Attachment 11

Main Street Draft Geotechnical Report – ECS 2008

WHERE BUSINESS AND THE ENVIRONMENT CONVERGE

GEOTECHNICAL ASSESSMENT REPORT - DRAFT

Main Street Dam Fish Ladder
Main Street, Pawtucket, RI

>
Prepared for:
Mr. Thomas Cook
EA Engineering, Science and Technology
2350 Post Road
Warwick, RI 02886

>
Project No. 05-208817.00
August 13, 2008

>
Prepared by:
Environmental Compliance Services, Inc. (ECS)
607 North Avenue, Suite 11
Wakefield, MA 01880
tel 781.246.8897 fax 781.246.8950
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ATTACHMENTS

ecs
WHERE BUSINESS AND THE ENVIRONMENT CONVERGE

607 North Avenue, Suite 11, Wakefield, MA 01880 tel 781.246.8897 fax 781.246.8950 www.ecsconsult.com

13 August 2008
Project No. 05-208817.00

Mr. Thomas Cook
EA Engineering, Science and Technology
2350 Post Road
Warwick, RI 02886

RE: Geotechnical Assessment
Report - DRAFT
Main Street Dam Fish Ladder
Main Street
Pawtucket, RI

Dear Mr. Cook:

Environmental Compliance Services, Inc. (ECS) is pleased to present the following geotechnical assessment report regarding historical geologic records review and geotechnical recommendations as they relate to the foundation and earthwork construction for the proposed fish ladder at the Main Street Dam located at Main Street in Pawtucket, Rhode Island. This historical data review and geotechnical recommendations report was performed in accordance with ECS Proposal No. 05-208817.P dated 18 July 2007 and our revised scope of work dated 3 June 2008. Limitations apply to this report as outlined in Attachment I.

The objective of the assessment was to determine existing conditions within the proposed construction area and to evaluate those conditions at the Main Street Dam to develop geotechnical recommendations for the design and construction of the foundation for the proposed fish ladder.

1.0 PROJECT DESCRIPTION

Fish passage in the lower Blackstone River is currently obstructed by three mill dams. Preliminary surveys by state and federal fisheries biologists have found suitable habitat and conditions for river herring (blueback herring and alewife), American shad and Atlantic salmon in the Blackstone River. The Natural Resources Conservation Service (NRCS) has entered into contracts with three of the dam owners to install fish passage through or adjacent to their dams. The three facilities are: Main Street Dam (Pawtucket Hydro Power), Slater Mill Dam (Historic Slater Mill), and Valley Falls Dam (Blackstone Hydro Power).

This geotechnical assessment report presents a geotechnical engineering evaluation with regards to foundation design for the fish ladder structure at the Main Street Dam. Slater Mill Dam and Valley Falls Dam geotechnical evaluations are presented in separate reports.

Where utilized, all elevations in this report reference the National Geodetic Vertical Datum (NGVD) of 1929 and are in feet (ft).

2.0 DETAILED SCOPE OF SERVICES

The Geotechnical Assessment Scope of Work (SOW) includes conducting geotechnical evaluation and foundation design services in regards to the fish ladder foundation construction. The SOW includes the preparation of a draft and final geotechnical report, which will include EA Engineering, Science and Technology (EA) comments. The geotechnical assessment reports will include the following:

- Historical Research Review of available documents.
- Foundation Design Considerations (design groundwater level, allowable soil bearing capacity, recommended foundation type, lateral earth pressures for foundation and retaining walls, liquefaction potential, and seismic considerations for structural design).
- Site Preparation, Excavation, and Backfilling Considerations.
- Recommendations (foundation type and in-situ testing).
- Assessment of existing rock (bearing, shear).
- Recommendations for anchoring fishway footings (Potentially rock anchors may be used to hold fishway piers in place). Anchor sizes and embedment lengths should be included in the report. The Client will provide horizontal and vertical forces and bending moments for design.
- Recommendations for sections to be included in Project Technical Specifications including geotechnical engineering support during rock excavation and shear pin placement (as necessary). Rock anchor installation, anchor installation requirements, and anchor testing.

3.0 DESCRIPTION OF SITE, GEOLOGY, AND PROPOSED CONSTRUCTION

3.1 DESCRIPTION OF SITE

The Main Street Dam is located along the Blackstone River adjacent to Pawtucket Hydro Power and the Main Street Bridge at the intersection of Roosevelt Avenue and Main Street in Pawtucket, Rhode Island. A Site Locus is provided as Figure 1 and a Site Photograph is provided as Figure 2.

3.2 GEOLOGY

The major bedrock group at the site is sedimentary rocks of the Narragansett Basin Group, locally known as the Rhode Island Formation. The Narragansett Basin Group occurs as a broad band, roughly 6 to 10 miles wide, and occupies the lowland area extending from southeastern Massachusetts, through the East Providence-Barrington-Warren-Bristol area, Providence, and west shore coastal areas to Narragansett. These rocks underlie Narragansett Bay and comprise large parts of the bay islands: Prudence, Conanicut Island (Jamestown), and Aquidnick Island (Newport/Middletown/Portsmouth). The constituent members of the formation include sandstones, shales, graphitic shale, conglomerates, and local coal seams (Portsmouth and Garden City in Cranston). However, at any locale, the rock should be expected to show great stratigraphic variability both laterally and with depth. The Narragansett Basin Group rocks tend to be less resistant to erosion and glacial scour in comparison to other rock formations in Rhode Island. Rock surface elevations can be highly variable within relatively short distances.

In general the overburden soils in Rhode Island are dominated by glacial till and outwash deposits. The distribution of the four general geologic soil types found in the state are as follows: upland till plains,

Narragansett till plains, end moraines, and outwash deposits. Glacial till is found over much of the eastern and western parts of the state. Outwash deposits are found near Providence, along the western edge of the Bay, and in southern Rhode Island. End moraines run east-west along the southern end of the state in Westerly and Charlestown and in Block Island. A fifth category of soil-types includes those that have been deposited since the end of the last glaciation. These soil-types may consist of alluvium, marine deposits, organic soils, and fill.

Where present, the soils at the site are expected to consist predominantly of glacial outwash, to a lesser extent glacial till, overlain by man-made fill.

3.3 PROPOSED CONSTRUCTION

The project involves the construction of a concrete fish ladder to be located at the Main Street Dam along river right (facing up river), adjacent to the existing retaining wall and bridge pier, and will terminate underneath the Main Street bridge. Typical dimensions of the fish ladder are approximately 4-ft wide, extend from the proposed fish ladder entrance, approximately 80-ft down stream of the base of the dam, to an additional approximately 115-ft down stream, at an 8 horizontal to 1 vertical (8H:1V) slope, double back 180 degrees up stream approximately 135-ft at an 8H:1V slope to the fish ladder exit at the crest of the dam. The fish ladder entrance and exit channels are to be level and designed such that there is a minimum of 2-ft of water depth at minimum pool operating levels. Based upon the 30 percent design drawings provided by EA, the down stream top of slab for the entrance turning pool is estimated to be Elevation (EL) -4.00-ft, the top of slab for the 180 degree turning pool is estimated to be EL 5.69-ft, and the top of slab for the fish ladder exit at the dam crest is estimated to be EL 15.06-ft. Based upon a review of the 30 percent design drawings, the foundation base for the fish ladder structure is to have a thickness of approximately 12-inches.

4.0 SUBSURFACE EXPLORATION PROGRAM

At the time of the report, a subsurface exploration program was not conducted for this geotechnical engineering evaluation and assessment. Due to existing site constraints, limited accessibility, and limited benefit to cost, a subsurface test boring and/or rock coring program was determined not to be economically feasible at this time for this project. Accordingly, the present evaluation is based on the historical document review, the site reconnaissance done by EA and ECS, and the data made available to ECS by EA.

