Town of Halifax

Supervisory Control and Data Acquisition (SCADA) Feasibility and Design Memorandum at the Monponsett Pond System

June 2015

Executive Summary

Feasible is defined as “capable of being done or carried out”. The goal of this assessment is to determine the feasibility of the installation of automated controls on a stationary dam sluice gate. Is that goal feasible? From an engineering perspective, the answer is yes, the project is feasible.

However, with most projects there are certain criteria that have to be identified and resolved for the project to be a success. Cost, ownership, and maintenance are all common project components that typically can accelerate, or unhinge, any project in the planning stages. For this specific project, these criteria and other project-specific challenges must be met that are outside the realm of implementable engineering and lie within the political and administrative aspects of this endeavor.

The practice of hydraulic automation is very common an areas of water management. For this specific project, we feel that the benefits of automated controls will include the following:

- Provide a sustainable water withdrawal management approach for the City of Brockton; allowing them to better regulate the required pool elevation of Silver Lake while allowing excess diversion waters to flow naturally through Stump Brook.
- Reducing the frequency of overflow through the Jones River, in turn reducing potential floodwaters and excessive velocities for migratory species. Historically, diverted water from East Monponsett Pond, above the regulated withdrawal amounts from Silver Lake, has been discharged to the Jones River.
- Allow more consistent flow through Stump Brook, increasing the flushing time of the pond system (i.e. reduces idled waters that are more prone to algal blooms).
- Provide consistent flow downstream of the Stump Brook Dam, sustaining the receiving habitats.
- Provide optimal stream velocities through the existing fish ladder in the event migratory fish passage is restored.
- Greatly reduce the City of Brockton’s operation and management responsibilities by not having to visit the dam site for manual raising or lowering of the gates.
- Better flood control in the event of significant forecasted rain events or storms.
- Will allow for operation of the gates in inclement weather or when snow cover prohibits manual operation. Using the winter of 2014-2015 as an example, there was a several month period where snow accumulation prevented access to the dam and manual controls.

These are all very desirable benefits, but there are project challenges that will also have to be carefully planned and agreed upon by both the City of Brockton and Town of Halifax in order for this project to be a success. The following list identifies hurdles that will have to be overcome to make this project a reality:

- Determine the final route of power to the dam site.
- Determine who will maintain the new controls and retain ownership of the electrical utilities installed.
- Acquire an easement from the Massachusetts Division of Fisheries and Wildlife to install power to the dam site.
- Acquire project funding, preferably through grants.
- Determine which party will apply for future grants.

The following report outlines our approach for determining the feasibility of automated controls at the Stump Brook Dam.

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1. Scope of Work

In the late fall of 2014, the Town of Halifax (Town) submitted an application to the Massachusetts Department of Environmental Protection (MassDEP) for project funding under the Sustainable Water Management Initiative (SWMI). The goal of the project was to assess the feasibility of installing automated controls at the Stump Brook Dam. This application was intended to complement the previously awarded SWMI funded project that the Town received in 2013 for the evaluation of the sustainability of the current water withdrawal within the watershed leading to the Stump Brook Dam. The specific project (previous report) completed in 2013 was the "SUSTAINABLE WATER MANAGEMENT INITIATIVE REPORT - Monponsett Pond and Silver Lake Water Use Operations and Improvement", prepared by Princeton Hydro, LLC and dated July 2013. This report will be referenced throughout this assessment, as its findings triggered the need for the current report.

The specific scope of services for this assignment, as identified in the FY2015 SWMI applications is as follows:

Task 1. Project Kick-Off Meeting and Preliminary Evaluation.

Task 2. Alternatives Evaluation and Draft Report.

Task 3. Final Report.

The full description of each task, as defined in the application, is included in Appendix A - FY2015 SWMI Scope of Services.

2. Introduction

At the headwaters of the Taunton River watershed lie the Monponsett Ponds. Split into a "west" and "east" basin by Route 58, the ponds play a unique role in this and two other watersheds (North River and Jones River Watersheds) due to a long history of man-made manipulations and interventions. In particular—and most notable—is the fact that the ponds serve as an artificial tributary (or secondary source) to Silver Lake, providing water to Silver Lake and ultimately the customers of the City of Brockton. The term "artificial" is used in reference to the large diameter aqueduct that was constructed to divert water from East Monponsett Pond to Silver Lake soon after the passed legislature of 1964.

Silver Lake has been a long standing stand-alone water source for the City of Brockton. In 1964, a significant drought and resulting water shortages prompted state officials to allow the modification of the Stump Brook Dam and construction of the connecting aqueduct from the ponds to Silver Lake. The Stump Brook Dam now creates an engineered barrier which controls the upstream elevations of West Monponsett Pond and East Monponsett Pond. There is a diversion station located on Route 36 abutting East Monponsett Pond that allows the gravity flow of water from East Monponsett Pond to Silver Lake in regulated withdrawal periods. While feasible from an engineering and consumer standpoint, what was not known in 1964 were the cascading environmental impacts that have proved to be profound and most concernedly, non-sustainable.

Forwarding to the present day, the environmental impacts due to manmade manipulation and prior mismanagement of the infrastructure have been devastating to the ponds, surrounding habitats, and abutting watersheds.

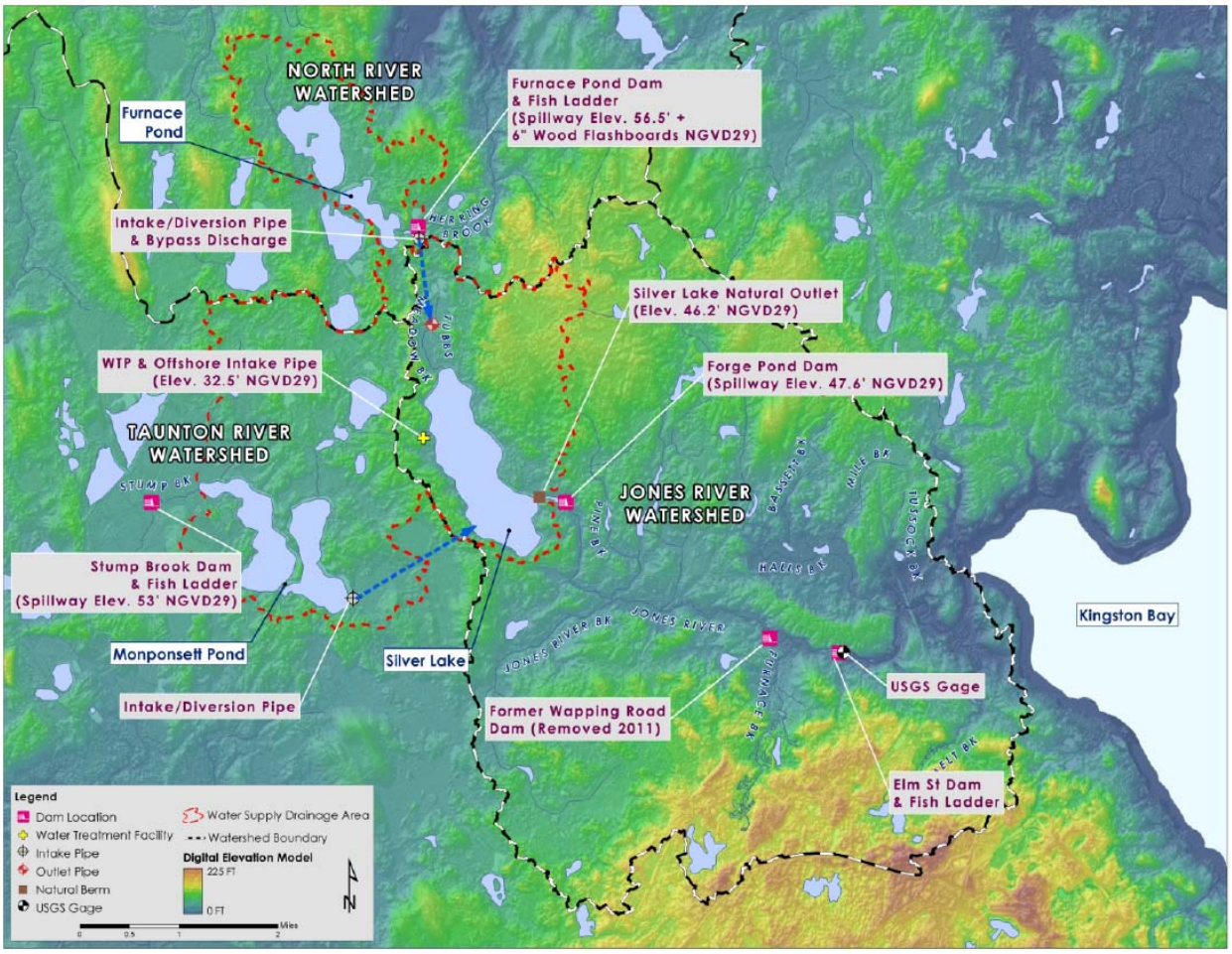


Figure 1 Subwatershed Boundary Map for the Primary Sources of Brockton's Water Supply System and Individual Water Supply Unit Drainage Areas[1]

The primary impacts to the ponds are:

- Algal blooms (with results as high as 1,900,000 cells/ml, note threshold is 70,000 cells/ml).
- Stagnation and idle flow due to diversions and dam impediment.
- Intermittent elevated water levels and flooding concerns.
- Low dissolved oxygen.
- Fish kills.
- Excess and nuisance vegetation.
- "Low-Flow" conditions downstream of the Stump Brook Dam.
- Unsuitable fish passage at the Stump Brook Dam.

The primary impacts to the abutting watersheds are:

- Lack of flow to recognized sensitive downstream habitats including Atlantic White Cedar Swamps, Red Maple Swamps and other grassy marshlands. These habitats are found in the downstream lands including the Stump Brook Wildlife Sanctuary, Stump Brook Preserve, and the Burrage Pond Wildlife Management Area.

[1] Source: "SUSTAINABLE WATER MANAGEMENT INITIATIVE REPORT - Monponsett Pond and Silver Lake Water Use Operations and Improvement", prepared by Princeton Hydro, LLC, dated July 2013.

- Downstream drought conditions resulting in stagnation and eutrophication.
- Significant impact to the Jones River and Watershed through the discharge of excess diversion (up to 10 MGD) resulting in river velocities preventing passage of migratory fish (River Herring and American Eel).

For one to understand the significance of this assessment, one must also understand the current state and operation of the watershed, water withdrawal practices, and the environmental and habitat concerns that focus on this particular dam. The previous SWMI report developed a detailed timeline and sequence of events until 2012 and also a detailed description of the contributing three watersheds (see Appendices B and C). It is not the intention of this assessment to redevelop these timelines and historical events, but to summarize them (see Section 4 – Project Background) and identify significant events since the completion of the previous SWMI report.

Figure 2 Stump Brook Dam

The existing dam is located in a remote area of the Burrage Pond Wildlife Management Area which is owned by the Massachusetts Division of Fisheries and Wildlife (DFW). The dam has two forms of manually operated hydraulic passage: an approximate 2-foot by 2-foot sluice gate and also a fish ladder that is 2-feet wide with a fixed bottom elevation of 47.3 and top elevation of 50 (elevation datum NAVD88). An excerpt from a former report entitled *"Forge Pond Dam Fish Passage Improvement Feasibility Study and Preliminary Design"* prepared by Gomez and Sullivan, dated July 2013 further describing the dam has been included in Appendix D. Historic reports and records have typically referenced a spillway elevation of 53.0 under the NGVD29; however, upon detailed survey of the dam, the elevation recorded was 51.91 under the NAVD88. A correction factor of +0.82-feet to convert from the NAVD88 to the NGVD29 equates to a recorded spillway elevation of 52.73. A copy of the detailed dam survey is included in Appendix E. The previous dam survey is included in Appendix F for comparison.

The immediate impoundment and abutting areas are comprised of an approximate 1,600 acre wildlife sanctuary consisting of abandoned cranberry bogs, wetlands, and two major ponds. Access to the dam is remote and requires prior authorization from the City of Brockton and/or the Massachusetts Division of Fisheries and Wildlife for motor vehicle access. Visitors can walk to the dam through the network of trails and bog roads but the physical location of the dam is approximately 1.2 miles from either of the two entrances at the Burrage Pond parking area off Elm Street (to the East) or a parking area off of Pleasant Street (to the North).

There is a long history of declining water quality in both the West and East Monponsett ponds. The West Pond is prone to algal blooms in the summer that result in beach closures for much of the season. In 2014, the West Pond had the longest consecutive streak of days closed due to algal blooms—well over 100 days and lasting into the month of December. During the months of October through May, the City of Brockton diverts up to 24 MGD from East Monponsett to Silver Lake reducing the flow of Stump Brook. The concern is that once the natural flushing of Stump Brook is halted, this leads to stagnant conditions that promote the frequent algal blooms. There have been additional concerns regarding flooding. In past events, water levels have risen after heavy rain events while the dam is at full closure, threatening private property. Finally, the environmental concerns of reducing the flow are the prevention of fish passage and minimizing the downstream flow to an expansive wetland system that relies on the waters of Stump Brook to support the ecosystem.

Figure 3 Fish Kills—A Negative Side-Effect of Aggressive Algal Blooms

Pond elevations are measured via a level sensor located at the dam. The level sensor is powered by a solar receiver. The solar receiver also powers a cellular communication device which transmits elevation data for Brockton to view. The existing cellular Remote Telemetry Unit (RTU) has functioned reliably to date.

Figure 4 Controls and Solar Receiver at the Existing Dam Site

Given the remote nature of the dam, it is far more operationally efficient to open and control the diversion from the Monponsett Ponds to Silver Lake via diversion pipeline at the East Monponsett Pond rather than spending the time to visit the dam on a frequent basis to control the elevations. Recent awareness and involvement by the City of Brockton has led to a more proactive management of the dam and controls and better communication with interested parties. The purpose of this assessment is to take this cooperative management accomplishments one step further to allow remote operation of the dam controls.

3. Assessment Purpose

The current set-up and operations plan promotes a non-sustainable condition (as stated in the previous report) for the Monponsett Ponds. Technology and infrastructure management methods exist that can remotely operate and maintain constant water levels in the Monponsett Ponds, reduce flooding the Jones River, and practice a sustainable management technique to serve the customers of Brockton and improve the water quality and habitat of Stump Brook (through a more consistent water flow) and the Monponsett Ponds.

The restoration activity proposed for this project and evaluation would be to automate the flow controls at the Stump Brook Dam, and to monitor and operate (based on defined settings of lake elevations) required flow passage and other criteria as determined by project stakeholders. Ultimately these settings would be adjusted to suit both water withdrawal and environmental demands to provide sustainability to both of these aspects. To date, both Federal and State offices (Environmental Protection Agency and Massachusetts Division of Ecologic Restoration) have participated in developing flow regimes and management strategies that are based upon sustainability of the watershed.

Hydraulic automation is a technology that is frequently seen at water and wastewater treatment plants, and other dams and reservoirs. These valves and controls would require modification to the existing supervisory control and data acquisition (SCADA) system infrastructure at the City of Brockton Treatment Plant located at Silver Lake.

Current technology allows users to control and monitor water treatment plants and other hydraulic management systems from an internet ready device (smartphone, tablet, etc.). These advancements have provided tremendous improvement in the operations and maintenance of all kinds of hydraulic processes and systems. The ultimate goal of this evaluation is to determin that it is feasible to install automated controls to remotely manage the water levels of Monponsett Ponds; the ability to do so would greatly reduce the man-hours needed to manually visit the dam, to adjust the gates quickly in times of impending flood emergencies, operate the aged infrastructure, and monitor the health of the up-stream and down-stream ecosystem. This assessment will identify critical design items such as:

- Recommended locations for automated controls (Stump Brook Dam, Diversion Stations, etc.).
- Review of available SCADA technology and compatibility requirements with existing SCADA controls of the Brockton Water Supply (BWS).
- Review of dam modifications to fit new controls at selected infrastructure points.
- Recommendations of material and technology suppliers.
- Determine operational procedures to maintain sustainable water levels at Monponsett Pond.

- Reduce excess diversion flows into the Jones River.
- Conceptual design elements and order-of-magnitude project costs.

The potential water withdrawal and environmental benefits of implementation based on this evaluation would be significant. This assessment shall serve as the basis for design, a needed step in the development process of a project of this nature. This approach would allow the water levels of Monponsett Pond(s) to be flushed by the Stump Brook on a more naturalistic basis. The Massachusetts Division of Ecologic Restoration (DER) is currently developing recommendations of optimal stream flow for Stump Brook which has seasonal patterns of higher and lower flows. By using this guidance to develop management protocols, the practice of regulating water levels by using the diversion of water from the Monponsett Ponds to Silver Lake (resulting in the inconsistent and sometimes excess flows to the Jones River) would be greatly reduced.

Along with this improvement, the following preliminary and final designs would look to implement a host of other measures such as installation of a passable fish ladder, further evaluation of optimal downstream flows for the Stump Brook to provide sustenance for the Atlantic White Cedar and Red Maple Swamps, and detailed analysis of the hydrological budget of Stump Brook.

4. Project Background

The events leading to the creation of the Stump Brook Dam and water withdrawal from the Monponsett Ponds date back to the late 1800's. Attached to this report is the timeline included in the previous SWMI report (Appendix B) identifying some of the more significant events from that era. This timeline captures diversion and policy decisions up to 2013, but does not identify critical milestones dealing with the water quality of the ponds since 2013. The following events have occurred in recent years dealing specifically with the water quality concerns of the Monponsett Ponds.

- **2012—Creation of the Monponsett Watershed Association (MWA).** In 2012, residents of Halifax, waterfront property owners, and other concerned citizens developed the Monponsett Watershed Association. Their mission statement is *"To* educate *the public and to restore and preserve the Monponsett Ponds consisting of the West Monponsett Pond and the East Monponsett Pond hereinafter referred to as Monponsett Ponds for clean water and safe recreational use."* Since its inception, the MWA has been instrumental in promoting the public concerns regarding the declining water quality of the ponds to residents, town officials, and State legislators.
- **2013—Central Plymouth County Water District Commission (CPCWDC).** When legislation allowing the construction of the Stump Brook Dam passed in 1964, there was also a provision for a new advisory commission to study available sources of water and water supply needs, among other responsibilities. The Commission was inactive for several years prior to 2014 but has since restarted scheduled meetings by the Advisory Board and by the three Commissioners. Included in Appendix G is the complete charter of the CPCWDC.
- **July 2013—Completion of the FY2013 SUSTAINABLE WATER MANAGEMENT INITIATIVE REPORT Monponsett Pond and Silver Lake Water Use Operations and Improvement.** This report was prepared by Princeton Hydro and identified the current state of sustainability of the water use of the Monponsett Ponds.

- **2014—Environmental Protection Agency Watershed Management Optimization Support Tool (WMOST).** In 2014, the US EPA conducted WMOST development for the Monponsett Watershed. The objective of the WMOST is to serve as a public-domain, efficient, and user-friendly tool for local water resource managers and planners to screen a wide-range of potential water resources management options across their watershed or jurisdiction for cost-effectiveness as well as environmental and economic sustainability.
- **2014—Massachusetts Division of Ecologic Restoration (DER) Priority Project Status.** In 2014, the Town of Halifax applied for and was granted priority project status by the DER. The DER is currently performing a related project to this assignment, looking to develop water discharge volumes through the Stump Brook Dam to assist in improving the water quality of West Monponsett Pond and Stump Brook.

The above milestones have been critical in the development of awareness of the current state of the waterbodies. This report will look to build from the identified studies and recommendations, and promote an implementable approach to improve the water quality of the watershed while meeting the management demands for water withdrawal.

5. Discussion of Options

The project objectives are to install the equipment and controls necessary to enable the City of Brockton Water Filtration Plant (WFP) to facilitate monitoring and control of reservoir levels and dam weir gate position, while simultaneously providing the Town with the ability to simply monitor reservoir levels.

The dam site is remote and, as such, power is not currently available at the location and communication options to the dam are limited. The WFP operators have installed equipment on the dam to facilitate remote monitoring of reservoir outlet flow via battery-backed cellular communications. The existing flowmeter is installed on the fish ladder section of the existing dam and transmits flow data in near real-time to an internet website via a hosted cellular service by the manufacturer Telog.

There are two primary decisions to make with regard to providing power to the dam site and communicating with this remote site. Options for each are described below.

5.1 Initial Considerations of Automated Controls—Site Electricity

With any project involving automated controls, the initial steps are to review power requirements and availability at project sites. With a project of this size, we anticipate that any future automation will require single or three-phase power, dependent on final sizing of equipment. The primary options for power at remote site include the following:

- Renewable energy (e.g. Solar panels)
- Gas powered generator
- Underground power lines

Each option presents challenges as is explained in the following sections.

5.1.1 Renewable Energy

Solar. The most common form of renewable energy equipment that is used in remote locations is solar power. Solar is easy to permit (with utility providers) and recent breakthroughs in

manufacturing have made it easy to produce and cost-effective. Solar panels have been used for monitoring equipment that typically requires minimal electrical current to function; however, it is anticipated that the power demanded by automation would require a larger solar array than desired and would not be feasible, based upon land coverage, easement acquisition, and environmental permitting requirements. This type of system will require routine maintenance and a system manager would have to be identified, either through the workforce of an existing City or Town department, or through contracted labor and the associated financial burden.

Figure 5 Solar Array at the Hyannis, MA Water Pollution Control Facility

Hydropower. Another renewable energy source is hydropower. Given that the project location has a viable stream flow, we felt that this option should be identified. Hydropower is the practice of generating electricity via a turbine that harnesses the kinetic energy of falling water which turns the blades—or vanes—of a hydraulic turbine, and then a generator rotor to develop electricity.

Hydropower has many benefits for the right applications. Applications include the massive (such as the Hoover Dam) to very small applications in remote parts of the world (called “micro-hydro”) which typically generate between 5 and 100 kW of electricity. The primary advantages of hydropower are that stream flow is more reliable than the wind (for powering windmills) and sun (for solar arrays). There is a very slow rate of change in the output capacity when compared to other forms of renewable energy.

While intriguing in nature, there would have to be additional detailed evaluations to further consider hydropower. While design arrangements for hydro plants vary, there are some common components that would have to be considered. The following steps outline a general approach to micro-hydro and identify considerations for this specific site:

1. Intake. A hydro station needs an intake from the dam. In this case, it would likely require major structural modifications to the Stump Brook Dam to core an open channel (similar to the existing sluice gate) to channel the appropriate flow. Most hydro dams have the intake on opposing sides of the fish passage so if the existing intake was utilized, a new fish passage would likely have to be constructed.
2. Racking and Influent Channel. Once water enters the dam intake, it would have to flow through some kind of trash rack or screen to prevent debris entering the turbine. This would also require increased maintenance by the manager of such a facility. After the trash rack, the flow would typically travel down a channel or pipe through a valve and enter a turbine.
3. Powerhouse. After flowing through the influent channel and valve, the water would enter a turbine. Next to the turbine would be the generator for electricity production. These components are usually located within an enclosure known as the “powerhouse”. From here, the generated electricity is transmitted to the user.

