Drought	Full Remov 1	49.00	335.10	336.86	335.73	336.88	0.000202	0.87	56.04	39.41	0.13	0.02		
MILLBURY DAM	4780.41	Drought	Removal RGC	49.00	335.10	336.86	335.73	336.88	0.000202	0.87	56.05	39.41	0.13	0.02		
MILLBURY DAM	4780.41	Drought	Rock Ramp R	49.00	335.10	336.86	335.73	336.88	0.000202	0.87	56.04	39.41	0.13	0.02		
MILLBURY DAM	4780.41	Drought	Exist R	49.00	335.10	336.86	335.73	336.88	0.000202	0.87	56.04	39.41	0.13	0.02		
MILLBURY DAM	4780.41	Average	Full Remov 2	139.00	335.10	337.83	336.13	337.87	0.000310	1.45	95.82	42.54	0.17	0.04		
MILLBURY DAM	4780.41	Average	Full Remov 1	139.00	335.10	337.83	336.13	337.87	0.000310	1.45	95.82	42.54	0.17	0.04		
MILLBURY DAM	4780.41	Average	Removal RGC	139.00	335.10	337.83	336.13	337.87	0.000310	1.45	95.84	42.54	0.17	0.04		
MILLBURY DAM	4780.41	Average	Rock Ramp R	139.00	335.10	337.83	336.13	337.87	0.000310	1.45	95.84	42.54	0.17	0.04		
MILLBURY DAM	4780.41	Average	Exist R	139.00	335.10	337.83	336.13	337.87	0.000310	1.45	95.84	42.54	0.17	0.04		
MILLBURY DAM	4780.41	Maximum	Full Remov 2	304.00	335.10	338.77	336.65	338.85	0.000504	2.22	137.09	45.57	0.23	0.09		
MILLBURY DAM	4780.41	Maximum	Full Remov 1	304.00	335.10	338.77	336.65	338.85	0.000504	2.22	137.09	45.57	0.23	0.09		
MILLBURY DAM	4780.41	Maximum	Removal RGC	304.00	335.10	338.77	336.65	338.85	0.000504	2.22	137.11	45.57	0.23	0.09		
MILLBURY DAM	4780.41	Maximum	Rock Ramp R	304.00	335.10	338.77	336.66	338.85	0.000504	2.22	137.11	45.57	0.23	0.09		
MILLBURY DAM	4780.41	Maximum	Exist R	304.00	335.10	338.77	336.65	338.85	0.000504	2.22	137.05	45.56	0.23	0.09		
MILLBURY DAM	4780.41	1-YR	Full Remov 2	350.00	335.10	338.95	336.78	339.04	0.000563	2.41	145.22	46.14	0.24	0.10		
MILLBURY DAM	4780.41	1-YR	Full Remov 1	350.00	335.10	338.95	336.78	339.04	0.000563	2.41	145.22	46.14	0.24	0.10		
MILLBURY DAM	4780.41	1-YR	Removal RGC	350.00	335.10	338.95	336.78	339.04	0.000563	2.41	145.23	46.14	0.24	0.10		
MILLBURY DAM	4780.41	1-YR	Rock Ramp R	350.00	335.10	338.95	336.78	339.04	0.000564	2.41	145.15	46.14	0.24	0.10		
MILLBURY DAM	4780.41	1-YR	Exist R	350.00	335.10	338.95	336.78	339.04	0.000563	2.41	145.18	46.14	0.24	0.10		
MILLBURY DAM	4780.41	2-YR	Full Remov 2	1350.00	335.10	341.30		341.72	0.001342	5.23	260.64	52.00	0.40	0.41	0.04	0.06
MILLBURY DAM	4780.41	2-YR	Full Remov 1	1350.00	335.10	341.30		341.72	0.001342	5.23	260.64	52.00	0.40	0.41	0.04	0.06
MILLBURY DAM	4780.41	2-YR	Removal RGC	1350.00	335.10	341.30	338.76	341.73	0.001341	5.23	260.73	52.01	0.40	0.41	0.04	0.06
MILLBURY DAM	4780.41	2-YR	Rock Ramp R	1350.00	335.10	341.30	338.76	341.72	0.001343	5.23	260.62	52.00	0.40	0.41	0.04	0.06
MILLBURY DAM	4780.41	2-YR	Exist R	1350.00	335.10	341.30	338.76	341.72	0.001343	5.23	260.63	52.00	0.40	0.41	0.04	0.06
MILLBURY DAM	4780.41	10-YR	Full Remov 2	3200.00	335.10	343.74		344.67	0.001898	8.00	600.66	294.38	0.51	0.85	0.17	0.11
MILLBURY DAM	4780.41	10-YR	Full Remov 1	3200.00	335.10	343.74		344.67	0.001898	8.00	600.70	294.40	0.51	0.85	0.17	0.11
MILLBURY DAM	4780.41	10-YR	Removal RGC	3200.00	335.10	343.74	341.13	344.67	0.001897	8.00	600.86	294.47	0.51	0.85	0.17	0.11
MILLBURY DAM	4780.41	10-YR	Rock Ramp R	3200.00	335.10	343.74	341.13	344.67	0.001897	8.00	600.86	294.47	0.51	0.85	0.17	0.11
MILLBURY DAM	4780.41	10-YR	Exist R	3200.00	335.10	343.74		344.67	0.001898	8.00	600.69	294.39	0.51	0.85	0.17	0.11
MILLBURY DAM	4780.41	50-YR	Full Remov 2	5800.00	335.10	345.30		346.60	0.002424	10.22	1212.68	459.64	0.59	1.30	0.31	0.28
MILLBURY DAM	4780.41	50-YR	Full Remov 1	5800.00	335.10	345.30		346.60	0.002422	10.22	1213.19	459.71	0.59	1.30	0.31	0.28
MILLBURY DAM	4780.41	50-YR	Removal RGC	5800.00	335.10	345.30	344.85	346.60	0.002422	10.22	1213.07	459.70	0.59	1.30	0.31	0.28
MILLBURY DAM	4780.41	50-YR	Rock Ramp R	5800.00	335.10	345.31		346.60	0.002421	10.22	1213.35	459.74	0.59	1.30	0.31	0.28
MILLBURY DAM	4780.41	50-YR	Exist R	5800.00	335.10	345.31		346.60	0.002417	10.21	1214.82	459.95	0.59	1.30	0.31	0.28
MILLBURY DAM	4780.41	100-YR	Full Remov 2	7300.00	335.10	345.91		347.36	0.002671	11.19	1505.32	500.79	0.63	1.52	0.39	0.37
MILLBURY DAM	4780.41	100-YR	Full Remov 1	7300.00	335.10	345.91		347.36	0.002670	11.19	1505.60	500.83	0.63	1.52	0.39	0.37
MILLBURY DAM	4780.41	100-YR	Removal RGC	7300.00	335.10	345.92	345.57	347.36	0.002666	11.18	1506.96	501.01	0.63	1.52	0.39	0.37
MILLBURY DAM	4780.41	100-YR	Rock Ramp R	7300.00	335.10	345.91		347.36	0.002671	11.19	1505.29	500.79	0.63	1.52	0.39	0.37
MILLBURY DAM	4780.41	100-YR	Exist R	7300.00	335.10	345.91		347.36	0.002671	11.19	1505.27	500.78	0.63	1.52	0.39	0.37
MILLBURY DAM	4386	Drought	Full Remov 2	49.00	334.74	336.53	336.11	336.65	0.004002	2.78	17.66	20.87	0.53	0.21		

HEC-RAS River: Reach #1 Reach: MILLBURY DAM (Continued)

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan	Shear LOB	Shear ROB
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)	(lb/sq ft)	(lb/sq ft)
MILLBURY DAM	4386	Drought	Full Remov 1	49.00	334.74	336.53	336.11	336.65	0.004002	2.78	17.66	20.87	0.53	0.21		
MILLBURY DAM	4386	Drought	Removal RGC	49.00	334.74	336.53	336.11	336.65	0.004002	2.78	17.66	20.87	0.53	0.21		
MILLBURY DAM	4386	Drought	Rock Ramp R	49.00	334.74	336.53	336.11	336.65	0.004002	2.78	17.66	20.87	0.53	0.21		
MILLBURY DAM	4386	Drought	Exist R	49.00	334.74	336.53	336.11	336.65	0.004002	2.78	17.66	20.87	0.53	0.21		
MILLBURY DAM	4386	Average	Full Remov 2	139.00	334.74	337.38	336.83	337.55	0.004001	3.37	41.21	36.46	0.56	0.28		
MILLBURY DAM	4386	Average	Full Remov 1	139.00	334.74	337.38	336.83	337.55	0.004001	3.37	41.21	36.46	0.56	0.28		
MILLBURY DAM	4386	Average	Removal RGC	139.00	334.74	337.38	336.83	337.55	0.004001	3.37	41.21	36.46	0.56	0.28		
MILLBURY DAM	4386	Average	Rock Ramp R	139.00	334.74	337.38	336.83	337.55	0.004001	3.37	41.21	36.46	0.56	0.28		
MILLBURY DAM	4386	Average	Exist R	139.00	334.74	337.38	336.83	337.55	0.004001	3.37	41.21	36.46	0.56	0.28		
MILLBURY DAM	4386	Maximum	Full Remov 2	304.00	334.74	338.17	337.58	338.40	0.004002	3.86	78.80	57.24	0.58	0.34		
MILLBURY DAM	4386	Maximum	Full Remov 1	304.00	334.74	338.17	337.58	338.40	0.004002	3.86	78.80	57.24	0.58	0.34		
MILLBURY DAM	4386	Maximum	Removal RGC	304.00	334.74	338.17	337.58	338.40	0.004002	3.86	78.80	57.24	0.58	0.34		
MILLBURY DAM	4386	Maximum	Rock Ramp R	304.00	334.74	338.17	337.58	338.40	0.004002	3.86	78.80	57.24	0.58	0.34		
MILLBURY DAM	4386	Maximum	Exist R	304.00	334.74	338.17	337.58	338.40	0.004002	3.86	78.80	57.24	0.58	0.34		
MILLBURY DAM	4386	1-YR	Full Remov 2	350.00	334.74	338.30	337.74	338.55	0.004003	4.06	86.17	58.07	0.59	0.37		0.02
MILLBURY DAM	4386	1-YR	Full Remov 1	350.00	334.74	338.30	337.74	338.55	0.004003	4.06	86.17	58.07	0.59	0.37		0.02
MILLBURY DAM	4386	1-YR	Removal RGC	350.00	334.74	338.30	337.74	338.55	0.004003	4.06	86.17	58.07	0.59	0.37		0.02
MILLBURY DAM	4386	1-YR	Rock Ramp R	350.00	334.74	338.30	337.74	338.55	0.004003	4.06	86.17	58.07	0.59	0.37		0.02
MILLBURY DAM	4386	1-YR	Exist R	350.00	334.74	338.30	337.74	338.55	0.004003	4.06	86.17	58.07	0.59	0.37		0.02
MILLBURY DAM	4386	2-YR	Full Remov 2	1350.00	334.74	340.16	339.40	340.85	0.004007	6.66	205.18	67.58	0.66	0.77	0.02	0.20
MILLBURY DAM	4386	2-YR	Full Remov 1	1350.00	334.74	340.16	339.40	340.85	0.004007	6.66	205.18	67.58	0.66	0.77	0.02	0.20
MILLBURY DAM	4386	2-YR	Removal RGC	1350.00	334.74	340.16	339.40	340.85	0.004007	6.66	205.18	67.58	0.66	0.77	0.02	0.20
MILLBURY DAM	4386	2-YR	Rock Ramp R	1350.00	334.74	340.16	339.40	340.85	0.004007	6.66	205.18	67.58	0.66	0.77	0.02	0.20
MILLBURY DAM	4386	2-YR	Exist R	1350.00	334.74	340.16	339.40	340.85	0.004007	6.66	205.18	67.58	0.66	0.77	0.02	0.20
MILLBURY DAM	4386	10-YR	Full Remov 2	3200.00	334.74	342.30	341.27	343.61	0.003869	9.26	424.07	342.73	0.71	1.26	0.09	0.07
MILLBURY DAM	4386	10-YR	Full Remov 1	3200.00	334.74	342.30	341.27	343.61	0.003869	9.26	424.07	342.73	0.71	1.26	0.09	0.07
MILLBURY DAM	4386	10-YR	Removal RGC	3200.00	334.74	342.30	341.27	343.61	0.003869	9.26	424.07	342.73	0.71	1.26	0.09	0.07
MILLBURY DAM	4386	10-YR	Rock Ramp R	3200.00	334.74	342.30	341.27	343.61	0.003869	9.26	424.07	342.73	0.71	1.26	0.09	0.07
MILLBURY DAM	4386	10-YR	Exist R	3200.00	334.74	342.30	341.27	343.61	0.003869	9.26	424.07	342.73	0.71	1.26	0.09	0.07
MILLBURY DAM	4386	50-YR	Full Remov 2	5800.00	334.74	343.90	343.90	345.47	0.003787	10.94	1120.47	486.29	0.74	1.61	0.15	0.38
MILLBURY DAM	4386	50-YR	Full Remov 1	5800.00	334.74	343.90	343.90	345.47	0.003787	10.94	1120.47	486.29	0.74	1.61	0.15	0.38
MILLBURY DAM	4386	50-YR	Removal RGC	5800.00	334.74	343.90	343.90	345.47	0.003787	10.94	1120.47	486.29	0.74	1.61	0.15	0.38
MILLBURY DAM	4386	50-YR	Rock Ramp R	5800.00	334.74	343.90	343.90	345.47	0.003787	10.94	1120.47	486.29	0.74	1.61	0.15	0.38
MILLBURY DAM	4386	50-YR	Exist R	5800.00	334.74	343.90	343.90	345.47	0.003787	10.94	1120.47	486.29	0.74	1.61	0.15	0.38
MILLBURY DAM	4386	100-YR	Full Remov 2	7300.00	334.74	344.53	344.53	346.19	0.003848	11.69	1428.71	492.66	0.75	1.78	0.17	0.53
MILLBURY DAM	4386	100-YR	Full Remov 1	7300.00	334.74	344.53	344.53	346.19	0.003848	11.69	1428.71	492.66	0.75	1.78	0.17	0.53
MILLBURY DAM	4386	100-YR	Removal RGC	7300.00	334.74	344.53	344.53	346.19	0.003848	11.69	1428.71	492.66	0.75	1.78	0.17	0.53
MILLBURY DAM	4386	100-YR	Rock Ramp R	7300.00	334.74	344.53	344.53	346.19	0.003848	11.69	1428.71	492.66	0.75	1.78	0.17	0.53
MILLBURY DAM	4386	100-YR	Exist R	7300.00	334.74	344.53	344.53	346.19	0.003848	11.69	1428.71	492.66	0.75	1.78	0.17	0.53

HEC-RAS River: Reach #1 Reach: MILLBURY DAM Profile: 100-YR

Reach	River Sta	Profile	Plan	E.G. US.	Min El Prs	BR Open Area	Prs O WS	Q Total	Min El Weir Flow	Q Weir	Delta EG	BR Open Vel
				(ft)	(ft)	(sq ft)	(ft)	(cfs)	(ft)	(cfs)	(ft)	(ft/s)
MILLBURY DAM	7218	100-YR	Full Remov 2	361.10	355.81	461.40	361.95	7300.00	360.01	704.91	1.65	14.29
MILLBURY DAM	7218	100-YR	Full Remov 1	361.10	355.81	461.40	361.95	7300.00	360.01	704.91	1.65	14.29
MILLBURY DAM	7218	100-YR	Removal RGC	361.10	355.81	461.40	361.95	7300.00	360.01	704.91	1.65	14.29
MILLBURY DAM	7218	100-YR	Rock Ramp R	361.10	355.81	461.40	361.95	7300.00	360.01	704.91	1.65	14.29
MILLBURY DAM	7218	100-YR	Exist R	361.10	355.81	461.40	361.95	7300.00	360.01	704.91	1.65	14.29
MILLBURY DAM	6529.47	100-YR	Full Remov 2	354.81	351.30	485.26	358.65	7300.00	354.01	1894.63	0.20	11.14
MILLBURY DAM	6529.47	100-YR	Full Remov 1	355.20	351.30	485.26		7300.00	354.01	2645.90	0.03	9.59
MILLBURY DAM	6529.47	100-YR	Removal RGC	355.20	351.30	485.26		7300.00	354.01	2642.01	0.03	9.60
MILLBURY DAM	6529.47	100-YR	Rock Ramp R	355.20	351.30	485.26		7300.00	354.01	2650.86	0.03	9.58
MILLBURY DAM	6529.47	100-YR	Exist R	355.20	351.30	485.26		7300.00	354.01	2651.38	0.03	9.58

APPENDIX E

COMPUTATIONS

SEDIMENT VOLUME
SCOUR AT UPSTREAM BRIDGES
ROCK RAMP

SEDIMENT VOLUME COMPS

CROSS SECTIONAL AREA BETWEEN TOP OF SED. & HARD RIVER BOTTOM COMPUTED IN SPREADSHEETS: "FIELD SURVEYED CROSS SECTION DATA"

SECTION	AREA (FT²) TOTAL	AREA (FT²) AVG.	DISTANCE (FT)	VOLUME (C.Y.)
I	107.6			
		195.7	416	3,015
H	283.7			
		321.8	318.1	3,791
G	359.8			
		487.3	62.1	1,121
F	614.7			
		614.7	28.0	637
E	614.7*			
			TOTAL	8,564

* ASSUME CONSTANT SEDIMENT VOLUME UP TO FACE OF DAM

SEDIMENT QUALITY ANALYSIS INDICATES THAT ALL SEDIMENT UP TO AND INCLUDING SECTION I IS CONTAMINATED.

SCOUR AT UPSTREAM BRIDGES

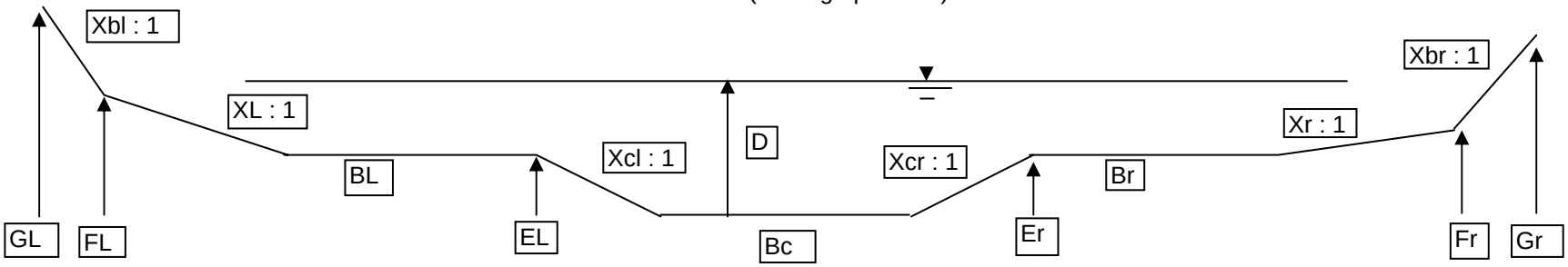
PROVIDENCE RD.

- SPREAD FOOTING AT ELEV. 78.0 (ROAD SURFACE = 95.1)
  - NEW DATUM ROAD SURFACE = 360.5 (NGVD 88)
  - 95.1 - 78.0 = 17.1
  - 360.5 - 17.1 = 343.4 FOOTING BOTTOM
- MAX. DEPTH @ ℄ OF CHANNEL = 342 (CDM BRIDGE SURVEY)
- CENTER OF CHAN. SCOURED BELOW FOOTING DEPTH
- RIGHT ABUT. APPEARS TO BE ON BEDROCK
- LEFT ABUT. NOT VISIBLE AT BASE DUE TO WATER

RIVERLIN ST.

- CHECKED REF. ELEV, DATUMS APPEAR IDENTICAL
- STEEL SHEETING DRIVEN TO EL. 319.0
- MAX. CHANNEL DEPTH = 340.5 (CDM BRIDGE SURVEY)
- OLD SPREAD FOOTINGS REMAIN IN PLACE
- NEW PILE INTEGRAL ABUTMENT SUPPORTS BRIDGE DECK.

MILLBURY DAM ROCK RAMP STRUCTURE
NESTED STONE CHANNEL - NORMAL DEPTH FLOW
(looking upstream)



Bottom Widths:	BL	0	Bc	0	Br	0	(ft)
Elevations & Channel Slope:	EL	1.75	So	0.02	Er	1.75	(ft)
	FL	2.00			Fr	2.00	
	GL	5.50	Dstart	0	Gr	5.50	
Side Slopes:	XL	5	Xcl	10	Xr	5	
	Xbl	2	Xcr	10	Xbr	2	
Bed Materials:	D50L	0.89	D50c	0.89	D50r	0.89	(ft)
	D84L	2.62	D84c	2.62	D84r	2.62	

DESIGN FLOWS

Spring Ave. Daily		Left Side		Center Channel				Right Side	
Occurance	Q (cfs)	D (ft)	V (fps)	D (ft)	V (fps)	Tau(lbs/sf)	n	D (ft)	V (fps)
10%	49.0	0.03	0.03	1.78	1.53	1.12	0.128	0.03	0.03
50%	138.5	0.75	0.71	2.50	2.40	2.01	0.121	0.75	0.71
90%	304.3	1.63	1.45	3.38	3.43	3.10	0.113	1.63	1.45
2	1037.0	3.65	3.01	5.40	5.71	5.60	0.1	3.65	3.01
10	3200.0	0	0	0.00	0.00	0.00	0	0	0
50	5800.0	0	0	0.00	0.00	0.00	0	0	0
100	7300.0	0	0	0.00	0.00	0.00	0	0	0

KCI TECHNOLOGIES

MILLBURY DAM REMOVAL - DETAILED ROCK RAMP CALCULATIONS

Note: Manning's n based on modified Musetter Relationship from PhD Thesis, Colorado State University