5.0 GEOTECHNICAL FOUNDATION ASSESSMENT

This section provides geotechnical recommendations for foundation design of the proposed fish ladder. Based upon the 30 percent Main Street Dam design drawings provided by EA the top of exposed rock at the site ranges in elevation from approximately EL 13-ft at the base of the dam to approximately EL. -15-ft along the down stream legs of the fish ladder. The bedrock river bottom at the proposed location of the fish ladder is highly variable in elevation, with 5-ft elevation differences along the down stream portion of the fish ladder to approximately 25-ft elevation differentials at the upstream portion of the fish ladder. The dam crest is at approximately EL 14-ft. As noted on Drawing No. C-4 (sheet 5 of 9), at the anticipated top of slab elevations for the fish ladder exit, turning pool, and entrance elevation (EL 15.06-ft, 5.69-ft, and -4.00-ft, respectively) the proposed concrete fish ladder structure foundation elements may be founded upon the existing bedrock.

For design purposes, it is assumed that the proposed fish ladder will not derive structural support from the dam, abutments, and/or other features of the existing dam at the site.

Foundation design shall meet the requirements of the Rhode Island State Building Code (Ninth Edition). Since the project design-development is at an early phase during the preparation of this report, ECS should be given the opportunity to review drawings and specifications upon further development, especially if revisions are made to the present structural arrangement.

5.1 FOUNDATION SUPPORT

Bedrock outcroppings were observed at the site during the site reconnaissance activities conducted by EA and based upon ECS' review of the available historical geologic literature, ECS recommends that the existing bedrock (the sandstone) at the site is a suitable bearing surface (upon subgrade preparation) for support of the fish ladder structure. The strength and stress deformation characteristics of the rock mass present at the Main Street Dam were considered to be 'average' or mean properties for the predominant rock type of the area, the sandstone. As the fish ladder will have a lightly loaded foundation and will be supported directly by rock, we recommend a maximum allowable design bearing stress of 8,000 psf.

Prior to placement of concrete for the fish ladder foundation system, the foundation bedrock subgrade should be cleared of any loose debris and rock until solid, stable bedrock is encountered. Foundation bearing surfaces as well as the poured concrete should be protected against frost if construction occurs during cold weather.

Based upon the general stratigraphy within the fish ladder area, the anticipated magnitude of the fish ladder loads, and construction utilizing a foundation system bearing on the existing bedrock, it is our opinion that the total and differential settlement due to the weight of the fish ladder structure, should be quite small (i.e., corresponding to elastic deformations alone). This conclusion is contingent upon the fish ladder structure bearing directly upon hard and sound rock.

5.2 TYPES OF FOUNDATION SUPPORT

As bedrock outcroppings were visible at the Main Street Dam during site reconnaissance conducted by EA and ECS, reinforced concrete footings are considered suitable for the support of the fish ladder structure elevated by concrete piers. Considering the bedrock river bottom surface profile in the 30 percent design drawings for the Main Street Dam and the fish ladder configuration design elevations, there may be nine (9) footings. We anticipate that the footings may be constructed adequately with favorable construction dewatering measures.

5.2.1 Grout Bag Leveling Mat Footing (Option 1)

The 30 percent design drawings present a grout bag leveling mat footing foundation for the support of the fish ladder structure elevated by concrete piers. It is anticipated that this footing option would be considered should there not be favorable dewatering measures for construction.

We anticipate that there will be a reduction in the sliding resistance between the bedrock subgrade and the geotextile of the grout bag leveling mat. The detailed design elements should be developed and evaluated together with the Structural Engineer designing the fish ladder during the next design phase. Functional pier geometry may control foundation support dimensions.

5.2.2 Hybrid Concrete Footing (Option 2)

An alternative foundation type would be to utilize a reinforced concrete 'hybrid' footing formed and poured directly upon exposed bedrock to support the fish ladder structure elevated by concrete piers. This footing option may be constructed with adequate dewatering methods to work 'in-the-dry' (such as a cofferdam and localized construction dewatering by collection sumps and pumping out within a localized cofferdam area) for preparation of rock subgrades for the construction of the footing. Functional pier geometry may control foundation support dimensions.

5.2.3 Pile 'Bents' [Drilled-in Shafts] (Option 3)

An additional alternative foundation type would be to utilize pile 'bents', where each 'bent' will have one or two rock-socketed drilled shafts into the bedrock to support the fish ladder structure elevated by concrete piers. The drilled-in shafts may extend as columns to support the fish ladder. The shaft-column elements may have a permanent steel casing, if necessary. This option may be constructed 'in-the-wet' utilizing land and water (a barge). Functional pier geometry may control foundation support dimensions. The detailed design of the 'bents' rock-socketed shaft-column (pier) elements should be developed together with the Structural Engineer design the fish ladder during the next design phase.

The selected foundation design alternative should be designed and constructed in accordance with the Rhode Island State building code.

5.3 GENERAL FOUNDATION DESIGN (GEOTECHNCIAL) CONSIDERATIONS

As this is an early phase of project development, foundation support system specific construction considerations for technical specifications is not feasible until a support system and fish ladder structural loadings have been finalized by the design team.

5.4 SEISMIC (GEOTECHNICAL) CONSIDERATIONS

ECS has evaluated the site seismic parameters in accordance with the Rhode Island State Building Code (Code). ECS has established that the proposed fish ladder structure meets general requirements of Seismic Use Group I, of the Code. Based upon the existing bedrock, the site meets the general parameters of Site Class B. Additionally, seismic coefficients for short periods (S_S) and one second period (S_1) of 0.236g and 0.061g, respectively, should be utilized for the site, per the Code.

5.4.1 Liquefaction

The project site would not be considered susceptible to liquefaction.

5.5 LATERAL PRESSURE FOR WALLS OF THE FISH LADDER

As the fish ladder will be located within the Blackstone River, the upstream portions of the fish ladder may be subject to lateral static and dynamic water forces, drag forces along the sides of the fish ladder, and negative suction forces at the downstream end of the fish ladder structure. Lateral hydrostatic

pressures acting on the fish ladder structure may be utilized as follows:

Coefficient of Hydrostatic Pressure:	K = 1
Rock Unit Weight:	γ = 150 pcf
Unit Weight of Water:	γ_w = 62.4 pcf

Additionally, due to the location of the fish ladder structure within and adjacent to the river, erosion control measures, such as the installation of a rip-rap slope, scour control, should be considered along the exposed side(s) of the downstream leg(s) of the fish ladder structure.

6.0 SITE PREPARATION, EXCAVATION, AND BACKFILL CONSIDERATIONS

Based upon a review of the 30 percent design drawings provided by EA, localized removal of bedrock will be required to achieve the proposed fish ladder structure layout and foundation element subgrades at this site. A review of the drawdown photographs provided by EA indicates that removal of miscellaneous debris and loose rock may be required to reach hard and sound bedrock. It should be noted that visual observation of down stream portions of the river bed along the proposed fish ladder alignment were not possible during the drawdown activities due to water accumulation within the variable topography of the bedrock down stream of the dam.

6.1 EXCAVATION TECHNIQUES AND SUPPORT

During rock removal and excavation for the fish ladder foundation open cut excavation techniques may be utilized. Excavation for the foundation system should proceed until sound, solid bedrock has been reached and should proceed in a controlled manner in accordance with the project specifications.

For excavations completely within granular layers (OSHA Type C) that exceed depths of 4-ft, earth slopes should not exceed 1.5 horizontal to 1 vertical (1.5H: 1V). Excavations and trenching should be performed in accordance with OSHA regulations (29 CFR 1926).