This is a very general description of hydropower. Given the major components and eventual maintenance requirements, we feel that this option would be discouraged among stakeholders. With the anticipation that any future work would be grant-funded, there are very few successful similar installations in this area to use as benchmarks, so this may appear questionable to granting agencies.

However, innovative approaches for the use of proven technologies have led to some notable achievements. Grant funding agencies provided millions of dollars in funding to an innovative stormwater technology in Provincetown that was a first of its kind application (the use of porous asphalt on Commercial Street, the first use of porous media for a driving surface in New England on a main municipal throughway), proving that proper planning can make innovations a reality.

If this approach was to be taken to the next level of evaluation, a more detailed investigation would be required to gather annual round flow rates, detailed structural evaluations to the dam itself, coordination with multiple stakeholders, and research on available technologies and applications for hydropower.

5.1.2 Generator

Another form of energy production would consist of a generator. Generators are relatively inexpensive and reliable. There are two forms of fuel that are typically used for generators—diesel fuel and natural gas (or propane). Because of the potential for a leak and subsequent contamination, diesel fuel would not be considered in an environmentally sensitive area. However, natural gas/propane generators are an option.

Generators were not seen as a good alternative because it would require travel to the remote site to replenish spent propane containers. There is a concern that the remote site can be inaccessible for months in the winter and that replenishing spent propane canisters could be problematic in different times of the year. This type of system will require maintenance.

Figure 6 Propane-Powered Generator

5.1.3 Underground Power Lines

The most reliable form of power is utility line power. The following is a list of locations closest to the dam site where there is existing three-phase power that could be run either underground or above-ground (see Appendix H for a figure of the proposed conduit routes):

1. Elm Street Entrance, located approximately 6,000 to 7,200 linear feet from the dam to the east; and

2. Pleasant Street Entrance, located approximately 7,700 linear feet from the dam to the west.
3. A third location within the Burrage Pond Wildlife Management Area (WMA) exists where three-phase utility poles are approximately 2,000 feet from the dam location, however, this option was disregarded as the Massachusetts Division of Fisheries and Wildlife (DFW) anticipates these will be scheduled for removal in the future.

In either of the above cases, an electrical conduit and resulting required easement would have to be granted through the Burrage Pond WMA under the management of the Massachusetts DFW. Depending on final routing of the power lines, the actual distance may vary by several hundred feet. DFW has stated that there may be future modification to the former bog roads that now serve as walking and maintenance trails networked throughout the WMA. Final routing will need to be confirmed as the project progresses.

Multiple meetings were held, both on and off site, with representatives from DFW, Town of Halifax (Town Administrator and Health Agent), and GHD. The first meeting was on-site on May 21, 2015 and attended by additional representatives from the City of Brockton. The second meeting was held off-site on June 4, 2015 to discuss logistics between DFW and the Town of Halifax. These meetings were an introduction of this project and concept to all regulatory members, a necessary step if any such work is to move forward. The following items represent significant considerations from the various meetings.

- Since an easement will be ultimately needed to provide maintenance to the lines that would power the dam, a title holder of the easement would need to be identified. Considering the dam is owned and operated by the City of Brockton, this would likely be the entity required to be named to the easement. An initial agreement or other form of acceptance would have to be obtained from the City acknowledging and approving this responsibility.
- Once the City of Brockton has agreed to manage any future power easements, the project would need approval from DFW and their Board of Directors. This would likely be accomplished through a series of meetings and presentations that identify the strong environmental benefits of automation at the dam when compared to the current dam conditions. This approval would identify specific project routes, required conduit details, and other necessary easement details.
- Once DFW approval is granted, the site would be subject to Article 97 deposition. In summary, the legislation of Article 97 states “the people shall have the right to clean air and water, freedom from excessive and unnecessary noise, and the natural, scenic, historic, and esthetic qualities of their environment.” “Lands and easements taken or acquired for such purposes shall not be used for other purposes or otherwise disposed of except by laws enacted by a two thirds vote, taken by yeas and nays, of each branch of the general court.” These public lands include both state owned lands and municipal lands acquired for conservation or recreational purposes.

  Since the Burrage Pond Area falls under this jurisdiction, the agreed upon conceptual easement would have to go through this process to secure the appropriate easement boundaries.
- Once the above steps are accomplished, plans for the design and construction of such power conduits can be implemented.

5.2 Initial Considerations of Communication Methods

With remote communications, there are two primary methods – radio and cellular.

- Radio communications utilize radio waves to transmit signals from one location to another. The advantage of radio communication is that they can use a fee-free frequency to transmit information. The disadvantage of this type of communication is that it relies upon the transmission and receiving sites to have line-of-sight communication, which in a rolling terrain area can make use of this type of signal difficult because the signal can be interrupted by obstructions such as buildings and excessive vegetation.
- Cellular communications utilize a cellular signal to communicate with an external service provider. The advantage of cellular communication is that the communications do not require line-of-sight communication with the transmission and receiving site as the already present cellular tower serves as the intermediary device. The disadvantage of this type of communication is that it has a monthly fee (just like a regular mobile device).

Based on discussions with the operators of the Brockton WTP, radio communications have proven to be challenging in the area. As a result, the level sensor that is owned and monitored by Brockton utilizes cellular communications. According to the operators, this method of communication has proven to be reliable since it was installed.

In addition, GHD conducted a field test to determine the signal strength of a cellular signal in the area of the dam and independently confirmed that this type of signal should be reliable.

6. Recommendations

In order to provide remote communication to the dam site, power and communication is required. A recommendation for each is discussed below.

6.1 Power

Due to the limitations posed by the renewable energy and generator alternatives, the recommended source of power for the dam site is underground line power. This type of power is reliable and requires negligible long-term maintenance. It does, however, pose some political hurdles with regard to securing an easement from DFW and determining who the owner and manager of the power lines and easement will be. These challenges are expanded on in Section 7.

6.2 Communication

As previously described, based on the experience of the Brockton WTP operators, radio communications have proven to be challenging in the area. The existing cellular Remote Telemetry Unit (RTU) has functioned reliably to date, which is evidence that cellular service is reliable at the dam site. Because cellular communications have proven to be reliable, it is recommended that cellular communications be used for the dam site.

While the existing Telog RTU has served the application, the device lacks the features necessary to reliably control the proposed dam weir gate. As such, it is recommended that the new flowmeter and weir control gate be equipped with a new Programmable Logic Controller (PLC) based control panel that utilizes the cellular communication medium to communicate from the dam site to the Brockton WFP.

The recommended solution includes a PLC-based control panel that facilitates:

- Monitoring and historization of dam flowrate.
- Calculation of daily, monthly, and annual flow total.

- Monitoring and historization of weir gate position.
- Remote control of weir gate position from the WTP.
- Monitoring of communication status to the dam PLC.

This solution requires the following scope of work:

- Design, installation, and programming of a PLC-based control panel at the dam site.
- Installation of new flow monitoring sensors in the fish ladder section of the dam.
- Connection of permanent power to the new PLC to provide reliable power to the PLC, cellular modem, flow sensor, and weir gate actuator.
- Design, installation, and programming of a new cellular modem at the Brockton WTP to facilitate communication to the dam PLC. Modem may be connected to an existing PLC at the WTP.
- Modification of the Brockton WTP's existing Supervisory Control and Data Acquisition (SCADA) system to facilitate remote monitoring, historization, reporting, and control of the new dam flow sensor, actuator, and dam PLC.

Upon implementation of the above recommendations, the Brockton WTP operations staff will be able to continuously record, monitor, and control the release of reservoir water through the Brockton WTP SCADA system. Either new reporting software will be supplied, or existing reporting software modified, to generate monthly status reports for the Town. The Brockton WTP operations staff will be responsible for transmitting the completed dam reports to Town staff on a monthly basis and upon request. Based on our experience with GE iFix software system that is in use at the Brockton WTP, integration of this proposed system into the Brockton system is unlikely to pose any challenges.

In addition, if the Town were to desire an independent means to show water level in the Monponsett Ponds, a stand-alone level sensor could be provided. This level sensor could then transmit via a cellular communication to a remote site that could display levels on a publically or privately accessible web site. This would be an additional monthly charge for the cellular device.

6.3 Mechanical Modifications

In addition to electrical and instrumentation upgrades, it is also recommended that the weir gates be replaced with electric actuators. The electric actuators will contain a motor which will allow the gates to be raised and lowered from a remote location.

An electric actuator is shown below. It operates on 480 Volt, 3 Phase power which can be achieved from nearly any typical line power source by using a transformer to decrease the voltage. The actuator has a handwheel to allow the gate to be manually raised and lowered in the event of a failure of the motor.

Figure 7 Electric Actuator

The actuator would sit on top of the gate as shown in the photo to the left.

Figure 8 Weir Gate With Electric Actuator

A signal could be transmitted from the PLC mentioned above to the actuator. The actuator would respond by lowering or raising the weir gate.

6.4 Conceptual Design Layout

The components of the system being proposed consists of the following:

- Two new weir gates with electric actuators at the Stump Brook Dam. The weir gates are proposed to be a 2-foot by 2-foot Rodney Hunt Weir gate or equal with a 3 Phase, 480 Volt compatible EIM or Limitorque electric actuator.
- A new level sensor located at the Dam site to detect water level. The proposed level sensor would be a Siemens ultrasonic level sensor.

- PLC-based control panel with a cellular modem at the dam site. Unless there is a preference otherwise, the recommended PLC manufacturer is Allen Bradley.
- New cellular modem at the Brockton WPT.
- Power supply which is proposed to be an underground route between an existing source and the dam site.

6.5 Order of Magnitude Costs

Order of Magnitude costs are defined as engineer estimates of probable costs based on the best available information at the time of development. These costs typically have a wide range due to the lack of detailed design information and additional investigations required to identify unknowns. These are intended for long-term financial planning to target optional grants within funding capabilities and to establish project feasibility as planning progresses.

A typical project would consist of the following components:

- Engineering:
  - Preliminary design that supports the securing of the easement.
  - Final Design suitable for municipal bidding.
  - Project permitting.
  - Bid services.
  - Construction administration services.
- Construction:
  - Install underground power supply.
  - Install remote monitoring equipment.
  - Replace weir gate with a new gate and motor operator.

The estimated project costs for the above recommended plan are as follows:

Power supply. Construction of the underground power supply, if estimated at $30 per linear foot for conduit is approximately $210,000 for conduit alone. Depending in routing, this value may vary slightly. Additional electrical components include the utility connection fee, transformers, pull poxes, and related infrastructure. In total, the order of magnitude cost for the total electrical components would be estimated at $200,000 to $300,000. Depending on routing and time of bid, variables affecting cost include economy of the bidding market, total length of conduit, and final sizing of wiring.

An additional cost of $150,000 should be carried for miscellaneous electrical items including transformers, pull boxes, service fees to utility companies, and other associated electrical costs.

Remote Monitoring Equipment. The remote monitoring equipment would consist of as many as two level sensors and PLC/communication panels for each. The approximate cost for this is $75,000 to 100,000.

New Gate and Motor Operator. The mechanical equipment that would be required includes two new weir gates and electric actuators. The approximate installed costs for these units and related accessories is $30,000 to $50,000.

Unknowns. There are several other unknowns that may add additional costs to the project. It is estimated that some amount of dewatering and sediment removal will be required. In order to do

this, the project would need to be permitted requiring sediment sampling. If contaminants show up in the sediment, this may trigger additional sampling and/or additional disposal costs depending on levels of contamination.

Soil borings would have to be performed at locations within the power line route to determine depth to groundwater. Although conduits typically have shallow cover (24-inches to 30-inches +/-), given the nature of the area, there may be groundwater encountered. This could raise the unit cost per foot of installation and may prompt additional dewatering or alternative forms of conduit installation (directional drilling) at additional project costs.

Administrative and legal costs would include any legal fees for easement development and any costs associated with land acquisition and/or transfer. As stated before, there is a unique dynamic between the relationships of the landowners (Town of Halifax), users (City of Brockton) and regulators (Commonwealth of Massachusetts). At this point, the approach for acquiring an easement for power and the assignment of maintenance of any new infrastructure has yet to be determined, and these action items may have a cost associated.

Order of magnitude engineering costs are typically between 10% and 40% of overall construction costs depending on project permitting and unknowns. As the project parameters become established, detailed estimates for preliminary and final designs can be developed.

The environmental sensitivity of this specific project will require significant project permitting. Given the extensive permitting likely required, we would budget an estimated Order of Magnitude cost of $50,000 to $100,000 to complete project permits. Potential permits would include:

1. MassDEP and Town - Wetlands Protection Act Notice of Intent & Order of Conditions. This is required for any new construction within a wetland area.
2. Massachusetts Environmental Policy Act - Environmental Notification Form. Alteration of 5,000+ SF of bordering or isolated vegetated wetlands, or alteration of one-half acre of other wetlands, or alteration of 1000+ SF of outstanding resource waters.
3. Massachusetts Historic Commission - Project Notification Form. For projects that require federal funding, licenses, or permitting.
4. Natural Heritage and Endangered Species Program (NHESP) - Rare Species Information Request Form. For any work within an estimated rare or endangered species habitat. The project location does fall within the boundaries of both the NHESP Priority Habitat of Rare Species and the NHESP Estimated Habitats of Rare Wildlife.
5. MassDEP – 401 Water Quality Certificate. Required for any project that includes the removal or alteration of 100 cy of dredge material.
6. MassDEP – Chapter 91 Waterways License. Modifications to an existing licensed structure or dredging of a navigable waterway.
7. MassDCR – Chapter 253 Dam Permit. Required for projects that alter an existing dam.
8. USACE – Clean Water Act Section 404 Programmatic General Permit. Required for projects involving discharge of dredged or fill material, or instream construction activities.
9. USEPA – National Pollutant Discharge Elimination System (NPDES). For construction sites over one acre in size that discharge to a wetland or other resource area.
10. Massachusetts Marine Fisheries - Fishway Permit. Required for modification to existing or proposed fish runs.

Summary of project costs are outlined in the following table.

Table 1 Summary of Project Costs

Item	Order of Magnitude Cost
Power Supply	$200,000 - $300,000
Misc. Electrical Items (transformers, pull boxes, etc.)	$150,000
Remote Monitoring Equipment	$75,000 - $100,000
New Gate and Motor Operator	$30,000 - $50,000
Construction Unknowns/Contingency	$50,000 - $150,000 +
Preliminary Design	$50,000
Permitting	$50,000 - $100,000
Final Design	$75,000
Bidding	$5,000
Construction Administration	$50,000 - $100,000
Total (rounded to nearest hundred thousand):	**$700,000 - $1,100,000**

6.6 Other

Although this report focused on the feasibility of installing automated controls, a final recommendation would be to fully open both sluice gate and fish ladder during periods of non-diversion. It is understood that the dam was created to raise water levels in the Monponsett Ponds to allow for the gravity diversion to Silver Lake during regulated periods. By leaving the sluice gate and fish ladder open during non-diversion periods, this will allow the most naturalistic flows (given the infrastructure) to the downstream habitat of Stump Brook. The one exception to this would be under extreme low flow conditions where the surface elevation falls under elevation 50.22 (NAVD88) if migratory fish passage is restored to the river.

If migratory fish passage is restored to the Stump Brook, we would want to ensure flow through the fish ladder at all times. Since the top of the sluice gate is at elevation 50.00 (NAVD88), this could theoretically allow the passage of Stump Brook with no flow through the fish ladder. By keeping the sluice gate closed in low flow conditions, this would prompt flow through the fish ladder.

7. Fish Passage Considerations

As part of this assignment, we also looked at the geometry of the sluice gate and fish ladder to determine if structural modifications would be needed to facilitate aquatic species, under both high and low flow conditions. The report prepared by Gomez and Sullivan, July 2013, entitled “Forge Pond Dam Fish Passage Improvement Feasibility Study and Preliminary Design, Jones River Kingston, MA” quotes guidance from the Massachusetts Division of Marine Fisheries regarding optimal velocities for two key migratory species, river herring and American eels:

"Marine Fisheries recommends a minimum water depth of 6 inches and a preferred range of 8-12 inches for the spawning migration of adult river herring. For the juvenile herring emigration, Marine Fisheries recommends a minimum water depth of 2 inches and a preferred range of 4-8 inches. Adult river herring travel in schools at a cruising speed of 2.8 feet per second (ft/s) and can reach burst speeds of 6.8 ft/s. Where these flows exceed maximum sustained swim speed, successful passage may still be possible, provided that fish can accomplish the needed swim speed without additional impendence such as low water depths. American eels travel at a cruising speed of 2.4 feet per second (ft/s) and can reach a burst speed of 6.0 to 7.0 ft/s."

Using the above as guidance, we performed preliminary calculations (using the critical depth and broad crest weir equations) to determine the velocities through the fish ladder and sluice gate. Attached in Appendix J are the calculations. We assumed that the upstream river elevations were consistent with the spill way (or weir) elevation of 51.91 (NAVD88) for the first scenario and that the second scenario assumed a water surface elevation at the top of the sluice gate. To verify and confirm preliminary calculations, we recommend installing flow meters and working with the City of Brockton to use their monitoring information to develop more accurate calculations.

Based on our approach, our preliminary opinion is that no major modification to the dam will be required to achieve optimal velocities for fish passage. Our calculations indicate that the velocity through the fish ladder is under 3.5 ft/s, given the water surface elevation at a maximum spillway height of 51.9 (NAVD88) and the sluice gate closed (worst case “velocity” scenario). These conditions will yield the highest velocity through the fish ladder, which is still estimated to be well under 6.8 ft/s. Opening the sluice gate under these conditions would only slow the velocity through the fish ladder.

The two factors that will impact the velocity through the fish ladder are the overall water elevation and the amount that the sluice gate is open. The sluice gate has a top elevation of 50.0 (NAVD88), which is under the top step of the fish ladder at 50.22 (NAVD88). Under extreme low flow conditions, this would theoretically allow for zero water passage through the fish ladder once the water surface elevation falls under 50.22 with either the sluice gate fully opened or closed.

Collaboration will be critical with agencies such as MA Department of Fish and Game to determine suitable programming if automated controls are installed. Rivers typically flow higher in the spring months (herring in migration) and lower in the summer and fall (the latter corresponds to herring out migration). Detailed manipulation of the sluice gate and fish ladder would have to be monitored during these periods to maintain adequate velocities while maintaining storage for Silver Lake.

8. Next Steps

As stated previously in this report, the existing conditions of the Stump Brook Dam—including the manmade hydraulic alterations, management practices, and numerous project stakeholders—presents logistical and political challenges.

For this project to be a success it will have to be funded, either through municipal funding, grant funding or a combination of both. Prior to this step, agreements and arrangements will also have to be secured between project stakeholders.

For consideration of this project, the first step would be to establish a form of power to the site and ownership of the easement. The dam itself is located on Town of Halifax Land; however the dam itself is owned and operated by the City of Brockton. To get power to the site, the DFW property will

have to be accessed via easement. Since the dam is crucial to the City of Brockton's water operations and the automation would offer both operation and environmental benefits, one would argue that the easement would be best suited for the City to obtain, through support of the Town of Halifax. However, this is a decision that must be decided upon by the elected officials of each party.

Assuming the easement arrangements between City of Brockton and Town of Halifax can be agreed upon, the next step would be to approach DFW with a direct plan and begin negotiations for easement rights through the Article 97 legislation. This may require a form of land swap, purchase, or other agreed upon approach as discussed in Section 5.1.3.

Once this process is established and input from the other project stakeholders is addressed, grants could be sought for design, permitting, and construction funds. Several towns within the Commonwealth have received generous grant funding for dam modification and fish passage. Given the extensive grant history with this project, we feel that the potential for future grant funding is highly probably given agreements are reached with all project stakeholders.

For any future grant consideration, more so for construction funds, applicants must exhibit coordination, agreement, and support for all major stakeholders. Given the ownership and operational dynamic for the Stump Brook Dam, an identified applicant with identified support partners would have to be established for any proposed grants. For example, most grants require a single application, but encourage support of other agencies. If the Town of Halifax were to apply for future grants, a necessity would be to have the written support from the City of Brockton. For almost all grant funded projects, if the subject project is not owned or operated by the applicant, it is required to provide proof of support from that owner.

Local grant success for wetland restorations have occurred in neighboring towns. A recent press release on the Commonwealths Executive Office of Environmental Affairs webpage identifies the following example of a true grant success story for habitat restoration:

> *"PLYMOUTH - Friday, February 27, 2015 - Energy and Environmental Affairs (EEA) Secretary Matthew Beaton today announced that the Department of Fish and Game's (DFG) Division of Ecological Restoration (DER) has received a $790,290 grant from the U.S. Fish and Wildlife Service (USFWS) for the restoration of 250 acres of coastal freshwater wetlands in Plymouth. This funding is the final amount needed for the Tidmarsh Restoration Project, the largest freshwater wetlands restoration effort to date in Massachusetts…*
>
> *…The USFWS grant complements funding of approximately $300,000 from the National Oceanic and Atmospheric Administration (NOAA), American Rivers, Gulf of Maine Council, USFWS, the Massachusetts Environmental Trust and DER. The U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS) holds the conservation easement on the property and is contributing $1.9 million for project implementation. The total project cost of approximately $3 million is projected create over $3.5 million dollars in economic activity."*

A comprehensive list of funding opportunities that may potentially fund work of this nature is included in Appendix I.

In closing, through cooperation, persistence, and certain resolve, this project could become a reality and a significant step in the overall management, sustainability, and improvements to the Monponsett Ponds and surrounding watershed. We would look forward to working with the involved communities to make this project a success.

9. Disclaimer

This report: has been prepared by GHD for the Town of Halifax and may only be used and relied on by the Town of Halifax for the purpose agreed between GHD and the Town of Halifax as set out in Section 1 of this report.

GHD otherwise disclaims responsibility to any person other than the Town of Halifax arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions, and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions, and any recommendations in this report are based on assumptions made by GHD described in this report (Sections 5, 6, and 7 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by the Town of Halifax and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

GHD has prepared the Order of Magnitude project costs set out in Section 6.3 of this report ("Order of Magnitude Costs") using information reasonably available to the GHD employee(s) who prepared this report; and based on assumptions and judgments made by GHD.

The Cost Estimate has been prepared for the purpose of future planning efforts and must not be used for any other purpose.

The Cost Estimate is an Order of Magnitude only. Actual prices, costs, and other variables may be different to those used to prepare the Cost Estimate and may change. Unless as otherwise specified in this report, no detailed quotation has been obtained for actions identified in this report. GHD does not represent, warrant, or guarantee that the work/project can or will be undertaken at a cost which is the same or less than the Cost Estimate.

Where estimates of potential costs are provided with an indicated level of confidence, notwithstanding the conservatism of the level of confidence selected as the planning level, there remains a chance that the cost will be greater than the planning estimate, and any funding would not be adequate. The confidence level considered to be most appropriate for planning purposes will vary depending on the conservatism of the user and the nature of the project. The user should therefore select appropriate confidence levels to suit their particular risk profile.

Appendices

Appendix A – FY2015 SWMI Scope of Services

SCOPE OF SERVICES – SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) FEASIBILITY AND DESIGN MEMORANDUM AT THE MONPONSETT POND SYSTEM.