WSEL	Pilot Channel								Left Side Channel								Right Side Channel								Channel Totals					Flow
ft	d (ft)	A (sf)	Wp (ft)	Rh (ft)	n	V (fps)	Q (cfs)	Tau	dL (ft)	A (sf)	Wp (ft)	Rh (ft)	n	V (fps)	Q (cfs)	Tau	dr (ft)	A (sf)	Wp (ft)	Rh (ft)	n	V (fps)	Q (cfs)	Tau	**Q (cfs)**	A (cf)	Vave (fps)	d(ft)	H(ft)	Interval
1.60	0.00	0.00	0.00	0.00	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**0.00**	0.00	0.00	0.00	0.00	
1.62	0.02	0.00	0.40	0.01	0.476	0.02	0.00	0.01	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**0.00**	0.00	0.02	0.02	0.02	
1.64	0.04	0.02	0.80	0.02	0.388	0.04	0.00	0.02	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**0.00**	0.02	0.04	0.04	0.04	
1.66	0.06	0.04	1.21	0.03	0.345	0.06	0.00	0.04	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**0.00**	0.04	0.06	0.06	0.06	
1.68	0.08	0.06	1.61	0.04	0.317	0.08	0.00	0.05	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**0.00**	0.06	0.08	0.08	0.08	
1.70	0.10	0.10	2.01	0.05	0.297	0.10	0.01	0.06	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**0.01**	0.10	0.10	0.10	0.10	
1.72	0.12	0.14	2.41	0.06	0.281	0.11	0.02	0.07	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**0.02**	0.14	0.11	0.12	0.12	
1.74	0.14	0.20	2.81	0.07	0.269	0.13	0.03	0.09	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**0.03**	0.20	0.13	0.14	0.14	
1.76	0.16	0.26	3.22	0.08	0.258	0.15	0.04	0.10	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**0.04**	0.26	0.15	0.16	0.16	
1.78	0.18	0.32	3.62	0.09	0.250	0.17	0.05	0.11	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**0.05**	0.32	0.17	0.18	0.18	
1.80	0.20	0.40	4.02	0.10	0.242	0.19	0.07	0.12	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**0.07**	0.40	0.19	0.20	0.20	
1.82	0.22	0.48	4.42	0.11	0.235	0.20	0.10	0.14	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**0.10**	0.48	0.20	0.22	0.22	
1.84	0.24	0.58	4.82	0.12	0.229	0.22	0.13	0.15	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**0.13**	0.58	0.22	0.24	0.24	
1.86	0.26	0.68	5.23	0.13	0.224	0.24	0.16	0.16	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**0.16**	0.68	0.24	0.26	0.26	
1.88	0.28	0.78	5.63	0.14	0.219	0.26	0.20	0.17	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**0.20**	0.78	0.26	0.28	0.28	
1.90	0.30	0.90	6.03	0.15	0.215	0.28	0.25	0.19	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**0.25**	0.90	0.28	0.30	0.30	
1.92	0.32	1.02	6.43	0.16	0.211	0.29	0.30	0.20	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**0.30**	1.02	0.29	0.32	0.32	
1.94	0.34	1.16	6.83	0.17	0.207	0.31	0.36	0.21	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**0.36**	1.16	0.31	0.34	0.34	
1.96	0.36	1.30	7.24	0.18	0.204	0.33	0.42	0.22	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**0.42**	1.30	0.33	0.36	0.36	
1.98	0.38	1.44	7.64	0.19	0.201	0.35	0.50	0.24	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**0.50**	1.44	0.35	0.38	0.38	
2.00	0.40	1.60	8.04	0.20	0.198	0.36	0.58	0.25	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**0.58**	1.60	0.36	0.40	0.40	
2.02	0.42	1.76	8.44	0.21	0.195	0.38	0.67	0.26	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**0.67**	1.76	0.38	0.42	0.42	
2.04	0.44	1.94	8.84	0.22	0.192	0.40	0.77	0.27	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**0.77**	1.94	0.40	0.44	0.44	
2.06	0.46	2.12	9.25	0.23	0.190	0.41	0.88	0.28	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**0.88**	2.12	0.41	0.46	0.46	
2.08	0.48	2.30	9.65	0.24	0.187	0.43	1.00	0.30	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**1.00**	2.30	0.43	0.48	0.48	
2.10	0.50	2.50	10.05	0.25	0.185	0.45	1.12	0.31	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**1.12**	2.50	0.45	0.50	0.50	
2.12	0.52	2.70	10.45	0.26	0.183	0.47	1.26	0.32	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**1.26**	2.70	0.47	0.52	0.52	
2.14	0.54	2.92	10.85	0.27	0.181	0.48	1.41	0.33	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**1.41**	2.92	0.48	0.54	0.54	
2.16	0.56	3.14	11.26	0.28	0.179	0.50	1.57	0.35	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**1.57**	3.14	0.50	0.56	0.56	
2.18	0.58	3.36	11.66	0.29	0.177	0.52	1.74	0.36	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**1.74**	3.36	0.52	0.58	0.58	
2.20	0.60	3.60	12.06	0.30	0.175	0.54	1.93	0.37	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**1.93**	3.60	0.54	0.60	0.60	
2.22	0.62	3.84	12.46	0.31	0.174	0.55	2.12	0.38	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**2.12**	3.84	0.55	0.62	0.62	
2.24	0.64	4.10	12.86	0.32	0.172	0.57	2.33	0.40	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**2.33**	4.10	0.57	0.64	0.65	
2.26	0.66	4.36	13.27	0.33	0.171	0.59	2.55	0.41	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**2.55**	4.36	0.59	0.66	0.67	
2.28	0.68	4.62	13.67	0.34	0.169	0.60	2.79	0.42	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**2.79**	4.62	0.60	0.68	0.69	
2.30	0.70	4.90	14.07	0.35	0.168	0.62	3.04	0.43	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**3.04**	4.90	0.62	0.70	0.71	
2.32	0.72	5.18	14.47	0.36	0.166	0.64	3.31	0.45	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**3.31**	5.18	0.64	0.72	0.73	
2.34	0.74	5.48	14.87	0.37	0.165	0.65	3.58	0.46	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**3.58**	5.48	0.65	0.74	0.75	
2.36	0.76	5.78	15.28	0.38	0.164	0.67	3.88	0.47	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**3.88**	5.78	0.67	0.76	0.77	
2.38	0.78	6.08	15.68	0.39	0.162	0.69	4.19	0.48	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**4.19**	6.08	0.69	0.78	0.79	
2.40	0.80	6.40	16.08	0.40	0.161	0.71	4.52	0.50	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**4.52**	6.40	0.71	0.80	0.81	
2.42	0.82	6.72	16.48	0.41	0.160	0.72	4.86	0.51	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**4.86**	6.72	0.72	0.82	0.83	
2.44	0.84	7.06	16.88	0.42	0.159	0.74	5.22	0.52	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**5.22**	7.06	0.74	0.84	0.85	
2.46	0.86	7.40	17.29	0.43	0.158	0.76	5.59	0.53	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**5.59**	7.40	0.76	0.86	0.87	
2.48	0.88	7.74	17.69	0.44	0.157	0.77	5.99	0.54	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**5.99**	7.74	0.77	0.88	0.89	
2.50	0.90	8.10	18.09	0.45	0.156	0.79	6.40	0.56	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**6.40**	8.10	0.79	0.90	0.91	
2.52	0.92	8.46	18.49	0.46	0.155	0.81	6.83	0.57	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**6.83**	8.46	0.81	0.92	0.93	
2.54	0.94	8.84	18.89	0.47	0.154	0.82	7.28	0.58	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**7.28**	8.84	0.82	0.94	0.95	
2.56	0.96	9.22	19.30	0.48	0.153	0.84	7.75	0.59	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**7.75**	9.22	0.84	0.96	0.97	
2.58	0.98	9.60	19.70	0.49	0.152	0.86	8.23	0.61	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**8.23**	9.60	0.86	0.98	0.99	
2.60	1.00	10.00	20.10	0.50	0.151	0.87	8.74	0.62	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**8.74**	10.00	0.87	1.00	1.01	
2.62	1.02	10.40	20.50	0.51	0.150	0.89	9.27	0.63	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**9.27**	10.40	0.89	1.02	1.03	
2.64	1.04	10.82	20.90	0.52	0.149	0.91	9.82	0.64	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**9.82**	10.82	0.91	1.04	1.05	
2.66	1.06	11.24	21.31	0.53	0.148	0.92	10.39	0.66	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**10.39**	11.24	0.92	1.06	1.07	
2.68	1.08	11.66	21.71	0.54	0.148	0.94	10.98	0.67	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**10.98**	11.66	0.94	1.08	1.09	
2.70	1.10	12.10	22.11	0.55	0.147	0.96	11.59	0.68	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**11.59**	12.10	0.96	1.10	1.11	
2.72	1.12	12.54	22.51	0.56	0.146	0.97	12.22	0.69	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**12.22**	12.54	0.97	1.12	1.13	
2.74	1.14	13.00	22.91	0.57	0.145	0.99	12.88	0.71	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**12.88**	13.00	0.99	1.14	1.16	
2.76	1.16	13.46	23.32	0.58	0.145	1.01	13.56	0.72	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**13.56**	13.46	1.01	1.16	1.18	
2.78	1.18	13.92	23.72	0.59	0.144	1.02	14.27	0.73	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**14.27**	13.92	1.02	1.18	1.20	
2.80	1.20	14.40	24.12	0.60	0.143	1.04	14.99	0.74	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**14.99**	14.40	1.04	1.20	1.22	
2.82	1.22	14.88	24.52	0.61	0.142	1.06	15.74	0.76	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**15.74**	14.88	1.06	1.22	1.24	
2.84	1.24	15.38	24.92	0.62	0.142	1.07	16.52	0.77	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**16.52**	15.38	1.07	1.24	1.26	
2.86	1.26	15.88	25.33	0.63	0.141	1.09	17.32	0.78	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**17.32**	15.88	1.09	1.26	1.28	
2.88	1.28	16.38	25.73	0.64	0.140	1.11	18.15	0.79	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**18.15**	16.38	1.11	1.28	1.30	
2.90	1.30	16.90	26.13	0.65	0.140	1.12	19.00	0.80	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**19.00**	16.90	1.12	1.30	1.32	
2.92	1.32	17.42	26.53	0.66	0.139	1.14	19.88	0.82	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**19.88**	17.42	1.14	1.32	1.34	

2.94	1.34	17.96	26.93	0.67	0.139	1.16	20.78	0.83	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**20.78**	17.96	1.16	1.34	1.36	
2.96	1.36	18.50	27.34	0.68	0.138	1.17	21.72	0.84	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**21.72**	18.50	1.17	1.36	1.38	
2.98	1.38	19.04	27.74	0.69	0.137	1.19	22.68	0.85	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**22.68**	19.04	1.19	1.38	1.40	
3.00	1.40	19.60	28.14	0.70	0.137	1.21	23.66	0.87	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**23.66**	19.60	1.21	1.40	1.42	
3.02	1.42	20.16	28.54	0.71	0.136	1.22	24.68	0.88	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**24.68**	20.16	1.22	1.42	1.44	
3.04	1.44	20.74	28.94	0.72	0.136	1.24	25.72	0.89	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**25.72**	20.74	1.24	1.44	1.46	
3.06	1.46	21.32	29.35	0.73	0.135	1.26	26.79	0.90	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**26.79**	21.32	1.26	1.46	1.48	
3.08	1.48	21.90	29.75	0.74	0.135	1.27	27.89	0.92	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**27.89**	21.90	1.27	1.48	1.51	
3.10	1.50	22.50	30.15	0.75	0.134	1.29	29.02	0.93	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**29.02**	22.50	1.29	1.50	1.53	
3.12	1.52	23.10	30.55	0.76	0.134	1.31	30.18	0.94	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**30.18**	23.10	1.31	1.52	1.55	
3.14	1.54	23.72	30.95	0.77	0.133	1.32	31.37	0.95	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**31.37**	23.72	1.32	1.54	1.57	
3.16	1.56	24.34	31.36	0.78	0.133	1.34	32.60	0.97	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**32.60**	24.34	1.34	1.56	1.59	
3.18	1.58	24.96	31.76	0.79	0.132	1.36	33.85	0.98	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**33.85**	24.96	1.36	1.58	1.61	
3.20	1.60	25.60	32.16	0.80	0.132	1.37	35.13	0.99	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**35.13**	25.60	1.37	1.60	1.63	
3.22	1.62	26.24	32.56	0.81	0.131	1.39	36.45	1.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**36.45**	26.24	1.39	1.62	1.65	
3.24	1.64	26.90	32.96	0.82	0.131	1.41	37.80	1.02	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**37.80**	26.90	1.41	1.64	1.67	
3.26	1.66	27.56	33.37	0.83	0.130	1.42	39.18	1.03	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**39.18**	27.56	1.42	1.66	1.69	
3.28	1.68	28.22	33.77	0.84	0.130	1.44	40.59	1.04	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**40.59**	28.22	1.44	1.68	1.71	
3.30	1.70	28.90	34.17	0.85	0.129	1.45	42.04	1.05	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**42.04**	28.90	1.45	1.70	1.73	
3.32	1.72	29.58	34.57	0.86	0.129	1.47	43.52	1.06	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**43.52**	29.58	1.47	1.72	1.75	
3.34	1.74	30.28	34.97	0.87	0.128	1.49	45.03	1.08	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	**45.03**	30.28	1.49	1.74	1.77	
3.36	1.76	30.98	35.17	0.88	0.128	1.51	46.71	1.10	0.01	0.00	0.05	0.00	0.582	0.01	0.00	0.01	0.01	0.00	0.05	0.00	0.582	0.01	0.00	0.01	**46.71**	30.98	1.51	1.76	1.80	
3.38	1.78	31.68	35.17	0.90	0.128	1.53	48.56	1.12	0.03	0.00	0.15	0.01	0.421	0.03	0.00	0.02	0.03	0.00	0.15	0.01	0.421	0.03	0.00	0.02	**48.56**	31.68	1.53	1.78	1.82	10%
3.40	1.80	32.38	35.17	0.92	0.128	1.56	50.44	1.14	0.05	0.01	0.25	0.02	0.363	0.05	0.00	0.03	0.05	0.01	0.25	0.02	0.363	0.05	0.00	0.03	**50.44**	32.39	1.56	1.80	1.84	
3.42	1.82	33.08	35.17	0.94	0.127	1.58	52.35	1.17	0.07	0.01	0.36	0.03	0.329	0.07	0.00	0.04	0.07	0.01	0.36	0.03	0.329	0.07	0.00	0.04	**52.35**	33.10	1.58	1.82	1.86	
3.44	1.84	33.78	35.17	0.96	0.127	1.61	54.29	1.19	0.09	0.02	0.46	0.04	0.305	0.09	0.00	0.05	0.09	0.02	0.46	0.04	0.305	0.09	0.00	0.05	**54.29**	33.82	1.61	1.84	1.88	
3.46	1.86	34.48	35.17	0.98	0.127	1.63	56.26	1.22	0.11	0.03	0.56	0.05	0.288	0.10	0.00	0.07	0.11	0.03	0.56	0.05	0.288	0.10	0.00	0.07	**56.27**	34.54	1.63	1.86	1.90	
3.48	1.88	35.18	35.17	1.00	0.127	1.66	58.27	1.24	0.13	0.04	0.66	0.06	0.274	0.12	0.01	0.08	0.13	0.04	0.66	0.06	0.274	0.12	0.01	0.08	**58.28**	35.26	1.65	1.88	1.92	
3.50	1.90	35.88	35.17	1.02	0.127	1.68	60.31	1.27	0.15	0.06	0.76	0.07	0.263	0.14	0.01	0.09	0.15	0.06	0.76	0.07	0.263	0.14	0.01	0.09	**60.33**	35.99	1.68	1.90	1.94	
3.52	1.92	36.58	35.17	1.04	0.126	1.71	62.39	1.29	0.17	0.07	0.87	0.08	0.253	0.16	0.01	0.10	0.17	0.07	0.87	0.08	0.253	0.16	0.01	0.10	**62.41**	36.72	1.70	1.92	1.96	
3.54	1.94	37.28	35.17	1.06	0.126	1.73	64.49	1.32	0.19	0.09	0.97	0.09	0.245	0.18	0.02	0.12	0.19	0.09	0.97	0.09	0.245	0.18	0.02	0.12	**64.52**	37.46	1.72	1.94	1.99	
3.56	1.96	37.98	35.17	1.08	0.126	1.75	66.63	1.34	0.21	0.11	1.07	0.10	0.238	0.19	0.02	0.13	0.21	0.11	1.07	0.10	0.238	0.19	0.02	0.13	**66.67**	38.20	1.75	1.96	2.01	
3.58	1.98	38.68	35.17	1.10	0.126	1.78	68.80	1.37	0.23	0.13	1.17	0.11	0.232	0.21	0.03	0.14	0.23	0.13	1.17	0.11	0.232	0.21	0.03	0.14	**68.86**	38.94	1.77	1.98	2.03	
3.60	2.00	39.38	35.17	1.12	0.126	1.80	71.01	1.39	0.25	0.16	1.27	0.12	0.226	0.23	0.04	0.15	0.25	0.16	1.27	0.12	0.226	0.23	0.04	0.15	**71.08**	39.69	1.79	2.00	2.05	
3.62	2.02	40.08	35.17	1.14	0.125	1.83	73.24	1.42	0.27	0.18	1.32	0.14	0.223	0.25	0.05	0.17	0.27	0.18	1.32	0.14	0.223	0.25	0.05	0.17	**73.33**	40.44	1.81	2.02	2.07	
3.64	2.04	40.78	35.17	1.16	0.125	1.85	75.51	1.44	0.29	0.21	1.36	0.15	0.219	0.27	0.06	0.19	0.29	0.21	1.36	0.15	0.219	0.27	0.06	0.19	**75.63**	41.19	1.84	2.04	2.09	
3.66	2.06	41.48	35.17	1.18	0.125	1.88	77.81	1.47	0.31	0.23	1.41	0.17	0.216	0.30	0.07	0.21	0.31	0.23	1.41	0.17	0.216	0.30	0.07	0.21	**77.95**	41.94	1.86	2.06	2.11	
3.68	2.08	42.18	35.17	1.20	0.125	1.90	80.15	1.49	0.33	0.26	1.45	0.18	0.212	0.32	0.08	0.22	0.33	0.26	1.45	0.18	0.212	0.32	0.08	0.22	**80.31**	42.70	1.88	2.08	2.13	
3.70	2.10	42.88	35.17	1.22	0.125	1.92	82.51	1.52	0.35	0.29	1.50	0.19	0.209	0.34	0.10	0.24	0.35	0.29	1.50	0.19	0.209	0.34	0.10	0.24	**82.71**	43.46	1.90	2.10	2.16	
3.72	2.12	43.58	35.17	1.24	0.124	1.95	84.91	1.54	0.37	0.32	1.54	0.21	0.206	0.36	0.11	0.26	0.37	0.32	1.54	0.21	0.206	0.36	0.11	0.26	**85.14**	44.22	1.93	2.12	2.18	
3.74	2.14	44.28	35.17	1.26	0.124	1.97	87.34	1.57	0.39	0.35	1.59	0.22	0.203	0.38	0.13	0.27	0.39	0.35	1.59	0.22	0.203	0.38	0.13	0.27	**87.61**	44.98	1.95	2.14	2.20	
3.76	2.16	44.98	35.17	1.28	0.124	2.00	89.80	1.59	0.41	0.38	1.63	0.23	0.201	0.40	0.15	0.29	0.41	0.38	1.63	0.23	0.201	0.40	0.15	0.29	**90.11**	45.74	1.97	2.16	2.22	
3.78	2.18	45.68	35.17	1.30	0.124	2.02	92.30	1.62	0.43	0.41	1.68	0.25	0.198	0.42	0.17	0.31	0.43	0.41	1.68	0.25	0.198	0.42	0.17	0.31	**92.65**	46.50	1.99	2.18	2.24	
3.80	2.20	46.38	35.17	1.32	0.124	2.04	94.83	1.64	0.45	0.45	1.72	0.26	0.196	0.44	0.19	0.32	0.45	0.45	1.72	0.26	0.196	0.44	0.19	0.32	**95.22**	47.27	2.01	2.20	2.26	
3.82	2.22	47.08	35.17	1.34	0.123	2.07	97.39	1.66	0.47	0.48	1.77	0.27	0.193	0.46	0.22	0.34	0.47	0.48	1.77	0.27	0.193	0.46	0.22	0.34	**97.82**	48.03	2.04	2.22	2.28	
3.84	2.24	47.78	35.17	1.36	0.123	2.09	99.98	1.69	0.49	0.51	1.81	0.28	0.191	0.48	0.24	0.35	0.49	0.51	1.81	0.28	0.191	0.48	0.24	0.35	**100.47**	48.80	2.06	2.24	2.31	
3.86	2.26	48.48	35.17	1.38	0.123	2.12	102.60	1.71	0.51	0.55	1.86	0.30	0.189	0.49	0.27	0.37	0.51	0.55	1.86	0.30	0.189	0.49	0.27	0.37	**103.15**	49.57	2.08	2.26	2.33	
3.88	2.28	49.18	35.17	1.40	0.123	2.14	105.26	1.74	0.53	0.58	1.90	0.31	0.187	0.51	0.30	0.38	0.53	0.58	1.90	0.31	0.187	0.51	0.30	0.38	**105.86**	50.34	2.10	2.28	2.35	
3.90	2.30	49.88	35.17	1.42	0.123	2.16	107.95	1.76	0.55	0.62	1.95	0.32	0.185	0.53	0.33	0.40	0.55	0.62	1.95	0.32	0.185	0.53	0.33	0.40	**108.61**	51.12	2.12	2.30	2.37	
3.92	2.32	50.58	35.17	1.44	0.122	2.19	110.67	1.79	0.57	0.66	1.99	0.33	0.183	0.55	0.36	0.41	0.57	0.66	1.99	0.33	0.183	0.55	0.36	0.41	**111.39**	51.89	2.15	2.32	2.39	
3.94	2.34	51.28	35.17	1.46	0.122	2.21	113.42	1.81	0.59	0.70	2.04	0.34	0.181	0.57	0.40	0.43	0.59	0.70	2.04	0.34	0.181	0.57	0.40	0.43	**114.21**	52.67	2.17	2.34	2.41	
3.96	2.36	51.98	35.17	1.48	0.122	2.24	116.21	1.84	0.61	0.74	2.08	0.35	0.179	0.59	0.43	0.44	0.61	0.74	2.08	0.35	0.179	0.59	0.43	0.44	**117.07**	53.45	2.19	2.36	2.43	
3.98	2.38	52.68	35.17	1.50	0.122	2.26	119.02	1.86	0.63	0.78	2.12	0.37	0.177	0.61	0.47	0.45	0.63	0.78	2.12	0.37	0.177	0.61	0.47	0.45	**119.96**	54.23	2.21	2.38	2.46	
4.00	2.40	53.38	35.17	1.52	0.122	2.28	121.87	1.89	0.65	0.82	2.17	0.38	0.176	0.62	0.51	0.47	0.65	0.82	2.17	0.38	0.176	0.62	0.51	0.47	**122.89**	55.01	2.23	2.40	2.48	
4.02	2.42	54.08	35.17	1.54	0.121	2.31	124.75	1.91	0.67	0.86	2.21	0.39	0.174	0.64	0.55	0.48	0.67	0.86	2.21	0.39	0.174	0.64	0.55	0.48	**125.85**	55.79	2.26	2.42	2.50	
4.04	2.44	54.78	35.17	1.56	0.121	2.33	127.66	1.94	0.69	0.90	2.26	0.40	0.173	0.66	0.59	0.50	0.69	0.90	2.26	0.40	0.173	0.66	0.59	0.50	**128.85**	56.57	2.28	2.44	2.52	
4.06	2.46	55.48	35.17	1.58	0.121	2.35	130.61	1.96	0.71	0.94	2.30	0.41	0.171	0.68	0.64	0.51	0.71	0.94	2.30	0.41	0.171	0.68	0.64	0.51	**131.89**	57.36	2.30	2.46	2.54	
4.08	2.48	56.18	35.17	1.60	0.121	2.38	133.58	1.99	0.73	0.99	2.35	0.42	0.170	0.69	0.69	0.52	0.73	0.99	2.35	0.42	0.170	0.69	0.69	0.52	**134.96**	58.15	2.32	2.48	2.56	
4.10	2.50	56.88	35.17	1.62	0.121	2.40	136.59	2.01	0.75	1.03	2.39	0.43	0.168	0.71	0.73	0.54	0.75	1.03	2.39	0.43	0.168	0.71	0.73	0.54	**138.06**	58.94	2.34	2.50	2.59	50%
4.12	2.52	57.58	35.17	1.64	0.120	2.43	139.63	2.04	0.77	1.08	2.44	0.44	0.167	0.73	0.79	0.55	0.77	1.08	2.44	0.44	0.167	0.73	0.79	0.55	**141.21**	59.73	2.36	2.52	2.61	
4.14	2.54	58.27	35.17	1.66	0.120	2.45	142.71	2.06	0.79	1.12	2.48	0.45	0.166	0.75	0.84	0.56	0.79	1.12	2.48	0.45	0.166	0.75	0.84	0.56	**144.38**	60.52	2.39	2.54	2.63	
4.16	2.56	58.97	35.17	1.68	0.120	2.47	145.81	2.09	0.81	1.17	2.53	0.46	0.164	0.77	0.90	0.58	0.81	1.17	2.53	0.46	0.164	0.77	0.90	0.58	**147.60**	61.31	2.41	2.56	2.65	
4.18	2.58	59.67	35.17	1.70	0.120	2.50	148.95	2.11	0.83	1.22	2.57	0.47	0.163	0.78	0.95	0.59	0.83	1.22	2.57	0.47	0.163	0.78	0.95	0.59	**150.85**	62.11	2.43	2.58	2.67	
4.20	2.60	60.37	35.17	1.72	0.120	2.52	152.11	2.14	0.85	1.27	2.62	0.48	0.162	0.80	1.01	0.60	0.85	1.27	2.62	0.48	0.162	0.80	1.01	0.60	**154.14**	62.91	2.45	2.60	2.69	
4.22	2.62	61.07	35.17	1.74	0.119	2.54	155.31	2.16	0.87	1.32	2.66	0.49	0.161	0.82	1.08	0.62	0.87	1.32	2.66	0.49	0.161	0.82	1.08	0.62	**157.46**	63.71	2.47	2.62	2.71	
4.24	2.64	61.77	35.17	1.76	0.119	2.57	158.54	2.18	0.89	1.37	2.71	0.50	0.160	0.83	1.14	0.63	0.89	1.37	2.71	0.50	0.160	0.83	1.14	0.63	**160.82**	64.51	2.49	2.64	2.74	
4.26	2.66	62.47	35.17	1.78	0.119	2.59	161.81	2.21	0.91	1.42	2.75	0.52	0.159	0.85	1.21	0.64	0.91	1.42	2.75	0.52	0.159	0.85	1.21	0.64	**164.22**	65.31	2.51	2.66	2.76	
4.28	2.68	63.17	35.17	1.80	0.119	2.61	165.10	2.23	0.93	1.47	2.80	0.53	0.158	0.87	1.28	0.65	0.93	1.47	2.80	0.53	0.158	0.87	1.28	0.65	**167.65**	66.11	2.54	2.68	2.78	
4.30	2.70	63.87	35.17	1.82	0.119	2.64	168.43	2.26	0.95	1.52	2.84	0.54	0.156	0.89	1.35	0.67	0.95	1.52	2.84	0.54	0.156	0.89	1.35	0.67	**171.12**	66.92	2.56	2.70	2.80	
4.32	2.72	64.57	35.17	1.84	0.118	2.66	171.79	2.28	0.97	1.57	2.88	0.55	0.155	0.90	1.42	0.68	0.97	1.57	2.88	0.55	0.155	0.90	1.42	0.68	**174.63**	67.72	2.58	2.72	2.82	
4.34	2.74	65.27	35.17	1.86	0.118	2.68	175.18	2.31	0.99	1.63	2.93	0.56	0.155	0.92	1.50	0.69	0.99	1.63	2.93	0.56	0.155	0.92	1.50	0.69	**178.17**	68.53	2.60	2.74	2.84	
4.36	2.76	65.97	35.17	1.88	0.118	2.71	178.60	2.33	1.01	1.68	2.97	0.57	0.154	0.94	1.58	0.70	1.01	1.68	2.97	0.57	0.154	0.94	1.58	0.70	**181.75**	69.34	2.62	2.76	2.87	
4.38	2.78	66.67	35.17	1.90	0.118	2.73	182.05	2.36	1.03	1.74	3.02	0.58	0.153	0.95	1.66	0.72	1.03	1.74	3.02	0.58	0.153	0.95	1.66	0.72	**185.37**	70.15	2.64	2.78	2.89	