Excavations adjacent to existing structures should be properly shored to prevent shifting and/or settlement of these structures. Underpinning existing foundations is recommended for any excavation that extends below and is within a horizontal distance equal to 1.5 times the cut below adjacent foundation subgrades. Shoring and underpinning should be designed by a professional engineer licensed in the state of Rhode Island.

6.2 TEMPORARY DEWATERING

As the fish ladder is proposed to be located within the river and to be interfaced with the existing dam structure, it is anticipated that dewatering during certain phases of foundation and fish ladder construction will be necessary. Measures should be taken to control water seepage, precipitation, infiltration, and river water inflow within the excavation to minimize disturbance, maintain the integrity of bearing surfaces, and permit foundation construction to proceed in-the-dry. It is likely that a localized temporary cofferdam type structure will be necessary during fish ladder construction activities at the Main Street Dam. Additionally, it is anticipated that the Pawtucket Hydro Power facility will be available to assist with diversion of a portion of the river flow through its facility during the construction phase.

The Contractor should select whichever dewatering method is most familiar and cost-effective while at the same time meeting the requirement to maintain a dry and stable excavation bottom during foundation construction.

6.3 BACKFILLING

As the fish ladder is proposed to be located within the river and founded directly upon bedrock, it is likely that backfilling activities will not be necessary for the construction of the Main Street Dam fish ladder.

Should backfill be required for construction, foundation elements should be supported upon crushed stone meeting the following requirements and upon review by the Engineer:

Crushed Stone

Sieve Size	Percent Finer by Weight
1 - inch	100
3/4 - inch	90-100
1/2 - inch	10-50
3/8 - inch	0-20
No. 4	0-5

Crushed stone should be durable crushed stone or crushed gravel stone, free of ice, snow, sand, silt, clay, loam, shale, or other deleterious matter. All crushed stone backfill beneath the fish ladder structure should be placed in loose lifts not exceeding 12-inches in thickness and compacted to at least 95 percent (%) of the maximum dry density per ASTM D1557, Method D. The backfill outside of the fish ladder limits should be compacted to a minimum of 92% of the maximum dry density. The percent compaction is determined in the field by ASTM D-1556 or ASTM D-2167.

7.0 RECOMMENDATIONS

ECS has identified the following items concerning foundation design and construction of the proposed fish ladder structure at the Main Street Dam that should be considered during the design phases:

1. As a fish ladder is a lightly loaded structure and its foundation will bear on bedrock, a subsurface exploration is not justified at this phase of its design-development. The costs associated with a drilling and rock coring program within an active river would be extensive.
2. A foundation system bearing directly upon solid and sound bedrock is recommended for this site.
3. As the fish ladder structure has a relatively lightly loaded foundation, a conservative presumptive allowable bearing stress from geotechnical literature for a foundation bearing on hard and sound sandstone bedrock (8,000 psf) is more than adequate to support the fish ladder structure and provides an ample factor of safety relative to bearing capacity.
4. A reinforced concrete footing foundation system is considered suitable to support the fish ladder structure for this site. Individual piers will be supported by their respective footings.

5. Considering the relatively variable topography of the bedrock river bed surface as an alternative, we recommend that the fish ladder structure at this site be supported by piles (shafts) socketed into the bedrock.
6. It is anticipated that a reduction in sliding resistance between the grout mat bags and the bedrock and between the reinforced concrete piers and the grout mat bags may be an issue in relation to overcoming sliding forces.
7. Based upon a review of the 30 percent design drawings provided by EA, a portion of the proposed fish ladder structure will be constructed and located under the Main Street Bridge. Therefore, the 'headroom' (towards the southeasterly arch support) available for construction should be reviewed. Where construction requires rig to operate under the bridge (i.e., for rock anchoring), the allowable headroom should be pre-established.
8. Based upon a review of the 30 percent design drawings provided by EA, in combination with observation of the rock outcrops in the river bed and abutting the Main Street bridge abutment (towards the southeasterly arch support), rock excavation for construction of the proposed fish ladder structure will be critical as rock removal (i.e., blasting, hoe-ramming, etc.) will be necessary based upon the proposed alignment. The effect of rock removal at the relatively close distance to the bridge abutment should be under very close control. Pre-construction baseline and construction vibration monitoring during rock removal activities should be pre-established.

7.1 DESIGN REVIEW

Since the project design-development is at an early phase (30 percent design) during the preparation of this report, ECS should be given the opportunity to review drawings and specifications upon further development, especially if revisions are made to the present structural arrangement. Additionally, upon selection of a foundation support system by the design team, ECS would be pleased to assist with preparation of a technical specification(s).

7.2 CONSTRUCTION QUALITY CONTROL

It is recommended that a Geotechnical Engineer or their representative be retained to provide engineering construction observation services during the excavation and foundation construction phases of the fish ladder. Construction phase engineering oversight will be of particular importance relative to the monitoring of foundation excavation, rock removal, and inspection of foundation excavations prior to concrete pours.

The Geotechnical Engineer should be retained by the Owner to observe and record accurate records regarding verification of subgrade materials during foundation excavation, verification that sound bedrock has been reached, verification of installation of foundation system elements as specified within the Project Specifications and Drawings, and as necessary types of backfill materials used, thickness of lifts, densities, percent compaction, type of compaction equipment and number of coverages, etc. Backfill compaction to be in accordance with the requirements of these recommendations which should be incorporated into the project specifications. ECS will be pleased to assist serving as the Geotechnical Engineer during the construction phase.

ECS appreciates the opportunity to assist EA Engineering, Science, and Technology, Inc. with its geotechnical consulting needs and look forward to our continued association with you on this project.

Should you have any questions concerning this report or require clarification of the above recommendations, please feel free to contact our office.

Sincerely,
Environmental Compliance Services, Inc.

Jennifer M. Rauch
Project Manager

Peer Reviewed By:
Cetin Soydemir, Ph.D., P.E.
Senior Geotechnical Consultant
Geotechnical Services, Inc.

w/ attachments:

