BRISTOL MILLS DAM FEASIBILITY STUDY

FOR THE

THE TOWN OF BRISTOL AND

BRISTOL DAM COMMITTEE

JANUARY 2018

WRIGHT-PIERCE
Engineering a Better Environment
70 YEARS 1947 - 2017

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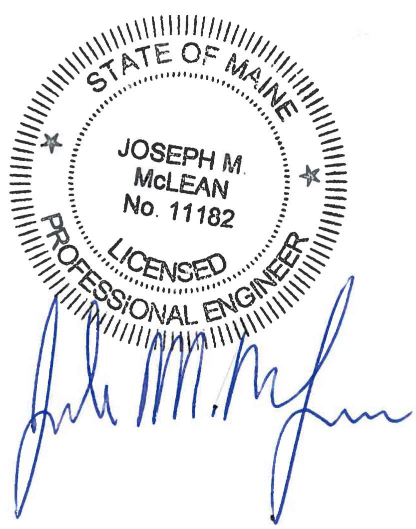

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BRISTOL MILLS
DAM FEASIBILITY STUDY
BRISTOL, MAINE

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SECTION 1

INTRODUCTION

1.1 BACKGROUND

The Town of Bristol, in partnership with the Bristol Dam Committee, retained Wright-Pierce to prepare a feasibility study to evaluate various alternatives for fish passage at the Bristol Mills Dam on the Pemaquid River in Bristol Mills, Maine. Refer to the site location map included in Appendix A.

The Bristol Mills Dam and the fishway are owned by the Town of Bristol. The Bristol Mills Dam impounds the Pemaquid River which is approximately 2.7 miles in length from the outlet of Biscay Pond, to the Bristol Mills Dam. Ultimately, the Pemaquid River flows through the Town of Bristol, prior to discharging into Boyd Pond, and eventually into Johns Bay.

The Bristol Mills Dam is located in the center of the Town of Bristol, near the intersection of Route 130 and Benner Road. With a length of approximately 90 feet and a height of approximately 12 feet, the dam has been an obstruction to alewives for some time. There is an active Fish Committee in Town, that has responsibility for the alewife run. The Fish Committee manages the fishway and volunteers each year to undertake a series of labor intensive management tasks, including the installation of a river wide leader fence to improve attraction conditions at the fishway during the spring alewife migration. Despite the efforts of the fish committee, the fishway consistently underperforms.

1.2 PURPOSE OF REPORT

The purpose of this report is to summarize the findings of a feasibility study at the Bristol Mills Dam that considers various alternatives for the site that incorporate the following needs and values: improved fish passage, firefighting water supply, recreational opportunities, and upstream water levels. In addition to evaluating concepts for the Bristol Dam site and its services, this report also describes the condition of the dam and the impoundment areas, as well as the hydrologic and hydraulic conditions in the Pemaquid River near the site, and concludes with a cost analysis of various alternatives.

SECTION 2

DAM AND FISHWAY CONDITIONS

2.1 GENERAL CONDITIONS

Wright-Pierce has performed a number of survey, design, and assessment tasks at the Bristol Mills Dam and fishway over the past five years. Initially, Wright-Pierce was retained by the Town of Bristol, with input by the Town Fish Committee, to evaluate the existing fishway and provide recommendations for improvement. As that scope of services commenced, Wright-Pierce was subsequently retained by the Town of Bristol Selectmen to inspect the structural condition of the dam, as well as to provide recommendations related to potential gate improvements.

The following paragraphs summarize our prior efforts. Additional information on the existing dam and fishway can be found in the following documents/reports:

- “Bristol Mills Fishway Improvement Plans” prepared by Wright-Pierce and included with this report as Appendix B.
- “Bristol Mills Dam – Fishway Improvements Evaluation” prepared by Wright-Pierce dated November 2014, as updated via memorandum on March 6, 2015, and included with this report as Appendix C
- “Bristol Mills Dam – Inspection/Evaluation Report” prepared by Wright-Pierce dated September 24, 2015 and included with this report as Appendix E.

2.2 FISHWAY CONDITION

2.2.1 2014 PIT TAG SURVEY

In the Spring of 2014, the Maine Department of Marine Resources (MeDMR) engaged in a Passive Integrated Transponder (PIT) tag survey at the Bristol Mills fishway. The number of fish tagged (22 total) represents a small sample size, however a few general trends can be seen in the data, as described further below.

Detection antennas were placed at several locations along the existing fishway. One antenna was placed at the fishway entrance. A second antenna was placed at the turning pool. A third antenna was placed halfway between the turning pool and the fishway exit. The fourth and final antenna was placed at the fishway exit. Each of these locations have been identified on the sketch in Figure 2-1, PIT Tag Summary (on the following page).

Twenty-two (22) adult alewife were tagged and released in close proximity to the fishway entrance. It is anticipated that some mortality was experienced due to the handling and tagging operation, however only six (6) fish were detected by the first antenna to successfully enter the fishway. Of the six (6) fish that entered, five (5) were detected at the turning pool. Each of these five (5) fish were detected by the third antenna. Ultimately only two (2) fish were able to successfully ascend and exit the ladder as detected by the fourth antenna. A summary of the PIT tag survey is included as Appendix D of this report.

It is important to note that the fishway was being operated with a number of “improvements” devised by the Town of Bristol Fish committee. This includes the use of a leader fence, as well as a sandbag wier and wooden chute at the fishway entrance. At the upstream end of the fishway (exit) there was a wooden baffle with an orifice being utilized to reduce flow in the fishway. Photos of these entrance and exit conditions are included on the following pages.

Overall this PIT tag study supported our observations and concerns with the fishway. The general reasons for fish not being able to ascend the fishway are detailed further in the following section (Section 2.2.2). These concerns are outlined as follows:

- Alewives are not adequately attracted to the entrance of the fishway
- Once at the entrance, alewives have difficulty entering the fishway
- Once in the fishway, alewives have difficulty traveling through the fishway
- The gate at the fishway exist does not adequately control flows

FIGURE 2-1
PIT Tag Summary

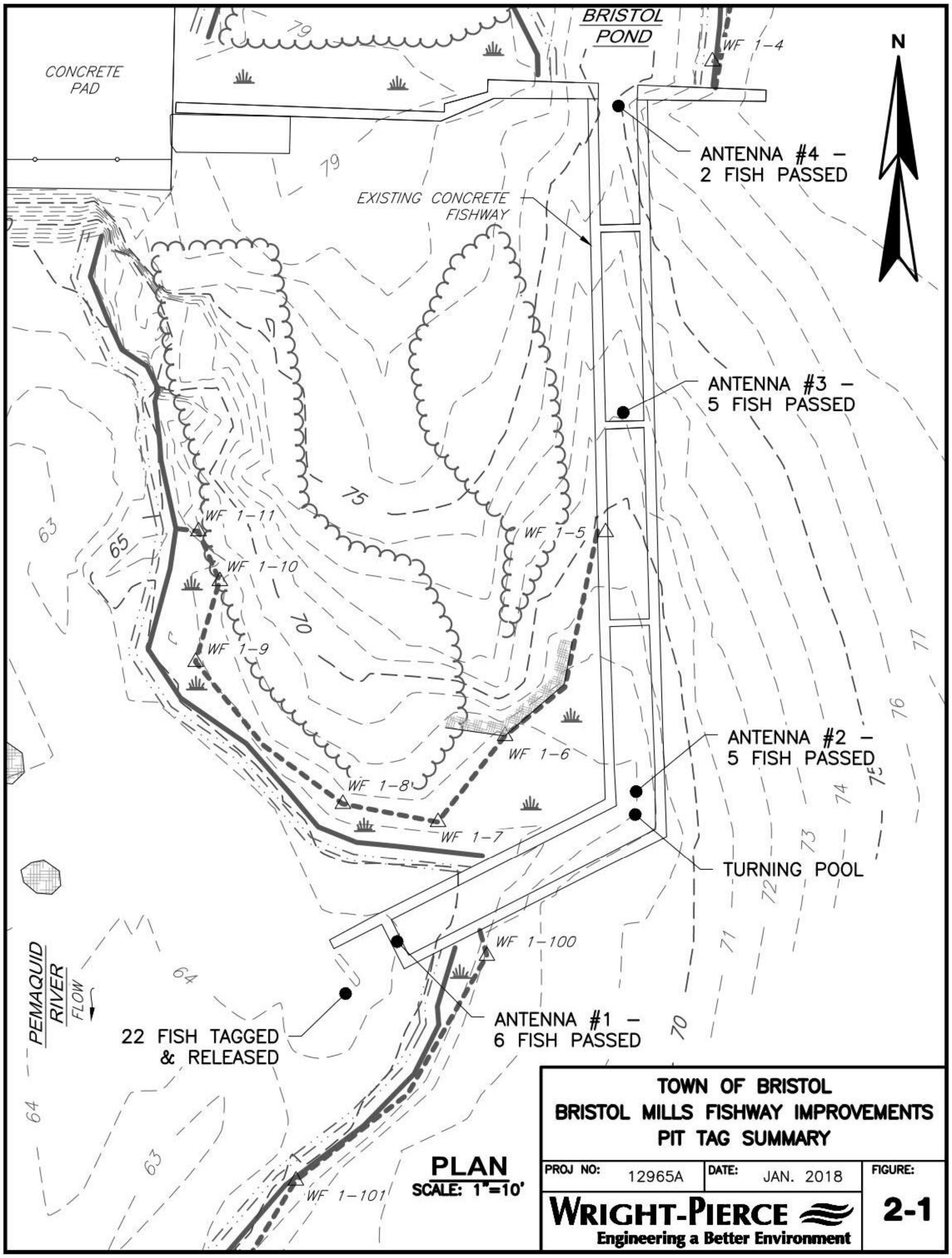


Photo 1: Fishway Entrance during PIT Tag Study

Photo 2: Fishway Entrance during PIT Tag Study

Photo 3: Dead Alewife in leader fence (trying to get upstream)

Photo 4: Fishway Exit during PIT Tag Study

2.2.2 2014 TOPOGRAPHIC SURVEY AND VISUAL OBSERVATIONS

Wright-Pierce deployed a two-man survey crew to the Bristol Mills fishway site in June of 2014 to collect existing conditions measurements and topography in the vicinity of the dam and fishway. Additional bathymetric survey and existing conditions topography was collected in November of 2014. Refer to the existing conditions and topographic survey plan prepared by Wright-Pierce, included in the preliminary engineering plan set dated November 2014 and provided in Appendix B of this report.

Wright-Pierce personnel have performed visual observations of the fishway on several occasions since 2014. Observations of the fishway by Wright-Pierce largely corroborated the conclusions of prior inspections by US Fish and Wildlife Services Staff and others. The following narrative states the main concerns of these observations along with a brief description of the issue.

<u>Alewives are not adequately attracted to the entrance of the fishway:</u> The existing fishway entrance is located approximately 80 feet downstream of the dam and associated spillway discharge. During verbal interviews with the Town of Bristol Fish Committee volunteers, there were a variety of accounts of substantial numbers of alewife bypassing the fishway entrance and collecting in the pool located just downstream of the Bristol Mills Dam, despite the leader fence that is put in place each year to guide alewives to the fishway entrance and block their movement to the base of the dam. This leader fence spans the entire width of the river and is angled slightly upstream to provide a "funneling" effect that directs migrating adults to the fishway entrance. The precise construction of the leader fence has evolved over the years to its current configuration. While the fence appears to be reasonably effective, flow through the fence continues to prove to be attractive to the migrating fish and many of the alewife attempt to find their way through. There are a certain percentage of migrating adults that make their way past the fence and to the upstream pool area. In some cases, these bypass attempts fail and result in increased mortality as evidenced by the deceased alewife that collect in the fence mesh.

<u>Once at the entrance, alewives have difficulty entering the fishway:</u> The migrating adults which are attracted to the fishway entrance location have difficulty physically getting into the fishway. The entrance channel of the fishway is "hung" above the water surface level of the Pemaquid

River, creating a barrier to entering fish. In addition to these observations, Fish Committee volunteers corroborated the inability for fish to enter the fishway under these conditions. To address this issue in 2014, the Fish Committee constructed a sandbag weir and step pool just downstream of the fishway entrance. Additionally, a wooden chute was constructed and attached to the lowermost denil baffle. The combination of these two modifications made a noticeable visual increase to the number of alewife entering the fishway. That said, the chute was only deemed marginally effective as it appeared that the elevation step and associated water velocity in the chute were a challenge for the alewife to overcome. This pool and chute was implemented during the 2014 PIT tag study performed by the MeDMR, and as noted above, only six (6) of the twenty-two (22) tagged alewife were successfully able to enter the fishway.

<u>Once in the fishway, alewives have difficulty traveling through the fishway</u>: The fishway is approximately 75 feet long and extends approximately 10.4 feet in elevation. There is no formal resting pool and the turning pool does not provide adequate resting velocities for ascending fish. As noted in the PIT tag survey, five (5) out of six (6) fish were able to ascend 2/3 of the fishway, but only two (2) were successfully able to exit the fishway and pass the dam. It is expected that the length and height of the fishway combined with inadequate resting areas result in exhaustive conditions. The majority of migrating fish are simply unable to maintain the velocity and effort required to ascend the overall height and length of the fishway without rest.

<u>The gate at the fishway exit does not adequately control flows:</u> At the upstream end of the fishway (exit) there is a bottom-draw gate that is used to regulate flow in the fishway. There are a number of concerns about this gate configuration that make it a challenge for migrating fish. For one, the gate creates a physical obstruction to the uppermost denil baffles and there is a length of fishway channel that extends below the gate where baffles are absent. Additionally, when the gate is closed partially the gate itself creates a hydraulic constriction at the fishway exit that creates increased velocities and turbulence. Even in a properly configured denil fishway, the uppermost baffles have an accelerated velocity and more turbulent condition than lower sections of the denil ladder (known as the vena contracta region). The absence of these uppermost baffles and the constriction created by the gate appears to exacerbate the turbulence and velocity concerns in the vena contracta region.

This condition appears to be a major contributing factor to the failure of migrating adults from completing their ascent of the fishway.

<u>Annual management of the fishway is excessive and unsustainable:</u> The Town of Bristol Fish Committee expends substantial effort to create the best possible passage conditions at the fishway. While these efforts likely improve the annual number of successfully migrating fish, these efforts are not sustainable over the long term. Substantial effort is expended to install and maintain the leader fence. As would be expected, debris regularly collects along the fence, which requires regular cleaning. High flow also can damage the fence, which requires repair. The sandbag weir utilized to create the entrance pool is also difficult to construct effectively and requires regular adjustment based upon flow conditions. Overall, the combination of these management efforts is excessive and it produces only marginally improved performance.

Based on these failures of the current fishway, Wright-Pierce in conjunction with the Maine DMR, NOAA, USFWS, and MCP developed plans for an improved fishway design. These designs are included in Section 5.1.

2.3 DAM CONDITION

2.3.1 2015 Dam Inspection Summary

Bristol Mills Dam is currently classified as an **Intermediate** size**, Low** Hazard dam.

During the 2015 inspection, the Bristol Mills Dam was found to be in **Fair to Poor condition** with the following major deficiencies noted;

1. Cracks along the downstream abutment at the former penstock outfall result in water leakage
2. Voids at bottom of downstream wall may result in water leakage
3. There is vegetation along the upstream embankment
4. There is concrete spalling around the former intake structure and in the sluiceway channel resulting in exposed stones and concrete.

More detailed descriptions, additional deficiencies, recommended repairs, and opinions of probable repair costs are provided within the complete report (Appendix E).

As part of this inspection, Wright-Pierce recommended to the Town of Bristol Selectmen that the following actions be taken to address the deficiencies found at the dam during the inspection and evaluation:

1. Repair the cracking on the downstream face by grouting the cracks
2. Fill the voids along the toe of the dam
3. Repair the spalled concrete areas along the upstream intake and sluiceway areas.

The repairs and recommendations noted above and described in more detail herein should be made in accordance to standard design practices, specifications and construction methods. Design of the repairs analyses to confirm the extent or the work should be completed by a qualified professional engineer experienced in the design and rehabilitation of dams throughout the evaluation, design and construction process.

2.3.2 Potential Gate and Safety Improvements

In addition to the Phase 1 inspection performed in 2015, the Town of Bristol Selectmen requested recommendations for potential options for replacement of the primary sluiceway boards with a more convenient and safely operable mechanical gate. Upon review of the dam configuration and performance of the hydrologic and hydraulic evaluation, a conceptual retrofit option was considered.

Wright-Pierce anticipates that the existing gate geometry will be maintained and that a stainless-steel sliding gate will be affixed to the upstream face of the dam over the existing sluiceway. This gate will be a “top draw” or “downward opening” style gate, which opens by sliding down the face of the dam and allowing water to flow over the top of the gate. Several options for actuating the gate were discussed (electric vs. manual operation). After discussion with the selectmen, it was determined that a manually operated gate was more appropriate for this site.

One of the primary safety concerns with the existing stoplog gates is the challenge associated with operating the gates (removing or placing boards in flowing water). Currently, each stoplog gate is placed or removed by hand. There is no safe access to the gates and unsafe conditions are compounded during higher flow events. One of the primary challenges with the manually actuated gate control at this site is that a person must get close to the gate to operate it. This will require the construction of a catwalk over the dam, so that a dam operator can safely travel to the gate actuator. It is anticipated that this catwalk would be constructed over the dam spillway area with dimensional lumber and could provide access to the gate from above. The manual actuator (hand wheel or crank handle) would then be mounted at a comfortable height in relation to the catwalk.

2.3.3 2016 Dam Condition Update

After issuance of the 2015 Dam Inspection Report, Wright-Pierce worked with the Town of Bristol Selectmen to determine remedial steps. At that time, there was substantive momentum related to the fishway reconstruction efforts. In these discussions, it was determined that the most cost effective path forward was to have the same contractor perform the necessary dam repairs at the time of the fishway reconstruction. Many of the costs associated with mobilization, demobilization, and some construction dewatering costs could be combined for an overall savings by combining the dam repair and fishway reconstruction projects.

The only exception to combining the projects was related to the scope of grout injection. As noted in the 2015 Inspection Report, there were a variety of cracks and leaks noted at the dam site. One of the most effective means of addressing these concerns is to inject grout into the dam structure to fill the internal voids/cracks and subsequently limit seepage through the concrete dam structure, as well as the interface between the concrete dam and underlying ledge surfaces.

Grout injection is a specialized type of work and there are only a few contractors in the State of Maine that have the appropriate experience. Therefore, The Town hired a specialty concrete contractor to do the grout injection ahead of the fishway/dam repair project.

In the Fall of 2016, the Town of Bristol retained the Knowles Industrial Services Corporation (KISC) to perform the grout injection work identified in the 2015 Dam inspection (refer to prior section). KISC performed several rounds of grout injection over the course of several days.

Wright-Pierce has not inspected the work completed by KISC. It is recommended that the grout injection work is inspected as soon as possible, at a time when the impoundment is at a normal level, but also when there is limited discharge over the dam spillway.

As noted in the 2015 Inspection Report, there is substantive surficial concrete work recommended at the dam site. Specifically, this includes surficial concrete repair at several cracks on the downstream dam face, as well as to fill voids along the downstream dam toe at the interface of the concrete structure and ledge surface. There is also substantive surficial concrete repair required along the upstream face of the dam, particularly in the area of the former penstock and existing stoplog spillway. It should also be noted that additional grout injections may be recommended based upon the results of inspection of the work completed in 2016.

Overall the dam remains in a Fair to Poor condition as identified in the 2015 Inspection Report even following the 2016 grout injections. It is anticipated that if the recommended scope of remedial work is completed, the dam can be upgraded to a Satisfactory Condition.

SECTION 3

RIVER/IMPOUNDMENT CONDITIONS

3.1 TOPOGRAPHIC AND BATHYMETRIC INFORMATION

3.1.1 Introduction

The Bristol Mills Dam creates an artificial impoundment in the Pemaquid River between the Dam and Biscay Pond. In evaluating the dam and potential modifications, it is important to understand the conditions within the river and impoundment, since modification to the dam could cause corresponding change to these impoundment conditions.

Topographic and Bathymetric data was compiled for the impoundment area. A plan and profile view of the impoundment is included in Appendix F. The plan and profile views show the approximate location of the bathymetric data points, as well as contour lines of the surrounding topography.

3.1.2 Topographic Data

Topographic information (LIDAR) for the project site was obtained from the Maine State Office of GIS to describe the surrounding topography. LIDAR is an instrument which consists of laser, a scanner, and a specialized GPS receiver. The laser scans the topography from an airplane or helicopter, and generates contour lines on the topography. At this scale, it is typical to depict this information with contours at 2-foot intervals.

The LIDAR for the site was used in displaying the topography surrounding the impoundment. The topography defines the stream banks as well as any flood plain areas. In general, the impoundment is broken up into 3 key segments: the Biscay Pond outlet to approximately 1000 feet downstream of the Partridge Bridge (northern Benner Road crossing), from downstream of the Partridge Bridge to the stone arch bridge (southern Benner Road crossing), and from the stone arch bridge to the Bristol Mills Dam. Table 1 (below) correlates these segments to the associated stationing included on the plans and profiles in Appendix F.

TABLE 3.1: KEY IMPOUNDMENT SEGMENTS

Name	Upstream Station	Downstream Station
Biscay Pond to Partridge Bridge	1+00	30+00
Partridge Bridge to Stone Arch Bridge	30+00	142+00
Stone Arch Bridge to Bristol Mills Dam	142+00	150+00

At the outlet of Biscay pond, the Pemaquid River impoundment is fairly confined by steep banks with slopes ranging from 5% to 14%. The width of the channel in this segment in generally from 50 to 70 feet wide. There is a slight bend in the channel near the Partridge Bridge, but otherwise remains relatively straight. Overall, this river segment is substantively developed by residential properties on each bank.

The central section of the impoundment between the Partridge Bridge and the Stone Arch Bridge is generally undeveloped. This section of the river has a wide wetland envelope and contains valuable wildlife habitat areas, particularly for inland wading birds and waterfowl. The Maine Department of Inland Fisheries and Wildlife (MeDIFW) has identified a substantive portion of this segment as significant inland wading bird and waterfowl habitat. The river channel can be as wide as 600 feet to 900 feet in some areas. The river channel is enveloped by flat wetlands. Most of this section is heavily wooded on either side of the river banks.

From the Stone Arch Bridge, to the Bristol Mills Dam, the river channel ranges from 30 feet to 70 feet in width. The surrounding topography slopes range from 3% to 8%. Ledge becomes more apparent and visible through this area. This section is also heavily developed by residential properties, transportation infrastructure, recreational uses, and former mill structures.

3.1.3 Bathymetric Data

A bathymetric survey was collected along the impoundment utilizing small personal watercraft. The survey started at the outlet of Biscay Pond and ended at the Bristol Mills Dam. Bathymetric data was collected by measuring the depth from the water’s surface to the top of channel substrate at the deepest point within the river channel cross section. A metal rod was used to infer sediment type (i.e. bedrock, gravel, fine sediment), and depth to refusal for fine sediment at several locations as shown on the profile sheet included in Appendix F of this report.

3.1.4 Key Impoundment Features

The data collected during the survey shows several notable features along the project profile. Within the central undeveloped segment of the impoundment, there is a notable ledge feature located at approximately station 83+00 (within the central, undeveloped section of the impoundment). At this location, there is a narrowing of the channel created by a ledge constriction. A relatively deep pool is located immediately downstream. It appears that during higher flow events, the water accelerates through the constriction and maintains the pool by scouring collected sediments in the pool area.

Other than this pool, channel depths throughout the central undeveloped impoundment section, remain fairly uniform (4'-5' +/-) and is underlain by approximately 9' +/- of fine sediment. This section contains marsh and wetland areas on either side of the river, with relatively wide river banks. Soil probes in this area indicate that substrate materials are generally a silty clay material.

As the river approaches the stone arch bridge (southern crossing of Benner Road, at approximate Sta. 142+00), there is a notable change in the river form and substrate. Ledge outcrops, steeper bed and banks slopes, and coarser substrates dominate the lower segment of the impoundment from the stone arch bride to the Bristol Mills Dam. Additionally, a prominent grade channel grade control is formed from the natural bedrock in close proximity to the stone arch bridge.

3.2 IMPOUNDMENT INFRASTRUCTURE

3.2.1 Introduction

Wright-Pierce compiled information for the infrastructure along the Bristol Mills Dam impoundment. The information was compiled primarily from a survey performed by Wright-Pierce on December 9, 2016, aerial imagery downloaded from the Maine Office of GIS, and several other site reconnaissance.

The purpose of the infrastructure survey is to document infrastructure along the impoundment between the outlet of Biscay Pond and the Bristol Mills Dam. Wright-Pierce photo documented relevant infrastructure including docks, walkways, waterfrontage, bridge abutments, and beaver dams.

3.2.2 Site Overview

Based on aerial photographs and survey data, most infrastructure appears to be in the uppermost section of the river (from the outlet of Biscay Pond to Partridge Bridge), and the furthest downstream section of the river (from the Stone Arch Bridge to Bristol Mills Dam). The infrastructure survey primarily focused on these 2 sections. Aerial imagery was used to analyze the infrastructure between Partridge Bridge, and the Stone Arch Bridge.

3.2.3 Infrastructure Survey Data

A map of the impoundment with approximate locations of the photographs taken, as well as a photo log, are included in Appendix G. The map uses geo-referencing and GIS software to show the approximate locations of the photographs taken during the on-site survey.

The upstream infrastructure is located mostly between the outlet of Biscay Pond and Partridge Bridge. In this section of the impoundment, most of the infrastructure is associated with residential properties with shoreline frontage. Many properties had docks in the water during the time of the survey as well.

Downstream infrastructure is located between the Stone Arch Bridge and the Bristol Mills Dam. In this section of the impoundment, most of the infrastructure is associated with bridges and public access areas. There are also private docks associated with residential properties downstream of the stone arch bridge. One of the residences in this section has a stone foundation that is also directly on the water as well.

The section between Partridge Bridge and the Stone Arch Bridge has little infrastructure. The only infrastructure that is in this area are 2 residential properties with private docks (Sta. 83 & Sta. 93 on map). In general, this section of the impoundment is surrounded by expansive wetlands with some ledge outcrops along the banks.

SECTION 4

HYDROLOGIC AND HYDRAULIC CONDITIONS

Hydrology is the science that encompasses the occurrence, distribution, movement, and properties of waters of the Earth. In looking at the Bristol Mills dam it is important to consider the movement of water at the site, in particular the rate of flow of water during the course of the year, as well as during extreme storm events. These flows are described below in Section 4.1 – Hydrologic Conditions.

Hydraulics is a branch of science concerned with the practical application of fluids, primarily liquids, in motion (fluid mechanics). Once rates of flow are known, it is then important to estimate the hydraulic performance of the dam during those flow (hydrologic) conditions. In particular, the hydraulic analysis performed as part of this study focuses on water levels, flow depths, velocities, as well as other hydraulic factors associated with the dam spillways, fishway, and impoundment areas.

4.1 HYDROLOGIC CONDITIONS

4.1.1 Introduction

Wright-Pierce has estimated the hydrologic conditions at the Bristol Mills Dam. These conditions are similar through the river study area of this report, as further explained in the subsections below.

This section evaluates several different conditions during times of calculated extreme flows, and monthly mean and median flows. These flows are calculated using USGS Regression Analysis (explained in 4.1.2 and 4.1.3 below). These types of analyses are helpful in determining what the flow conditions will be for extreme flow events, and normal monthly flows.

4.1.2 Extreme Hydrologic Conditions

The USGS Regression Analysis was performed to estimate the extreme flows. The estimated extreme flows for various recurrence intervals were calculated utilizing the equations outlined in

USGS Publication 99-4008 – Estimating Peak Flows for Ungauged, Unregulated Streams in Maine.

The overall watershed area of the Pemaquid River tributary to the Bristol Mills Dam is approximately 31.9 square miles. There is also a substantial area of lakes, ponds, and wetlands throughout the watershed associated with the Pemaquid Chain of Lakes and smaller tributaries. According to the National Wetlands Inventory (NWI) mapping, there are approximately 10.6 square miles of wetlands and surface waters within the wetland area (approx. 33% of the overall watershed).

Extreme flows at the Bristol Mills Dam were estimated for the 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year events. These estimates are provided below in Table 4.1. It is important to recognize that these recurrence intervals are only a statistical probability. For example, it is probable that the 2-year flow estimate is reached or exceeded within a given two-year period, which also correlates to a 50% probability that the event will occur or exceed annually.

TABLE 4.1
EXTREME FLOW ESTIMATES FOR THE PEMAQUID RIVER
AT THE BRISTOL MILLS DAM

Recurrence Interval (Annual Probability)	Extreme Flow Estimate (cubic feet per second – cfs)
2-Year Event (50%)	211
5-Year Event (20%)	286
10-Year Event (10%)	336
25-Year Event (4%)	399
50-Year Event (2%)	445
100-Year Event (1%)	496

4.1.3 Monthly Hydrologic Conditions

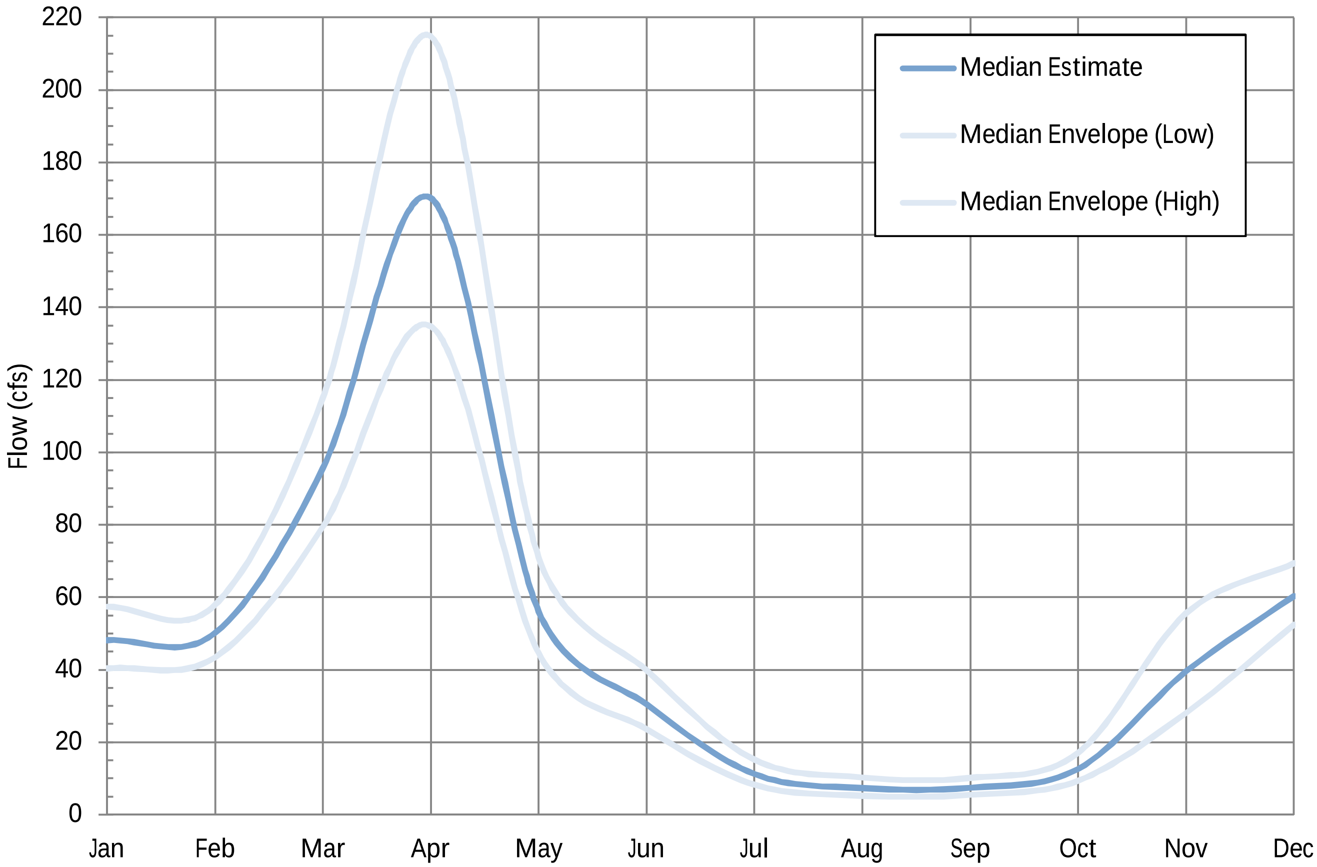
The estimated monthly mean and median flows were calculated utilizing the equations outlined in USGS Publication 2004-5026 – Estimating Monthly, Annual, Low 7-day, and 10-year Streamflow's for Ungauged Rivers in Maine. This type of analysis relies upon watershed statistics such as watershed area, areal percentage of wetlands within the watershed, fraction of watershed underlain by aquifers, distance from the watershed centroid to the coast, mean annual precipitation, and mean winter precipitation. The results of these calculations are shown in Table 4.2 below.

TABLE 4.2: MEDIAN & MEAN FLOW ESTIMATES

Month	Median Flow (cfs)	Mean Flow (cfs)
January	48	74
February	50	73
March	96	146
April	170	189
May	56	73
June	30	49
July	11	21
August	7	15
September	7	16
October	13	33
November	40	67
December	60	90

The river flows vary during different times of the year, as shown in Table 4.2 above. This is typical in most river or stream systems during the year. Figure 4-1 below shows a graph of these conditions where the spring months of March, April, and May are the high flow months, and the months of July, August, September, and October are the months of low flow. Figure 4-1 utilizes the estimated median monthly flows given in Table 4.2 above.

Figure 4-1
Estimated Median Monthly Flow Hydrograph for The Pemaquid River in the Vicinity of the Bristol Mills Dam



4.2 DAM SPILLWAY HYDRAULICS

4.2.1 Existing Dam Spillway Performance

The hydraulic modeling for dam spillway performance was completed using the U.S. Army Corps of Engineers Hydraulic Engineering Center's River Analysis System (HEC-RAS) computer program (Version 4.1.0). HEC-RAS is a computer software designed to perform one-dimensional hydraulic calculations for a network of natural and constructed channels. The system can perform steady and unsteady flow water surface profile calculations.

The HEC-RAS model for this evaluation of the Bristol Mills Dam was developed using a combination of the data collected during a variety of efforts by Wright-Pierce. Model input parameters and geometry of specific physical features, including downstream cross sections, were primarily obtained from available topographic plans, GIS data, and survey data collected previously by Wright-Pierce.

Peak storm flows estimated in the hydrologic analysis were routed through the HEC-RAS model. In addition to the different storm events, two different physical conditions were evaluated in the model. These conditions were with all boards removed from the dam and the other condition was with the primary sluiceway filled with boards. Pertinent results of the modeling are shown below in Tables 4.3, 4.4, & 4.5.

Table 4.3 provides a series of peak water surface elevations in the impoundment above the dam under various conditions. Of interest is the difference between the water surface elevations when comparing the condition with boards in the primary sluiceway, to the condition when all boards are removed from the sluiceway. As shown, this difference varies slightly based upon the storm event, but is generally in the range of 5 to 7 inches (0.4 to 0.6 feet) of difference.

TABLE 4.3
SUMMARY OF PEAK WATER SURFACE ELEVATIONS
AT THE BRISTOL MILLS DAM (FEET)

Recurrence Interval (Annual Probability)	All Boards Removed	Boards in Primary Sluiceway	Difference in Elevation
2-year Event (50%)	77.79	78.35	0.56
5-year Event (20%)	78.23	78.78	0.55
10-year Event (10%)	78.50	79.01	0.51
25-year Event (4%)	78.82	79.26	0.44
50-year Event (2%)	79.01	79.44	0.43
100-year Event (1%)	79.21	79.61	0.40

Another key result is related to the available freeboard at the dam. Freeboard is generally defined as the difference between the lowest point of the dam crest and the resulting upstream peak water surface elevation. A freeboard of 0.5 feet would indicate that the dam is within 0.5 feet from overtopping, and a negative freeboard value would indicate that the dam is overtopping. Overtopping of a dam is considered dam failure and can lead to a variety of unpredictable conditions, including severe erosion, property damage, uncontrolled dam breach, and potential loss of life. The State of Maine does not have any specific state standards for freeboard performance or inflow design floods (IDF). The preparation of a specific hazard analysis or IDF study was not part of this exercise, however it is a somewhat standard practice to provide for at least a foot of freeboard in the desired design storm. Based upon our understanding of the dam and its existing hazard classification (Low Hazard Structure), we suggest that a minimum level of performance at this location would be for the dam to maintain at least a foot of freeboard during the 50-year event (2% annual probability) and for there to be positive freeboard during the 100-year storm (1% annual probability). The modeled available freeboard provided by the existing dam has been identified below in Table 4.4.

TABLE 4.4
AVAILABLE FREEBOARD
EXISTING DAM CONFIGURATION (FEET)

Recurrence Interval (Annual Probability)	All Boards Removed	Boards in Primary Sluiceway
2-year Event (50%)	1.71	1.15
5-year Event (20%)	1.27	0.72
10-year Event (10%)	1.00	0.49
25-year Event (4%)	0.68	0.24
50-year Event (2%)	0.49	0.06
100-year Event (1%)	0.29	(-0.11)

As shown in Table 4.4, there is insufficient freeboard in the 50-year event and the dam may be overtopping in the 100-year storm. While freeboard is increased by removing all boards in the primary sluiceway, it is not sufficient to increase the freeboard to recommended levels.

4.2.2 Recommended Dam Spillway Improvements

Another goal of the dam spillway conditions assessment was to evaluate potential options for replacement of the primary sluiceway boards with a more conveniently and safely operable mechanical gate. Upon review of the dam configuration and performance of the hydrologic and hydraulic evaluation, two conceptual retrofit options were considered.

In each concept, we anticipated that the existing gate geometry would be maintained and that a stainless-steel sliding gate would be affixed to the upstream face of the dam over the existing sluiceway. This gate would be a “top draw” or “downward opening” style gate, which opens by sliding down the face of the dam and allowing water to flow over the top of the gate.

The main difference between the two concepts is related to how the gate is operated. These options are described further below:

<u>Concept #1 – Electric Actuator</u>: One of the primary safety concerns with the existing stoplogs in the sluiceway is the challenges associated with operating the gate (removing or placing the boards). There is no safe access and the safety concerns are compounded during flow events. One way to address this issue is to install the gate described above and to have an electric actuator. The electric actuator will include a small electric motor at the top of the gate, and a small control panel to be installed in a suitably safe location on the upland river bank. During a storm (or whenever adjustment is needed) the gate could be operated from a safe vantage point by the touch of a button.

<u>Concept #2 – Manual Actuator</u>: While the electric actuator is a convenient option, it may be more expensive. This is largely due to the need to bring in electrical services to the dam (which is assumed not to currently exist), as well as the cost of the motor and electrical components. The cheapest actuator option is to utilize a manual control. The challenge with the manual control is that a person must get close to the gate to operate it. This would require the construction of a catwalk over the dam. It is likely that this catwalk could be constructed over the dam spillway area from lumber and could provide access to the gate from above.

4.3 River/Impoundment Hydraulic Conditions

Water level measurements of the Pemaquid River, were taken by a volunteer of the Bristol Mills Dam committee. The measurements were taken between September 2015 and April 2017, during several different conditions. The elevations reported in the tables that follow have translated the measurments into a known vertical elevation. This elevation reference is the North American Vertical Datum of 1988 (NAVD88), which can be generally referred to as the height above sea level.

The measurements listed in Table 4.5 below show water levels under normal dam operation at various dates. The dates that were observed cover several different flow conditions during the year. Water levels for these conditions fluctuate approximately 3 feet.

TABLE 4.5
SUMMARY OF NORMAL DAM OPERATION MEASUREMENTS (FEET-NAVD88)

Date Observed	Water Level Elevation at Bridge Above Bristol Mills Dam (Feet) (Site #1)	Water Level Elevation at Stone Arch Bridge (Feet) (Site #1A)	Water Level Elevation at Partridge Bridge (Feet) (Site #2)
9/16/15*	77.1	77.1	77.1
9/21/15	77.1	77.1	77.1
10/1/15	77.5	77.6	78.0
5/14/16	78.2	78.4	78.3
7/22/16	77.4	77.5	77.4
9/2/16	77.2	77.2	77.2
9/13/16	77.1	77.1	76.9
10/4/16	76.9	76.9	76.7
1/14/17	78.9	79.4	79.4
4/15/17*	78.8	79.1	79.4

Water levels with an * next to the date observed are shown in Appendix F

Table 4.6 below shows water level elevations during dam drawdown events. In particular, the measurements taken on October 27, 2016, were taken at the time of a drought. Arguably, the water levels observed at this date during the October 27th drawdown, would be the lowest conditions that would be observed. This measurement is of interest, because it would closely simulate an event where the dam structure was not present. However, the Bristol Dam Committee and the Town decided early in this process that any concept that altered or removed the Bristol Mills Dam would construct additional water control structures that would maintain water level at within its current range.

TABLE 4.6
SUMMARY OF DAM DRAWDOWN EVENTS (FEET – NAVD88)

Date Observed	Water Level Elevation at Bridge Above Bristol Mills Dam (Feet) (Site #1)	Water Level Elevation at Stone Arch Bridge (Feet) (Site #1A)	Water Level Elevation at Partridge Bridge (Feet) (Site #2)
9/24/15	74.9	76.7	76.6
10/27/16*	71.3	76	76.8

Water levels with an * next to the date observed are shown in Appendix F

The highest (4/15/17) and lowest (10/27/16) observed water levels, as well as the median water level (9/16/15) observed, have been plotted on the river profile have been included in Appendix F of this report. These observed dates were chosen to visually represent the variance of water levels under certain conditions. The highest variance in water levels occur downstream of the Stone Arch Bridge at Site #1 (approximately 7 feet), whereas the variance at the Stone Arch Bridge (Site #1A), and Partridge Bridge (Site #2) is approximately 3 feet.