Task 1. Project Kick-Off Meeting and Preliminary Evaluation. This task would start with the project kick-off of all parties including the Town's of Halifax and Brockton, MassDEP, Monponsett Watershed Association and other interested parties. This meeting will be held to discuss the work to date (most recently the previous SWMI funded report on Monponsett Pond, MADER efforts and WMOST results), collaboration and review of the existing hydrology of the area and review facilities considered for SCADA enhancements. These facilities may include the Stump Brook Dam, Monponsett Diversion Station, Silver Lake Treatment Facility and Brockton Water Department Offices.

Deliverable: Meeting Minutes

Task 2. Alternatives Evaluation and Draft Report. This task will include the technical research, feasibility and logistics of SCADA control for the use of monitoring water level information. Since the BWS already has SCADA control for portions of their water system, it will be critical step to understand what operating platform they are using and what the compatible technologies are.

SCADA controls will be evaluated for two general types of sites being monitoring sites and control sites. Monitoring sites include workplaces where water levels can be monitored and manipulated. These sites would include Brockton Water Department and Halifax Water Department Offices. Control sites would be locations where hard infrastructure is located, such as the Stump Brook Dam and Diversion Station.

Once all of the monitoring and control sites have been evaluated, detailed investigations including radio or cellular communication testing would occur to determine signal strength, reliability and best option for each Town. Included in this task will be the review of web based and wireless control systems where online monitoring can be set up on wireless devises for increased convenience of operations. We will look to develop a realistic and reliable wireless communication platform that can be monitored by Town Staff and approved personnel.

The collection of the above information will provide the consultants with the required information to develop a feasible and financeable program to implement SCADA technology and control. A draft report will be presented summarizing the findings of this task for consideration to all parties.

Deliverable: Draft Report

Task 3. Final Report. This task will develop a final report on the information gathered in Task 2 and other information. Recommendation for modifications for control sites will be provided for final design documents. These recommendations would include modifications to the Stump Brook Dam fish ladder and sluice gate and potential modifications to the dam itself. For example, a new spill way and automated gate may need to be larger than the existing outlets on the dam. The recommendation would identify size, location, installation method and SCADA compatible equipment for installation.

An operations plan would be developed to recommend functional water levels and allow for flood waters to pass through Stump Brook, as nature intended, rather than artificially through the Jones River. This plan would also provide the BWS with optimal, but not excessive, water levels to meet their demand and minimize excess draw.

Conceptual design methodologies and cost estimates will also be presented for final design plans and construction.

Deliverable: Final report

Appendix B - Excerpts from “Sustainable Water Management Initiative Report, Monponsett Pond and Silver Lake Water Use Operations and Improvement”, Princeton Hydro LLC, July 2013

In December 2012, the Town of Halifax applied to the Massachusetts Department of Environmental Protection (MADEP) for a grant pursuant to the Sustainable Watershed Management Initiative (SWMI) program. In March 2013, MADEP announced that Halifax was awarded funding to hire a consultant to evaluate water management practices and recommend options to improve water quality and provide sustainable flows in Stump Brook. This document is a comprehensive report of the activities, findings, and recommendations prepared by Princeton Hydro, LLC of Ringoes, New Jersey pursuant to SWMI project "BRP 2012-06 – Monponsett Pond[1] and Silver Lake Water Use Operations and Improvements".

The City of Brockton's water supply (BWS) system relies on water sourced from Silver Lake for more than 90% of the finished water the City delivers to its roughly 110,000 customers. Silver Lake is located approximately 20 miles outside of Brockton in Kingston, Massachusetts. Brockton's withdrawal from Silver Lake is part of a more than 100-year old, complex water management operation that now diverts surface water across two drainage divides into a third for treatment, then delivery and ultimate consumption in a distant part of one of the contributing watersheds.

The BWS system is controversial, contentious, and various perspectives flourish. The most prominent stakeholder issues include:

- Maintain cost and reliability of source water for the City of Brockton
- Reduce negative impacts of cultural eutrophication in Monponsett Pond, Furnace Pond, and Silver Lake
- Improve hydrologic connectivity and re-naturalize flow regimes to Herring Brook, Stump Brook, and Jones River to support aquatic life
- Alleviate flooding effects on lakeside and riverfront properties.

This report is organized into five main sections, each with several subsections. The first main section begins with a timeline of key infrastructure, legislative, and water use trend developments that provide context to the findings and recommendations in this report. Section 1 also includes a description of the objectives that underpin the Sustainable Water Management program including stream flow criteria; a discussion of ways to consider the value of clean water; and, a comparison of the terms *sustained* and *sustainable*. The project setting is characterized in Section 2 with subsections separated into hydrogeologic traits; compilation of daily climate records observed since 1900; and basic aspects of the water system infrastructure and operation. In Section 3 we assess a water balance in detail for Silver Lake, Monponsett Pond, and Furnace Pond using monthly statistics derived from daily flow and climate data for the period 1997 – 2012. Section 4 includes nutrient loading analyses and Section 5 presents trophic structure modeling pertinent to the cultural eutrophication of each lake in the system. In Section 6, we provide a summary of the overall findings and emphasize disparities between current practice and sustainability. We provide conceptual management alternatives in Section 7. Section 8 contains references cited. Figures, tables, and certain calculations are embedded in the narrative.

[1] As referenced herein, "Monponsett Pond" refers to two basins, East Monponsett Pond and West Monponsett Pond, that share a common water surface elevation and are connected by culvert.

1.0 BACKGROUND

Following the American Civil War, southeast Massachusetts, led by Brockton, became the epicenter of US shoe-making, textile, and related industries. As the 19th century closed, Brockton's demand exceeded its local ability to supply water from the Avon Reservoir (a.k.a. Brockton Reservoir) and in 1899 the Massachusetts Legislature enacted Chapter 356; "*An act to authorize the city of Brockton to take an additional water supply*."

1.1 Acts of the Massachusetts Legislature with Respect to Brockton's Water Supply

Chapter 356 Section 1 reads as follows: "The city of Brockton, for the purpose of increasing its water supply, may take and hold the water of Silver Lake in the towns of Plympton, Kingston, Halifax, and Pembroke, and may also take, by purchase, or otherwise, and hold all lands, rights of way, and easements necessary for holding **and preserving such water and protecting its purity**; *provided*, that **water for domestic purposes, and lands necessary for preserving the quality of such water, shall be taken only with the advice and approval of the state Board of Health**." [Emphasis added[2].]

At its outset, Act 356 authorized the diversion of water across the natural watershed divide; from the headwaters of the Jones River watershed into the Taunton River watershed. And although Act 356 pre-dated the current framework of state and federal statutes enacted to manage and protect environmental resources, the Legislature in 1899 exercised considerable foresight regarding such matters by stipulating conditions to preserve and protect water quality and by conferring oversight to the state Board of Health.

In response to severe drought conditions in the early 1960s, in 1964 the Massachusetts Legislature approved Act 371; "*An act establishing the Central Plymouth County Water District and authorizing the City of Brockton to extend its source of water supply.*" The legislators declared Act 371 to be, "… **an emergency law, necessary for the immediate preservation of public convenience.**" [Emphasis added.]

In addition to establishing the Central Plymouth County Water District[3], Act 371 authorized Brockton to divert water to Silver Lake from sources located in two different watersheds. Act 371 authorized flow from the Taunton River watershed by diversion of Monponsett Pond into Silver Lake and from the North River basin, by diversion of Furnace Pond into Silver Lake. Act 371 set timing and water elevation conditions on when diversions into Silver Lake could occur; the water elevation conditions triggered Brockton to establish or modify water control structures at Monponsett and Furnace Pond, respectively.

[2] Princeton Hydro does not assert claims regarding legal status of items herein; rather, our purpose is to illustrate context.

[3] The Central Plymouth County Water District (CPCWD) was established by the Act to consist of an Advisory Board and a Commission with duties to provide oversight for water supply resources in the affected communities. The CPCWD has largely been inactive since it was created.

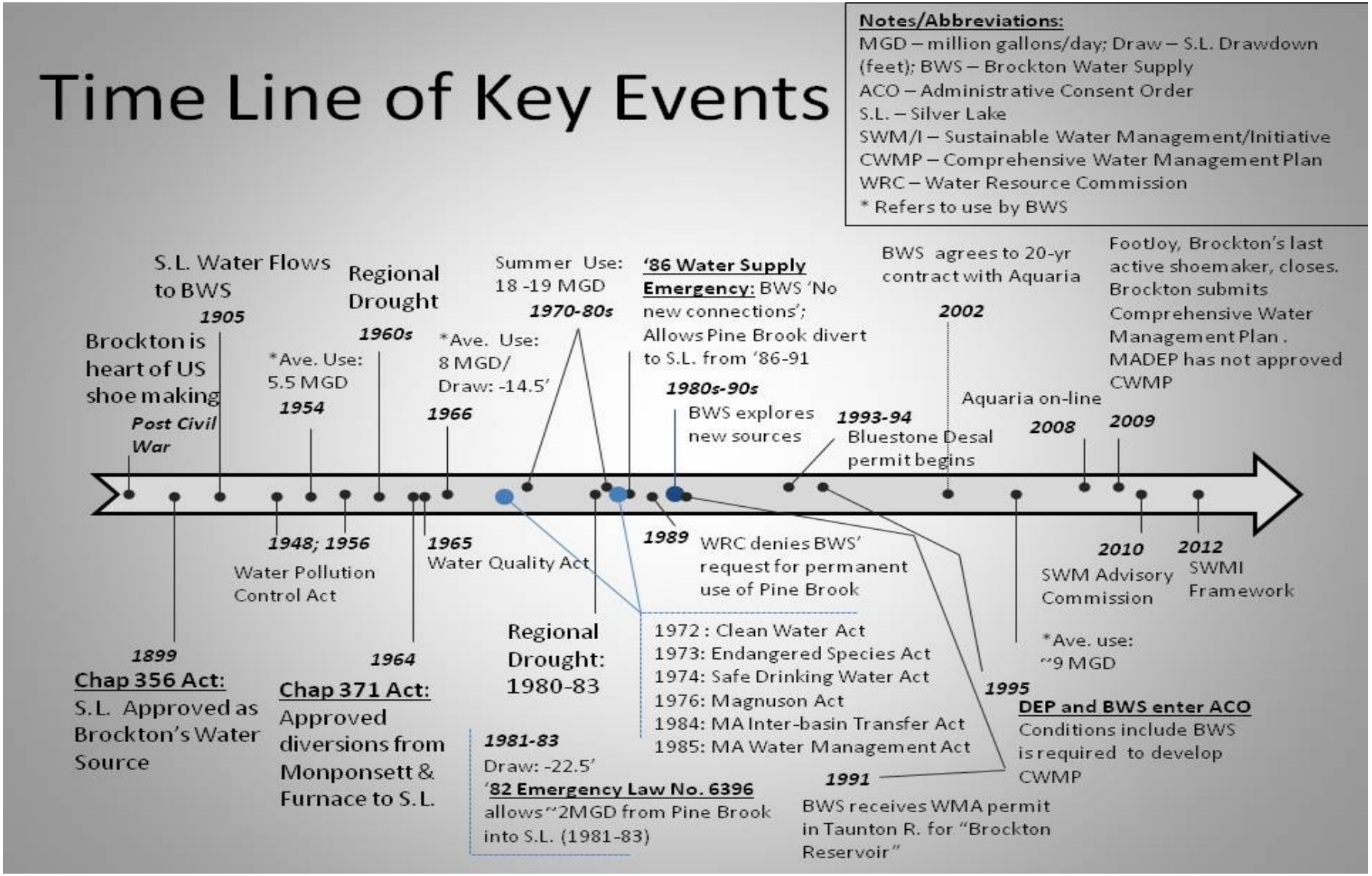


FIGURE 1. Time line (not to scale) of key events involving Brockton's water supply system as well as major federal and state legislative actions pertinent to natural resources management.

The Act also required Brockton to construct a water treatment plant at Silver Lake with through-put treatment capacity of "not less than" 20 MGD.

Of note, Section 8 of Act 371 proclaimed, "… *nothing in this act shall be construed as preventing the normal use of the aforesaid Furnace Pond and Monponsett Pond for bathing, boating, fishing and other purposes, …*". And continuing, Section 8 also stated, "*There shall be no diversion of water from Furnace Pond or Monponsett Pond into Silver Lake, if, in the opinion of the department of public health, the diversion of such waters would endanger the public health.*

Chapter 237 of the Acts of 1981 ("*An act further regulating the source of water supply for the City of Brockton*"), required establishment of water control structures to prevent diversion of water from Monponsett Pond below elevation 52 feet and to prevent diversion of water from Furnace Pond below elevation 56 feet (National Geodetic Vertical Datum 1929).

As a consequence of its expanded customer base (Brockton experienced an increase in residential development and population between 1960s-1980s) and deteriorating, leaky water conveyance system, average daily water use grew from approximately 5.5 million gallons per day (MGD) to more than 13 MGD between the mid-1950s and early 1980s and average summer season use peaked at 18-19 MGD by the late 1970s – early 1980s.

In 1981, during a period of intense drought (1980-'83), the Silver Lake water surface was drawn down more than 22 feet below the lake's outlet elevation and was even lower than the BWS intake level. In 1982, an emergency law (no. 6396) was enacted that authorized diversions from Pine Brook into Silver Lake that averaged approximately 2 MGD between 1981 and early 1983.

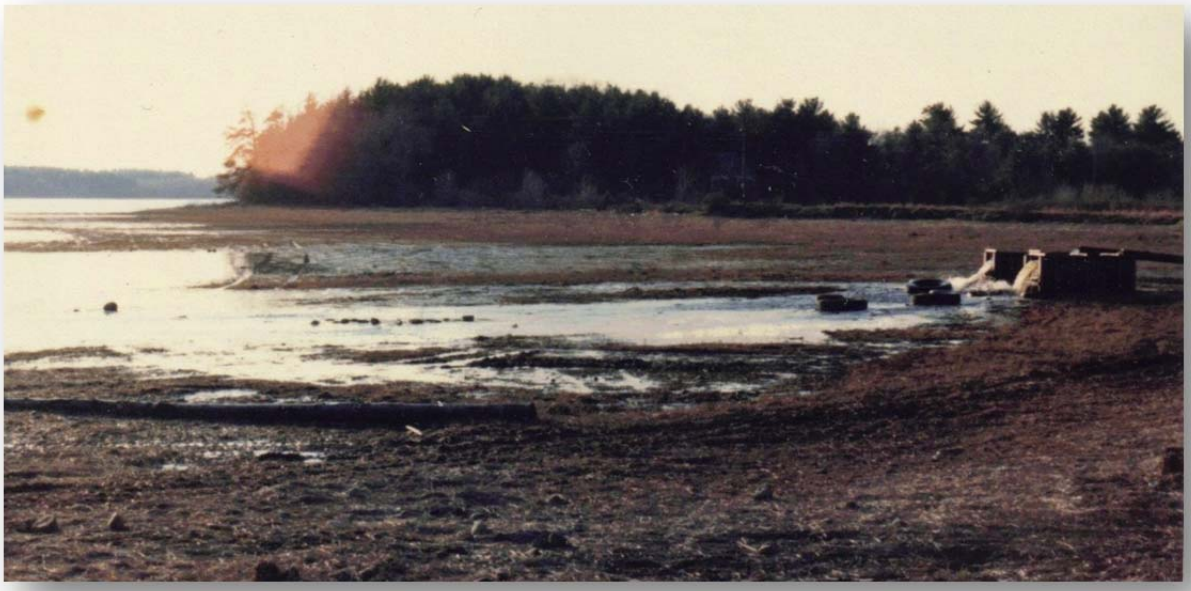


FIGURE 2. Photograph from 1981 showing emergency diversion of approximately 2 MGD from Pine Brook into Silver Lake during episode of severe drought and drawdown. Pine Brook emergency diversions lasted 1981-'83.

Through the mid-1980s, the BWS system was in crisis. In 1986, the Massachusetts Department of Environmental Protection (MADEP) issued Brockton with an Administrative Order (AO) followed by an Emergency Declaration; the latter required Brockton to control its water demand and develop two local water supplies (i.e., Hubbard Avenue well and Brockton (a.k.a. Avon) Reservoir). The Emergency Declaration also allowed BWS to divert water from Pine Brook into Silver Lake for six months per year between 1986 and 1991. In 1988, BWS applied to the Water Resource Commission (WRC) seeking permanent use of the Pine Brook diversion; however, the WRC denied BWS' request and an appeal by BWS to State Superior Court upheld the WRC's decision; meaning that BWS was not authorized permanent use of Pine Brook to supplement Silver Lake.

In 1995, Brockton and the Massachusetts Commonwealth entered into an Administrative Consent Order (ACO; ACO-SE-95-5005[4]) that discharged the Emergency Declaration and required BWS to establish a Board of Water Commissioners; appoint a full-time professional water systems manager; undertake a series of specific actions intended to coordinate water supply activities with certain other communities; develop a Comprehensive Water Management Plan (CWMP) for existing supplies; and assess the possibility of developing new water supply wells for Brockton. The intent of the CWMP was to address many of the same stakeholder concerns identified in this report. Among the MADEP's core requirements for the CWMP was a provision that Brockton optimize its water supplies in manners that minimize environmental impacts.

By 2009, Brockton had met certain of the ACO requirements. Of note, although Brockton had submitted several versions of its CWMP, including responses to MADEP review comments, as of 2013, the Department had not approved the CWMP, the ACO remained in effect, and BWS had not developed a strategy to reduce environmental impacts.

1.2 Alternative Water Supply Sources – Focus on Desalination

The 1986 Emergency Declaration as well as the 1995 ACO, in part, required BWS to seek water sources that could off-set reliance on the Silver Lake supply system. In the late 1980s, BWS unsuccessfully tried to permanently integrate Pine Brook into its Silver Lake supply network. In 1991, BWS obtained a Water Management Act (WMA) permit to re-activate the Avon/Brockton Reservoir as a water source. Avon Reservoir dates from the 1880s and had been used by BWS until the 1950s. The original safe yield of Avon Reservoir was 1.5 MGD (Kasperson 1969); however, the 1991 WMA permit limited use to 0.83 MGD.

In the 1990s, Brockton explored the possible development of groundwater supply wells in the City, but low yield and/or poor water quality were cited as reasons why local groundwater sources have not emerged as significant contributors to the BWS water supply mix.

In the mid-1990s, Brockton also evaluated the use of Taunton River as a source of water, yet that proposal was rejected due to opposition that considered the project environmentally unsound. The Brockton Water Commission also considered linking to the Massachusetts Water Resources Authority

[4] ACO-SE-1995-5005 was subsequently amended several times.

(MWRA), a system that delivers water to the Boston Metropolitan area from a reservoir network located in central and western Massachusetts. The Commission dismissed connecting to MWRA because of concerns about rising water costs as well as financing MWRA projects that were not tangible to the City's own economic development plight (Crawford 2013).

Beginning in the early 1990s, a desalination plant began to take shape that offered a viable alternative water source for Brockton. The Dighton desalination plant, first called Bluestone and later renamed Aquaria, was based on an intake feature located in the tidal portion of the Taunton River at Dighton, Massachusetts approximately 16 miles downriver from Brockton. The treatment plant was based primarily on reverse osmosis (RO) technology. The plant's location was selected to maximize RO efficiency by extracting Taunton River water during part of the out-going tide cycle when the raw water bears its lowest average dissolved solids load. The Dighton plant was designed and built with capacity to finish (i.e., treat to potable use standards) 5 MGD at optimal operating conditions, based on a maximum intake rate of approximately 21,000 gallons per minute, which is equivalent to roughly 5.5 MGD based on the average tide cycle "windows" (Jeff Hanson, personal communication 2013). Typically, summer low-flows in the Taunton River reduce RO treatment efficiency because lower freshwater discharge in the non-tidal river reach means higher dissolved solids loads at the Dighton intake. Under normal climate patterns, the months August through October provide less than optimal operating conditions for the Dighton plant simply because the raw water source is too salty. For 10 months each year, the Dighton plant is capable of providing 5 MGD treated water to BWS.

Beside its RO efficiency constraints, which essentially amount to an intake limit coupled with seasonally elevated dissolved solids, the Dighton plant has a secondary limit to its maximum treatment capacity; i.e., the static pressure capacity of the 15-inch distribution pipeline to Brockton.

In 2002, BWS entered into a contract with Aquaria that included payments from BWS to Aquaria for 20 years once the desalination plant became operational. The contract fee structure was coupled to firm commitments by Aquaria that would incrementally increase the supply of Dighton water to BWS beginning with 1.9 MGD in the first year of availability (CDM 2008). Based on the water supply commitment schedule, by 2013, Aquaria must be capable of supplying approximately 3 MGD to BWS.

The Dighton plant became active in 2008 and as of this report date, the Aquaria desalination plant is capable of supplying approximately 3 MGD of treated water to BWS, yet BWS purchases only enough water from Aquaria (~0.3 MGD) to ensure that emergency supplies are ready if needed. In 2009, BWS was projected to provide base payments to Aquaria of approximately $4M pursuant to the contract (CDM 2008). In its response to MADEP review comments regarding the CWMP, BWS stated (CDM 2009), "*DEP must remember that Aquaria was always intended to be, and remains, a supplemental water source*."

1.3 Acts of the Federal and State Legislatures With Respect to Natural Resources Management

Until the late 1800s, resource exploitation and pollutant discharge activities in the U.S. were largely unrestrained. By the early 20th century, the rapidly growing industrialization movement meant that some enterprises successfully asserted dominant common law positions owing to the societal

importance/concentrated economic and political power of their particular industry. Other cases struck more subtle common law balances between industry and neighbors (Aspen Law website, 2013).

Some of the earliest Federal legislation initiatives regarding natural resources management emphasized the maintenance of water supply as well as the protection of water quality; i.e., Water Supply and Water Pollution Control Acts of the 1940s, '50s, and '60s. Subsequent legislative actions during the 1970s – '80s focused more specifically on aspects of water quality (as well as solid waste management and air quality), especially addressing pollutant sources and attaining specific numerical measures of water quality. During this period, legislation such as the Endangered Species Act and Magnuson Act also acknowledged ***habitat*** as essential units of natural resource management. More recently, greater understanding of linkages between water supply/water quality and overall watershed ecosystem functions have led to sustainable management initiatives that seek to balance human and ecological uses of natural resources, especially water.

1.4 Natural Flow Regime

The quantity, timing, and quality of water flows is integral to managing water allocation required to sustain ecosystems, human livelihood, and societal well-being. River biota evolved in response to dynamic combinations of magnitude, duration, frequency, timing, and rate of change of flow as well as physicochemical traits of the water through such flow variation (Nilsson and Renöfält 2008). The body of regulatory emphasis regarding flow management to date has concentrated on adhering to a minimum low-flow threshold, rather than maintaining natural variability within the system.