FIGURES

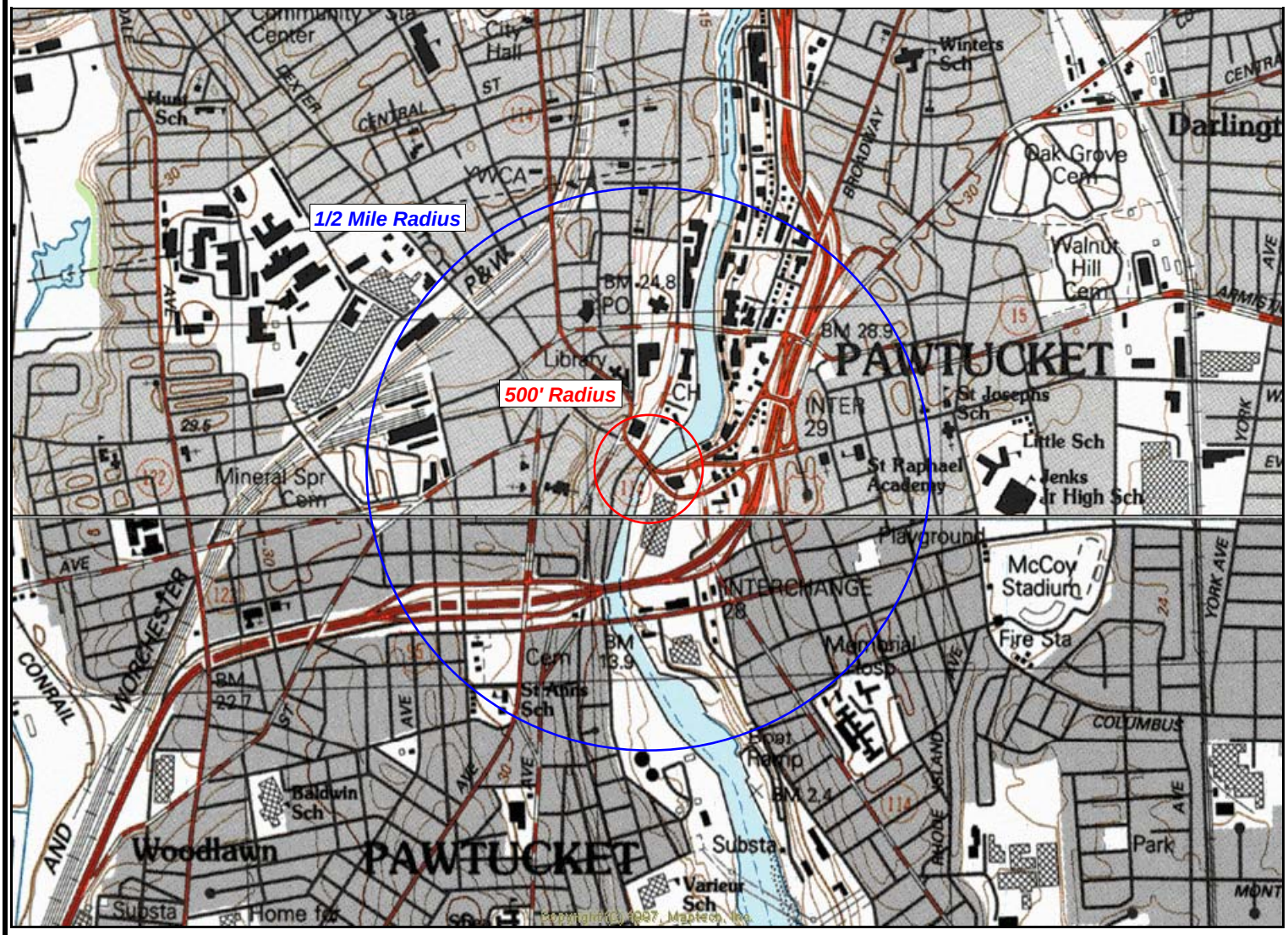
Environmental Compliance Services, Inc.
607 North Avenue, Wakefield, MA 01880
Phone (781)-246-8897 Fax (781)-246-8950
www.ecsconsult.com

SITE LOCUS

Figure: 1

Main Street Dam Fish Ladder
Main Street
Pawtucket, RI
02860

Job Number: 05-208817



1 | 1/2 | 0 | 1 Mile

1 inch = 1500 feet

Contour Interval: 3 Meters

North

Base Map: U.S. Geological Survey; Quadrangle Location: Attleboro

UTM Coordinates: 19 0302169 East / 46 38562 North

Map Edited: 1987 *Map Revised: none* *Generated By: JMR*

ecs
607 North Avenue Suite 11 * Wakefield, MA 01880
Phone: 781-246-8697 Fax: 781-246-8950

CLIENT:
EA ENGINEERING, SCIENCE & TECHNOLOGY, INC.

GRAPHIC SCALE:
0 #

PROJECT:
MAIN STREET DAM FISH LADDER
MAIN STREET
PAWTUCKET, RHODE ISLAND

TITLE:
SITE PHOTOGRAPH

COMPUTER CADFILE :05-208817 FIG 2 MAIN STREET PHOTO

DRAWN BY:	DESIGNED BY:	CHECKED BY:	APPROVED BY:
JMR	-	CS	JMR
SCALE:	DATE:	JOB NO.:	FIGURE NO.:
N.T.S.	AUG. 2008	05-208817	2

LIMITATIONS

Explorations
The analyses and recommendations submitted in this report are based in part upon the data obtained from a limited number of subsurface explorations which were based upon the project scope of work and understanding. The nature and extent of variations between these explorations may not become evident until construction. If variations then appear evident, it may be necessary to reevaluate the recommendations of this report.

The generalized soil profile described in the text of this report is intended to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized and have been developed within the text of this report, by interpretations of widely spaced explorations and samples; actual soil transitions are probably more erratic. For specific information, refer to the test boring logs.

Water level readings have been made in the explorations under conditions stated on the enclosed logs. These data have been reviewed and interpretations have been made in the text of this report. However, it must be noted that fluctuations in the level of groundwater may occur due to variations in rainfall, temperature and other factors occurring since the time observations were made.

Review
It is recommended that ***Environmental Compliance Services, Inc. (ECS)*** be provided the opportunity to review the final design plans and specifications to evaluate the appropriate implementation of the recommendations provided herein.

In the event that any changes in the proposed general project development are planned (e.g., building footprint size and location, etc.), the conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed and conclusions of this report are modified or verified in writing by ***ECS.***

Construction
It is also recommended that ***ECS*** be provided the opportunity to perform the recommended construction phase monitoring services to verify that the intent of our recommendations is being properly implemented in the field during construction.

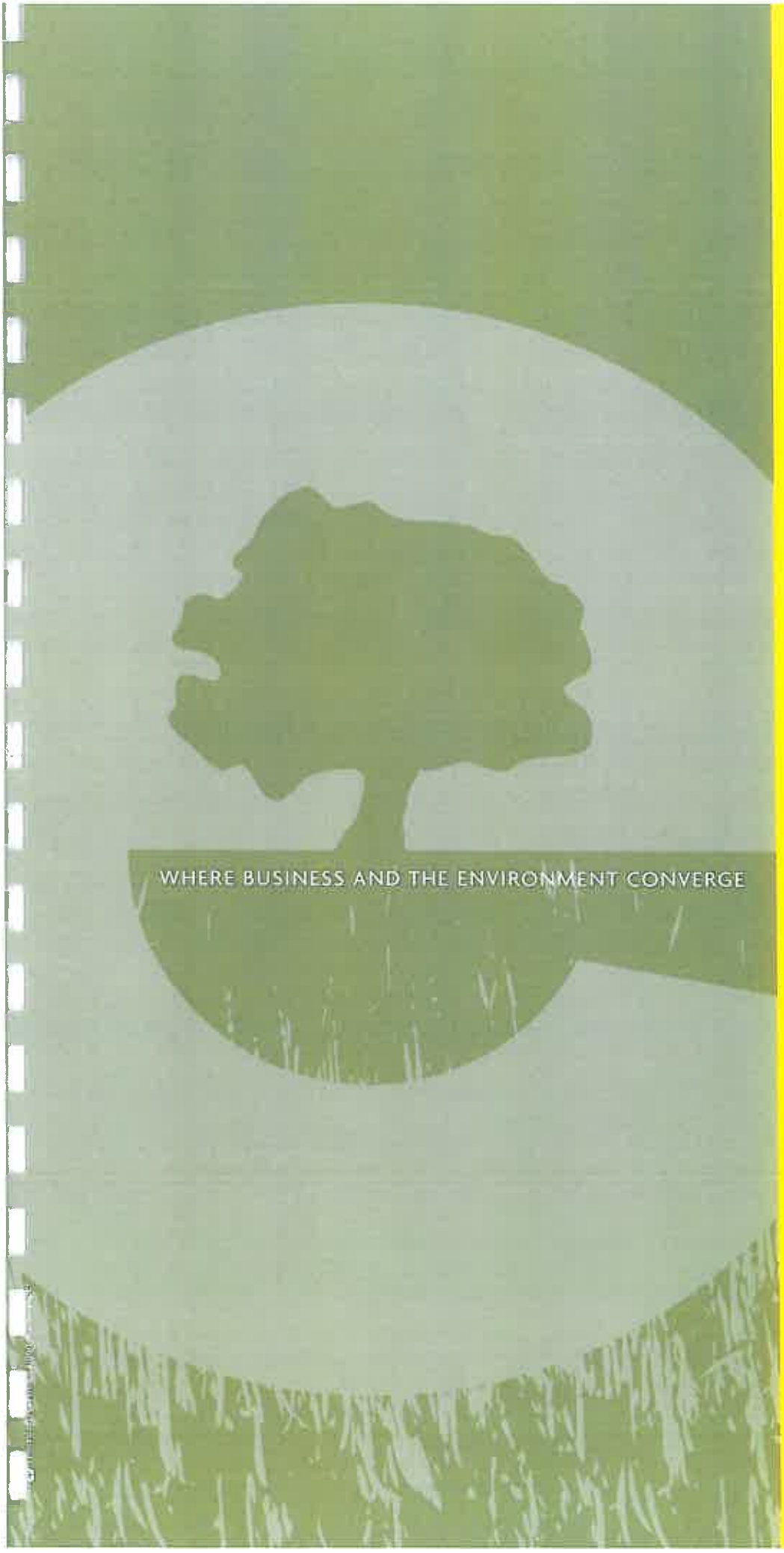
Topographic Data
This report is based on topographic data developed by others referenced herein unless otherwise noted in the report text. No warranty, expressed or implied, is made as to the accuracy of topographic data developed by others.