4.40	2.80	67.37	35.17	1.92	0.118	2.75	185.54	2.38	1.05	1.80	3.06	0.59	0.152	0.97	1.74	0.73	1.05	1.80	3.06	0.59	0.152	0.97	1.74	0.73	**189.03**	70.97	2.66	2.80	2.91	
4.42	2.82	68.07	35.17	1.94	0.118	2.78	189.06	2.41	1.07	1.85	3.11	0.60	0.151	0.99	1.83	0.74	1.07	1.85	3.11	0.60	0.151	0.99	1.83	0.74	**192.72**	71.78	2.68	2.82	2.93	
4.44	2.84	68.77	35.17	1.96	0.117	2.80	192.60	2.43	1.09	1.91	3.15	0.61	0.150	1.00	1.92	0.75	1.09	1.91	3.15	0.61	0.150	1.00	1.92	0.75	**196.44**	72.60	2.71	2.84	2.95	
4.46	2.86	69.47	35.17	1.98	0.117	2.82	196.18	2.46	1.11	1.97	3.20	0.62	0.149	1.02	2.01	0.77	1.11	1.97	3.20	0.62	0.149	1.02	2.01	0.77	**200.21**	73.42	2.73	2.86	2.98	
4.48	2.88	70.17	35.17	2.00	0.117	2.85	199.80	2.48	1.13	2.03	3.24	0.63	0.148	1.04	2.11	0.78	1.13	2.03	3.24	0.63	0.148	1.04	2.11	0.78	**204.01**	74.24	2.75	2.88	3.00	
4.50	2.90	70.87	35.17	2.01	0.117	2.87	203.44	2.51	1.15	2.09	3.29	0.64	0.147	1.05	2.20	0.79	1.15	2.09	3.29	0.64	0.147	1.05	2.20	0.79	**207.85**	75.06	2.77	2.90	3.02	
4.52	2.92	71.57	35.17	2.03	0.117	2.89	207.12	2.53	1.17	2.15	3.33	0.65	0.147	1.07	2.30	0.80	1.17	2.15	3.33	0.65	0.147	1.07	2.30	0.80	**211.72**	75.88	2.79	2.92	3.04	
4.54	2.94	72.27	35.17	2.05	0.116	2.92	210.82	2.56	1.19	2.21	3.38	0.66	0.146	1.09	2.41	0.82	1.19	2.21	3.38	0.66	0.146	1.09	2.41	0.82	**215.64**	76.70	2.81	2.94	3.06	
4.56	2.96	72.97	35.17	2.07	0.116	2.94	214.56	2.58	1.21	2.28	3.42	0.67	0.145	1.10	2.51	0.83	1.21	2.28	3.42	0.67	0.145	1.10	2.51	0.83	**219.59**	77.53	2.83	2.96	3.08	
4.58	2.98	73.67	35.17	2.09	0.116	2.96	218.33	2.61	1.23	2.34	3.47	0.68	0.144	1.12	2.62	0.84	1.23	2.34	3.47	0.68	0.144	1.12	2.62	0.84	**223.58**	78.36	2.85	2.98	3.11	
4.60	3.00	74.37	35.17	2.11	0.116	2.99	222.13	2.63	1.25	2.41	3.51	0.69	0.144	1.14	2.74	0.85	1.25	2.41	3.51	0.69	0.144	1.14	2.74	0.85	**227.60**	79.19	2.87	3.00	3.13	
4.62	3.02	75.07	35.17	2.13	0.116	3.01	225.96	2.66	1.27	2.47	3.56	0.70	0.143	1.15	2.85	0.86	1.27	2.47	3.56	0.70	0.143	1.15	2.85	0.86	**231.67**	80.02	2.90	3.02	3.15	
4.64	3.04	75.77	35.17	2.15	0.116	3.03	229.83	2.68	1.29	2.54	3.60	0.70	0.142	1.17	2.97	0.88	1.29	2.54	3.60	0.70	0.142	1.17	2.97	0.88	**235.77**	80.85	2.92	3.04	3.17	
4.66	3.06	76.47	35.17	2.17	0.115	3.06	233.73	2.70	1.31	2.60	3.64	0.71	0.142	1.19	3.09	0.89	1.31	2.60	3.64	0.71	0.142	1.19	3.09	0.89	**239.90**	81.68	2.94	3.06	3.19	
4.68	3.08	77.17	35.17	2.19	0.115	3.08	237.65	2.73	1.33	2.67	3.69	0.72	0.141	1.20	3.21	0.90	1.33	2.67	3.69	0.72	0.141	1.20	3.21	0.90	**244.08**	82.52	2.96	3.08	3.22	
4.70	3.10	77.87	35.17	2.21	0.115	3.10	241.61	2.75	1.35	2.74	3.73	0.73	0.140	1.22	3.34	0.91	1.35	2.74	3.73	0.73	0.140	1.22	3.34	0.91	**248.29**	83.36	2.98	3.10	3.24	
4.72	3.12	78.57	35.17	2.23	0.115	3.13	245.60	2.78	1.37	2.81	3.78	0.74	0.140	1.24	3.47	0.93	1.37	2.81	3.78	0.74	0.140	1.24	3.47	0.93	**252.55**	84.20	3.00	3.12	3.26	
4.74	3.14	79.27	35.17	2.25	0.115	3.15	249.62	2.80	1.39	2.88	3.82	0.75	0.139	1.25	3.61	0.94	1.39	2.88	3.82	0.75	0.139	1.25	3.61	0.94	**256.83**	85.04	3.02	3.14	3.28	
4.76	3.16	79.97	35.17	2.27	0.115	3.17	253.68	2.83	1.41	2.95	3.87	0.76	0.138	1.27	3.74	0.95	1.41	2.95	3.87	0.76	0.138	1.27	3.74	0.95	**261.16**	85.88	3.04	3.16	3.30	
4.78	3.18	80.67	35.17	2.29	0.114	3.20	257.76	2.85	1.43	3.02	3.91	0.77	0.138	1.28	3.88	0.96	1.43	3.02	3.91	0.77	0.138	1.28	3.88	0.96	**265.53**	86.72	3.06	3.18	3.33	
4.80	3.20	81.37	35.17	2.31	0.114	3.22	261.88	2.88	1.45	3.10	3.96	0.78	0.137	1.30	4.03	0.97	1.45	3.10	3.96	0.78	0.137	1.30	4.03	0.97	**269.93**	87.57	3.08	3.20	3.35	
4.82	3.22	82.07	35.17	2.33	0.114	3.24	266.03	2.90	1.47	3.17	4.00	0.79	0.137	1.32	4.17	0.99	1.47	3.17	4.00	0.79	0.137	1.32	4.17	0.99	**274.37**	88.41	3.10	3.22	3.37	
4.84	3.24	82.77	35.17	2.35	0.114	3.26	270.21	2.93	1.49	3.24	4.05	0.80	0.136	1.33	4.32	1.00	1.49	3.24	4.05	0.80	0.136	1.33	4.32	1.00	**278.85**	89.26	3.12	3.24	3.39	
4.86	3.26	83.47	35.17	2.37	0.114	3.29	274.42	2.95	1.51	3.32	4.09	0.81	0.136	1.35	4.48	1.01	1.51	3.32	4.09	0.81	0.136	1.35	4.48	1.01	**283.37**	90.11	3.14	3.26	3.41	
4.88	3.28	84.17	35.17	2.39	0.114	3.31	278.66	2.98	1.53	3.39	4.14	0.82	0.135	1.36	4.63	1.02	1.53	3.39	4.14	0.82	0.135	1.36	4.63	1.02	**287.93**	90.96	3.17	3.28	3.44	
4.90	3.30	84.87	35.17	2.41	0.113	3.33	282.93	3.00	1.55	3.47	4.18	0.83	0.134	1.38	4.79	1.03	1.55	3.47	4.18	0.83	0.134	1.38	4.79	1.03	**292.52**	91.82	3.19	3.30	3.46	
4.92	3.32	85.57	35.17	2.43	0.113	3.36	287.24	3.03	1.57	3.55	4.23	0.84	0.134	1.40	4.96	1.04	1.57	3.55	4.23	0.84	0.134	1.40	4.96	1.04	**297.15**	92.67	3.21	3.32	3.48	
4.94	3.34	86.27	35.17	2.45	0.113	3.38	291.57	3.05	1.59	3.63	4.27	0.85	0.133	1.41	5.13	1.06	1.59	3.63	4.27	0.85	0.133	1.41	5.13	1.06	**301.82**	93.53	3.23	3.34	3.50	
4.96	3.36	86.97	35.17	2.47	0.113	3.40	295.94	3.08	1.61	3.71	4.32	0.86	0.133	1.43	5.30	1.07	1.61	3.71	4.32	0.86	0.133	1.43	5.30	1.07	**306.53**	94.39	3.25	3.36	3.52	
4.98	3.38	87.67	35.17	2.49	0.113	3.43	300.34	3.10	1.63	3.79	4.36	0.87	0.132	1.45	5.47	1.08	1.63	3.79	4.36	0.87	0.132	1.45	5.47	1.08	**311.28**	95.25	3.27	3.38	3.55	90%
5.00	3.40	88.37	35.17	2.51	0.113	3.45	304.77	3.13	1.65	3.87	4.41	0.88	0.132	1.46	5.65	1.09	1.65	3.87	4.41	0.88	0.132	1.46	5.65	1.09	**316.07**	96.11	3.29	3.40	3.57	
5.25	3.65	97.12	35.17	2.76	0.111	3.74	362.78	3.43	1.90	4.94	4.96	1.00	0.126	1.66	8.21	1.24	1.90	4.94	4.96	1.00	0.126	1.66	8.21	1.24	**379.20**	107.01	3.54	3.65	3.84	
5.50	3.90	105.87	35.17	3.01	0.109	4.02	425.67	3.74	2.15	6.14	5.52	1.11	0.121	1.86	11.41	1.38	2.15	6.14	5.52	1.11	0.121	1.86	11.41	1.38	**448.49**	118.16	3.80	3.90	4.12	
5.75	4.15	114.62	35.17	3.26	0.107	4.30	493.42	4.05	2.40	7.47	6.08	1.23	0.117	2.05	15.33	1.53	2.40	7.47	6.08	1.23	0.117	2.05	15.33	1.53	**524.08**	129.56	4.05	4.15	4.40	
6.00	4.40	123.37	35.17	3.51	0.106	4.59	566.01	4.36	2.65	8.92	6.64	1.34	0.114	2.25	20.04	1.67	2.65	8.92	6.64	1.34	0.114	2.25	20.04	1.67	**606.09**	141.21	4.29	4.40	4.69	
6.25	4.65	132.12	35.17	3.76	0.104	4.87	643.43	4.67	2.90	10.49	7.20	1.46	0.111	2.44	25.61	1.81	2.90	10.49	7.20	1.46	0.111	2.44	25.61	1.81	**694.64**	153.11	4.54	4.65	4.97	
6.50	4.90	140.87	35.17	4.01	0.103	5.15	725.66	4.98	3.15	12.19	7.76	1.57	0.108	2.63	32.10	1.95	3.15	12.19	7.76	1.57	0.108	2.63	32.10	1.95	**789.86**	165.26	4.78	4.90	5.25	
6.75	5.15	149.62	35.17	4.25	0.102	5.43	812.70	5.29	3.40	14.02	8.32	1.68	0.105	2.82	39.58	2.10	3.40	14.02	8.32	1.68	0.105	2.82	39.58	2.10	**891.87**	177.66	5.02	5.15	5.54	
7.00	5.40	158.37	35.17	4.50	0.100	5.71	904.54	5.60	3.65	15.97	8.88	1.80	0.103	3.01	48.13	2.24	3.65	15.97	8.88	1.80	0.103	3.01	48.13	2.24	**1000.80**	190.31	5.26	5.40	5.83	2 Year
7.25	5.65	167.12	35.17	4.75	0.099	5.99	1001.15	5.91	3.90	18.02	9.10	1.98	0.102	3.26	58.75	2.46	3.90	18.02	9.10	1.98	0.102	3.26	58.75	2.46	**1118.66**	203.16	5.51	5.65	6.12	

Millbury Dam Step Pool Summary Table 1

Design Criteria: Velocities <3.0 fps/Depth > 0.7 feet/ Lift = 0.5 feet/ EDF = 5/ Pool Lengths >10 feet

Table 1a Velocity Values for each weir notch and station for all design flows

		49 cfs (Minimum)					138.5 cfs (Average)					304.3 cfs (Maximum)				
ID.	**Weir Length**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Step 1	56.0	2.51	1.47	0.00	0.00	0.00	2.75	2.45	0.86	0.00	0.00	3.42	2.97	2.75	0.00	0.00
Step 2	56.0	2.56	1.45	0.00	0.00	0.00	2.76	2.46	0.85	0.00	0.00	3.26	2.82	2.63	0.00	0.00
Step 3	63.0	2.48	1.33	0.00	0.00	0.00	2.58	2.31	0.48	0.00	0.00	2.93	2.54	2.37	0.00	0.00
Step 4	63.0	2.54	1.30	0.00	0.00	0.00	2.67	2.39	0.23	0.00	0.00	2.98	2.59	2.41	0.00	0.00
Step 5	63.0	2.55	1.30	0.00	0.00	0.00	2.70	2.42	0.00	0.00	0.00	3.00	2.61	2.44	0.00	0.00
Step 6	63.0	2.55	1.30	0.00	0.00	0.00	2.72	2.43	0.00	0.00	0.00	3.02	2.63	2.45	0.00	0.00
Step 7	63.0	2.55	1.30	0.00	0.00	0.00	2.72	2.44	0.00	0.00	0.00	3.03	2.63	2.46	0.00	0.00

Table 1b Water Depth for each weir notch and station for all design flows

		49 cfs (Minimum)					138.5 cfs (Average)					304.3 cfs (Maximum)				
ID.	**Weir Length**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Step 1	56.0	1.37	0.24	0.00	0.00	0.00	1.99	0.81	0.09	0.00	0.00	2.76	1.61	0.83	0.00	0.00
Step 2	56.0	1.36	0.23	0.00	0.00	0.00	1.99	0.81	0.09	0.00	0.00	2.86	1.70	0.92	0.00	0.00
Step 3	63.0	1.33	0.20	0.00	0.00	0.00	1.93	0.75	0.03	0.00	0.00	2.84	1.67	0.89	0.00	0.00
Step 4	63.0	1.32	0.19	0.00	0.00	0.00	1.90	0.72	0.01	0.00	0.00	2.81	1.64	0.86	0.00	0.00
Step 5	63.0	1.32	0.19	0.00	0.00	0.00	1.89	0.71	0.00	0.00	0.00	2.79	1.63	0.84	0.00	0.00
Step 6	63.0	1.32	0.19	0.00	0.00	0.00	1.88	0.70	0.00	0.00	0.00	2.78	1.62	0.83	0.00	0.00
Step 7	63.0	1.32	0.19	0.00	0.00	0.00	1.88	0.70	0.00	0.00	0.00	2.78	1.61	0.83	0.00	0.00

- within acceptable range- good fish passage
- on the fringe of acceptable range- moderate to questionable fish passage
- not acceptable range- unlikely for any fish passage
- no baseflow through weirs

Table 1c Pool Depth required for EDF at 5 lb/sft^2

Station 1	5.23	2.64	1.26		
Station 2	4.48	2.31	1.16		
Station 3	3.13	1.60	0.79		
Station 4	3.29	1.67	0.81		
Station 5	3.38	1.71	0.83		
Station 6	3.44	1.74	0.83		
Station 7	3.47	1.75	0.84		

Millbury Dam Step Pool Summary Table 2

Design Criteria: Velocities <3.0 fps/Depth > 0.7 feet/ Lift = 0.5 feet/
EDF = 5/ Pool Lengths >10 feet

Downstream		**49 cfs**			**138.5 cfs**			**304.3 cfs**		
	Weir No.	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Step 1	Weir Elevation	337.23	338.43	339.23	337.23	338.43	339.23	337.23	338.43	339.23
	Weir Length	10.00	42.00	4.00	10.00	42.00	4.00	10.00	42.00	4.00
	Depth	1.37	0.24	0.00	1.99	0.81	0.09	2.76	1.61	0.83
	Velocity	2.51	1.47	0.00	2.75	2.45	0.86	3.42	2.97	2.75
Step 2	Weir Elevation	337.73	338.93	339.73	337.73	338.93	339.73	337.73	338.93	339.73
	Weir Length	10.00	42.00	4.00	10.00	42.00	4.00	10.00	42.00	4.00
	Depth	1.36	0.23	0.00	1.99	0.81	0.09	2.86	1.70	0.92
	Velocity	2.56	1.45	0.00	2.76	2.46	0.85	3.42	2.97	2.75
Step 3	Weir Elevation	338.23	339.43	340.23	338.23	339.43	340.23	338.23	339.43	340.23
	Weir Length	11.00	48.00	4.00	11.00	48.00	4.00	11.00	48.00	4.00
	Depth	1.33	0.20	0.00	1.93	0.75	0.03	2.93	2.54	2.37
	Velocity	2.48	1.33	0.00	2.58	2.31	0.48	2.84	1.67	0.89
Step 4	Weir Elevation	338.73	339.93	340.73	338.73	339.93	340.73	338.73	339.93	340.73
	Weir Length	11.00	48.00	4.00	11.00	48.00	4.00	11.00	48.00	4.00
	Depth	1.32	0.19	0.00	1.90	0.72	0.01	2.81	1.64	0.86
	Velocity	2.54	1.30	0.00	2.67	2.39	0.23	2.98	2.59	2.41
Step 5	Weir Elevation	339.23	340.43	341.23	339.23	340.43	341.23	339.23	340.43	341.23
	Weir Length	11.00	48.00	4.00	11.00	48.00	4.00	11.00	48.00	4.00
	Depth	1.32	0.19	0.00	1.89	0.71	0.00	2.79	1.63	0.84
	Velocity	2.55	1.30	0.00	2.70	2.42	0.00	3.00	2.61	2.44
Step 6	Weir Elevation	339.73	340.93	341.73	339.73	340.93	341.73	339.73	340.93	341.73
	Weir Length	11.00	48.00	4.00	11.00	48.00	4.00	11.00	48.00	4.00
	Depth	1.32	0.19	0.00	1.88	0.70	0.00	2.78	1.62	0.83
	Velocity	2.55	1.30	0.00	2.72	2.43	0.00	3.02	2.63	2.45
Step 7	Weir Elevation	340.23	341.43	342.23	340.23	341.43	342.23	340.23	341.43	342.23
	Weir Length	11.00	48.00	4.00	11.00	48.00	4.00	11.00	48.00	4.00
	Depth	1.32	0.19	0.00	1.88	0.70	0.00	2.78	1.61	0.83
	Velocity	2.55	1.30	0.00	2.72	2.44	0.00	3.03	2.63	2.46
Upstream										

MILLBURY DAM				1/3/2001 (rev1 10/20/04)
Frequency:	10%		blue = input	KCI Technologies
TARGET Q:	49		orange = mu	CHH (KLH)
Tail Water elevation:	338.23	338.23	338.23	Assumed
WEIR STEP 1				
Weir elevation	337.2	338.4	339.2	Length Total
Weir length	10.0	42.0	4.0	56.00
C coefficient	2.7	2.5	0.0	
Tail Water (H2)	1.00	-0.20	-1.00	
Head Water (H1)	1.469	0.269	-0.531	
H2 / H1	0.681	-0.743	1.884	
Q / Q1	0.728	1.000	1.000	
Q1	47.26	14.60	0.00	Q Total
Q	34.40	14.60	0.00	49.00
$\Sigma = H_0 / (H_0 + L_w)$	0.42	0.08	-0.21	
Velocity	**2.51**	**1.47**	**0.00**	
H1	1.47	0.27	0.00	
	0.00	0.00	0.00	
Water depth	**1.37**	**0.24**	**0.00**	
Head Water Elev.	338.70	338.70	338.70	
WEIR STEP 2				
Weir elevation	337.7	338.9	339.7	Length Total
Weir length	10.0	42.0	4.0	56.00
C coefficient	2.7	2.5	0.0	
Tail Water (H2)	0.97	-0.23	-1.03	
Head Water (H1)	1.464	0.264	-0.536	
H2 / H1	0.662	-0.875	1.922	
Q / Q1	0.742	1.000	1.000	
Q1	46.98	14.13	0.00	Q Total
Q	34.87	14.13	0.00	49.00
$\Sigma = H_0 / (H_0 + L_w)$	0.42	0.08	-0.22	
Velocity	**2.56**	**1.45**	**0.00**	
H1	1.46	0.26	0.00	
	0.00	0.00	0.00	
Water depth	**1.36**	**0.23**	**0.00**	
Head Water Elev.	339.19	339.19	339.19	
WEIR STEP 3				
Weir elevation	338.2	339.4	340.2	Length Total
Weir length	11.0	48.0	4.0	63.00
C coefficient	2.6	2.5	0.0	
Tail Water (H2)	0.96	-0.24	-1.04	
Head Water (H1)	1.426	0.226	-0.574	
H2 / H1	0.676	-1.044	1.807	
Q / Q1	0.732	1.000	1.000	
Q1	49.57	12.71	0.00	Q Total
Q	36.29	12.71	0.00	49.00
$\Sigma = H_0 / (H_0 + L_w)$	0.59	0.18	-1.35	
Velocity	**2.48**	**1.33**	**0.00**	
H1	1.43	0.23	0.00	
	0.00	0.00	0.00	
Water depth	**1.33**	**0.20**	**0.00**	
Head Water Elev.	339.66	339.66	339.66	

MILLBURY DAM				1/3/2001 (rev1 10/20/04)
Frequency:	10%		blue = input	KCI Technologies
TARGET Q:	49		orange = mu	CHH (KLH)
Tail Water elevation:	338.23	338.23	338.23	Assumed
WEIR STEP 4				
Weir elevation	338.7	339.9	340.7	Length Total
Weir length	11.0	48.0	4.0	63.00
C coefficient	2.6	2.5	0.0	
Tail Water (H2)	0.93	-0.27	-1.07	
Head Water (H1)	1.420	0.220	-0.580	
H2 / H1	0.653	-1.245	1.850	
Q / Q1	0.749	1.000	1.000	
Q1	49.20	12.13	0.00	Q Total
Q	36.87	12.13	0.00	49.00
$\Sigma = H_0 / (H_0 + L_w)$	0.59	0.18	-1.38	
Velocity	**2.54**	**1.30**	**0.00**	
H1	1.42	0.22	0.00	
	0.00	0.00	0.00	
Water depth	**1.32**	**0.19**	**0.00**	
Head Water Elev.	340.15	340.15	340.15	
WEIR STEP 5				
Weir elevation	339.2	340.4	341.2	Length Total
Weir length	11.0	48.0	4.0	63.00
C coefficient	2.6	2.5	0.0	
Tail Water (H2)	0.92	-0.28	-1.08	
Head Water (H1)	1.418	0.218	-0.582	
H2 / H1	0.648	-1.283	1.858	
Q / Q1	0.753	1.000	1.000	
Q1	49.13	12.03	0.00	Q Total
Q	36.97	12.03	0.00	49.00
$\Sigma = H_0 / (H_0 + L_w)$	0.59	0.18	-1.39	
Velocity	**2.55**	**1.30**	**0.00**	
H1	1.42	0.22	0.00	
	0.00	0.00	0.00	
Water depth	**1.32**	**0.19**	**0.00**	
Head Water Elev.	340.65	340.65	340.65	
WEIR STEP 6				
Weir elevation	339.7	340.9	341.7	Length Total
Weir length	11.0	48.0	4.0	63.00
C coefficient	2.6	2.5	0.0	
Tail Water (H2)	0.92	-0.28	-1.08	
Head Water (H1)	1.418	0.218	-0.582	
H2 / H1	0.648	-1.290	1.859	
Q / Q1	0.753	1.000	1.000	
Q1	49.12	12.01	0.00	Q Total
Q	36.99	12.01	0.00	49.00
$\Sigma = H_0 / (H_0 + L_w)$	0.59	0.18	-1.39	
Velocity	**2.55**	**1.30**	**0.00**	
H1	1.42	0.22	0.00	
	0.00	0.00	0.00	
Water depth	**1.32**	**0.19**	**0.00**	
Head Water Elev.	341.15	341.15	341.15	