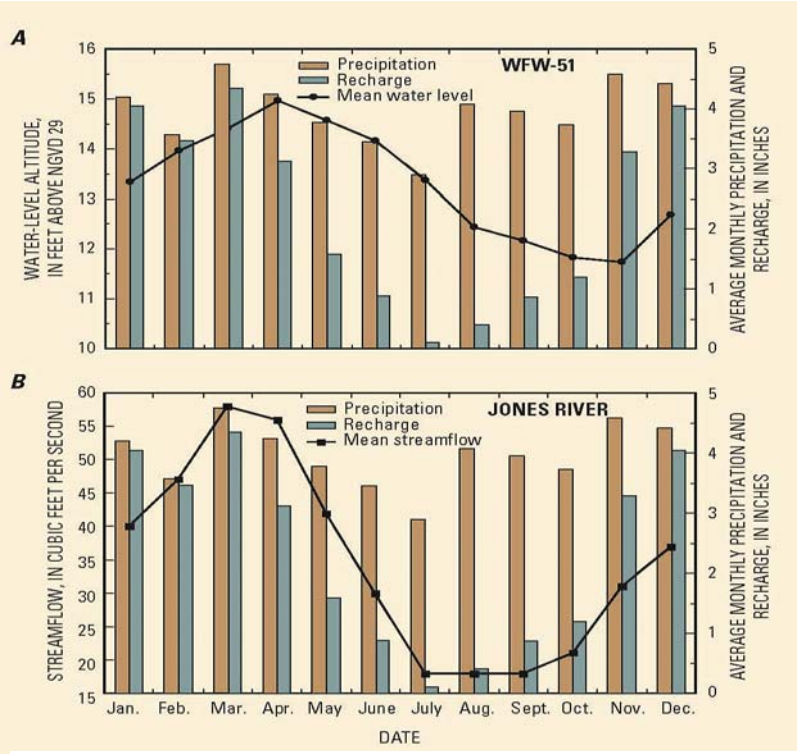


FIGURE 3. Charts of long-term average monthly groundwater elevation (above) and stream flow (below) for parts of southeast Massachusetts. [Source: Masterson and Walter 2009]. Note that while the Jones River hydrograph does exhibit a natural flow pattern at Kingston, MA, actual flows in the Jones River were altered by barriers as well as periods of interrupted/altered outflow from Silver Lake.

Figure 3 illustrates examples of hydrologic variability in groundwater elevation, stream flow, precipitation, and recharge in southeastern Massachusetts. The charts depict long-term monthly average conditions for an observation well in Wareham, MA (Figure 3 above) and a stream gauge on Jones River in Kingston, MA (Figure 3 below). Groundwater level data represent averages over a 45-year span;

stream flows encompass 40 years of observation; and, climate records cover 75 years. The monthly patterns for groundwater level, stream flow, and recharge are all correlated because these factors are inter-related.

As indicated by the long-term average stream flow in Jones River at Kingston, the low flow periods in July/August are inherently vulnerable points for prolonged stress to manifest in the ecosystem.

1.5 What is Sustainable Water Management?

Water occupies at least three critical, yet distinct roles that dovetail in human – environmental interactions (Lant 2004). First, water contributes vitally to human health; whether for potable domestic or for sanitation purposes. Next, water is a raw material necessary as a production factor for industrial and marketable goods, agriculture/livestock, transportation, and energy. Lastly, water is also the primary factor in producing ecosystem services; where *ecosystem services* refers collectively to the items that benefit humans and human society, including clean water, clean air, fisheries stocks, lumber, recreation, etc. The multitude of ecosystem services emanate from the various components of the hydrologic cycle. Although listed above in a specific order, priority rankings for the three critical roles of water identified herein is a matter of perspective and that fact lies at the center of the controversy of Brockton water supply management.

In 2010, Massachusetts established the Sustainable Water Management Initiative (SWMI), an associated Advisory Committee, and a technical subcommittee all combined with an objective to develop and implement water policy that supports ecological needs and fulfills human economic requirements. The overall principle adopted by SWMI is stated as:

> *The Commonwealth's water resources are public resources that require sustainable management practices for the well-being and safety of our citizens, protection of the natural environment, and for economic growth.*

There is a fundamental difference between the terms *sustainable* and *sustainability* that is important to note with respect to water supply. In certain traditional engineering and hydrogeologic contexts, sustainable refers to the withdrawal rate of water that can be maintained over time without dewatering the system, whereas sustainability considers effects to a broad range of conditions including water quality, ecology, and socioeconomic factors that must respond to changes in steady-state status that occur due to withdrawal (Devlin and Sophocleous 2004). The magnitude of long-term water withdrawal that exceeds sustainability depends on the hydrologic effects that society is willing to tolerate, including the actual cost of infrastructure, labor, energy, and related items necessary to obtain, treat, and distribute water.

1.6 Key Components of Sustainable Water Management Initiative Framework

Beginning in 2014, the SWMI framework will guide MADEP's permitting via the Water Management Act. The SWMI framework has three key parts:

I. **Safe Yield** – the maximum amount of water withdrawal that is allotted at a major basin scale during drought conditions;
II. **Seasonal Streamflow Criteria** – emphasis on maintaining the magnitude and timing of natural flow regime seasonally and at a sub-basin scale based on negative relationships between aquatic health and groundwater withdrawal and impervious surfaces; and,
III. **Baseline** – a basin-scale reference point against which requests to withdraw water will be compared to assess whether a request is an increase for the particular basin.

Safe Yield

At its standard approach, the SWMI Safe Yield amounts to 55% of the annual 90th percentile (Q90) simulated non-impacted[5] flow that was calculated for the main stem river of a particular basin. The annual Q90 is the stream flow that is exceeded 90% of the time throughout a year. The Q90 statistic describes a low flow condition of a river. The annual Q90 flow is combined from model-simulated monthly non-impacted Q90 flows. Simulated non-impacted Q90 conditions are considered by MADEP to generally represent the state's severe drought of 1965 (MADEP 2012). Using stream flow gauges for index watersheds, flow duration curve (FDC; refer to Figure 4 for example of FDC of select New England rivers) statistics are transformed to continuous time-series stream flows for un-gauged watersheds by relating sets of basin characteristics such as proportions of forest/wetland/impervious cover, geology, watershed landform, basin area, stream gradient, etc. (Archfield et al. 2007). In effect, SWMI determined that the volume of water that can be removed 'safely' from a major watershed equals 55% of a statistically conservative estimate of the drought flow for the watershed's largest river. By extension, the remaining 45% of the watershed's estimated annual base flow is available in the river for drought protection and to fulfill the statutory need that withdrawals remain dependable.

The standard Safe Yield estimation approach of SWMI is not applicable to the hydrogeologic conditions of southeastern Massachusetts; i.e., the Plymouth – Carver aquifer system, Cape Cod, Nantucket Island, and Martha's Vineyard (MADEP 2012). Most of Brockton's water source originates in the Plymouth – Carver aquifer system, an area that consists of glacially-derived sand and gravel deposits. Southeastern Massachusetts differs from other parts of the Commonwealth in that much of the groundwater in the aquifer systems discharges directly to the ocean rather than to rivers. Additionally, rivers in the region tend to be shallow and exhibit relatively stable, groundwater-driven flows. Figure 4, illustrates the relative stability of discharge in the Jones River, which is underlain by the Plymouth – Carver aquifer system, as compared to some other New England rivers.

[5] USGS/MADEP models estimate a natural flow condition that is unaffected by water withdrawals, dams, or other flow restrictions.

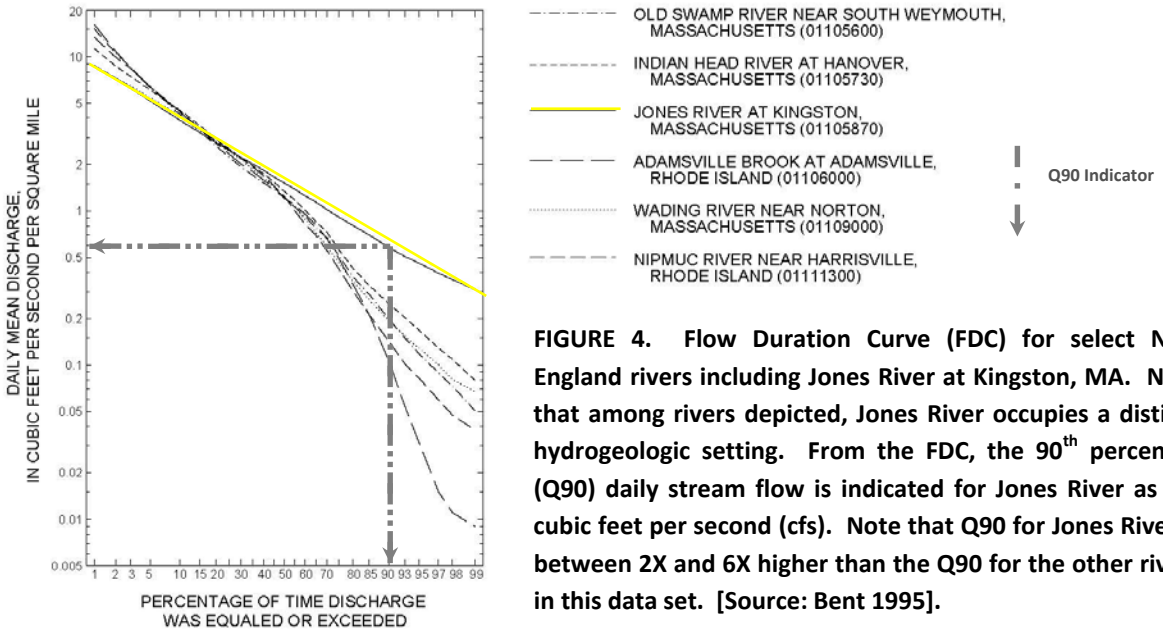


FIGURE 4. Flow Duration Curve (FDC) for select New England rivers including Jones River at Kingston, MA. Note that among rivers depicted, Jones River occupies a distinct hydrogeologic setting. From the FDC, the 90th percentile (Q90) daily stream flow is indicated for Jones River as 0.6 cubic feet per second (cfs). Note that Q90 for Jones River is between 2X and 6X higher than the Q90 for the other rivers in this data set. [Source: Bent 1995].

For the atypical conditions of southeast Massachusetts that includes Silver Lake; i.e., headwaters to Jones River, the Safe Yield estimate was based on 25% of the monthly mean simulated non-impacted flow values for the Jones River as calculated by Archfield et al. 2009. The value 25% of monthly mean estimated non-impacted flows for Jones River was considered to approximate 55% of the monthly Q90 flows for the Jones River basin (MADEP 2012). Based on the preceding approach, the Safe Yield estimate for the Jones River watershed to the river mouth and including Silver Lake, but excluding the across-basin diversions into Silver Lake, is 12.6 MGD (MADEP 2012). Note that the average BWS withdrawal from Silver Lake is approximately 9 MGD or more than 70% of the total Safe Yield estimate for the entire Jones River basin. Furthermore, BWS is not the only public water supplier in the Jones River (or Taunton or North River) basin. The Towns of Kingston, Duxbury, Plympton, and Pembroke collectively withdraw approximately 1.7 MGD from the Jones River basin.

Seasonal Streamflow Criteria

In developing Seasonal Streamflow Criteria, biological categories of flowing waters were established according to existing conditions of the fishery. Fishery condition was expressed as the relative abundance of fluvial fish. A USGS regression model (Armstrong et al, 2011) that incorporates flow, impervious cover, and various natural basin traits was applied to discriminate five distinct biological categories – refer to Figure 5. Category 1 represents high quality habitat with relatively slight human alteration (e.g., in terms of flow manipulation and impervious cover) that exhibits a rich and diverse assemblage of fish; whereas, Category 5 reflects severely altered habitat as expressed by the fish community assemblage. While the regression model has limitations, especially for predictions at the site-specific level, overall, the regression relationship between rate of withdrawal and fluvial fish community is clear (Paul 2012); "*sites with high rates of withdrawal tend to have significantly fewer fluvial fish than sites with lower withdrawals*."

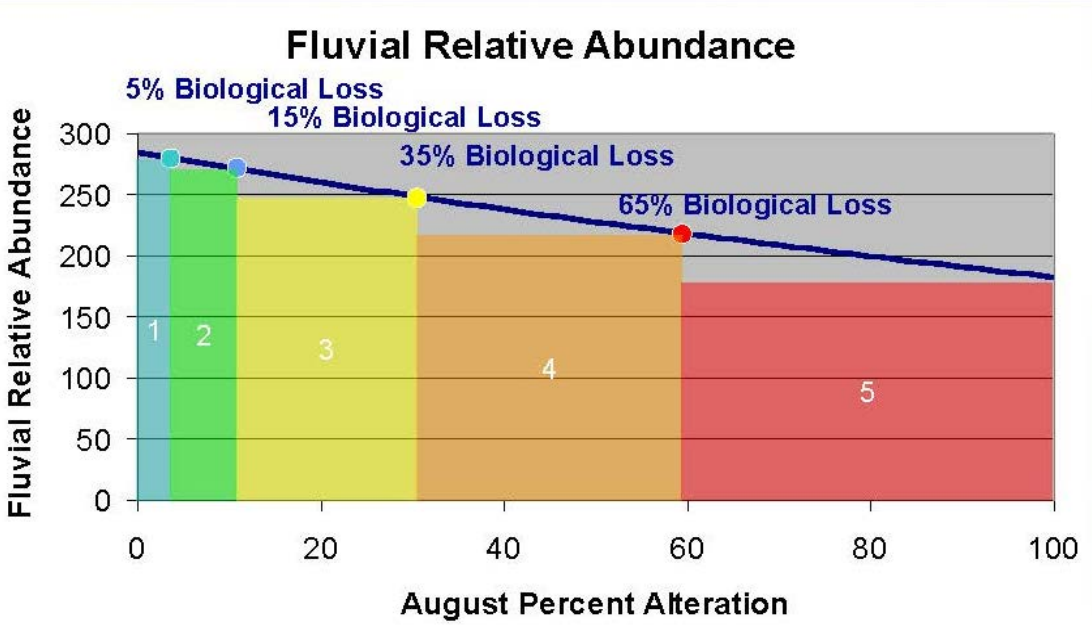


FIGURE 5. Chart of Biological Criteria based on Fluvial Fish Relative Abundance showing categorical alignment with modeled proportions of alteration from the estimated August median (P50) stream flow. Percent alteration from August P50 flow is modeled based on groundwater withdrawal. [Source: Richards 2010].

In watersheds with low impervious cover, Groundwater Withdrawal Levels (GWL), estimates of altered flow in a stream due only to groundwater withdrawal, correspond to the inflection points in the biological categories derived from the estimated August median (P50) flows (MADEP 2012). The Seasonal Streamflow Criteria are the maximum recommended water withdrawals specific to protect each of the habitat categories. In developing Seasonal Streamflow Criteria, alteration of the August P50 flow was considered the appropriate benchmark because in August, typically demand is high and flow is low; therefore, managing withdrawals to balance water availability at such critical timing makes sustainability a primary driver.

Baseline

In the SWMI framework, baseline is the reference point against which new or expanded withdrawal requests are to be compared. For each basin, baseline is the highest of the 2003 – 2005 average water use plus 5%; or, the 2005 water use plus 5%. The additional 5% is a factor that allows for economic growth; however, if baseline equals the registered volume, then no additional water use can be authorized. Additionally, baseline cannot be less than the registered volume; baseline must comply with existing permitted volume; and, baseline cannot exceed the Department's 20-year forecasts (MADEP 2012).

Public water systems (PWS) with sources in multiple basins must adhere to the individual baseline requirements of each basin in the PWS' source mix.

The SWMI framework establishes three tiers for proposed water withdrawals that are based on the combination of whether the proposal is an increase in baseline and whether the proposal is predicted to alter the GWL and/or Biological Category. Proposed water withdrawals that exceed baseline and that are predicted to alter GWL and/or Biological Category are required to develop and implement a mitigation plan regarding the withdrawal in excess of baseline.

Appendix C – Excerpts from “Sustainable Water Management Initiative Report, Monponsett Pond and Silver Lake Water Use Operations and Improvement”, Princeton Hydro LLC, July 2013

2.0 SITE SETTING

The City of Brockton and its water supply sources are located in Plymouth County, in the glacially-influenced Seaboard Lowland section of the New England physiographic province.

The BWS regional landscape appearance is dominated by unconsolidated material that was transported and deposited through Pleistocene glacier contact (e.g., moraines), glacial meltwater (e.g., stratified sand and gravel deposits), and as basin relics of ice block features (e.g., kettle ponds and wetlands). The region is characterized by an abundance of lakes, ponds, peat-filled wetlands, streams, and small rivers intermingled within a gentle undulating landscape (refer to Figure 6).

The BWS system diverts water from headwaters portions of three watersheds as follows: (1) Furnace Pond with natural outlet Herring Brook is located in the North River watershed; (2) Monponsett Pond with natural outlet Stump Brook is located in the Taunton River watershed (same watershed that includes City of Brockton); and, (3) Silver Lake is the headwaters of the Jones River, located in the Jones River watershed.

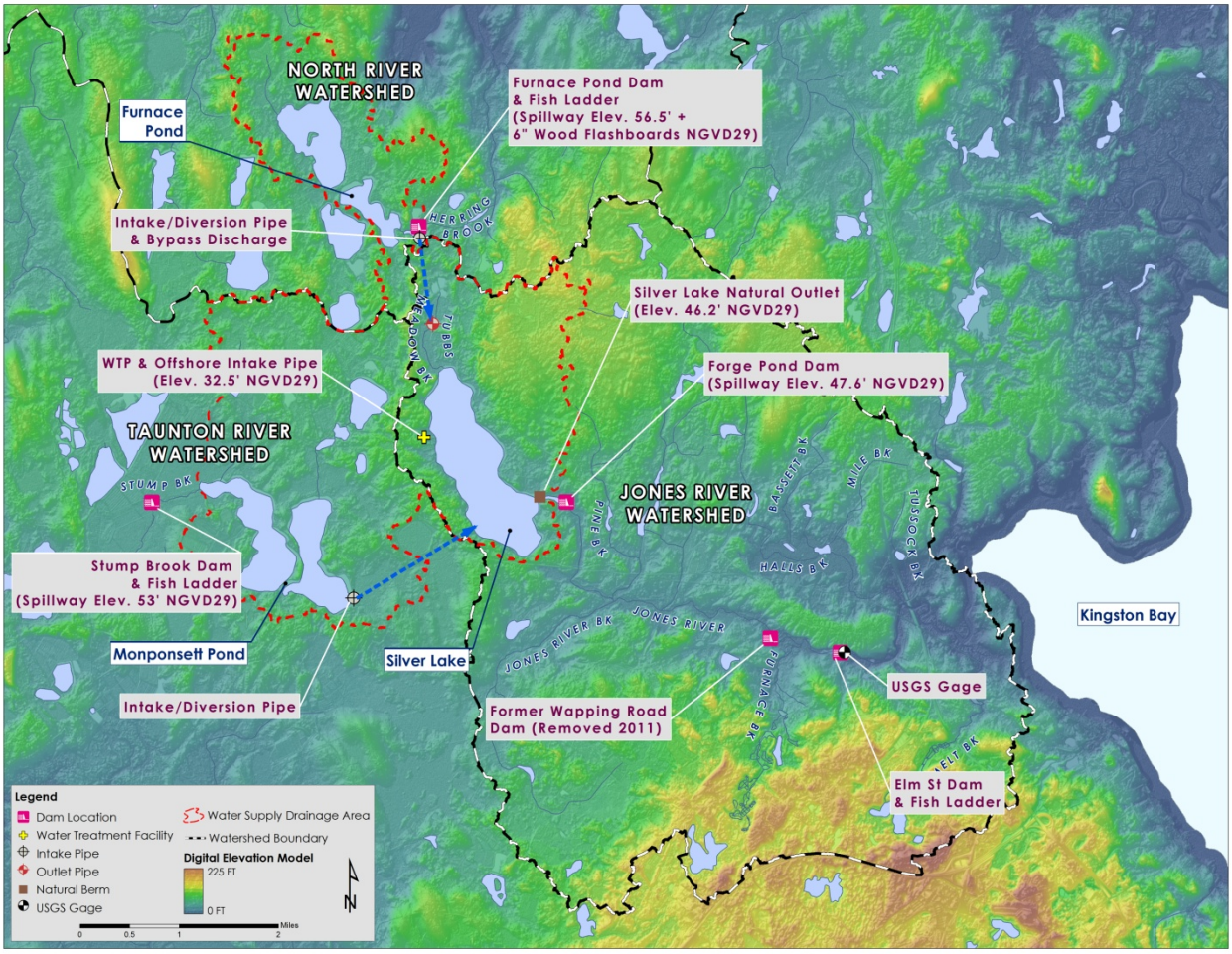


FIGURE 6. Subwatershed boundary map for the primary sources of Brockton's water supply system and individual water supply unit drainage areas.

2.1 Regional Hydrogeologic Traits

The primary water-bearing deposits in the BWS area are stratified sand and gravel of the Plymouth – Carver – Kingston – Duxbury (PCKD) aquifer system (Masterson et al. 2009). The regional, unconfined PCKD aquifer system water table is shallow and frequently intersects the landscape's variable surface, particularly the many relic ice block features (e.g., kettle basins).

Interactions between surface water features, including wetlands, and groundwater largely are determined by the position of local and regional flow paths. Figure 7 conveys the fact that a common, general regional water table is exhibited in the project area. While local elevation differences impart subtle variability, water surface elevations, particularly those within the Brockton water supply setting, adhere to a narrow range. Moreover, based on the hydrogeologic framework of the region, streams and rivers gain groundwater throughout their length.

Proximity to the coast sets a regional base elevation for the water table and also imparts a mixing zone between freshwater that originates inland, and seawater. Additionally, because seawater is denser than freshwater, a freshwater lens overlies saltwater. In some areas, excessive groundwater pumping has contaminated freshwater supplies.

The depth to bedrock surface in the vicinity of BWS features; i.e., Silver Lake, Monponsett Pond, and Furnace Pond, ranges from approximately 20 to 170 feet. The relatively thin, yet highly permeable and transmissive sand and gravel deposits of the PCKD aquifer system are extraordinarily efficient in terms of recharge and movement of groundwater. Masterson et al. (2009) reported hydraulic conductivities in the stratified sand and gravel deposits that range above 150 feet per day. Conversely, crystalline bedrock in the region generally supports wells of poor yield. Note that the City of Brockton is largely underlain by crystalline bedrock and supply wells in the City tend to be of sufficient yield only for on-lot domestic or irrigation demands.

Although a common regional water table is expressed in this landscape, rivers exhibit natural watershed areas that are based on topography. The BWS system artificially consolidates water from three separate river basins (e.g., headwaters portions of Taunton, North, and Jones), then BWS exports an average of 9 to 10 MGD to a distant part of the Taunton River watershed where the water is used and subsequently discharged into the Taunton River. In addition to the treated water volume that is used directly in the BWS distribution system (i.e., 9-10 MGD), during the diversion season (October through May) and in response to certain events outside of the diversion season, BWS diverts water from the Taunton (Monponsett Pond) and North (Furnace Pond) River watersheds into Silver Lake during periods in which water occasionally discharges from Silver Lake into Jones River.