Use of Report
This Geotechnical Engineering Report has been prepared by ECS for the exclusive use of ***EA Engineering, Science and Technology, Inc.*** in reference to the ***Slater Mill Dam Fish Ladder, located at 67 Roosevelt Avenue, in Pawtucket, Rhode Island*** and is intended to be in accordance with generally accepted soil and foundation engineering practices. No other warranty, expressed or implied is made.

The soil and foundation engineering information presented in this report contains specific interpretations and conclusions of subsurface conditions encountered at the site, which is based upon the project understanding, that are recommended to be incorporated into the final design documents. When incorporated into and used in conjunction with the Contract Documents (drawings and specifications), the conclusions and recommendations presented in this Geotechnical Report provide specific information which the Contractor can utilize to plan/execute the proposed site work. Contractors wishing a copy of the report may obtain it only with the authorization of the Owner and with the understanding that its scope is limited to recommended considerations for the design and construction of the proposed facility.

Attachment 12

Slater Mill Final Geotechnical Report – ECS 2008



GEOTECHNICAL ASSESSMENT REPORT - FINAL

SLATER MILL DAM
67 ROOSEVELT AVENUE
PAWTUCKET, RI

>
Prepared for:
Mr. Thomas Cook
EA Engineering
2350 Post Road
Warwick, RI 02886

>
Project No. 05-208817.00
July 28, 2008

Prepared By:
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Mr. Thomas Cook
EA Engineering, Science and Technology
2350 Post Road
Warwick, RI 02886

28 July 2008
Project No. 05-208817.00

RE: Geotechnical Assessment Report - FINAL
Slater Mill Dam
67 Roosevelt Avenue
Pawtucket, RI

Dear Mr. Cook:

Environmental Compliance Services, Inc. (ECS) is pleased to present the following geotechnical assessment report regarding historical geologic records review and geotechnical recommendations as they relate to the foundation and earthwork construction for the proposed fish ladder at the Slater Mill Dam located at 67 Roosevelt Avenue in Pawtucket, Rhode Island. The historical data review and geotechnical recommendations report were performed in accordance with ECS Proposal No. 05-208817.P dated 18 July 2007 and our revised scope of work dated 3 June 2008.

The objective of the assessment was to determine existing conditions within the proposed construction area and to evaluate those conditions at the Slater Mill Dam to develop geotechnical recommendations for the design and construction of the foundation for the proposed fish ladder.

1.0 PROJECT DESCRIPTION

Fish passage in the lower Blackstone River is currently obstructed by three mill dams. Preliminary surveys by state and federal fisheries biologists have found suitable habitat and conditions for river herring (blueback herring and alewife), American shad and Atlantic salmon in the Blackstone River. The Natural Resources Conservation Service (NRCS) has entered into contracts with three of the dam owners to install fish passage through or adjacent to their dams. The three facilities are: Main Street Dam (Pawtucket Hydro Power), Slater Mill Dam (Historic Slater Mill), and Valley Falls Dam (Blackstone Hydro Power).

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Where utilized, all elevations in this report reference the Nation Geodetic Vertical Datum (NGVD) of 1929 and are in feet.

2.0 DETAILED SCOPE OF SERVICES

The Geotechnical Assessment Scope of Work (SOW) includes conducting geotechnical evaluation and foundation design services in regards to the fish ladder foundation construction. The SOW includes the preparation of a draft and final geotechnical report, which will include EA Engineering, Science and Technology (EA) comments. The geotechnical assessment reports will include the following:

- Historical Research Review of available documents.
- Foundation Design Considerations (design groundwater level, allowable soil bearing capacity, recommended foundation type, lateral earth pressures for foundation and retaining walls, liquefaction potential, and seismic considerations for structural design).
- Site Preparation, Excavation, and Backfilling Considerations.
- Recommendations (foundation type and in-situ testing).
- Assessment of existing rock (bearing, shear).
- Recommendations for anchoring fishway footings (shear pins if needed since existing rock will be removed and the entire fishway will be on rock). The Client will provide horizontal forces for design.
- Recommendations for sections to be included in Project Technical Specifications including geotechnical engineering support during rock excavation and shear pin placement (as necessary). Rock anchor installation, anchor installation requirements, and anchor testing.

3.0 DESCRIPTION OF SITE, GEOLOGY, AND PROPOSED CONSTRUCTION

3.1 DESCRIPTION OF SITE

The Slater Mill Dam is located along the Blackstone River adjacent to the Historic Slater Mill at 67 Roosevelt Avenue in Pawtucket, Rhode Island. Slater Mill Dam was constructed in 1793 and spans the width of the Blackstone River at the Slater Mill. As ECS understands, the Slater Mill Dam is constructed of wood timbers. A Site Locus is provided as Figure 1 and an Aerial Map is provided as Figure 2.

3.2 GEOLOGY

The major bedrock group at the site is sedimentary rocks of the Narragansett Basin Group, locally known as the Rhode Island Formation. The Narragansett Basin Group occurs as a broad band, roughly 6 to 10 miles wide, and occupies the lowland area extending from southeastern Massachusetts, through the East Providence-Barrington-Warren-Bristol area, Providence, and west shore coastal areas to Narragansett. These rocks underlie Narragansett Bay and comprise large parts of the bay islands: Prudence, Conanicut Island (Jamestown), and Aquidnick Island (Newport/Middletown/Portsmouth). The constituent members of the formation include sandstones, shales, graphitic shale, conglomerates, and local coal seams (Portsmouth and Garden City in Cranston). However, at any locale, the rock should be expected to show great stratigraphic variability both laterally and with depth. The Narragansett Basin Group rocks tend to be less resistant to erosion and glacial scour in comparison to other rock formations in Rhode Island. Rock surface elevations can be highly variable within relatively short distances.

In general the overburden soils in Rhode Island are dominated by glacial till and outwash deposits. The distribution of the four general geologic soil types found in the state are as follows: upland till plains, Narragansett till plains, end moraines, and outwash deposits. Glacial till is found over much of the eastern and western parts of the state. Outwash deposits are found near Providence, along the western edge of the Bay, and in southern Rhode Island. End moraines run east-west along the southern end of the state in Westerly and Charlestown and in Block Island. A fifth category of soil-types includes those that have been deposited since the end of the last glaciation. These soil-types may consist of alluvium, marine deposits, organic soils, and fill.