MILLBURY DAM				1/3/2001 (rev1 10/20/04)
Frequency:	**10%**		**blue = input**	KCI Technologies
TARGET Q:	**49**		**orange = mu**	CHH (KLH)
Tail Water elevation:	**338.23**	338.23	338.23	Assumed
WEIR STEP 7				
Weir elevation	**340.2**	**341.4**	**342.2**	Length Total
Weir length	**11.0**	**48.0**	**4.0**	**63.00**
C coefficient	2.6	2.5	0.0	
Tail Water (H2)	0.92	-0.28	-1.08	
Head Water (H1)	1.418	0.218	-0.582	
H2 / H1	0.647	-1.291	1.859	
Q / Q1	0.753	1.000	1.000	
Q1	49.12	12.00	0.00	Q Total
Q	37.00	12.00	0.00	**49.00**
$\Sigma = H_0 / (H_0 + L_w)$	0.59	0.18	-1.39	
Velocity	**2.55**	**1.30**	**0.00**	
H1	1.42	0.22	0.00	
	0.00	0.00	0.00	
Water depth	**1.32**	**0.19**	**0.00**	
Head Water Elev.	341.65	341.65	341.65	

MILLBURY DAM				1/3/2001 (rev1 10/20/04)
Frequency:	50%		blue = input	KCI Technologies
TARGET Q:	138.5		orange = mu	CHH (KLH)
Tail Water elevation:	338.84	338.84	338.84	Assumed
WEIR STEP 1				
Weir elevation	337.2	338.4	339.2	Length Total
Weir length	10.0	42.0	4.0	56.00
C coefficient	2.7	2.7	2.4	
Tail Water (H2)	1.61	0.41	-0.39	
Head Water (H1)	2.105	0.905	0.105	
H2 / H1	0.765	0.453	-3.726	
Q / Q1	0.653	0.869	1.000	
Q1	83.63	96.11	0.32	Q Total
Q	54.63	83.55	0.32	138.50
$\Sigma = H_0 / (H_0 + L_w)$	0.51	0.23	0.03	
Velocity	**2.75**	**2.45**	**0.86**	
H1	2.11	0.90	0.10	
	0.00	0.00	0.00	
Water depth	**1.99**	**0.81**	**0.09**	
Head Water Elev.	339.33	339.33	339.33	
WEIR STEP 2				
Weir elevation	337.7	338.9	339.7	Length Total
Weir length	10.0	42.0	4.0	56.00
C coefficient	2.7	2.7	2.4	
Tail Water (H2)	1.60	0.40	-0.40	
Head Water (H1)	2.103	0.903	0.103	
H2 / H1	0.763	0.448	-3.853	
Q / Q1	0.655	0.872	1.000	
Q1	83.49	95.79	0.31	Q Total
Q	54.69	83.49	0.31	138.50
$\Sigma = H_0 / (H_0 + L_w)$	0.51	0.23	0.03	
Velocity	**2.76**	**2.46**	**0.85**	
H1	2.10	0.90	0.10	
	0.00	0.00	0.00	
Water depth	**1.99**	**0.81**	**0.09**	
Head Water Elev.	339.83	339.83	339.83	
WEIR STEP 3				
Weir elevation	338.2	339.4	340.2	Length Total
Weir length	11.0	48.0	4.0	63.00
C coefficient	2.7	2.7	2.3	
Tail Water (H2)	1.60	0.40	-0.40	
Head Water (H1)	2.035	0.835	0.035	
H2 / H1	0.787	0.482	-11.203	
Q / Q1	0.630	0.855	1.000	
Q1	87.09	97.74	0.06	Q Total
Q	54.88	83.56	0.06	138.50
$\Sigma = H_0 / (H_0 + L_w)$	0.67	0.46	0.03	
Velocity	**2.58**	**2.31**	**0.48**	
H1	2.04	0.84	0.04	
	0.00	0.00	0.00	
Water depth	**1.93**	**0.75**	**0.03**	
Head Water Elev.	340.27	340.27	340.27	

MILLBURY DAM				1/3/2001 (rev1 10/20/04)
Frequency:	50%		blue = input	KCI Technologies
TARGET Q:	138.5		orange = mu	CHH (KLH)
Tail Water elevation:	338.84	338.84	338.84	Assumed
WEIR STEP 4				
Weir elevation	338.7	339.9	340.7	Length Total
Weir length	11.0	48.0	4.0	63.00
C coefficient	2.7	2.7	2.3	
Tail Water (H2)	1.54	0.34	-0.46	
Head Water (H1)	2.009	0.809	0.009	
H2 / H1	0.764	0.415	-50.994	
Q / Q1	0.654	0.887	1.000	
Q1	85.26	93.24	0.01	Q Total
Q	55.76	82.73	0.01	138.50
$\Sigma = H_0 / (H_0 + L_w)$	0.67	0.45	0.01	
Velocity	**2.67**	**2.39**	**0.23**	
H1	2.01	0.81	0.01	
	0.00	0.00	0.00	
Water depth	**1.90**	**0.72**	**0.01**	
Head Water Elev.	340.74	340.74	340.74	
WEIR STEP 5				
Weir elevation	339.2	340.4	341.2	Length Total
Weir length	11.0	48.0	4.0	63.00
C coefficient	2.7	2.7	0.0	
Tail Water (H2)	1.51	0.31	-0.49	
Head Water (H1)	1.999	0.799	-0.001	
H2 / H1	0.755	0.387	805.411	
Q / Q1	0.663	0.900	1.000	
Q1	84.58	91.60	0.00	Q Total
Q	56.10	82.40	0.00	138.50
$\Sigma = H_0 / (H_0 + L_w)$	0.67	0.44	0.00	
Velocity	**2.70**	**2.42**	**0.00**	
H1	2.00	0.80	0.00	
	0.00	0.00	0.00	
Water depth	**1.89**	**0.71**	**0.00**	
Head Water Elev.	341.23	341.23	341.23	
WEIR STEP 6				
Weir elevation	339.7	340.9	341.7	Length Total
Weir length	11.0	48.0	4.0	63.00
C coefficient	2.7	2.7	0.0	
Tail Water (H2)	1.50	0.30	-0.50	
Head Water (H1)	1.996	0.796	-0.004	
H2 / H1	0.751	0.376	122.645	
Q / Q1	0.667	0.904	1.000	
Q1	84.34	91.01	0.00	Q Total
Q	56.23	82.27	0.00	138.50
$\Sigma = H_0 / (H_0 + L_w)$	0.67	0.44	0.00	
Velocity	**2.72**	**2.43**	**0.00**	
H1	2.00	0.80	0.00	
	0.00	0.00	0.00	
Water depth	**1.88**	**0.70**	**0.00**	
Head Water Elev.	341.73	341.73	341.73	

MILLBURY DAM				1/3/2001 (rev1 10/20/04)
Frequency:	**50%**		**blue = input**	KCI Technologies
TARGET Q:	**138.5**		**orange = mu**	CHH (KLH)
Tail Water elevation:	**338.84**	338.84	338.84	Assumed
WEIR STEP 7				
Weir elevation	**340.2**	**341.4**	**342.2**	Length Total
Weir length	**11.0**	**48.0**	**4.0**	**63.00**
C coefficient	2.7	2.7	0.0	
Tail Water (H2)	1.50	0.30	-0.50	
Head Water (H1)	1.995	0.795	-0.005	
H2 / H1	0.750	0.372	94.935	
Q / Q1	0.668	0.906	1.000	
Q1	84.26	90.80	0.00	Q Total
Q	56.28	82.22	0.00	**138.50**
$\Sigma = H_0 / (H_0 + L_w)$	0.67	0.44	-0.01	
Velocity	**2.72**	**2.44**	**0.00**	
H1	2.00	0.79	0.00	
	0.00	0.00	0.00	
Water depth	**1.88**	**0.70**	**0.00**	
Head Water Elev.	342.22	342.22	342.22	

MILLBURY DAM				1/3/2001 (rev1 10/20/04)
	90%		**blue = input**	KCI Technologies
TARGET Q:	**304.3**		**orange = mu**	CHH (KLH)
Tail Water elevation:	**339.51**	339.51	339.51	Assumed
WEIR STEP 1				
Weir elevation	**337.2**	**338.4**	**339.2**	Length Total
Weir length	**10.0**	**42.0**	**4.0**	56.00
C coefficient	2.9	2.7	2.7	
Tail Water (H2)	2.28	1.08	0.28	
Head Water (H1)	2.945	1.745	0.945	
H2 / H1	0.774	0.619	0.296	
Q / Q1	0.644	0.773	0.934	
Q1	146.93	259.38	9.75	Q Total
Q	94.60	200.59	9.11	**304.30**
$\Sigma = H_0 / (H_0 + L_w)$	0.60	0.37	0.24	
Velocity	**3.42**	**2.97**	**2.75**	
H1	2.94	1.75	0.95	
	0.00	0.00	0.00	
Water depth	**2.76**	**1.61**	**0.83**	
Head Water Elev.	340.17	340.17	340.17	
WEIR STEP 2				
Weir elevation	**337.7**	**338.9**	**339.7**	Length Total
Weir length	**10.0**	**42.0**	**4.0**	56.00
C coefficient	2.9	2.7	2.6	
Tail Water (H2)	2.44	1.24	0.44	
Head Water (H1)	3.023	1.823	1.023	
H2 / H1	0.809	0.683	0.435	
Q / Q1	0.606	0.726	0.878	
Q1	153.58	277.49	10.96	Q Total
Q	93.13	201.54	9.62	**304.30**
$\Sigma = H_0 / (H_0 + L_w)$	0.60	0.38	0.25	
Velocity	**3.26**	**2.82**	**2.63**	
H1	3.02	1.82	1.02	
	0.00	0.00	0.00	
Water depth	**2.86**	**1.70**	**0.92**	
Head Water Elev.	340.75	340.75	340.75	
WEIR STEP 3				
Weir elevation	**338.2**	**339.4**	**340.2**	Length Total
Weir length	**11.0**	**48.0**	**4.0**	63.00
C coefficient	2.9	2.7	2.7	
Tail Water (H2)	2.52	1.32	0.52	
Head Water (H1)	2.974	1.774	0.974	
H2 / H1	0.848	0.746	0.537	
Q / Q1	0.557	0.672	0.825	
Q1	164.43	303.99	10.20	Q Total
Q	91.59	204.29	8.42	**304.30**
$\Sigma = H_0 / (H_0 + L_w)$	0.75	0.64	0.49	
Velocity	**2.93**	**2.54**	**2.37**	
H1	2.97	1.77	0.97	
	0.00	0.00	0.00	
Water depth	**2.84**	**1.67**	**0.89**	
Head Water Elev.	341.20	341.20	341.20	

MILLBURY DAM				1/3/2001 (rev1 10/20/04)
	90%		blue = input	KCI Technologies
TARGET Q:	304.3		orange = mu	CHH (KLH)
Tail Water elevation:	339.51	339.51	339.51	Assumed
WEIR STEP 4				
Weir elevation	338.7	339.9	340.7	Length Total
Weir length	11.0	48.0	4.0	63.00
C coefficient	2.9	2.7	2.7	
Tail Water (H2)	2.47	1.27	0.47	
Head Water (H1)	2.947	1.747	0.947	
H2 / H1	0.840	0.729	0.501	
Q / Q1	0.569	0.687	0.845	
Q1	161.83	297.00	9.79	Q Total
Q	92.01	204.02	8.27	304.30
$\Sigma = H_0 / (H_0 + L_w)$	0.75	0.64	0.49	
Velocity	**2.98**	**2.59**	**2.41**	
H1	2.95	1.75	0.95	
	0.00	0.00	0.00	
Water depth	**2.81**	**1.64**	**0.86**	
Head Water Elev.	341.68	341.68	341.68	
WEIR STEP 5				
Weir elevation	339.2	340.4	341.2	Length Total
Weir length	11.0	48.0	4.0	63.00
C coefficient	2.9	2.7	2.7	
Tail Water (H2)	2.45	1.25	0.45	
Head Water (H1)	2.932	1.732	0.932	
H2 / H1	0.835	0.720	0.480	
Q / Q1	0.575	0.695	0.856	
Q1	160.42	293.19	9.56	Q Total
Q	92.25	203.87	8.18	304.30
$\Sigma = H_0 / (H_0 + L_w)$	0.75	0.63	0.48	
Velocity	**3.00**	**2.61**	**2.44**	
H1	2.93	1.73	0.93	
	0.00	0.00	0.00	
Water depth	**2.79**	**1.63**	**0.84**	
Head Water Elev.	342.16	342.16	342.16	
WEIR STEP 6				
Weir elevation	339.7	340.9	341.7	Length Total
Weir length	11.0	48.0	4.0	63.00
C coefficient	2.9	2.7	2.7	
Tail Water (H2)	2.43	1.23	0.43	
Head Water (H1)	2.924	1.724	0.924	
H2 / H1	0.832	0.715	0.468	
Q / Q1	0.579	0.700	0.862	
Q1	159.66	291.14	9.44	Q Total
Q	92.38	203.78	8.14	304.30
$\Sigma = H_0 / (H_0 + L_w)$	0.75	0.63	0.48	
Velocity	**3.02**	**2.63**	**2.45**	
H1	2.92	1.72	0.92	
	0.00	0.00	0.00	
Water depth	**2.78**	**1.62**	**0.83**	
Head Water Elev.	342.65	342.65	342.65	

MILLBURY DAM				1/3/2001 (rev1 10/20/04)
	90%		**blue = input**	KCI Technologies
TARGET Q:	**304.3**		**orange = mu**	CHH (KLH)
Tail Water elevation:	**339.51**	339.51	339.51	Assumed
WEIR STEP 7				
Weir elevation	**340.2**	**341.4**	**342.2**	Length Total
Weir length	**11.0**	**48.0**	**4.0**	**63.00**
C coefficient	2.9	2.7	2.7	
Tail Water (H2)	2.42	1.22	0.42	
Head Water (H1)	2.919	1.719	0.919	
H2 / H1	0.830	0.712	0.461	
Q / Q1	0.581	0.702	0.865	
Q1	159.25	290.04	9.37	Q Total
Q	92.45	203.74	8.11	**304.30**
$\Sigma = H_0 / (H_0 + L_w)$	0.74	0.63	0.48	
Velocity	**3.03**	**2.63**	**2.46**	
H1	2.92	1.72	0.92	
	0.00	0.00	0.00	
Water depth	**2.78**	**1.61**	**0.83**	
Head Water Elev.	343.15	343.15	343.15	

MILLBURY DAM			
Frequency:	90%		
TARGET Q:	304.3		
Tail Water elevation:	339.51	339.51	339.51
WEIR STEP 1			
Weir elevation	337.23	338.43	339.23
Weir length	10	42	4
Q	94.60	200.59	9.11
Velocity	3.42	2.97	2.75
Water depth	2.76	1.61	0.83
Head Water Elev.	340.17	340.17	340.17
Allowable EDF	5	5	5
Drop	0.665	0.665	0.665
Length Max	10	10	10
Width (1.5 x Weir)	15	63	6
Design Depth	5.23	2.64	1.26
Downstream Elev.	334.28	336.87	338.25
WEIR STEP 2			
Weir elevation	337.73	338.93	339.73
Weir length	10	42	4
Q	93.13	201.54	9.62
Velocity	3.26	2.82	2.63
Water depth	2.86	1.70	0.92
Head Water Elev.	340.75	340.75	340.75
Allowable EDF	5	5	5
Drop	0.578	0.578	0.578
Length Max	10	10	10
Width (1.5 x Weir)	15	63	6
Design Depth	4.48	2.31	1.16
Downstream Elev.	335.69	337.87	339.02
WEIR STEP 3			
Weir elevation	338.23	339.43	340.23
Weir length	11	48	4
Q	91.59	204.29	8.42
Velocity	2.93	2.54	2.37
Water depth	2.84	1.67	0.89
Head Water Elev.	341.20	341.20	341.20
Allowable EDF	5	5	5
Drop	0.451	0.451	0.451
Length Max	10	10	10
Width (1.5 x Weir)	16.5	72	6
Design Depth	3.13	1.60	0.79
Downstream Elev.	337.63	339.15	339.96

WEIR STEP 4			
Weir elevation	338.73	339.93	340.73
Weir length	11.00	48.00	4.00
Q	92.01	204.02	8.27
Velocity	2.98	2.59	2.41
Water depth	2.81	1.64	0.86
Head Water Elev.	341.68	341.68	341.68
Allowable EDF	5	5	5
Drop	0.473	0.473	0.473
Length Max	10	10	10
Width (1.5 x Weir)	16.5	72	6
Design Depth	3.29	1.67	0.81
Downstream Elev.	337.91	339.53	340.39
WEIR STEP 5			
Weir elevation	339.23	340.43	341.23
Weir length	11.00	48.00	4.00
Q	92.25	203.87	8.18
Velocity	3.00	2.61	2.44
Water depth	2.79	1.63	0.84
Head Water Elev.	342.16	342.16	342.16
Allowable EDF	5	5	5
Drop	0.485	0.485	0.485
Length Max	10	10	10
Width (1.5 x Weir)	16.5	72	6
Design Depth	3.38	1.71	0.83
Downstream Elev.	338.29	339.96	340.85
WEIR STEP 6			
Weir elevation	339.73	340.93	341.73
Weir length	11.00	48.00	4.00
Q	92.38	203.78	8.14
Velocity	3.02	2.63	2.45
Water depth	2.78	1.62	0.83
Head Water Elev.	342.65	342.65	342.65
Allowable EDF	5	5	5
Drop	0.492	0.492	0.492
Length Max	10	10	10
Width (1.5 x Weir)	16.5	72	6
Design Depth	3.44	1.74	0.83
Downstream Elev.	338.72	340.42	341.33

WEIR STEP 7			
Weir elevation	340.23	341.43	342.23
Weir length	11.00	48.00	4.00
Q	92.45	203.74	8.11
Velocity	3.03	2.63	2.46
Water depth	2.78	1.61	0.83
Head Water Elev.	343.15	343.15	343.15
Allowable EDF	5	5	5
Drop	0.496	0.496	0.496
Length Max	10	10	10
Width (1.5 x Weir)	16.5	72	6
Design Depth	3.47	1.75	0.84
Downstream Elev.	339.19	340.90	341.82

APPENDIX F

SEDIMENT QUALITY DATA

Environmental Laboratories, Inc.
587 East Middle Turnpike, P.O.Box 370, Manchester, CT 06040
Tel. (860) 645-1102 Fax (860) 645-0823

Analysis Report

January 02, 2007

FOR: Attn: Mr. John Zahner
Fuss & O'Neill, Inc.
146 Hartford Road
Manchester, CT 06040

Sample Information		Custody Information		Date	Time
Matrix:	SOIL	Collected by:	JZ	12/19/06	9:30
Location Code:	F&O	Received by:	LB	12/20/06	12:01
Rush Request:		Analyzed by:	see "By" below		
P.O.#:					

SDG I.D.: GAH78837
Phoenix I.D.: AH78837

Laboratory Data

Client ID: MILLBURY DAM 748061219-01

Parameter	Result	RL	Units	Date	Time	By	Reference
Silver	0.679	0.5	mg/Kg	12/21/06		EKT	SW6010
Arsenic	57.9	1	mg/Kg	12/21/06		EKT	SW6010
Barium	251	0.5	mg/Kg	12/21/06		EKT	SW6010
Cadmium	3.33	0.5	mg/Kg	12/21/06		EKT	SW6010
Chromium	140	0.5	mg/Kg	12/21/06		EKT	SW6010
Copper	2480	5	mg/Kg	12/22/06		EK	SW6010
Mercury - Soil	4.30	0.50	mg/kg	12/21/06		RS	SW-7471
Nickel	26.8	0.5	mg/Kg	12/21/06		EKT	SW6010
Lead	447	0.5	mg/Kg	12/21/06		EKT	SW6010
Selenium	< 2.5	2.5	mg/Kg	12/21/06		EKT	SW6010
Vanadium	27.3	0.5	mg/Kg	12/21/06		EKT	6010
Zinc	1170	5	mg/Kg	12/22/06		EK	SW6010
Percent Solid	50		%	12/20/06		C/D	E160.3
pH	7.12	0.10	pH Units	12/20/06	23:00	CD	E150.1/SW9045
Tot.Org.Carbon	28000	100	mg/kg	12/27/06		JL	EPA Kahn 6/99
Mercury Digestion	Completed			12/21/06		D	SW7471
Soil Extraction for PCB	Completed			12/20/06		CJCS/E	SW3545
Soil Ext. Semi-Vol BN	Completed			12/20/06		CJCS/E	SW3545
Total Metals Digest	Completed			12/20/06		AG	SW846 - 3050
Tot.Org.Carbon Preparation	Completed			12/20/06		D	
Polychlorinated Biphenyls							
PCB-1016	ND	780	ug/Kg	12/21/06		MH	SW 8082
PCB-1221	ND	780	ug/Kg	12/21/06		MH	SW 8082
PCB-1232	ND	780	ug/Kg	12/21/06		MH	SW 8082

Parameter	Result	RL	Units	Date	Time	By	Reference
PCB-1242	ND	780	ug/Kg	12/21/06		MH	SW 8082
PCB-1248	ND	780	ug/Kg	12/21/06		MH	SW 8082
PCB-1254	ND	780	ug/Kg	12/21/06		MH	SW 8082
PCB-1260	ND	780	ug/Kg	12/21/06		MH	SW 8082
PCB-1262	ND	780	ug/Kg	12/21/06		MH	SW 8082
PCB-1268	ND	780	ug/Kg	12/21/06		MH	SW 8082
QA/QC Surrogates							
% DCBP (Surrogate Rec)	75		%	12/21/06		MH	SW 8082
% TCMX (Surrogate Rec)	82		%	12/21/06		MH	SW 8082

Polynuclear Aromatic HC

2-Methylnaphthalene	820	660	ug/Kg	12/24/06		HM	SW 8270
Acenaphthene	780	660	ug/Kg	12/24/06		HM	SW 8270
Acenaphthylene	ND	660	ug/Kg	12/24/06		HM	SW 8270
Anthracene	1000	660	ug/Kg	12/24/06		HM	SW 8270
Benz(a)anthracene	1800	660	ug/Kg	12/24/06		HM	SW 8270
Benzo(a)pyrene	1500	660	ug/Kg	12/24/06		HM	SW 8270
Benzo(b)fluoranthene	1300	660	ug/Kg	12/24/06		HM	SW 8270
Benzo(ghi)perylene	1100	660	ug/Kg	12/24/06		HM	SW 8270
Benzo(k)fluoranthene	ND	660	ug/Kg	12/24/06		HM	SW 8270
Chrysene	1800	660	ug/Kg	12/24/06		HM	SW 8270
Dibenz(a,h)anthracene	ND	660	ug/Kg	12/24/06		HM	SW 8270
Fluoranthene	2200	660	ug/Kg	12/24/06		HM	SW 8270
Fluorene	ND	660	ug/Kg	12/24/06		HM	SW 8270
Indeno(1,2,3-cd)pyrene	770	660	ug/Kg	12/24/06		HM	SW 8270
Naphthalene	1900	660	ug/Kg	12/24/06		HM	SW 8270
Phenanthrene	3300	660	ug/Kg	12/24/06		HM	SW 8270
Pyrene	3200	660	ug/Kg	12/24/06		HM	SW 8270
QA/QC Surrogates							
% 2-Fluorobiphenyl	45		%	12/24/06		HM	SW 8270
% Nitrobenzene-d5	*NR		%	12/24/06		HM	SW 8270
% Terphenyl-d14	31		%	12/24/06		HM	SW 8270

Comments:

* Poor surrogate recovery was observed. The other surrogates associated with this sample were within QA/QC criteria. No further action was necessary.

If there are any questions regarding this data, please call Phoenix Client Services at extension 200.