SECTION 5

FISH PASSAGE OPTIONS

5.1 GENERAL

In general, the entire basis of this report and analysis of options has been driven by the recognized the need to improve the connection of aquatic habitats and fish passage across the Dam at Bristol Mills. In Section 2 of this report, the condition of the existing fishway is described in detail, along with a variety of the deficiencies associated with its function. This section outlines three (3) fish passage improvement scenarios.

The first scenario (Option A) involves improvements and repair to the existing dam, as well as the reconstruction of a new Denil fishway. Option B involves the removal of the dam and replacement of its water level management functions at new nature-like fishway structure located near the Stone Arch Bridge near Benner Road. Option C involves the reconstruction of the dam with a lower crest level (partial removal) and a reconfigured fishway including both structural Denil and nature-like elements.

A set of preliminary engineering design plans for fish passage improvements have been provided in Appendix B and Appendix K. Refer to these plans for additional information regarding the improvement options.

5.2 OPTION A: RECONSTRUCT THE DENIL FISHWAY AND REPAIR THE DAM

In the Spring of 2014, Wright-Pierce was initially retained by the Town of Bristol Fish Committee to evaluate the existing fishway and make recommendations for improvement. In the years that followed, Wright-Pierce coordinated with the Fish Committee and the Town of Bristol Selectmen to develop an optimized structural fishway to accommodate the existing dam. This design was commented on and approved by Maine DMR, NOAA, and USFWS. Additionally, the Town of Bristol Selectmen retained Wright-Pierce to inspect the dam and make recommendations associated with repairing the dam, as well as additional gate improvements.

Option A represents the culmination of the aforementioned years of fishway analysis and dam infrastructure review. The results of our dam inspection and recommendations for repair are outlined in Section 2 of this report. In addition to the associated dam repairs and gate improvements, Option A also seeks to address the variety of concerns associated with the performance of the existing fishway. The associated concerns and performance of the existing fishway are outlined in Section 2 of this report.

The concerns over attraction for fish to find the entrance at the Bristol Mills Fishway are of particular importance. The existing practice to install and maintain the mesh leader fence is marginally effective and unsustainable in the long term. In the recent past, Wright-Pierce, the Town Selectmen, and the Town Fish Committee discussed the replacement of this leader fence with a more permanent dam structure. While the dam structure may be more practical than the leader fence, there are a number of long term maintenance concerns related to the structure, as well as environmental impacts. A solution that involves a more permanent dam structure also involves a substantial capital investment.

Overall, it was determined that a more feasible option would be to relocate the fishway entrance to the toe of the existing dam, which is a more attractive location for migrating fish. While the entrance relocation is also a substantial capital investment, it eliminates many of the environmental and maintenance concerns associated with a permanent leader dam structure.

Along with relocating the entrance, the proposed fishway has also been extended lower, which alleviates the existing problem in which most fish are not able to enter the fishway because it is hung above the base-level water surface. Additionally, the entrance channel has been extended to provide less turbulent and more favorable entrance conditions. A stoplog slot has also been added to the fishway entrance, which can be utilized to create an attraction jet from the entrance, as well as increase the depth of water in the fishway entrance pool.

To relocate the fishway entrance, the overall ladder has been reconfigured with a more pronounced “switch-back” and two distinctly separate Denil ladder sections separated by a resting pool. A new section of Denil ladder will be extended from the new resting pool area to the relocated entrance of the fishway. In this condition, migrating fish will travel approximately five vertical feet from the fishway entrance to the new resting pool. From the resting pool, migrating fish will travel an additional six vertical feet to the fishway exit.

At the fishway exit, the existing gate is proposed for removal and an approximate 16-foot-long extension is proposed. The fishway extension will allow for the installation of needed upper baffles, as well as the ability to install a series of optional extension baffles. These extension baffles can be utilized, as needed, to regulate flow in the fishway and adjust the exit condition to varying headpond levels. Along the fishway exit extension, a wooden platform is proposed to provide maintenance access, as well as facilitate future counting surveys and fishway observation. Plans for this option have been reviewed, commented on, and approved by Maine DMR, NOAA, and USFWS.

As part of the review by State and Federal Agencies, it was also noted that a single four (4) foot wide Denil fishway would not accommodate the potential future restoration of the fishery. Based upon the standards developed by the USFWS and comparison to other similar fishways around New England, a single 4-foot wide Denil fishway should be able to accommodate around 200,000 to 300,000 alewives annually. Based upon estimates by the State of Maine Department of Marine Resources, the alewife run in the Pemaquid River has the potential to reach 660,000 fish annually. As such, it was recommended by State and Federal Agencies that a second 4-foot Denil fishway ladder is added in the future as the fishery is restored and the annual run grows. This second (twin) 4-foot Denil has been included in the cost of Option A.

Overall, Option A will retain the existing dam, its impoundment, and uses. It will also make necessary structural and functional improvements to the dam and provide a new and improved structural fishway. This fishway is designed primarily for passage of alewife, trout species, and Atlantic salmon should they be reintroduced to the Pemaquid River. This fish passage design is not designed for maximum passage efficiency of American Shad or American Eel. Comments received by NOAA on this design requested that additional passage be constructed for American Eel if this design were to be installed.

Operation and Maintenance of a Denil style fishway is generally focused on management of the internal baffles and attraction conditions. The fishway should be inspected regularly to review and remove debris (sticks, trash, etc.) which may get caught in or obstruct the fishway baffles. The regularity of these inspections will vary based upon the debris load in the waterbody, however it should be assumed that a thorough inspection/cleaning of the fishway should occur semi-annually (Spring and Fall), with periodic inspections to verify performance at least weekly (or more) during upstream migratory season. Also, the entrance to the fishway (downstream end) should be inspected regularly to ensure that effective and attractive entrance conditions are being maintained. It is common for a wooden stop-log style gate to be provided at the fishway entrance so that adjustments can be made to accommodate changes in flow and tailwater conditions. More sophisticated Denil fishways have also been fitted with a mechanical gate that can be operated with a hand wheel (or electronic sensors) to allow for easier operation. It is possible that the gate at the fishway entrance may need to be adjusted multiple times over the course of the year and/or fish migration season to ensure optimal fish passage.

A concrete flume with wooden baffles requires little maintenance, as a well-constructed concrete flume should have a design life of over 50 years, if not 75. Care for the concrete is typical of other concrete structures, which includes periodic inspection and potential surficial patching in areas that are damaged. However, overall concrete maintenance is minimal.

Conversely, the wooden baffles, stoplogs, or other internal components should be removed and inspected annually. Wooden components should be replaced as needed, which is likely to occur within 7 to 12 years of the life of the wooden components.

5.3 OPTION B: REPLACE DAM WITH "NATURE-LIKE" FISHWAY AND WATER LEVEL CONTROL

Another option being considered for improved fish passage and aquatic habitat connectivity is to simply remove the existing dam, and replace with other water control structures that would require minimal to no maintenance and allow for full fish passage. Removal of the dam provides the most effective and efficient passage of fish and other aquatic organisms. However, this option will also affect a variety of other impoundment features and uses. As such, Option B also includes a number of other improvements to replace some of the dam's current features and mitigate for other impacts to existing uses.

The most notable impacts associated with replacement of the dam with nature-like water control structures include the following:

- Town of Bristol Fire Department's use of the impoundment as a firefighting water supply,
- Recreational use of the impoundment area for swimming and boating/paddling

This option retains the following features within the current state by replacing the dam with nature-like water control structures:

- High-value wildlife habitats located in the vast wetland complex that envelope the impoundment
- Management of the water level regime throughout the greater Pemaquid Chain of Lakes.

Option B has been developed to completely remove the existing dam structure, while also replacing many of the existing dam functions with a new nature-like fishway structure and water control structure. That said, some of these impoundment features, such as the firefighting water supply and recreational swimming will require some level of additional off-site replacement of these services to mitigate for those impacts.

In our review of the river and impoundment conditions (further described in Section 3 of this report), a rather notable ledge feature was revealed in the area of the stone arch bridge where Benner Road crosses the impoundment. This area of ledge is a natural grade control and constriction of the Pemaquid River channel. It is likely that this ledge feature played a significant role in the natural evolution and formation of the wetland complex located upstream. Furthermore, the crest of this ledge feature is approximately only 2.5 feet lower than the existing dam crest elevation.

The placement of a nature-like fishway in and around the natural ledge near Benner Road will replace several key functions of the existing dam. Specifically, the nature-like fishway acts as a new water level control structure for the upstream areas that will maintain water level within its current range. The most upstream stone weir crest of the fishway will manage water levels in the same manner as the existing dam. Therefore, the uses within the impoundment upstream of the stone arch bridge crossing of Benner Road will not be altered by Option B (Full Dam Replacement). By entirely replacing the dam with the proposed nature-like fishway, the following uses will be maintained just as they exist today:

- Recreational use of the Pemaquid River impoundment for boating/paddling
- Management of the water level regime in the greater Pemaquid Chain of Lakes
- High-Value Wildlife Habitats and function/value of the impoundment wetland complex

The nature-like fishway proposed under Option B will not be able to replace the entire function of the dam. Specifically, the current dry hydrant utilized by the Town of Bristol Fire Department in the immediate vicinity of the existing dam will require relocation under this scenario. Section 6 of this report has been prepared as a general analysis of the Town of Bristol Fire Water Supply systems across its municipal extents. A variety of concepts have been provided that may improve general firefighting water supply within the Department Service area, as well as options to replace the current firefighting water supply located at the Bristol Mills Dam.

The relocation of services to Ellingwood Park would allow for water to be loaded at the same rate as the Bristol Mills Dam location. Under drought conditions, trucks would be able to make use of the drive to Benner Road, as well as the loop in the proposed plan. While the water source volumes and loading rates at this site would be equivalent to the current water supply, Town of Bristol Fire chief has expressed concern that the Ellingwood Park design did not allow fires within the immediate vicinity of Bristol Mills village to be reached by hose, and also the drive distances would be farther.

Additionally, the recreational swimming opportunities provided by the immediate dam impoundment will also require relocation and mitigation. It is understood that the swimming area immediately upstream of the existing dam is a unique feature. However, the provision for some new swimming opportunities coupled with a variety of other recreational enhancements within the impoundment are possible. Section 7 of this report highlights these recreational enhancements.

As noted above, Option B (Full replacement of the Bristol Mills Dam) would consist of full removal of the Dam, installation of a nature-like fishway near the stone arch bridge, and alternatives to firefighting water supply as well as recreational use.

Nature-like fishways are man-made structures, which are constructed out of natural materials (boulders, cobble, gravel) in an effort to create diverse physical structures and hydraulic conditions that resemble natural stream/river systems.

A rock pool and weir fishway is similar to a step-pool stream morphology. These types of rock pool and weir fishways can be reliably constructed on slopes as steep as 1foot vertical to 20 feet horizontal (1V:20H), which is suitable for species such as alewife, Atlantic Salmon, and brook trout. However, flatter slopes of 1V:30H are more effective at providing passage for the species listed above, as well as shad, smelt, bass, and other weaker swimming species.

The principle advantage of nature-like fishways is that they provide conditions that replicate natural systems and, therefore maximize the diverse physical characteristics needed by a wide variety of migratory and resident fish assemblages. Nature-like fishways also generally require minimal maintenance (compared to structural fishways) and are generally not operated. However, nature-like fishways generally require much larger land footprint than structural fishways and can be costly to construct.

It is important to note that while the static lift associated with the dry hydrant will be maintained, there will be a reduction in the volume of water available for firefighting purposes. The existing supply of water is somewhat infinite, as it is connected to the greater Pemaquid Chain of Lakes. Once the impoundment is lowered, there will be a stretch of free-flowing river between the Lakes and the impoundment, which effectively breaks the direct storage link. That said, a volume of at least 150,000 gallons will be maintained at the dam location, which will be a satisfactory volume of water from a fire insurance rating perspective. However, the final determination related to the adequacy of firefighting water supply is subject to review by the Town of Bristol Fire Department. Additional improvements (outlined in Section 6 of this report) may still be required to maintain the Town’s existing firefighting capabilities.

Drawing C-2 in Appendix K depicts a nature-like rock pool and weir fishway channel concept. The fishway consists of weirs stepped at approximately 7 inches vertically spaced horizontally at 20 feet on center (1V:30H).

Maintenance of nature-like fishways is minimal and consists mainly of a periodic inspection to ensure that major debris (large wood, large debris, etc.) has not obstructed the weir geometry. Nature-like fishways generally do not have any operable components, however it is possible for debris can obstruct the weir geometry and require some maintenance.

It should also be noted that the Option B could allow for some of the existing dam structure to remain. This may be desirable to maintain some form of the cultural or historic resource value that has been identified by many residents. In particular, the portions of the dam closest to either shore and/or the abutments could remain, while still allowing for the intent of Option B to be effective. There may be additional cost associated with preserving some of the structure. For the purposes of cost estimation purposes, additional cost associated with preserving portions of the dam have not been included.

5.4 OPTION C: PARTIAL DAM REPLACEMENT

Option C has been prepared to represent a condition in-between reconstruction of the Denil fishway and repair of the dam (Option A) and replacement of the dam with a “nature-like” fishway and water control (Option B). As such, Option C considers the partial removal of the dam. The partial removal/replacement will allow for some form of the fire-fighting water supply and recreational swimming opportunities impacted by Option B to be maintained at the current site.

Preservation of the firefighting water supply in its current location adjacent to the Bristol Mills Dam was a primary factor in the development of Option C. Specifically, the National Fire Protection Association (NFPA) code requires that dry hydrants are constructed with a static vertical lift of no more than fifteen (15) feet. Additionally, most modern fire pumping apparatus will maintain a full pumping capacity at static lift heights up to ten (10) feet. As such, Option C was developed to remove a portion of the dam, while maintaining a static lift height of 10 feet. Option B follows these parameters as well.

Drawing C-3 in Appendix K depicts the Option C concept. As shown, the impoundment is being lowered approximately five feet from its current levels. This will maintain ten (10) feet of static vertical lift for the dry hydrant, while also preserving a meaningful impoundment for swimming and recreation.

While Option C involves removal of a portion of the dam and a five-foot reduction in the impoundment, the dam will remain approximately eight (8) feet tall. This height is a bit too large to practically overcome with a reasonably sized nature-like fishway. As such, Option C includes a section of nature-like fishway below the dam, as well as a small section of Denil ladder.

While it may be possible to simply remove a portion of the existing dam, it is likely more practical to remove the entire existing dam structure and build a new smaller dam within the same basic footprint. The existing dam is a relatively old structure and the long-term costs associated with maintenance/repair required to maintain the dam in a suitable condition would likely offset the costs to simply rebuild a new and smaller structure.

Much like Option B above, the static lift associated with the dry hydrant will be maintained, but there will be a reduction in the volume of water available for firefighting purposes. With that said, a volume of at least 150,000 gallons will be maintained at the dam location, which will be a satisfactory volume of water from a fire insurance rating perspective.

The recreational swimming opportunities at this location may also be diminished by the reduction in the impoundment associated with Option C. Overall, a swimming hole will remain above the dam, however some additional swimming opportunities and recreational improvements (outlined in Section 7 of this report) may still be warranted. The Town of Bristol Parks and Recreation Committee and/or the Town of Bristol Selectmen should carefully consider the changes to swimming opportunities associated with Option C, along with the appropriate potential recreation improvements for mitigation of those changes.

Another key element of Option C is that the lowered impoundment and fishway associated with the smaller dam structure, will also require the construction of a nature-like fishway at the Benner Road Bridge (as outlined in Option B). While the smaller dam and fishway will accomplish the goals of allowing the fire water supply and some elements of the recreational swimming to remain at the existing dam site, the nature-like fishway will still be required to manage water levels in the impoundment and preserve the recreational and wildlife values upstream of Benner Road.

SECTION 6

FIREFIGHTING WATER SUPPLY

6.1 GENERAL

6.1.1 Existing System Review

A key function of the Bristol Mills Dam lies in the use of the associated impoundment as a convenient and reliable source of water for firefighting purposes.

Currently, the Bristol Fire & Rescue relies on a dry hydrant in the Bristol Mills Dam impoundment as a reliable source of water for firefighting purposes. There are six (6) other sources of firefighting water supply in the service area. An overview map of the Bristol Fire & Rescue service area (five road miles from each Fire Station), as well as associated firefighting water supply locations has been included as Figure 1 in Appendix L.

6.1.2 NATIONAL FIRE PROTECTION ASSOCIATION (NFPA) CODE - 1142

The publication NFPA 1142 - *Standard on Water Supplies for Suburban and Rural Fire Fighting* is generally regarded as the authoritative guidance associated with standards for providing water for rural fire protection for structure fires. Within those guidelines a recurring theme is that granting of significant judgement to the authority having jurisdiction (AHJ), in this case Bristol Fire & Rescue.

Within the context of NFPA 1142, the following chapters are most relevant to this discussion:

- Chapter 4 - Calculating Minimum Water Supplies
- Chapter 7 - Water Supply
- Chapter 8 - Dry Hydrants
- Annex B - Water Supply

Annex B discusses water supply sources (rivers, cisterns, etc.)

6.1.3 ISO Insurance Ratings

ISO (Insurance Services Office, Inc.) is a leading source of information about property/casualty insurance risk. ISO collects information that is useful in many aspects of insurance underwriting. The collected information includes evaluations of many public safety features, including public fire protection. ISO performs the evaluations as a service to the insurance industry, and as an advisory organization, insurers may utilize this information as they see fit to develop fire insurance rates for the community.

ISO provides an overall rating for the fire protection in a community on a 1 to 10 scale, with Class 1 representing exemplary fire protection, and class 10 indicates that the areas' fire suppression program does not meet minimum criteria. Based upon e-mail correspondence with ISO dated May 2017, properties within 5 roadway miles of a fire station in the Town of Bristol were rated as a Class 9. Properties located outside of a 5 mile distance from a fire station were rated as a Class 10.

6.1.4 Modifications to Current Water Supply

If modification to the current water supply is required by the associated fish passage alternative, it will require close coordination with Bristol Fire and Rescue, as well as NFPA regulations. Impacts to insurance ratings (ISO) should also be considered.

6.2 ASSESSMENT OF OTHER WATER SUPPLY OPTIONS

6.2.1 General

Chapter 8 of NFPA 1142 discusses design standards for Dry Hydrants (while, again, giving significant latitude to the Authority having jurisdiction [AHJ]). Section 8.5.1 indicates that there shall be not less than 2' of water above the inlet strainer and not less than 1' of water below the inlet strainer. Section 8.5.2 stipulates that the "Depth of the water shall be based on the 50-year drought level for the water source."

As noted in NFPA 1142, a variety of options exist with regard to alternate sources of firefighting flows, although selection of an alternative approach is subject to the AHJ's concurrence and approval.

6.2.2 Site-Supply Options

Wright-Pierce has interviewed the Fire Chief and performed site reconnaissance around the Town of Bristol. The existing fire water supplies have been documented, and additional potential supply sites have been identified. It should be noted that each of the identified sites have only been evaluated as concepts. More detailed engineering investigations would be required to make definitive determinations of the details (i.e. size and location of cisterns, dry hydrant configurations, etc.). Additionally, the concepts will also require coordination with adjacent property owners and/or state agencies to acquire appropriate easements/permissions to develop these locations as fire water supply sites. Prior to advancing designs at these locations, coordination should occur with the appropriate property owners.

The map included as Figure 1 in Appendix L identifies the general location of each of the existing sites, as well as each of the identified potential sites. An additional sketch of each site is also included in Appendix L, which further details each site and potential improvements. A brief description of each site is included as follows:

<u>Site E1 – Bristol Mills Dam:</u> The Bristol Mills Dam site is a valuable source of firefighting water supply for the Bristol Fire and Rescue. Its location near the Bristol Mills Fire Station and large volume of good quality water, make it an excellent source. Fire truck circulation in this location is good, and allows for several trucks to be in queue.

The Bristol Mills site may require alteration under the potential fish passage alternatives at the Bristol Mills Dam. Most significantly, if the Bristol Mills Dam were removed, the Bristol Mills site would be substantially altered as a source of firefighting water supply.

Site E2 – Round Pond: The Round Pond site is located near the Round Pond Fire Station and also close by to significant structures as identified by the Bristol Fire Chief. Water quality at the site appears good, and water volume available appears to be minimal. Fire truck circulation is not ideal, but in talks with the Bristol Fire Chief, the Town of Bristol is currently working towards improvements.

Site E3 – Northern Point Road: The Northern Point Road hydrant is located near the Round Pond Fire Station. Water quality at the site is poor due to the culvert restricting flow, and the water being brackish. There is very little volume available, and fire truck circulation is not ideal. In conversations with the Fire Chief, it was mentioned that this location would not be used.

Site E4 – Transfer Road: The Transfer Road Hydrant is located in the transfer station, on a small pond. Water quality at the site appears to be good, however water volume available appears to be minimal. It was indicated by the Fire Chief that in draught conditions, this pond held its water table. The transfer road would accommodate fire trucks and provide good truck circulation as well.

Site E5 – New Harbor Pond: The New Harbor Pond is located near the New Harbor Fire Station and in close proximity to substantial structures in the service area. Water quality at the site appears good and there is a large volume of water available. There is also a large gravel driveway allowing for good truck circulation.

Site E6 – Bristol Road, New Harbor: The Bristol Road, New Harbor hydrant is located near the New Harbor Fire Station and close to substantial structures in the service area. The water in the pond appears to be clean and of good quality, and it appears that there is a large amount of water available. Sight distance at this site is poor and the road is relatively narrow, making this location not ideal for truck circulation.

Site E7 – Bristol Road: The Bristol Road hydrant is located near the Hammond Lumber and is between New Harbor Fire Station and Bristol Mills Fire Station. The water in this area appears to be clear and clean, however it also appears to be rather shallow. The hydrant pulls from Pemaquid

River though, so quantity does not appear to be of concern. The hydrant is located in a large parking lot, which allows for good truck circulation and for trucks to be in queue.

<u>Site P1 – Bristol Road:</u> The Bristol Road potential hydrant location was identified by the Fire Chief as a potential source of water in the Town of Bristol. It is not ideal, as it is not located near any major structures or fire stations. However, providing a gravel access at this site would allow for good truck circulation and could accommodate several trucks. The water at this site appears to be clean and of good quality. The pond has been known to dry up during draught conditions, but it is possible that this source could be utilized in an emergency situation.

<u>Site P2 – Partridge Bridge:</u> The Partridge Bridge location has an ample supply of good quality water. Water levels in this area have been discussed in previous sections, but there is a large quantity of water coming from Biscay Pond. The drawbacks of Partridge Bridge is sight distance in the area is poor, and the location is a few miles away from the Bristol Mills Fire Station. That said, the Fire Chief has stated that residential structure development around this area has been growing in recent years and there are no other sources of water supply in the area. Truck circulation could be improved by providing an improvement to the gravel shoulders. Installation of a dry hydrant would also be relatively simple at this site and it would be a high volume and quality water supply.

<u>Site P3 – Split Rock Road:</u> Split Rock Road potential hydrant is located near the Bristol Mills Fire Station along Bristol Road. Currently, truck circulation in this location is not ideal, but improvements can be made to the gravel shoulder to allow for trucks to be in queue. Improvements would also need to be made at the pond outlet (culvert inlet) to retain the water in the pond. Currently, the pond is heavily influenced by beaver activity at the pond outlet. The water appears to be of good quality, and there is ample supply of water as well.

<u>Site P4 – Upper Round Pond Road:</u> The Upper Round Pond potential hydrant is located between the Bristol Mills Fire Station and the Round Pond Fire Station on Upper Round Pond Road. The water in this location appears to be clean water and there is a large supply available. Improvements to the gravel shoulder would need to be made to improve truck circulation. Upper Round Pond

Road is also relatively narrow, and does not provide good sight distance in the area. This location could utilize a simple dry hydrant and a gravel shoulder.

Site P5 – Lower Round Pond Road: The Lower Round Pond potential hydrant is located near the Bristol Mills Fire Station on the Lower Round Pond Road. This location could utilize a simple dry hydrant and an improvement to the gravel shoulder. The water supply in this area appears to be of good quality and there is a large supply available. The crossing is located on a corner though, which would make truck circulation and traffic control challenging.

Site P6 – Carl Bailey Road: The Carl Bailey potential hydrant is located on Carl Bailey Road between Bristol Mills Fire Station and New Harbor Fire Station. The water in this area appears to be clear and of good quality. However, it was indicated by the Fire Chief that in times of draught conditions, this water source is too low for the pump intakes. Also, another challenging piece about this location is the width of Carl Bailey Road. The road is narrow, making it difficult for 2 cars to pass. It is possible that this source could be utilized in an emergency.

Site P7 – Transfer Road: The Transfer Road potential hydrant is located at the transfer station. In discussions with the Town and the Fire Chief, this location was identified as a potential location for a cistern system. The hydrant would be pulling from the Boyd Pond outlet which appears to be quality water and a large quantity is available. Improvements could be made to the access which would allow for trucks to circulate and be in queue. This location could also serve multiple fire stations as well.

P8 – Ellingwood Park: The Ellingwood Park potential hydrant is located near the Bristol Mills Fire Station along the Pemaquid River. There is a high volume of good quality water in this area, as well as a truck circulation area that would accommodate fire trucks in queue. This site was selected by the Dam Committee to develop into a more detailed plan to be the primary replacement source if the dam were to be replaced with other water control structures. Improvements could be made to the current boat launch, as well as including a paved roadway connecting the proposed loop to Benner Road. In conjunction with these improvements, a conceptual plan incorporating recreational improvements of Ellingwood Park are included as Appendix M of this report, and further discussed in Section 7.

6.3 CONCLUSIONS

Based on our assessment, it appears that there are viable additional options for fire water supply development in multiple locations in Bristol. One or more of these alternatives can maintain and potentially improve firefighting supply options, as well as associated fire insurance ratings for the Town of Bristol.

Bristol Fire and Rescue is the authority having jurisdiction (AHJ) at the Bristol Mills Dam site. Further discussion related to the viability of potential modifications or further site development should be coordinated with Bristol Fire and Rescue.

SECTION 7

RECREATIONAL ALTERNATIVES

7.1 GENERAL

The impoundment area located immediately upstream of the Bristol Mills Dam is a popular recreational swimming location in the Town of Bristol. The depth of water, surrounding ledge, and central location in the community contribute to its value and use.

Several of the fish passage options (described in Section 5) have the potential to change the nature of this recreational use. While the unique qualities of the swimming area at the existing dam will be a challenge to replicate, there are a variety of other recreational opportunities that could be created or enhanced in the community.

7.2 ELLINGWOOD PARK ENHANCEMENTS

Ellingwood Park is a public recreational area located along the impoundment and just upstream of the existing dam. The Park is managed by the Town of Bristol Department of Parks and Recreation. As part of this study, Wright-Pierce consulted with the Town of Bristol Parks and Recreation committee to review Ellingwood Park and discuss potential improvements and enhancements to the existing recreational uses. A concept plan can be found in Appendix M of this report.

One of the primary focuses for enhancement is related to swimming, since that is the principle recreational use associated with the immediate impoundment area at the existing dam. Some swimming use occurs at Ellingwood Park; however, it appears to be underutilized. As shown on the conceptual improvements plan, access to the deeper sections of the impoundment adjacent to Ellingwood Park can be improved by the construction of a new platform, stairs, and dock. This platform and dock will be located on and/or adjacent to the current ledge feature in this area and will allow easy access to the more swimmable locations.

In addition to the access improvements, parking was also identified as a need in order to accommodate more use of Ellingwood Park for swimming and increased use of the boat ramp in recent years. In addition to providing access improvements for swimming the recreational plan also includes improvements to parking. Adjacent to the swimming access improvements, more passive recreational enhancements could be provided by expanding the lawn area and including some passive recreational amenities, such as picnic tables, grill stands, and/or other features that would enhance passive uses adjacent to the swimming access.

One of the principle uses at Ellingwood Park is the gravel boat launch. This launch area provides small watercraft access to the impoundment area along the Pemaquid River. The launch is popular with kayakers, wildlife observers, and fisherman seeking access to the large wetland system enveloping the high-value habitat areas around the Pemaquid River impoundment.

Based upon site observations and discussion with the Town of Bristol Parks and Recreation Committee, the existing launch site can become congested at times with parked vehicles and trailers. The parking and vehicular circulation is limited at the site and only a handful of vehicles can park at one time before the site becomes overcrowded, particularly if trailered vehicles are utilizing the site. Additionally, the gravel surfaces are susceptible to erosion, which is compounded by insufficient drainage infrastructure. As such, substantive erosion occurs at the site annually, and new gravel is regularly imported to the site to restore the gravel surfaces.

The conceptual recreational improvements plan also seeks to improve the boat launch area by improving vehicular circulation, and parking. The proposed boat launch area would also be improved with more durable wearing surfaces (pavement), as well as via improvements to the drainage system to convey surface water around the site in a stable manner. A more durable ramps surface (i.e. concrete planks) would also be utilized along the ramp to allow for improved trailered boat access to the River.

It should also be noted, that many of these site and access improvements associated with the boat launch could also be designed to provide for improved firefighting water supply access (refer to Section 6 of this report, particularly the discussion of Option P8). Refer to the plans included in

Appendix M, which overlay the additional potential improvements associated with fire water supply.

SECTION 8

COST ANALYSIS

8.1 GENERAL

There are many potential combinations of improvements to fish passage and dam conditions which may occur at the Bristol Mills Dam. These improvements could include major repair/reconstruction of the dam, fishway reconstruction, as well as modification/development of firefighting water supply systems. Each of these major topics is covered in the following sections of the report and associated cost estimates have been provided in Appendix N.

It should be noted that many of the cost estimates provided have been prepared with conceptual level design development. As such, these estimates should be representative of the order of magnitude of these costs, however further engineering and design is recommended to further refine these values. It should be noted that these costs include estimates for permitting and final engineering design. However, additional costs may be required or warranted, such as legal costs, costs associated with land/easement acquisition, historical/cultural studies, and/or construction management/inspections.

8.2 OPTION A: REPAIR EXISTING DAM & REPLACE FISHWAY

To create a basis of comparison for the cost associated with each option, we have combined the initial capital costs along with ongoing operation and maintenance, as well as, future capital costs over a fifty-year period. The following sections outline each of these costs.

Initial Capital Investment

The initial capital investment includes the engineering, permitting, and construction costs associated with the initial construction of the improvements. A Structural Inspection Report was performed by Wright-Pierce in September 2015, and is provided as Appendix E. Further detail related to the condition of the dam and associated costs are provided in that report. Currently, the condition of the dam is classified as Fair to Poor with some major deficiencies and this estimate anticipates improving the dam to a Satisfactory condition. The improvements associated with fishway construction are also described elsewhere in this report, specifically Section 5 and Appendix C. Further detail related to the estimate of these costs is included in Appendix N. These costs are as follows:

Repair of Bristol Mills Dam (to Satisfactory condition): $80,000
Spillway and Gate Improvements: $60,000
Eel Ladder Construction: $60,000
<u>Construction of a new Denil Fishway: $240,000</u>
Total Initial Capital Investment: $440,000

<u>General Maintenance and Operation</u>

There is a variety of general maintenance and operation that is associated with Option A. Specifically, these costs are associated with the ongoing operational needs of the dam and fishway. This includes some level of staff/volunteer time to operate the dam gates and operate the fishway generally throughout the year, and also at key fish passage season. There are also a variety of miscellaneous maintenance items, which may include replacement of fishway baffles, minor concrete and/or gate repairs. Periodic inspection of the Dam and fishway by qualified engineering personnel is also included. Overall, the annual average of these costs is estimated as follows:

General Maintenance and Operation (annual average): $6,000

<u>Future Capital Investment</u>

Option A should consider a variety of future capital investments associated with the proposed structures. Most particularly, the existing Dam is an old structure. The majority of repair recommendations will improve the condition of the dam. However, at its core, the existing dam remains an old structure. The life of these repairs to an aging structure is less than the life of new construction and it is likely that further repair will be required in the coming decades. Conversely, the fishway structure is generally new concrete construction and is anticipated to have a longer life span before requiring substantive repair.

In addition to future capital investment in the dam structure, there will also be a need to expand the capacity of the fishway in the future. A single Denil fishway (as initially proposed) will eventually reach capacity as the fishery is restored and a second Denil will need to be added. Based upon other similar restoration efforts in the State of Maine, it is anticipated that the fishway may be required in 10-years.

Overall the future capital investment at the site is anticipated to be as follows:
Future Capital Investment (Addition of Second Denil): $180,000 (in approximately 10 years)
Future Capital Investment (Repair of Dam/Fishway): $50,000 (in approximately 20 years)

<u>Fifty-year Cost Estimate</u>
Each of the costs noted above have been combined over the next fifty-year period to provide a single anticipated cost for each option. The anticipated fifty-year cost estimate is as follows:

Option A – Fifty-year Cost Estimate: $1,045,000

8.3 OPTION B: FULL DAM REPLACEMENT

To create a basis of comparison for the cost associated with each option, we have combined the initial capital costs along with ongoing operation and maintenance, as well as, future capital costs over a fifty-year period. The following sections outline each of these costs.

<u>Initial Capital Investment</u>
The initial capital investment includes the engineering, permitting, and construction costs associated with the initial construction of the improvements. Option B consists of a full replacement of the Bristol Mills Dam. The existing dam structure would be removed, and replaced with a nature-like fishway by the stone arch bridge. This replacement would require improvements to the firefighting water supply as well as improvements to Ellingwood Park. Further discussion on this Option is outlined in Section 5. The following costs have been estimated:

Demolition of Existing Dam: $100,000

Construction of Nature-Like Fishway: $170,000

Ellingwood Park Fire Water Supply Improvements: $80,000

<u>Ellingwood Park Enhancements: $260,000</u>

Total Initial Capital Investment: $610,000

<u>General Maintenance and Operation</u>

There is some general maintenance associated with Option B. Some periodic inspection of the nature-like fishway should occur by qualified personnel. Additionally, there is a need to inspect the fishway and potentially remove collected debris at the notches or along the weirs. Removal of unwanted vegetative growth may also be a consideration.

With the enhancements made at Ellingwood Park, there has been discussion of additional maintenance needs at Ellingwood Park. This estimate assumes that there is currently maintenance occurring at the Bristol Mills Dam site associated with the fire water supply, the access road, and recreational activity adjacent to the Dam. As such, it is anticipated that those maintenance efforts will be reallocated to Ellingwood park upon completion the construction of this option and therefore would not be an overall change in maintenance from the existing condition.

Overall, the annual average of maintenance costs is estimated as follows:

General Maintenance cost (annual average): $1,500

<u>Future Capital Investment</u>

Option B should consider also consider some future capital investment. At some point in the future a large storm event (such as the 100-year flood) has the potential to damage the fishway structure. Depending on the final details of the fishway (i.e. steel ledge pins, mortar, grout) there may also be a need for substantive repair to the structure at some point in the future. These repairs could include isolated repair of individual weirs or boulder sections. Overall the future capital investment at the site is anticipated to be as follows:

Future Capital Investment (repair of fishway): $50,000 (in approximately 50 years)

Fifty-year Cost Estimate

Each of the costs noted above have been combined over the next fifty-year period to provide a single anticipated cost for each option. The anticipated fifty-year cost estimate is as follows:

Option B - Fifty Year Cost Estimate: $735,000

8.4 OPTION C: PARTIAL DAM REPLACEMENT

To create a basis of comparison for the cost associated with each option, we have combined the initial capital costs along with ongoing operation and maintenance, as well as, future capital costs over a fifty-year period. The following sections outline each of these costs.

Initial Capital Investment

The initial capital investment includes the engineering, permitting, and construction costs associated with the initial construction of the improvements. Option C is to remove the existing Bristol Mills Dam, and replace with a smaller dam structure. Option C would also require similar nature-like fishway improvements included in Option B, and would also require additional fishway improvements at the Bristol Mills Dam location. This option would allow for fire water supply to remain at its current location, as well as some of the current recreational swimming use. However, some level of recreational improvements and/or firefighting water supply improvements may still be warranted. As such, the total initial capital investments may vary based upon further development of firefighting water supply and recreational enhancements. Cost worksheets can be found in Appendix N of this report. Further discussion on this Option is outlined in Section 5. The following costs have been estimated:

Demolition of Existing Dam: $100,000

Reconstruction of New Dam Structure: $350,000

Fishway Construction at Dam: $300,000

Fishway Construction at Benner Road: $170,000

Potential Ellingwood Park Recreational Enhancements: $260,000

Potential Ellingwood Park Fire Water Supply Improvements: $80,000

Total Initial Capital Investment: $920,000 to $1,260,000

General Maintenance and Operation

There are a variety of general maintenance and operational tasks associated with Option C. Specifically, these costs are associated with the ongoing operational needs of the dam and fishways. This includes some level of staff/volunteer time to operate the dam gates and operate the fishway generally throughout the year, and also at key fish passage season. There are also a variety of miscellaneous maintenance items, which may include replacement of fishway baffles, minor concrete and/or gate repairs. Periodic inspection of the Dam and fishway by qualified engineering personnel is also included. Overall, the annual average of these costs is estimated as follows:

General Maintenance Cost (annual average): $7,000

Future Capital Investment

Option C should consider a variety of future capital investments associated with the proposed structures. Similar to Options A and B, there are a variety of costs that may be required associated with dam repair and repair to the proposed fishway structures. Overall the future capital investment at the site is anticipated to be as follows:

Future Capital Investment (repair of fishway): $150,000 (in approximately 50 years)

Fifty-year Cost Estimate

Each of the costs noted above have been combined over the next fifty-year period to provide a single anticipated cost for each option. The anticipated fifty-year cost estimate is as follows:

Option C – Fifty-year Cost Estimate: $1,420,000 to $1,760,000

8.5 COST SUMMARY OF OPTIONS A THRU C

The following table has been provided as a summary of the cost associated with Options A thru C. As shown, the table provides a breakdown of associated costs over time.

TABLE 8.2 - COST SUMMARY TABLE

Option	Initial Capital Investment	Additional Investment Years (1 to 10)	Additional Investment Years (11 to 20)	Additional Investment (Years 21 to 50)	Total 50-year Estimate
Option A	$440,000	$240,000	$110,000	$255,000	$1,045,000
Option B	$610,000	$15,000	$15,000	$95,000	$735,000
Option C	$920,000 to $1,260,000	$70,000	$70,000	$360,000	$1,420,000 to $1,760,000

8.6 FIREFIGHTING WATER SUPPLY IMPROVEMENTS

Some of the fish passage improvements may require adjustments to existing firefighting water supply sites or development of new sites. Table 8.1 outlines the associated costs to develop the sites identified in Section 6 of this report. It should be noted that these costs may vary based upon further coordination with the Town of Bristol Fire Department. A cost breakdown of each individual location can be found in Appendix N of this report.

TABLE 8.3

FIREFIGHTING WATER SUPPLY SITE MODIFICATION/DEVELOPMENT

Site	Total Estimated construction cost
Site P1 – Bristol Road	$86,400.00
Site P2 – Partridge Bridge	$77,400.00
Site P3 – Split Rock Road	$94,200.00
Site P4 – Upper Round Pond Road	$55,200.00
Site P5 – Lower Round Pond Road	$58,200.00

Site P6 – Carl Bailey Road	$58,200.00
Site P7 – Transfer Road	$634,800.00
Site P8A* – Improvements to the Ellingwood Park Boat Launch	$71,400.00
Site P8B* - Additional Improvement in conjunction with Ellingwood Park Recreational Enhancements	$80,000.00

* The Ellingwood Park Boat Launch and Park have multiple options for firefighting water supply improvements. The cost associated with Site P8A is reflective of constructing improvements to the boat ramp area focused only on the firefighting water supply (as shown on the sketch in Appendix L). The cost associated with P8B is the additional incremental cost associated with fire water supply improvements shown on the recreational enhancement plans included in Appendix M.

SECTION 9

CONCLUSION

The Bristol Mills Dam, located in the Town of Bristol, represents a primary barrier to migratory fish traveling from the Atlantic Ocean, along the Pemaquid River, and up to the Pemaquid Chain of Lakes. While originally built for industrial mill purposes, the dam no longer serves any commercial or industrial uses. Currently, the dam's primary function is to manage water levels, provide recreational swimming opportunities and to supply firefighting water. A fishway is located at the existing dam site, however there are a variety of problems with its performance, which are limiting the passage of fish and aquatic organisms. Most specifically, the population of alewife in the Pemaquid ecosystem is being limited by the dam and fishway, as they are restricted from accessing upstream habitat areas.

There are three (3) improvement scenarios contemplated in this report (described in further detail in Section 5). Option A involves the reconstruction of a new fishway and repair to the existing dam. Option B involves replacement of the dam with a new "nature-like" fishway, as well as associated enhancements to recreation in Ellingwood Park and development of a new firefighting water supply. Option C seeks a compromise position that involves a smaller dam at the existing location to provide some preservation of the firefighting water supply and recreation use, while providing for fish passage with a variety of new nature-like structures and a section of denil fishway.

Section 8 provides an analysis of cost associated with each of these options, and other sections of the report describe a variety of other aspects related to the options associated with the river, impoundment, dam, as well as associated firefighting water supply alternatives and potential recreational enhancements. It seems that Option C is the most costly scenario by a substantial margin. Costs associated with Option A (Reconstruct the Denil Fishway and Repair the Dam) and Option B (Replace Dam with "Nature-like" Fishway and Water Level Control) are similar, however Option B is less expensive over a fifty-year period.

Prior to determining a path forward, the Town of Bristol should evaluate the associated benefits and drawbacks across each of the options related to fish passage, firefighting water supply, recreational use, and the natural resources of the greater Pemaquid ecosystem. Cost associated with each option is a significant factor, however the value of recreational opportunity, as well as the value of aquatic resources are priceless and will require careful consideration.