Where present, the soils at the site are expected to consist predominantly of glacial outwash, to a lesser extent glacial till, overlain by man-made fill.

3.3 PROPOSED CONSTRUCTION

The project involves the construction of a concrete fish ladder to be located at the Slater Mill Dam along river right (facing up river), adjacent to the existing stone retaining wall. Fish ladders are a method that provides the passage of water down in a manner that allows fish to swim up stream around an existing dam, when dam removal is not feasible. Fish ladders provide a pathway around the dam to good fish spawning habitat further up river. Typical dimensions of the fish ladder are approximately 4-feet (ft) wide, extend from the proposed fish ladder entrance at the base of the dam approximately 58-ft down stream, at an 8 horizontal to 1 vertical (8H:1V) slope, double back 180 degrees up stream approximately 70-ft at an 8H:1V slope to the fish ladder at the crest of the dam. The fishways entrance and exit channels are to be level and designed such that there is a minimum of 2-feet of water depth at minimum pool operating levels. Based upon the 30 percent design drawings provided by EA, the down stream top of slab for the entrance turning pool is estimated to be Elevation (EL) 15.10-ft, the top of slab for the 180 degree turning pool is estimated to be EL 18.54-ft, and the top of slab for the fish ladder exit at the dam crest is estimated to be El 21.0-ft. Based upon a review of the 30 percent design drawings, the foundation base for the fish ladder structure is to have a thickness of approximately 12-inches.

4.0 SUBSURFACE EXPLORATION PROGRAM

At the time of the report, a subsurface exploration program was not conducted for this geotechnical engineering evaluation and assessment. Due to existing site constraints, limited accessibility, and limited benefit to cost, a subsurface test boring and/or rock coring program was determined to not be economically feasible at this time for this project. Accordingly, the present evaluation is based on the historical document review, the site reconnaissance done by EA and ECS, and the data made available to ECS by EA.

5.0 GEOTECHNICAL FOUNDATION ASSESSMENT

This section provides geotechnical recommendations for foundation design of the proposed fish ladder structure. Based upon the 30 percent Slater Mill Dam design drawings provided by EA the top of exposed rock at the site ranges in elevation from approximately EL 16-ft at the down stream portion of the fish ladder to approximately EL 23-ft at the upstream portion of the fish ladder. The dam crest is at approximately EL 23.47-ft. As noted on Drawing No.4, at the anticipated top of slab elevations for the fish ladder exit, turning pool, and entrance elevation (EL. 21.03-ft, 18.54-ft, and 15.10-ft, respectively) the proposed concrete fish ladder will be founded upon the existing bedrock, following subgrade (rock) preparation.

For design purposes, it is assumed that the proposed fish ladder will not derive structural support from the dam, abutments, and/or other features of the existing dam at the site.

Foundation design shall meet the requirements of the Rhode Island State Building Code (Ninth Edition). Since the project design-development is at an early phase during the preparation of this report, ECS should be given the opportunity to review drawings and specifications upon further development, especially if revisions are made to the present structural arrangement.

5.1 FOUNDATION SUPPORT

As bedrock outcroppings were visible at the Slater Mill Dam during site reconnaissance conducted by EA and ECS, a shallow foundation system is considered suitable for the support of the fish ladder structure. Based upon the 30 percent design drawings for the Slater Mill Dam fish ladder configuration, the fish ladder should be designed as a mat foundation (i.e., a continuous footing with construction and contraction joints, as appropriate). The reinforced concrete mat foundation should bear directly upon the existing bedrock.

The strength and stress deformation characteristics of the rock mass present at the Slater Mill Dam were considered to be 'average' or mean properties for the predominant rock type of the area, the sandstone. As the fish ladder will have a relatively lightly loaded foundation and will be supported directly by rock, we recommend an allowable design bearing stress of 8,000 psf. It is likely that geometric requirements will control the mat design.

Prior to placement of concrete for the footings, the foundation bedrock subgrade should be cleared of any loose debris and rock until solid, stable bedrock is encountered. Foundation bearing surfaces as well as the poured concrete should be protected against frost if construction occurs during cold weather.

Based upon the general stratigraphy within the fish ladder area, the anticipated magnitude of the fish ladder loads, and construction utilizing a mat foundation bearing on the existing bedrock, it is our opinion that the total and differential settlement due to the weight of the fish ladder structure, should be quite small (i.e., corresponding to elastic deformations alone). This conclusion is contingent upon the fish ladder structure bearing directly upon hard and sound rock.

5.2 SLIDING AND OVERTURNING RESISTANCE

For design, a coefficient of friction between the bedrock and concrete mat foundation of 0.60 is recommended. Minimum recommended factor of safety for overturning and sliding is 2.0 for this site.

5.3 SEISMIC (GEOTECHNICAL) CONSIDERATIONS

ECS has evaluated the site seismic parameters in accordance with the Rhode Island State Building Code (Code). ECS anticipated that the proposed fish ladder structure meets general requirements of Seismic Use Group I, the Code. Based upon the existing bedrock, the site meets the general parameters of Site Class B. Additionally, seismic coefficients for short periods (S_S) and one second period (S_1) of 0.236 and 0.061, respectively, should be utilized to develop the design response spectrum for the site, per the Code.

5.3.1 Liquefaction

Bedrock is not a material considered to be susceptible to liquefaction.

5.4 LATERAL PRESSURE FOR WALLS OF THE FISH LADDER

As the fish ladder will be located within the Blackstone River, the upstream portions of the fish ladder will be subject to lateral static and dynamic water forces, drag forces along the sides of the fish ladder, and negative suction forces at the downstream end of the fish ladder structure. Lateral hydrostatic pressures acting on the fish ladder structure may be utilized as follows:

Coefficient of Hydrostatic Pressure:	$K = 1$
Rock Unit Weight:	$\gamma = 150$ pcf
Unit Weight of Water:	$\gamma_w = 62.4$ pcf

Additionally, due to the location of the fish ladder structure within and adjacent to the river, erosion control measures, such as the installation of a rip-rap slope, scour control, should be considered along the exposed side(s) of the downstream leg(s) of the fish ladder structure.

6.0 SITE PREPARATION, EXCAVATION, AND BACKFILL CONSIDERATIONS

Based upon a review of the 30 percent design drawings provided by EA, bedrock excavation will be required to achieve the proposed foundation slab subgrades. A review of the drawdown photographs provided by EA indicates that removal of miscellaneous debris, a concrete foundation pier, and loose rock may be required to reach hard and sound bedrock.

6.1 EXCAVATION TECHNIQUES AND SUPPORT

During rock removal and excavation for the fish ladder foundation open cut excavation techniques may be utilized. Excavation for the mat foundation should proceed until sound, solid bedrock has been reached and should proceed in a controlled manner in accordance with the project specifications. For excavations completely within granular layers (OSHA Type C) that exceed depths of 4 feet, earth slopes should not exceed 1.5 horizontal to 1 vertical (1.5H: 1V). Excavations and trenching should be performed in accordance with OSHA regulations (29 CFR 1926).

Excavations adjacent to existing structures should be properly shored to prevent shifting and/or settlement of these structures. Underpinning existing foundations is recommended for any excavation that extends below and is within a horizontal distance equal to 1.5 times the cut below adjacent foundation subgrades. Shoring and underpinning should be designed by a professional engineer licensed in the state of Rhode Island.