ND=Not detected BDL=Below Detection Limit RL=Reporting Limit

Phyllis Shiller, Laboratory Director
January 02, 2007

PHOENIX
Environmental Laboratories, Inc.
587 East Middle Turnpike, P.O.Box 370, Manchester, CT 06040
Tel. (860) 645-1102 Fax (860) 645-0823

Analysis Report

January 02, 2007

FOR: Attn: Mr. John Zahner
Fuss & O'Neill, Inc.
146 Hartford Road
Manchester, CT 06040

Sample Information		Custody Information		Date	Time
Matrix:	SOIL	Collected by:	JZ	12/19/06	9:45
Location Code:	F&O	Received by:	LB	12/20/06	12:01
Rush Request:		Analyzed by:	see "By" below		
P.O.#:					

SDG I.D.: GAH78837
Phoenix I.D.: AH78838

Laboratory Data

Client ID: MILLBURY DAM 748061219-02

Parameter	Result	RL	Units	Date	Time	By	Reference
Silver	< 0.5	0.5	mg/Kg	12/21/06		EKT	SW6010
Arsenic	15.8	1	mg/Kg	12/21/06		EKT	SW6010
Barium	51.3	0.5	mg/Kg	12/21/06		EKT	SW6010
Cadmium	0.507	0.5	mg/Kg	12/21/06		EKT	SW6010
Chromium	49.2	0.5	mg/Kg	12/21/06		EKT	SW6010
Copper	91.4	0.5	mg/Kg	12/21/06		EKT	SW6010
Mercury - Soil	1.29	0.10	mg/kg	12/21/06		RS	SW-7471
Nickel	11.6	0.5	mg/Kg	12/21/06		EKT	SW6010
Lead	112	0.5	mg/Kg	12/21/06		EKT	SW6010
Selenium	< 2.5	2.5	mg/Kg	12/21/06		EKT	SW6010
Vanadium	13.2	0.5	mg/Kg	12/21/06		EKT	6010
Zinc	134	0.5	mg/Kg	12/21/06		EKT	SW6010
Percent Solid	60		%	12/20/06		C/D	E160.3
pH	7.14	0.10	pH Units	12/20/06	23:00	CD	E150.1/SW9045
Tot.Org.Carbon	25000	100	mg/kg	12/27/06		JL	EPA Kahn 6/99
Mercury Digestion	Completed			12/21/06		D	SW7471
Soil Extraction for PCB	Completed			12/20/06		CJCS/E	SW3545
Soil Ext. Semi-Vol BN	Completed			12/20/06		CJCS/E	SW3545
Total Metals Digest	Completed			12/20/06		AG	SW846 - 3050
Tot.Org.Carbon Preparation	Completed			12/20/06		D	
Polychlorinated Biphenyls							
PCB-1016	ND	650	ug/Kg	12/21/06		MH	SW 8082
PCB-1221	ND	650	ug/Kg	12/21/06		MH	SW 8082
PCB-1232	ND	650	ug/Kg	12/21/06		MH	SW 8082

Parameter	Result	RL	Units	Date	Time	By	Reference
PCB-1242	ND	650	ug/Kg	12/21/06		MH	SW 8082
PCB-1248	ND	650	ug/Kg	12/21/06		MH	SW 8082
PCB-1254	ND	650	ug/Kg	12/21/06		MH	SW 8082
PCB-1260	ND	650	ug/Kg	12/21/06		MH	SW 8082
PCB-1262	ND	650	ug/Kg	12/21/06		MH	SW 8082
PCB-1268	ND	650	ug/Kg	12/21/06		MH	SW 8082
QA/QC Surrogates							
% DCBP (Surrogate Rec)	63		%	12/21/06		MH	SW 8082
% TCMX (Surrogate Rec)	83		%	12/21/06		MH	SW 8082

Polynuclear Aromatic HC

2-Methylnaphthalene	ND	550	ug/Kg	12/24/06		HM	SW 8270
Acenaphthene	890	550	ug/Kg	12/24/06		HM	SW 8270
Acenaphthylene	ND	550	ug/Kg	12/24/06		HM	SW 8270
Anthracene	1000	550	ug/Kg	12/24/06		HM	SW 8270
Benz(a)anthracene	1400	550	ug/Kg	12/24/06		HM	SW 8270
Benzo(a)pyrene	900	550	ug/Kg	12/24/06		HM	SW 8270
Benzo(b)fluoranthene	1100	550	ug/Kg	12/24/06		HM	SW 8270
Benzo(ghi)perylene	ND	550	ug/Kg	12/24/06		HM	SW 8270
Benzo(k)fluoranthene	ND	550	ug/Kg	12/24/06		HM	SW 8270
Chrysene	1300	550	ug/Kg	12/24/06		HM	SW 8270
Dibenz(a,h)anthracene	ND	550	ug/Kg	12/24/06		HM	SW 8270
Fluoranthene	2600	550	ug/Kg	12/24/06		HM	SW 8270
Fluorene	900	550	ug/Kg	12/24/06		HM	SW 8270
Indeno(1,2,3-cd)pyrene	ND	550	ug/Kg	12/24/06		HM	SW 8270
Naphthalene	1400	550	ug/Kg	12/24/06		HM	SW 8270
Phenanthrene	3700	550	ug/Kg	12/24/06		HM	SW 8270
Pyrene	2100	550	ug/Kg	12/24/06		HM	SW 8270
QA/QC Surrogates							
% 2-Fluorobiphenyl	61		%	12/24/06		HM	SW 8270
% Nitrobenzene-d5	74		%	12/24/06		HM	SW 8270
% Terphenyl-d14	44		%	12/24/06		HM	SW 8270

Comments:

If there are any questions regarding this data, please call Phoenix Client Services at extension 200.
ND=Not detected BDL=Below Detection Limit RL=Reporting Limit

Phyllis Shiller, Laboratory Director
January 02, 2007

PHOENIX
Environmental Laboratories, Inc.
587 East Middle Turnpike, P.O.Box 370, Manchester, CT 06040
Tel. (860) 645-1102 Fax (860) 645-0823

Analysis Report

January 02, 2007

FOR: Attn: Mr. John Zahner
Fuss & O'Neill, Inc.
146 Hartford Road
Manchester, CT 06040

Sample Information		Custody Information		Date	Time
Matrix:	SOIL	Collected by:	JZ	12/19/06	10:30
Location Code:	F&O	Received by:	LB	12/20/06	12:01
Rush Request:		Analyzed by:	see "By" below		
P.O.#:					

SDG I.D.: GAH78837
Phoenix I.D.: AH78839

Laboratory Data

Client ID: MILLBURY DAM 748061219-03

Parameter	Result	RL	Units	Date	Time	By	Reference
Silver	< 0.5	0.5	mg/Kg	12/21/06		EKT	SW6010
Arsenic	45.6	1	mg/Kg	12/21/06		EKT	SW6010
Barium	120	0.5	mg/Kg	12/21/06		EKT	SW6010
Cadmium	1.99	0.5	mg/Kg	12/21/06		EKT	SW6010
Chromium	92.1	0.5	mg/Kg	12/21/06		EKT	SW6010
Copper	2400	5.0	mg/Kg	12/29/06		LK	SW6010
Mercury - Soil	2.80	0.10	mg/kg	12/21/06		RS	SW-7471
Nickel	18.4	0.5	mg/Kg	12/21/06		EKT	SW6010
Lead	356	0.5	mg/Kg	12/21/06		EKT	SW6010
Selenium	< 2.5	2.5	mg/Kg	12/21/06		EKT	SW6010
Vanadium	20.5	0.5	mg/Kg	12/21/06		EKT	6010
Zinc	519	0.5	mg/Kg	12/21/06		EKT	SW6010
Percent Solid	55		%	12/20/06		C/D	E160.3
pH	6.94	0.10	pH Units	12/20/06	23:00	CD	E150.1/SW9045
Tot.Org.Carbon	20000	100	mg/kg	12/27/06		JL	EPA Kahn 6/99
Mercury Digestion	Completed			12/21/06		D	SW7471
Soil Extraction for PCB	Completed			12/20/06		CJCS/E	SW3545
Soil Ext. Semi-Vol BN	Completed			12/20/06		CJCS/E	SW3545
Total Metals Digest	Completed			12/20/06		AG	SW846 - 3050
Tot.Org.Carbon Preparation	Completed			12/20/06		D	
Polychlorinated Biphenyls							
PCB-1016	ND	720	ug/Kg	12/21/06		MH	SW 8082
PCB-1221	ND	720	ug/Kg	12/21/06		MH	SW 8082
PCB-1232	ND	720	ug/Kg	12/21/06		MH	SW 8082

Parameter	Result	RL	Units	Date	Time	By	Reference
PCB-1242	ND	720	ug/Kg	12/21/06		MH	SW 8082
PCB-1248	ND	720	ug/Kg	12/21/06		MH	SW 8082
PCB-1254	ND	720	ug/Kg	12/21/06		MH	SW 8082
PCB-1260	ND	720	ug/Kg	12/21/06		MH	SW 8082
PCB-1262	ND	720	ug/Kg	12/21/06		MH	SW 8082
PCB-1268	ND	720	ug/Kg	12/21/06		MH	SW 8082
QA/QC Surrogates							
% DCBP (Surrogate Rec)	46		%	12/21/06		MH	SW 8082
% TCMX (Surrogate Rec)	39		%	12/21/06		MH	SW 8082

Polynuclear Aromatic HC

2-Methylnaphthalene	1800	600	ug/Kg	12/21/06		HM	SW 8270
Acenaphthene	1400	600	ug/Kg	12/21/06		HM	SW 8270
Acenaphthylene	720	600	ug/Kg	12/21/06		HM	SW 8270
Anthracene	3300	600	ug/Kg	12/21/06		HM	SW 8270
Benz(a)anthracene	5000	600	ug/Kg	12/21/06		HM	SW 8270
Benzo(a)pyrene	3800	600	ug/Kg	12/21/06		HM	SW 8270
Benzo(b)fluoranthene	3300	600	ug/Kg	12/21/06		HM	SW 8270
Benzo(ghi)perylene	2200	600	ug/Kg	12/21/06		HM	SW 8270
Benzo(k)fluoranthene	1100	600	ug/Kg	12/21/06		HM	SW 8270
Chrysene	5000	600	ug/Kg	12/21/06		HM	SW 8270
Dibenz(a,h)anthracene	ND	600	ug/Kg	12/21/06		HM	SW 8270
Fluoranthene	5500	600	ug/Kg	12/21/06		HM	SW 8270
Fluorene	1500	600	ug/Kg	12/21/06		HM	SW 8270
Indeno(1,2,3-cd)pyrene	1800	600	ug/Kg	12/21/06		HM	SW 8270
Naphthalene	2800	600	ug/Kg	12/21/06		HM	SW 8270
Phenanthrene	9200	600	ug/Kg	12/21/06		HM	SW 8270
Pyrene	7500	600	ug/Kg	12/21/06		HM	SW 8270
QA/QC Surrogates							
% 2-Fluorobiphenyl	56		%	12/21/06		HM	SW 8270
% Nitrobenzene-d5	52		%	12/21/06		HM	SW 8270
% Terphenyl-d14	53		%	12/21/06		HM	SW 8270

Comments:

If there are any questions regarding this data, please call Phoenix Client Services at extension 200.
ND=Not detected BDL=Below Detection Limit RL=Reporting Limit

Phyllis Shiller, Laboratory Director
January 02, 2007

PHOENIX
Environmental Laboratories, Inc.
587 East Middle Turnpike, P.O.Box 370, Manchester, CT 06040
Tel. (860) 645-1102 Fax (860) 645-0823

Analysis Report

January 02, 2007

FOR: Attn: Mr. John Zahner
Fuss & O'Neill, Inc.
146 Hartford Road
Manchester, CT 06040

Sample Information		Custody Information		Date	Time
Matrix:	SOIL	Collected by:	JZ	12/19/06	11:00
Location Code:	F&O	Received by:	LB	12/20/06	12:01
Rush Request:		Analyzed by:	see "By" below		
P.O.#:					

SDG I.D.: GAH78837
Phoenix I.D.: AH78840

Laboratory Data

Client ID: MILLBURY DAM 748061219-04

Parameter	Result	RL	Units	Date	Time	By	Reference
Silver	1.18	0.5	mg/Kg	12/21/06		EKT	SW6010
Arsenic	71.6	1	mg/Kg	12/21/06		EKT	SW6010
Barium	169	0.5	mg/Kg	12/21/06		EKT	SW6010
Cadmium	2.77	0.5	mg/Kg	12/21/06		EKT	SW6010
Chromium	94	0.5	mg/Kg	12/21/06		EKT	SW6010
Copper	3730	10.0	mg/Kg	12/29/06		TH	SW6010
Mercury - Soil	3.46	0.50	mg/kg	12/21/06		RS	SW-7471
Nickel	28	0.5	mg/Kg	12/21/06		EKT	SW6010
Lead	822	0.5	mg/Kg	12/21/06		EKT	SW6010
Selenium	< 2.5	2.5	mg/Kg	12/21/06		EKT	SW6010
Vanadium	28	0.5	mg/Kg	12/21/06		EKT	6010
Zinc	702	0.5	mg/Kg	12/21/06		EKT	SW6010
Percent Solid	56		%	12/20/06		C/D	E160.3
pH	6.06	0.10	pH Units	12/20/06	23:00	CD	E150.1/SW9045
Tot.Org.Carbon	42000	100	mg/kg	12/27/06		JL	EPA Kahn 6/99
Mercury Digestion	Completed			12/21/06		D	SW7471
Soil Extraction for PCB	Completed			12/20/06		CJCS/E	SW3545
Soil Ext. Semi-Vol BN	Completed			12/20/06		CJCS/E	SW3545
Total Metals Digest	Completed			12/20/06		AG	SW846 - 3050
Tot.Org.Carbon Preparation	Completed			12/20/06		D	
Polychlorinated Biphenyls							
PCB-1016	ND	700	ug/Kg	12/21/06		MH	SW 8082
PCB-1221	ND	700	ug/Kg	12/21/06		MH	SW 8082
PCB-1232	ND	700	ug/Kg	12/21/06		MH	SW 8082

Client ID: MILLBURY DAM 748061219-04 Phoenix I.D.: AH78840

Parameter	Result	RL	Units	Date	Time	By	Reference
PCB-1242	ND	700	ug/Kg	12/21/06		MH	SW 8082
PCB-1248	ND	700	ug/Kg	12/21/06		MH	SW 8082
PCB-1254	ND	700	ug/Kg	12/21/06		MH	SW 8082
PCB-1260	ND	700	ug/Kg	12/21/06		MH	SW 8082
PCB-1262	ND	700	ug/Kg	12/21/06		MH	SW 8082
PCB-1268	ND	700	ug/Kg	12/21/06		MH	SW 8082
QA/QC Surrogates							
% DCBP (Surrogate Rec)	61		%	12/21/06		MH	SW 8082
% TCMX (Surrogate Rec)	62		%	12/21/06		MH	SW 8082

Polynuclear Aromatic HC

2-Methylnaphthalene	1900	590	ug/Kg	12/21/06		HM	SW 8270
Acenaphthene	1200	590	ug/Kg	12/21/06		HM	SW 8270
Acenaphthylene	1900	590	ug/Kg	12/21/06		HM	SW 8270
Anthracene	3700	590	ug/Kg	12/21/06		HM	SW 8270
Benz(a)anthracene	8000	590	ug/Kg	12/21/06		HM	SW 8270
Benzo(a)pyrene	7100	590	ug/Kg	12/21/06		HM	SW 8270
Benzo(b)fluoranthene	8100	590	ug/Kg	12/21/06		HM	SW 8270
Benzo(ghi)perylene	5600	590	ug/Kg	12/21/06		HM	SW 8270
Benzo(k)fluoranthene	2400	590	ug/Kg	12/21/06		HM	SW 8270
Chrysene	8800	590	ug/Kg	12/21/06		HM	SW 8270
Dibenz(a,h)anthracene	1500	590	ug/Kg	12/21/06		HM	SW 8270
Fluoranthene	7400	590	ug/Kg	12/21/06		HM	SW 8270
Fluorene	1900	590	ug/Kg	12/21/06		HM	SW 8270
Indeno(1,2,3-cd)pyrene	5000	590	ug/Kg	12/21/06		HM	SW 8270
Naphthalene	3800	590	ug/Kg	12/21/06		HM	SW 8270
Phenanthrene	9200	590	ug/Kg	12/21/06		HM	SW 8270
Pyrene	8700	590	ug/Kg	12/21/06		HM	SW 8270
QA/QC Surrogates							
% 2-Fluorobiphenyl	83		%	12/21/06		HM	SW 8270
% Nitrobenzene-d5	82		%	12/21/06		HM	SW 8270
% Terphenyl-d14	60		%	12/21/06		HM	SW 8270

Comments:

If there are any questions regarding this data, please call Phoenix Client Services at extension 200.
ND=Not detected BDL=Below Detection Limit RL=Reporting Limit

Phyllis Shiller, Laboratory Director
January 02, 2007

PHOENIX
Environmental Laboratories, Inc.
587 East Middle Turnpike, P.O.Box 370, Manchester, CT 06040
Tel. (860) 645-1102 Fax (860) 645-0823

Analysis Report

January 02, 2007

FOR: Attn: Mr. John Zahner
Fuss & O'Neill, Inc.
146 Hartford Road
Manchester, CT 06040

Sample Information		Custody Information		Date	Time
Matrix:	SOIL	Collected by:	JZ	12/19/06	11:30
Location Code:	F&O	Received by:	LB	12/20/06	12:01
Rush Request:		Analyzed by:	see "By" below		
P.O.#:					

SDG I.D.: GAH78837
Phoenix I.D.: AH78841

Laboratory Data

Client ID: MILLBURY DAM 748061219-05

Parameter	Result	RL	Units	Date	Time	By	Reference
Silver	< 0.5	0.5	mg/Kg	12/21/06		EKT	SW6010
Arsenic	5.61	1	mg/Kg	12/21/06		EKT	SW6010
Barium	30.8	0.5	mg/Kg	12/21/06		EKT	SW6010
Cadmium	2.44	0.5	mg/Kg	12/21/06		EKT	SW6010
Chromium	111	0.5	mg/Kg	12/21/06		EKT	SW6010
Copper	74.5	0.5	mg/Kg	12/21/06		EKT	SW6010
Mercury - Soil	< 0.10	0.10	mg/kg	12/21/06		RS	SW-7471
Nickel	20.9	0.5	mg/Kg	12/21/06		EKT	SW6010
Lead	34.8	0.5	mg/Kg	12/21/06		EKT	SW6010
Selenium	< 2.5	2.5	mg/Kg	12/21/06		EKT	SW6010
Vanadium	15.4	0.5	mg/Kg	12/21/06		EKT	6010
Zinc	84.4	0.5	mg/Kg	12/21/06		EKT	SW6010
Percent Solid	84		%	12/20/06		C/D	E160.3
pH	6.65	0.10	pH Units	12/20/06	23:00	CD	E150.1/SW9045
Tot.Org.Carbon	< 100	100	mg/kg	12/27/06		JL	EPA Kahn 6/99
Mercury Digestion	Completed			12/21/06		D	SW7471
Soil Extraction for PCB	Completed			12/20/06		CJCS/E	SW3545
Soil Ext. Semi-Vol BN	Completed			12/20/06		CJCS/E	SW3545
Total Metals Digest	Completed			12/20/06		AG	SW846 - 3050
Tot.Org.Carbon Preparation	Completed			12/20/06		D	
Polychlorinated Biphenyls							
PCB-1016	ND	470	ug/Kg	12/21/06		MH	SW 8082
PCB-1221	ND	470	ug/Kg	12/21/06		MH	SW 8082
PCB-1232	ND	470	ug/Kg	12/21/06		MH	SW 8082

Parameter	Result	RL	Units	Date	Time	By	Reference
PCB-1242	ND	470	ug/Kg	12/21/06		MH	SW 8082
PCB-1248	ND	470	ug/Kg	12/21/06		MH	SW 8082
PCB-1254	ND	470	ug/Kg	12/21/06		MH	SW 8082
PCB-1260	ND	470	ug/Kg	12/21/06		MH	SW 8082
PCB-1262	ND	470	ug/Kg	12/21/06		MH	SW 8082
PCB-1268	ND	470	ug/Kg	12/21/06		MH	SW 8082
QA/QC Surrogates							
% DCBP (Surrogate Rec)	102		%	12/21/06		MH	SW 8082
% TCMX (Surrogate Rec)	97		%	12/21/06		MH	SW 8082

Polynuclear Aromatic HC

2-Methylnaphthalene	ND	390	ug/Kg	12/21/06		HM	SW 8270
Acenaphthene	ND	390	ug/Kg	12/21/06		HM	SW 8270
Acenaphthylene	ND	390	ug/Kg	12/21/06		HM	SW 8270
Anthracene	ND	390	ug/Kg	12/21/06		HM	SW 8270
Benz(a)anthracene	ND	390	ug/Kg	12/21/06		HM	SW 8270
Benzo(a)pyrene	400	390	ug/Kg	12/21/06		HM	SW 8270
Benzo(b)fluoranthene	ND	390	ug/Kg	12/21/06		HM	SW 8270
Benzo(ghi)perylene	ND	390	ug/Kg	12/21/06		HM	SW 8270
Benzo(k)fluoranthene	ND	390	ug/Kg	12/21/06		HM	SW 8270
Chrysene	ND	390	ug/Kg	12/21/06		HM	SW 8270
Dibenz(a,h)anthracene	ND	390	ug/Kg	12/21/06		HM	SW 8270
Fluoranthene	ND	390	ug/Kg	12/21/06		HM	SW 8270
Fluorene	ND	390	ug/Kg	12/21/06		HM	SW 8270
Indeno(1,2,3-cd)pyrene	ND	390	ug/Kg	12/21/06		HM	SW 8270
Naphthalene	ND	390	ug/Kg	12/21/06		HM	SW 8270
Phenanthrene	ND	390	ug/Kg	12/21/06		HM	SW 8270
Pyrene	400	390	ug/Kg	12/21/06		HM	SW 8270
QA/QC Surrogates							
% 2-Fluorobiphenyl	86		%	12/21/06		HM	SW 8270
% Nitrobenzene-d5	81		%	12/21/06		HM	SW 8270
% Terphenyl-d14	57		%	12/21/06		HM	SW 8270

Comments:

If there are any questions regarding this data, please call Phoenix Client Services at extension 200.
ND=Not detected BDL=Below Detection Limit RL=Reporting Limit

Phyllis Shiller, Laboratory Director
January 02, 2007

PHOENIX
Environmental Laboratories, Inc.
587 East Middle Turnpike, P.O.Box 370, Manchester, CT 06040
Tel. (860) 645-1102 Fax (860) 645-0823

QA/QC Report

January 02, 2007

QA/QC Data

SDG I.D.: GAH78837

Parameter	Blank	Dup RPD	LCS %	LCSD %	LCS RPD	MS Rec %	MS Dup Rec %	RPD
QA/QC Batch 69371, Sample No: AH78887 (AH78837, AH78838, AH78839, AH78840, AH78841)								
ICP Metals - Soil								
Aluminum	BDL	10.0	104	101	2.9	NC	NC	NC
Antimony	BDL	NC	90.3	88.1	2.5	78.4	79.3	1.1
Arsenic	BDL	NC	90.6	87.9	3.0	84.6	86.2	1.9
Barium	BDL	19.2	99.6	96.9	2.7	91.8	94.0	2.4
Beryllium	BDL	NC	98.6	96.2	2.5	91.7	96.6	5.2
Boron	BDL	---	---	---	NC	---	---	NC
Cadmium	BDL	NC	91.1	89.2	2.1	83.2	84.7	1.8
Calcium	BDL	---	---	---	NC	---	---	NC
Chromium	BDL	32.5	98.7	95.8	3.0	90.8	91.7	1.0
Cobalt	BDL	NC	96.6	94.7	2.0	89.9	91.4	1.7
Copper	BDL	10.3	100	98.4	1.6	94.7	97.6	3.0
Iron	BDL	9.90	---	---	NC	NC	NC	NC
Lead	BDL	1.90	96.1	93.7	2.5	88.5	89.7	1.3
Magnesium	BDL	---	---	---	NC	---	---	NC
Manganese	BDL	56.3	106	102	3.8	NC	NC	NC
Molybdenum	BDL	---	---	---	NC	---	---	NC
Nickel	BDL	NC	97.8	94.4	3.5	89.1	91.9	3.1
Phosphorus	BDL	---	---	---	NC	---	---	NC
Potassium	BDL	---	---	---	NC	---	---	NC
Selenium	BDL	NC	86.9	84.2	3.2	81.5	81.4	0.1
Silver	BDL	NC	94.1	92.1	2.1	87.8	88.6	0.9
Sodium	BDL	---	---	---	NC	---	---	NC
Thallium	BDL	NC	92.9	90.7	2.4	87.2	88.2	1.1
Tin	BDL	---	---	---	NC	---	---	NC
Vanadium	BDL	11.5	98.1	95.9	2.3	92.0	93.8	1.9
Zinc	BDL	19.4	93.8	91.8	2.2	87.6	86.9	0.8
QA/QC Batch 69399, Sample No: AH79078 (AH78837, AH78838, AH78839, AH78840, AH78841)								
Mercury - Soil	BDL	NC	89			105	97	7.9

If there are any questions regarding this data, please call Phoenix Client Services at extension 200.