APPENDIX A

Site Location Map

Bristol Dam
Project Location

PROJ NO:	DATE:
12965B	Oct 2017

WRIGHT-PIERCE
Engineering a Better Environment

FIGURE: 1

clm W:\GIS_Development\Projects\ME\Bristol\12965B_BristolDamFeasibility\MXDs\Figure1_Aerial_Loc_8x11.mxd

APPENDIX B

Fishway Design Plans

TOWN OF BRISTOL

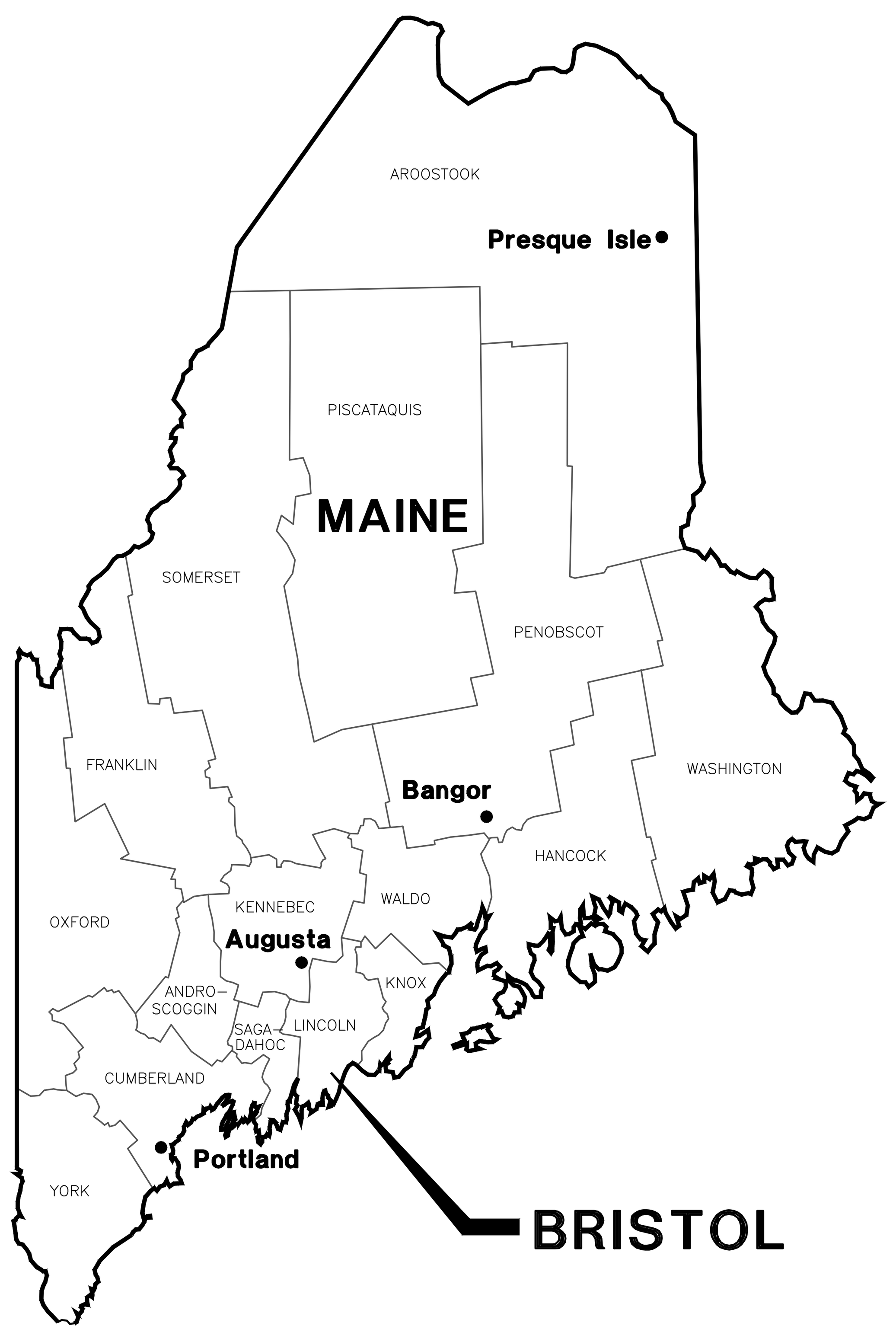
PERMIT DRAWINGS FOR

BRISTOL MILLS FISHWAY IMPROVEMENTS

BRISTOL, MAINE

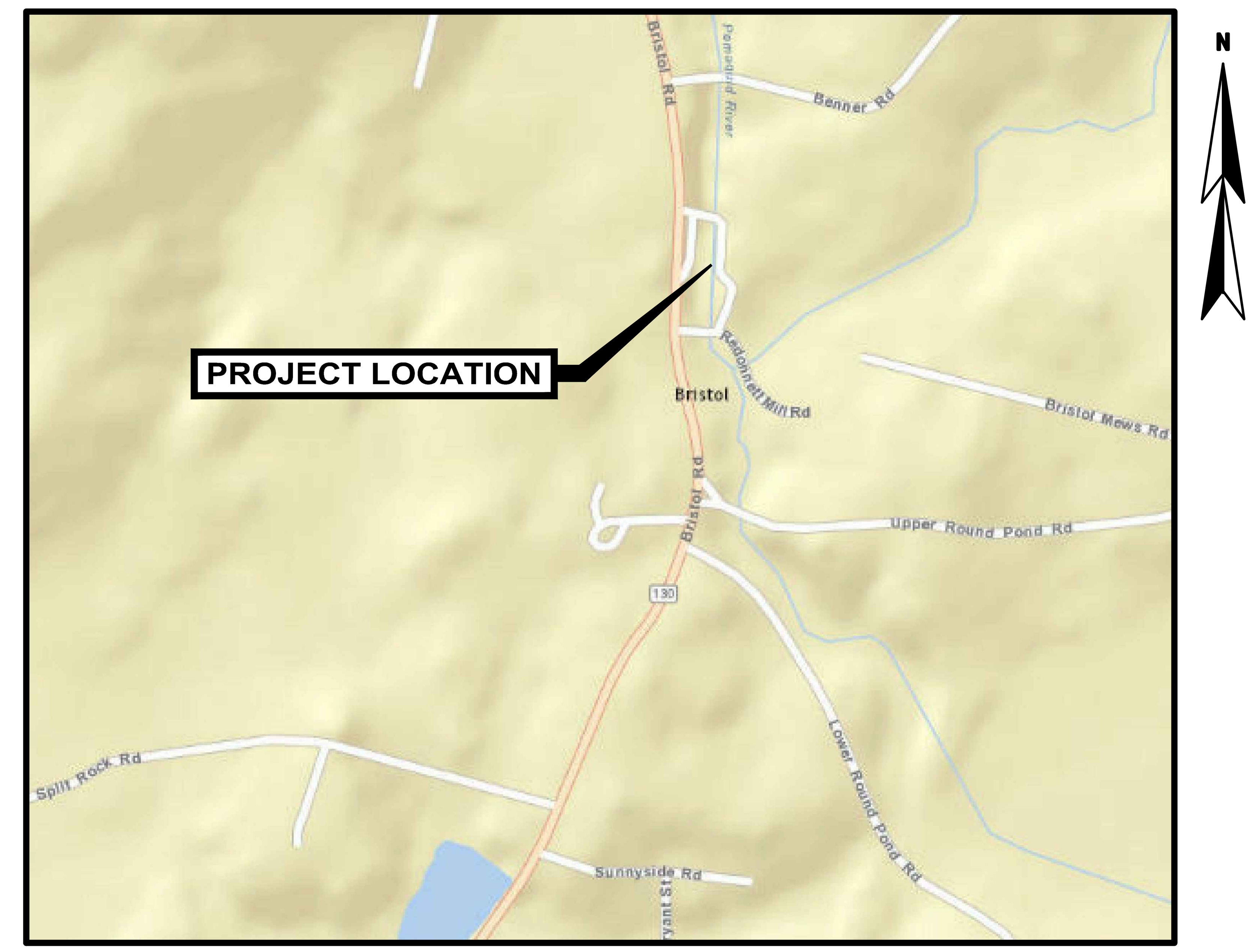
MAY 2015

FOR PERMITTING PURPOSES ONLY



DRAWING INDEX

DRAWING	TITLE
–	COVER SHEET
C–1	GENERAL NOTES, LEGEND & ABBREVIATIONS
C–2	EXISTING CONDITIONS & DEMOLITION PLAN
C–3	PROPOSED SITE PLAN
C–4	PROPOSED FISHWAY PROFILE & DETAILS I
C–5	PROPOSED FISHWAY SECTIONS I
C–6	PROPOSED FISHWAY SECTIONS II & DETAILS II
C–7	EROSION CONTROL NOTES & DETAILS



LOCATION PLAN
SCALE: NTS

WRIGHT-PIERCE
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WP PROJECT NO. 12965A

GENERAL NOTES

1. THE CONTRACTOR IS REFERRED TO SECTION 01050 OF THE SPECIFICATIONS REGARDING COORDINATION WITH OTHERS, INCLUDING RESPONSIBILITIES AND RELATED COSTS.

2. IF APPLICABLE, BELOW GRADE UTILITY INFORMATION IS BASED ON INFORMATION PROVIDED BY EACH UTILITY. LOCATION OF PUBLIC UTILITIES, IF SHOWN, IS ONLY APPROXIMATE AND MAY NOT BE COMPLETE. PRIVATE UNDERGROUND UTILITIES SUCH AS, BUT NOT LIMITED TO, SEWER LINES, WELLS, WATER LINES AND BURIED ELECTRICAL SERVICE ENTRANCES ARE NOT SHOWN. THE CONTRACTOR SHALL ASCERTAIN THE LOCATION AND SIZE OF EXISTING UTILITIES IN THE FIELD WITH THE RESPECTIVE UTILITY COMPANY REPRESENTATIVE AND LOCAL RESIDENTS PRIOR TO COMMENCING WORK. REFER TO SPECIFICATION SECTION 01050. ADDITIONAL TEST PITS, BEYOND THOSE SHOWN, MAY BE REQUIRED.

   FIRE DEPARTMENT
   BRISTOL FIRE AND RESCUE
   FIRE CHIEF – PAUL LEEMAN, JR.
   TEL. 207-592-5531

3. DO NOT SCALE DRAWINGS UNLESS OTHERWISE NOTED. WRITTEN DIMENSIONS AND STATIONING SHALL PREVAIL. SURVEY COMPLETED BY WRIGHT-PIERCE.

4. THE OWNER WILL BE RESPONSIBLE FOR OBTAINING THE PERMITS LISTED IN THE SUPPLEMENTARY OR SPECIAL CONDITIONS. IT IS THE RESPONSIBILITY OF THE CONTRACTOR TO BE FAMILIAR WITH THE APPLICABLE PROVISIONS OF EACH PERMIT AS THEY APPLY TO THE WORK PRIOR TO BIDDING AND ABIDE BY THOSE PROVISIONS DURING CONSTRUCTION. ALL OTHER PERMITS ARE THE RESPONSIBILITY OF THE CONTRACTOR.

5. IN THOSE INSTANCES WHERE POWER OR TELEPHONE POLE SUPPORT IS REQUIRED, THE CONTRACTOR SHALL PROVIDE A MINIMUM 48-HOUR NOTIFICATION TO UTILITY COMPANIES. NO ADDITIONAL PAYMENT WILL BE PROVIDED FOR TEMPORARY BRACING OF UTILITIES.

6. THE OWNER SHALL BE RESPONSIBLE FOR OBTAINING ALL NECESSARY RIGHTS OF WAY AND EASEMENTS. THE CONTRACTOR SHALL VERIFY THAT THE NECESSARY EASEMENTS HAVE BEEN SECURED BY THE OWNER. IT IS THE RESPONSIBILITY OF THE CONTRACTOR TO BE FAMILIAR WITH THE APPLICABLE PROVISIONS OF EACH EASEMENT AS THEY APPLY TO THE WORK PRIOR TO BIDDING AND ABIDE BY THOSE PROVISIONS DURING CONSTRUCTION.

7. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE LAYOUT OF ALL PROPOSED LINES AND STRUCTURES AS SHOWN ON THE DRAWINGS. THE LAYOUT PLAN SHALL BE REVIEWED BY THE ENGINEER PRIOR TO CONSTRUCTION.

8. CONTRACTOR SHALL MINIMIZE CLEARING OPERATIONS. CLEARING AND GRUBBING SHALL BE IN ACCORDANCE WITH SPECIFICATION SECTION 02110. CLEARING LIMITS SHALL BE AS INDICATED ON THE DRAWINGS, BUT AT ALL TIMES WITHIN EXISTING PROPERTY LINES OR EASEMENTS. ALL GRUBBINGS AND EXCESS EXCAVATED MATERIAL WILL BE DISPOSED OF AT A SITE PROVIDED BY THE CONTRACTOR IN COMPLIANCE WITH ALL STATE AND LOCAL LAWS.

9. CONTRACTOR SHALL CONTROL DUST TO A TOLERABLE LIMIT AS OUTLINED IN SPECIFICATION SECTION 01562. CONTRACTOR SHALL NOT TRACK OR SPILL EARTH AND DEBRIS ON PUBLIC STREETS OUTSIDE THE PROJECT AREA. STREETS OPENED TO THE PUBLIC SHALL BE KEPT SWEPT AND FREE OF DEBRIS.

10. THE CONTRACTOR SHALL BE RESPONSIBLE FOR RESETTING ALL EXISTING PROPERTY MONUMENTATION THAT IS DISTURBED BY HIS OPERATIONS AT NO EXPENSE TO THE OWNER. THIS WORK IS TO BE DONE BY A LAND SURVEYOR REGISTERED IN THE STATE OF MAINE.

11. THE CONTRACTOR SHALL COMPLY WITH ALL APPLICABLE REGULATIONS OF THE OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA).

12. THE CONTRACTOR SHALL NOT HAVE ANY RIGHT OF PROPERTY IN ANY MATERIALS TAKEN FROM ANY EXCAVATION. SUITABLE EXCAVATED MATERIAL MAY BE INCORPORATED IN THE PROJECT, WITH EXCESS MATERIAL DISPOSED OF AT A LOCATION PROVIDED BY THE CONTRACTOR. THESE PROVISIONS SHALL IN NO WAY RELIEVE THE CONTRACTOR OF HIS OBLIGATIONS TO PROPERLY DISPOSE OF AND REPLACE ANY MATERIAL DETERMINED BY THE ENGINEER TO BE UNSUITABLE FOR BACKFILLING. THE CONTRACTOR SHALL DISPOSE OF UNSUITABLE AND EXCESS MATERIAL IN ACCORDANCE WITH THE APPLICABLE SECTIONS OF THE CONTRACT DOCUMENTS.

12. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE PREVENTION OF EROSION AND WATERBORNE TURBIDITY. ALL DISTURBED EARTH SURFACES ARE TO BE STABILIZED IN THE SHORTEST PRACTICAL TIME AND TEMPORARY EROSION CONTROL DEVICES SHALL BE EMPLOYED UNTIL SUCH TIME AS ADEQUATE SOIL STABILIZATION HAS BEEN ACHIEVED. TEMPORARY STORAGE OF EXCAVATED MATERIAL IS TO BE IN A MANNER THAT WILL MINIMIZE EROSION. THE CONTRACTOR SHALL DISPOSE OF UNSUITABLE EXCAVATED MATERIAL AT A SITE PROVIDED BY HIM WHICH IS IN COMPLIANCE WITH ALL STATE AND LOCAL LAWS. MATERIALS AND METHODS USED FOR TEMPORARY EROSION CONTROL SHALL BE AS SPECIFIED BY THE "MAINE EROSION AND SEDIMENT CONTROL HANDBOOK FOR CONSTRUCTION: BEST MANAGEMENT PRACTICES" PREPARED BY THE MAINE SOIL AND WATER CONSERVATION COMMISSION. REFER TO SPECIFICATION SECTION 02270.

CIVIL DEMOLITION NOTES

1. REFER TO THE EXISTING SITE PLAN, DRAWING C-2, FOR ADDITIONAL INFORMATION REGARDING EXISTING FACILITIES. REFER TO DRAWING C-2 FOR LIMITS OF WORK.

3. REFER TO SPECIFICATION SECTION 01010, WHICH CONTAINS INFORMATION ON CONSTRAINTS OF CONSTRUCTION SEQUENCING.

4. THE CONTRACTOR SHALL BE RESPONSIBLE FOR REMOVING AND DISPOSING OF ALL DEMOLISHED, EQUIPMENT AND MATERIALS. DISPOSAL SHALL BE IN ACCORDANCE WITH ALL STATE AND LOCAL REGULATIONS. THE OWNER RESERVES THE RIGHT TO RETAIN ANY SUCH EQUIPMENT AND MATERIALS DESIGNATED FOR DEMOLITION FOR HIS USE. SUCH MATERIALS TO BE RETAINED SHALL BE PROPERLY STORED IN AN ON-SITE LOCATION. COORDINATE LOCATION AND MATERIALS TO BE SALVAGED WITH THE OWNER/ENGINEER.

5. THE CONTRACTOR SHALL KEEP A RECORD OF DEMOLITION AS PART OF THE PROJECT RECORD DOCUMENTS IN ACCORDANCE WITH SPECIFICATION SECTION 01720.

6. CONTRACTOR IS REFERRED TO SPECIFICATION SECTION 01050 FOR COORDINATION WITH OTHERS.

7. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE APPROPRIATE TREATMENT OF FLOWS RESULTING FROM PRECIPITATION AND HIS DEWATERING OPERATIONS.

SITE GRADING NOTES

1. STRIPPING OF TOPSOIL (LOAM) SHALL BE IN ACCORDANCE WITH SPECIFICATION SECTION 02115. REFER TO DRAWING C-2, FOR LIMIT OF WORK AND STRIPPING.

2. ALL AREAS THAT ARE EXCAVATED, FILLED, OR OTHERWISE DISTURBED BY THE CONTRACTOR SHALL BE LOAMED, GRADED, LIMED, FERTILIZED, SEEDED AND MULCHED, UNLESS OTHERWISE NOTED. THE TOP 4 INCHES OF SOIL SHALL BE LOAM. REFER TO SPECIFICATION SECTION 02480, LANDSCAPING/LOAM AND SEED.

3. THE CONTRACTOR SHALL PROVIDE PROPER EROSION AND TURBIDITY CONTROL AND DRAINAGE MEASURES IN ALL AREAS OF WORK, AND CONFINE SOIL SEDIMENT TO WITHIN THE LIMITS OF EXCAVATION AND GRADING. PRIOR TO BEGINNING EXCAVATION WORK, EROSION CONTROL FENCE SHALL BE INSTALLED AT THE DOWN GRADIENT PERIMETER OF THE ACTUAL LIMITS OF GRUBBING AND/OR GRADING, AND AS SHOWN ON THE DRAWINGS. EROSION CONTROL MEASURES SHOWN ON THE DRAWINGS ARE A MINIMUM, CONTRACTOR SHALL TAKE ALL OTHER NECESSARY MEASURES. EROSION CONTROL FENCE SHALL ALSO BE INSTALLED AT THE DOWN GRADIENT PERIMETER OF THE TOPSOIL STOCKPILES. ALL DISTURBED EARTH SURFACES SHALL BE STABILIZED IN THE SHORTEST PRACTICAL TIME AND TEMPORARY EROSION CONTROL DEVICES AND/OR TURBIDITY CURTAINS SHALL BE EMPLOYED UNTIL SUCH TIME AS ADEQUATE SOIL STABILIZATION HAS BEEN ACHIEVED. TEMPORARY STORAGE OF EXCAVATED MATERIAL SHALL BE STABILIZED IN A MANNER THAT WILL MINIMIZE EROSION. ALL INSTALLED EROSION CONTROL FACILITIES SHALL BE REMOVED AT THE END OF THE PROJECT. REFER TO SPECIFICATION SECTION 02270.

4. ALL ELEVATIONS REFER TO THE NATIONAL GEODETIC VERTICAL DATUM. ORIENTATION IS GRID NORTH MAINE STATE PLANE COORDINATE SYSTEM. PROJECT BENCH MARK WILL BE PROVIDED BY THE ENGINEER.

SITE LAYOUT NOTES

1. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE LAYOUT OF ALL PROPOSED WORK AS SHOWN ON THE DRAWINGS. THE ENGINEER WILL PROVIDE TWO POINTS THAT DEFINE THE HORIZONTAL CONTROL. THE CONTRACTOR SHALL BE RESPONSIBLE FOR MAINTAINING THIS PROVIDED LAYOUT INFORMATION THROUGHOUT THE COURSE OF CONSTRUCTION. REPORT ANY LAYOUT DISCREPANCIES IMMEDIATELY TO THE ENGINEER.

2. IN GENERAL, THE GIVEN STRUCTURE LOCATIONS ARE TO THE OUTSIDE FACE OF THE STRUCTURE FOUNDATION WALL, NOT FOOTINGS. REFER TO THE STRUCTURAL DRAWINGS FOR BUILDING AND STRUCTURE DIMENSIONS.

3. THE LOCATION AND LIMITS OF ALL ON-SITE WORK AND STORAGE AREAS SHALL BE REVIEWED/COORDINATED WITH, AND ACCEPTABLE TO, THE OWNER AND ENGINEER. THE CONTRACTOR SHALL LIMIT HIS ACTIVITIES TO THESE AREAS.

4. WRITTEN DIMENSIONS SHALL PREVAIL. DO NOT SCALE DISTANCES FROM THE DRAWINGS. REPORT ANY DISCREPANCIES IMMEDIATELY TO THE ENGINEER.

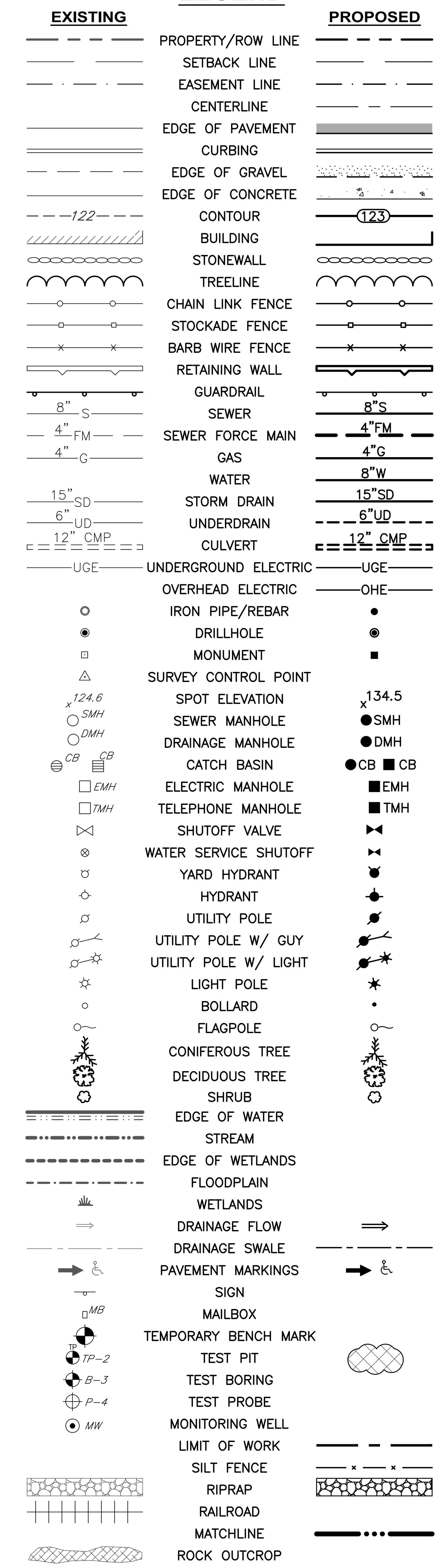
SURVEY NOTES:

HORIZONTAL COORDINATE SYSTEM; ASSUMED MAINE STATE PLANE, WEST ZONE, U.S. FOOT

VERTICAL DATUM: NAVD 88

EXISTING CONDTIONS SURVEY WAS COMPLETED BY WRIGHT-PIERCE.

LEGEND



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1	ISSUED FOR PERMITTING	JMM	5-15

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CAD: RPB
CHECKED BY: JMM
DATE: 5-12-15
APPROVED BY: JMM
DATE: 5-12-15
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TOWN OF BRISTOL
BRISTOL MILLS FISHWAY IMPROVEMENTS
BRISTOL, MAINE

GENERAL NOTES, LEGEND & ABBREVIATIONS

DRAWING
C-1

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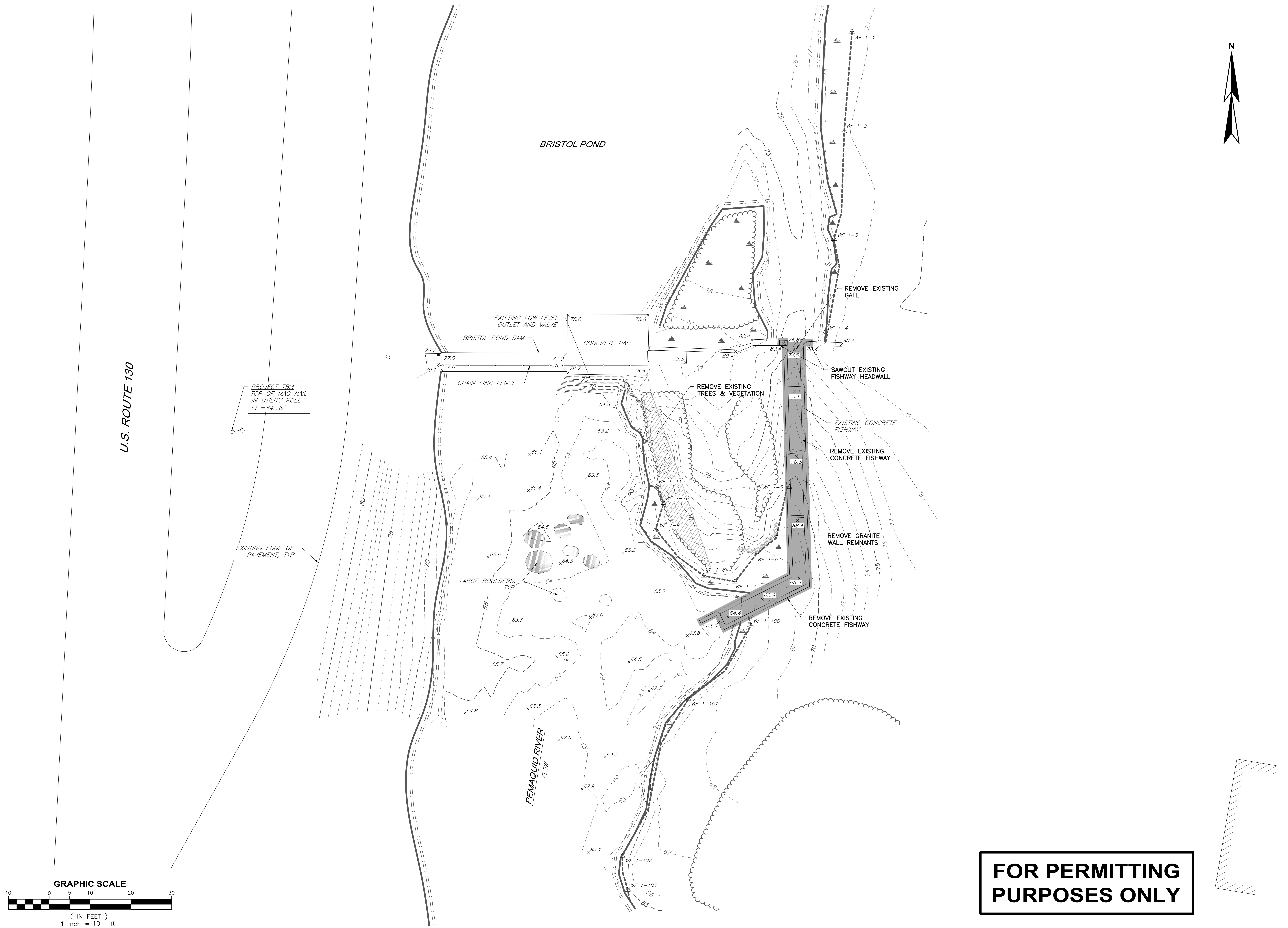

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TOWN OF BRISTOL
BRISTOL MILLS FISHWAY IMPROVEMENTS
BRISTOL, MAINE

EXISTING CONDITION & DEMOLITION PLAN

DRAWING
C-2

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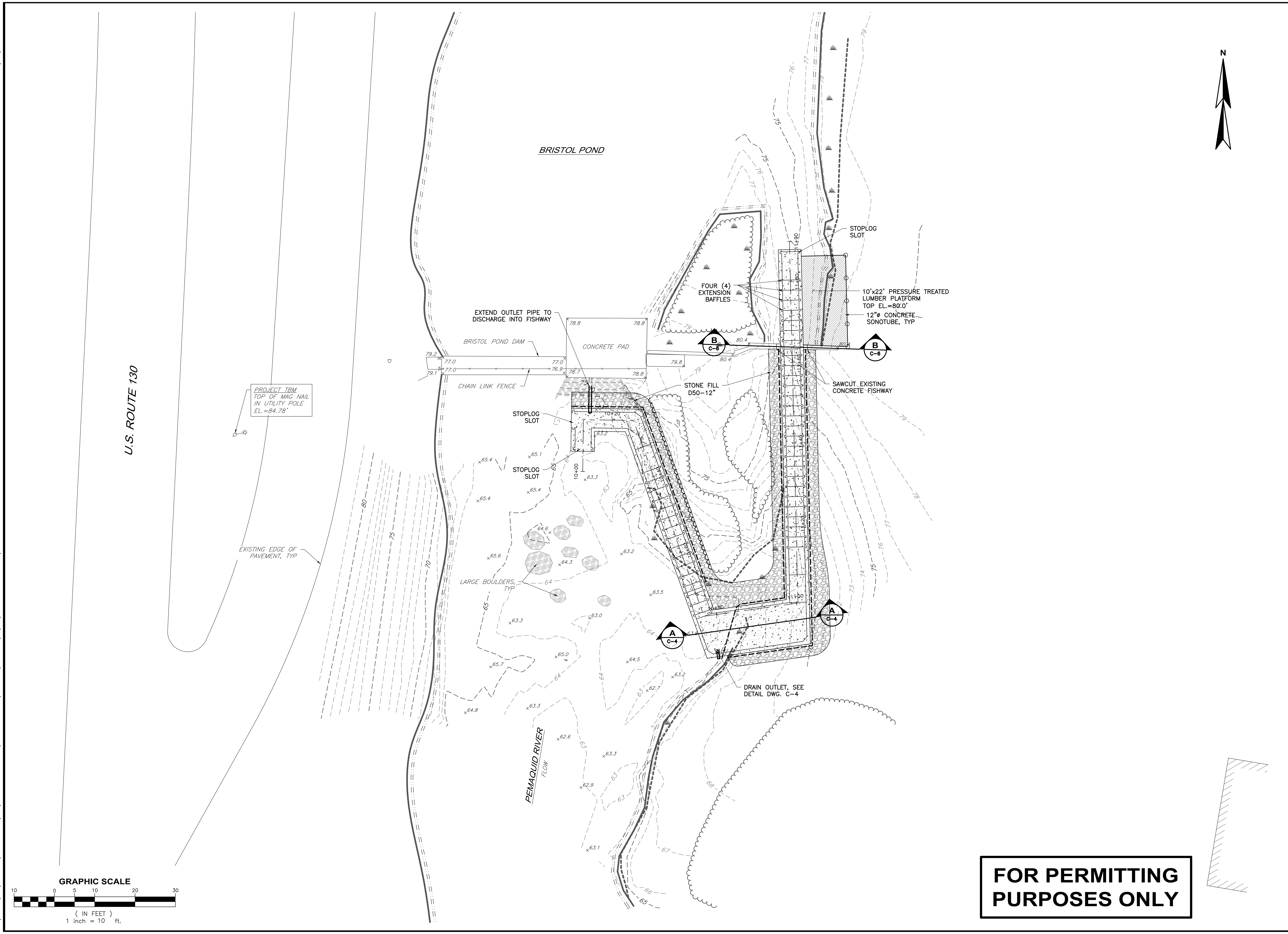

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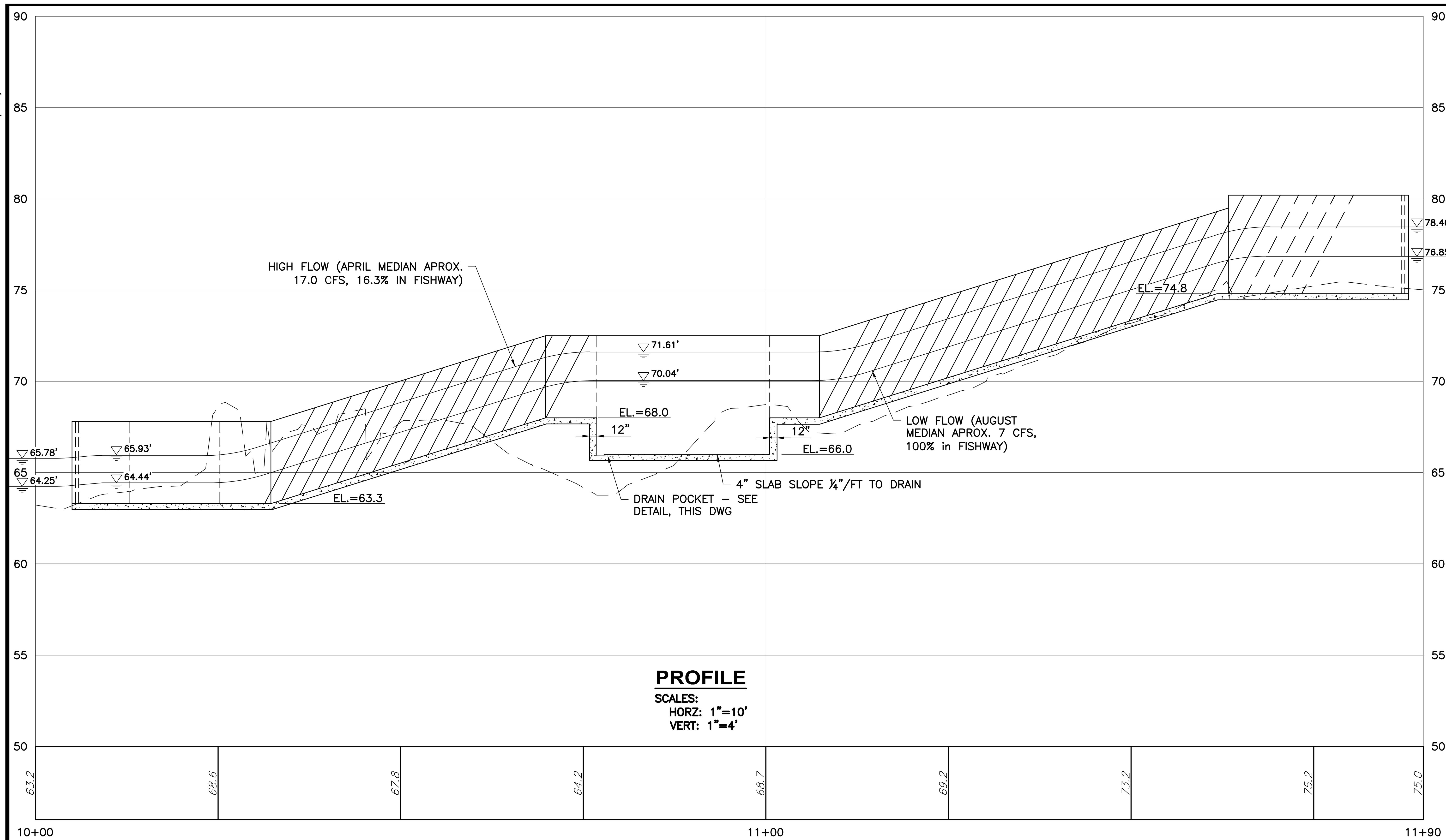
TOWN OF BRISTOL
BRISTOL MILLS FISHWAY IMPROVEMENTS
BRISTOL, MAINE

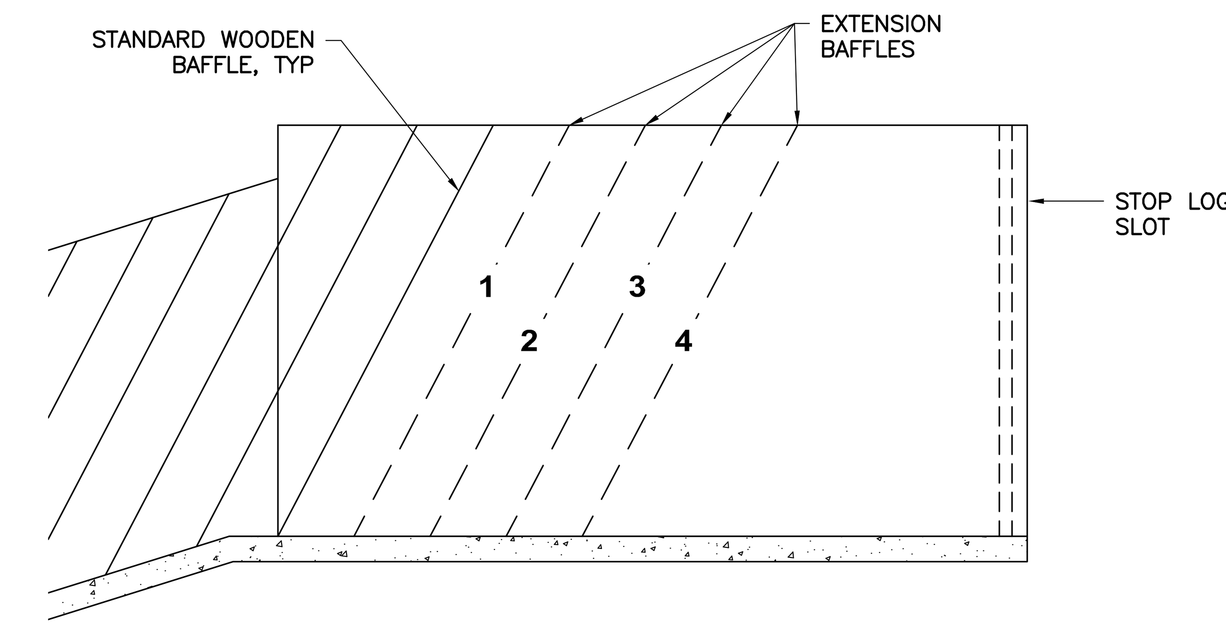
PROPOSED SITE PLAN

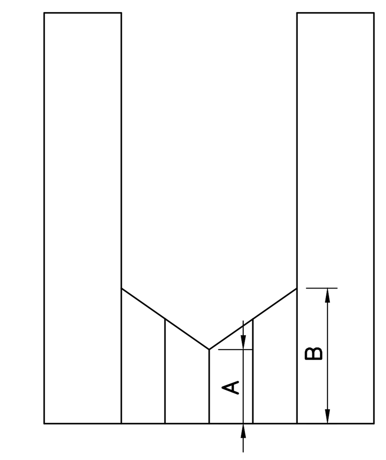
DRAWING
C-3



PROFILE

SCALES:
HORZ: 1"=10'
VERT: 1"=4'





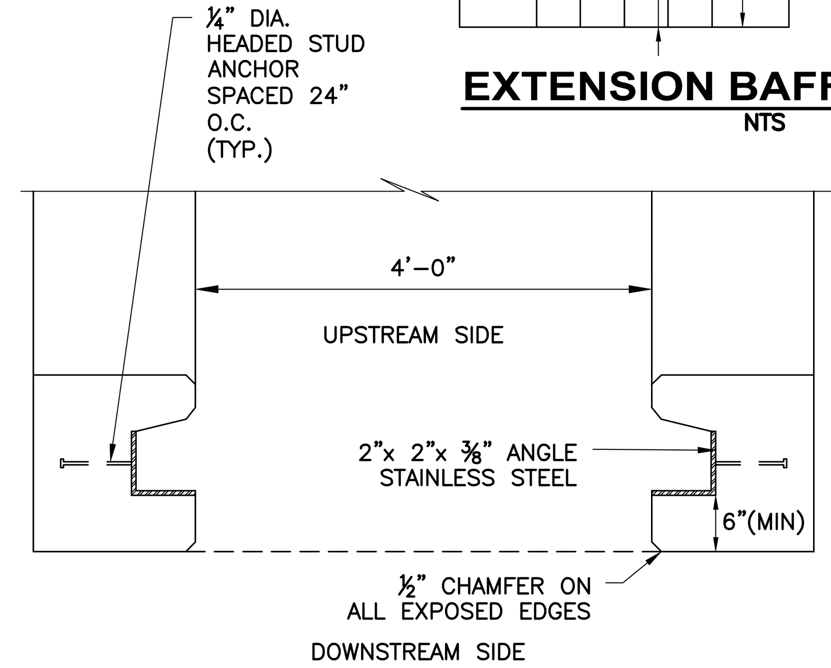
EXTENSION BAFFLE DIMENSIONS

	1	2	3	4
A	17.00"	22.50"	28.00"	33.50"
B	29.00"	34.50"	40.00"	45.50"

NOTE
1. EXTENSION BAFFLES SHALL HAVE THE SAME CONSTRUCTION AND DIMENSIONS AS STANDARD BAFFLES, WITH THE EXCEPTION OF DIMENSIONS A AND B IDENTIFIED IN THE TABLE ABOVE AND SHOWN ON THE ADJACENT DETAIL. ADDITIONAL 2x6 HORIZONTAL BRACING SHOULD BE ADDED.