6.2 TEMPORARY DEWATERING

As the fish ladder is proposed to be located within the river and to be interfaced with the existing dam structure, it is anticipated that dewatering during certain phases of foundation and fish ladder construction will be necessary. Measures should be taken to control water seepage, precipitation, infiltration, and river water inflow within the excavation to minimize disturbance, maintain the integrity of bearing surfaces, and permit foundation construction to proceed in-the-dry. It is likely that a localized temporary cofferdam type structure may be necessary during fish ladder construction activities at the Slater Mill Dam.

The Contractor should select whichever dewatering method is most familiar and cost-effective while at the same time meeting the requirement to maintain a dry and stable excavation bottom during foundation construction.

6.3 BACKFILLING

As the fish ladder is proposed to be located within the river and founded directly upon bedrock, it is likely that backfilling activities will not be necessary for the construction of the Slater Mill Dam fish ladder.

Should backfill be required for construction, foundation elements should be supported upon crushed stone meeting the following requirements and upon review by the Engineer:

Crushed Stone

Sieve Size	Percent Finer by Weight
1 - inch	100
3/4 - inch	90-100
1/2 - inch	10-50
3/8 - inch	0-20
No. 4	0-5

Crushed stone should be durable crushed stone or crushed gravel stone, free of ice, snow, sand, silt, clay, loam, shale, or other deleterious matter. All crushed stone backfill beneath the fish ladder structure should be placed in loose lifts not exceeding 12-inches in thickness and compacted to at least 95 percent (%) of the maximum dry density per ASTM D1557, Method D, where applicable. The backfill outside of the fish ladder limits should be compacted to a minimum of 92% of the maximum dry density. The percent compaction is determined in the field by ASTM D-1556 or ASTM D-2167.

7.0 RECOMMENDATIONS

ECS has documented the following information concerning the foundation design and construction of the proposed fish ladder structure at the Slater Mill Dam:

1. As a fish ladder has a relatively lightly loaded structure and its foundation will bear on bedrock, a subsurface exploratory program is not justified at this phase of its design-development. The costs associated with a drilling and rock coring program within an active river would be extensive.
2. A shallow foundation system is considered suitable to support the fish ladder structure for this site. A reinforced concrete mat foundation (i.e., a continuous footing) bearing directly upon solid and sound bedrock is recommended.
3. As the fish ladder structure has a relatively lightly loaded foundation, an 'average' presumptive allowable bearing stress provided in geotechnical literature for a foundation bearing on hard and sound sandstone bedrock (8,000 psf) is more than adequate to support the fish ladder structure and provides an ample factor of safety relative to bearing capacity.

7.1 DESIGN REVIEW

Since the project design-development is at an early phase (30 percent design) during the preparation of this report, ECS should be given the opportunity to review drawings and specifications upon further development, especially if revisions are made to the present structural arrangement.

7.2 CONSTRUCTION QUALITY CONTROL

It is recommended that a Geotechnical Engineer or their representative be retained to provide engineering construction observation services during the excavation and foundation construction phases of the fish ladder. Construction phase engineering oversight will be of particular importance relative to the monitoring of foundation excavation, rock removal, and inspection of foundation excavations prior to concrete pours.

The Geotechnical Engineer should be retained by the Owner to observe and record accurate records regarding verification of subgrade materials during foundation excavation, verification that sound bedrock has been reached, verification of installation of rock dowels as specified within the Project Specifications and Drawings, and as necessary types of backfill materials used, thickness of lifts, densities, percent compaction, type of compaction equipment and number of coverages, etc. Backfill compaction to be in accordance with the requirements of these recommendations which should be incorporated into the project specifications. ECS will be pleased to assist serving as the Geotechnical Engineer during the construction phase.

FIGURES

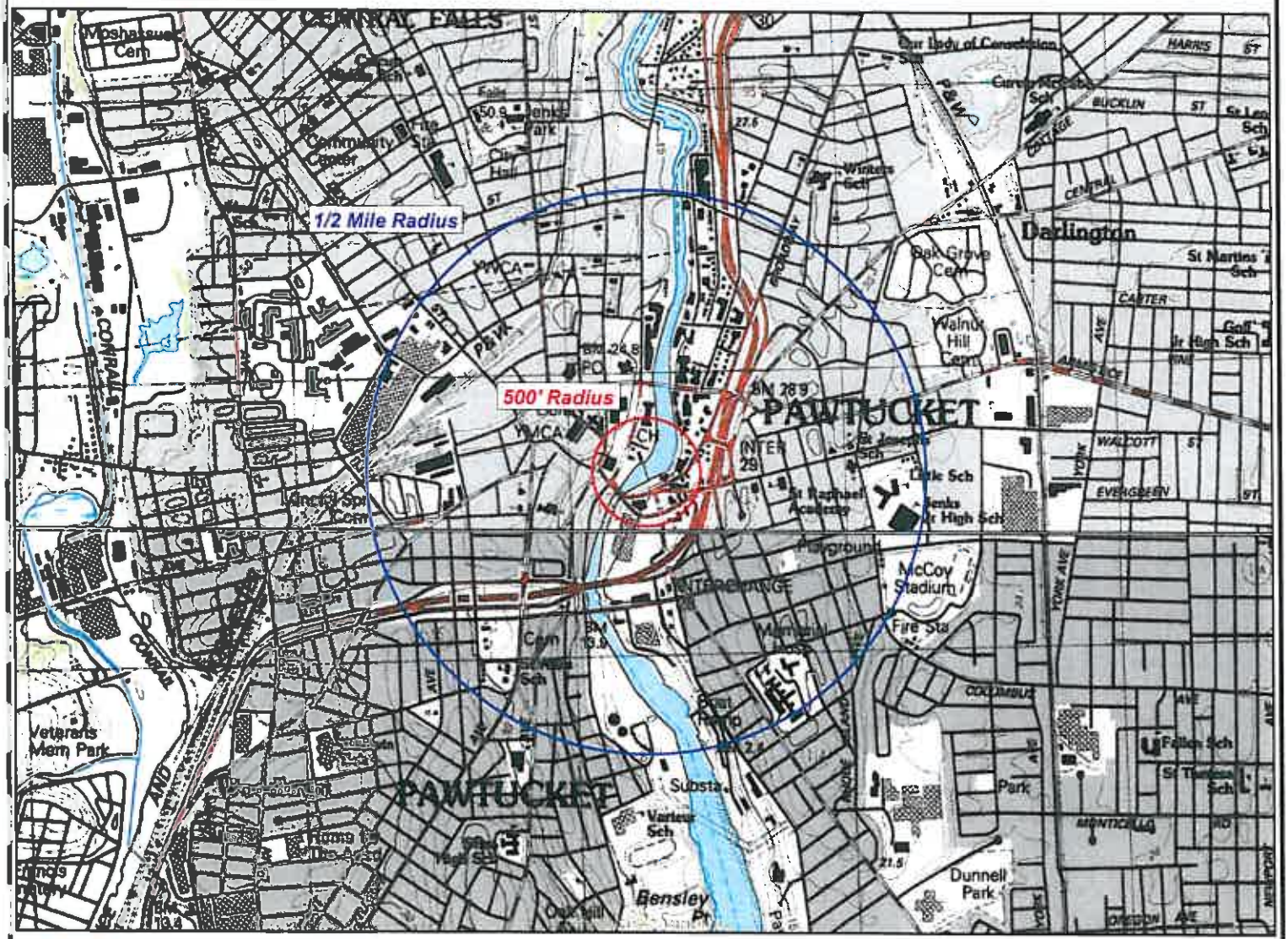
Environmental Compliance Services, Inc.
607 North Avenue, Wakefield, MA 01880
Phone (781)-246-8897 Fax (781)-246-8950
www.ecsconsult.com