RPD - Relative Percent Difference
LCS - Laboratory Control Sample
LCSD - Laboratory Control Sample Duplicate
MS - Matrix Spike
MS Dup - Matrix Spike Duplicate
NC - No Criteria

Phyllis Shiller, Laboratory Director
January 02, 2007

Environmental Laboratories, Inc.
587 East Middle Turnpike, P.O.Box 370, Manchester, CT 06040
Tel. (860) 645-1102 Fax (860) 645-0823

QA/QC Report

January 02, 2007

QA/QC Data

SDG I.D.: GAH78837

Parameter	Blank	Dup RPD	LCS %	LCSD %	LCS RPD	MS Rec %	MS Dup Rec %	RPD
QA/QC Batch 69604, Sample No: AH78837 (AH78837, AH78838, AH78839, AH78840, AH78841)								
Tot.Org.Carbon	BDL	0.0	96.9					

If there are any questions regarding this data, please call Phoenix Client Services at extension 200.

RPD - Relative Percent Difference
LCS - Laboratory Control Sample
LCSD - Laboratory Control Sample Duplicate
MS - Matrix Spike
MS Dup - Matrix Spike Duplicate
NC - No Criteria

Phyllis Shiller, Laboratory Director
January 02, 2007

PHOENIX

Environmental Laboratories, Inc.
587 East Middle Turnpike, P.O.Box 370, Manchester, CT 06040
Tel. (860) 645-1102 Fax (860) 645-0823

QA/QC Report

January 02, 2007

QA/QC Data

SDG I.D.: GAH78837

Parameter	Blank	LCS %	LCSD %	LCS RPD	MS Rec %	MS Dup Rec %	RPD
QA/QC Batch 69121, Sample No: AH77911 (AH78837, AH78838, AH78839, AH78840, AH78841)							
Semivolatiles							
2-Methylnaphthalene	ND	45	76	51.2			
Acenaphthene	ND	45	79	54.8	82	84	2.4
Acenaphthylene	ND	40	64	46.2			
Anthracene	ND	50	91	58.2			
Benz(a)anthracene	ND	53	89	50.7			
Benzo(a)pyrene	ND	50	86	52.9			
Benzo(b)fluoranthene	ND	52	88	51.4			
Benzo(ghi)perylene	ND	42	69	48.6			
Benzo(k)fluoranthene	ND	55	96	54.3			
Chrysene	ND	52	90	53.5			
Dibenz(a,h)anthracene	ND	55	91	49.3			
Fluoranthene	ND	55	102	59.9			
Fluorene	ND	48	86	56.7			
Indeno(1,2,3-cd)pyrene	ND	51	84	48.9			
Naphthalene	ND	41	72	54.9			
Phenanthrene	ND	51	89	54.3			
Pyrene	ND	52	97	60.4	104	98	5.9
% 2-Fluorobiphenyl	68	46	77	50.4	78	86	9.8
% Nitrobenzene-d5	66	46	76	49.2	74	81	9.0
% Terphenyl-d14	90	57	100	54.8	106	99	6.8
QA/QC Batch 69288, Sample No: AH78347 (AH78837, AH78838, AH78839, AH78840, AH78841)							
Polychlorinated Biphenyls							
PCB-1016	ND	127	124	2.4	136	136	0.0
PCB-1221	ND						
PCB-1232	ND						
PCB-1242	ND						
PCB-1248	ND						
PCB-1254	ND						
PCB-1260	ND	139	135	2.9	140	139	0.7
PCB-1262	ND						
PCB-1268	ND						
% DCBP (Surrogate Rec)	84	89	88	1.1	88	88	0.0

QA/QC Data

SDG I.D.: GAH78837

Parameter	Blank	LCS %	LCSD %	LCS RPD	MS Rec %	MS Dup Rec %	RPD
% TCMX (Surrogate Rec)	84	86	85	1.2	84	88	4.7
QA/QC Batch 69523, Sample No: AH79909 (AH78837, AH78838)							
Semivolatiles							
2-Methylnaphthalene	ND	84	84	0.0			
Acenaphthene	ND	83	83	0.0	91	91	0.0
Acenaphthylene	ND	68	68	0.0			
Anthracene	ND	95	95	0.0			
Benz(a)anthracene	ND	85	85	0.0			
Benzo(a)pyrene	ND	85	85	0.0			
Benzo(b)fluoranthene	ND	87	87	0.0			
Benzo(ghi)perylene	ND	76	76	0.0			
Benzo(k)fluoranthene	ND	91	91	0.0			
Chrysene	ND	88	88	0.0			
Dibenz(a,h)anthracene	ND	92	92	0.0			
Fluoranthene	ND	98	98	0.0			
Fluorene	ND	91	91	0.0			
Indeno(1,2,3-cd)pyrene	ND	87	87	0.0			
Naphthalene	ND	81	81	0.0			
Phenanthrene	ND	91	91	0.0			
Pyrene	ND	93	93	0.0	113	109	3.6
% 2-Fluorobiphenyl	77	87	87	0.0	92	90	2.2
% Nitrobenzene-d5	68	79	79	0.0	84	80	4.9
% Terphenyl-d14	67	100	100	0.0	111	107	3.7

If there are any questions regarding this data, please call Phoenix Client Services at extension 200.

RPD - Relative Percent Difference
LCS - Laboratory Control Sample
LCSD - Laboratory Control Sample Duplicate
MS - Matrix Spike
MS Dup - Matrix Spike Duplicate
NC - No Criteria

Phyllis Shiller, Laboratory Director
January 02, 2007

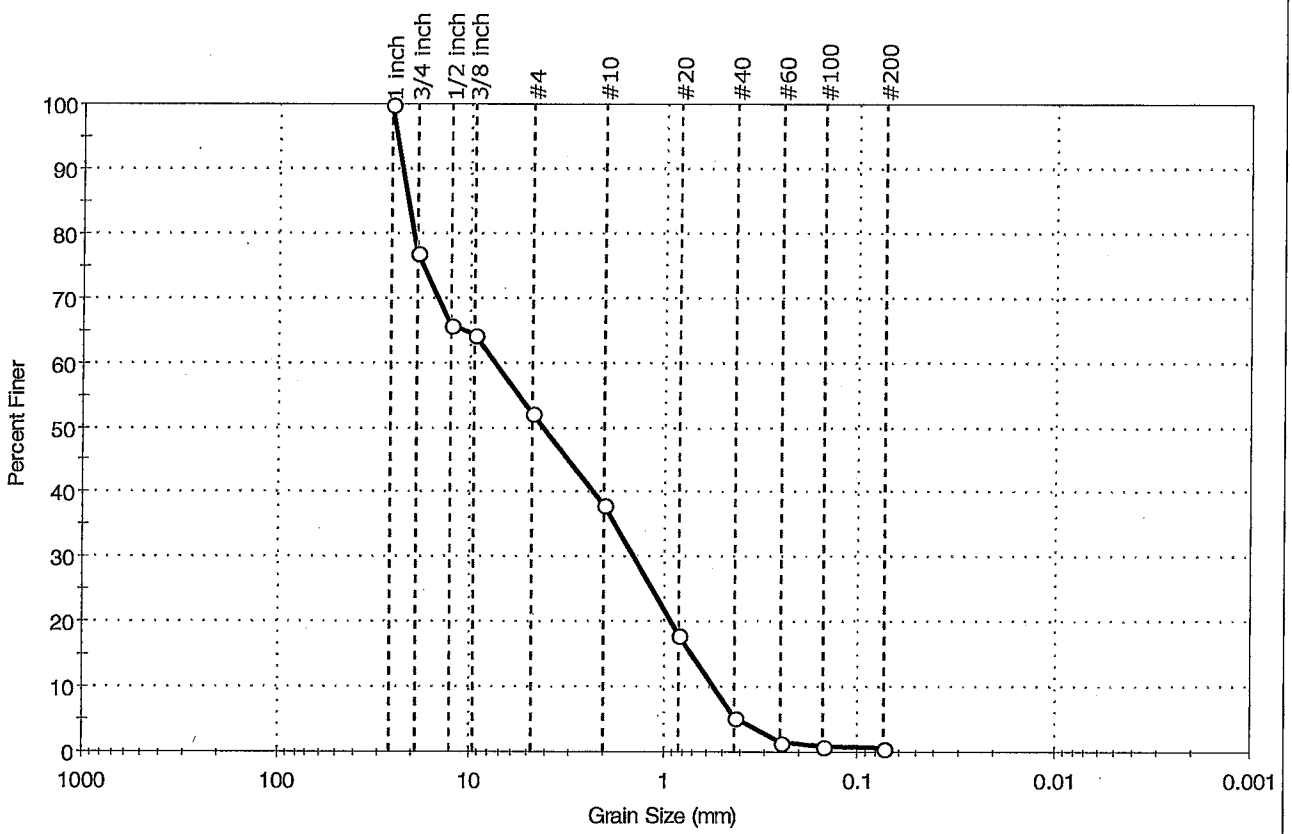
APPENDIX G

SEDIMENT GRADATION DATA

GeoTesting express
a subsidiary of Geocomp Corporation

Client:	Fuss & ONeill, Inc				
Project:	Mass Electric Dam				
Location:	Millbury, MA			Project No:	GTX-6773
Boring ID: ---		Sample Type:	bag	Tested By:	pcs
Sample ID:06206-712-01A		Test Date:	06/14/06	Checked By:	jdt
Depth : ---		Test Id:	91923		
Test Comment:	---				
Sample Description:	Moist, dark olive gray sand with gravel				
Sample Comment:	---				

Particle Size Analysis - ASTM D 422



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	47.8	51.7	0.5

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1 Inch	25.70	100		
3/4 Inch	19.00	77		
1/2 Inch	12.70	66		
3/8 Inch	9.51	64		
#4	4.75	52		
#10	2.00	38		
#20	0.84	18		
#40	0.42	5		
#60	0.25	2		
#100	0.15	1		
#200	0.074	1		

Coefficients

D_{85} =21.0933 mm	D_{30} =1.4084 mm
D_{60} =7.4370 mm	D_{15} =0.7138 mm
D_{50} =4.1520 mm	D_{10} =0.5460 mm
C_u =13.621	C_c =0.488

Classification

ASTM Poorly graded sand with gravel (SP)

AASHTO Stone Fragments, Gravel and Sand (A-1-a (0))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

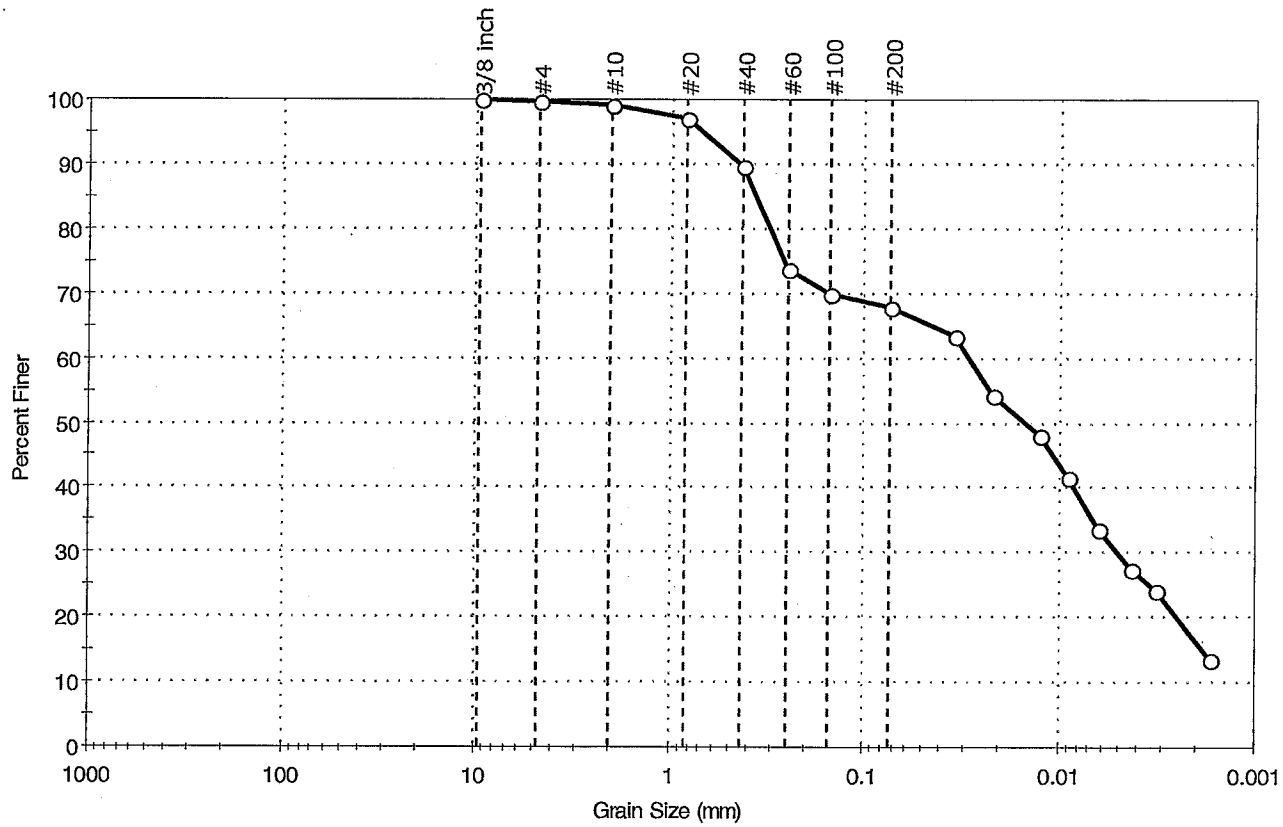
Sand/Gravel Hardness : HARD

printed 6/14/2006 1:59:00 PM

GeoTesting express
a subsidiary of Geocomp Corporation

Client:	Fuss & ONeill, Inc		
Project:	Mass Electric Dam		
Location:	Millbury, MA	Project No:	GTX-6773
Boring ID: ---	Sample Type: bag	Tested By:	pcs
Sample ID:06206-712-01B	Test Date: 06/14/06	Checked By:	jdt
Depth : ---	Test Id: 91928		
Test Comment:	---		
Sample Description:	Moist, very dark gray sandy silt		
Sample Comment:	---		

Particle Size Analysis - ASTM D 422



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	0.3	31.9	67.8

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
3/8 Inch	9.51	100		
#4	4.75	100		
#10	2.00	99		
#20	0.84	97		
#40	0.42	90		
#60	0.25	74		
#100	0.15	70		
#200	0.074	68		
---	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0341	63		
---	0.0215	54		
---	0.0125	48		
---	0.0090	41		
---	0.0063	34		
---	0.0043	27		
---	0.0032	24		
---	0.0017	14		

Coefficients

D_{85} =0.3649 mm	D_{30} =0.0050 mm
D_{60} =0.0288 mm	D_{15} =0.0018 mm
D_{50} =0.0146 mm	D_{10} =0.0014 mm
C_u =20.571	C_c =0.620

Classification

ASTM N/A

AASHTO Silty Soils (A-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

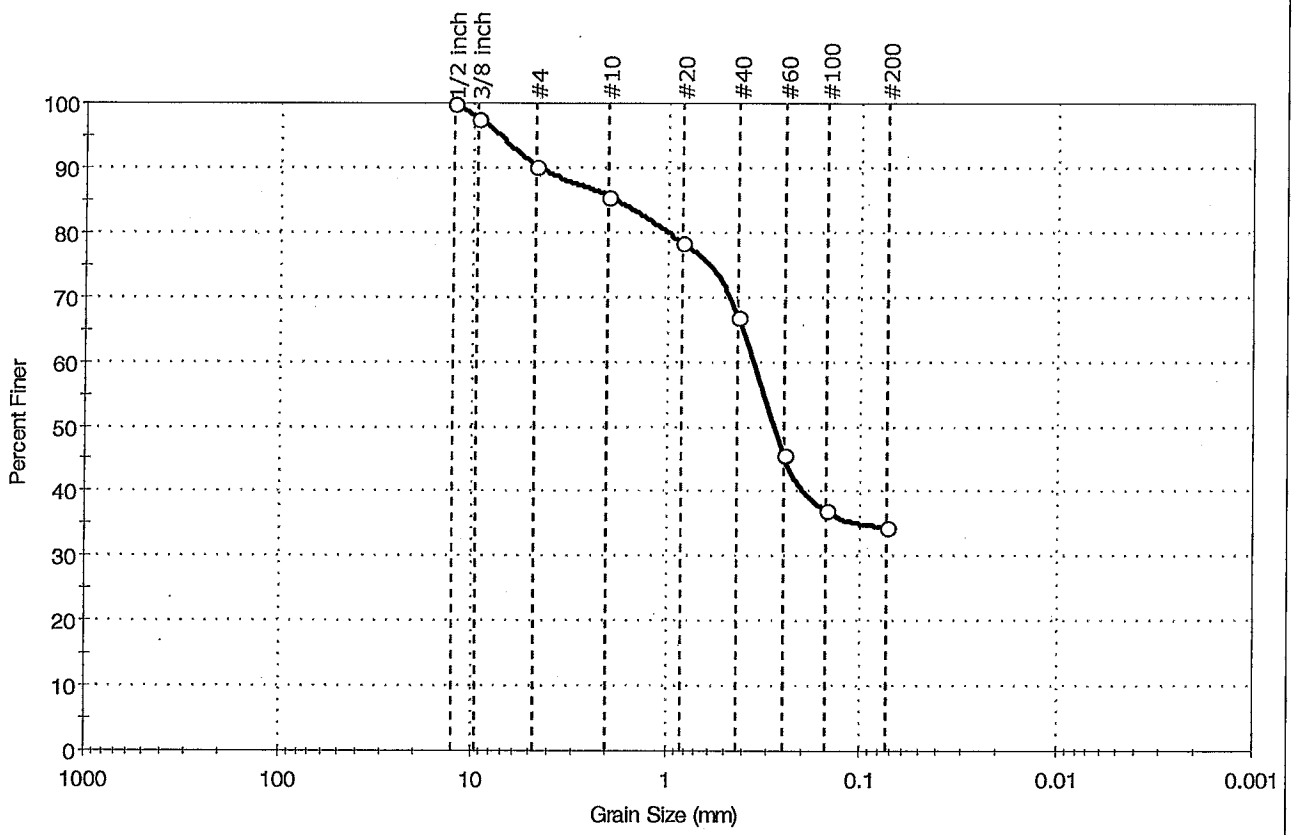
Sand/Gravel Hardness : HARD

printed 6/14/2006 1:59:21 PM

GeoTesting express
a subsidiary of Geocomp Corporation

Client:	Fuss & ONeill, Inc		
Project:	Mass Electric Dam		
Location:	Millbury, MA	Project No:	GTX-6773
Boring ID: ---	Sample Type: bag	Tested By:	pcs
Sample ID:06206-712-01C	Test Date: 06/14/06	Checked By:	jdt
Depth : ---	Test Id: 91924		
Test Comment:			
Sample Description:	Moist, very dark gray clayey sand		
Sample Comment:	---		

Particle Size Analysis - ASTM D 422



% Cobble	% Gravel	% Sand	% Silt & Clay Size
--	9.6	55.9	34.5

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1/2 Inch	12.70	100		
3/8 Inch	9.51	98		
#4	4.75	90		
#10	2.00	86		
#20	0.84	78		
#40	0.42	67		
#60	0.25	46		
#100	0.15	37		
#200	0.074	35		

Coefficients

D_{85} = 1.8473 mm D_{30} = N/A
D_{60} = 0.3569 mm D_{15} = N/A
D_{50} = 0.2786 mm D_{10} = N/A
C_u = N/A C_c = N/A

Classification

ASTM N/A

AASHTO Silty Gravel and Sand (A-2-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

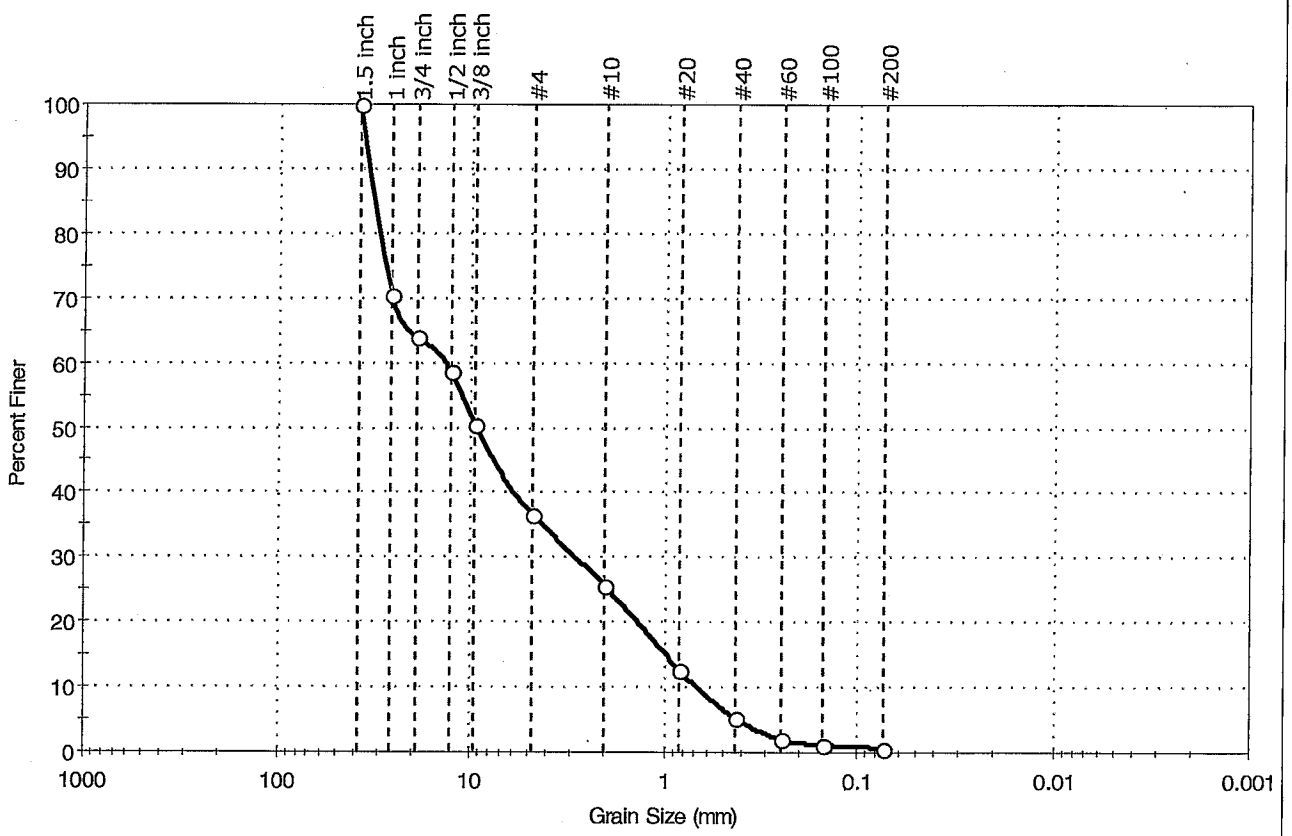
Sand/Gravel Hardness : HARD

printed 6/14/2006 1:59:47 PM

GeoTesting express
a subsidiary of Geocomp Corporation

Client:	Fuss & ONeill, Inc				
Project:	Mass Electric Dam				
Location:	Millbury, MA			Project No:	GTX-6773
Boring ID: ---		Sample Type:	bag	Tested By:	pcs
Sample ID:06206-712-02A		Test Date:	06/14/06	Checked By:	jdt
Depth : ---		Test Id:	91925		
Test Comment:	---				
Sample Description:	Moist, very dark grayish brown gravel with sand				
Sample Comment:	---				

Particle Size Analysis - ASTM D 422



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	63.4	36.0	0.6

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1.5 inch	38.10	100		
1 inch	25.70	70		
3/4 inch	19.00	64		
1/2 inch	12.70	59		
3/8 inch	9.51	50		
#4	4.75	37		
#10	2.00	26		
#20	0.84	13		
#40	0.42	5		
#60	0.25	2		
#100	0.15	1		
#200	0.074	1		