In contrast to an ecological or hydrological perspective, BWS regards the artificially interconnected surface features that include Silver Lake, Monponsett Pond, and Furnace Pond as though they adhere to a single common watershed.

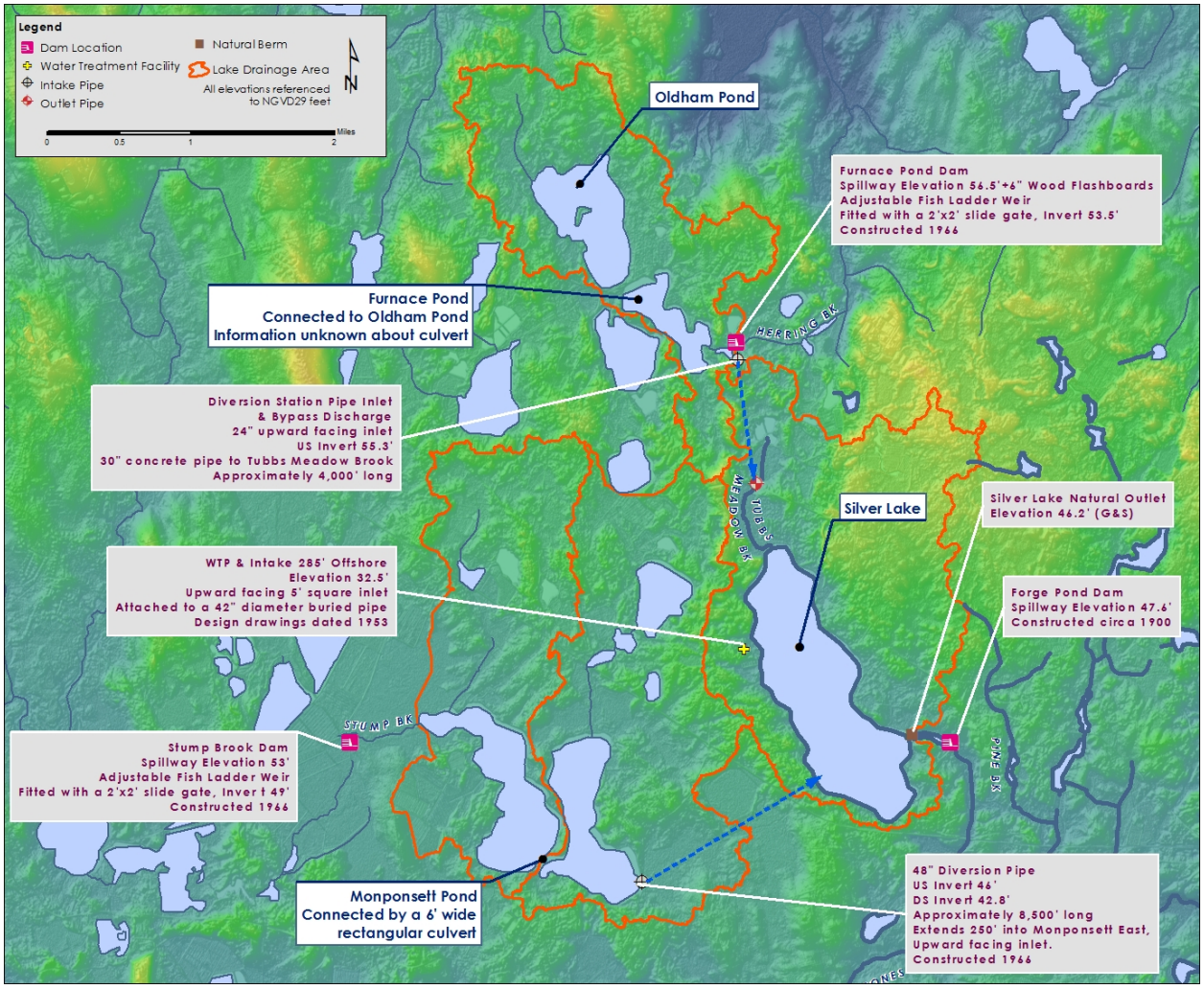


FIGURE 7. Project location map depicting regional topography, surface water features and their individual drainage areas, and major components of Brockton's water supply system.

Several USGS studies reinforce these findings: Masterson and Walter (2009) reported that 57% of annual precipitation infiltrates the land surface and becomes groundwater recharge; Carlson and Lyford (2005) reported comparable groundwater recharge for the region. Both of the referenced USGS reports also stated, due to high recharge capacity, there is minimal runoff for the region. Ultimately, the fate of infiltrated water on a regional basis is well defined; USGS reported ~95% is discharged either as streamflow or as groundwater seepage at the coast, with diversions of surface and groundwater accounting for the balance. True consumptive use of the water from either public supplies (reservoirs, rivers, and well fields) or from private wells in the region is reported by USGS to be relatively small because waste water is returned directly to the groundwater through on-lot septic management systems or as treated effluent discharged to rivers.

2.2 Regional Climate Data

Princeton Hydro compiled regional climate data sets from multiple observation stations located throughout the project setting. The primary data sets included daily temperature (minimum, maximum, mean) and precipitation measurements. Using the measured climate variables, Princeton Hydro calculated potential evapo-transpiration (PET) values on a daily basis using the Hargreaves – Samani (1982) method.

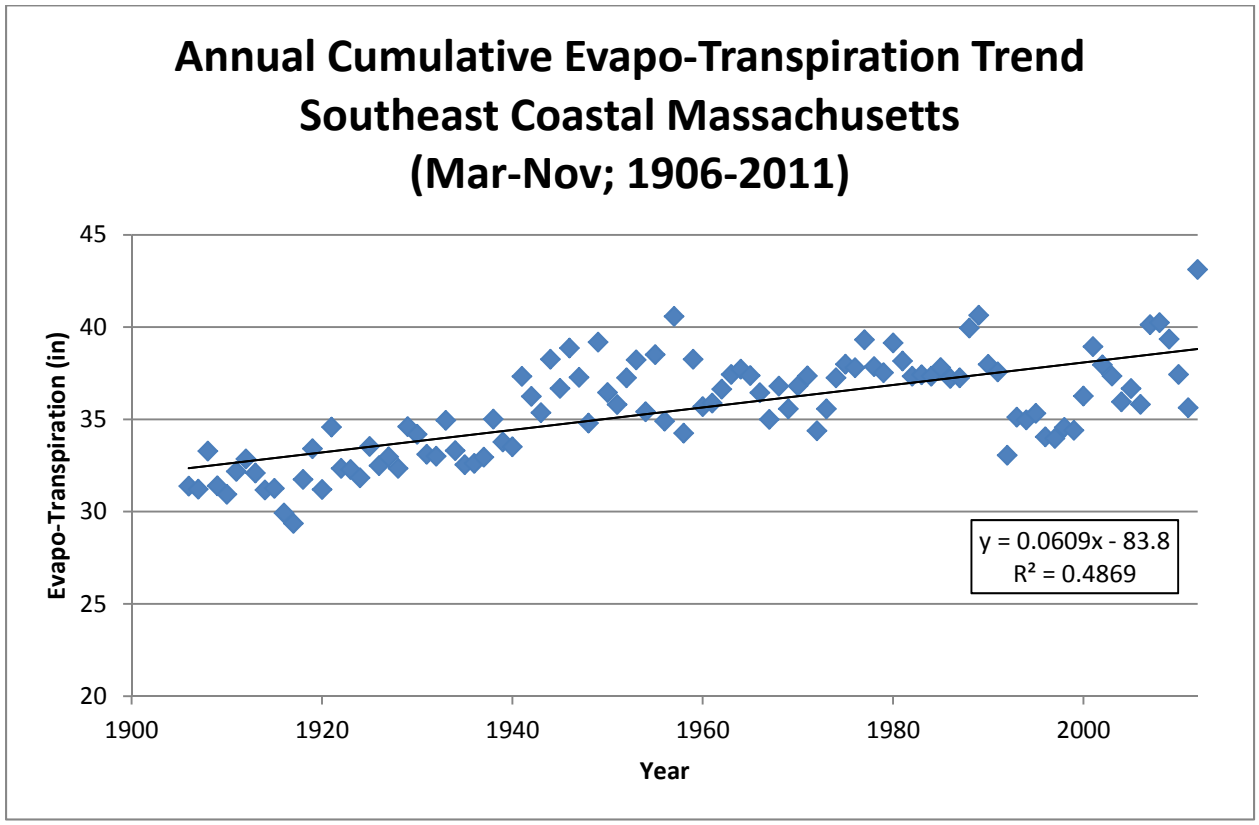


FIGURE 8. Chart showing total potential evapo-transpiration for Southeast Coastal Massachusetts for the months March – November spanning period 1906 to 2011.

To identify possible trends indicative of climate change that may be underway in the region, Princeton Hydro examined various time-series relationships related to temperature and precipitation. We assessed maximum, minimum, and average temperature on daily, monthly, seasonal, and annual time-step basis; monthly, seasonal, and annual precipitation; the frequency and length of precipitation – free periods on seasonal and annual basis; and, total PET for various assumed growing season periods.

Of the combinations of factors we evaluated, the time series of total PET calculated for the growing season exhibited the strongest correlation for a trend through time. As indicated by Figure 8, total calculated PET for the growing season (e.g., March through November), increased approximately 15% or more since the beginning of the 1900s.

2.3 Regional Water Budget

USGS (Masterson et al. 2009) calculated a simple regional water budget for the southeast coastal aquifer systems, expressed as:

Precipitation (P) – Evapotranspiration (ET) = Aquifer Recharge (R)

Using long-term (1931 – 2006) climate records from within the region, USGS reported average annual P as 47 inches and annual ET estimated to be 20 inches; therefore, as calculated above R equals 27 inches or approximately 57% of the region's average annual precipitation. Using stream flow measurements, USGS concluded that roughly 70% of the average annual recharge (~19 inches) for the region is expressed as stream base flow that is discharged to the estuary and another approximately 25% of recharge (6.8 inches) directly enters the coastal margin through the aquifer interface. The remaining 5% of annual recharge is equivalent to the water volume withdrawn from wells (Masterson et al. 2009).

In Section 1.3, charts of long-term monthly recharge, water table elevation, and stream flow were shown that demonstrated correlation among these three factors. Although groundwater systems (hydrologically) exhibit a time lag with respect to climate, the PCKD aquifer system is particularly vulnerable to drought. As evidenced by the regional water budget, 95% of annual recharge is discharged to the estuary as stream flow or as direct seepage through the aquifer/estuary interface. Additionally, because an extensive array of wetlands, ponds, and lakes is effectively embedded in the regional unconfined water table, ET processes efficiently remove water from the aquifer. Furthermore, the unconsolidated PCKD aquifer system is highly transmissive, meaning that water retention within the aquifer is brief; in other words, this aquifer stores water poorly. In periods of drought or in areas where water withdrawal rates are high, the PCKD may be readily depleted.

2.4 Brockton Water Supply System

Brockton's primary sources of potable water are located approximately 20 miles southeast of the City of Brockton, in the Towns of Halifax, Plympton, Kingston, and Pembroke (all of which, including Brockton are in Plymouth County). As indicated by the panel of USGS topographic maps below on Figure 9, the regional landscape exhibits long-standing human alteration. Review of the earliest map in Figure 9 illustrates the relatively sparse land development that existed in the water supply area prior to Brockton's use of Silver Lake. Subsequent maps show the pattern and density of land development in the BWS setting, including conversion of Great Cedar Swamp at the outlet of Monponsett Pond for cranberry production.

Others, notably Hanson-Murphy Associates (2006), provide a thorough description of the BWS system infrastructure. To recap in brief, beginning in 1905, Brockton began to pipe water from Silver Lake to the City for potable supply purposes because the City's Avon Reservoir lacked both the reliable capacity and water quality needed to satisfy Brockton's demands (Kasperson 1969). By the mid-1960s, Brockton's water demand exceeded the reliable yield of Silver Lake and in the late 1960s, diversions from Furnace Pond and Monponsett Pond into Silver Lake were constructed to augment the BWS system. In conjunction with the Furnace/Monponsett supplemental diversions, Brockton established

fixed weir elevations for Furnace and Monponsett Ponds and also constructed a water filtration plant at Silver Lake. Prior to building the Silver Lake Water Treatment Plant (WTP), the raw water quality of Silver Lake as delivered to Brockton was suitable for potable use.

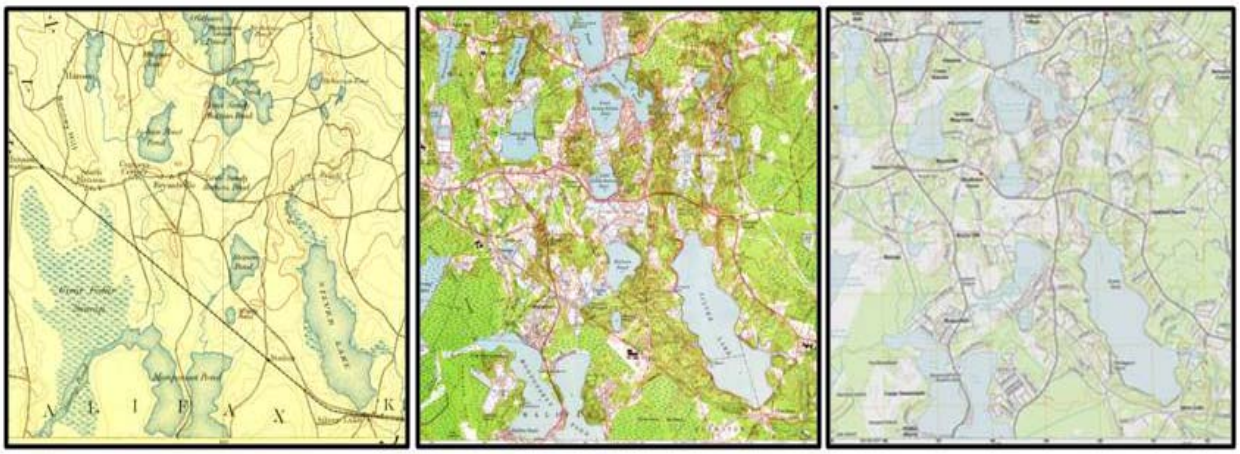


FIGURE 9. Panel of USGS Topographic maps for the City of Brockton's principal water supply source area. The 1888 map pre-dates Brockton's diversion from Silver Lake; the 1962 map preceded Brockton's diversion of Monponsett and Furnace Pond into Silver Lake; and the 2012 map shows existing conditions.

Appendix D - Excerpt from “Forge Pond Dam Fish Passage Improvement Feasibility Study and Preliminary Design”, Gomez and Sullivan, July 2013

demand hours of 10 pm to 6 am, one pump operates, withdrawing about 350,000 gallons per hour (Brockton, 2009).

The water level of Silver Lake is read from inside the level house, located approximately 20 feet from the shore near the WTP. Recent WTP upgrades have allowed lake level to be determined automatically and recorded by the operators' SCADA (Supervisory Control and Data Acquisition) system. Water levels are recorded once per day (in the morning) in inches above (+) or below (-) a reference mark equal to the Forge Pond Dam spillway[6] (Brockton, 2009).

Plant upgrades completed in April 2009 included systems to recycle lagoon supernatant back to the head of the plant (rather than being returned to Silver Lake).

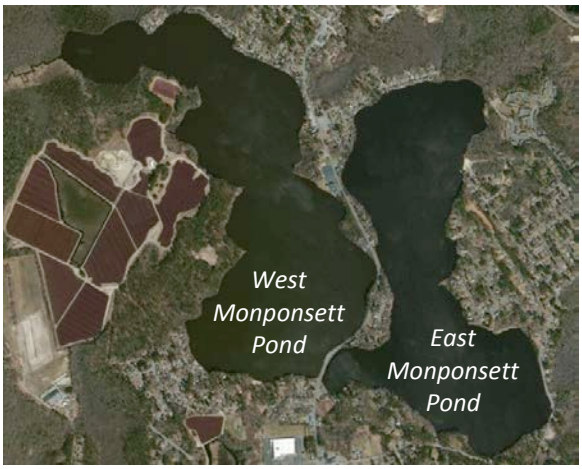
3.2.2 Monponsett Pond

Monponsett Pond is located southwest of Silver Lake in Halifax, within the Taunton River basin. It is split into an east and west lake by Route 58 with a 6-foot-wide rectangular concrete conduit connection. The pond has a maximum depth of approximately 13 feet with a watershed area of approximately 6 square miles. Refer back to **Figure 3.1-1** for the location of Monponsett Pond.

According to Brockton (2009), diversions from Monponsett Pond to Silver Lake take place between October and May when:

- Water level in Silver Lake is below full (47.5 feet NGVD); and
- Water levels in Monponsett Pond are above the minimum water level (52.0 feet NGVD). Brockton typically diverts water above a minimum water level of 52.5 feet.

In order to prevent flooding, diversions from Monponsett Pond to Silver Lake may occur throughout the year by written request from the Towns of Halifax or Hanson, or when the pond elevation exceeds 53.0 feet. Flooding in the vicinity of Monponsett Pond occurs when the water level is higher than the spillway elevation of 53 feet. Diversions between June and September require prior DEP authorization, a minimum of two days in advance (Brockton, 2009).



Water is also withdrawn from Monponsett Pond by local cranberry growers for consumptive and return uses at cranberry bogs in the area (Brockton, 2009).

The area surrounding Monponsett Pond is developed and the ponds are used for recreational purposes. The herbicide fluridone has been used in the pond for control of invasive plant growth of primarily fanwort and milfoil, which has become extensive in recent years (HMA, 2006).

[6] Brockton uses 47.5 feet NGVD for this elevation.

Stump Brook Dam and Fish Ladder

The natural discharge point of the interconnected ponds is through Stump Brook located on the northwesterly corner of the west lake. Stump Brook flows to Robbins Pond in Halifax which flows to the Satucket River in the Taunton River Watershed. Water level in the lake is controlled by Stump Brook Dam which is located approximately 3,000 feet downstream from the mouth of the brook on Monponsett Pond. The dam has a spillway crest elevation of 53.0 feet.

At the time the current dam was constructed, an earthen dam, located just upstream, was removed. According to the 1966 construction drawings, the top of the original dam was approximately at elevation 51.0 feet. Because the Acts of the Legislature precluded water diversion when the pond level is below 52.5 feet, the new dam was constructed with a crest elevation of 53.0 feet. The increased elevation provides approximately 28 MG of additional storage when the ponds are at the elevation of the crest. However, as noted above, at this level (53.0 feet), residents around the ponds experience problems with basement flooding, septic system operation, and loss of beach front, prompting requests from town officials in Halifax to discharge water from the ponds, which is typically achieved by diversion of additional water to Silver Lake. This type of overflow diversion usually occurs in the fall and winter months, but does occur in the spring and summer as well (HMA, 2006).

The dam contains a spillway and a 2-foot wide flume connected to a fish ladder below. Within the flume, there is an adjustable 2-foot by 2-foot sluice gate that can be used to control the water level in Monponsett Pond (between elevations 51.0 and 53.0 feet), which also releases to Stump Brook. The dam also contains a low-level outlet that does not appear to be used.

The adjustable weir fish ladder has been fitted with an upstream ultrasonic flow meter to approximate the flow down the ladder. Inspection of the meter by HMA in 2005 indicated that it was operational; however flow measurements appeared to be out of calibration. According to Brockton (2009), operators from the Silver Lake WTP monitor the gage weekly year-round and more frequently during diversions to check on the flow over the fish ladder and to Stump Brook. The stage-discharge equation used for the flow meter is based on a 2-foot flume width (equation is approximately discharge = 0.1035 x stage$^{1.5}$, with discharge in mgd, stage in inches). The flow meter only measures flow down the fish ladder; flow over the wider spillway is not metered. Operators also use depth of water over the flume to estimate adequate flow.

Brockton (2009) reports that releases to the fish ladder are made to Stump Brook when the diversion to Silver Lake is in use, when herring are running, or when requested by the towns of Halifax and Hanson. When the diversion is in use, a continuous flow of 0.9 mgd over the fish ladder is required (Brockton typically targets an average of 0.9 mgd over the diversion period). The gate of the fish ladder is also gradually lowered during summer months, when no water is being diverted, to keep a consistent flow in Stump Brook (Brockton, 2009).

HMA (2006) noted that the design of the fish ladder is such that debris can build up in the areas between the steps of the ladder. Flow across the ladder appeared to be good but the intermediate pool areas can be severely reduced by the collection of materials. Although the fish ladder has been classified in the last *MarineFisheries* fish passage survey (Reback et al., 2005) as in "good condition" and "passable function," the downstream waterways are very complex and may require additional work to fully address the concerns of fish passage.

HMA (2006) also reported that probing of the upstream face of the dam indicated a substantial build-up of silt, measuring approximately 2.3 feet deep in one area. This is likely the result of low or no flow stream velocity. The stagnated water has also resulted in significant vegetative and algal growth in the brook.

The dam is situated in the Burrage Pond wildlife management area (formerly a 1,600+ acre cranberry bog site) and is located remote from paved roadways making it somewhat difficult to access. From the WTP it takes approximately 20 minutes to reach Stump Brook Dam by car.