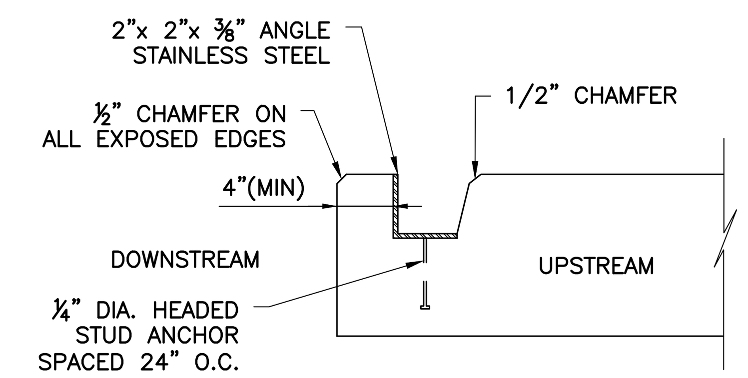
EXTENSION BAFFLE DETAIL

NTS



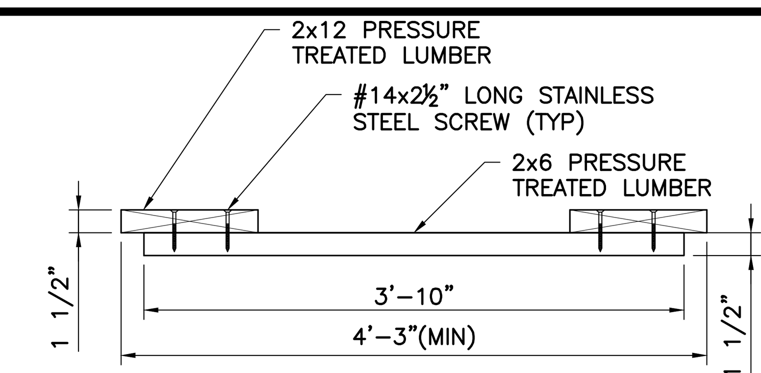
STOPLOG SLOT DETAIL

NTS



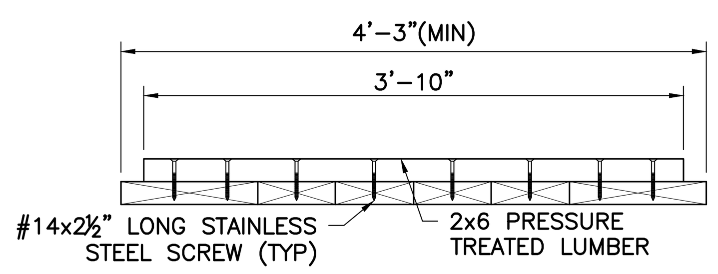
STOPLOG SLOT SECTION AT BOTTOM OF WEIR BOARD OPENING

NTS



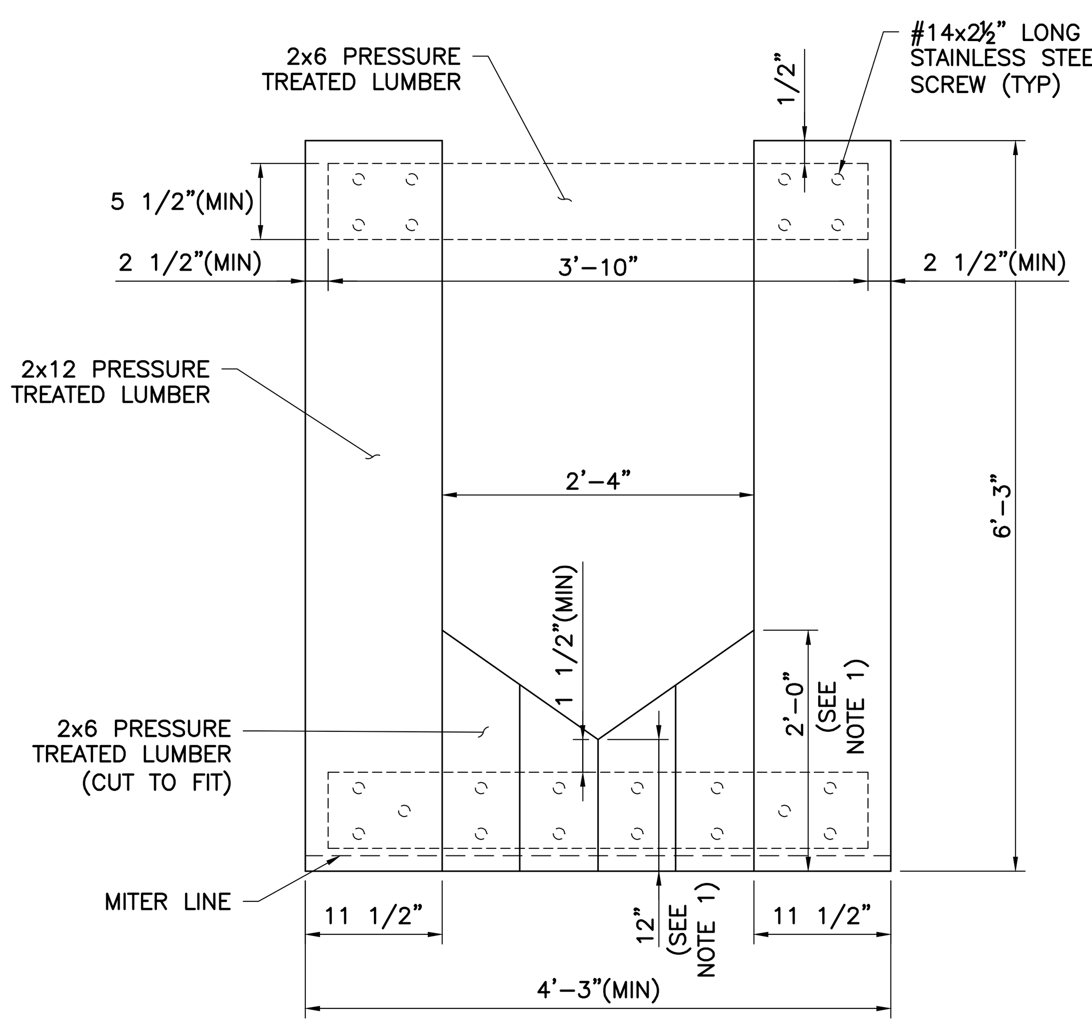
WOODEN BAFFLE SECTION A

NTS

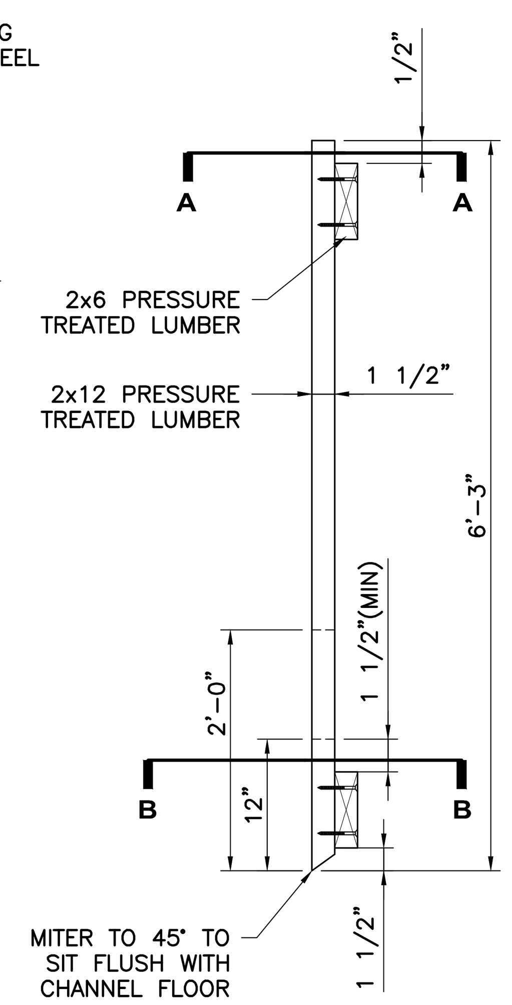


WOODEN BAFFLE SECTION B

NTS



PLAN

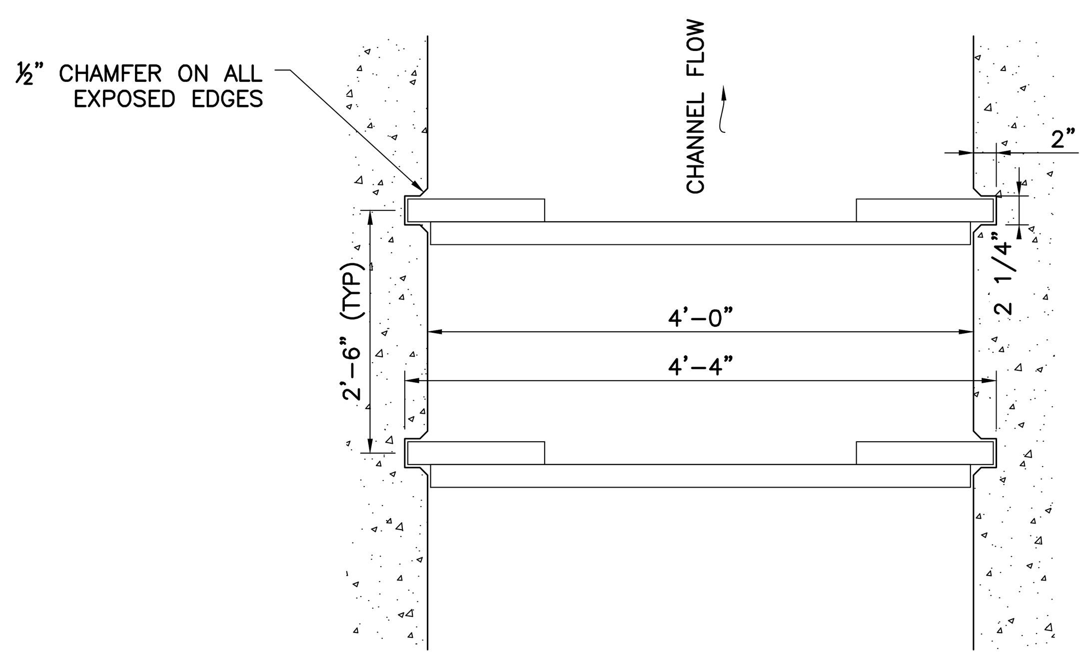


ELEVATION

NOTE
1. REFER TO PROFILE AND DETAIL FOR BAFFLE NOTCH DIMENSIONS OF EXTENSION BAFFLES

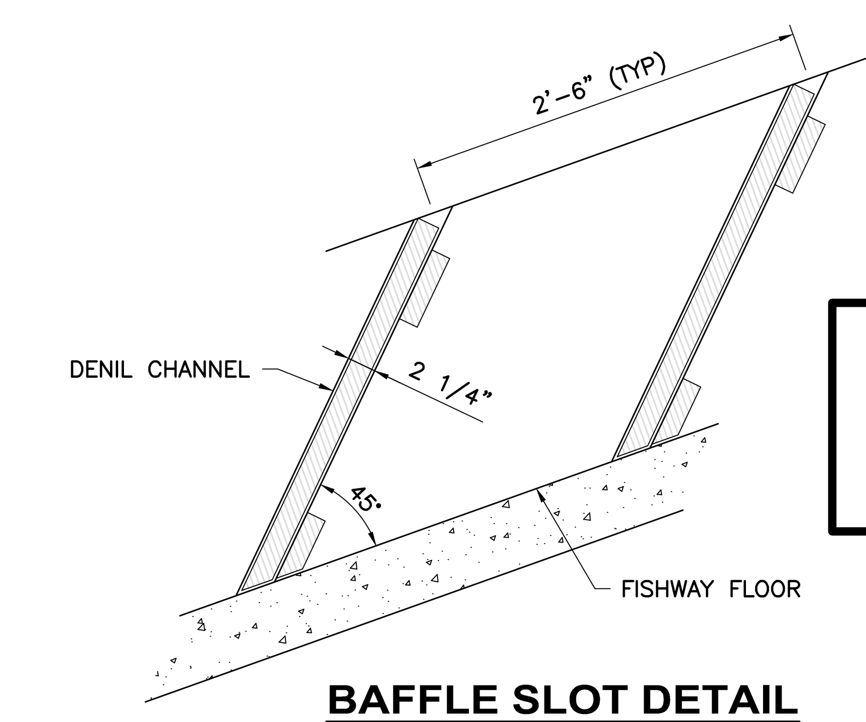
STANDARD WOODEN BAFFLE DETAIL

NTS



BAFFLE SLOT DETAIL

NTS



BAFFLE SLOT DETAIL

NTS

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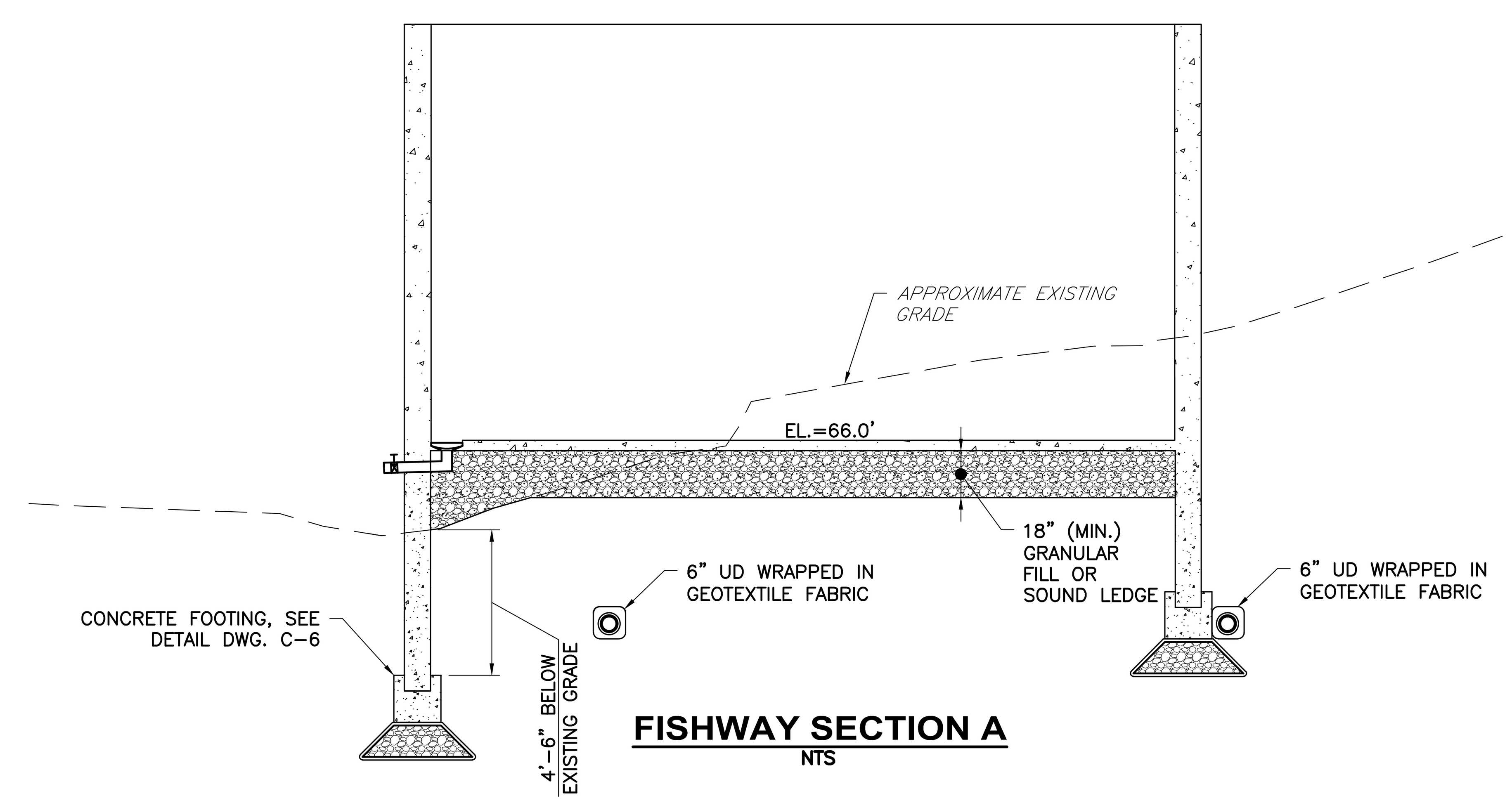
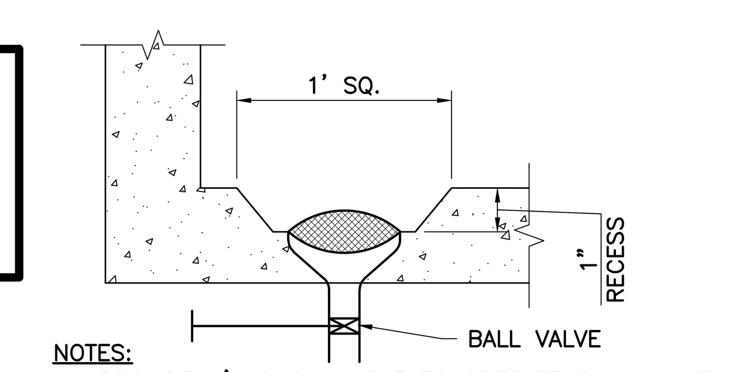


FISHWAY SECTION A

NTS



NOTES:
1. PROVIDE 4' LONG HANDLE TO OPERATE BALL VALVE.
2. CAST BALL VALVE DRAIN NIPPLE INTO THE FLOOR RECESS.

DRAIN POCKET DETAIL

NTS

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TOWN OF BRISTOL
BRISTOL MILLS FISHWAY IMPROVEMENTS
BRISTOL, MAINE

PROPOSED FISHWAY PROFILE & DETAILS I

DRAWING
C–4

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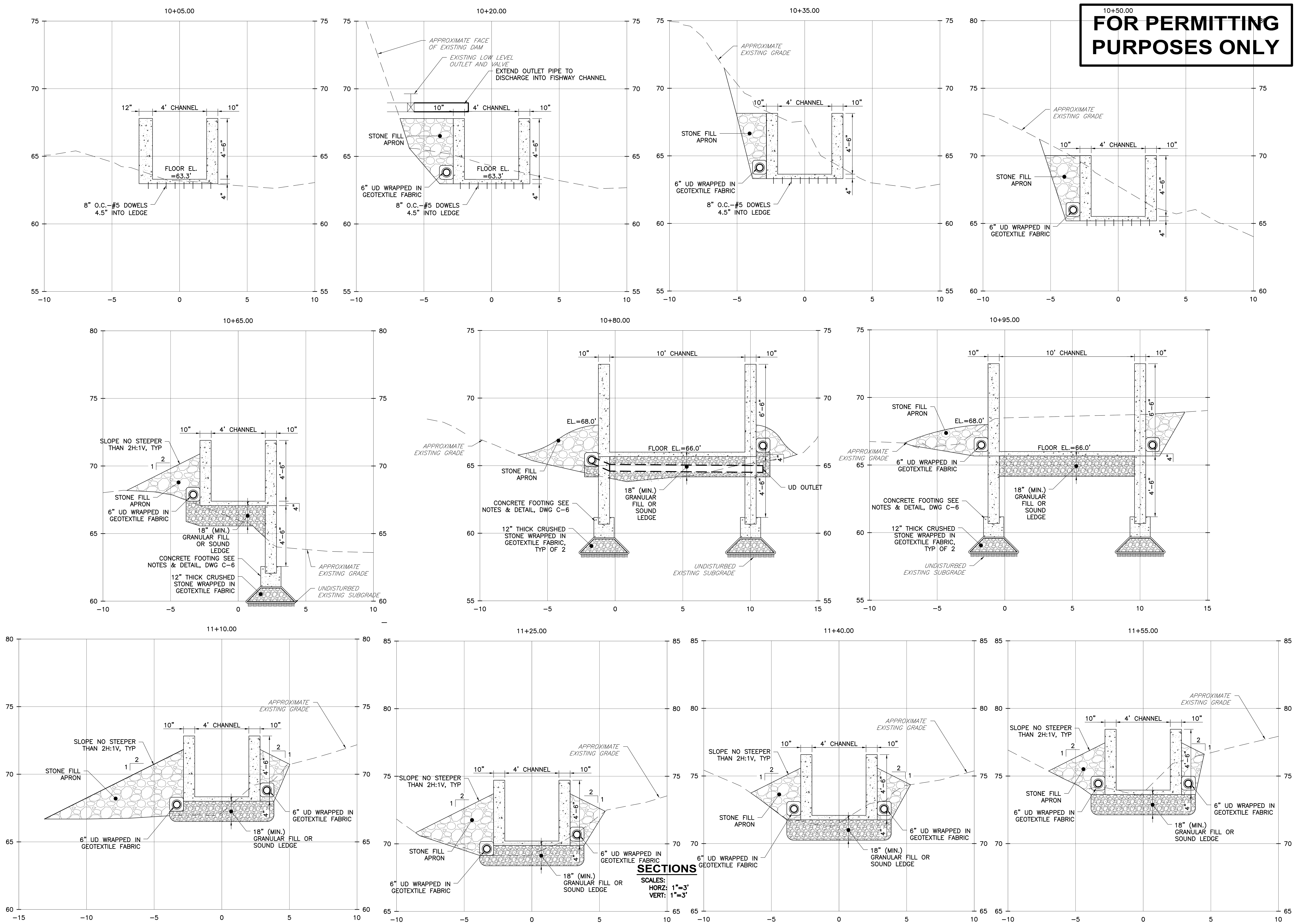

SECTIONS

SCALES:
HORZ: 1"=3'
VERT: 1"=3'

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BRISTOL, MAINE

PROPSED FISHWAY SECTIONS I

DRAWING
C-5

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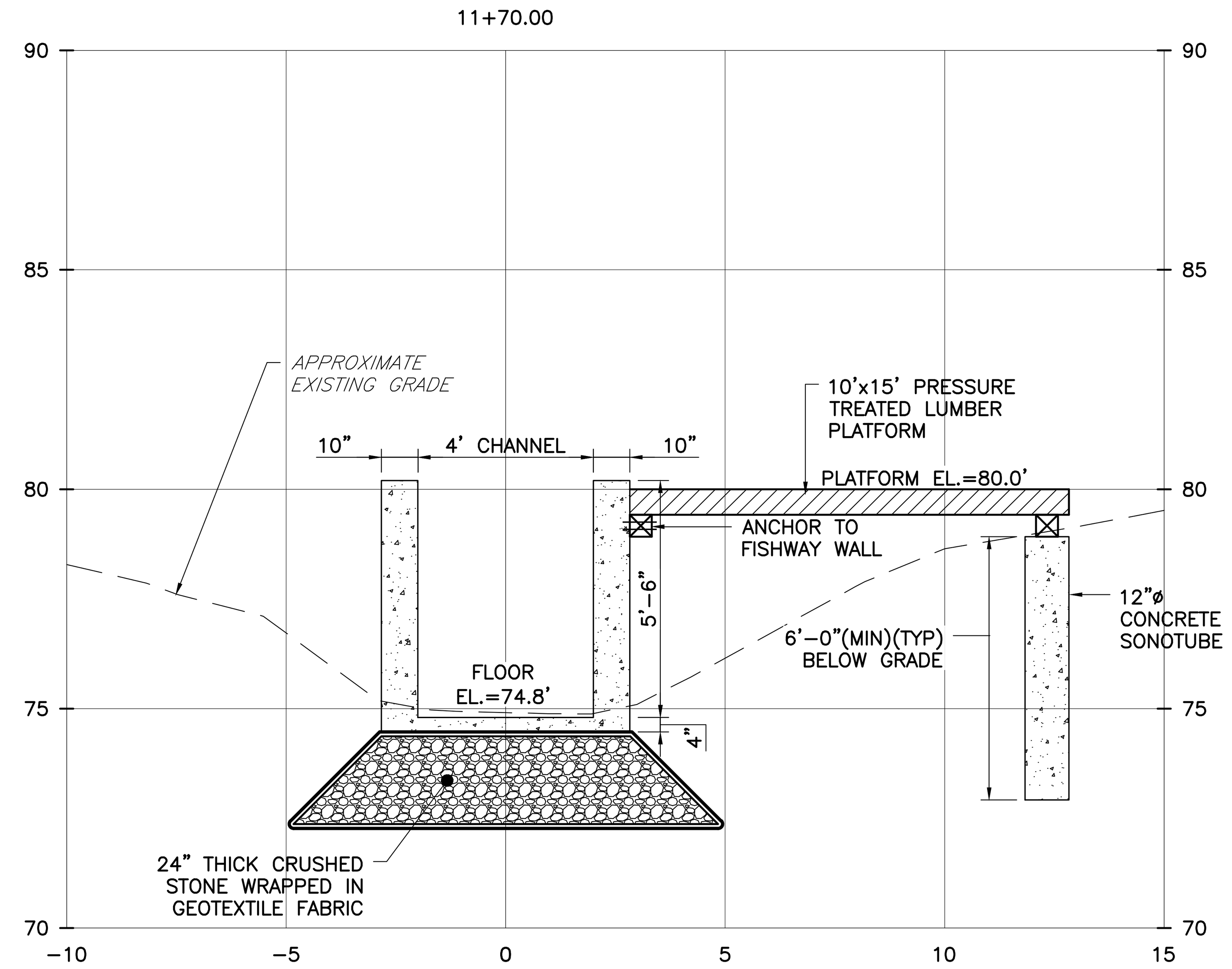
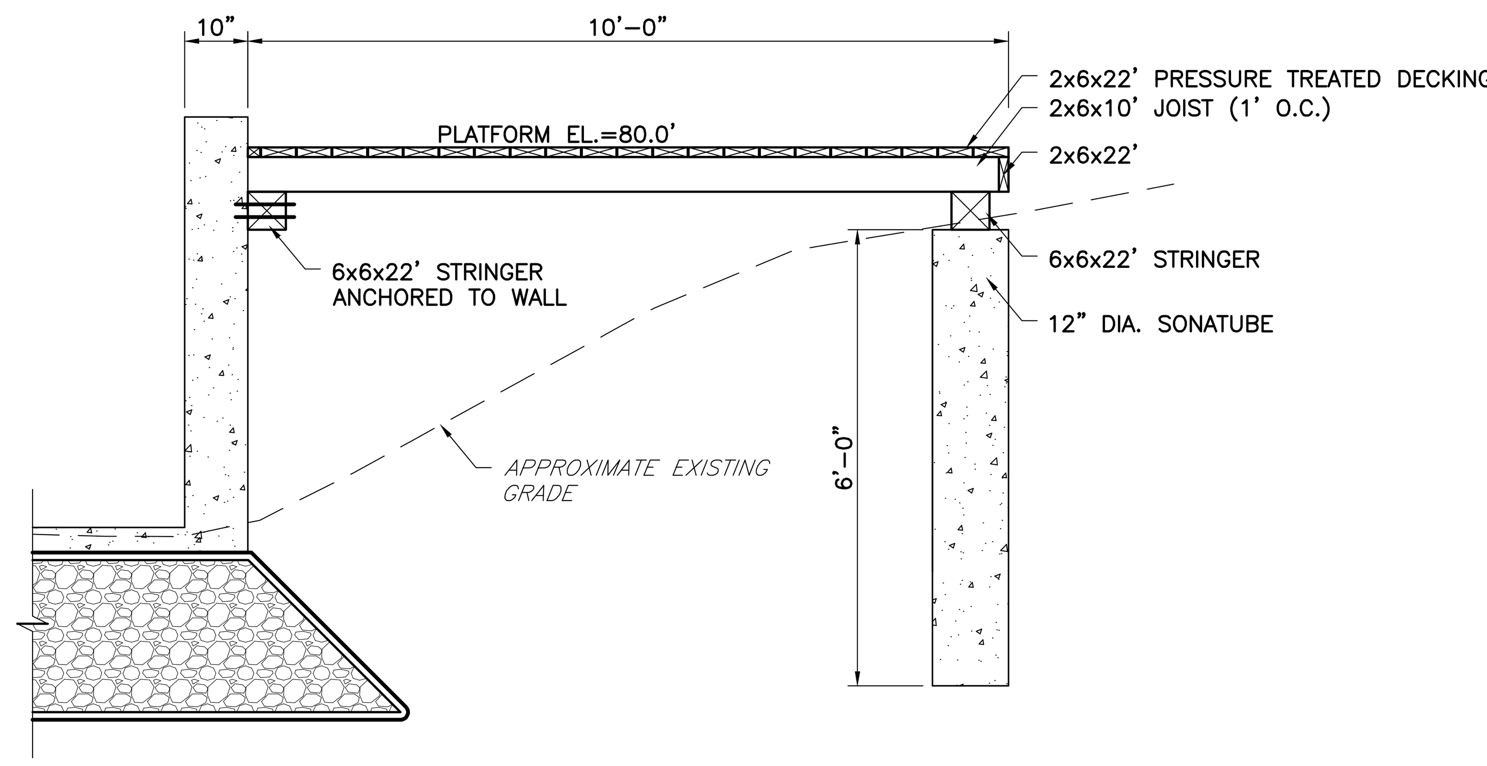


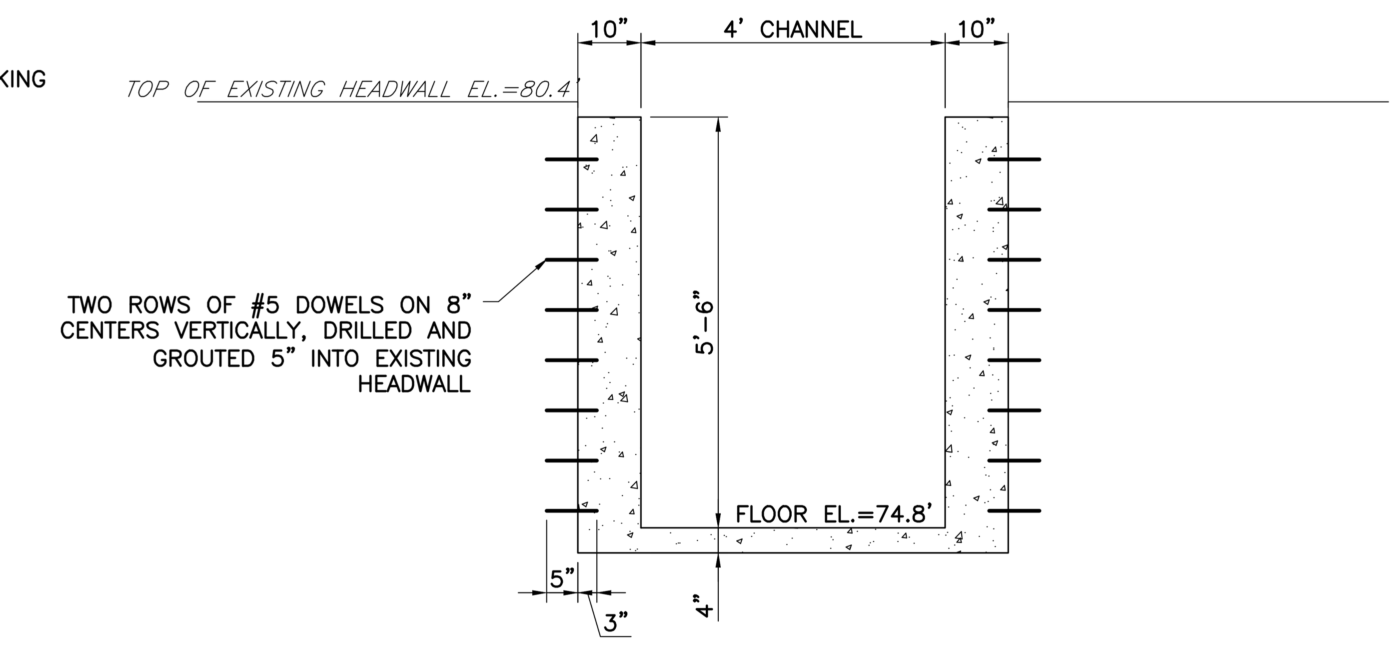
SECTION

SCALES:
HORZ: 1"=3'
VERT: 1"=3'



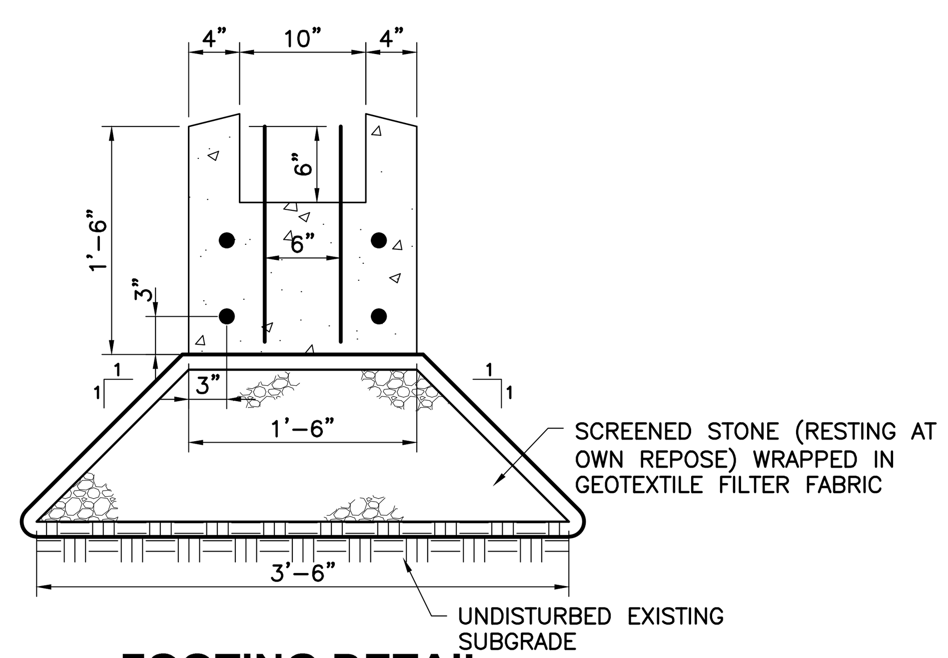
PLATFORM DETAIL

NTS



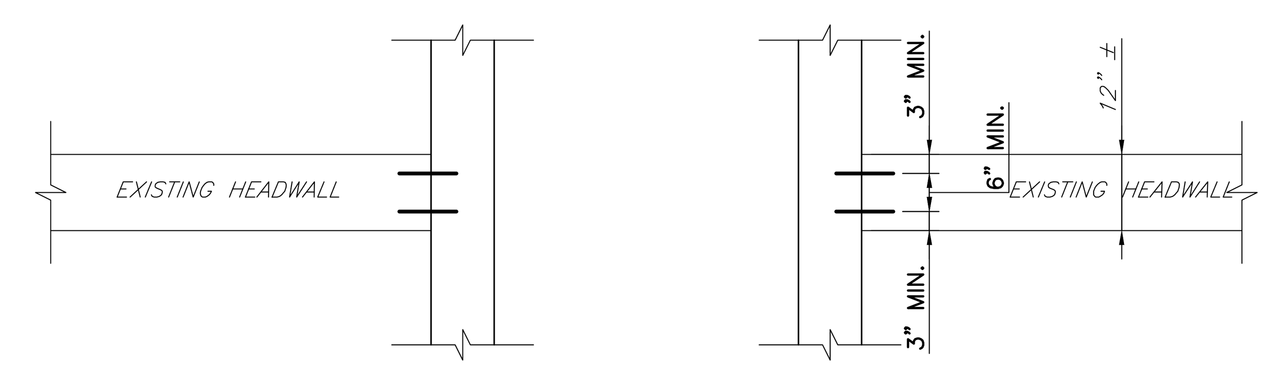
FISHWAY CONNECTION TO EXISTING HEADWALL SECTION B

NTS



FOOTING DETAIL

NTS

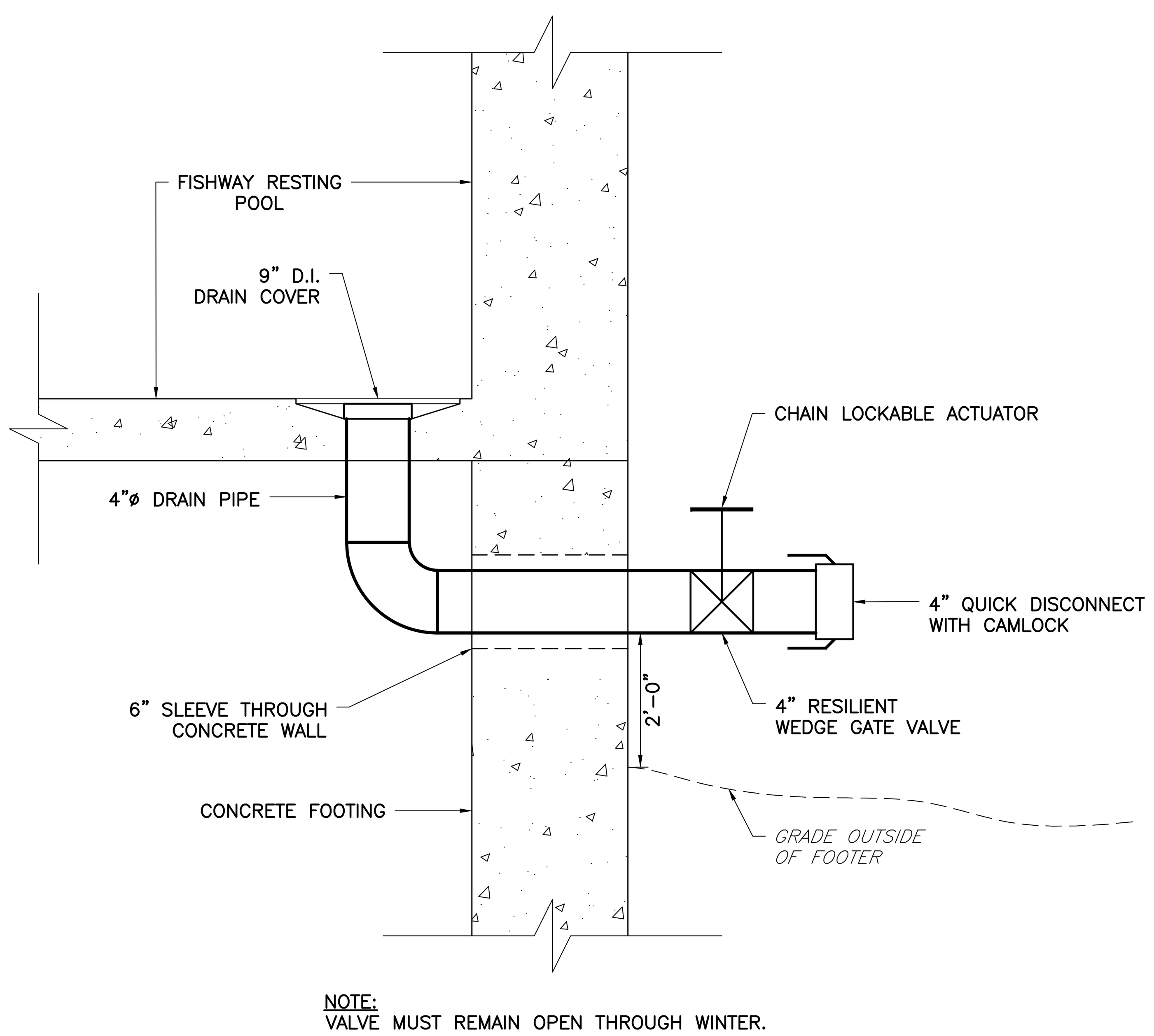


FISHWAY CONNECTION TO EXISTING HEADWALL PLAN

NTS

CONCRETE FOOTING NOTES:

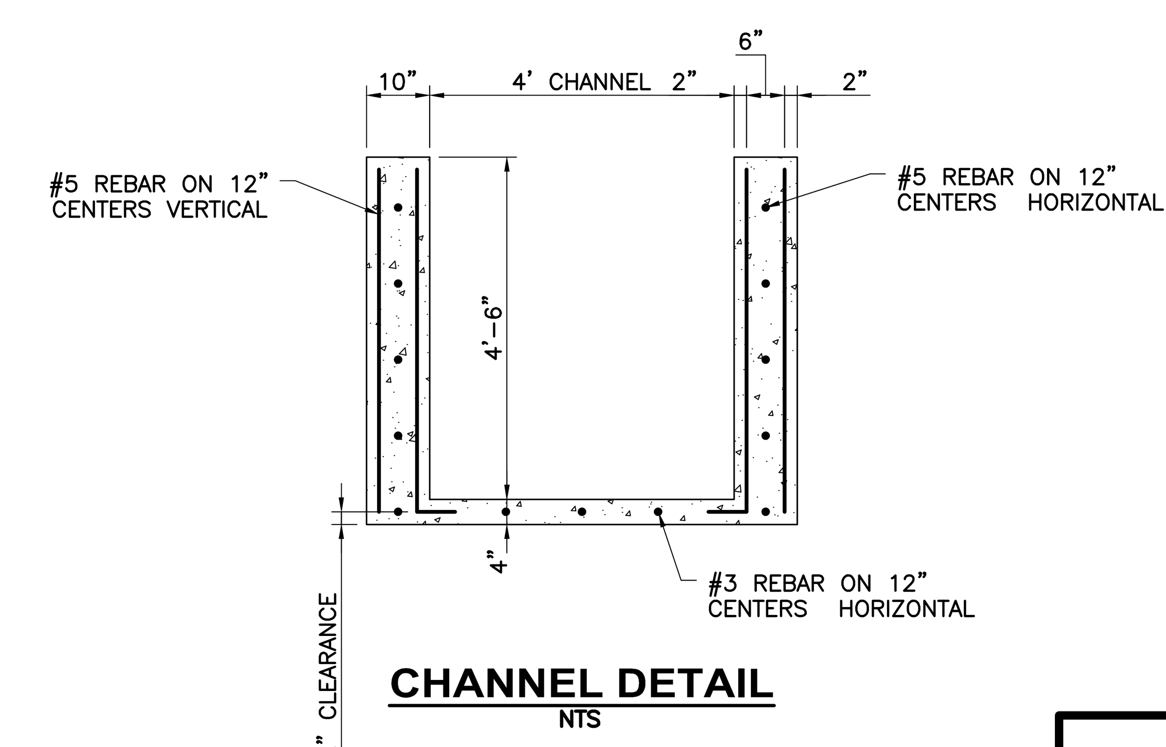
1. MAXIMIZE BEDROCK FOR FOOTING REPLACEMENT, DOWELING INTO AND CASTING ONTO CLEANED BEDROCK SURFACES.
2. WALL FOOTINGS ON CRUSHED STONE WRAPPED IN GEOTEXTILE FABRIC ARE SHOWN WHERE IT IS ANTICIPATED BEDROCK WILL NOT BE ENCOUNTERED, SHALLOW ENOUGH TO GET A MINIMUM FROST DEPTH OF 6'-0". WHEN BEDROCK IS ENCOUNTERED LESS THAN 6'-0" DEPTH, ADJUST WALL HEIGHT ACCORDINGLY.