Coefficients

D_{85} = 31.2031 mm D_{30} = 2.8146 mm
D_{60} = 14.0503 mm D_{15} = 0.9793 mm
D_{50} = 9.3013 mm D_{10} = 0.6560 mm
C_u = 21.418 C_c = 0.859

Classification

ASTM Poorly graded gravel with sand (GP)

AASHTO Stone Fragments, Gravel and Sand (A-1-a (0))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

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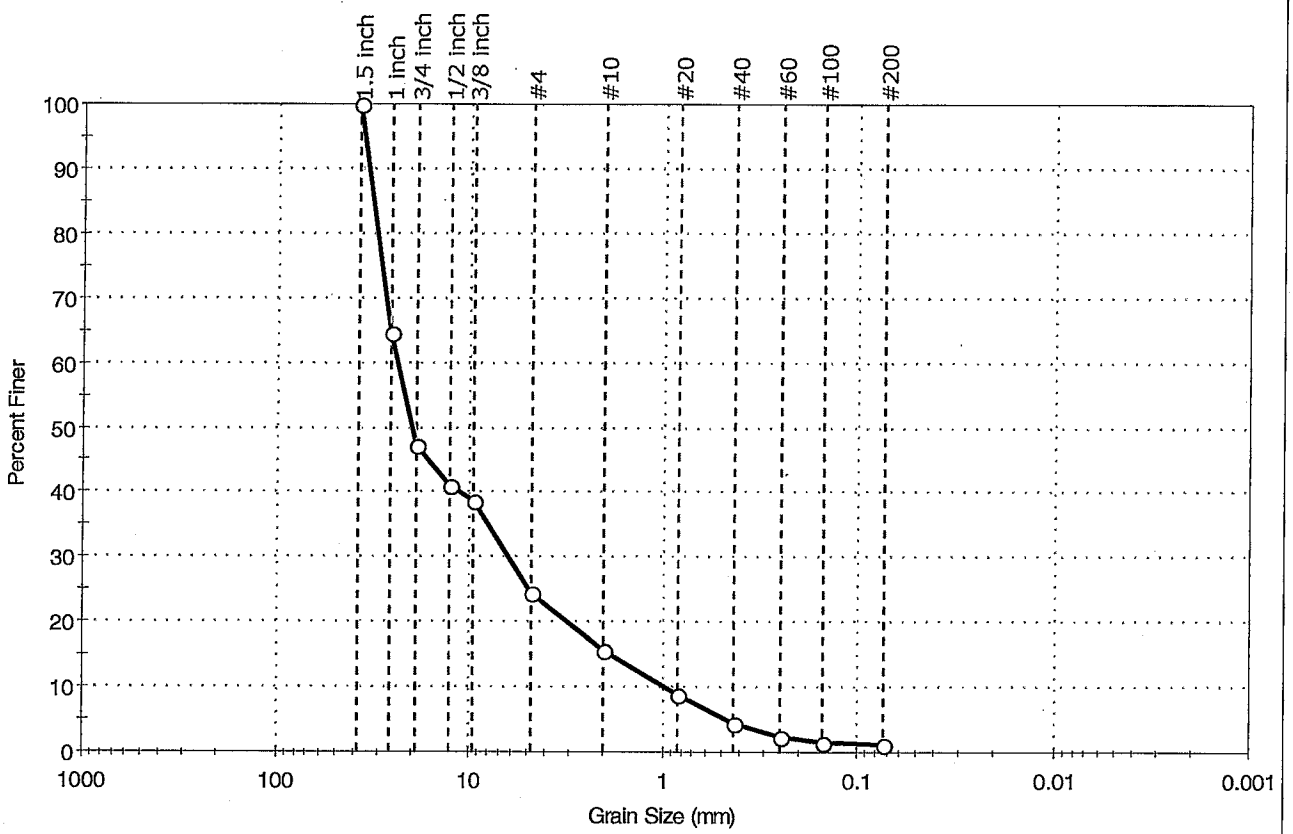
GeoTesting express
a subsidiary of Geocomp Corporation

Client:	Fuss & ONeill, Inc		
Project:	Mass Electric Dam		
Location:	Millbury, MA	Project No:	GTX-6773
Boring ID: ---	Sample Type: bag	Tested By:	pcs
Sample ID:06206-712-02B	Test Date: 06/14/06	Checked By:	jdt
Depth : ---	Test Id: 91926		
Test Comment: ---			
Sample Description:	Moist, very dark gray gravel with sand		
Sample Comment: ---			

Particle Size Analysis - ASTM D 422



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	75.5	23.4	1.1

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1.5 Inch	38.10	100		
1 Inch	25.70	65		
3/4 Inch	19.00	47		
1/2 Inch	12.70	41		
3/8 Inch	9.51	39		
#4	4.75	25		
#10	2.00	16		
#20	0.84	9		
#40	0.42	4		
#60	0.25	2		
#100	0.15	1		
#200	0.074	1		

Coefficients

D_{85} = 32.2431 mm D_{30} = 6.2227 mm
D_{60} = 23.7244 mm D_{15} = 1.8644 mm
D_{50} = 19.9503 mm D_{10} = 0.9654 mm
C_u = 24.575 C_c = 1.691

Classification

ASTM Well-graded gravel with sand (GW)

AASHTO Stone Fragments, Gravel and Sand (A-1-a (0))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

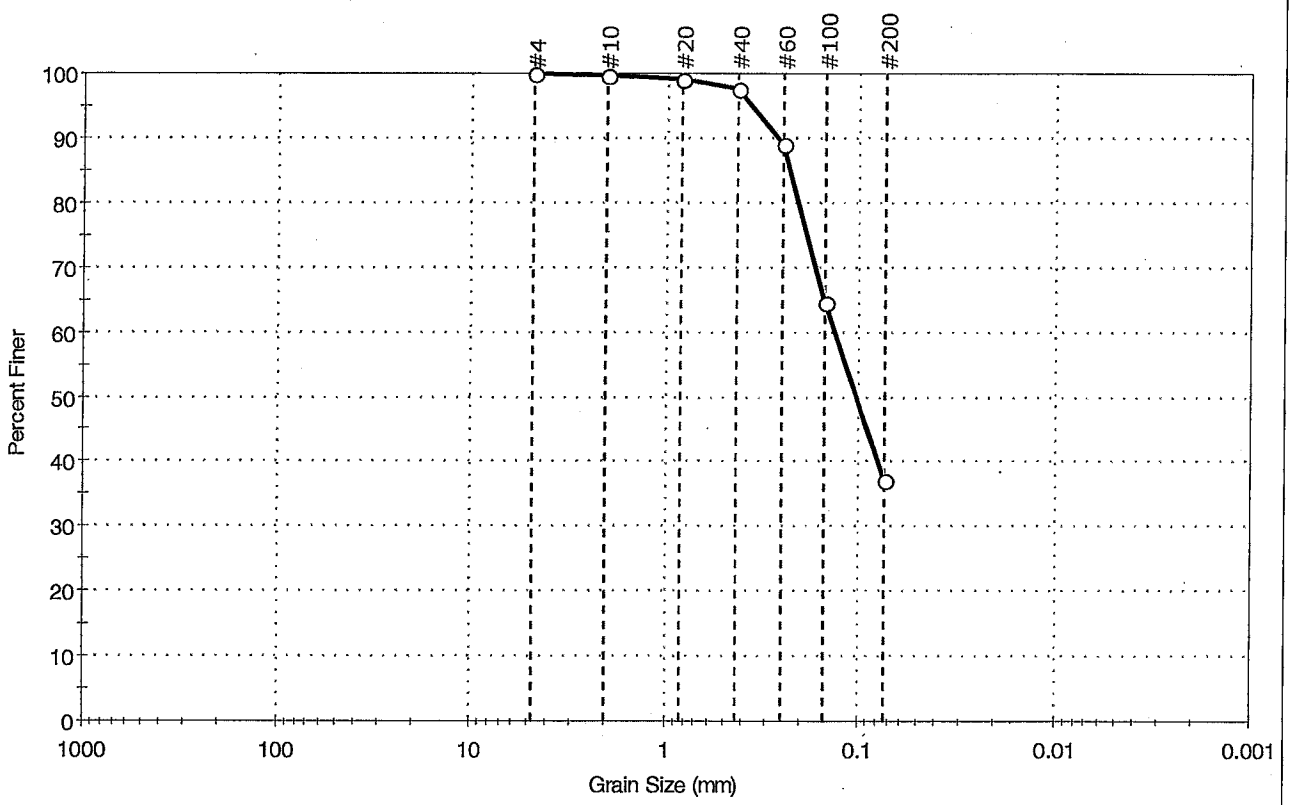
Sand/Gravel Hardness : HARD

printed 6/14/2006 2:00:16 PM

GeoTesting express
a subsidiary of Geocomp Corporation

Client:	Fuss & ONeill, Inc				
Project:	Mass Electric Dam				
Location:	Millbury, MA			Project No:	GTX-6773
Boring ID: ---		Sample Type:	bag	Tested By:	pcs
Sample ID:06206-712-03A		Test Date:	06/13/06	Checked By:	jdt
Depth : ---		Test Id:	91927		
Test Comment:	---				
Sample Description:	Moist, dark olive brown silty sand				
Sample Comment:	---				

Particle Size Analysis - ASTM D 422



% Cobble	% Gravel	% Sand	% Silt & Clay Size
---	0.0	62.8	37.2

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
#4	4.75	100		
#10	2.00	100		
#20	0.84	99		
#40	0.42	98		
#60	0.25	89		
#100	0.15	65		
#200	0.074	37		

Coefficients

D_{85} = 0.2291 mm D_{30} = N/A
D_{60} = 0.1329 mm D_{15} = N/A
D_{50} = 0.1028 mm D_{10} = N/A
C_u = N/A C_c = N/A

Classification

ASTM N/A

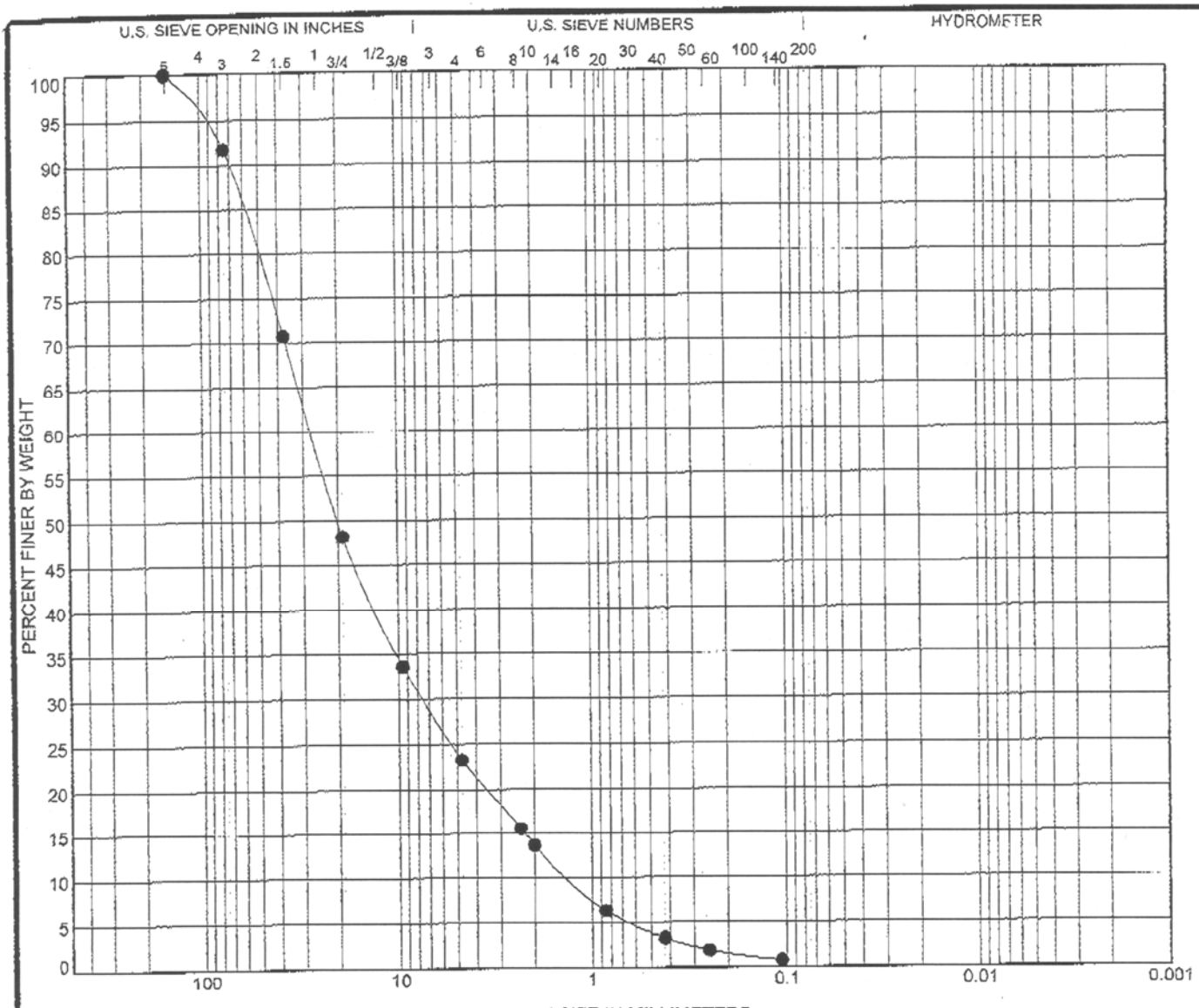
AASHTO Silty Soils (A-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

printed 6/14/2006 2:00:33 PM



	% COBBLES	% GRAVEL		% SAND			% FINES	
		coarse	fine	coarse	medium	fine	SILT	CLAY
●		68.5						

	NMC	LL	PL	PI	D100	D60	D30	D10	Cc	Cu
●				NT	152.4	27.158	7.475	1.308	1.57	20.76

	Specimen Identification	MATERIAL DESCRIPTION	METHOD	USCS	AASHTO
●	S1	Largest Particle: 5.1 x 3.3 x 2.5 inches			
		874.6 grams			

KCI TECHNOLOGIES

GRAIN SIZE DISTRIBUTION

Project: Blackstone
Client:
Location:
Date: 6/22/06

Figure No.

KCI Job No. 01065385

KCI SOIL CLASSIFICATION BLACKSTONE.GPJ KCI1.GDT 6/22/06

APPENDIX H

SAMPLE DETAILS

RIFFLE GRADE CONTROL/ROCK RAMP
FLOW CONSTRICTOR/STEP POOL
BOULDER GARDEN

PLOTTED: "08:57 PM on Wednesday, March 14, 2007"
BY: Jeffrey Swaner Division: Environmental Planning
FILE: M:\2003\0103134.07\drawings\woodrow\de01crom.dgn

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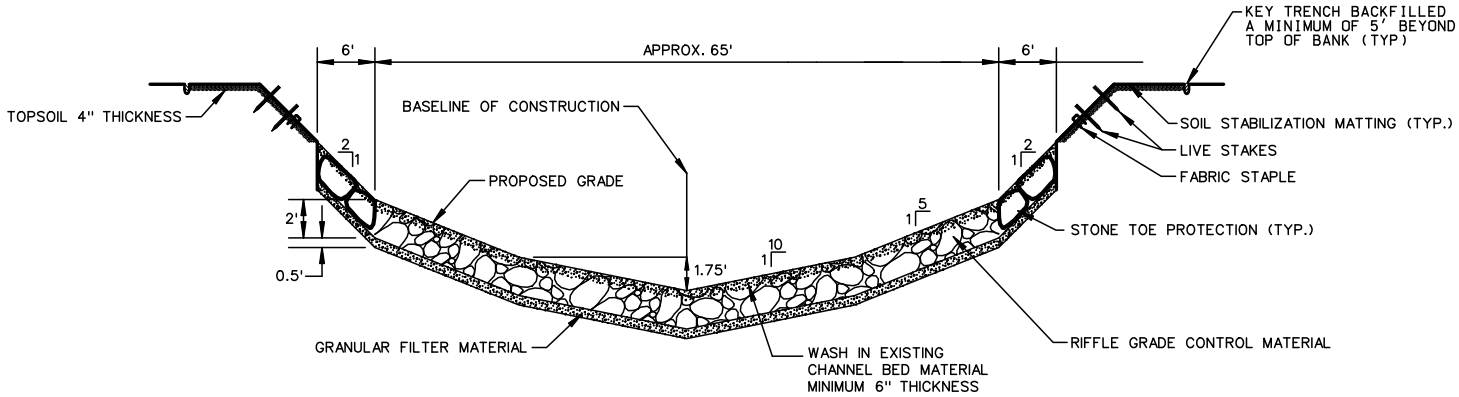
HUNT VALLEY, MD 21030
PHONE: (410) 316-7800
FAX: (410) 316-7817
www.kci.com

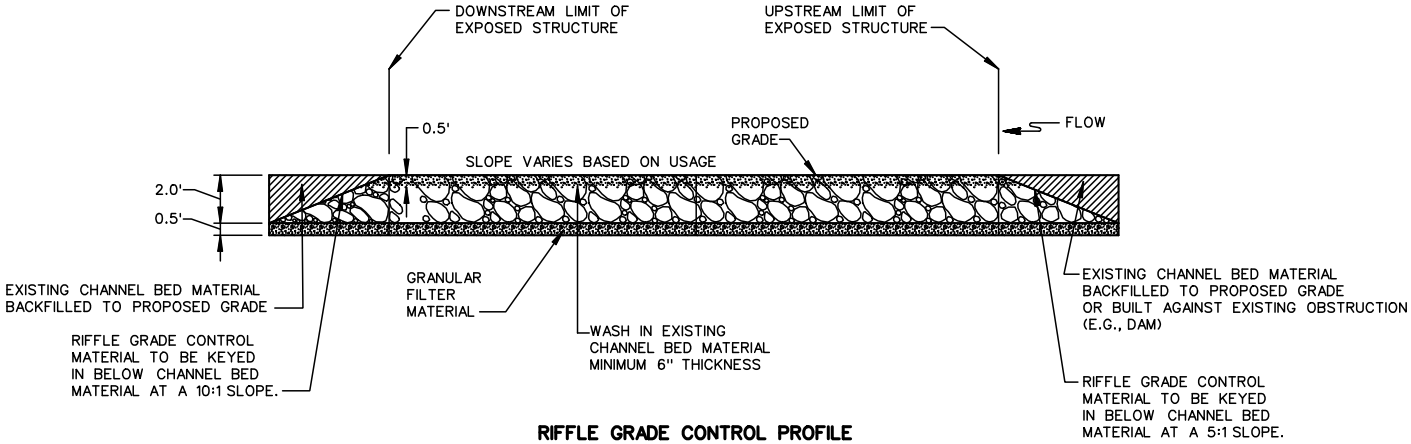
DATE:

SCALE: AS SHOWN

RIFFLE GRADE CONTROL / ROCK RAMP DETAILS
SAMPLE

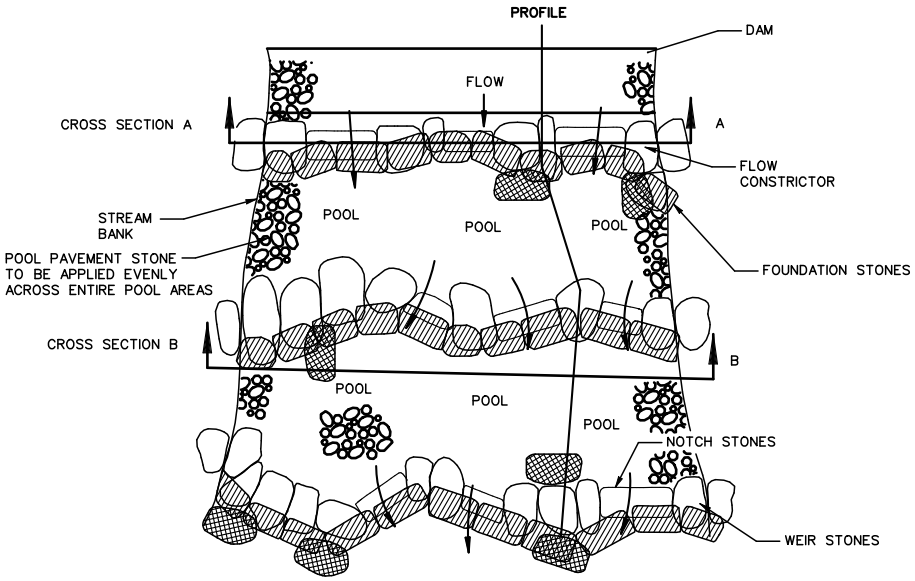


RIFFLE CROSS SECTION
LOW FLOW CROSSOVER
SCALE: NOT TO SCALE



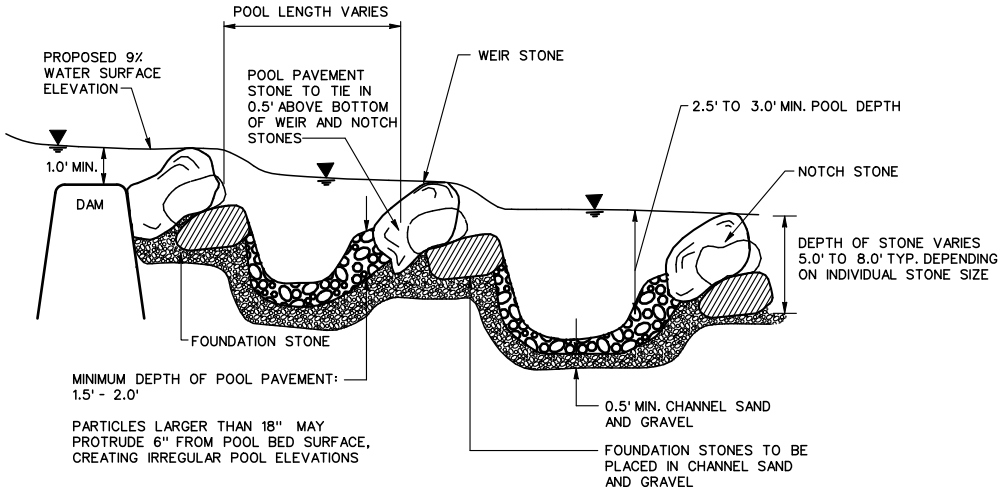
RIFFLE GRADE CONTROL PROFILE
SCALE: NOT TO SCALE

NOTE: STONE FOR RIFFLE GRADE CONTROL STRUCTURES SHALL BE PLACED SO THAT IT IS SHINGLED IN THE DOWNSTREAM DIRECTION.



PLAN VIEW – FLOW CONSTRICTOR AND STEP POOL SYSTEM

NOT TO SCALE



PROFILE THROUGH STEP/POOL

NOT TO SCALE

NOTE: THE CONTRACTOR SHALL REFER TO THE SPECIAL PROVISIONS FOR SPECIFIC TYPES AND COLORATIONS OF STONE/RIPRAP THAT MUST BE USED WITHIN THE PROJECT LIMITS.