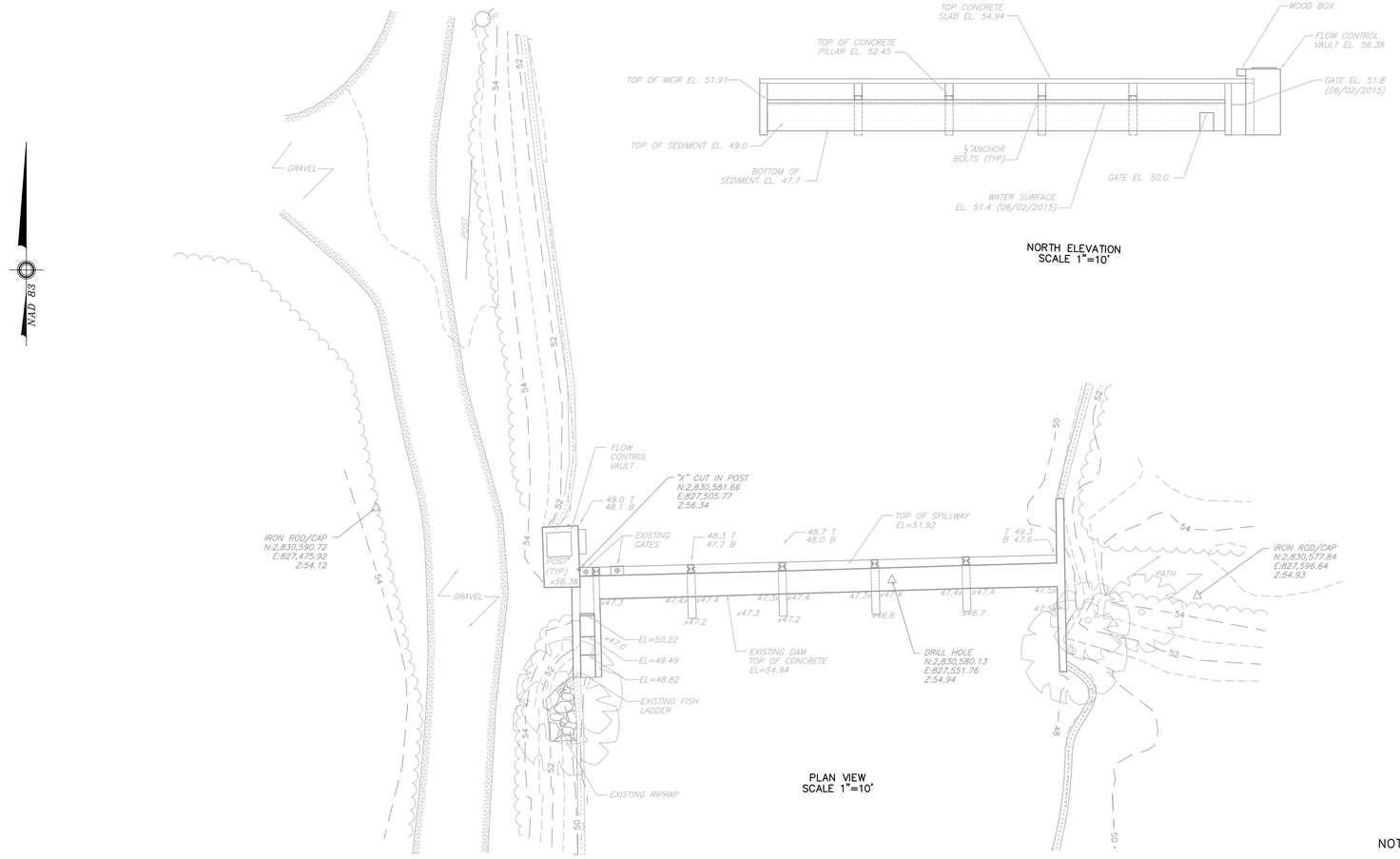
Intake Pipe and Diversion Station (to Silver Lake)

Transfer from Monponsett Pond to Silver Lake occurs through a gravity-fed aqueduct located in the southeastern corner of the east pond. A 48-inch gate valve at the Monponsett Pond diversion station is opened remotely or manually to initiate transfer from Monponsett Pond to Silver Lake. Water flows from the diversion station by gravity to Widgeon's Point in Silver Lake. Recent WTP upgrades now permit remote valve operation through use of the operator SCADA system at the WTP (Brockton, 2009).

Brockton (2009) notes that while it is possible to open the valve partway, in practice the valve is generally operated as either fully open or fully closed. Typically, when the diversion is being used, the valve is fully open all day. The daily diversion volumes are generally the same from day to day.

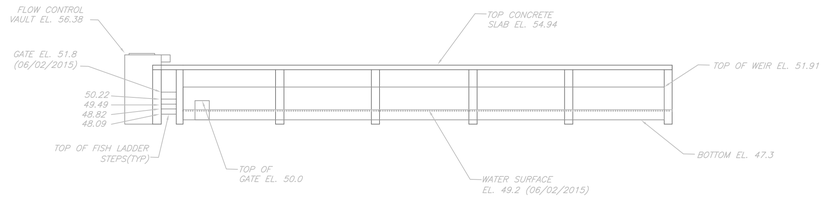
The 48-inch-diameter intake pipe extends approximately 250' off shore, with a grated, upward facing inlet at elevation 46.0 feet (i.e., 7 feet below the surface of the pond at overflow level). The diversion station contains a gage glass for manually monitoring pond level and readings are referenced above or below elevation of 52.5 feet, which was the minimum elevation for diversion established by the 1964 legislation. In the Acts of 1981, Chapter 237, the minimum level was reduced to elevation 52'-0" in response to the drought and severe drawdown at Silver Lake that occurred at that time. Readings are recorded generally on a daily basis, along with the reading from a totalizing flow meter in the diversion pipe (HMA, 2006). As noted previously, diversions of this poor quality water impacts the nutrient level, DO, and temperature of Silver Lake, due to the input of about 30 mgd when the valve is open.

Appendix E – Detailed Dam Survey



PLAN VIEW
SCALE 1"=10'

NORTH ELEVATION
SCALE 1"=10'



SOUTH ELEVATION
SCALE 1"=10'

NOTES:

1. THE CONTROL SURVEY FOR THIS PROJECT IS BASED ON THE MASSACHUSETTS STATE PLANE COORDINATE SYSTEM (SPCS), ESTABLISHED BY USE OF OF A GPS INSTRUMENT. THE GPS INSTRUMENT RECORDED SUFFICIENT GPS DATA TO OBTAIN SUB-CENTIMETER RESULTS.

2. THE HORIZONTAL DATUM IS THE NORTH AMERICAN DATUM OF 1983 (NAD83).

3. THE VERTICAL DATUM IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) TO CONVERT ELEVATIONS TO THE NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD29) ADD 0.82'

GRAPHIC SCALE

10 0 5 10 20 40

(IN FEET)
1 inch = 10 ft.

JOB NO: GHD1-2291

Green Seal Environmental, Inc.
114 State Road, Building B
Sagamore Beach, MA 02562
Tel: (508) 888-6034
Fax: (508) 888-1506
www.gseenv.com

REVISIONS

NO.	DATE	COMMENT

LEGEND

- UTILITY POLE
- EDGE OF WATER
- GRAVEL ROAD
- 50 MAJOR CONTOUR
- 49 MINOR CONTOUR
- TREE LINE
- 48.3 T / 47.7 B TOP AND BOTTOM OF SEDIMENT

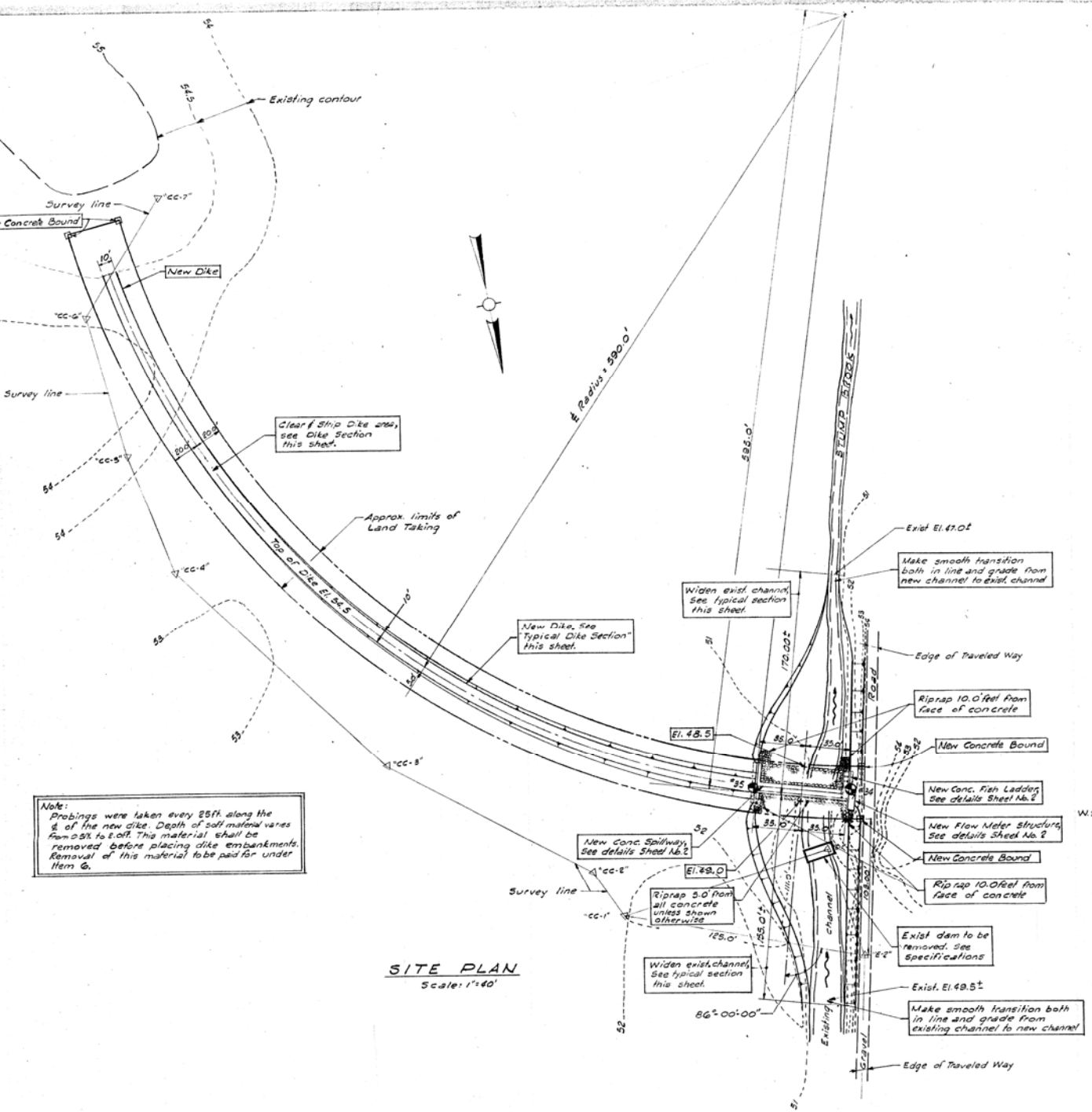
LOCUS:
Stump Brook Dam
Halifax, MA

PREPARED FOR:
GHD INC.

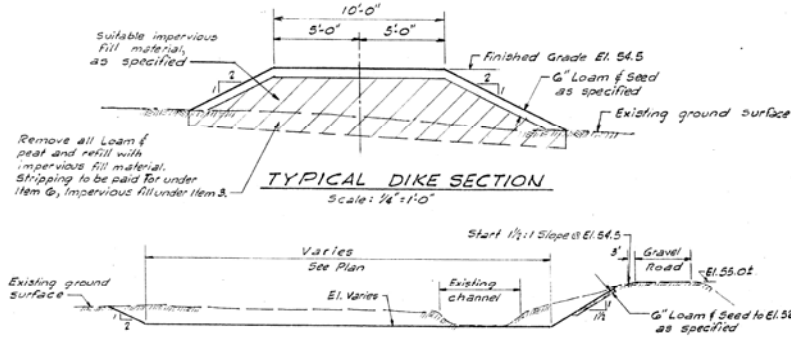
DRAWING TITLE:
EXISTING CONDITIONS

CAD TECH:	CHECKED BY:
J. PICHARDO	T.BENNETT
	DATE: 06/10/2015
	SCALE: 1" = 10'
	SHEET: 1 OF 1

Appendix F – Previous Dam Survey



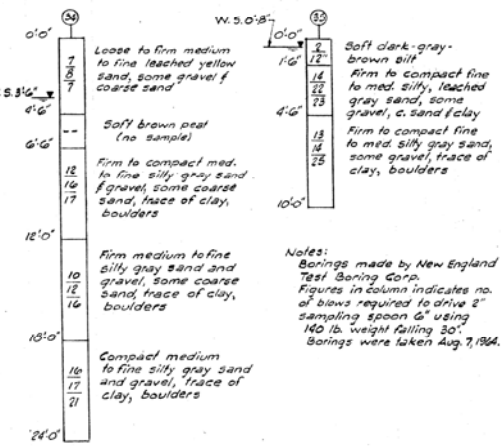
SITE PLAN
Scale: 1"=40'



TYPICAL DIKE SECTION
Scale: 1/4"=1'-0"

TYPICAL SECTION THRU IMPROVED CHANNELS
Scale: 1"=10'

BORING LOGS
Scale: 1"=4'



Notes:
Borings made by New England Test Boring Corp.
Figures in column indicates no. of blows required to drive 2" sampling spoon 6" using 140 lb. weight falling 30".
Borings were taken Aug. 7, 1964.

GENERAL NOTES

1. Topographical plan from survey made by Camp, Dres... McKee in June, 1964.
2. All elevations refer to U.S.G.S. datum to convert to ... of Brockton base add 1.56'.
3. The location of pipes and other underground stru... are not warranted to be exact nor is it warranted ... all underground structures are shown.
4. Boring locations are shown thus: ⊕ #34
5. The Right of Way for access to the Dam Site is from Elm...
6. Notes pertaining to new work shown thus: [ ]
7. City will obtain all necessary easements and r... of way for the construction of this project. The Co... shall not move on any private property without writ... consent from the Owner.
8. Contractor shall place new Standard Highway Conc... Bounds at all four corners indicated on this Plan.

Date	Chk'd.	Revision

Drawn by: EAD
Checked by: RV
Approved by: VEH
Date: Sep
Scale: As Noted

CITY OF BROCKTON, MASSACHUSETTS
WATER WORKS IMPROVEMENTS

CONTRACT NO. 6
MONPONSETT POND DIVERSION
OUTLET WORKS

SITE PLAN AND DETAILS

CAMP, DRESSER & McKEE
Consulting Engineers
Boston, Mass.

SHEET
200-

Appendix G – CPCWDC Charter

DIVISION 4. - CENTRAL PLYMOUTH COUNTY WATER DISTRICT

FOOTNOTE(S):

--- (**4**) ---

Editor's note— The preamble to Acts 1964, c. 371, the act from which this article has been derived, reads as follows:

Whereas, the deferred operation of this act would tend to defeat its purpose, which is in part to establish immediately the Central Plymouth County Water District and to authorize immediately the city of Brockton to extend its source of water supply, therefore, it is hereby declared to be an emergency law, necessary for the immediate preservation of the public convenience.

Be it enacted, etc., as follows:

Sec. 441. - Central Plymouth County Water District established; composition.

There is hereby established the Central Plymouth County Water District, hereinafter called the district, consisting of the city of Brockton and the towns of East Bridgewater, Halifax, Hanson, Kingston, Pembroke, Plympton and Whitman.

(Acts 1964, c. 371, § 1)

Sec. 442. - Water district advisory board.

There shall be in the district an advisory board consisting of a member of the board of selectmen or other person designated by the board of selectmen of each of the towns in the district, the mayor of the city of Brockton or his designee, and a member of the city council of said city to be appointed by the mayor. The advisory board shall serve without compensation and shall meet on the first Monday of the months of May and November or oftener as required. It shall elect annually a chairman and secretary from its membership and shall keep records of its deliberations and actions and its recommendations to the commission.

(Acts 1964, c. 371, § 2)

Sec. 443. - Water district commission.

The district shall be under the direction of a commission consisting of three commissioners, hereinafter called the commission, who shall be appointed by the advisory board. One of said commissioners shall be a resident of the city of Brockton. The initial appointment of said commissioners shall be as follows: one commissioner to be appointed for a term of one year, one for a term of two years, and one for a term of three years. Thereafter all appointments shall be for a term of three years except that an appointment to fill a vacancy shall be for the balance of the unexpired term. Said commissioners shall serve without compensation until such time as the city of Brockton cedes ownership in its water supply facilities to the district. A commissioner may be removed from office for cause and after a hearing by a vote of three-fourths of the membership of the advisory board. Any vacancy in the office of commissioner shall be filled by the advisory board within three months.

The commission shall meet no later than one month after all appointments have been made and said commission at its first meeting and annually thereafter, on or before the first Monday in May, shall elect one of its members to serve as chairman of the commission.

The commission shall, in co-operation with and with the advice of the state department of public health, the department of agriculture and the water resources commission, investigate available surface and subsurface sources of water supply for the district and the allocation of said supplies within the district, and shall study the water supply needs and resources of Plymouth county and the adjacent portions of Norfolk county, with priority given to the study of Cleveland Pond in Abington, and to ground water in the city of Brockton and the towns of Hanson, Halifax, East Bridgewater and Whitman.

The commission shall also investigate all pertinent matters relating to the quantity of water required, the quantity of water to be obtained from available sources, its quality, the best method of protecting the purity of the water, the construction, operation and maintenance of the works for storing, conveying or purifying the water and the cost of the same, the damages to property and all other matters pertaining to the subject.

The commission may expend for engineering and other assistance and other expenses such sums as may be appropriated therefor.

The commission shall report fully with plans and estimates to the general court on or before the fourth Wednesday in January, nineteen hundred and sixty-six and shall append to its report drafts of legislation to carry its recommendations into effect.

(Acts 1964, c. 371, § 3)

Sec. 444. - Diversion of certain waters authorized; construction of water filtration plant; limitation.

The city of Brockton, hereinafter called the city, for the purpose of increasing its water supply is hereby authorized to divert surplus flow as defined in section nine from Furnace Pond, situated in the town of Pembroke, and Monponsett Pond situated in the towns of Halifax and Hanson, into Silver Lake and thence to the city and the towns also supplied; provided that no diversion shall be made and no necessary lands shall be acquired under this act [division] without first obtaining the advice and approval of the department of public health and that the location of all intake structures and treatment works hereunder shall be subject to the approval of said department. Before any property is taken or any construction is begun the city shall submit to the commission at least two copies of all construction plans, specifications, estimates, plans and descriptions of property to be taken, and of proposed easements, and the commission within sixty days after receipt of any such information, shall notify the city in writing of any recommendations it may have concerning the proposed work. The city shall study all such recommendations and whenever feasible the city shall adopt such recommendations. The city shall proceed forthwith with the design and construction of a suitable water filtration plant at Silver Lake having a capacity of not less than twenty million gallons per day, to purify all water supplied. Any rights granted under this section to the city or to the district to divert surplus flow from said Furnace Pond or said Monponsett Pond shall be revoked and cease to be of any effect if said water filtration plant is not constructed and actually in use on or before October first, nineteen hundred and sixty-eight. The commission may prohibit any diversions when the water level of Silver Lake is above elevation forty-six and one-half, United States Coast and Geodetic Survey base. All authority granted to the

city by this act [division] shall be vested in its board of water commissioners, hereinafter called the board.

(Acts 1964, c. 371, § 4)

Sec. 445. - Eminent domain proceedings authorized.

The city for the purpose aforesaid, may take by eminent domain, acquire or hold by purchase or otherwise all land, rights-of-way and easements necessary for diverting and purifying such water from the aforesaid ponds and conveying same to Silver Lake. No land shall be taken at Furnace Pond except for necessary spillway and diversion structures near the outlet of Furnace Pond, and no land shall be taken at Monponsett Pond except for necessary spillway and diversion structures. The city shall obtain the advice of the commission with regard to the taking of land.

(Acts 1964, c. 371, § 5)

Sec. 446. - Erection of structures, etc.; laying pipe.

The city may erect on lands taken or held under the provisions of this act [division], diversion works and other structures and may make excavations, procure and operate machinery and provide such other means and appliances and do such other things as may be necessary for the effective use of the aforesaid auxiliary supplies, and for that purpose may lay down and maintain aqueducts, conduits, pipes and other works, in, under, on or over any lands, watercourses, or public or private ways, and along any such ways in said towns of Pembroke, Hanson, Halifax, and Plympton, in such manner as not unnecessarily to obstruct the same; and for the purpose of constructing, laying, maintaining, operating and repairing such conduits, pipes and other works, and for all proper purposes of this act [division], the city may dig up in such manner as to cause the least hindrance to public travel, and shall restore and keep in repair such ways where they have been dug up, to the satisfaction of the proper authority in the respective town in which such ways are situated. The city shall not enter upon the location of any railroad corporation or construct or lay any aqueducts, pipes, conduits or other works within such location except at such time and in such manner as it may agree upon with such railroad corporation, or, in case of failure so to agree, as may be approved by the department of public utilities.

(Acts 1964, c. 371, § 6)

Sec. 447. - Laying out future public ways not to prejudice city rights.

If any public way shall hereafter be laid out in whole or in part over said aqueducts, pipes or conduits such laying out shall not prejudice the right of the city to care for, alter or repair the aqueducts, pipes or conduits therein or thereunder. All such public ways shall as far as possible conform to the grade of such aqueducts, pipes or conduits, and their surfaces shall be no less than four feet above the top of such aqueducts, pipes or conduits, unless a different construction is agreed upon between the city and the town in which such ways are situated.

(Acts 1964, c. 371, § 7)

Sec. 448. - Treble damages for unlawful diversion, destruction, etc.; penalty;

normal use of certain ponds not prohibited; when diversion prohibited.

If any person shall without the consent of the board and of the commission use any water taken after entry into the diversion system or obtained under this act [division], or shall wantonly or maliciously divert the water or any part thereof or corrupt the same or destroy or injure any intake structure, pipe, conduit or other property held, owned or used by the city under the authority of and for the purpose of this act [division], he shall forfeit and pay to the city three times the amount of damages assessed therefor, to be recovered in an action of tort; and on conviction of any of the wanton or malicious acts aforesaid may be punished by a fine not exceeding three hundred dollars or by imprisonment in a jail or house of correction for a term not exceeding one year.

Notwithstanding the provisions of sections one hundred and sixty and one hundred seventy-two of chapter one hundred and eleven of the General Laws, nothing in this act [division] shall be construed as preventing the normal use of the aforesaid Furnace Pond and Monponsett Pond for bathing, boating, fishing and other purposes, nor shall the provisions of this act [division] prevent the withdrawal of sufficient water for flooding or irrigation of cranberry bogs, nor shall the provisions of this act [division] prevent the return flow of such flood waters from cranberry bogs to the aforesaid ponds. There shall be no diversion of water from Furnace Pond or from Monponsett Pond into Silver Lake, if, in the opinion of the department of public health, the diversion of such waters would endanger the public health.

(Acts 1964, c. 371, § 8)

Sec. 449. - Manner of construction of facilities to allow flow of water; limitation on diversion.

The city shall construct facilities at or near the present outlets of the aforesaid Furnace and Monponsett ponds in such a manner as to allow a minimum daily flow of three hundred thousand gallons from Furnace Pond, a minimum daily flow of nine hundred thousand gallons from Monponsett Pond to pass downstream at all times when water is being diverted except in case of emergency when less water may be discharged downstream if ordered by the department of public health and approved by said commission and this flow shall be measured and recorded and such records maintained by said city. Notwithstanding the aforesaid minimum flow, sufficient water shall be allowed to pass downstream, at all times when water is being diverted to allow herring to travel upstream and downstream. During the months of October to May, inclusive, all flows in excess of the aforementioned minimum flows may be diverted into Silver Lake but no diversion shall be made from Furnace Pond when the water level of Furnace Pond is below elevation fifty-six, United States Coast and Geodetic Survey base. During the months of June through September, inclusive, no flow may be diverted, from said ponds except when, in the opinion of said commission, an emergency exists due to imminent flooding. At such times of emergency, for the purpose of preventing flooding and damage to property in the vicinity of said pond, the commission may, subject to the approval of the department of public health, authorize the diversion of excess waters at stated times during said months but, in no case, may the ponds be drawn down below the minimum elevations established in this section. Control works shall be constructed by the city to prevent diversion from Furnace Pond when the water level in Furnace Pond is below elevation fifty-six, United States Coast and Geodetic Survey base. Control works shall be constructed to prevent diversions from Monponsett Pond when the water level in Monponsett Pond is below elevation fifty-two and one-half United States Coast and Geodetic

Survey base. Notwithstanding the provisions of section forty of chapter forty of the General Laws, water shall not be drawn from Furnace Pond below elevation fifty-six nor from Monponsett Pond below elevation fifty-two and one-half, United States Coast and Geodetic Survey base. It shall be the sole responsibility of the city to assume all costs of water filtration or purification required by the department of public health because of the public use of Furnace, Oldham and Monponsett ponds, as provided in section eight in order that they may be permanently usable by the public for the purposes described therein.