NOTE:
VALVE MUST REMAIN OPEN THROUGH WINTER.

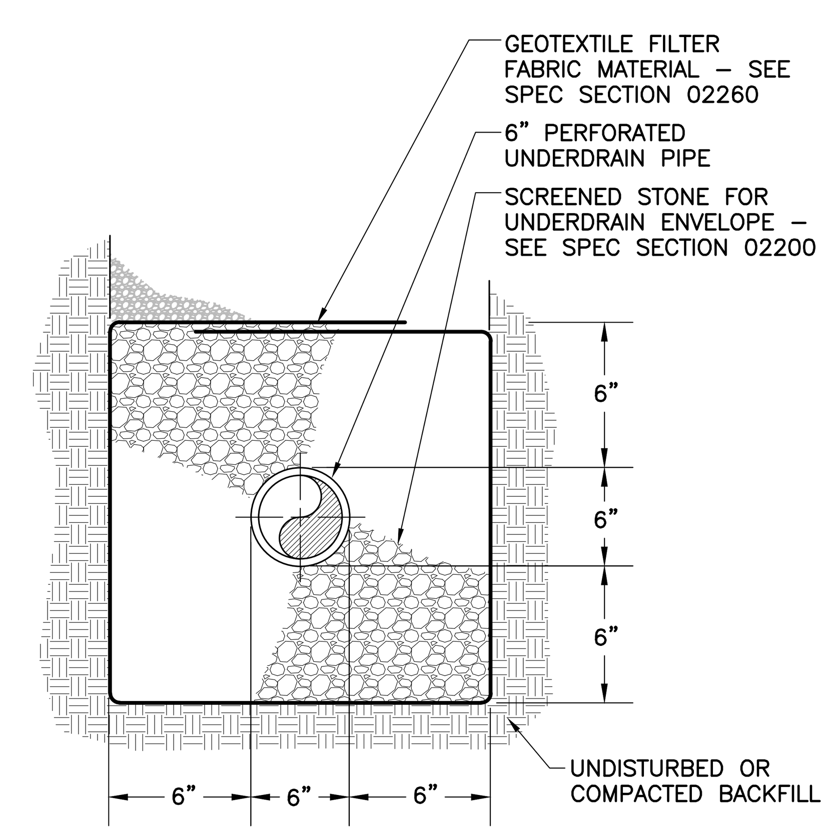
DRAIN PIPE DETAIL

NTS



CHANNEL DETAIL

NTS



6" UNDERDRAIN SECTION

NTS

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TOWN OF BRISTOL
BRISTOL MILLS FISHWAY IMPROVEMENTS
BRISTOL, MAINE

PROPOSED FISHWAY SECTIONS II & DETAILS II

DRAWING
C-6

EROSION AND SEDIMENTATION CONTROL NOTES

THIS PLAN HAS BEEN DEVELOPED AS A STRATEGY TO CONTROL SOIL EROSION AND SEDIMENTATION DURING AND AFTER CONSTRUCTION. THIS PLAN IS BASED ON THE STANDARDS AND SPECIFICATIONS FOR EROSION PREVENTION IN DEVELOPING AREAS AS CONTAINED IN THE "MAINE EROSION AND SEDIMENT CONTROL BEST MANAGEMENT PRACTICES", MAINE DEPARTMENT OF ENVIRONMENTAL PROTECTION DATED MARCH 2003.

THE PROPOSED LOCATIONS OF SILTATION AND EROSION CONTROL STRUCTURES ARE SHOWN ON THE SITE PLAN.

1. ALL SEDIMENT AND EROSION CONTROL MEASURES SHALL BE DONE IN ACCORDANCE WITH THE "MAINE EROSION AND SEDIMENT CONTROL BEST MANAGEMENT PRACTICES", MAINE DEPARTMENT OF ENVIRONMENTAL PROTECTION, DATED MARCH 2003.
2. THOSE AREAS UNDERGOING ACTUAL CONSTRUCTION WILL BE MAINTAINED IN AN UNTREATED OR UNVEGETATED CONDITION FOR THE MINIMUM TIME REQUIRED. IN GENERAL AREAS TO BE VEGETATED SHALL BE PERMANENTLY STABILIZED WITHIN 15 DAYS OF FINAL GRADING AND TEMPORARILY STABILIZED WITHIN 30 DAYS OF INITIAL DISTURBANCE OF THE SOIL.
3. SEDIMENT BARRIERS (SILT FENCE, STONE CHECK DAMS, ETC.) SHOULD BE INSTALLED PRIOR TO ANY SOIL DISTURBANCE OF UPGRADIENT DRAINAGE AREAS.
4. INSTALL SILT FENCE AT TOE OF SLOPES TO FILTER SILT FROM RUNOFF. SEE SILT FENCE DETAIL FOR PROPER INSTALLATION. SILT FENCE WILL REMAIN IN PLACE PER NOTE #5.
5. ALL EROSION CONTROL STRUCTURES WILL BE INSPECTED, REPLACED AND/OR REPAIRED EVERY 7 DAYS AND IMMEDIATELY FOLLOWING ANY SIGNIFICANT RAINFALL OR SNOW MELT OR WHEN NO LONGER SERVICEABLE DUE TO SEDIMENT ACCUMULATION OR DECOMPOSURE. SEDIMENT DEPOSITS MUST BE REMOVED WHEN THEY REACH APPROXIMATELY ONE HALF THE HEIGHT OF THE BARRIER. SEDIMENT CONTROL DEVICES SHALL REMAIN IN PLACE AND BE MAINTAINED BY THE CONTRACTOR UNTIL AREAS UPSLOPE ARE PERMANENTLY STABILIZED.
6. NO SLOPES, EITHER PERMANENT OR TEMPORARY, SHALL BE STEEPER THAN TWO HORIZONTAL TO ONE VERTICAL (2 TO 1) UNLESS STABILIZED WITH RIPRAP OR OTHER STRUCTURAL MEANS.
7. IF FINAL SEEDING AND SODDING IS NOT EXPECTED PRIOR TO THE ANTICIPATED DATE OF THE FIRST KILLING FROST, USE TEMPORARY ANNUAL RYEGRASS SEEDING AND MULCHING ON ROUGH GRADED SUBSOIL TO PROTECT THE SITE AND DELAY PERMANENT LOAMING, FINE GRADING, AND SEEDING OR SODDING UNTIL SPRING.
8. WHEN FEASIBLE, TEMPORARY SEEDING OF DISTURBED AREAS THAT HAVE NOT BEEN FINISH GRADED SHALL BE COMPLETED 30 DAYS PRIOR TO THE FIRST KILLING FROST.
9. DURING THE CONSTRUCTION PHASE, INTERCEPTED SEDIMENT WILL BE RETURNED TO THE SITE AND REGRADED ONTO OPEN AREAS. POST SEEDING SEDIMENT, IF ANY, WILL BE DISPOSED OF IN AN ACCEPTABLE MANNER.
10. REVEGETATION MEASURES WILL COMMENCE UPON COMPLETION OF CONSTRUCTION EXCEPT AS NOTED ABOVE. ALL DISTURBED AREAS NOT OTHERWISE STABILIZED WILL BE GRADED, SMOOTHED, AND REVEGETATED.
11. ALL TEMPORARY EROSION CONTROL MEASURES SHALL BE REMOVED ONCE THE SITE IS STABILIZED.
12. STABILIZATION SCHEDULE BEFORE WINTER:

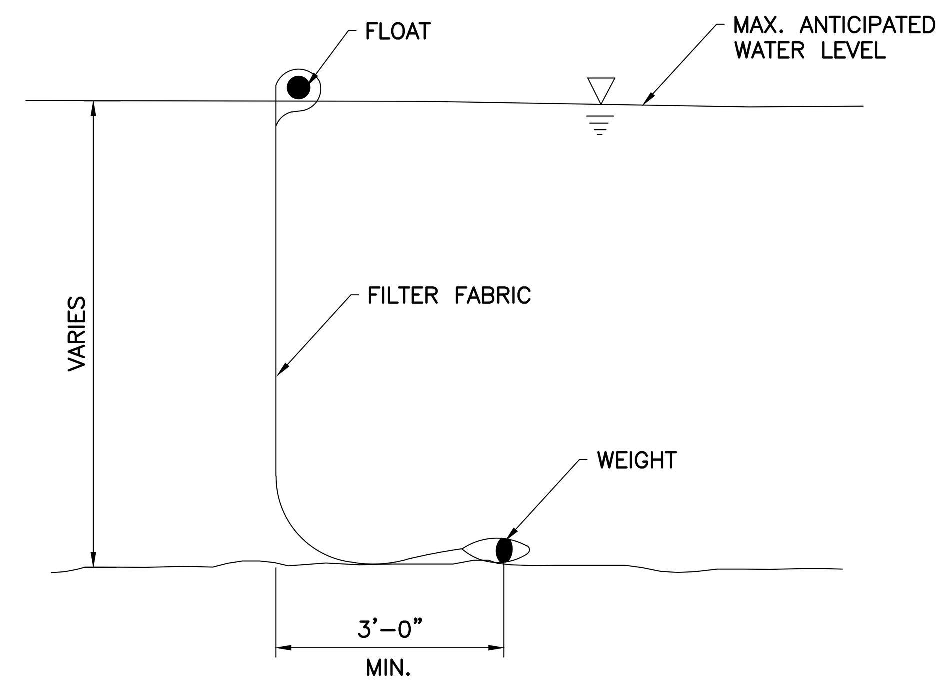
SEPTEMBER 15	ALL DISTURBED AREAS MUST BE SEEDED AND MULCHED. ALL SLOPES MUST BE STABILIZED, SEEDED AND MULCHED. SLOPES 3:1 OR GREATER TO BE STABILIZED WITH EROSION CONTROL MATTING AND SEEDED. ALL DISTURBED AREAS TO BE PROTECTED WITH AN ANNUAL GRASS MUST BE SEEDED AT A SEEDING RATE OF 3 POUNDS PER 1,000 SQUARE FEET AND MULCHED.
OCTOBER 1	ALL GRASS-LINED DITCHES AND CHANNELS MUST BE STABILIZED WITH MULCH OR EROSION CONTROL BLANKET.
NOVEMBER 15	ALL STONE-LINED DITCHES AND CHANNELS MUST BE CONSTRUCTED AND STABILIZED. SLOPES THAT ARE COVERED WITH RIPRAP MUST BE CONSTRUCTED BY THAT DATE.
DECEMBER 1	ALL DISTURBED AREAS WHERE THE GROWTH OF VEGETATION FAILS TO BE AT LEAST THREE INCHES TALL OR AT LEAST 75% OF THE DISTURBED SOIL IS COVERED BY VEGETATION, MUST BE PROTECTED FOR OVER-WINTER.

EROSION - WINTER CONSTRUCTION

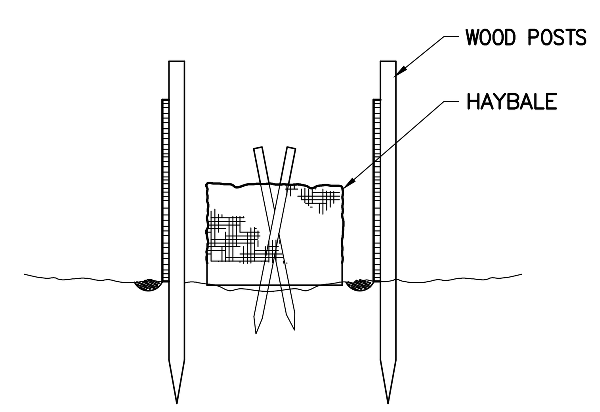
1. WINTER CONSTRUCTION PERIOD DEFINED: NOVEMBER 1 THROUGH APRIL 15
2. WINTER EXCAVATION AND EARTHWORK SHALL BE DONE SUCH THAT NO MORE THAN 1 ACRE OF THE SITE IS WITHOUT STABILIZATION AT ANY ONE TIME.
3. EXPOSED AREA SHOULD BE LIMITED SUCH THAT THE AREA CAN BE MULCHED IN ONE DAY PRIOR TO ANY SNOW EVENT.
4. CONTINUATION OF EARTHWORK OPERATIONS ON ADDITIONAL AREAS SHALL NOT BEGIN UNTIL THE EXPOSED SOIL SURFACE ON THE AREA BEING WORKED HAS BEEN STABILIZED SUCH THAT NO LARGER AREA OF THE SITE IS WITHOUT EROSION CONTROL PROTECTION AS LISTED IN ITEM 2 ABOVE.
5. AN AREA SHALL BE CONSIDERED TO HAVE BEEN STABILIZED WHEN EXPOSED SURFACES HAVE BEEN EITHER MULCHED WITH STRAW AT A RATE OF 100 LB. PER 1,000 SQUARE FEET (WITH OR WITHOUT SEEDING) OR DORMANT SEEDED, MULCHED AND ADEQUATELY ANCHORED BY AN APPROVED ANCHORING TECHNIQUE. IN ALL CASES, MULCH SHALL BE APPLIED SUCH THAT SOIL SURFACE IS NOT VISIBLE THROUGH THE MULCH.
6. BETWEEN THE DATES OF OCTOBER 15 AND APRIL 1ST, LOAM OR SEED WILL NOT BE REQUIRED. DURING PERIODS OF ABOVE-FREEZING TEMPERATURES, THE SLOPES SHALL BE FINE GRADED AND EITHER PROTECTED WITH MULCH OR TEMPORARILY SEEDED AND MULCHED UNTIL SUCH TIME AS THE FINAL TREATMENT CAN BE APPLIED. IF THE DATE IS AFTER NOVEMBER 1ST AND IF THE EXPOSED AREA HAS BEEN LOAMED, FINAL GRADED AND IS SMOOTH, THEN THE AREA MUST BE STABILIZED WITH MULCH. IF CONSTRUCTION CONTINUES DURING FREEZING WEATHER, ALL EXPOSED AREAS SHALL BE GRADED BEFORE FREEZING AND THE SURFACE TEMPORARILY PROTECTED FROM EROSION BY THE APPLICATION OF MULCH. SLOPES SHALL NOT BE LEFT EXPOSED OVER THE WINTER OR ANY OTHER EXTENDED TIME OF WORK SUSPENSION UNLESS TREATED IN THE ABOVE MANNER. UNTIL SUCH TIME AS WEATHER CONDITIONS ALLOW DITCHES TO BE FINISHED WITH THE PERMANENT SURFACE TREATMENT, EROSION SHALL BE CONTROLLED BY THE INSTALLATION OF BALES OF HAY OR STONE CHECK DAMS IN ACCORDANCE WITH THE STANDARD DETAILS.
7. THE APPLICATION OF MULCH TO FINE GRADED AREAS WILL BE STABILIZED AS FOLLOWS:
   A) BETWEEN THE DATES OF NOVEMBER 1ST AND APRIL 15TH ALL MULCH SHALL BE ANCHORED BY EITHER PEG LINE, MULCH NETTING, ASPHALT EMULSION, CHEMICAL TACK OR WOOD CELLULOSE FIBER.
   B) MULCH NETTING SHALL BE USED TO ANCHOR MULCH IN ALL DRAINAGE WAYS WITH A SLOPE GREATER THAN 3% FOR SLOPES EXPOSED TO DIRECT WINDS AND FOR ALL OTHER SLOPES GRATER THAN 8%.
   C) MULCH NETTING SHALL BE USED TO ANCHOR MULCH IN ALL AREAS WITH SLOPES GREATER THAN 15%. AFTER OCTOBER 1ST, THE SAME APPLIES FOR ALL SLOPES GREATER THAN 8%.
8. AFTER NOVEMBER 1ST THE CONTRACTOR SHALL APPLY MULCH AND ANCHORING ON ALL BARE EARTH AT THE END OF EACH WORKING DAY.
9. DURING WINTER CONSTRUCTION PERIODS ALL SNOW SHALL BE REMOVED FROM AREAS OF MULCHING PRIOR TO PLACEMENT.

EROSION CONTROL - WETLAND NOTES

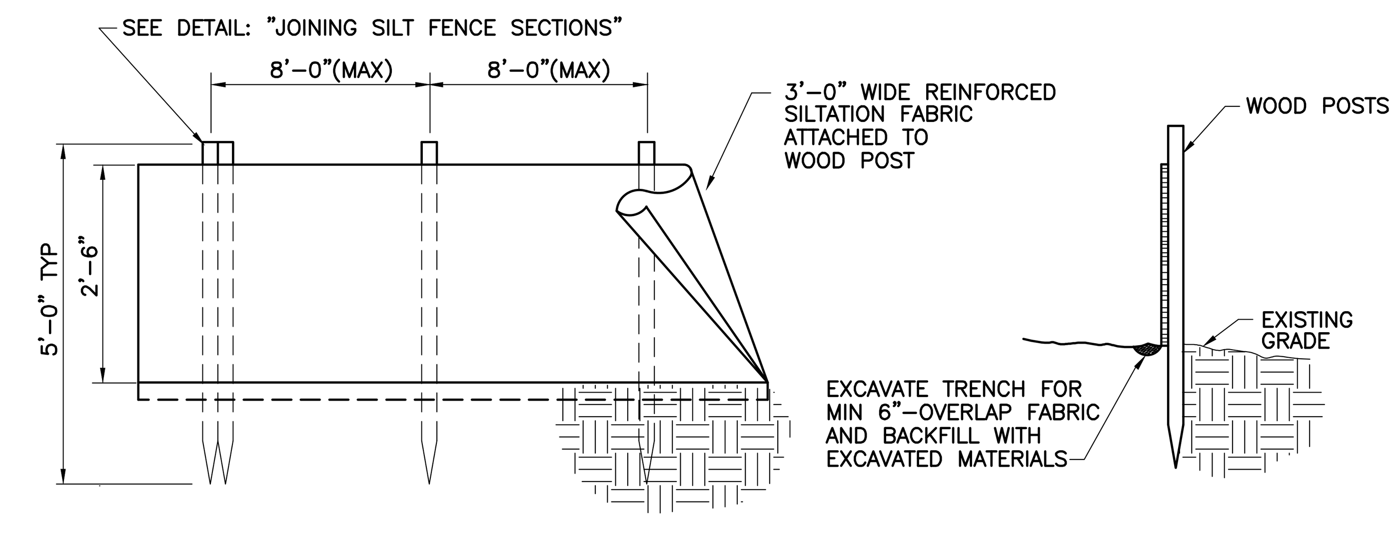
1. WETLANDS AND SURFACE WATERS (EXCEPTING THOSE WHICH ARE TO BE FILLED IN ACCORDANCE WITH STATE AND FEDERAL REGULATIONS) WILL BE PROTECTED WITH SILT FENCE INSTALLED AT THE EDGE OF THE WETLAND OR THE BOUNDARY OF WETLAND DISTURBANCE.
2. IF THE WORK INCLUDES CROSSING OF WETLANDS AND/OR STREAMS, THE CONTRACTOR SHALL TAKE SPECIAL PRECAUTIONS WORKING IN THESE AREAS
3. ANY WETLAND CROSSING WORK SHALL BE COMPLETED BETWEEN THE PERIOD OF MAY 1 AND SEPTEMBER 30
4. ALL EROSION CONTROL MEASURES SHALL BE IN PLACE PRIOR TO COMMENCING CONSTRUCTION WITHIN OR ADJACENT TO WETLAND AREAS.
5. WETLAND VEGETATIVE LAYERS SHALL BE REMOVED AND SALVAGED FOR RESTORATION OF THE DISTURBED AREAS.
6. STORAGE AREAS FOR WETLAND MATERIALS SHALL BE PROPERLY PROTECTED AGAINST EROSION.
7. SEEDING OF THE DISTURBED AREAS WITHIN WETLAND AREAS SHALL UTILIZE MIXTURES APPROPRIATE FOR WETLAND AREAS AS OUTLINED IN THE SPECIFICATIONS.



FLOATING SEDIMENT TURBIDITY CURTAIN
NTS



COMBINATION SILT FENCE AND HAY BALE BARRIER
SCALE: "NTS"



SILT FENCE INSTALLATION DETAIL
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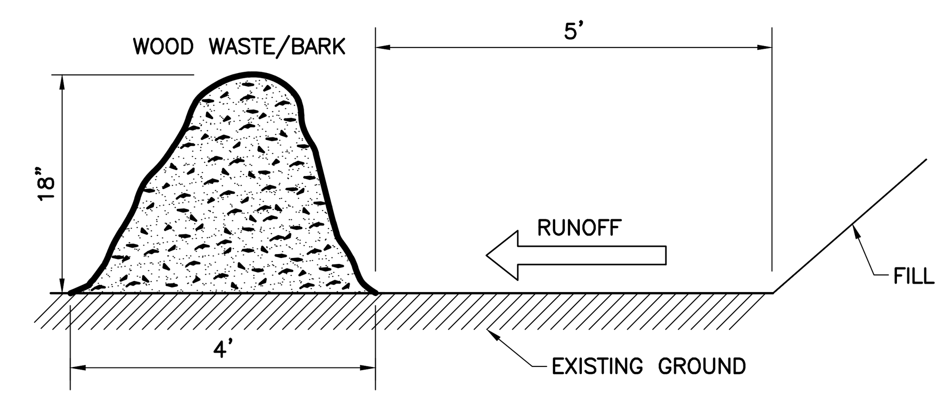
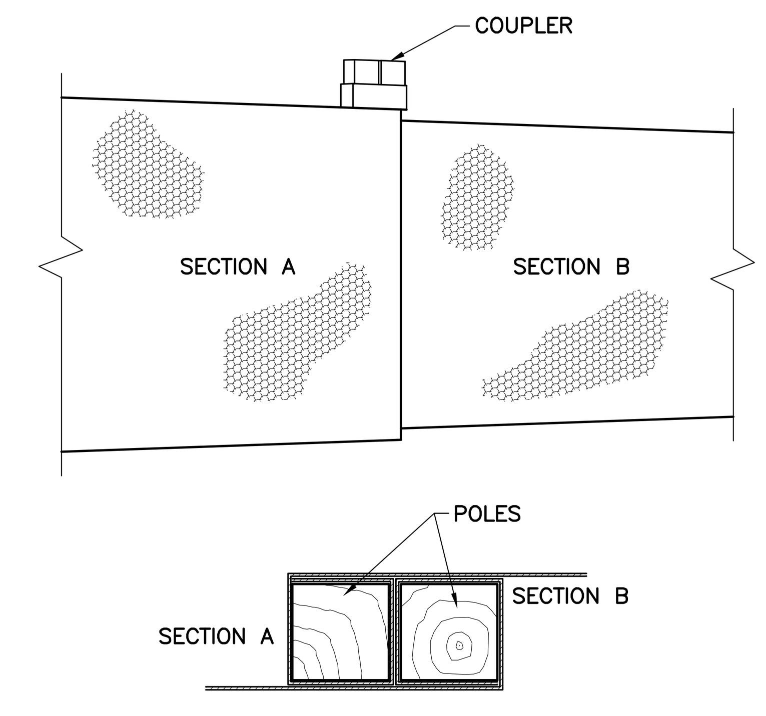
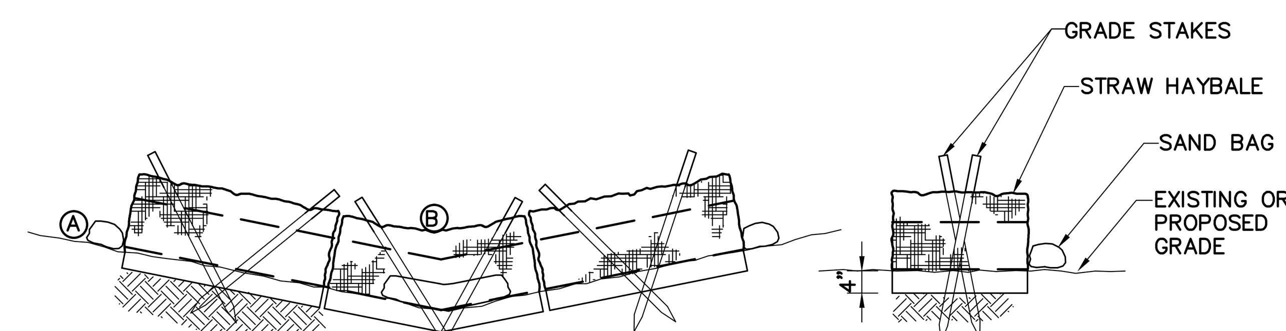


WOOD WASTE/BARK FILTER BERM
SCALE: "NTS"

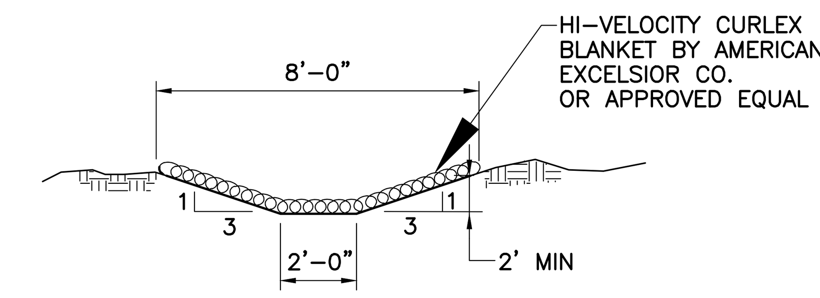


JOINING SILT FENCE SECTIONS
SCALE: "NTS"

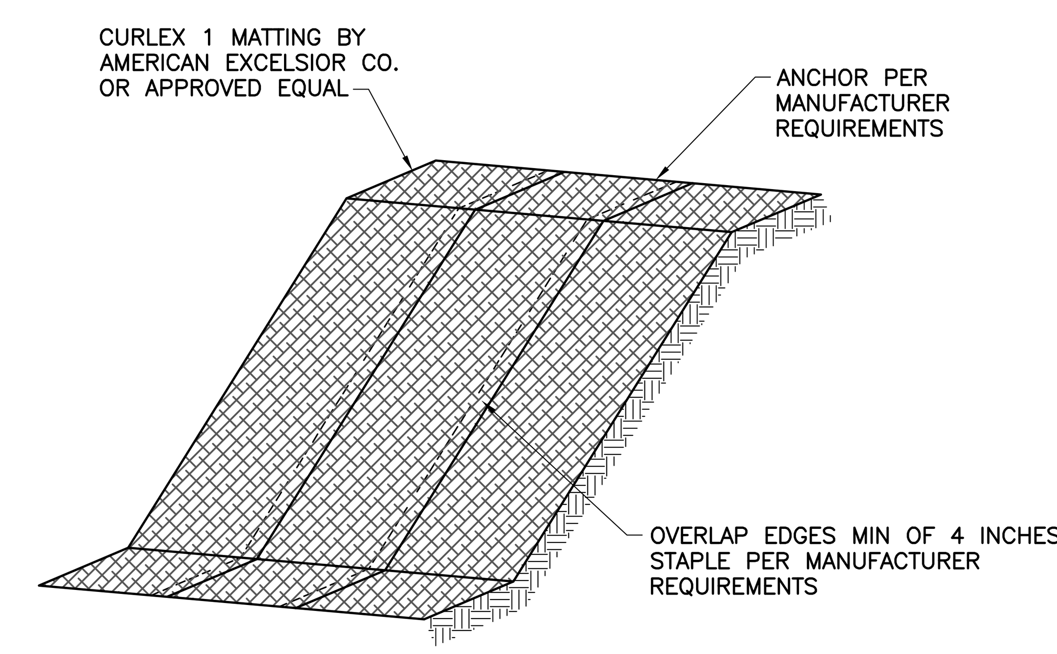


EROSION CHECK TO BE STRAW HAYBALES SECURED TO THE GROUND WITH TWO 4' LONG GRADE STAKES FOR EACH BALE. SAND BAG AS REQUIRED, PLACE SUFFICIENT BALES TO ESTABLISH ELEVATIONS AT A AT LEAST 6 INCHES ABOVE OVERFLOW AT B

STRAW HAY BALE CHECK DAM
SCALE: "NTS"



EROSION CONTROL MATTING - DITCHES
SCALE: "NTS"



INSTALL ON SLOPES 3:1 OR GREATER

EROSION CONTROL MATTING - SLOPES
SCALE: "NTS"

FOR PERMITTING PURPOSES ONLY

NO.	SUBMISSIONS/REVISIONS	APP'D	DATE
1	ISSUED FOR PERMITTING	JMM	5-15

DESIGNED BY: JMM
CAD COORD: RPB
CAD: RPB
CHECKED BY: JMM
DATE: 5-12-15
APPROVED BY: JMM
DATE: 5-12-15
PROJECT NO: 12965A

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TOWN OF BRISTOL
BRISTOL MILLS FISHWAY IMPROVEMENTS
BRISTOL, MAINE

EROSION CONTROL NOTES & DETAILS

DRAWING
C-7

APPENDIX C

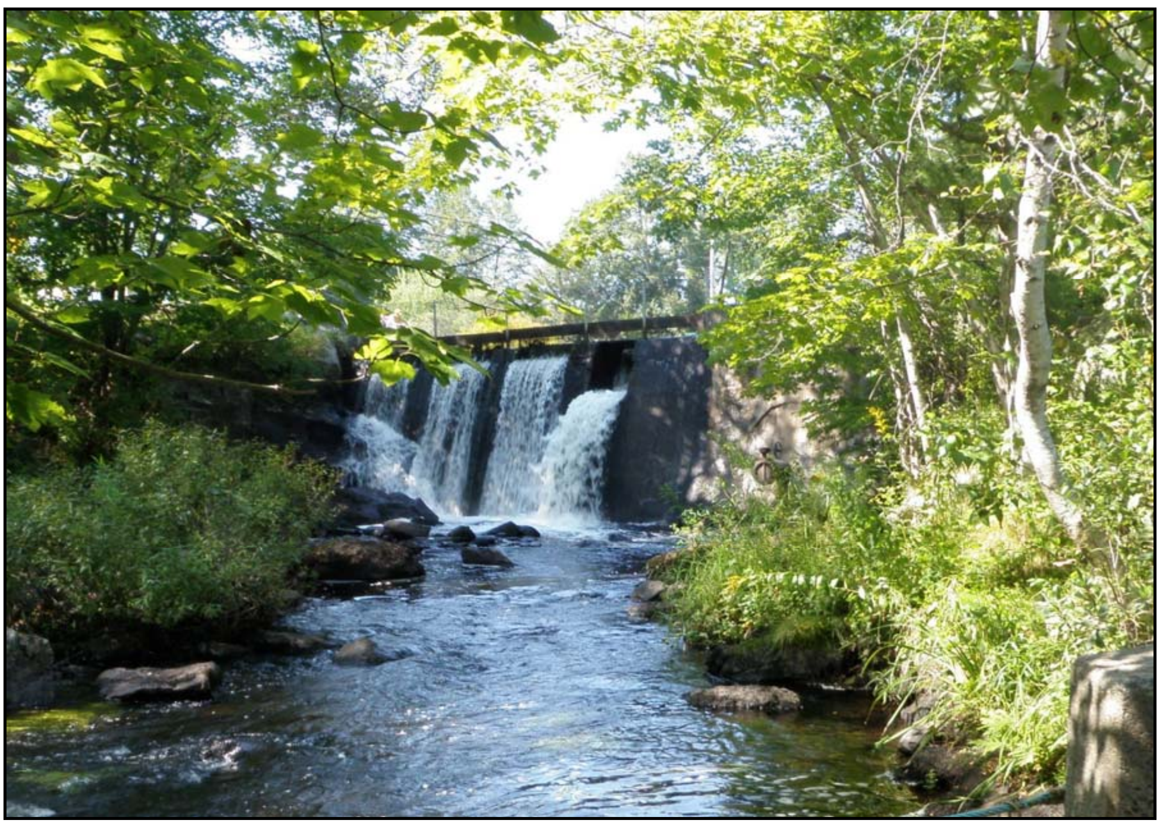
Bristol Mills Fishway Improvements Evaluation

BRISTOL MILLS DAM
PEMAQUID RIVER – BRISTOL, MAINE

FISHWAY IMPROVEMENTS EVALUATION

Prepared for the
TOWN OF BRISTOL, MAINE

November 2014



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BRISTOL MILLS DAM ON THE PEMAQUID RIVER
FISHWAY IMPROVEMENTS EVALUATION

NOVEMBER 2014

STATE OF MAINE
JOSEPH M
McLEAN
No. 11182
LICENSED
PROFESSIONAL ENGINEER

Prepared By:

Wright-Pierce
99 Main Street
Topsham, Maine 04086
(207) 725-8721

BRISTOL MILLS DAM

PEMAQUID RIVER – BRISTOL, ME

FISHWAY IMPROVEMENTS EVALUATION

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SECTION 1
INTRODUCTION

1.1 BACKGROUND

The Bristol Mills Dam impounds the Pemaquid River and is owned by the Town of Bristol. There is an active alewife committee in Town which manages the fishway and volunteers each year to undertake a series of labor intensive management tasks, including the installation of a river wide leader fence to improve attraction conditions at the fishway during the Spring Alewife migration. Despite the efforts of the alewife committee, the fishway consistently underperforms. The current number of alewife passing upstream represents only a small fraction of the Pemaquid's adult alewife productivity potential.

In 2005 the U.S. Fish and Wildlife Service performed an assessment of the fishway and noted a variety of deficiencies. Further evaluation and monitoring in 2014 confirmed many of the hindrances to passage, namely:

- Alewives are not adequately attracted to the entrance of the fishway
- Once at the entrance, alewives have difficulty entering the fishway
- Once in the fishway, alewives have difficulty traveling through the fishway
- The gate at the fishway exit does not adequately control flows

While the dam itself is owned by the Town of Bristol, the fishway is owned by the State of Maine Department of Marine Resources (MeDMR). In 2013, the Town and MeDMR partnered with the Maine Coastal Program, Gulf of Maine Council on the Marine Environment and the National Oceanic and Atmospheric Administration (NOAA) and issued a Request for Proposals from qualified engineering firms to provide assessment, design, and permitting services for improvements to the fishway.

1.2 PURPOSE OF REPORT

The purpose of this report is to summarize the existing conditions assessment of the fishway, as well as to outline the recommended improvements. Additionally, a hydrologic and hydraulic assessment of the proposed fishway has been provided.

A set of preliminary engineering design plans for the fishway improvements accompanies this report separately. These plans have been prepared by Wright-Pierce and are dated November 2014. Refer to these plans for additional information regarding the existing conditions of the fishway and the recommended improvements.

SECTION 2
EXISTING FISHWAY ASSESSMENT

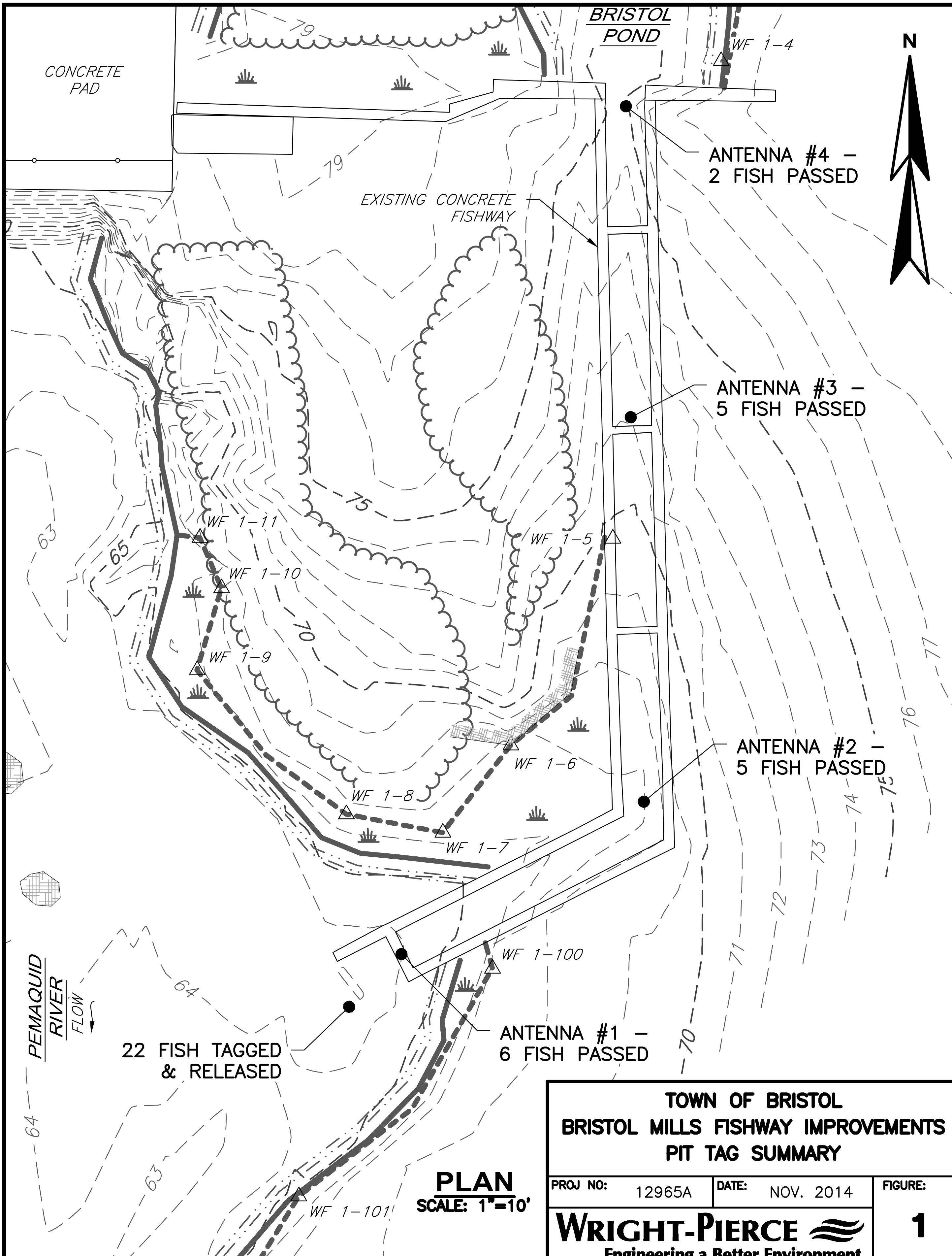
2.1 2014 PIT TAG SURVEY

In the Spring of 2014, the Maine Department of Marine Resources (MeDMR) engaged in a Passive Integrated Transponder (PIT) tag survey at the Bristol Mills fishway. The number of fish tagged (22 total) represents a small sample size, however a few general trends can be seen in the data, as described further below.

Detection antennas were placed at several locations along the existing fishway. One antenna was placed at the fishway entrance. A second antenna was placed at the turning pool. A third antenna was placed halfway between the turning pool and the fishway exist. The fourth and final antenna was placed at the fishway exit. Each of these locations have been identified on the sketch in Figure 1 – PIT Tag Summary.

Twenty-two (22) adult alewife were tagged and released in close proximity to the fishway entrance. It is anticipated that some mortality was experienced due to the handling and tagging operation, however only six (6) fish were detected by the first antenna to successfully enter the fishway. Of the six (6) fish that entered, five (5) were detected at the turning pool. Each of these five (5) fish were detected by the third antenna. Ultimately only two (2) fish were able to successfully ascend and exit the ladder as detected by the fourth antenna.

For further information related to this PIT tag survey, contact Ms. Claire Enterline of the MeDMR.



TOWN OF BRISTOL
BRISTOL MILLS FISHWAY IMPROVEMENTS
PIT TAG SUMMARY

PROJ NO: 12965A	DATE: NOV. 2014	FIGURE: 1

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2.2 2014 TOPOGRAPHIC SURVEY AND VISUAL OBSERVATIONS

Wright-Pierce deployed a two man survey crew to the Bristol Mills fishway site in June of 2014 to collect existing conditions measurements and topography in the vicinity of the dam and fishway. Additional bathymetric survey and existing conditions topography was collected in November of 2014. Refer to the existing conditions and topographic survey plan prepared by Wright-Peirce, included in the preliminary engineering plan set dated November 2014 and provided under separate cover.

Wright-Pierce personnel have performed visual observations of the fishway on several occations over the past year. Photographs taken of the fishway during these observations are included as Appendix A.

Observations of the fishway by Wright-Pierce largely corroborated the conclusions of prior inspections by US Fish and Wildlife Services Staff and others. The following narrative states the main concerns of these observations along with a brief description of the issue.

<u>Alewives are not adequately attracted to the entrance of the fishway:</u> The existing fishway entrance is located approximately 80 feet downstream of the dam and associated spillway discharge. During verbal interviews with the Town of Bristol alewife committee volunteers, there were a variety of accounts of substantial numbers of alewife bypassing the fishway entrance and collecting in the pool located just downstream of the Bristol Mills Dam. To address this concern, the Alewife committee deploys a mesh leader fence during each passage season (refer to photo 19 in appendix A). This leader fence spans the entire width of the river and is angled slightly upstream to provide a “funneling” effect that directs migrating adults to the fishway entrance. The precise construction of the leader fence has evolved over the years to its current configuration. While the fence appears to be reasonably effective, flow through the fence continues to prove to be attractive to the migrating fish and numbers of the alewive attempt to find their way through. There are a certain percentage of migrating adults that make their way past the fence and to the upstream pool area. In some cases, these bypass attempts fail and result in increased mortality as evidenced by the deceased alewife that collect in the fence mesh (refer to photos 16 and 17 in Appendix A).