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Hunt Valley, MD 21030
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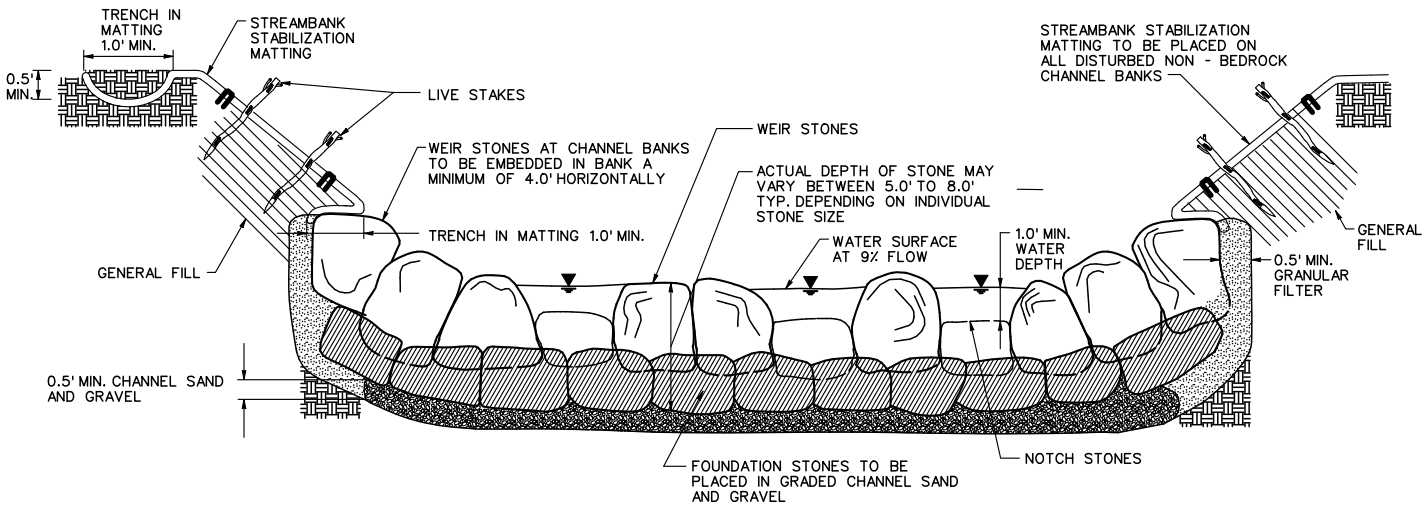
DATE:

SCALE: AS SHOWN

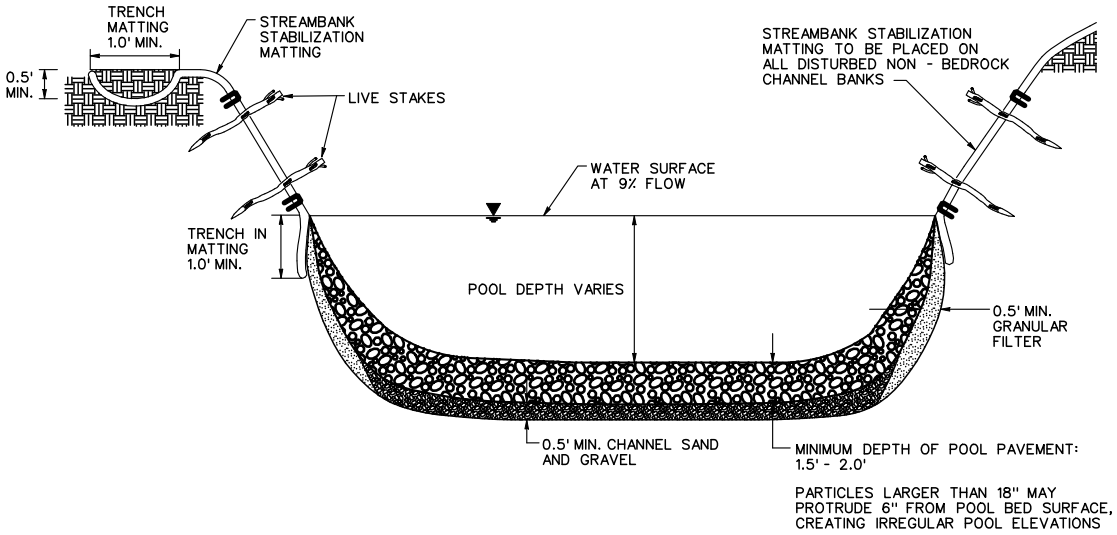
FLOW CONSTRICTOR AND STEP POOL SYSTEM SAMPLE

PLOTTED: "08:59 PM on Wednesday, March 14, 2007"
BY: Jeffrey Swoner Division: Environmental Planning
FILE: M:\2003\0103134.07\drawings\woodrow\de01crom.dgn



CROSS-SECTION A THROUGH FLOW CONSTRICTOR

NOT TO SCALE



CROSS-SECTION B THROUGH POOL

NOT TO SCALE

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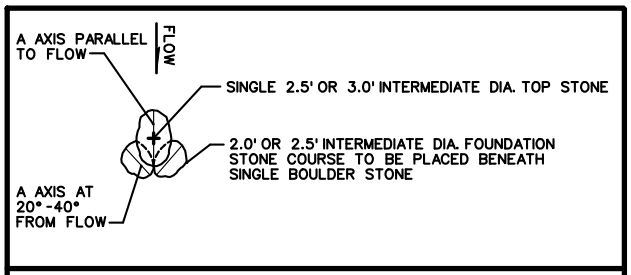
DATE:

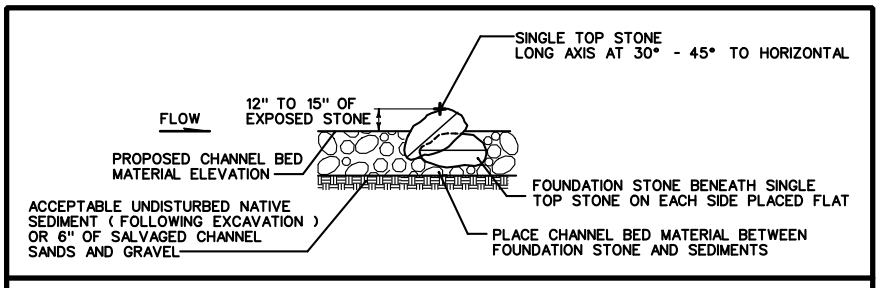
SCALE: AS SHOWN

FLOW CONSTRICTOR AND STEP POOL SYSTEM SAMPLE

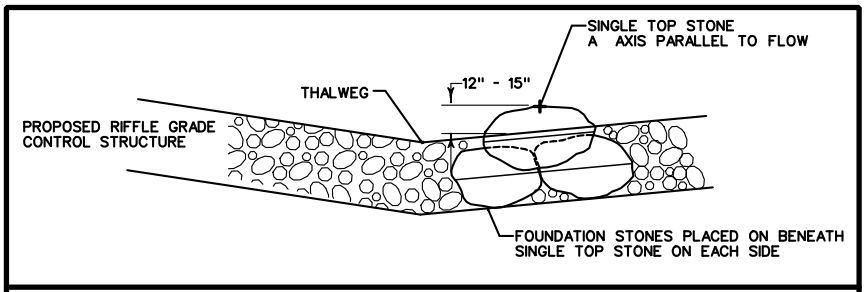
PLOTTED: "09:00 PM on Wednesday, March 14, 2007"
BY: Jeffrey Swaner Division: Environmental Planning
FILE: M:\2003\0103134.07\drawings\woodrow\de01crom.dgn



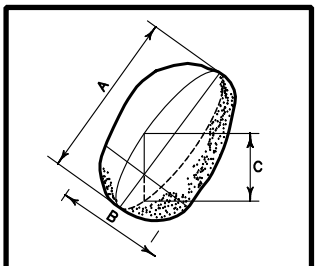
BOULDER GARDEN: MAIN CHANNEL/ CREST
TOP VIEW/ PLAN
NOT TO SCALE



BOULDER GARDEN PROFILE
NOT TO SCALE



BOULDER GARDEN CROSS-SECTION
NOT TO SCALE



A = LONGEST AXIS (LENGTH)
B = INTERMEDIATE AXIS (WIDTH)
C = SHORTEST AXIS (THICKNESS)

ROCK AXIS DEFINITION
NOT TO SCALE

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FAX: (410) 316-7817
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DATE:

SCALE: AS SHOWN

BOULDER GARDEN/ STONE MEASUREMENT DETAILS SAMPLE

PLOTTED: "09:00 PM on Wednesday, March 14, 2007"
BY: Jeffrey Swoner Division: Environmental Planning
FILE: M:\2003\0103134.07\drawings\woodrow\de01crom.dgn

APPENDIX I

OPINION OF COST

FUSS & O'NEILL, INC.

146 HARTFORD ROAD
MANCHESTER, CONNECTICUT

OPINION OF CONSTRUCTION COST		DATE PREPARED :	20-Mar-07
Type:	**Order of Magnitude**		
PROJECT :	MILLBURY DAM	Field Sketch & Measurements	
LOCATION :	MILLBURY, MA		
DESCRIPTION:	DAM REMOVAL WITH RGC ALTERNATIVE		
DRAWING NO. :		ESTIMATOR : JAZ	CHECKED BY : PWM

OPINION OF CONSTRUCTION COST - ORDER OF MAGNITUDE: An opinion of cost made without detailed engineering data. Costs may be estimated by comparison with similar projects. It is normally expected that an estimate of this type would be accurate within plus 50% or minus 30%. Since Fuss & O'Neill has no control over the cost of labor, materials, equipment or services furnished by others, or over the Contractor(s)' methods of determining prices, or over competitive bidding or market conditions, Fuss & O'Neill's opinion of probable Total Project Costs and Construction Costs are made on the basis of Fuss & O'Neill's experience and qualifiations and represent Fuss & O'Neill's best judgment as an experienced and qualified professional engineer, familiar with the construction industry; but Fuss & O'Neill cannot and does not guarantee that proposals, bids or actual Total Project or Construction Costs will not vary from opinions of probable cost prepared by Fuss & O'Neill. If prior to the bidding or negotiating Phase the Owner wishes greater assurance as to Total Project or Construction Costs, the Owner shall employ an independent cost estimator.

ITEM NO.	ITEM	UNIT MEAS.	NO. UNITS	PER UNIT	TOTAL COST
SITE ACCESS WORK					
02552	Processed Aggregate Base	C.Y.	500	45.00	$22,500.00
SOIL AND EROSION CONTROL					
02291	Sedimentation and Erosion Control	L.S.	1	15,000.00	$15,000.00
02297	Anti-Tracking Apron	L.S.	1	3,000.00	$3,000.00
SITE PREPARATION WORK					
02110	Clearing and Grubbing	L.S.	1	4,000.00	$4,000.00
	Dewatering area	L.S.	1	10,000.00	$10,000.00
WATER CONTROL					
02199	Control of Water	L.S.	1	50,000.00	$50,000.00
DEMOLITION					
	Demolish Spillway	L.S.	1	50,000.00	$50,000.00
EARTHWORK					
	Shape river banks	L.S.	1	20,000.00	$20,000.00
	Former mill channel closeoff	L.S.	1	30,000.00	$30,000.00
BANK STABILIZATION					
	Toe stone (up to 2-yr flood) (1 x 500' x 3' x 6')	C.Y.	350	100.00	$35,000.00
	Matting (2 to 5-yr flood) (2 x 400' x 8')	S.Y.	750	3.00	$2,250.00
	Vegetative plantings (> 5-yr flood)	L.S.	1	10,000.00	$10,000.00
SEDIMENT MANAGEMENT					
	Dredge and dewater material	C.Y.	1,000	20.00	$20,000.00
	Haul to AMREC (Charlton, 15 miles)	C.Y.	1,000	21.00	$21,000.00
	Tipping fee, Non Hazardous Waste (AMREC)	C.Y.	200	40.00	$8,000.00
	Tipping fee, Hazardous Waste	C.Y.	800	336.00	$268,800.00
RIFFLE GRADE CONTROL					
	Granular filter material (2 x .5' x 150' x 55')	C.Y.	300	45.00	$13,500.00
	RGC Material (2 x 2' x 150' x 55')	C.Y.	1,250	80.00	$100,000.00
	Wash in point bar material	L.S.	1	10,000.00	$10,000.00
	Boulder garden	E.A.	10	1,000.00	$10,000.00
	Point bar (100' x 50' x 3')	C.Y.	550	40.00	$22,000.00
SITE STABILIZATION WORK					
	Restore dewatering basin, S&E controls	L.S.	1	10,000.00	$10,000.00
	Riparian Zone Grading & Seeding/Plantings	S.Y.	2,000	20.00	$40,000.00
GENERAL CONDITIONS					
	Mobilization & Demobilization	L.S.	1	25,000.00	$25,000.00
	Survey, Construction Stakeout	L.S.	1	5,000.00	$5,000.00
	Toilets/Drinking Water	Month	4	200.00	$800.00
	Site Trailer	L.S.	1	20,000.00	$20,000.00
	Testing Laboratory	L.S.	1	5,000.00	$5,000.00
	SUBTOTAL				$830,850.00
	CONTINGENCY (30%)				$249,255.00
	TOTAL COST (ROUNDED TO NEAREST $1,000)				$1,080,000.00

FUSS & O'NEILL, INC.

146 HARTFORD ROAD
MANCHESTER, CONNECTICUT

OPINION OF CONSTRUCTION COST		DATE PREPARED :	20-Mar-07
Type:	**Order of Magnitude**		
PROJECT :	MILLBURY DAM	Field Sketch & Measurements	
LOCATION :	MILLBURY, MA		
DESCRIPTION:	COMPLETE DAM REMOVAL ALTERNATIVE		
DRAWING NO. :		ESTIMATOR : JAZ	CHECKED BY : PWM

OPINION OF CONSTRUCTION COST - ORDER OF MAGNITUDE: An opinion of cost made without detailed engineering data. Costs may be estimated by comparison with similar projects. It is normally expected that an estimate of this type would be accurate within plus 50% or minus 30%. Since Fuss & O'Neill has no control over the cost of labor, materials, equipment or services furnished by others, or over the Contractor(s)' methods of determining prices, or over competitive bidding or market conditions, Fuss & O'Neill's opinion of probable Total Project Costs and Construction Costs are made on the basis of Fuss & O'Neill's experience and qualifiations and represent Fuss & O'Neill's best judgment as an experienced and qualified professional engineer, familiar with the construction industry; but Fuss & O'Neill cannot and does not guarantee that proposals, bids or actual Total Project or Construction Costs will not vary from opinions of probable cost prepared by Fuss & O'Neill. If prior to the bidding or negotiating Phase the Owner wishes greater assurance as to Total Project or Construction Costs, the Owner shall employ an independent cost estimator.

ITEM NO.	ITEM	UNIT MEAS.	NO. UNITS	PER UNIT	TOTAL COST
SITE ACCESS WORK					
02552	Processed Aggregate Base	C.Y.	500	45.00	$22,500.00
SOIL AND EROSION CONTROL					
02291	Sedimentation and Erosion Control	L.S.	1	20,000.00	$20,000.00
02297	Anti-Tracking Apron	L.S.	1	3,000.00	$3,000.00
SITE PREPARATION WORK					
02110	Clearing and Grubbing	L.S.	1	8,000.00	$8,000.00
	Dewatering area	L.S.	1	10,000.00	$10,000.00
WATER CONTROL					
02199	Control of Water	L.S.	1	80,000.00	$80,000.00
DEMOLITION					
	Demolish Spillway	L.S.	1	50,000.00	$50,000.00
EARTHWORK					
	Shape river banks	L.S.	1	50,000.00	$50,000.00
	Former mill channel closeoff	L.S.	1	30,000.00	$30,000.00
BANK STABILIZATION					
	Toe stone (up to 2-yr flood) (2 x 1000' x 3' x 6')	C.Y.	1400	100.00	$140,000.00
	Matting (2 to 5-yr flood) (2 x 1000' x 8')	S.Y.	1800	3.00	$5,400.00
	Vegetative plantings (> 5-yr flood)	L.S.	1	20,000.00	$20,000.00
SEDIMENT MANAGEMENT					
	Dredge and dewater material	C.Y.	8,600	20.00	$172,000.00
	Haul to AMREC (Charlton, 15 miles)	C.Y.	8,600	21.00	$180,600.00
	Tipping fee, Non Hazardous Waste (AMREC)	C.Y.	4,600	40.00	$184,000.00
	Tipping fee, Hazardous Waste	C.Y.	4,000	336.00	$1,344,000.00
SITE STABILIZATION WORK					
	Restore dewatering basin, S&E controls	L.S.	1	10,000.00	$10,000.00
	Riparian Zone Grading & Seeding/Plantings	S.Y.	2,000	20.00	$40,000.00
	RGC at Dorothy Brook confluence	L.S.	1	30,000.00	$30,000.00
GENERAL CONDITIONS					
	Mobilization & Demobilization	L.S.	1	35,000.00	$35,000.00
	Survey, Construction Stakeout	L.S.	1	5,000.00	$5,000.00
	Toilets/Drinking Water	Month	4	200.00	$800.00
	SUBTOTAL				$2,440,300.00
	CONTINGENCY (30%)				$732,090.00
	TOTAL COST (ROUNDED TO NEAREST $1,000)				$3,172,000.00

FUSS & O'NEILL, INC.

146 HARTFORD ROAD
MANCHESTER, CONNECTICUT

OPINION OF CONSTRUCTION COST		DATE PREPARED :	20-Mar-07
Type:	**Order of Magnitude**		
PROJECT :	MILLBURY DAM	Field Sketch & Measurements	
LOCATION :	MILLBURY, MA		
DESCRIPTION:	ROCK RAMP ALTERNATIVE		
DRAWING NO. :		ESTIMATOR : JAZ	CHECKED BY : PWM

OPINION OF CONSTRUCTION COST - ORDER OF MAGNITUDE: An opinion of cost made without detailed engineering data. Costs may be estimated by comparison with similar projects. It is normally expected that an estimate of this type would be accurate within plus 50% or minus 30%. Since Fuss & O'Neill has no control over the cost of labor, materials, equipment or services furnished by others, or over the Contractor(s)' methods of determining prices, or over competitive bidding or market conditions, Fuss & O'Neill's opinion of probable Total Project Costs and Construction Costs are made on the basis of Fuss & O'Neill's experience and qualifiations and represent Fuss & O'Neill's best judgment as an experienced and qualified professional engineer, familiar with the construction industry; but Fuss & O'Neill cannot and does not guarantee that proposals, bids or actual Total Project or Construction Costs will not vary from opinions of probable cost prepared by Fuss & O'Neill. If prior to the bidding or negotiating Phase the Owner wishes greater assurance as to Total Project or Construction Costs, the Owner shall employ an independent cost estimator.

ITEM NO.	ITEM	UNIT MEAS.	NO. UNITS	PER UNIT	TOTAL COST
SITE ACCESS WORK					
02552	Processed Aggregate Base	C.Y.	500	45.00	$22,500.00
SOIL AND EROSION CONTROL					
02291	Sedimentation and Erosion Control	L.S.	1	15,000.00	$15,000.00
02297	Anti-Tracking Apron	L.S.	1	3,000.00	$3,000.00
SITE PREPARATION WORK					
02110	Clearing and Grubbing	L.S.	1	4,000.00	$4,000.00
	Dewatering area	L.S.	1	10,000.00	$10,000.00
WATER CONTROL					
02199	Control of Water	L.S.	1	30,000.00	$30,000.00
DEMOLITION					
	Demolish Spillway	L.S.	1	10,000.00	$10,000.00
EARTHWORK					
	Shape river banks	L.S.	1	20,000.00	$20,000.00
	Former mill channel closeoff	L.S.	1	30,000.00	$30,000.00
BANK STABILIZATION					
	Toe stone (up to 2-yr flood) (1 x 350' x 3' x 6')	C.Y.	230	100.00	$23,000.00
	Matting (2 to 5-yr flood) (2 x 400' x 8')	S.Y.	750	3.00	$2,250.00
	Vegetative plantings (> 5-yr flood)	L.S.	1	10,000.00	$10,000.00
SEDIMENT MANAGEMENT					
	Dredge and dewater material	C.Y.	100	20.00	$2,000.00
	Haul to AMREC (Charlton, 15 miles)	C.Y.	100	21.00	$2,100.00
	Tipping fee, Non Hazardous Waste (AMREC)	C.Y.	-	40.00	$0.00
	Tipping fee, Hazardous Waste	C.Y.	100	336.00	$33,600.00
ROCK RAMP					
	Granular filter material (1 x .5' x 200' x 55')	C.Y.	200	45.00	$9,000.00
	RR Material (1 x 2' x 200' x 55')	C.Y.	820	80.00	$65,600.00
	Wash in point bar material	L.S.	1	10,000.00	$10,000.00
	Boulder garden	E.A.	7	1,000.00	$7,000.00
	Point bar (120' x 25' x 4')	C.Y.	450	40.00	$18,000.00
SITE STABILIZATION WORK					
	Restore dewatering basin, S&E controls	L.S.	1	10,000.00	$10,000.00
	Riparian Zone Grading & Seeding/Plantings	S.Y.	2,000	20.00	$40,000.00
GENERAL CONDITIONS					
	Mobilization & Demobilization	L.S.	1	25,000.00	$25,000.00
	Survey, Construction Stakeout	L.S.	1	5,000.00	$5,000.00
	Toilets/Drinking Water	Month	4	200.00	$800.00
	Site Trailer	L.S.	1	20,000.00	$20,000.00
	Testing Laboratory	L.S.	1	5,000.00	$5,000.00
	SUBTOTAL				$432,850.00
	CONTINGENCY (30%)				$129,855.00
	TOTAL COST (ROUNDED TO NEAREST $1,000)				$563,000.00

FUSS & O'NEILL, INC.

146 HARTFORD ROAD
MANCHESTER, CONNECTICUT

OPINION OF CONSTRUCTION COST		DATE PREPARED :	20-Mar-07
Type:	**Order of Magnitude**		
PROJECT :	MILLBURY DAM	Field Sketch & Measurements	
LOCATION :	MILLBURY, MA		
DESCRIPTION:	STEP POOL ALTERNATIVE		
DRAWING NO. :		ESTIMATOR : JAZ	CHECKED BY : PWM

OPINION OF CONSTRUCTION COST - ORDER OF MAGNITUDE: An opinion of cost made without detailed engineering data. Costs may be estimated by comparison with similar projects. It is normally expected that an estimate of this type would be accurate within plus 50% or minus 30%. Since Fuss & O'Neill has no control over the cost of labor, materials, equipment or services furnished by others, or over the Contractor(s)' methods of determining prices, or over competitive bidding or market conditions, Fuss & O'Neill's opinion of probable Total Project Costs and Construction Costs are made on the basis of Fuss & O'Neill's experience and qualifiations and represent Fuss & O'Neill's best judgment as an experienced and qualified professional engineer, familiar with the construction industry; but Fuss & O'Neill cannot and does not guarantee that proposals, bids or actual Total Project or Construction Costs will not vary from opinions of probable cost prepared by Fuss & O'Neill. If prior to the bidding or negotiating Phase the Owner wishes greater assurance as to Total Project or Construction Costs, the Owner shall employ an independent cost estimator.

ITEM NO.	ITEM	UNIT MEAS.	NO. UNITS	PER UNIT	TOTAL COST
SITE ACCESS WORK					
02552	Processed Aggregate Base	C.Y.	500	45.00	$22,500.00
SOIL AND EROSION CONTROL					
02291	Sedimentation and Erosion Control	L.S.	1	15,000.00	$15,000.00
02297	Anti-Tracking Apron	L.S.	1	3,000.00	$3,000.00
SITE PREPARATION WORK					
02110	Clearing and Grubbing	L.S.	1	4,000.00	$4,000.00
	Dewatering area	L.S.	1	10,000.00	$10,000.00
WATER CONTROL					
02199	Control of Water	L.S.	1	30,000.00	$30,000.00
DEMOLITION					
	Demolish Spillway	L.S.	1	10,000.00	$10,000.00
EARTHWORK					
	Shape river banks	L.S.	1	20,000.00	$20,000.00
	Former mill channel closeoff	L.S.	1	30,000.00	$30,000.00
BANK STABILIZATION					
	Toe stone (up to 2-yr flood) (1 x 350' x 3' x 6')	C.Y.	230	100.00	$23,000.00
	Matting (2 to 5-yr flood) (2 x 400' x 8')	S.Y.	750	3.00	$2,250.00
	Vegetative plantings (> 5-yr flood)	L.S.	1	10,000.00	$10,000.00
SEDIMENT MANAGEMENT					
	Dredge and dewater material	C.Y.	100	20.00	$2,000.00
	Haul to AMREC (Charlton, 15 miles)	C.Y.	100	21.00	$2,100.00
	Tipping fee, Non Hazardous Waste (AMREC)	C.Y.	-	40.00	$0.00
	Tipping fee, Hazardous Waste	C.Y.	100	336.00	$33,600.00
STEP POOL					
	Granular filter material (7 x .5' x 50' x 25')	C.Y.	165	55.00	$9,075.00
	Pool pavement material (7 x 2' x 50' x 25')	C.Y.	650	65.00	$42,250.00
	Foundation stone (7 x 2' x 4' x 65')	C.Y.	140	110.00	$15,400.00
	Weir stone (7 x 4' x 4' x 65')	C.Y.	270	140.00	$37,800.00
	Bank tie-in	L.S.	1	20,000.00	$20,000.00
	Point bar (130' x 20' x 4')	C.Y.	400	40.00	$16,000.00
SITE STABILIZATION WORK					
	Restore dewatering basin, S&E controls	L.S.	1	10,000.00	$10,000.00
	Riparian Zone Grading & Seeding/Plantings	S.Y.	2,000	20.00	$40,000.00
GENERAL CONDITIONS					
	Mobilization & Demobilization	L.S.	1	25,000.00	$25,000.00
	Survey, Construction Stakeout	L.S.	1	5,000.00	$5,000.00
	Toilets/Drinking Water	Month	4	200.00	$800.00
	Site Trailer	L.S.	1	20,000.00	$20,000.00
	Testing Laboratory	L.S.	1	5,000.00	$5,000.00
	SUBTOTAL				$463,775.00
	CONTINGENCY (30%)				$139,132.50
	TOTAL COST (ROUNDED TO NEAREST $1,000)				$603,000.00