(Acts 1964, c. 371, § 9)

Sec. 450. - Water to be supplied to certain towns.

The board shall, upon application by the selectmen of any town herein named and with the approval of the commission, supply such town with a public water supply. In case a town not herein named desires a supply of water as aforesaid, such town shall first obtain from the department of public health and from the commission an opinion in writing to the effect that one or more of the aforesaid Furnace and Monponsett Ponds, is a natural and proper source of supply for the town and upon presentation of such an opinion the said board shall furnish water to said town by delivering the same in a main water pipe, reservoir or tank to the town, under the head or pressure required and maintained by the city, unless it be delivered in some other manner by agreement between the parties interested. The board shall have the direction and control of all connections made between the city and town system, but the cost of such connections shall be paid by the town for which they are made.

(Acts 1964, c. 371, § 10)

Sec. 451. - Water price.

The price to be paid by any town for water delivered to it, or by any person, corporation or water company taking said water under authority of the selectmen of such town, if not determined by mutual agreement, shall be determined by three commissioners to be appointed by the supreme judicial court, upon application of either party and notice to the other; and the award of said commissioners when accepted by the court shall be binding upon both parties for a period to be designated by the court.

(Acts 1964, c. 371, § 11)

Sec. 452. - Limitating on applicability of act to certain towns.

Nothing in this act [division] shall interfere with the right granted to the town of Pembroke by chapter two hundred and eighty of the acts of nineteen hundred and thirty, nor prevent the town of Plympton, Hanson or Halifax from taking an independent supply of water from said ponds, provided, that satisfactory arrangements cannot be made with said city therefor; and provided, further, that whenever said water is taken by any town as an independent source of supply it shall be taken under the advice and with the approval of the commission and the department of public health, and subject to the restrictions which said department may impose; and provided, further, that each town taking an independent supply of water shall pay its proportionate part of the damages which the city may be called upon to pay for any improvements to said auxiliary supplies required due to the taking of an independent supply by said towns.

(Acts 1964, c. 371, § 12)

Sec. 453. - Application to act to Abington, Rockland and Whitman.

Nothing in this act [division] shall interfere with rights granted to the towns of Abington, Rockland and Whitman by chapter two hundred and six of the acts of eighteen hundred and eighty-five, relating to the taking of water supply from Great Sandy Bottom Pond, or by chapter six hundred and eighteen of the acts of nineteen hundred and forty-five authorizing the aforesaid towns to take water by means of wells or filter galleries on their property near Furnace Pond.

(Acts 1964, c. 371, § 13)

Secs. 454—465. - Reserved.

Appendix H – Conduit Location Map

TOWN OF HALIFAX

TOWN OF HANSON

Burrage Pond Wildlife Management Area
Commonwealth of Massachusetts
Division of Fish and Wildlife

Burrage Pond Wildlife Management Area
Commonwealth of Massachusetts
Division of Fish and Wildlife

OPTION A

OPTION B

STUMP BROOK
DAM LOCATION

West Monponsett
Pond

ELM STREET

POND STREET

WOODBINE AVENUE

ELM ASPEN STREET

EDEN COURT

ARNA STREET

PLYMOUTH STREET

OPTION	LENGTH (FT)	
Option A	7165	
Option B	7731	
EASEMENT WIDTH	**OPTION**	**AREA (ACRES)**
10	A	1.7
15	A	2.5
20	A	3.3
10	B	1.8
15	B	2.7
20	B	3.6

Paper Size ARCH D

0 175 350 700 Feet

Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
Grid: NAD 1983 StatePlane Massachusetts Mainland FIPS 2001 Feet

LEGEND

OPTION A OPTION B

TOWN OF HALIFAX, MA
Supervisory Control and Data Aquisition (SCADA) Feasibilty and Design Memorandum at the Monponsett Pond System
Sustainable Water Management Initiative Gran t- FY 2015

Job Number 86-18735
Revision A
Date 03 Jun 2015

PROPOSED CONDUIT LOCATIONS

Figure 1

G:\86\18735\GIS\Maps\MXD_Deliverables\Halifax.mxd

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:jjobrien

1545 Iyannough Road, Hyannis Massachusetts 02601 USA T 1 508 362 5680 F 1 508 362 5684 E hyamail@ghd.com W www.ghd.com

Appendix I – Dam Removal Funding

Financial and Technical Assistance for Infrastructure Removal/Repair and Planning

CATEGORY 1 – Dams and similar unregulated impoundments

In addition to the Massachusetts Dam and Seawall Repair and Removal Fund, other sources of financial assistance are available. While this is not a complete list it will be updated periodically and additional sources added when discovered. If you are aware of opportunities not listed here, please send helpful suggestions including web links, to John Clarkeson at john.clarkeson@state.ma.us.

The information contained here is provided for assistance only. While the information provided is based on current research, many programs to change over time. Therefore, EEA offers no guarantee or assurance of its accuracy. Interested applicants need to check with the particular program in which they are interested and review the most current documents published by that program. This document is not to be cited as a reference.

Other helpful links:

Federal Grant Search Resources:

www.grants.gov

https://www.cfda.gov/index?s=main&mode=list&tab=list

EEA's Grant and Loan Guide:

http://www.mass.gov/eea/grants-and-tech-assistance/grants-and-loans/eea-grants-guide/

1 The information contained here is provided for assistance only. While the information provided is based on current research, many programs to change over time. Therefore, EEA offers no guarantee or assurance of its accuracy. Interested applicants need to check with the particular program in which they are interested and review the most current documents published by that program. This document is not to be cited as a reference.

Financial and Technical Assistance for Infrastructure Removal/Repair and Planning

CATEGORY 1 – Dams and similar unregulated impoundments

Category 1: Dams and similar unregulated impoundments *X = applications for this phase of a project are considered.*	**Conceptual Design**	**Feasibility Studies**	**Final Design**	**Permitting**	**Construction**
Massachusetts Executive Office of Energy and Environmental Affairs Dam and Seawall Repair and Removal Fund Program			X	X	X
Army Corp of Engineers – New England Planning Assistance to States Program	X	X			
Army Corp of Engineers- New England Emergency Streambank and Shoreline Protection	X	X	X		X
Army Corp of Engineers- New England Flood Reduction Projects	X	X	X		X
Army Corp of Engineers- New England Aquatic Ecosystem Restoration Projects	X	X	X		X
Army Corp of Engineers- New England Environmental Restoration	X	X	X		X
United States Department of Agriculture Rural Water and Environmental Programs	X	X			

Financial and Technical Assistance for Infrastructure Removal/Repair and Planning

CATEGORY 1 – Dams and similar unregulated impoundments

Category 1: Dams and similar unregulated impoundments X = applications for this phase of a project are considered.	**Conceptual Design**	**Feasibility Studies**	**Final Design**	**Permitting**	**Construction**
United States Department of Agriculture Watershed Restoration and Enhancement Agreement Authority		X			X
United States Department of Agriculture Emergency Watershed Protection Program					X
United States Department of Agriculture Watershed and Flood Prevention Operations (WFPO) Program	X	X	X		X
United States Department of the Interior Water Resources on Indian Lands	X	X			
United States Department of the Interior Landscape Conservation Cooperatives (LCC) Program	X	X	X		
United States Department of the Interior North American Wetlands Conservation Fund			X		X
United States Department of Commerce Investments for Public Works and Economic Development Facilities					X

Financial and Technical Assistance for Infrastructure Removal/Repair and Planning

CATEGORY 1 – Dams and similar unregulated impoundments

Category 1: Dams and similar unregulated impoundments X = applications for this phase of a project are considered.	**Conceptual Design**	**Feasibility Studies**	**Final Design**	**Permitting**	**Construction**
Massachusetts Executive Office of Energy and Environmental Affairs Massachusetts Environmental Trust	X (for partial or full removal)	X (for partial or full removal)	X (for partial or full removal)	X (for partial or full removal)	X (for partial or full removal)
Massachusetts Department of Conservation and Recreation River and Harbor Grant Program		X	X	X	X
Massachusetts Department of Environmental Protection 604b Assessment Program	X	X			
Section 319 Nonpoint Source Competitive Grants Program				X	X
Massachusetts Department of Environmental Protection State Revolving Loan Fund: Clean Water Fund	X	X	X	X	X
Massachusetts Department of Fish and Game Wetlands and River Restoration and Revitalization Priority Projects	X (for partial or full removal)	X (for partial or full removal)	X (for partial or full removal)	X (for partial or full removal)	X (for partial or full removal)
NOAA in partnership with American Rivers Community-Based Restoration Program River Grants		X	X		X

Financial and Technical Assistance for Infrastructure Removal/Repair and Planning

CATEGORY 1 – Dams and similar unregulated impoundments

Category 1: Dams and similar unregulated impoundments X = applications for this phase of a project are considered.	**Conceptual Design**	**Feasibility Studies**	**Final Design**	**Permitting**	**Construction**
The National Audubon Society & Toyota The Toyota Together Green Innovation Grants Program	X	X	X		X

The information contained here is provided for assistance only. While the information provided is based on current research, many programs to change over time. Therefore, EEA offers no guarantee or assurance of its accuracy. Interested applicants need to check with the particular program in which they are interested and review the most current documents published by that program. This document is not to be cited as a reference.

Financial and Technical Assistance for Infrastructure Removal/Repair and Planning

CATEGORY 1 – Dams and similar unregulated impoundments

Federal Resources

U.S. Army Corps of Engineers, New England District

Planning Assistance to States (Section 22) Program

Funding Available: Maximum $500,000 annually to each State or Tribe
Average Award Granted: $25,000 to $75,000
Eligibility: State or Tribe and non-federal entity
Summary: The needed planning assistance is determined by the individual State or Native American Tribe. Every year, each State, Native American Tribe, local government, or other non-Federal entity can provide the Corps of Engineers its request for studies under the program, and the Corps of Engineers then accommodates as many studies as possible within the funding allotment. Typical studies are only planning level of detail; they do not include detailed design for project construction. The studies generally involve the analysis of existing data for planning purposes, using standard engineering techniques, although some data collection is often necessary.
Additional Information: Types of studies conducted in recent years under the program include the following:

- Water Supply and Demand Studies
- Water Quality Studies
- Environmental Conservation Studies
- Environmental Restoration Studies
- Wetland Evaluation Studies
- Dam Safety/Failure Studies
- Flood Damage Reduction Studies
- Flood Plain Management Studies
- Coastal Zone Management/Protection Studies
- Harbor/Port Studies

Match Requirements: 50-50% federal to non-federal match
Link: http://www.nao.usace.army.mil/BusinessWithUs/FloodPlainManagement/PAS.aspx
Contact Information: Program Manager, Phone - 757.201.7825

Financial and Technical Assistance for Infrastructure Removal/Repair and Planning

CATEGORY 1 – Dams and similar unregulated impoundments

Emergency Streambank and Shoreline Protection (Section 14)

Funding Available: N/A
Average Award Granted: N/A but the maximum Federal expenditure at any one site is $1,500,000
Eligibility:
Summary: Section 14 of the 1946 Flood Control Act provides the Corps of Engineers authority to construct emergency shoreline and streambank protection works to protect public facilities, such as bridges, roads, public buildings, sewage treatment plants, water wells, and non-profit public facilities, such as churches, hospitals, and schools.
Additional Information: The Feasibility Study is 100 percent federally funded up to $100,000.
Match Requirements: Costs over the $100,000 are shared 50/50 with the non-federal sponsor. Final design (plans and specifications) and construction costs are 65 percent Federal 35 percent non-Federal.
Link: http://www.nae.usace.army.mil/Missions/PublicServices/ContinuingAuthoritiesProgram/Section14.aspx
Contact: Chris Hatfield, Phone - 978.318.8520

Flood Damage Reduction Projects (Section 205)

Funding Available: N/A
Average Award Granted: N/A but maximum Federal cost for planning, design, and construction of any one project is $7,000,000
Eligibility: with non-Federal government agencies, such as cities, counties, special authorities, or units of state government
Summary: Section 205 of the 1948 Flood Control Act authorizes the Corps of Engineers to study, design, and construct small flood control projects in partnership. Flood control projects are not limited to any particular type of improvement. Levee and channel modifications are examples of flood control projects constructed utilizing the Section 205 authority.
Additional Information: The Corps conducts an initial appraisal early in the Feasibility Study to determine whether the project meets program criteria and provides a basis for determining scope and cost of an entire feasibility study. The solution must be economically feasible and environmentally acceptable. If an acceptable alternative is identified in the feasibility study, the Corps prepares plans and specifications, and then manages construction of the project.
Match Requirements: The feasibility study is 100 percent federally funded up to $100,000. Costs over the $100,000 are shared 50/50 with the non-federal sponsor. Final design (plans and specifications) and construction cost are 65 percent Federal 35 percent non-Federal.
Link: http://www.nae.usace.army.mil/Missions/PublicServices/ContinuingAuthoritiesProgram/Section205.aspx
Contact: Chris Hatfield, Phone - 978.318.8520

Financial and Technical Assistance for Infrastructure Removal/Repair and Planning

CATEGORY 1 – Dams and similar unregulated impoundments

Aquatic Ecosystem Restoration Projects (Section 206)

Funding Available: N/A
Average Award Granted: N/A but limited to $5 million in Federal cost
Eligibility: Non-federal agencies
Summary: Under the authority provided by Section 206 of the Water Resources Development Act of 1996, the Corps may plan, design and build projects to restore aquatic ecosystems for fish and wildlife. Projects conducted in New England under this program have included eelgrass restoration, salt marsh and salt pond restoration, freshwater wetland restoration, anadromous fish passage and dam removal, river restoration, and nesting bird island restoration.
Additional Information: The process for Section 206 projects begins after a non-federal sponsor requests Corps of Engineers assistance under the program. When funding is available, the Corps of Engineers prepares a feasibility study, beginning with an estimate of the overall scope and cost of the study and a determination of whether the project is in the federal interest.
Match Requirements: The feasibility study is cost shared 50 percent Federal 50 percent Non-Federal after the first $100,000 in study costs. The first $100,000 in study cost is federally funded. Design and construction cost are 65 percent Federal 35 percent non-Federal
Link: http://www.nae.usace.army.mil/Missions/PublicServices/ContinuingAuthoritiesProgram/Section206.aspx
Contact: Larry Oliver, Phone - 978.318.8347

Environmental Restoration (Section 1135)

Funding Available: N/A
Average Award Granted: N/A but limited to $5 million in Federal cost
Eligibility: non-federal agencies
Summary: Under the authority provided by Section 1135 of the Water Resources Development Act of 1986, the Corps may plan, design and build modifications to existing Corps projects, or areas degraded by Corps projects, to restore aquatic habitats for fish and wildlife. Projects conducted in New England under this program have included salt marsh and salt pond restoration, estuary restoration, freshwater wetland restoration, anadromous fish passage, and river restoration.
Additional Information: When funding is available, the Corps of Engineers prepares a feasibility study, beginning with an estimate of the overall scope and cost of the study and a determination of whether the project is in the federal interest. The feasibility study formulates alternatives to achieve the restoration, evaluates the environmental effects of the alternatives, documents the project requirements, and provides a scope and cost estimate for project implementation.
Match Requirements: The feasibility study is cost shared 50 percent Federal 50 percent Non-Federal after the first $100,000 in study costs. The first $100,000 in study cost is federally funded. Design and construction cost are 75 percent Federal 25 percent non-Federal
Link: http://www.nae.usace.army.mil/Missions/PublicServices/ContinuingAuthoritiesProgram/Section1135.aspx
Contact: Larry Oliver, Phone - 978.318.8347

Financial and Technical Assistance for Infrastructure Removal/Repair and Planning

CATEGORY 1 – Dams and similar unregulated impoundments

U.S. Department of Agriculture- Rural Development

Rural Water and Environmental Programs

Funding Available: Water projects used $741 million in FY2012, $602 million in FY2013
Average Award Granted: N/A
Eligibility: Public bodies, non-profit organizations and recognized Indian tribes
Summary: Water and Environmental Programs (WEP) provides loans, grants and loan guarantees for drinking water, sanitary sewer, solid waste and storm drainage facilities in rural areas and cities and towns of 10,000 or less. Program assistance is provided in many ways, including direct or guaranteed loans, grants, technical assistance, research and educational materials.
Additional Information: Predevelopment planning assistance is available to assist in paying costs associated with developing a complete application for a proposed project. WEP also makes grants to nonprofit organizations to provide technical assistance and training to assist rural communities with their water, wastewater, and solid waste problems.
Match Requirements: N/A
Link: http://www.rurdev.usda.gov/UWEP_HomePage.html
Contact: Steven Chrabascz, Phone - 413-253-4334 or email at steven.chrabascz@ma.usda.gov

U.S. Department of Agriculture- Forest Service

Watershed Restoration and Enhancement Agreement Authority

Funding Available: $4 million
Average Award Granted: N/A
Eligibility: States, local or tribal governments, private and nonprofit entities, and private landowners.
Summary: Projects that protect, enhance, or restore resources within a watershed and provide tangible benefits to achieving Forest Service goals and objectives are allowable. Project types are not limited to actual projects on the ground; for example, stream gabion installation, check dam construction, fish habitat restoration, or culvert cleaning. Watershed analysis studies, habitat surveys and wildlife species monitoring, depending on the benefit to resources within the watershed, are also permissible.
Match Requirements: Match Requirements are not applicable to this program.
Link: https://www.cfda.gov/?s=program&mode=form&tab=step1&id=73c38aa3683fc789cedce7aa16f1df53
Contact: Watershed and Aquatics, 201 14th Street NW, Room 3SE, Washington, District of Columbia 20024 Phone - 202.205.1790

Financial and Technical Assistance for Infrastructure Removal/Repair and Planning

CATEGORY 1 – Dams and similar unregulated impoundments

US Department of Agriculture- Natural Resource and Conservation Service

Emergency Watershed Protection Program

Funding Available: N/A
Average Award Granted: N/A
Eligibility: Public and private landowners are eligible for assistance but must be represented by a project sponsor. The project sponsor must be a public agency of state, county, or city government, or a special district or tribal government.
Summary: The purpose of the Emergency Watershed Protection (EWP) program is to undertake emergency measures, including the purchase of flood plain easements, for runoff retardation and soil erosion prevention to safeguard lives and property from floods, drought, and the products of erosion on any watershed whenever fire, flood or any other natural occurrence is causing or has caused a sudden impairment of the watershed. EWP work can include: removing debris from stream channels, road culverts, and bridges; reshaping and protecting eroded banks; correcting damaged drainage facilities; repairing levees and structures; reseeding damaged areas; and purchasing floodplain easements.
Additional Information: Landowners interested in enrolling their land in a permanent EWP-FPE easement should contact their local USDA Service Center for more information. EWP-FPE is not available in all areas at all times and is most commonly available to landowners in areas recently impacted by a natural disaster such as widespread flooding. For more information regarding program eligibility and availability.
Match Requirements: NRCS may bear up to 75 percent of the construction cost of emergency measures or up to 90 percent in limited resource areas.
Link: http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/ewp/
Contact: Office Locator - http://offices.sc.egov.usda.gov/locator/app?service=page/CountyMap&state=MA&stateName=Massachusetts&stateCode=25

Watershed and Flood Prevention Operations (WFPO) Program

Funding Available: N/A
Average Award Granted: N/A
Eligibility: State and local agencies
Summary: The Watershed and Flood Prevention Operations (WFPO) Program provides technical and financial assistance to States, local governments and Tribes (project sponsors) to plan and implement authorized watershed project plans for the purpose of: watershed protection, flood mitigation, water quality improvements, soil erosion reduction, rural, municipal and industrial water supply, irrigation, water management, sediment control, fish and wildlife enhancement, hydropower. Works of improvement include floodwater retarding dams and reservoirs, are owned and operated by the sponsoring local organizations and participating individuals.
Additional Information: Projects selected aim to prevent erosion, floodwater, and sediment damage; to further the conservation, development, utilization, and disposal of water; and to further the conservation and proper utilization of land in authorized watersheds.
Match Requirements: Surveys and investigations are made and detailed designs, specifications, and engineering cost estimates are prepared for construction of structural measures. Watershed plans involving Federal contributions in excess of $5,000,000 for contribution, or construction of any single structure having a capacity in excess of 2,500 acre feet, require Congressional approval
Link: http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/programs/landscape/wfpo/?cid=nrcs143_008271
Contact: David Arthur, Watershed Operations Program Specialist, Phone - 202.690.2819

Financial and Technical Assistance for Infrastructure Removal/Repair and Planning

CATEGORY 1 – Dams and similar unregulated impoundments

U.S. Department of the Interior – Bureau of Indian Affairs

Water Resources on Indian Lands

Funding Available: FY 12 - $21,246,805; FY 13 est $13,578,233; FY 14 est $11,064,000
Average Award Granted: The range is $10,000 to $200,000
Eligibility: Federally Recognized Indian Tribal Governments and Native American Organizations authorized by Indian tribal governments
Summary: This program was created to support Indian tribes in the effective and efficient management, planning, and use of their water resources. Funds are used by tribes to conduct water management and planning project and activities for the purpose of managing and conserving their water resources and to participate in the on-going water rights negotiation and litigation activities to protect and secure their lawful water rights.
Additional Information: Awards are made on an annual basis and the funds remain available until expended by the contractor or grantee.
Match Requirements: No match required
Link: https://www.cfda.gov/?s=program&mode=form&tab=step1&id=a4282e5a120f60bacbe8da5bff46c6fa
Contact: Division Chief, Bureau of Indian Affairs, Division of Natural Resources, Office of Trust Services, 1849 C Street, NW, MS 4650 MIB, Washington, District of Columbia 20240. Phone - 202.208.3956

U.S. Department of the Interior – Fish and Wildlife Service

Landscape Conservation Cooperatives (LCC) Program

Funding Available: $16,000,000
Average Award Granted: Range from $1,000 to $1,000,000
Eligibility: Unrestricted
Summary: Financial assistance will be awarded for projects that advance the LCC mission by addressing: Theme A - Integrating Assessment and Planning for Aquatic Resource Conservation at Landscape Scales. Theme B - Developing a Network of Ecologically Functional and Connected Landscapes by Facilitating Landscape Conservation Design. By leveraging resources and strategically targeting science to inform conservation decisions and actions, Cooperatives are being established to create a network of partners to ensure the sustainability of land, water, wildlife and cultural resources.
Additional Information: Financial assistance will be awarded for science projects and LCC-prioritized biological planning, conservation design and adaptive management projects to include: research; inventory design and implementation; monitoring; goal and priority setting associated with efficient and effective conservation; development of implementation strategies; and projects supporting all other FWS organizational efforts, including planning, establishment maintenance, and general business operations.
Match Requirements: No match required
Link: http://www.grants.gov/search/search.do;jsessionid=whSqR28Js1FJVwJ6gxQhrx2Cprv221dhTlpPsy7LH3XYc1MyLmv4!-665777865?oppId=173973&mode=VIEW
Contact: Cecilia Todd, Phone - 703.358.2055 or cecilia_todd@fws.gov