Once at the entrance, alewives have difficulty entering the fishway: The migrating adults which are attracted to the fishway entrance location have difficulty physically getting into the fishway. The entrance channel of the fishway is “hung” above the water surface level of the Pemaquid River, creating a barrier to entering fish. In addition to these observations, alewife committee volunteers corroborated the inability for fish to enter the fishway under these conditions. To address this issue in 2014, the alewife committee constructed a sandbag weir and step pool just downstream of the fishway entrance. Additionally, a wooden chute was constructed and attached to the lowermost denil baffle. The combination of these two modifications (inclusion of the wier/pool and chute, refer to photo 18) made a noticeable visual increase to the number of alewife entering the fishway. That said, the chute was only deemed marginally effective as it appeared that the elevation step and associated water velocity in the chute were a challenge for the alewife to overcome. This pool and chute were implemented during the 2014 PIT tag study performed by the MeDMR, and as noted above, only six (6) of the twenty-two (22) tagged alewife were successfully able to enter the fishway.

Once in the fishway, alewives have difficulty traveling through the fishway: The fishway is approximately 75 feet long and extends approximately 10.4 feet in elevation. There is no formal resting pool and the turning pool does not provide adequate resting velocities for ascending fish. As noted in the PIT tag survey, five (5) out of six (6) fish were able to ascend 2/3 of the fishway, but only two (2) were successfully able to exit the fishway and pass the dam. It is expected that the length and height of the fishway combined with inadequate resting areas, result in exhaustive conditions. The majority of migrating fish are simply unable to maintain the veloocity and effort required to ascend the overall height and length of the fishway without rest.

The gate at the fishway exit does not adequately control flows: At the upstream end of the fishway (exit) there is a bottom-draw gate that is used to regulate flow in the fishway. There are a number of concerns about this gate configuration that make it challenging for migrating fish. For one, the gate creates a physical obstruction to the uppermost denil baffles and there is a length of fishway channel that extends below the gate where baffles are absent. Additionally, the gate itself creates a hydraulic constriction at the fishway exit that creates increased velocities and turbulence. Even in a properly configured denil fishway, the uppermost baffles have an accelerated velocity and more turbulent condition than lower sections of the denil ladder [refer to discussion of the vena contracta region in the publication referenced in Section 4.3 (Odeh, 2003)]. The absence of these uppermost baffles and the constriction created by the gate appears to exacerbate the turbulence and velocity concerns in the vena contracta region. This condition appears to be a major contributing factor to the failure of migrating adults from completing their ascent of the fishway.

<u>Annual management of the fishway is excessive and unsustainable:</u> The Town of Bristol Alewife committee expends substantial effort to create the best possible passage conditions at the fishway. While these efforts do improve the annual volume of successfully migrating fish, these efforts are not likely sustainable over the long term. Substantial effort is expended to install and maintain the leader fence. As would be expected, debris regularly collects along the fence, which requires regular cleaning. High flow also can damage the fence, which requires repair. The sandbag weir utilized to create the entrance pool is also difficult to construct effectively and requires regular adjustment based upon flow conditions. Overall, the combination of these management efforts is excessive and it produces only marginally improved performance.

SECTION 3
PROPOSED IMPROVEMENTS

3.1 EXISTING DENIL LADDER CHARACTERISTICS

The observations of the existing fishway (described in Section 2.2) reflect a number of concerns related to the attraction, entrance, and exit configuration of the fishway. Despite those concerns, the basic configuration of the denil fishway appears to be within acceptable parameters. The existing conditions survey and supplemental field measurements demonstrate that the existing denil fishway has the following basic characteristics:

Fishway Slope :: 1 foot vertical to 7 feet horizontal (14.5%)
Fishway Channel Width :: 36 inches (3 feet)
Fishway Channel Height :: 54 inches (4.5 feet)
Baffle Spacing :: 24 inches (2 feet) on center
Baffle Clear Width :: 21 inches (1.75 feet)
Baffle Angle :: 45 degrees
Baffle Notch Height :: 9 inches (0.75 feet) measured along the baffle plane

Each of the aforementioned characteristics are deemed appropriate and acceptable.

3.2 IMPROVEMENT RECOMMENDATIONS

A set of preliminary engineering design plans for the fishway improvements accompanies this report separately. These plans have been prepared by Wright-Pierce and are dated November 2014. Refer to these plans for additional information regarding the existing conditions of the fishway and the recommended improvements.

The concerns over attraction at the Bristol Mills Fishway are of particular importance. The existing practice to install and maintain the mesh leader fence is marginally effective and unsustainable in the long term. Over the past year, Wright-Pierce, the Town Selectmen, and the

Town Alewife Committee discussed the replacement of this leader fence with a more permanent dam structure. While the dam structure may be more practical than the leader fence, there are a number of long term maintenance concerns related the structure, as well as environmental impacts. A solution that involves a more permanent dam structure also involves a substantial capital investment. Overall, it was determined that a more feasible option would be to relocate the fishway entrance to the toe of the existing dam, which is a more attractive location for migrating fish. While the entrance relocation is also a substantial capital investment, it eliminates many of the environmental and maintenance concerns associated with a permanent leader dam structure.

Along with relocating the entrance, the proposed fishway has also been extended lower, which alleviates the existing elevation concerns. Additionally, the entrance channel has been extended to provide less turbulent and more favorable entrance conditions. A stoplog slot has also been added to the fishway entrance, which can be utilized to create an attraction jet from the entrance, as well as increase the depth of water in the fishway entrance pool.

To relocate the fishway entrance, the overall ladder has been reconfigured with a more pronounced “switch-back” and two distinctly separate denil ladder sections separated by a resting pool. The upper section of the existing ladder can be utilized, however the lower section is of the existing ladder will be demolished. A new section of denil ladder will be extended from the new resting pool area to the relocated entrance of the fishway. In this condition, migrating fish will travel approximately five vertical feet from the fishway entrance to the new resting pool. From the resting pool, migrating fish will travel an additional six vertical feet to the fishway exit.

At the fishway exit, the existing gate is proposed for removal and an approximate 16 foot long extension is proposed. The fishway extension will allow for the installation of needed upper baffles, as well as the ability to install a series of optional extension baffles. These extension baffles can be utilized, as needed, to regulate flow in the fishway and adjust the exit condition to varying headpond levels. Along the fishway exit extension, a wooden platform is proposed to provide maintenance access, as well as facilitate future counting surveys and fishway observation.

SECTION 4
HYDROLOGIC AND HYDRAULIC ANALYSIS

4.1 WATERSHED INFORMATION

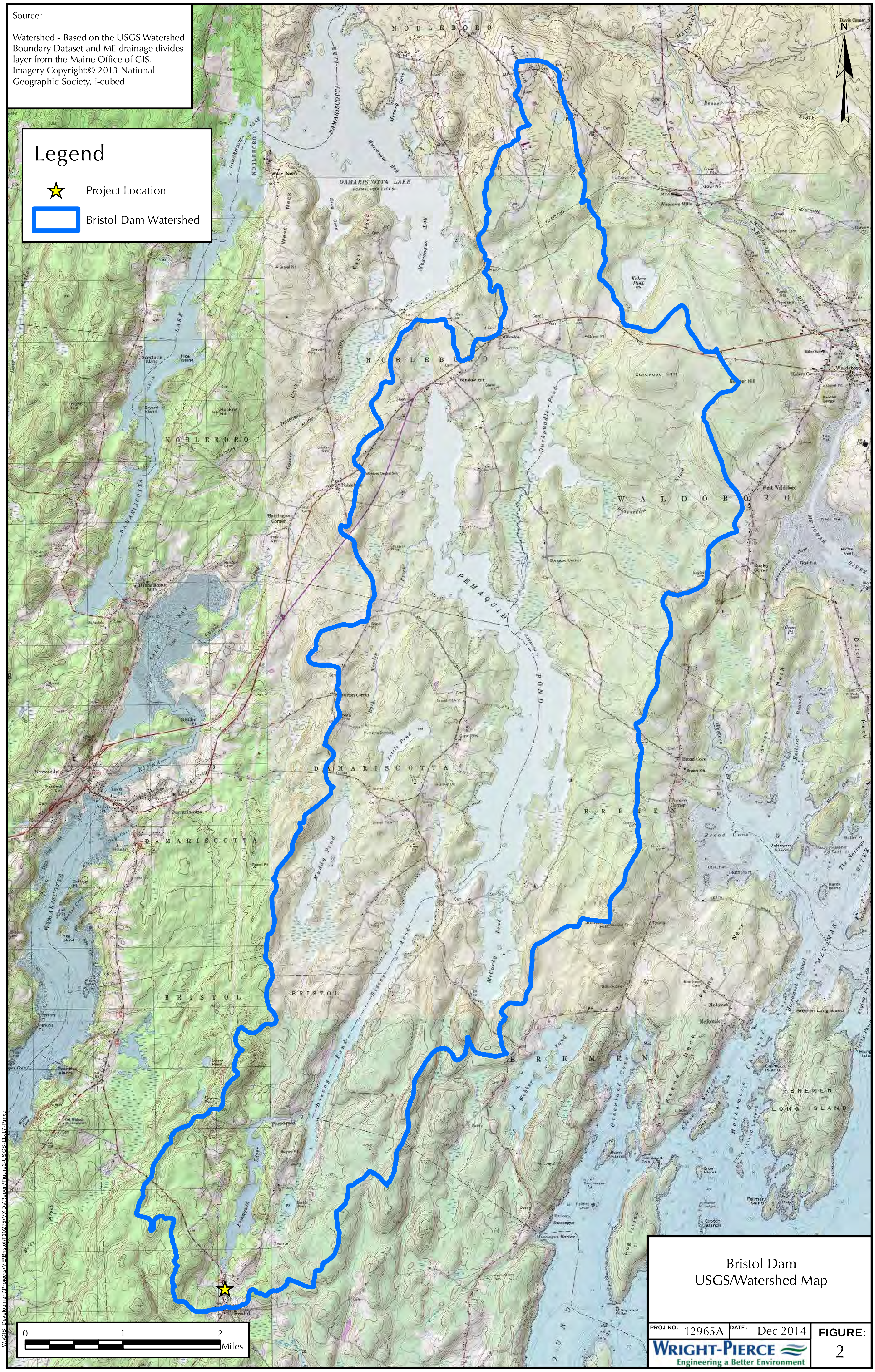
The Bristol Mills Dam is located on the Pemaquid River in the Town of Bristol. There are a series of upstream lakes and ponds, refered to collectively as the Pemaquid Chain of Lakes; including Biscay Pond, McCurdy Pond, Muddy Pond, Little Pond, Pemaquid Pond and Duckpuddle Pond. The overall watershed totals approximately 31.9 square miles and covers terrain in the municipalities of Bristol, Damariscotta, Nobleboro, Waldoboro and Bremen.

A desktop GIS analysis was performed to derive a series of explanatory variables for the USGS Regression analysis described below in Section 4.2. These characteristics include the following:

- Total Watershed Area = 31.897 square miles
- Areal Percentage of Sand And Gravel Aquifers = 0.0%
- Watershed Centroid Distance from the Gulf of Maine Line = 36.64 Miles
- Mean Annual Precipitation = 48.43 inches
- Mean Winter Precipitation = 11.58 inches
- Areal Percentage of NWI mapped wetlands/open water = 33.15%

4.2 USGS REGRESSION ANALYSIS

Wright-Pierce performed a regression analysis for the Pemaquid River at the project site utilizing the methodology outlined in the United States Geological Survey (USGS) Scientific Investigations Report 2004-5026, titled "Estimating Monthly, Annual, and Low 7-Day, 10-Year Streamflows for Ungaged Rivers in Maine. This method utilizes twenty-six streamflow gaging stations located around the state with 10-years or more of recorded streamflow records to develop predictive equations based upon five explanatory variables. These five explanatory variables include drainage basin area, areal fraction of the drainage basin underlain by sand and gravel aquifers, distance from the coast to the drainage basin centroid, mean drainage basin annual precipitation, and mean drainage basin winter precipitation.


Source:
Watershed - Based on the USGS Watershed Boundary Dataset and ME drainage divides layer from the Maine Office of GIS.
Imagery Copyright:© 2013 National Geographic Society, i-cubed
Legend
Project Location
Bristol Dam Watershed
N
0
1
2
Miles
Bristol Dam
USGS/Watershed Map
PROJ NO: 12965A
DATE: Dec 2014
FIGURE: 2
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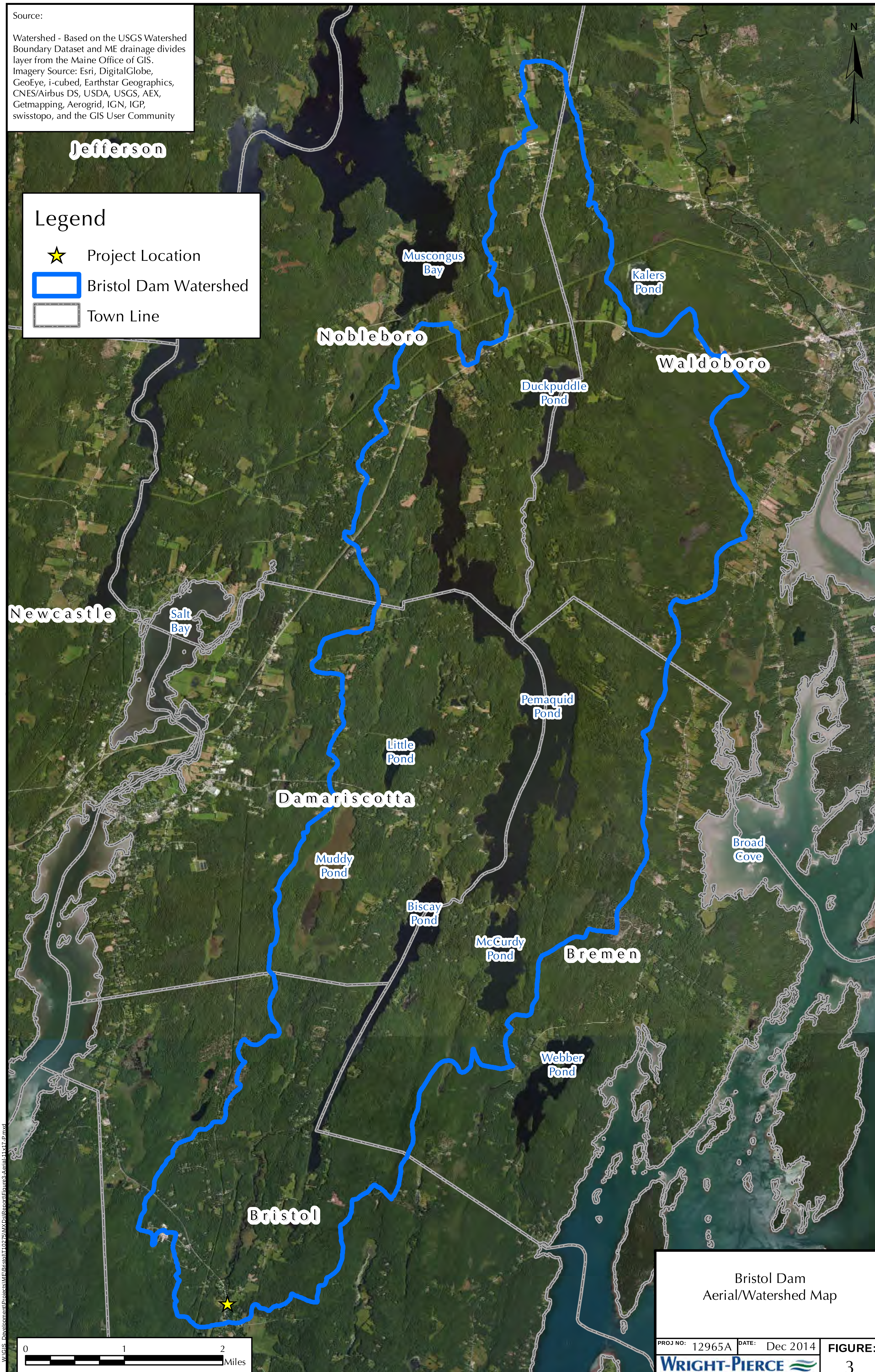

Source:
Watershed - Based on the USGS Watershed Boundary Dataset and ME drainage divides layer from the Maine Office of GIS.
Imagery Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
Legend
Project Location
Bristol Dam Watershed
Town Line
N
Jefferson
Muscongus Bay
Kalers Pond
Nobleboro
Waldoboro
Duckpuddle Pond
Newcastle
Salt Bay
Pemaquid Pond
Little Pond
Damariscotta
Broad Cove
Muddy Pond
Biscay Pond
McCurdy Pond
Bremen
Webber Pond
Bristol
0
1
2
Miles
Bristol Dam
Aerial/Watershed Map
PROJ NO: 12965A
DATE: Dec 2014
FIGURE: 3
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Table 4.1 states the mean and median monthly stream flows estimated by this regression technique and the median monthly stream flows have been depicted in Figure 4. Regression calculation worksheets are contained in Appendix B.

Table 4.1 – Estimated Mean and Median Monthly Flow Rates

Month	Median (cfs)	Mean (cfs)
January	48	74
February	50	73
March	96	146
April	170	189
May	56	72
June	30	49
July	11	21
August	7	15
September	7	16
October	13	33
November	39	67
December	60	90

4.3 HEC-RAS HYDRAULIC MODEL

The hydraulic analysis for the Bristol Mills Dam and Fishway was completed using the U.S. Army Corps of Engineers (USACE) Hydraulic Engineering Center's River Analysis System (HEC-RAS v. 4.1.0) computer program. HEC-RAS is computer software designed to perform one-dimensional hydraulic calculations for a full network of natural and constructed channels.

The HEC-RAS model was constructed with four (4) reaches. One reach that represents the Pemaquid River upstream of the dam/fishway, another that represents the Pemaquid River downstream of the dam/fishway, a third reach that represents the dam spillway, and a fourth reach that represents the proposed fishway. Two (2) junctions were utilized to connect these reaches; one that split flow from the upstream Pemaquid River to the Dam and fishway, as well as another that converged flow from the dam and fishway to the downstream Pemaquid River reach. A plan diagram of the HEC-RAS model construction is contained in Appendix C, along with pertinent excerpts from the HEC-RAS model results.

The Bristol Mills Dam Fishway was modeled as a 30.8 foot wide Broad Crested weir, with a crest elevation of 77 feet and a breadth of 5 feet. There is a stoplog gate and a low flow outlet located at the dam which could increase discharges from the modeled configuration, however based upon observations at the site and discussions with the Town, it appears that these outlets are generally closed during normal dam operations. Additionally, it was observed that a stoplog board can be added to the top of the concrete spillway during lower flow summer periods to raise the impoundment level above the concrete crest. Unfortunately, the Town does not appear to have a formal dam operations plan in place, so the use of the additional board to raise the impoundment is not entirely predictable. For the purposes of this analysis, modeling has focused on the concrete spillway conditions, with no boards in place.

The proposed fishway improvements were also included in the HEC-RAS model construction. In particular, the HEC-RAS model was focused on describing flow rates through the fishway and associated hydraulic conditions at key fishway locations. A stage-discharge curve was developed for the proposed denil fishway utilizing the methodology outlined in the ASCE publication "Discharge Rating Equation and Hydraulic Characteristics of Standard Denil Fishways" by Mufeed Odeh published in 2003 in the Journal of Hydraulic Engineering, Vol. 129. A worksheet for these calculations and the stage-discharge curve developed is included in Appendix D.

4.4 ATTRACTION FLOW SUMMARY

As noted above, the HEC-RAS model was utilized to determine the relative split of flow between the dam spillway and the fishway. During normal dam spillway operation (defined above as a 30.8 foot long concrete spillway with the crest at elevation 77.0 feet), it is anticipated that the fishway can be effectively managed with normal baffle operation (all standard denil baffles in place and no extension baffles included). Table 4.2 below, indicates the relative performance of the fishway during median monthly flow conditions.

Table 4.2 – Median Fishway Flow Performance (Normal Baffle Operation)

Month	Total Median Flow (cfs)	Median Fishway Flow (cfs)	% of Flow in Fishway	Impoundment Elevation (Feet)
January	48	11.9	24.8 %	77.59’
February	50	12.1	24.2 %	77.61’
March	96	16.2	16.9 %	77.99’
April	170	22.4	13.2 %	78.50’
May	56	12.1	21.6 %	77.61’
June	30	10.0	33.3 %	77.35’
July	11	7.7	69.5 %	77.12’
August	7	6.9	97.9 %	77.02’
September	7	6.9	97.9 %	77.02’
October	13	8.0	61.5 %	77.16’
November	39	11.1	27.8 %	77.50’
December	60	13.1	31.8 %	77.70’

In addition to the median flow conditions, a higher spring flow (1.5 times the April Median = 255 cfs) was also evaluated. The use of extension baffles was also considered during this flow condition. The Flow performance of the fishway during the high flow condition with a variety of extension baffle configurations is summarized below in Table 4.3.

Table 4.3 – High Flow Performance (Normal and Extension Baffle Operation)

Baffle Operation	Total Flow (cfs)	Median Fishway Flow (cfs)	% of Flow in Fishway	Impoundment Elevation (Feet)	Fishway Channel Freeboard (Feet)
Normal Baffles	255	28.8	11.3 %	78.97’	0.64’
Extension Baffles 1 and 2	255	21.9	8.6 %	79.01’	1.12’

As shown in Table 4.2, a healthy percentage of flow is conveyed through the fishway during median monthly flow conditions under normal spillway and fishway operation. In higher spring flow events (shown in Table 4.3), the fishway may reach maximum flow carrying capacity, as well as the extent of its functional limits. During these high flow conditions, one or two of the extension baffles may warrant installation. However, operation of the fishway with extension baffles should be limited to maximize the percentage of flow being carried by the fishway.

In addition to the flow being carried by the fishway, attraction and passability are also a function of the hydraulic characteristics at the fishway entrance. The proposed fishway has been designed with a stoplog slot at the fishway entrance to adjust the hydraulic characteristics and create an attractive velocity “jet” at the fishway entrance. Tailwater levels at the fishway entrance (water surface elevation in the Pemaquid River) will fluctuate seasonally, as will flow through the fishway. These changing conditions will require some operation of the stoplogs at the fishway entrance to create desirable conditions. Table 4.4 summarizes the fishway entrance conditions during a variety of seasonal flows.

Table 4.4 – Fishway Entrance Conditions

Month	Total Flow (cfs)	River Surface Elevation	Stoplog Height (Feet)	Entrance Pool Elevation	Step Height from River to Pool (Feet)	Depth of Entrance Pool (Feet)
January	48	64.99’	0.75’	65.18’	0.19’	1.18’
February	50	65.00’	0.75’	65.18’	0.18’	1.18’
March	96	65.36’	1.25’	65.81’	0.45’	1.81’
April	170	65.78’	1.25’	65.91’	0.13’	1.91’
1.5 X April	255	66.13’	1.25’	66.14’	0.01’	2.14’
May	56	65.06’	0.75’	65.20’	0.14’	1.20’
June	30	64.70’	0.75’	65.18’	0.48’	1.18’
July	11	64.41’	0.25’	64.60’	0.19’	0.60’
August	7	64.25’	0.25’	64.55’	0.30’	0.55’
September	7	64.25’	0.25’	64.55’	0.30’	0.55’
October	13	64.47’	0.25’	64.61’	0.14’	0.61’
November	39	64.91’	0.75’	65.18’	0.27’	1.18’
December	60	65.09’	0.75’	65.19’	0.10’	1.19’

Note: Conditions stated in the table above assumes Normal Baffle Operation (no Extension Baffles).

As stated in Table 4.4, a variety of stoplog heights may be required ranging from 0.25 feet to1.25 feet. The one-dimensional nature of the hydraulic modeling performed makes it difficult to determine the relationship of the flow jet created by the stoplog operation to the flow conditions in the Pemaquid River. However, it is anticipated that a stoplog operation similar to that noted in Table 4.4 will produce desirable results. Some adjustment will likely be warranted based upon actual field conditions post-construction.

4.5 RESTING POOL PERFORMANCE

Since normal operation of the fishway will result in overall heights of at least 11 feet (fishway entrance to fishway exit) a resting pool has been provided. As shown on the preliminary design plans (under separate cover) the resting pool has been widened to a width of eight (8) feet and totals approximately 25 feet in length. The hydraulic performance of the resting pool has been summarized below in Table 4.5 – Resting Pool Hydraulic Performance.

Table 4.5 – Resting Pool Hydraulic Performance

Month	Resting Pool Surface Elevation	Resting Pool Depth (Feet)	Average Pool Velocity (ft/s)
January	71.54’	2.54’	0.58
February	71.56’	2.56’	0.59
March	71.93’	2.93’	0.69
April	72.42’	3.42’	0.82
1.5 X April	72.86’	3.86’	0.93
May	71.56’	2.56’	0.59
June	71.35’	2.35’	0.53
July	71.09’	2.09’	0.46
August	71.00’	2.00’	0.43
September	71.00’	2.00’	0.43
October	71.13’	2.13’	0.47
November	71.46’	2.46’	0.56
December	71.66’	2.66’	0.62

Note: Conditions stated in the table above assumes Normal Baffle Operation (no Extension Baffles).

SECTION 5
CONCLUSIONS

The existing fishway has a variety of deficiencies related to attraction, entrance conditions, and flow regulation/exit conditions. Current fishway management practices are also unsustainable. After a series of discussions with the Town of Bristol and project partners, it was determined that the fishway entrance required relocation and reconstruction.

A substantial section of the existing fishway can be maintained, however, the lowermost portion of the fishway will be demolished. A new entrance channel, exit channel, and resting pool will be added, as well as a new section of denil ladder.

The existing gate will be removed from fishway and flow regulation will be possible by adding extension baffles. An upper stoplog slot has also been included to completely stop flow for maintenance and inspection purposes. Up to four (4) extension baffles can be added to the normal baffle operation. One or two baffles may be required during the highest flow periods to prevent the fishway from exceeding capacity. The remaining baffles provide additional management flexibility for dam spillway operations. For example, if the Town raises the impoundment by adding boards to the top of the concrete spillway, the fishway can be extended higher to provide appropriate performance.

The relocation of the fishway entrance will provide for more attractive conditions for migratory fish and will eliminate the need for a leader fence (or other type of leader/funneling mechanism). Additionally, the use of stoplogs at the fishway entrance will create an adjustable velocity "jet" to further attract migrating fish to the ladder. This stoplog slot will require seasonal adjustment to optimize the velocity jet and depth of water in the entrance channel along with fluctuations in water levels in the Pemaquid River.

The proposed fishway improvements also include a new resting pool approximately half way along the fishway. The new resting pool will provide for recovery of the migrating fish as they travel the approximate 11 feet in height from the downstream channel to the upstream impoundment.

APPENDIX A
Existing Conditions Photos

Photo 1 – 9/5/13.

Photo 2 – 9/5/13.

Photo 3 – 3/26/14.

Photo 4 – 3/26/14.

Photo 5 – 3/26/14.

Photo 6 – 3/26/14.

Photo 7 – 3/26/14.

Photo 8 –3/26/14.

Photo 9 – 3/26/14.

Photo 10 – 3/16/14.

Photo 11 – 3/26/14.

Photo 12 – 3/26/14.

Photo 13 – 3/26/14.

Photo 14 – 3/26/14.

Photo 15 – 3/26/14.

Photo 16 – 6/17/14.

Photo 17 – 6/17/14.

Photo 18 – 6/17/14.

Photo 19 – 6/17/14.

APPENDIX B
USGS Regression Calculation Worksheet

USGS Regression Equations for Estimating Monthly, Annual, and Low 7-day, 10-year Streamflows for Ungaged Rivers in Maine (USGS Publication 2004-5026)

Project Number:	12965A
Stream Name:	Pemaquid River
Stream Point of Interest:	Bristol Mills Dam
Stream Location:	Bristol, ME

Watershed Area	31.897	sq.mi.
Sand and Gravel Aquifers	0.0000	decimal fraction within watershed
Distance from Coast	36.640	miles
Mean Annual Precipitation	48.430	inches
Mean Winter Precipitation	11.580	inches

General Regression Estimates

	Flow (cfs)	ASEP		Ave. EYR
$Q_{7,10}$	1.34	0.87	2.04	2.9
$Q_{annual\ mean}$	65.71	60.88	70.93	9.9
$Q_{annual\ median}$	35.58	31.10	40.71	6.9

MEDIAN ESTIMATES

Month	Flow (cfs)	ASEP		Ave. EYR
Jan	48.12	40.37	57.36	8.9
Feb	50.14	43.42	57.91	17.5
Mar	95.57	79.42	115.07	13.3
Apr	170.16	134.77	214.74	3.8
May	56.01	44.59	70.91	3.9
Jun	30.46	23.61	39.84	4.3
Jul	11.22	8.29	15.19	3.6
Aug	7.35	5.24	10.30	3.9
Sep	7.44	5.44	10.17	5.4
Oct	12.65	9.39	17.06	8.3
Nov	39.52	28.10	55.57	4.4
Dec	60.34	52.44	69.39	21.6

MEAN ESTIMATES

Month	Flow (cfs)	ASEP		Ave. EYR
Jan	73.98	66.43	82.41	29.9
Feb	73.09	65.93	80.98	41.2
Mar	146.28	115.56	185.19	7.3
Apr	189.03	159.54	223.82	4.9
May	72.53	61.07	86.17	7.0
Jun	48.55	41.46	56.86	13.1
Jul	20.62	16.64	25.57	8.4
Aug	14.60	11.39	18.72	8.6
Sep	16.40	13.14	20.49	13.9
Oct	33.28	26.86	41.27	17.0
Nov	66.52	54.15	81.76	11.9
Dec	90.39	79.18	103.14	28.9

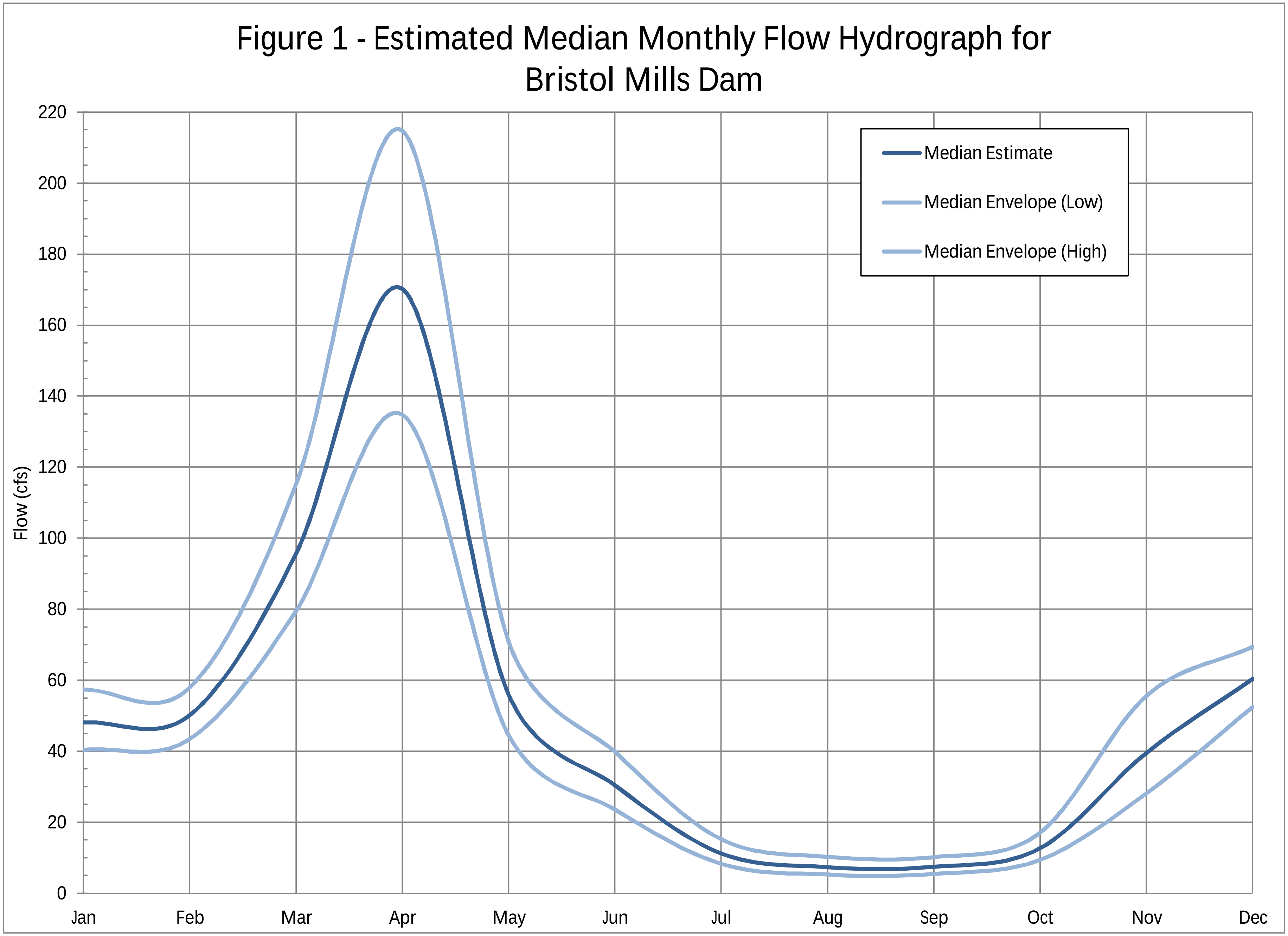
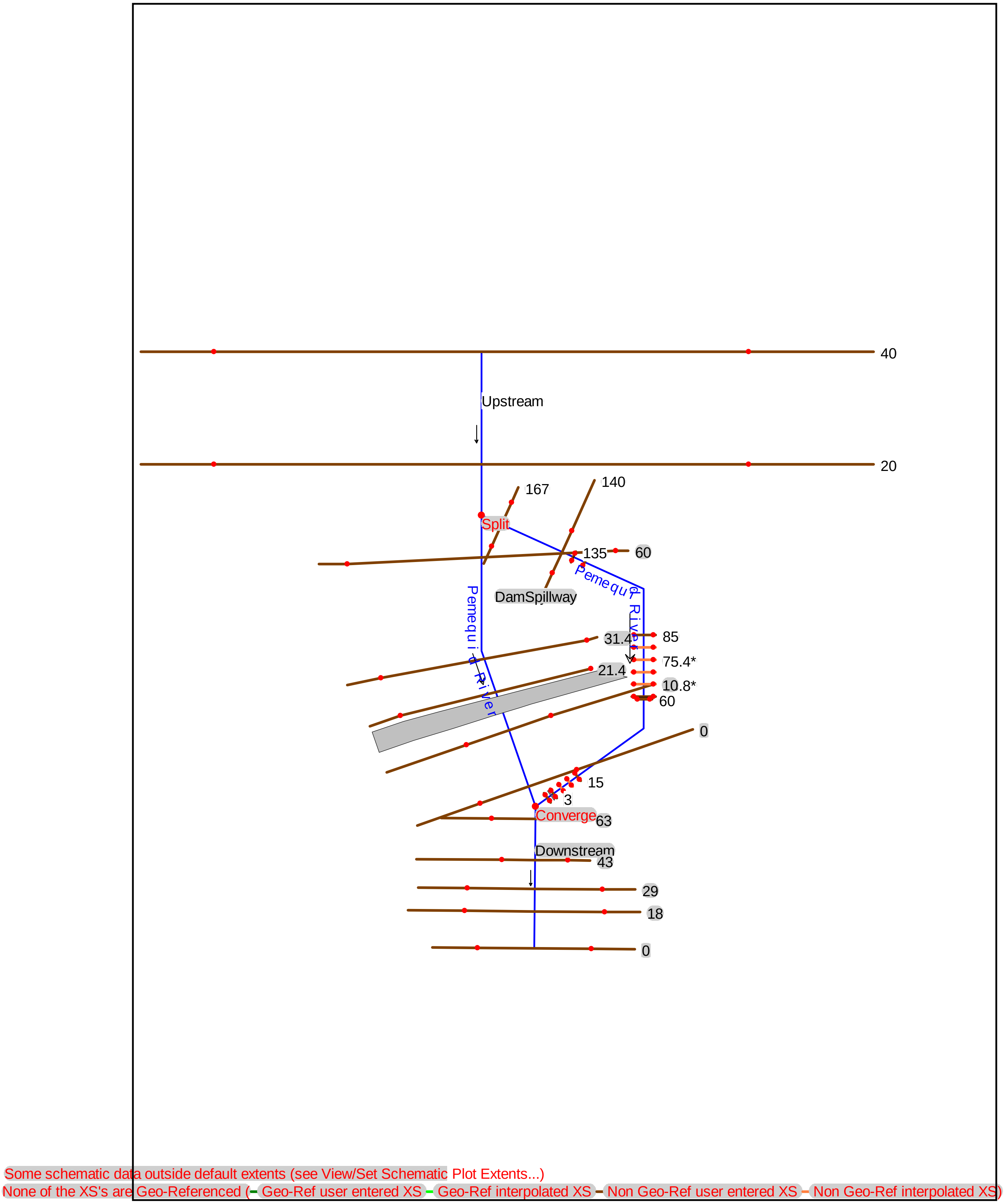
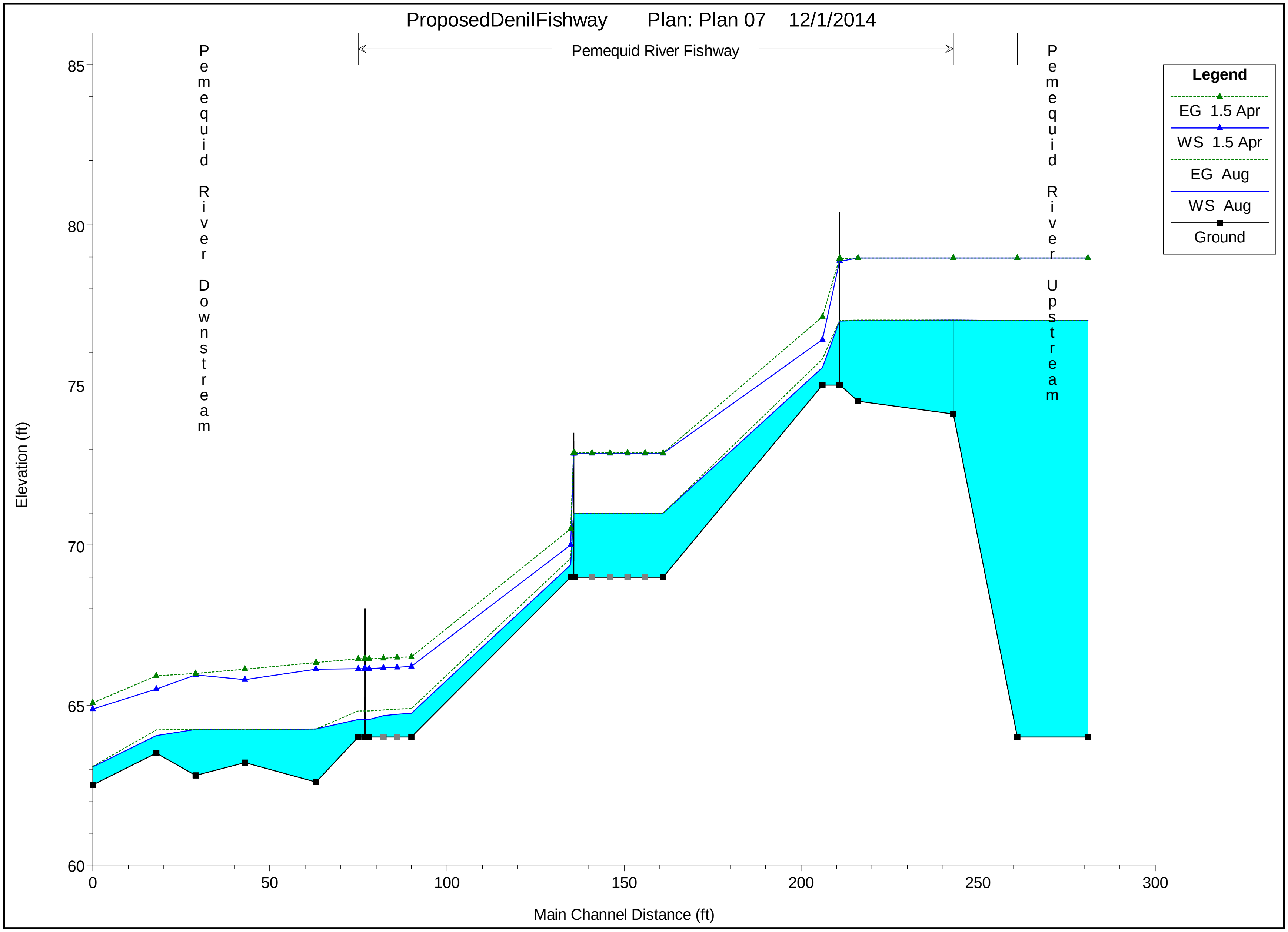
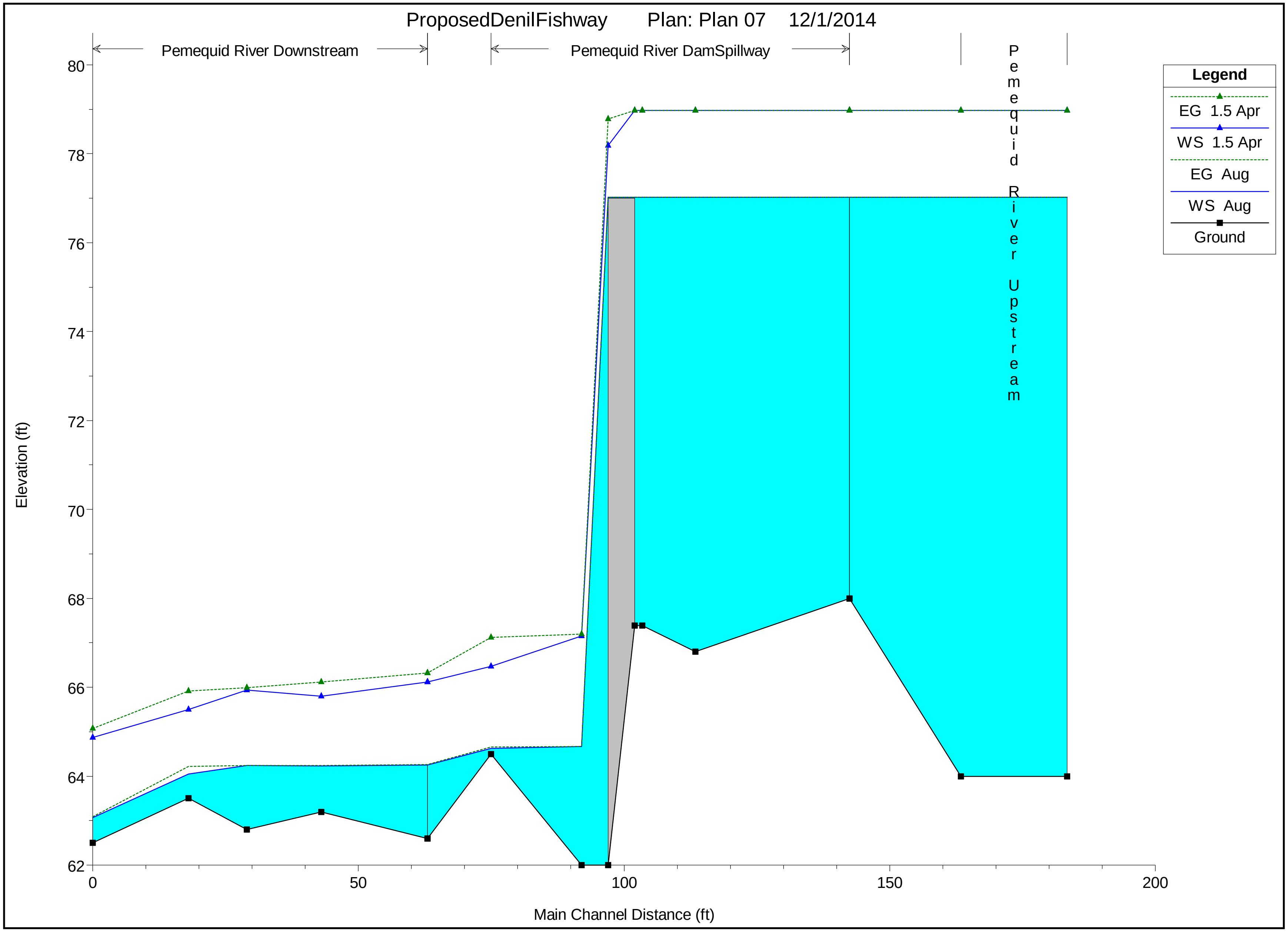