SITE LOCUS

Figure: 1

Slater Mill Dam
67 Roosevelt Avnue
Pawtucket, RI
02860

Job Number: 05-208817



1 — 1/2 — 0 — 1 Mile

1 inch = 1500 feet

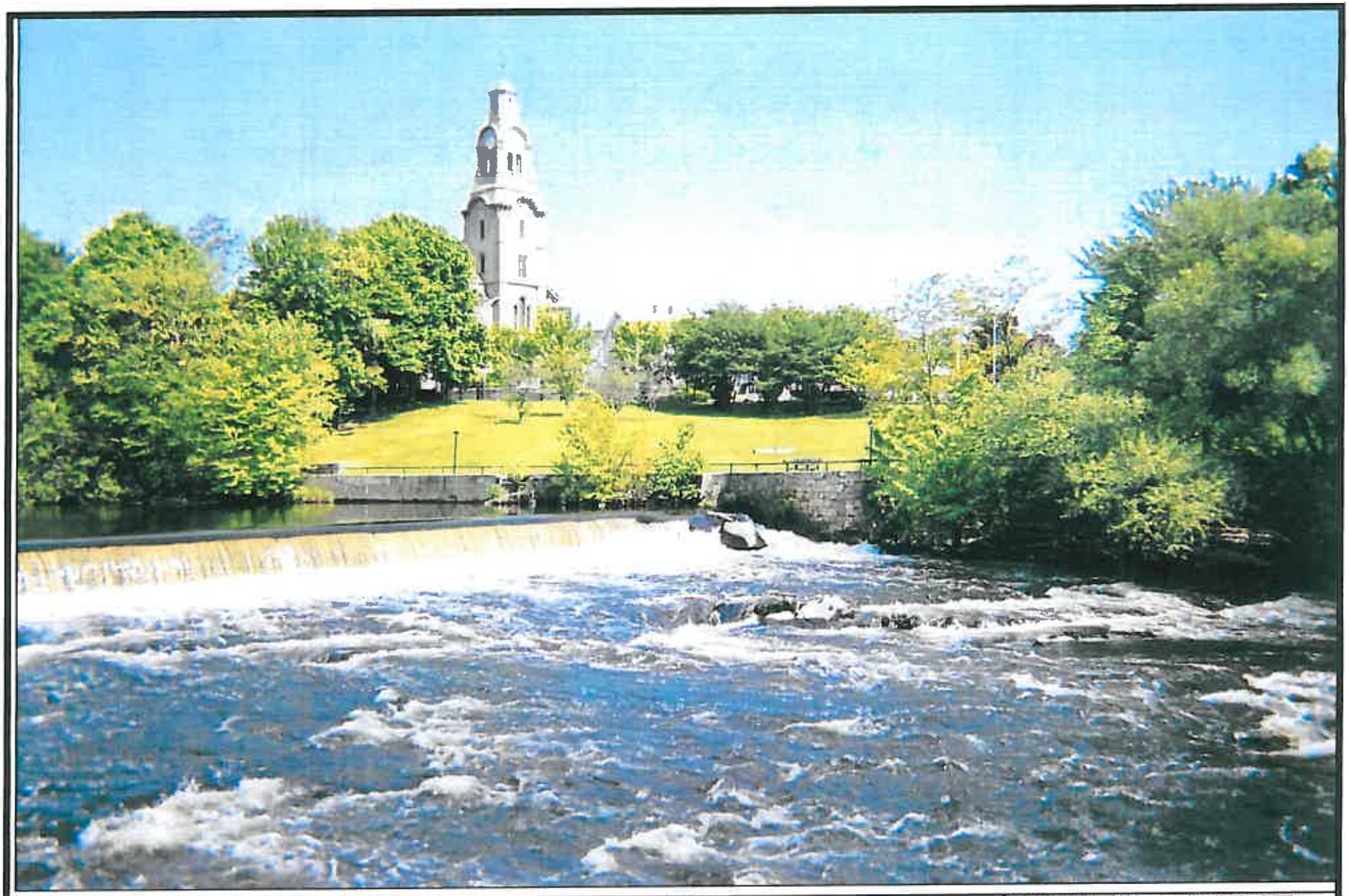
Contour Interval: 3 Meters

North

Base Map: U.S. Geological Survey; Quadrangle Location: Attleboro

UTM Coordinates: 19 0302272 East / 46 38637 North

Map Edited: 1987 *Map Revised: none* *Generated By: JMR*



ecs
607 North Avenue Suite 11 • Wakefield, MA 01880
Phone: 781-246-5597 Fax: 781-246-5060

CLIENT:
EA ENGINEERING, SCIENCE AND TECHNOLOGY

GRAPHIC SCALE:

PROJECT:
SLATER MILL DAM FISH LADDER
67 ROOSEVELT AVENUE
PAWTUCKET, RHODE ISLAND

TITLE:
SITE PHOTOGRAPH

COMPUTER CADFILE 05-208817 FIG 2 SLATER MILL PHOTO

DRAWN BY:	DESIGNED BY:	CHECKED BY:	APPROVED BY:
–	–	JMR	JMR
SCALE:	DATE:	JOB NO:	FIGURE NO:
N.T.S.	JUNE 2008	05-208817	2

ATTACHMENT I

LIMITATIONS

Explorations

The analyses and recommendations submitted in this report are based in part upon the data obtained from a limited number of subsurface explorations which were based upon the project scope of work and understanding. The nature and extent of variations between these explorations may not become evident until construction. If variations then appear evident, it may be necessary to reevaluate the recommendations of this report.

The generalized soil profile described in the text of this report is intended to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized and have been developed within the text of this report, by interpretations of widely spaced explorations and samples; actual soil transitions are probably more erratic. For specific information, refer to the test boring logs.

Water level readings have been made in the explorations under conditions stated on the enclosed logs. These data have been reviewed and interpretations have been made in the text of this report. However, it must be noted that fluctuations in the level of groundwater may occur due to variations in rainfall, temperature and other factors occurring since the time observations were made.

Review

It is recommended that ***Environmental Compliance Services, Inc. (ECS)*** be provided the opportunity to review the final design plans and specifications to evaluate the appropriate implementation of the recommendations provided herein.

In the event that any changes in the proposed general project development are planned (e.g., building footprint size and location, etc.), the conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed and conclusions of this report are modified or verified in writing by ***ECS.***

Construction

It is also recommended that ***ECS*** be provided the opportunity to perform the recommended construction phase monitoring services to verify that the intent of our recommendations is being properly implemented in the field during construction.

Topographic Data

This report is based on topographic data developed by others referenced herein unless otherwise noted in the report text. No warranty, expressed or implied, is made as to the accuracy of topographic data developed by others.

Use of Report

This Geotechnical Engineering Report has been prepared by ECS for the exclusive use of ***EA Engineering, Science and Technology, Inc.*** in reference to the ***Slater Mill Dam Fish Ladder, located at 67 Roosevelt Avenue, in Pawtucket, Rhode Island*** and is intended to be in accordance with generally accepted soil and foundation engineering practices. No other warranty, expressed or implied is made.

The soil and foundation engineering information presented in this report contains specific interpretations and conclusions of subsurface conditions encountered at the site, which is based upon the project understanding, that are recommended to be incorporated into the final design documents. When incorporated into and used in conjunction with the Contract Documents (drawings and specifications), the conclusions and recommendations presented in this Geotechnical Report provide specific information which the Contractor can utilize to plan/execute the proposed site work. Contractors wishing a copy of the report may obtain it only with the authorization of the Owner and with the understanding that its scope is limited to recommended considerations for the design and construction of the proposed facility.