North American Wetlands Conservation Fund

Funding Available: FY 13 $61,579,941; FY 14 est. $77,602,527; FY 15 est. $70,000,000
Average Award Granted: Average award is approximately $42,000 and $710,000 for Small Grants and U.S. Standard Grants, respectively
Eligibility: Available to private or public organizations or to individuals who have developed partnerships to carry out wetlands conservation projects in the U.S., Canada, and Mexico.
Summary: Funds may also be used to restore, manage, and/or enhance wetland ecosystems and other habitat for migratory birds and other fish and wildlife. Projects must provide long-term conservation for wetlands-associated migratory birds and other wetlands-associated wildlife. Coastal Wetlands Planning, Protection and Restoration act-derived funds eligible for NAWCA projects may be used only in U.S. coastal wetlands ecosystems.
Additional Information: From September 1990 through March 2014, approximately 5,000 partners in 2,421 projects have received nearly $1.3 billion in grants. They have contributed another $2.7 billion in matching funds to affect 27.5 million acres of habitat.
Match Requirements: At least 50 percent of project costs, except that the activities located on Federal lands and waters can be funded with 100 percent Federal funding.
Link: http://www.fws.gov/birdhabitat/Grants/NAWCA/index.shtm
Contact: Division of Bird Habitat Conservation, Phone – 703.358-1784 or dbhc@fws.gov

Department of Commerce – Economic Development Administration

Investments for Public Works and Economic Development Facilities

Funding Available: estimated from FY 12 $138,528,000
Average Award Granted: $1.70 million
Eligibility: District Organization, Indian Tribe or a consortium of Indian Tribes; state, city, or other political subdivision of a State, including a special purpose unit of a State or local government engaged in economic or infrastructure development activities, or a consortium of such political subdivisions; institution of higher education or a consortium of institutions of higher education; or public or private non-profit organization or association acting in cooperation with officials of a political subdivision of a State
Summary: Grants support the construction or rehabilitation of essential public infrastructure and facilities necessary to generate or retain private sector jobs and investments, attract private sector capital, and promote regional competitiveness, innovation, and entrepreneurship, including investments that expand and upgrade infrastructure to attract new industry, support technology-led development, accelerate new business development, and enhance the ability of regions to capitalize on opportunities presented by free trade.
Additional Information: Characteristic projects include investments in facilities such as water and sewer systems, industrial access roads, business parks, port facilities, rail spurs, skill-training facilities, business incubator facilities, brownfield redevelopment, eco-industrial facilities, and telecommunications and broadband infrastructure improvements necessary for business creation, retention and expansion
Match Requirements: Generally, the amount of the EDA grant may not exceed 50 percent of the total cost of the project.
Link: https://www.cfda.gov/?s=program&mode=form&tab=step1&id=bb43024afbdae1a42b2b4ffa8fa5aec9
Contact: Philip Saputo, Phone - 202.400.0662 or email at psaputo@eda.gov

State Resources

Executive Office of Energy and Environmental Affairs (EEA)
Massachusetts Environmental Trust (MET)

MET General Grants Program

Funding Available: $1,000,000
Average Award Granted: $5,000 to over $100,000
Eligibility: Eligible organizations generally include 501(c)(3) nonprofit organizations and municipalities. Unincorporated organizations may apply provided that they have an eligible fiscal sponsor
Summary: The Trust supports cooperative efforts to restore, protect, and improve water and water-related resources of the Commonwealth. Grants funds are generated through the sale of environment themed license plates. Our goals are to improve and safeguard the quality of the waterways throughout the Commonwealth. We fund nonprofit organizations, municipalities, scientists and educational institutions through four distinct programs.
Additional Information: The Trust utilizes a two-stage application process. The first stage is a Letter of Inquiry commonly due in the fall. The letter of inquiry must follow the format provided in the RFR. Successful applicants will be invited to prepare a full proposal for a deadline the following spring.
Match Requirements: No match is required.
Link: http://www.mass.gov/eea/met
Contact: Bill Hinkley, Phone - 617.626.1045 or email at william.hinkley@state.ma.us.

Department of Conservation and Recreation (DCR)

Rivers and Harbors Grant Program

Funding Available: N/A
Average Award Granted: Varies
Eligibility: Federal agencies, municipalities and non-profits
Summary: Grants requiring matching funds for studies, surveys, design & engineering, environmental permitting and construction that address problems on coastal & inland waterways, lakes, ponds and great ponds. Grants are awarded in the following categories: 1) Coastal Waterways - for commercial and recreational navigation safety & to improve coastal habitat by improving tidal interchange; 2) Inland Waterways - to improve recreational use, water quality & wildlife habitats; 3) Erosion Control - to protect public facilities and reduce downstream sedimentation; 4) Flood Control - to reduce flood potentials.
Additional Information:
Match Requirements:
Link: http://www.mass.gov/eea/waste-mgnt-recycling/water-resources/preserving-water-resources/water-grants.html
Contact: Kevin Mooney, **Phone** – 781.740.1600 x103 or email at kevin.mooney@state.ma.us.

Financial and Technical Assistance for Infrastructure Removal/Repair and Planning

CATEGORY 1 – Dams and similar unregulated impoundments

Department of Environmental Protection (DEP)

604b Assessment Program

Funding Available: $180,000
Average Award Granted: N/A
Eligibility: Regional Public Comprehensive Planning Organizations or Interstate Organizations
Summary: The 604b grant funds watershed or subwatershed based nonpoint source assessment and planning projects with the overall goal of the 1) determination of the nature, extent and causes of water quality problems, 2) assessment of impacts and determination of pollutant loads reductions necessary to meet water quality standards; 3) development of green infrastructure projects that manage wet weather to maintain or restore natural hydrology; and 4) development of assessments, preliminary designs and implementation plans that will address water quality impairments in impaired watersheds.
Additional Information: The Commonwealth's procurement rules prohibit MassDEP or any other RFR issuer from consulting with potential applicants to develop project ideas once an RFR is issued. Potential applicants are encouraged to contact MassDEP before the RFR issue date to refine project ideas and obtain feedback.
Match Requirements: None required but local financial commitment is considered during the evaluation
Link: http://www.mass.gov/eea/agencies/massdep/water/grants/604b-water-quality-management-planning-grants.html
Contact: Gary Gonyea, 604(b) RFR Coordinator, MassDEP, Bureau of Resource Protection, Division of Municipal Services 1 Winter Street Boston Ma 02108. Phone – 617.556.1152 or email at gary.gonyea@state.ma.us

State Revolving Fund (SRF)

Funding Available: applicant cap of $30 million
Average Award Granted: N/A
Eligibility: Cities, Towns, Water and Wastewater Districts
Summary: Established by The Federal Water Quality Act of 1987, the SRF program is a joint federal-state financing program that provides subsidized interest loans for the construction of publicly owned water supply facilities, water pollution abatement facilities, and implementation of non-point source management projects. This competitive program funds projects in the form of loans at 2% interest. Projects that benefit water quality and habitat restoration are eligible this loan program. Additionally, clean water projects with the primary focus of nutrient reduction may be eligible for 0% interest loans.
Additional Information: To be considered for funding priority, communities must have appropriated the necessary local project funds or have committed to a schedule to obtain those funds.
Match Requirements: The program offers financing primarily by means of loans to the applicant.
Link: http://www.mass.gov/eea/agencies/massdep/water/grants/state-revolving-fund.html .
Contact: Steven McCurdy, Director, MassDEP Division Municipal Services 1 Winter Street Boston Ma 02108. Phone – 617.556.5779 or email at steven.mccurdy@state.ma.us.

Section 319 Nonpoint Source Competitive Grants Program

Funding Available: $1,000,000 - $1,500,000 annually
Average Award Granted: $10,000 - $500,000
Eligibility: Available to any Massachusetts private or public organization
Summary: This grant program is authorized under Section 319 of the federal Clean Water Act for implementation projects that address the prevention, control, and abatement of nonpoint source (NPS) pollution. In general, eligible projects must: implement measures that address the prevention, control, and abatement of NPS pollution; target the major source(s) of nonpoint source pollution within a watershed/subwatershed; contain an appropriate method for evaluation the project results; and must address activities that are identified in the Massachusetts NPS Management Plan.
Additional Information: Projects from all basins are eligible and encouraged. Projects should be of manageable size, but should strive to be comprehensive projects addressing all major identified nonpoint sources affecting water quality in the watershed or subwatershed.
Match Requirements: To be eligible to receive funding, a 40% non-federal match is required from the grantee.
Link: http://www.mass.gov/eea/agencies/massdep/water/grants/watersheds-water-quality.html#2
Contact: Jane Peirce, 319 Program Coordinator, MassDEP Bureau of Resource Protection, 627 Main Street Worcester MA 01608. Phone – 508.767.2792 or email at jane.peirce@state.ma.us

Department of Fish and Game (DFG)

Wetlands and River Restoration and Revitalization Priority Projects

Funding Available: N/A
Average Award Granted: $5,000 to $ 55,000
Eligibility: Open to public agencies and (c) (3) certified non-profit organizations, including, but not limited to state agencies, cities and towns, regional planning agencies, watershed organizations, and land trusts.
Summary: Managed by the Division of Ecological Restoration, Priority Projects are selected through a state-wide, competitive process. Projects that bring significant ecological and community benefits to the Commonwealth are sought. Once we've selected a project to the Priority Project list, we work with the project owner and other project team members to bring the project to fruition.
Additional Information: Selected projects are eligible for technical services such as data collection, engineering, design work, and permitting; project management and fundraising assistance from DER staff; and small grants. DER works with the project owner each year to determine the type of assistance that will be most useful.
Match Requirements:
Link: http://www.mass.gov/eea/agencies/dfg/der/aquatic-habitat-restoration/river-restoration/
Contact: River Projects – Nick Wildman, Phone - 617.626.1527 or email at nick.wildman@state.ma.us;
Wetland Projects – Georgeann Keer, Phone 617. 626.1246 or email at georgeann.keer@state.ma.us

Foundation Resources

The American Rivers Organization & NOAA

Community-Based Restoration Program River Grants

Funding Available: N/A
Average Award Granted: Maximum award request is $150,000
Eligibility: organizations such as civic associations and conservation groups; state, local and Tribal governments; and other commercial2 and nonprofit organizations
Summary: Since 2001, American Rivers and the National Oceanic and Atmospheric Administration (NOAA) Community-based Restoration Program have provided financial and technical assistance for river restoration projects benefiting diadromous fish species. The American Rivers-NOAA River Grants funds stream barrier removal projects in the Northeast. Grants are provided for three distinct phases: Construction, Engineering Design and Feasibility Analysis.
Additional Information: Applications are being evaluated based upon the following priority criteria: ecological merits of the project, technical feasibility of the project, timeliness in completion of funded phase; benefits provided to the local community, and financial clarity and strength of the application.
NOTE: Applicants must contact American Rivers to discuss the potential project prior to submitting an application
Match Requirements: While non-federal matching funds are not required, matching funds greatly enhance the merit of the application.
Link: http://www.americanrivers.org/initiative/grants/projects/american-rivers-and-noaa-community-based-restoration-program-river-grants-2/
http://www.americanrivers.org/assets/pdfs/dam-removal-docs/ar-noaa-grant-2013-funding-guidelines.pdf
Contact: National Coordinator: Serena McClain 1101 14th St NW, Washington DC or email at rivergrants@AmericanRivers.org.
Northeast Coordinator: Amy Singler 413.584.2183 or email at asingler@americanrivers.org

The National Audubon Society & Toyota

The Toyota TogetherGreen Innovation Grants Program

Funding Available: approximately $1,000,000
Average Award Granted: $25,000
Eligibility: Funding is open to branch, office, or other operational units of the National Audubon Society (including National or State Offices; field units such as Audubon Centers and Sanctuaries), or be an Audubon Certified Chapter, or Audubon Certified Chapter-run Center or Sanctuary. Independent Audubon entities that wish to participate in a cooperative arrangement with National Audubon Society for this purpose are also eligible. Other organizations are encouraged to apply if they partner with an Audubon group on their project.
Summary: Since 2008 Toyota and Audubon, through the Toyota TogetherGreen Innovation Grants program, have funded innovative community-based conservation projects. Projects supported by Toyota TogetherGreen tackle environmental projects as diverse as the populations they serve. Each year, the Toyota TogetherGreen Innovation Grants fund projects that conserve or restore habitat and protect species, improve water quality or quantity, and reduce the threat of climate change by reducing energy use and improving efficiency.
Additional Information: Toyota TogetherGreen Innovation Grants may not be used for indirect costs, overhead, or other expenses not directly related to the project. Funds may not be used for legal actions, land acquisitions, endowments, lobbying, electioneering, or construction of buildings.
Match Requirement: Matching funds can include in-kind or direct financial support and must represent 25 – 50% of the grant
Link: http://www.togethergreen.org/grants/program-overview
Contact: Grants Manager, email at grants@audubon.org

Appendix J - Calculations

Halifax Dam 6/18/2015

All in 1988 Datum

Objective - Calculate the velocity of water at fish ladder and sluice gate. Compare if water velocity will be greater or less than fish speed.

Criteria (Per Marine Fisheries)

1. Adult river herring travel in schools at a cruising speed of 2.8 feet per second (ft/s) and can reach burst speeds of 6.8 ft/s.
2. American eels travel at a cruising speed of 2.4 feet per second (ft/s) and can reach a burst speed of 6.0 to 7.0 ft/s.
3. Marine Fisheries recommends a minimum water depth of 6 inches and a preferred range of 8-12 inches for the spawning migration of adult river herring.
4. For the juvenile herring emigration, Marine Fisheries recommends a minimum water depth of 2 inches and a preferred range of 4-8 inches.
5. Where these flows exceed maximum sustained swim speed, successful passage may still be possible, provided that fish can accomplish the needed swim speed without additional impendence such as low water depths.

Dam Info (from Survey June 2015)

Length	80	ft
Weir Elev	51.91	
Bottom of Dam Elev	47.3	

River Info (Upstream) (from Survey June 2015)

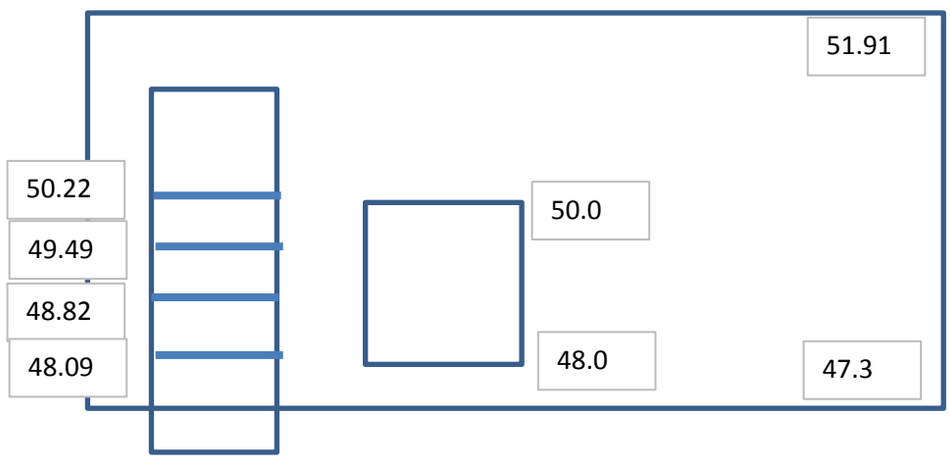
Top of Sediment Elev	49	Range from 48.3-48.7-49-49.3
Bottom of Sediment Elev	47.7	Range from 47.7-48
W.S.E. on 6/2/2015	51.4	

Sluice Gate Info

Quantity	1	
Top of Sluice Gate Elev	50	
Width	2.3	ft
Height	2	ft

Fish Ladder Info (from Survey June 2015)

Quantity	1	
Top of Lowest Step Elev	48.09	
Top of Highest Step Elev	50.22	
Top of Gate Elev	51.8	
Width	2	ft



Critical Depth (yc) Equation

yc = (q^2 / g)^(1/3) (M&E, Collection and Pumping of Wastewater)

q = (yc^3 * g)^(1/2)

Q = q * L

Broad Crested Weir Equation

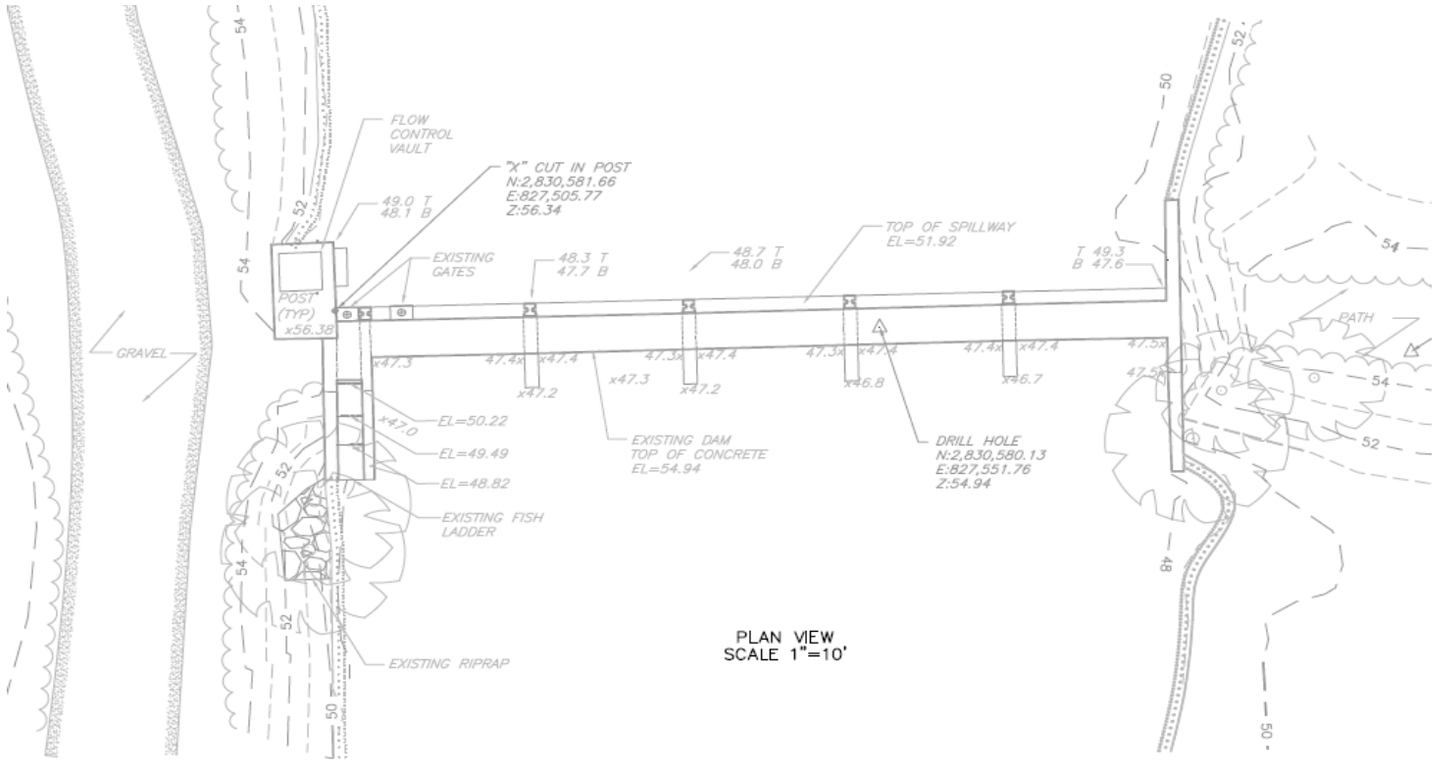
Q = C * L * H^1.5 (reference MRD's Calcs from Cambridge WWTP)

Calculations

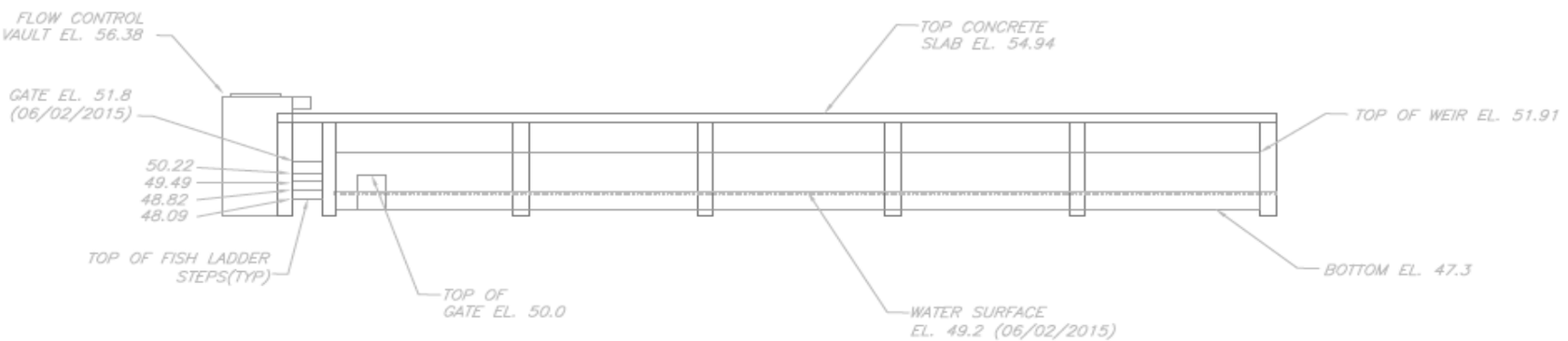
C	Length, L (ft)	Head, H (ft)	Flow Q (ft3/s)	Area A (ft2)	Velocity of Water (ft/s)	Higher than Cruising Speed?	Higher than Cruising Speed?	Higher than Burst Speed?	Higher than Burst Speed?	Critical Depth yc (ft)	Notes
Fish Ladder Top Step Only (Sluice Gate Fully Closed)						Herring	Eel	Herring	Eel		
2.65	2	1.69	11.64	3.38	3.45	Yes	Yes	No	No	1.02	Worst Case, 6' breadth, upstream w.s.e. up to dam weir elev.
2.65	2	0.80	3.79	1.60	2.37	No	No	No	No		
Sluice Gate (Fully Opened)											
3.3	2.3	2.00	21.47	4.60	4.67	Yes	Yes	No	No	1.39	Worst Case, 1' breadth, w.s.e. up to El. 50.00, all flow thru slide gate.
3.3	2.3	1.00	7.59	2.30	3.30	Yes	Yes	No	No		

Conclusion

Under worst case scenarios, velocity thru fish ladder or sluice gate exceeds the cruising speeds but does not exceed the burst speeds of both kinds of species.



PLAN VIEW
SCALE 1"=10'



SOUTH ELEVATION
SCALE 1"=10'

GHD Inc

1545 Iyannough Road

Hyannis MA 02601

T: 1 774 470 1630 F: 1 774 470 1631 E: hyamail@ghd.com

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