Figure 1 - Estimated Median Monthly Flow Hydrograph for
Bristol Mills Dam
Median Estimate
Median Envelope (Low)
Median Envelope (High)
Flow (cfs)
0
20
40
60
80
100
120
140
160
180
200
220
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

APPENDIX C
HEC-RAS Model Excerpts


40
Upstream
20
167
140
Split
135
60
Pemequid River
DamSpillway
Pemequid River
31.4
85
75.4*
21.4
10.8*
60
0
15
3
Converge
63
Downstream
43
29
18
0
Some schematic data outside default extents (see View/Set Schematic Plot Extents...)
None of the XS's are Geo-Referenced (Geo-Ref user entered XS Geo-Ref interpolated XS Non Geo-Ref user entered XS Non Geo-Ref interpolated XS)


ProposedDenilFishway Plan: Plan 07 12/1/2014
Pemequid River Fishway
Pemequid River Downstream
Pemequid River Upstream
Legend
EG 1.5 Apr
WS 1.5 Apr
EG Aug
WS Aug
Ground
Elevation (ft)
Main Channel Distance (ft)
85
80
75
70
65
60
0
50
100
150
200
250
300


ProposedDenilFishway Plan: Plan 07 12/1/2014
Pemequid River Downstream
Pemequid River DamSpillway
Pemequid River Upstream
Legend
EG 1.5 Apr
WS 1.5 Apr
EG Aug
WS Aug
Ground
Elevation (ft)
Main Channel Distance (ft)
80
78
76
74
72
70
68
66
64
62
0
50
100
150
200

HEC-RAS Plan: Plan 07

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width
			(cfs)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)
Upstream	40	Jan	48.00	64.00	77.59	77.59	0.000000	0.06	823.35	93.22
Upstream	40	Feb	50.00	64.00	77.61	77.61	0.000000	0.06	825.50	93.34
Upstream	40	Mar	96.00	64.00	77.99	77.99	0.000001	0.11	861.69	95.76
Upstream	40	Apr	170.00	64.00	78.50	78.50	0.000001	0.19	911.17	100.96
Upstream	40	May	56.00	64.00	77.61	77.61	0.000000	0.07	825.50	93.34
Upstream	40	Jun	30.00	64.00	77.39	77.39	0.000000	0.04	805.56	92.26
Upstream	40	Jul	11.00	64.00	77.12	77.12	0.000000	0.01	780.30	90.87
Upstream	40	Aug	7.00	64.00	77.02	77.02	0.000000	0.01	771.18	90.36
Upstream	40	Sep	7.00	64.00	77.02	77.02	0.000000	0.01	771.18	90.36
Upstream	40	Oct	13.00	64.00	77.16	77.16	0.000000	0.02	783.80	91.06
Upstream	40	Nov	40.00	64.00	77.50	77.50	0.000000	0.05	815.73	92.81
Upstream	40	Dec	60.00	64.00	77.70	77.70	0.000000	0.07	833.65	93.78
Upstream	40	1.5 Apr	255.00	64.00	78.97	78.98	0.000003	0.27	960.74	107.70
Upstream	20	Jan	48.00	64.00	77.59	77.59	0.000000	0.06	823.35	93.22
Upstream	20	Feb	50.00	64.00	77.61	77.61	0.000000	0.06	825.50	93.34
Upstream	20	Mar	96.00	64.00	77.99	77.99	0.000001	0.11	861.69	95.76
Upstream	20	Apr	170.00	64.00	78.50	78.50	0.000001	0.19	911.17	100.96
Upstream	20	May	56.00	64.00	77.61	77.61	0.000000	0.07	825.50	93.34
Upstream	20	Jun	30.00	64.00	77.39	77.39	0.000000	0.04	805.56	92.26
Upstream	20	Jul	11.00	64.00	77.12	77.12	0.000000	0.01	780.30	90.87
Upstream	20	Aug	7.00	64.00	77.02	77.02	0.000000	0.01	771.18	90.36
Upstream	20	Sep	7.00	64.00	77.02	77.02	0.000000	0.01	771.18	90.36
Upstream	20	Oct	13.00	64.00	77.16	77.16	0.000000	0.02	783.80	91.06
Upstream	20	Nov	40.00	64.00	77.50	77.50	0.000000	0.05	815.73	92.81
Upstream	20	Dec	60.00	64.00	77.70	77.70	0.000000	0.07	833.65	93.78
Upstream	20	1.5 Apr	255.00	64.00	78.97	78.98	0.000003	0.27	960.73	107.70
Fishway	167	Jan	11.90	74.10	77.59	77.59	0.000048	0.31	39.11	26.41
Fishway	167	Feb	12.10	74.10	77.61	77.61	0.000048	0.31	39.65	26.84
Fishway	167	Mar	16.20	74.10	77.99	77.99	0.000046	0.34	50.20	28.45
Fishway	167	Apr	22.40	74.10	78.50	78.50	0.000042	0.37	65.55	31.57
Fishway	167	May	12.10	74.10	77.61	77.61	0.000048	0.31	39.65	26.84
Fishway	167	Jun	10.00	74.10	77.39	77.39	0.000046	0.29	34.43	20.93
Fishway	167	Jul	7.65	74.10	77.12	77.12	0.000042	0.26	29.47	17.55
Fishway	167	Aug	6.85	74.10	77.02	77.02	0.000039	0.25	27.76	17.03
Fishway	167	Sep	6.85	74.10	77.02	77.02	0.000039	0.25	27.76	17.03
Fishway	167	Oct	8.00	74.10	77.16	77.16	0.000043	0.26	30.20	17.77
Fishway	167	Nov	11.10	74.10	77.50	77.51	0.000047	0.30	37.05	24.16
Fishway	167	Dec	13.10	74.10	77.70	77.70	0.000048	0.32	42.29	27.07
Fishway	167	1.5 Apr	28.75	74.10	78.97	78.97	0.000039	0.39	80.92	34.00
Fishway	140	Jan	11.90	74.50	77.58	77.58	0.000083	0.37	32.37	18.62
Fishway	140	Feb	12.10	74.50	77.60	77.60	0.000083	0.37	32.74	18.79
Fishway	140	Mar	16.20	74.50	77.99	77.99	0.000076	0.40	41.69	27.80
Fishway	140	Apr	22.40	74.50	78.50	78.50	0.000065	0.43	56.34	29.85
Fishway	140	May	12.10	74.50	77.60	77.60	0.000083	0.37	32.74	18.79
Fishway	140	Jun	10.00	74.50	77.39	77.39	0.000080	0.35	28.80	17.48
Fishway	140	Jul	7.65	74.50	77.12	77.12	0.000073	0.31	24.34	15.93
Fishway	140	Aug	6.85	74.50	77.02	77.02	0.000069	0.30	22.80	15.36
Fishway	140	Sep	6.85	74.50	77.02	77.02	0.000069	0.30	22.80	15.36
Fishway	140	Oct	8.00	74.50	77.16	77.16	0.000074	0.32	25.01	16.17
Fishway	140	Nov	11.10	74.50	77.50	77.50	0.000082	0.36	30.87	18.15
Fishway	140	Dec	13.10	74.50	77.70	77.70	0.000082	0.38	34.70	21.07
Fishway	140	1.5 Apr	28.75	74.50	78.97	78.97	0.000057	0.45	71.32	34.58
Fishway	135	Jan	11.90	75.00	77.54	77.58	0.000473	1.56	7.64	3.01
Fishway	135	Feb	12.10	75.00	77.56	77.60	0.000480	1.57	7.70	3.01
Fishway	135	Mar	16.20	75.00	77.93	77.98	0.000617	1.84	8.81	3.01
Fishway	135	Apr	22.40	75.00	78.42	78.49	0.000810	2.18	10.29	3.02
Fishway	135	May	12.10	75.00	77.56	77.60	0.000480	1.57	7.70	3.01
Fishway	135	Jun	10.00	75.00	77.35	77.38	0.000407	1.41	7.07	3.01
Fishway	135	Jul	7.65	75.00	77.09	77.12	0.000320	1.22	6.29	3.01
Fishway	135	Aug	6.85	75.00	77.00	77.02	0.000289	1.14	6.00	3.01
Fishway	135	Sep	6.85	75.00	77.00	77.02	0.000289	1.14	6.00	3.01
Fishway	135	Oct	8.00	75.00	77.13	77.16	0.000333	1.25	6.41	3.01

HEC-RAS Plan: Plan 07 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width
			(cfs)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)
Fishway	135	Nov	11.10	75.00	77.46	77.50	0.000446	1.50	7.41	3.01
Fishway	135	Dec	13.10	75.00	77.66	77.70	0.000514	1.64	7.99	3.01
Fishway	135	1.5 Apr	28.75	75.00	78.86	78.96	0.000996	2.47	11.62	3.02
Fishway	132.5		Inl Struct							
Fishway	130	Jan	11.90	75.00	75.79	76.18	0.011152	5.05	2.36	3.00
Fishway	130	Feb	12.10	75.00	75.79	76.19	0.011205	5.08	2.38	3.00
Fishway	130	Mar	16.20	75.00	75.97	76.45	0.011480	5.59	2.90	3.00
Fishway	130	Apr	22.40	75.00	76.20	76.80	0.012114	6.24	3.59	3.01
Fishway	130	May	12.10	75.00	75.79	76.19	0.011205	5.08	2.38	3.00
Fishway	130	Jun	10.00	75.00	75.70	76.05	0.011048	4.77	2.10	3.00
Fishway	130	Jul	7.65	75.00	75.59	75.88	0.010793	4.34	1.76	3.00
Fishway	130	Aug	6.85	75.00	75.55	75.82	0.010784	4.19	1.64	3.00
Fishway	130	Sep	6.85	75.00	75.55	75.82	0.010784	4.19	1.64	3.00
Fishway	130	Oct	8.00	75.00	75.60	75.91	0.010936	4.43	1.81	3.00
Fishway	130	Nov	11.10	75.00	75.75	76.13	0.011124	4.94	2.25	3.00
Fishway	130	Dec	13.10	75.00	75.84	76.26	0.011255	5.21	2.51	3.00
Fishway	130	1.5 Apr	28.75	75.00	76.41	77.13	0.012701	6.78	4.24	3.01
Fishway	85	Jan	11.90	69.00	71.54	71.55	0.000034	0.58	20.36	8.01
Fishway	85	Feb	12.10	69.00	71.56	71.57	0.000035	0.59	20.52	8.01
Fishway	85	Mar	16.20	69.00	71.93	71.94	0.000043	0.69	23.48	8.01
Fishway	85	Apr	22.40	69.00	72.42	72.43	0.000053	0.82	27.40	8.02
Fishway	85	May	12.10	69.00	71.56	71.57	0.000035	0.59	20.52	8.01
Fishway	85	Jun	10.00	69.00	71.35	71.36	0.000030	0.53	18.84	8.01
Fishway	85	Jul	7.65	69.00	71.09	71.10	0.000025	0.46	16.77	8.01
Fishway	85	Aug	6.85	69.00	71.00	71.00	0.000023	0.43	16.00	8.01
Fishway	85	Sep	6.85	69.00	71.00	71.00	0.000023	0.43	16.00	8.01
Fishway	85	Oct	8.00	69.00	71.13	71.14	0.000026	0.47	17.09	8.01
Fishway	85	Nov	11.10	69.00	71.47	71.47	0.000033	0.56	19.73	8.01
Fishway	85	Dec	13.10	69.00	71.66	71.66	0.000037	0.62	21.28	8.01
Fishway	85	1.5 Apr	28.75	69.00	72.86	72.88	0.000063	0.93	30.95	8.02
Fishway	80.2*	Jan	11.90	69.00	71.54	71.55	0.000034	0.58	20.36	8.01
Fishway	80.2*	Feb	12.10	69.00	71.56	71.57	0.000035	0.59	20.52	8.01
Fishway	80.2*	Mar	16.20	69.00	71.93	71.94	0.000043	0.69	23.47	8.01
Fishway	80.2*	Apr	22.40	69.00	72.42	72.43	0.000053	0.82	27.40	8.02
Fishway	80.2*	May	12.10	69.00	71.56	71.57	0.000035	0.59	20.52	8.01
Fishway	80.2*	Jun	10.00	69.00	71.35	71.36	0.000030	0.53	18.84	8.01
Fishway	80.2*	Jul	7.65	69.00	71.09	71.10	0.000025	0.46	16.77	8.01
Fishway	80.2*	Aug	6.85	69.00	71.00	71.00	0.000023	0.43	16.00	8.01
Fishway	80.2*	Sep	6.85	69.00	71.00	71.00	0.000023	0.43	16.00	8.01
Fishway	80.2*	Oct	8.00	69.00	71.13	71.14	0.000026	0.47	17.09	8.01
Fishway	80.2*	Nov	11.10	69.00	71.47	71.47	0.000033	0.56	19.73	8.01
Fishway	80.2*	Dec	13.10	69.00	71.66	71.66	0.000037	0.62	21.28	8.01
Fishway	80.2*	1.5 Apr	28.75	69.00	72.86	72.88	0.000063	0.93	30.95	8.02
Fishway	75.4*	Jan	11.90	69.00	71.54	71.55	0.000034	0.58	20.36	8.01
Fishway	75.4*	Feb	12.10	69.00	71.56	71.57	0.000035	0.59	20.52	8.01
Fishway	75.4*	Mar	16.20	69.00	71.93	71.94	0.000043	0.69	23.47	8.01
Fishway	75.4*	Apr	22.40	69.00	72.42	72.43	0.000053	0.82	27.40	8.02
Fishway	75.4*	May	12.10	69.00	71.56	71.57	0.000035	0.59	20.52	8.01
Fishway	75.4*	Jun	10.00	69.00	71.35	71.36	0.000030	0.53	18.84	8.01
Fishway	75.4*	Jul	7.65	69.00	71.09	71.10	0.000025	0.46	16.77	8.01
Fishway	75.4*	Aug	6.85	69.00	71.00	71.00	0.000023	0.43	16.00	8.01
Fishway	75.4*	Sep	6.85	69.00	71.00	71.00	0.000023	0.43	16.00	8.01
Fishway	75.4*	Oct	8.00	69.00	71.13	71.14	0.000026	0.47	17.09	8.01
Fishway	75.4*	Nov	11.10	69.00	71.46	71.47	0.000033	0.56	19.73	8.01
Fishway	75.4*	Dec	13.10	69.00	71.66	71.66	0.000037	0.62	21.28	8.01
Fishway	75.4*	1.5 Apr	28.75	69.00	72.86	72.88	0.000063	0.93	30.94	8.02
Fishway	70.6*	Jan	11.90	69.00	71.54	71.55	0.000034	0.58	20.36	8.01
Fishway	70.6*	Feb	12.10	69.00	71.56	71.57	0.000035	0.59	20.52	8.01
Fishway	70.6*	Mar	16.20	69.00	71.93	71.94	0.000043	0.69	23.47	8.01
Fishway	70.6*	Apr	22.40	69.00	72.42	72.43	0.000054	0.82	27.39	8.02

HEC-RAS Plan: Plan 07 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width
			(cfs)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)
Fishway	70.6*	May	12.10	69.00	71.56	71.57	0.000035	0.59	20.52	8.01
Fishway	70.6*	Jun	10.00	69.00	71.35	71.36	0.000030	0.53	18.84	8.01
Fishway	70.6*	Jul	7.65	69.00	71.09	71.10	0.000025	0.46	16.76	8.01
Fishway	70.6*	Aug	6.85	69.00	71.00	71.00	0.000023	0.43	16.00	8.01
Fishway	70.6*	Sep	6.85	69.00	71.00	71.00	0.000023	0.43	16.00	8.01
Fishway	70.6*	Oct	8.00	69.00	71.13	71.14	0.000026	0.47	17.08	8.01
Fishway	70.6*	Nov	11.10	69.00	71.46	71.47	0.000033	0.56	19.73	8.01
Fishway	70.6*	Dec	13.10	69.00	71.66	71.66	0.000037	0.62	21.28	8.01
Fishway	70.6*	1.5 Apr	28.75	69.00	72.86	72.88	0.000063	0.93	30.94	8.02
Fishway	65.8*	Jan	11.90	69.00	71.54	71.55	0.000034	0.58	20.36	8.01
Fishway	65.8*	Feb	12.10	69.00	71.56	71.57	0.000035	0.59	20.51	8.01
Fishway	65.8*	Mar	16.20	69.00	71.93	71.94	0.000043	0.69	23.47	8.01
Fishway	65.8*	Apr	22.40	69.00	72.42	72.43	0.000054	0.82	27.39	8.02
Fishway	65.8*	May	12.10	69.00	71.56	71.57	0.000035	0.59	20.51	8.01
Fishway	65.8*	Jun	10.00	69.00	71.35	71.36	0.000030	0.53	18.84	8.01
Fishway	65.8*	Jul	7.65	69.00	71.09	71.10	0.000025	0.46	16.76	8.01
Fishway	65.8*	Aug	6.85	69.00	71.00	71.00	0.000023	0.43	16.00	8.01
Fishway	65.8*	Sep	6.85	69.00	71.00	71.00	0.000023	0.43	16.00	8.01
Fishway	65.8*	Oct	8.00	69.00	71.13	71.14	0.000026	0.47	17.08	8.01
Fishway	65.8*	Nov	11.10	69.00	71.46	71.47	0.000033	0.56	19.73	8.01
Fishway	65.8*	Dec	13.10	69.00	71.66	71.66	0.000037	0.62	21.27	8.01
Fishway	65.8*	1.5 Apr	28.75	69.00	72.86	72.88	0.000063	0.93	30.94	8.02
Fishway	61	Jan	11.90	69.00	71.54	71.55	0.000034	0.58	20.36	8.01
Fishway	61	Feb	12.10	69.00	71.56	71.57	0.000035	0.59	20.51	8.01
Fishway	61	Mar	16.20	69.00	71.93	71.94	0.000043	0.69	23.47	8.01
Fishway	61	Apr	22.40	69.00	72.42	72.43	0.000054	0.82	27.39	8.02
Fishway	61	May	12.10	69.00	71.56	71.57	0.000035	0.59	20.51	8.01
Fishway	61	Jun	10.00	69.00	71.35	71.36	0.000030	0.53	18.83	8.01
Fishway	61	Jul	7.65	69.00	71.09	71.10	0.000025	0.46	16.76	8.01
Fishway	61	Aug	6.85	69.00	71.00	71.00	0.000023	0.43	16.00	8.01
Fishway	61	Sep	6.85	69.00	71.00	71.00	0.000023	0.43	16.00	8.01
Fishway	61	Oct	8.00	69.00	71.13	71.14	0.000026	0.47	17.08	8.01
Fishway	61	Nov	11.10	69.00	71.46	71.47	0.000033	0.56	19.73	8.01
Fishway	61	Dec	13.10	69.00	71.66	71.66	0.000037	0.62	21.27	8.01
Fishway	61	1.5 Apr	28.75	69.00	72.86	72.88	0.000063	0.93	30.93	8.02
Fishway	60.5		Inl Struct							
Fishway	60	Jan	11.90	69.00	69.56	69.84	0.009523	4.29	2.78	5.00
Fishway	60	Feb	12.10	69.00	69.56	69.85	0.009409	4.29	2.82	5.00
Fishway	60	Mar	16.20	69.00	69.69	70.03	0.009228	4.72	3.43	5.00
Fishway	60	Apr	22.40	69.00	69.85	70.28	0.009183	5.26	4.26	5.00
Fishway	60	May	12.10	69.00	69.56	69.85	0.009409	4.29	2.82	5.00
Fishway	60	Jun	10.00	69.00	69.50	69.75	0.009451	4.02	2.49	5.00
Fishway	60	Jul	7.65	69.00	69.42	69.63	0.009637	3.67	2.08	5.00
Fishway	60	Aug	6.85	69.00	69.39	69.58	0.009781	3.54	1.93	5.00
Fishway	60	Sep	6.85	69.00	69.39	69.58	0.009781	3.54	1.93	5.00
Fishway	60	Oct	8.00	69.00	69.43	69.64	0.009639	3.73	2.14	5.00
Fishway	60	Nov	11.10	69.00	69.54	69.80	0.009276	4.15	2.68	5.00
Fishway	60	Dec	13.10	69.00	69.60	69.90	0.009312	4.40	2.98	5.00
Fishway	60	1.5 Apr	28.75	69.00	70.01	70.51	0.009220	5.72	5.03	5.00
Fishway	15	Jan	11.90	64.00	65.23	65.39	0.003153	3.22	3.70	3.01
Fishway	15	Feb	12.10	64.00	65.23	65.40	0.003250	3.27	3.70	3.01
Fishway	15	Mar	16.20	64.00	65.84	65.98	0.001995	2.93	5.54	3.01
Fishway	15	Apr	22.40	64.00	65.96	66.18	0.003251	3.80	5.89	3.01
Fishway	15	May	12.10	64.00	65.25	65.41	0.003152	3.23	3.75	3.01
Fishway	15	Jun	10.00	64.00	65.22	65.33	0.002300	2.74	3.66	3.01
Fishway	15	Jul	7.65	64.00	64.79	64.95	0.004527	3.22	2.37	3.00
Fishway	15	Aug	6.85	64.00	64.74	64.89	0.004365	3.08	2.23	3.00
Fishway	15	Sep	6.85	64.00	64.74	64.89	0.004365	3.08	2.23	3.00
Fishway	15	Oct	8.00	64.00	64.81	64.98	0.004590	3.28	2.44	3.00
Fishway	15	Nov	11.10	64.00	65.23	65.37	0.002778	3.01	3.68	3.01
Fishway	15	Dec	13.10	64.00	65.25	65.44	0.003665	3.49	3.76	3.01

HEC-RAS Plan: Plan 07 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width
			(cfs)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)
Fishway	15	1.5 Apr	28.75	64.00	66.21	66.50	0.003947	4.33	6.63	3.01
Fishway	11.*	Jan	11.90	64.00	65.22	65.38	0.003274	3.26	3.65	3.01
Fishway	11.*	Feb	12.10	64.00	65.22	65.39	0.003380	3.31	3.65	3.01
Fishway	11.*	Mar	16.20	64.00	65.83	65.97	0.002022	2.94	5.51	3.01
Fishway	11.*	Apr	22.40	64.00	65.94	66.17	0.003324	3.84	5.84	3.01
Fishway	11.*	May	12.10	64.00	65.23	65.40	0.003271	3.27	3.69	3.01
Fishway	11.*	Jun	10.00	64.00	65.21	65.32	0.002360	2.76	3.62	3.01
Fishway	11.*	Jul	7.65	64.00	64.76	64.93	0.005061	3.35	2.28	3.00
Fishway	11.*	Aug	6.85	64.00	64.71	64.87	0.004894	3.20	2.14	3.00
Fishway	11.*	Sep	6.85	64.00	64.71	64.87	0.004894	3.20	2.14	3.00
Fishway	11.*	Oct	8.00	64.00	64.78	64.96	0.005123	3.41	2.34	3.00
Fishway	11.*	Nov	11.10	64.00	65.21	65.36	0.002869	3.05	3.64	3.01
Fishway	11.*	Dec	13.10	64.00	65.23	65.43	0.003834	3.55	3.69	3.01
Fishway	11.*	1.5 Apr	28.75	64.00	66.19	66.48	0.004044	4.38	6.57	3.01
Fishway	7.*	Jan	11.90	64.00	65.20	65.37	0.003408	3.31	3.60	3.01
Fishway	7.*	Feb	12.10	64.00	65.20	65.37	0.003525	3.37	3.60	3.01
Fishway	7.*	Mar	16.20	64.00	65.82	65.96	0.002050	2.96	5.48	3.01
Fishway	7.*	Apr	22.40	64.00	65.93	66.16	0.003401	3.87	5.79	3.01
Fishway	7.*	May	12.10	64.00	65.21	65.38	0.003403	3.32	3.64	3.01
Fishway	7.*	Jun	10.00	64.00	65.19	65.32	0.002424	2.79	3.59	3.01
Fishway	7.*	Jul	7.65	64.00	64.72	64.92	0.005899	3.53	2.16	3.00
Fishway	7.*	Aug	6.85	64.00	64.67	64.85	0.005739	3.38	2.03	3.00
Fishway	7.*	Sep	6.85	64.00	64.67	64.85	0.005739	3.38	2.03	3.00
Fishway	7.*	Oct	8.00	64.00	64.74	64.94	0.005958	3.60	2.23	3.00
Fishway	7.*	Nov	11.10	64.00	65.20	65.35	0.002969	3.09	3.59	3.01
Fishway	7.*	Dec	13.10	64.00	65.21	65.41	0.004026	3.61	3.63	3.01
Fishway	7.*	1.5 Apr	28.75	64.00	66.17	66.47	0.004147	4.42	6.51	3.01
Fishway	3	Jan	11.90	64.00	65.18	65.36	0.003540	3.36	3.55	3.01
Fishway	3	Feb	12.10	64.00	65.18	65.36	0.003668	3.41	3.54	3.01
Fishway	3	Mar	16.20	64.00	65.81	65.95	0.002083	2.98	5.44	3.01
Fishway	3	Apr	22.40	64.00	65.91	66.14	0.003497	3.91	5.72	3.01
Fishway	3	May	12.10	64.00	65.20	65.37	0.003536	3.37	3.59	3.01
Fishway	3	Jun	10.00	64.00	65.18	65.31	0.002487	2.81	3.55	3.01
Fishway	3	Jul	7.65	64.00	64.60	64.88	0.010330	4.28	1.79	3.00
Fishway	3	Aug	6.85	64.00	64.55	64.82	0.010380	4.13	1.66	3.00
Fishway	3	Sep	6.85	64.00	64.55	64.82	0.010380	4.13	1.66	3.00
Fishway	3	Oct	8.00	64.00	64.61	64.91	0.010439	4.36	1.84	3.00
Fishway	3	Nov	11.10	64.00	65.18	65.33	0.003066	3.12	3.55	3.01
Fishway	3	Dec	13.10	64.00	65.19	65.40	0.004246	3.68	3.56	3.01
Fishway	3	1.5 Apr	28.75	64.00	66.14	66.45	0.004276	4.47	6.43	3.01
Fishway	1.5		Inl Struct							
Fishway	0	Jan	11.90	64.00	64.79	65.18	0.011152	5.05	2.36	3.00
Fishway	0	Feb	12.10	64.00	64.79	65.19	0.011205	5.08	2.38	3.00
Fishway	0	Mar	16.20	64.00	65.29	65.56	0.005195	4.19	3.86	3.01
Fishway	0	Apr	22.40	64.00	65.76	66.04	0.004306	4.24	5.28	3.01
Fishway	0	May	12.10	64.00	64.89	65.21	0.007969	4.51	2.68	3.00
Fishway	0	Jun	10.00	64.00	64.70	65.05	0.011048	4.77	2.10	3.00
Fishway	0	Jul	7.65	64.00	64.59	64.88	0.010793	4.34	1.76	3.00
Fishway	0	Aug	6.85	64.00	64.55	64.82	0.010784	4.19	1.64	3.00
Fishway	0	Sep	6.85	64.00	64.55	64.82	0.010784	4.19	1.64	3.00
Fishway	0	Oct	8.00	64.00	64.60	64.91	0.010936	4.43	1.81	3.00
Fishway	0	Nov	11.10	64.00	64.75	65.13	0.011124	4.94	2.25	3.00
Fishway	0	Dec	13.10	64.00	64.90	65.26	0.009218	4.86	2.70	3.00
Fishway	0	1.5 Apr	28.75	64.00	66.13	66.44	0.004316	4.49	6.41	3.01
DamSpillway	60	Jan	36.10	68.00	77.59	77.59	0.000000	0.07	501.73	77.82
DamSpillway	60	Feb	37.90	68.00	77.61	77.61	0.000000	0.08	503.52	77.85
DamSpillway	60	Mar	79.80	68.00	77.99	77.99	0.000001	0.15	533.48	78.44
DamSpillway	60	Apr	147.60	68.00	78.50	78.50	0.000004	0.26	573.11	79.22
DamSpillway	60	May	37.90	68.00	77.61	77.61	0.000000	0.08	503.52	77.85
DamSpillway	60	Jun	20.00	68.00	77.39	77.39	0.000000	0.04	486.87	76.76

HEC-RAS Plan: Plan 07 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width
			(cfs)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)
DamSpillway	60	Jul	3.35	68.00	77.12	77.12	0.000000	0.01	466.03	74.35
DamSpillway	60	Aug	0.15	68.00	77.02	77.02	0.000000	0.00	458.59	73.47
DamSpillway	60	Sep	0.15	68.00	77.02	77.02	0.000000	0.00	458.59	73.47
DamSpillway	60	Oct	5.00	68.00	77.16	77.16	0.000000	0.01	468.89	74.69
DamSpillway	60	Nov	28.90	68.00	77.50	77.50	0.000000	0.06	495.36	77.69
DamSpillway	60	Dec	46.90	68.00	77.70	77.70	0.000001	0.09	510.31	77.99
DamSpillway	60	1.5 Apr	226.25	68.00	78.97	78.97	0.000007	0.37	611.07	79.96
DamSpillway	31.4	Jan	36.10	66.80	77.59	77.59	0.000000	0.07	508.28	60.38
DamSpillway	31.4	Feb	37.90	66.80	77.61	77.61	0.000000	0.07	509.67	60.45
DamSpillway	31.4	Mar	79.80	66.80	77.99	77.99	0.000001	0.15	533.07	61.62
DamSpillway	31.4	Apr	147.60	66.80	78.50	78.50	0.000003	0.26	564.45	63.79
DamSpillway	31.4	May	37.90	66.80	77.61	77.61	0.000000	0.07	509.67	60.45
DamSpillway	31.4	Jun	20.00	66.80	77.39	77.39	0.000000	0.04	496.75	59.80
DamSpillway	31.4	Jul	3.35	66.80	77.12	77.12	0.000000	0.01	480.37	58.96
DamSpillway	31.4	Aug	0.15	66.80	77.02	77.02	0.000000	0.00	474.45	58.65
DamSpillway	31.4	Sep	0.15	66.80	77.02	77.02	0.000000	0.00	474.45	58.65
DamSpillway	31.4	Oct	5.00	66.80	77.16	77.16	0.000000	0.01	482.64	59.08
DamSpillway	31.4	Nov	28.90	66.80	77.50	77.50	0.000000	0.06	503.34	60.13
DamSpillway	31.4	Dec	46.90	66.80	77.70	77.70	0.000000	0.09	514.94	60.72
DamSpillway	31.4	1.5 Apr	226.25	66.80	78.97	78.97	0.000006	0.38	595.86	67.14
DamSpillway	21.4	Jan	36.10	67.39	77.59	77.59	0.000000	0.09	415.55	52.36
DamSpillway	21.4	Feb	37.90	67.39	77.61	77.61	0.000000	0.09	416.75	52.41
DamSpillway	21.4	Mar	79.80	67.39	77.99	77.99	0.000002	0.18	436.98	53.19
DamSpillway	21.4	Apr	147.60	67.39	78.50	78.50	0.000005	0.32	463.95	54.23
DamSpillway	21.4	May	37.90	67.39	77.61	77.61	0.000000	0.09	416.75	52.41
DamSpillway	21.4	Jun	20.00	67.39	77.39	77.39	0.000000	0.05	405.54	51.96
DamSpillway	21.4	Jul	3.35	67.39	77.12	77.12	0.000000	0.01	391.29	51.40
DamSpillway	21.4	Aug	0.15	67.39	77.02	77.02	0.000000	0.00	386.13	51.19
DamSpillway	21.4	Sep	0.15	67.39	77.02	77.02	0.000000	0.00	386.13	51.19
DamSpillway	21.4	Oct	5.00	67.39	77.16	77.16	0.000000	0.01	393.26	51.48
DamSpillway	21.4	Nov	28.90	67.39	77.50	77.50	0.000000	0.07	411.26	52.19
DamSpillway	21.4	Dec	46.90	67.39	77.70	77.70	0.000001	0.11	421.32	52.58
DamSpillway	21.4	1.5 Apr	226.25	67.39	78.97	78.97	0.000010	0.46	490.01	55.21
DamSpillway	20		Inl Struct							
DamSpillway	10	Jan	36.10	62.00	65.73	65.73	0.000024	0.40	108.44	43.33
DamSpillway	10	Feb	37.90	62.00	65.75	65.75	0.000026	0.42	109.36	43.34
DamSpillway	10	Mar	79.80	62.00	66.16	66.17	0.000076	0.77	127.21	43.60
DamSpillway	10	Apr	147.60	62.00	66.67	66.69	0.000162	1.23	149.60	43.93
DamSpillway	10	May	37.90	62.00	65.75	65.75	0.000026	0.42	109.35	43.34
DamSpillway	10	Jun	20.00	62.00	65.51	65.51	0.000010	0.24	99.11	42.26
DamSpillway	10	Jul	3.35	62.00	65.06	65.06	0.000000	0.05	80.81	39.38
DamSpillway	10	Aug	0.15	62.00	64.66	64.66	0.000000	0.00	65.67	36.82
DamSpillway	10	Sep	0.15	62.00	64.66	64.66	0.000000	0.00	65.67	36.82
DamSpillway	10	Oct	5.00	62.00	65.15	65.15	0.000001	0.07	84.47	39.97
DamSpillway	10	Nov	28.90	62.00	65.64	65.64	0.000017	0.33	104.48	43.07
DamSpillway	10	Dec	46.90	62.00	65.85	65.85	0.000036	0.50	113.70	43.40
DamSpillway	10	1.5 Apr	226.25	62.00	67.15	67.19	0.000258	1.67	170.90	44.25
DamSpillway	0	Jan	36.10	64.50	65.49	65.71	0.035194	3.75	9.62	23.28
DamSpillway	0	Feb	37.90	64.50	65.50	65.73	0.034730	3.80	9.97	23.43
DamSpillway	0	Mar	79.80	64.50	65.78	66.13	0.030040	4.72	16.92	25.51
DamSpillway	0	Apr	147.60	64.50	66.13	66.63	0.026517	5.70	25.89	26.43
DamSpillway	0	May	37.90	64.50	65.50	65.73	0.034634	3.80	9.98	23.44
DamSpillway	0	Jun	20.00	64.50	65.34	65.50	0.036264	3.17	6.31	20.23
DamSpillway	0	Jul	3.35	64.50	64.95	65.05	0.041337	2.59	1.29	6.16
DamSpillway	0	Aug	0.15	64.50	64.63	64.66	0.059047	1.44	0.10	1.62
DamSpillway	0	Sep	0.15	64.50	64.63	64.66	0.059047	1.44	0.10	1.62
DamSpillway	0	Oct	5.00	64.50	65.02	65.14	0.040593	2.81	1.78	7.34
DamSpillway	0	Nov	28.90	64.50	65.44	65.62	0.032464	3.38	8.55	22.80
DamSpillway	0	Dec	46.90	64.50	65.57	65.83	0.033148	4.03	11.64	24.15
DamSpillway	0	1.5 Apr	226.25	64.50	66.47	67.12	0.024097	6.45	35.06	27.33

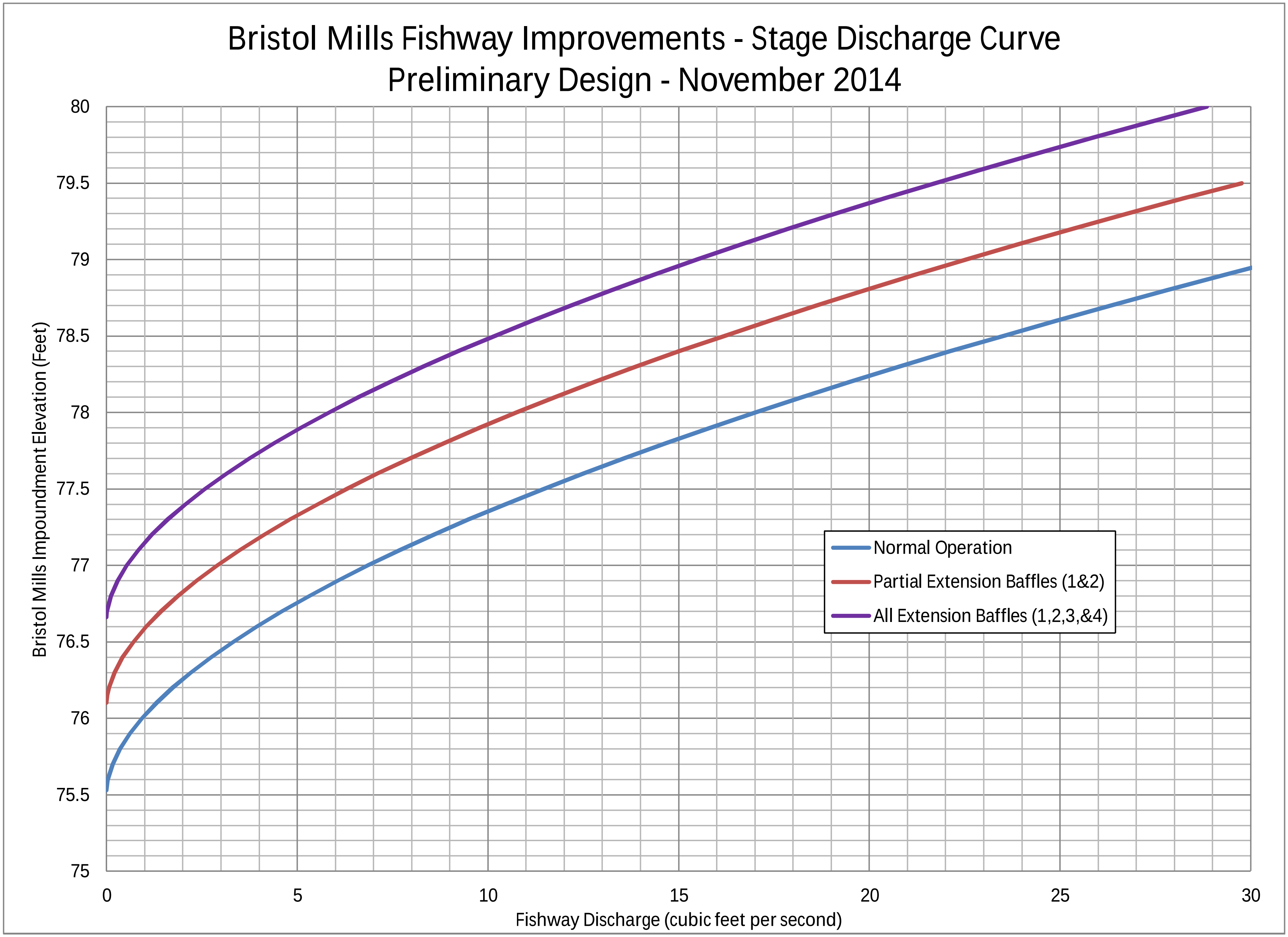
HEC-RAS Plan: Plan 07 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width
			(cfs)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)
Downstream	63	Jan	48.00	62.60	64.99	65.02	0.001465	1.52	31.49	19.99
Downstream	63	Feb	50.00	62.60	65.00	65.04	0.001542	1.57	31.86	20.12
Downstream	63	Mar	96.00	62.60	65.36	65.45	0.004569	2.41	39.77	29.86
Downstream	63	Apr	170.00	62.60	65.78	65.92	0.006897	3.03	56.03	40.73
Downstream	63	May	56.00	62.60	65.06	65.10	0.001776	1.70	32.92	20.49
Downstream	63	Jun	30.00	62.60	64.79	64.81	0.000824	1.08	27.70	19.09
Downstream	63	Jul	11.00	62.60	64.41	64.42	0.000271	0.53	20.71	18.07
Downstream	63	Aug	7.00	62.60	64.25	64.26	0.000173	0.39	17.86	17.63
Downstream	63	Sep	7.00	62.60	64.25	64.26	0.000173	0.39	17.86	17.63
Downstream	63	Oct	13.00	62.60	64.47	64.48	0.000326	0.60	21.73	18.22
Downstream	63	Nov	40.00	62.60	64.91	64.93	0.001161	1.34	29.93	19.44
Downstream	63	Dec	60.00	62.60	65.09	65.14	0.001932	1.79	33.60	20.72
Downstream	63	1.5 Apr	255.00	62.60	66.12	66.33	0.007654	3.62	70.45	42.54
Downstream	43	Jan	48.00	63.20	64.91	64.97	0.005536	1.88	25.54	33.07
Downstream	43	Feb	50.00	63.20	64.93	64.99	0.005623	1.92	26.08	33.25
Downstream	43	Mar	96.00	63.20	65.22	65.33	0.007485	2.71	36.24	36.81
Downstream	43	Apr	170.00	63.20	65.54	65.75	0.009733	3.67	48.86	41.16
Downstream	43	May	56.00	63.20	64.98	65.04	0.005885	2.04	27.62	33.78
Downstream	43	Jun	30.00	63.20	64.74	64.77	0.004586	1.50	19.99	30.62
Downstream	43	Jul	11.00	63.20	64.39	64.40	0.003935	1.06	10.36	23.82
Downstream	43	Aug	7.00	63.20	64.23	64.25	0.004563	1.01	6.93	19.19
Downstream	43	Sep	7.00	63.20	64.23	64.25	0.004563	1.01	6.93	19.19
Downstream	43	Oct	13.00	63.20	64.44	64.46	0.003922	1.11	11.66	24.85
Downstream	43	Nov	40.00	63.20	64.84	64.89	0.005190	1.72	23.26	32.27
Downstream	43	Dec	60.00	63.20	65.00	65.07	0.006054	2.11	28.61	34.11
Downstream	43	1.5 Apr	255.00	63.20	65.79	66.12	0.012508	4.63	60.72	51.65
Downstream	29	Jan	48.00	62.80	64.94	64.94	0.000302	0.63	76.12	55.80
Downstream	29	Feb	50.00	62.80	64.95	64.96	0.000317	0.65	77.08	56.22
Downstream	29	Mar	96.00	62.80	65.27	65.28	0.000627	1.00	95.58	60.14
Downstream	29	Apr	170.00	62.80	65.63	65.66	0.001006	1.44	117.66	60.87
Downstream	29	May	56.00	62.80	65.00	65.01	0.000364	0.70	79.85	57.42
Downstream	29	Jun	30.00	62.80	64.76	64.76	0.000166	0.45	66.43	51.34
Downstream	29	Jul	11.00	62.80	64.39	64.40	0.000058	0.23	48.63	48.40
Downstream	29	Aug	7.00	62.80	64.24	64.24	0.000040	0.17	41.12	47.59
Downstream	29	Sep	7.00	62.80	64.24	64.24	0.000040	0.17	41.12	47.59
Downstream	29	Oct	13.00	62.80	64.45	64.45	0.000069	0.25	51.26	48.68
Downstream	29	Nov	40.00	62.80	64.86	64.87	0.000240	0.55	72.11	54.00
Downstream	29	Dec	60.00	62.80	65.03	65.04	0.000395	0.74	81.63	58.18
Downstream	29	1.5 Apr	255.00	62.80	65.94	65.99	0.001413	1.87	136.62	61.92
Downstream	18	Jan	48.00	63.50	64.70	64.91	0.053830	3.68	13.06	32.85
Downstream	18	Feb	50.00	63.50	64.71	64.93	0.053704	3.71	13.48	33.40
Downstream	18	Mar	96.00	63.50	64.96	65.23	0.047784	4.23	22.69	42.27
Downstream	18	Apr	170.00	63.50	65.22	65.60	0.041719	4.91	34.65	46.63
Downstream	18	May	56.00	63.50	64.75	64.97	0.053109	3.79	14.76	35.03
Downstream	18	Jun	30.00	63.50	64.55	64.73	0.052153	3.46	8.66	23.22
Downstream	18	Jul	11.00	63.50	64.21	64.38	0.057119	3.24	3.39	10.74
Downstream	18	Aug	7.00	63.50	64.04	64.22	0.053141	3.36	2.09	5.92
Downstream	18	Sep	7.00	63.50	64.04	64.22	0.053141	3.36	2.09	5.92
Downstream	18	Oct	13.00	63.50	64.26	64.43	0.056282	3.28	3.96	12.20
Downstream	18	Nov	40.00	63.50	64.64	64.84	0.054279	3.55	11.26	29.98
Downstream	18	Dec	60.00	63.50	64.77	65.00	0.052994	3.85	15.56	36.02
Downstream	18	1.5 Apr	255.00	63.50	65.50	65.91	0.040757	5.19	49.12	59.81
Downstream	0	Jan	48.00	62.50	63.69	63.76	0.010006	2.21	21.70	33.40
Downstream	0	Feb	50.00	62.50	63.70	63.78	0.010007	2.24	22.30	33.64
Downstream	0	Mar	96.00	62.50	64.04	64.16	0.010006	2.81	34.19	36.75
Downstream	0	Apr	170.00	62.50	64.48	64.65	0.010005	3.30	51.58	43.40
Downstream	0	May	56.00	62.50	63.76	63.84	0.010006	2.33	24.06	34.34
Downstream	0	Jun	30.00	62.50	63.51	63.56	0.010002	1.89	15.88	30.99
Downstream	0	Jul	11.00	62.50	63.16	63.20	0.010017	1.52	7.25	19.70
Downstream	0	Aug	7.00	62.50	63.06	63.09	0.010008	1.31	5.32	17.94
Downstream	0	Sep	7.00	62.50	63.06	63.09	0.010008	1.31	5.32	17.94
Downstream	0	Oct	13.00	62.50	63.21	63.25	0.010006	1.60	8.15	20.47

HEC-RAS Plan: Plan 07 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width
			(cfs)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)
Downstream	0	Nov	40.00	62.50	63.61	63.68	0.010010	2.08	19.21	32.39
Downstream	0	Dec	60.00	62.50	63.79	63.88	0.010007	2.38	25.21	34.78
Downstream	0	1.5 Apr	255.00	62.50	64.87	65.08	0.010003	3.63	70.25	50.88

APPENDIX D
Denil Fishway Stage-Discharge Worksheet



Bristol Mills Fishway Improvements - Stage Discharge Curve
Preliminary Design - November 2014
Bristol Mills Impoundment Elevation (Feet)
Fishway Discharge (cubic feet per second)
80
79.5
79
78.5
78
77.5
77
76.5
76
75.5
75
0
5
10
15
20
25
30
Normal Operation
Partial Extension Baffles (1&2)
All Extension Baffles (1,2,3,&4)

APPENDIX D

PIT Tag Summary & Results

Results of 2014 PIT tag study

From: "Enterline, Claire" <Claire.Enterline@maine.gov>
To: Joseph McLean <joseph.mclean@wright-pierce.com>; "Slade Moore (smoore@bioconserve.net)" <smoore@bioconserve.net>
Sent: Friday, August 15, 2014 3:00 PM
Subject: RE: Bristol Mills fishway monitoring

Hi Joe,

My apologies for not getting back to you more quickly. I do not have the volunteer count data (the run estimate) entered yet… but I can try to get these data to you by the week after next, or sooner.

I did do the analysis of the tagging data, and have put the summarized data into a table below. I do not have exact measurements between the antennas right now, but I can go to the ladder and take the measurements and then calculate swim speeds between the antennas.

I'll describe briefly where we placed the antennas to give you a better understanding of the results below. The first antenna was placed at the top of the ramp at the entrance to the fishway on the downstream side. The second antenna was placed in the turn pool. The third antenna was placed in the denil section half-way between the turn pool and the fishway exit. The fourth antenna was placed at the water control gate at the fishway exit.

I'll summarize the results here. Please keep in mind that these results likely underestimate the true ability of alewives to navigate the ladder. When fish are tagged, it's added stress to their system. There was likely some mortality associated with the tagging, and more fish did not enter the fishway compared to if we had not handled them at all. Of the 22 fish that we tagged, only 6 fish, or 27.3% of the tagged fish, made it up the ramp to enter the fishway and be detected by the first antenna (likely underestimate of true efficiency). Only 2 tagged fish (9.1% of all tagged fish), successfully navigated the entire fishway and reached the top

This idea follows the fish that we did see. If the fish had not been handled, likely more of them would have made it to the top. Because the sample size (number of fish we did get data for) is so small, the data are highly variable, as you can see between the difference in the average and median time to move between antennas. That said, there was a consistent pattern. Of the 6 fish that entered the fishway, only 1 did not make it to the turn pool (second antenna).

Of the remaining five fish, all made it past antenna 2. There was some going back and forth between antenna 1 and antenna 2, each fish made on average 2 attempts to make it above antenna 2 in the turn pool.

All of the five fish that made it past the turn pool (second antenna), made it half-way up the second denil section (antenna 3). There was, again, some going back and forth between antenna 2 and antenna 3, each fish made on average 1.4 attempts to make it above antenna 3, half-way up the second denil section.

Of the fish that made it to antenna 3, only two successfully reached the top (antenna 4). One of these two, was actually not detected by antenna 4, but it reached antenna 3, and was not detected descending, so I assume it did reach the top and was not detected (which does happen, the detection system is not 100% efficient).

I hope that this is helpful. Let me know if you'd like the count data asap and I'll make it a high priority.

	A1&A2	A2&A3	A3&A4	Detected Fish	All Tagged Fish
Average Time Between (seconds)	1099	923	7		
Median Time Between (seconds)	30	1	6		
Avg. # Attempts per fish	2.0	1.4	1		
Prop. Fish Successfully Reaching Top				33.3%	9.1%
Prop. Fish Reaching A3				83.3%	22.7%
Prop. Fish Reaching A2				83.3%	22.7%
Prop. Fish Reaching A1				100.0%	27.3%

NOTE: 1000 seconds is roughly 17 minutes

APPENDIX E

Dam Inspection Reports

DRAFT

BRISTOL MILLS DAM

INSPECTION / EVALUATION REPORT

DAM NAME:	**Bristol Mills Dam**
STATE DAM ID#:	**06063**
NID ID#:	**ME00280**
MEMA ID#:	**077**
OWNER:	**Town of Bristol**
TOWN:	**Bristol, Maine**
CONSULTANT:	**Wright-Pierce**
DATE OF INSPECTION:	**September 24, 2015**

WRIGHT-PIERCE
Engineering a Better Environment

EXECUTIVE SUMMARY

This Inspection/Evaluation Report details the inspection and evaluation of the Bristol Mills Dam (ME-00280) located in the Town of Bristol, Lincoln County, Maine on the Pemaquid River near the village of Bristol. The inspection was conducted on September 24, 2015 by Wright-Pierce.

Bristol Mills Dam is currently classified as an **Intermediate, Low** Hazard dam.

In general, Bristol Mills Dam was found to be in **Fair to Poor condition** with the following major deficiencies noted;

1. Cracks along the downstream abutment at the former penstock outfall result in water leakage
2. Voids at bottom of downstream wall may result in water leakage
3. There is vegetation along the upstream embankment
4. There is concrete spalling around the former intake structure and in the sluiceway channel resulting in exposed stones and concrete.

More detailed descriptions, additional deficiencies, recommended repairs, and opinions of probable repair costs are provided within this report.

It should be noted that a detailed Inflow Design Flood Study (IDF) was not performed as part of this study.

Wright-Pierce recommends that the following actions be taken to address the deficiencies found at the dam during the inspection and evaluation:

1. Repair the cracking on the downstream face by grouting the cracks
2. Fill the voids along the toe of the dam
3. Repair the spalled concrete areas along the upstream intake and sluiceway areas.
4. Prepare an Emergency Action Plan for the Dam
5. Prepare a structural stability analysis of the dam
6. Perform an Inflow Design Flood Study (IDF) to determine the appropriate design IDF and further evaluate the dam's spillway capacity to determine stability during the IDF event.

The repairs and recommendations noted above and described in more detail herein should be made in accordance to standard design practices, specifications and construction methods. Design of the repairs analyses to confirm the extent or the work should be completed by a qualified professional engineer experienced in the design and rehabilitation of dams throughout the evaluation, design and construction process.

PREFACE

The assessment of the general condition of the dam reported herein was based upon available data and visual inspections. Detailed investigations and analyses involving topographic mapping, subsurface investigations, testing and detailed computational evaluations were beyond the scope of this report unless reported otherwise.

In reviewing this report, it should be realized that the reported condition of the dam was based on observations of field conditions at the time of inspection, along with data available to the inspection team.

It is critical to note that the condition of the dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the reported condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

____

Jan Wiegman, P.E.
Maine License No.: 5852
Project Manager
Wright-Pierce

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APPENDICES

SECTION 1

1.0 DESCRIPTION OF PROJECT

1.1 General

1.1.1 Authority

The Town of Bristol retained Wright-Pierce to perform a visual inspection and develop an Inspection/Evaluation report of conditions for the Bristol Mill dam in the Town of Bristol, Lincoln County, Maine. This inspection and report were performed in accordance with Maine Revised Statutes Title 37-B"Department of Defense, Veterans and Emergency Management" Chapter 24 Dam Safety.

1.1.2 Purpose of Work

The purpose of this investigation was to inspect and evaluate the present condition of the dam and appurtenant structures to provide information that will assist in both prioritizing dam repair needs and planning/conducting maintenance and operation.

The investigation was divided into four parts: 1) obtain and review available reports, investigations, and data previously submitted to the owner pertaining to the dam and appurtenant structures; 2) perform a visual inspection of the site; 3) evaluate the status of an emergency action plan for the site and; 4) prepare and submit a final report presenting the evaluation of the structure, including recommendations and remedial actions, and opinion of probable costs.

1.1.3 Definitions

To provide the reader with a better understanding of the report, definitions of commonly used terms associated with dams are provided in Appendix D. Many of these terms may be included in this report. The terms are presented under common categories associated with dams which include: 1) orientation; 2) dam components; 3) size classification; 4) hazard classification; and 5) miscellaneous.

1.2 Description of Project

Sections of this report are based upon available documentation, including previous inspection reports and other available information as identified in Appendix C. Other historical information obtained during the inspection, has been incorporated into this report. This material is intended to provide general information. The accuracy of this referenced information was not verified as it was outside the scope of work for this inspection.

The completion of detailed stability analyses, subsurface investigations, and underwater investigations are beyond the scope of this evaluation.

1.2.1 Location

Bristol Mills Dam, also known as Pemaquid River Dam, is located on the Pemaquid River in the Town of Bristol, Lincoln County, Maine. The dam was reportedly built by Lincoln County Electric Company in 1914. The dam impounds water from the Pemaquid River and is located at the southern end of the impoundment. The Pemaquid River originates from a series of three nearby ponds, Pemaquid, McCurdy and Biscay ponds The center of the dam spillway is located at coordinates latitude 43^0 57.608’ North and longitude 69^0 30.552’ West.

There is no road over the dam. The dam is unsecured and can be accessed from the right embankment (west) from the Bristol Dam Loop or from the left embankment (east) cross private property.

The location of the Bristol Mills Dam and impoundment are shown in Figure 1: Locus Plan. An aerial photograph of the dam is provided as Figure 2: Aerial Map.

1.2.2 Owner/Caretaker

See Table 1.1 (end of this section) for current owner and caretaker data (names and contact information).

1.2.3 Purpose of the Dam

As indicated Table 1.1 the current purpose of the dam is for fishing, swimming and recreational use and as a source for fire protection water supply. The dam was apparently originally constructed for electrical generation purposes.

1.2.4 Description of the Dam and Appurtenances

Bristol Mills Dam, (National ID ME00280 / State ID 05063 MEMA ID 077) as shown in Figure 5: Site Sketch consists of a concrete gravity dam with a spillway, an old intake structure and an east wall with a fishway.

The dam appears to be founded on ledge with rock out croppings observed at the toe of the dam, along the western abutment and at the intake structure. No earth embankments are associated with this structure.

The dam is approximately 16 feet high at its maximum and 110 feet in length. The 36 foot long spillway is a broad crested weir with a flat 5 foot wide crest and battered upstream and downstream faces. The spillway crest contains three bays separated by 1 foot high by 2 foot wide piers and slots for stop logs. A 3 foot wide by 3.5 foot deep sluiceway is also incorporated into the crest of the structure. The sluiceway has stop log channels on the upstream side of the sluiceway.

In the center of the dam is a 20 foot wide former intake structure which was part of the former hydropower plant and contains a 64 inch steel penstock. The top of the intake is 12 feet wide and is 3 feet above the crest of the dam. The upstream end of the penstock is still open and there is a rectangular opening under the slab. The downstream face of the penstock has been filled with concrete and has a 12” diameter steel pipe with a butterfly valve as a low level outlet through the former penstock opening. It is not visible where the concrete fill of the penstock ends.

The primary water level control is through a three foot wide sluiceway with stop logs in the center of the dam. In addition there are three 5 foot wide be 1 foot deep weirs with stop logs on the spillway. The overall lowest spillway along the right side of the dam has a length of 33 feet and is a 5 foot wide broad crested weir. The fishway gate provides a secondary high water impoundment water level control and consists of a 3 foot wide by 5 foot tall hand operated wooden gate.

1.2.5 Operations and Maintenance

The dam is operated and maintained by the Town of Bristol, Maine.

1.2.6 Size Classification

Bristol Mills Dam height varies from 10 feet to 16 feet and has a maximum storage capacity of 8,534 acre-feet. Refer to Appendix D for definitions of height of dam and storage.

Bristol Mills Dam is an **Intermediate** size structure.

1.2.7 Hazard Potential Classification

The dam controls flow on the Pemaquid River, which begins at the outlet of Biscay Pond and flows south about 3 miles to the Bristol Mills Dam then flows south to Boyd Pond and then outlets to the Fossett's Cove in the Atlantic Ocean.

There is a bridge approximately 300 feet downstream of the dam and several residences along the river below the bridge. According to the State MEMA files the dam has a low hazard rating.

1.3 Pertinent Engineering Data

1.3.1 Impoundment

According to prior dam inspections the impoundment has a surface area of approximately 2,000 acres and a maximum storage of 8,534 acre-feet. The watershed area is approximately 31.9 square miles and includes the Pemaquid Chain of Lakes The drainage area is predominantly gently sloping and forested with some development, primarily seasonal and permanent residences on the shores of Biscay, Pemaquid and McCurdy Ponds.

1.3.2 Reservoir

The reservoir also known as Bristol Pond is a relatively small body of water between the dam and the Bridge immediately upstream of the dam. The impoundment extends northward and has a minor influence on the water levels in Biscay Pond approximately 14,000 feet up river. Biscay Pond does not have any outlet control other than the Pemaquid River.

1.3.3 Discharges at the Dam Site

No records of peak extreme discharges from the dam site were found nor reviewed.

1.3.4 General Elevations (feet)

Elevations are based upon an On-Ground Survey performed by Wright-Pierce. Vertical Datum is referenced to NGVD29.

A.	Top of Dam (at Concrete Pad)	Elevation 78.8+/- Feet
B.	Left dam crest	Elevation 80.4 +/- Feet
C.	Normal Pool	Elevation 77.0 +/- Feet
D.	Spillway Crest	Elevation 76.0 +/- Feet
E.	Upstream Water at Time of Inspection	Elevation 74.1 +/- Feet

F. Downstream Water at Time of Inspection Elevation 62 +/- Feet

1.3.5 Main Spillway Data

A. Type Broad crested, concrete spillway/weir
B. Weir Length 33 +/- Feet
C. Weir Crest Elevation Elevation 77.0 +/- Feet

1.3.7 Design and Construction Records and History

No construction records are available for this structure. A chronological record of significant events involving repairs is as follows;

- Circa 1914 – Built by Lincoln County Electric Company
- 1994 – Significant reconstruction work conducted on the dam
- 1998 – Inspection Report by MBP Consulting
- 1999 – Dam Condition and Hazard Inspections by Maine Emergency Management Agency

1.3.8 Operating Records

Limited operating records were reviewed during the inspection and preparation of this report.

1.4 Summary Data

1.1 SUMMARY DATA TABLE

Required Phase I Report Data	**Data Provided by the Inspecting Engineer**
National ID #	ME-00280
Dam Name	Bristol Mills Dam
Dam Name (Alternate)	Pemaquid River Dam
River Name	Pemaquid River
Impoundment Name	Pemaquid River
Hazard Class	Significnat
Size Class	Intermediate
Dam Type	Gravity - Dry-Laid Stone Rubble, Concrete
Dam Purpose	Recreational, Fire Protection
Structural Height of Dam (feet)	16 +/-
Hydraulic Height of Dam (feet)	16 +/-
Drainage Area (sq. mi.)	31.9 +/-
Reservoir Surface Area (sq. mi.)	3.1 +/-
Normal Impoundment Volume (acre-feet)	8,534 +/-
Max Impoundment Volume ((top of dam) acre-feet)	UNK
SDF Impoundment Volume (acre-feet)	UNK
Spillway Type	Broad Crested, Uncontrolled Weir
Spillway Length (feet)	33’ +/-
Freeboard at Normal Pool (feet)	1.75’ +/-
Principal Spillway Capacity (cfs)	404 +/-

Required Phase I Report Data	Data Provided by the Inspecting Engineer
Auxiliary Spillway Capacity (cfs)	Not Applicable
Low-Level Outlet Capacity (cfs)	20 +/-
Spillway Design Flood (100-year flow rate - cfs)	2524 +/-
Winter Drawdown (feet below normal pool)	none
Drawdown Impoundment Vol. (acre-feet)	Not Applicable
Latitude	43° 57’ 36.95” N
Longitude	69° 30’ 32.93” W
City/Town	Bristol
County Name	Lincoln
Public Road on Crest	No
Public Bridge over Spillway	No
EAP Date (if applicable)	None
Owner Name	Town of Bristol
Owner Address	1268 Bristol Road
Owner Town	Bristol, ME 04539
Owner Phone	207-677-2116
Owner Emergency Phone	
Owner Type	Municipality or Political subdivision
Caretaker Name	Town of Bristol
Caretaker Address	1268 Bristol Road
Caretaker Town	Bristol, ME 04539
Caretaker Phone	207-677-2116
Caretaker Emergency Phone	0
Date of Field Inspection	09/24/2015
Consultant Firm Name	Wright-Pierce
Inspecting Engineer	Jan B. S. Wiegman, P.E.
Engineer Phone Number	(207) 725-8721

SECTION 2

2.0 INSPECTION

2.1 Visual Inspection

Bristol Mills Dam was inspected on September 24, 2015. At the time of the inspection, the temperature was near 75 F and sunny with a light wind. Photographs to document the current conditions of the dam were taken during the inspection and are included in Appendix A. The level of the impoundment was estimated to be at an elevation of 74.1 +/- feet about 1'-11" below the top of spillway crest. Water was flowing through the sluiceway and through the low elevation outlet. Underwater areas were not inspected. A copy of the inspection checklist is included in Appendix B.

2.1.1 General Findings

In general, Bristol Mills Dam was found to be in Fair to Poor condition with some deteriorated concrete. The specific concerns are identified in more detail in the sections below:

2.1.2 Dam

- Abutments

  Both abutments appear to be stable and in good condition. There were some cracks noted and limited seepage along the center and right interfaces with the rock.

  Shrub growth was present in close proximity to the dam abutment along the center and left upstream faces of the abutment.

- Upstream Face Main Spillway

  The upstream concrete face is battered and is cast concrete over a stone masonry wall. The exact thickness is unknown.

  The condition of the concrete upstream face is fair. Several horizontal cracks where observed. Cracks varied in width up to about an inch. Some erosion of the concrete was observed.

  There was some spalling of the concrete surface on the former intake structure wall.

  The concrete on the left spillway was in good condition and no notable cracks or erosion was observed.

- Downstream Face Right Side

  The downstream concrete face is slightly battered. No unusual movement was observed. Face appeared to be straight and true.

  Concrete is in fair to poor condition with voids observed at the bottom of wall. It was not discernable if water was moving below the wall because of the downstream water levels and the splash from the lower level outlet. The wall face has some horizontal vertical cracks in the concrete surface with signs of efflorescence, indicating that water does migrate through the cracks from behind the wall. At the time of the inspection no water was observed coming out of the cracks along the right abutment.

Cracking was noted in the arc around the former penstock outlet with a small amount of water expressing through the cracks. The water level behind the dam was approximately 3 feet below the normal levels. From staining below the cracks it appears that water does leak from the cracks when the water level behind the dam is at the normal level. The cracks are around 1 inch wide and some of the concrete has spalled near the joint.

There were voids at the dam interface with the bedrock adjacent to the former penstock facility. Water was noted leaking from the dam rock interface.

- Crest

  The condition of the concrete slab crest is fair. Some erosion of the concrete surface was observed on the concrete piers. No reinforcing steel was observed. The stop log slots were observed along the spillway crest, although the stop logs were not in place at the time of the inspection.

  The stop logs in the sluiceway were also not installed. The sluiceway did have some cracking at concrete joints and on the interior of the sluiceway there was a loss of concrete along the walls which exposed the stones and concrete.

- Instrumentation

  No instruments were observed at the dam.

- Access Roads and Gates

  There is no road to or over the dam. The dam is unsecured and can be accessed from the right embankment (west) from Bristol Dam Loop. The access to the left dam embankment is across private property which is accessible from the private driveway and bridge just north of the embankment or private driveway off the Redonnett Mill Road.

- Drains

  No drains were observed during the inspection. However the downstream concrete wall has some voids along the toe.

2.1.3 Appurtenant Structures

- Sluiceway

  On the Westerly side, there is a 3 feet wide stop log controlled sluiceway. The stop logs were not in place at the time of the inspection. There was cracking of the concrete observed at the horizontal joints and there were exposed stones within the sluiceway walls where the concrete sparge has spalled.

- Fishway

  On the Easterly side there is a 3 foot wide by 5 foot tall timber weir gate. The gate is controlled by a manually operated screw drive with a stem attached to the gate and frame. The wooden gate opens from the bottom of the weir and is at the upper entrance to the fishway. The gate appears to be functional and discharges directly into the fishway.

  The fishway itself is a concrete trough with wooden weirs and is characterized as a denil ladder type of fishway. There was some erosion adjacent to the concrete side walls of the fishway which may be caused by a combination of seepage next to the fishway and by high flows over the dam that run along the side of the fishway.

- Low Level Outlet
  The low level outlet is a 12 inch diameter pipe that is located in the former penstock area and has a hand operated butterfly valve at the pipe outlet. The valve was open at the time of the inspection.

- Safety Fence
  There is a safety fence along the spillway to that consists of metal pipe posts fastened to the spillway and coated metal fabric fence material fastened to the posts. The bottom of the fence material is about 18” above the spillway crest and runs from the right embankment to the raised penstock slab and across the penstock slab at the face of the dam. The condition of the fence is fair and is makeshift in appearance. Access to the dam spillway is not restricted.

2.1.4 Downstream Area

The channel immediately downstream of the dam is comprised primarily of ledge and cobbles. There are boulders arranged in a line across the river to assist in directing fish to the entrance to the fishway on the east side of the river. The banks of the river have a moderate growth of trees and brush. About 300 feet downstream of the dam is a bridge crossing of Redonnett Mill Road. Approximately 800 feet downstream of the Redonnett Mill Road bridge is the Upper Round Pond Road bridge.

2.1.5 Reservoir Area

No unusual conditions were observed upstream of the dam. The upstream channel is formed by the Pemaquid River. Approximately 150 feet upstream of the dam there is a bridge crossing of the Pemaquid River which constricts the width of the river to approximately 15 wide opening under the bridge.

The Pemaquid River flows from the outlet of Biscay Pond approximately 14,000 feet to the Bristol Mills Dam. Above Biscay Pond there are a series of ponds that are closely connected that form the headwaters of the Pemaquid River including Pemaquid Pond, McCurdy Pond, Duckpuddle Pond, Little Pond and Muddy Pond.

2.2 Caretaker Interview

No interview or information was obtained.

2.3 Operation and Maintenance Procedures

2.3.1 Operational Procedures

There are no written operational procedures for the Dam.

2.3.2 Maintenance of Dam

Maintenance has been performed on the Bristol Mills Dam on an as-needed basis by the Town of Bristol.

2.4 Emergency Warning System

No Emergency Action Plan (EAP) has been developed for Bristol Mills Dam.

2.5 Hydrologic/Hydraulic Data

The Bristol Mills Dam is an **Intermediate** sized, **Low** hazard structure. Maine Statues require that the Inflow Design Flood (IDF) is determined in accordance with U.S. Army Corps of Engineer's procedures.

We recommend that a formal IDF study is performed to determine the appropriate IDF for the structure.

2.6 Structural Stability

No formal stability evaluations have been completed for this structure since the original design; no records of the original design computations were available for review at the time of the preparation of this report.

SECTION 3

3.0 ASSESSMENTS AND RECOMMENDATIONS

3.1 Assessments

In general, the overall condition of Bristol Mills Dam is ***FAIR to POOR condition.*** The dam was found to have the following deficiencies:

1. Cracking in the concrete along the upstream face.
2. Spillway concrete erosion
3. Voids at bottom of downstream wall and along the rock interface near the penstock area
4. Cracks on the downstream face in the area of the former penstock
5. No formal Emergency Action Plan for the dam has been developed

The following recommendations and remedial measures generally describe the recommended approach to address current deficiencies at the dam. Prior to undertaking recommended maintenance, repairs, or remedial measures, the applicability of environmental permits needs to be determined for activities that may occur within resource areas under the jurisdiction of local conservation commissions, DEP, or other regulatory agencies.

3.2 Studies and Analyses

The following studies or analyses are recommended to evaluate concerns and comply with current regulations. These studies and analyses shall be performed by a qualified professional engineer experienced dams and hydrology, maintenance and monitoring activities.

1. Perform a site specific Inflow Design Flood (IDF) study in accordance with Maine Statute and the procedures outlined by the U.S. Army Corps of Engineers.

2. Perform a hydrologic and hydraulic analysis to determine performance of the Dam's Spillway during the IDF (see above). Prepare recommendations for spillway improvement based upon spillway performance during the IDF event. A structure that cannot discharge the inflow associated with the design flood will be overtopped in an uncontrolled manner that could damage the structure and threaten downstream areas.

3. Perform a structural stability analysis of the dam for overturning.

3.3 Recurrent (Yearly) Maintenance Recommendations

1. Perform regular monitoring and inspection of the dam, spillway, and gates, including areas of observed concrete deterioration, leakage through walls, unwanted vegetation development, accumulation of debris or other areas of suspected movement or concerns, to check for signs of deteriorating conditions. Complete formal inspections of the dam in accordance with current state regulations. As the dam is currently classified as a low hazard potential structure, formal inspections are required every ten (10) years.
2. Regular maintenance activities should be continued to control and prevent further growth of unwanted vegetation, as was noted in areas during the inspection, as well as remove debris from the spillway. Mowing grass and cutting brush should be performed at least twice per year (i.e., late spring and fall). All cuttings from brush and other vegetation should be removed from the site and properly disposed.

3.4 Minor Repair Recommendations

The following recommendations should be implemented to maintain the integrity and improve the overall condition of the dam but do not alter the current design of the dam. These recommendations may require design by a professional engineer and construction by a contractor experienced in dam construction or repair.

- There are no remedial modifications recommendations at this time.

3.5 Remedial Modification Recommendations

The following modifications should be implemented to improve the safety and integrity of the dam and to extend the life of the structure. These recommendations will likely require design by a professional engineer and construction by a contractor experienced in dam repair.

Repairs are needed to address the condition of the concrete on the downstream faces and at the sluiceway and around the former intake structure as well as improve the structural stability of the dam.

- Repair spalled concrete and fill cracks along the upstream face at the sluiceway walls and the former intake structure.
- Repair voids at the toe of the dam.
- Repair cracks on the downstream face at the former penstock outlet and along the rock interface with the dam
- Perform the additional studies noted in Section 3.2.

3.6 Alternatives

No alternatives for replacement were considered.

3.7 Opinion of Probable Construction Costs

The following conceptual opinions of probable costs have been developed for the recommendations and remedial measures noted above. The costs shown herein are based on limited investigation and are provided for general information only. This should not be considered an engineer's estimate, as construction costs may be less or considerably more than indicated.

Studies and Analyses

1. Site Specific IDF Study		$6,000 - $8,000
2. Prepare Emergency Action Plan		$3,000 - $4,000
3. Structural Stability Calculations		$2,000 - $3,000
	Total	$12,000 - $16,000

Recurrent (Yearly) Maintenance Recommendations

1. Regular monitoring and inspection		$1,000 - $3,000
2. Regular maintenance		$1,000 - $3,000
	Total	$2,000 - $6,000

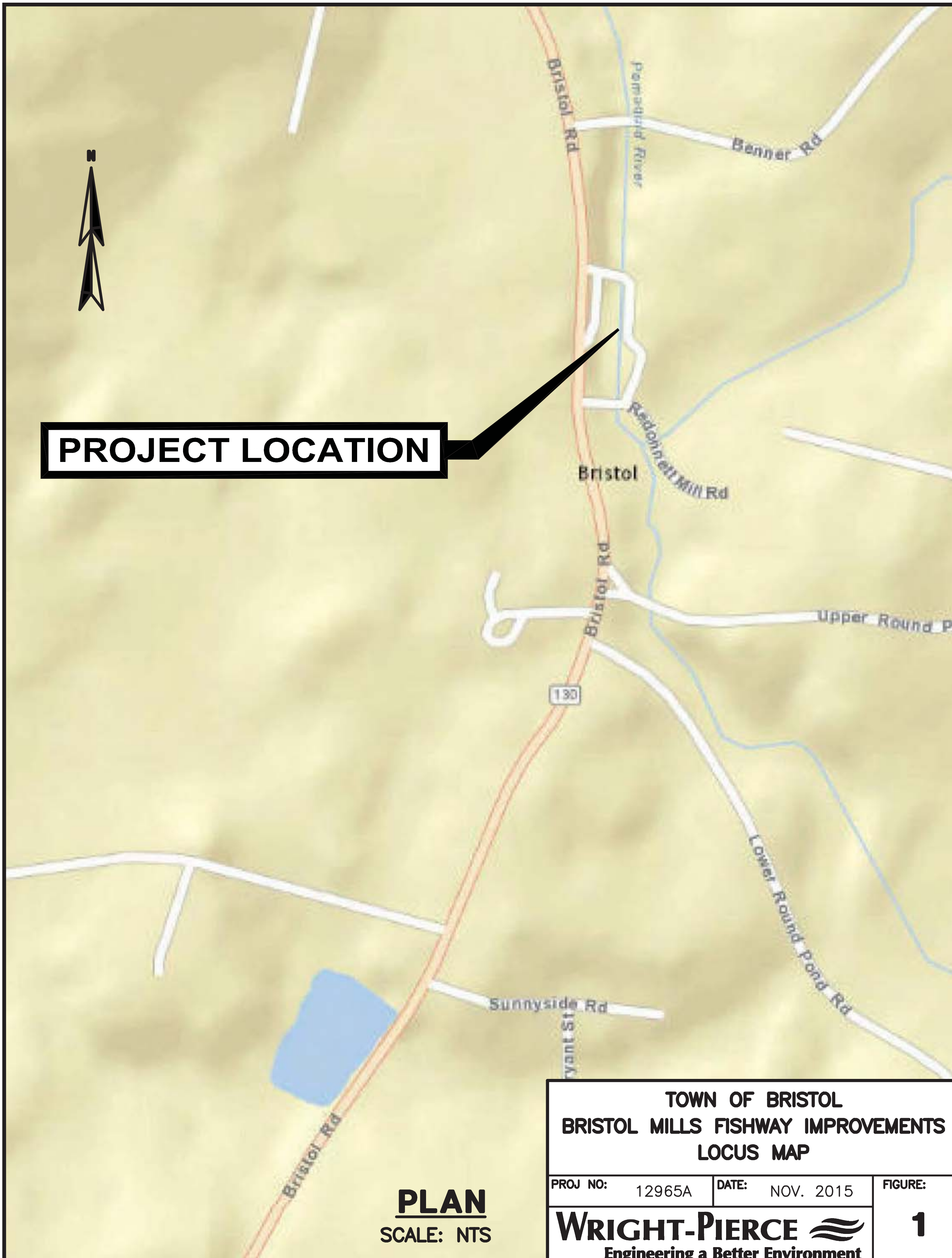
Minor Repair Recommendations

1. None

Remedial Modification Recommendations

1.	Mobilize / Demobilize	$ 7,000 - $ 10,000
2.	Upstream Face: repair spalled concrete and fill cracks in former intake and sluiceway	$ 8,000 - $ 12,000
3.	Fill Voids at Toe of Dam	$ 9,000 - $ 12,000
4.	Repair Cracks on Downstream face at penstock outfall and along rock interface	$ 8,000 - $ 11,000
	Subtotal	$32,000 - $45,000
	Engineering & Design	$ 2,500 - $3,500
	Permitting	$ 2,000 - $2,500
	Construction Administration	$ 2,000 - $3,000
		$6,500 - $9,000
	40%Contingency	$13,000 - $18,000
	Opinion of Probable Construction Cost	**$51,500 - $72,000**

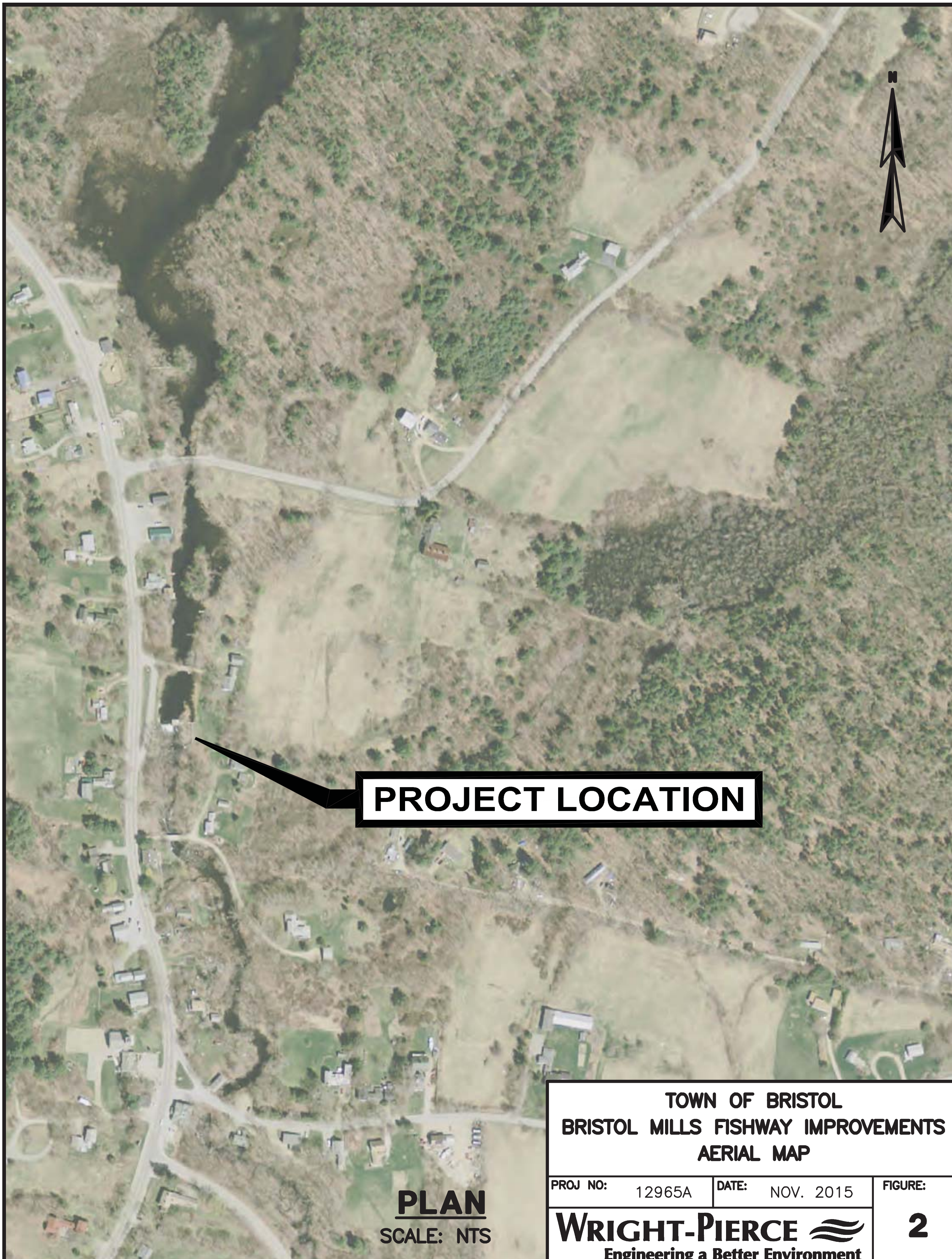
FIGURES



TOWN OF BRISTOL
BRISTOL MILLS FISHWAY IMPROVEMENTS
LOCUS MAP

PROJ NO: 12965A	DATE: NOV. 2015	FIGURE: 1

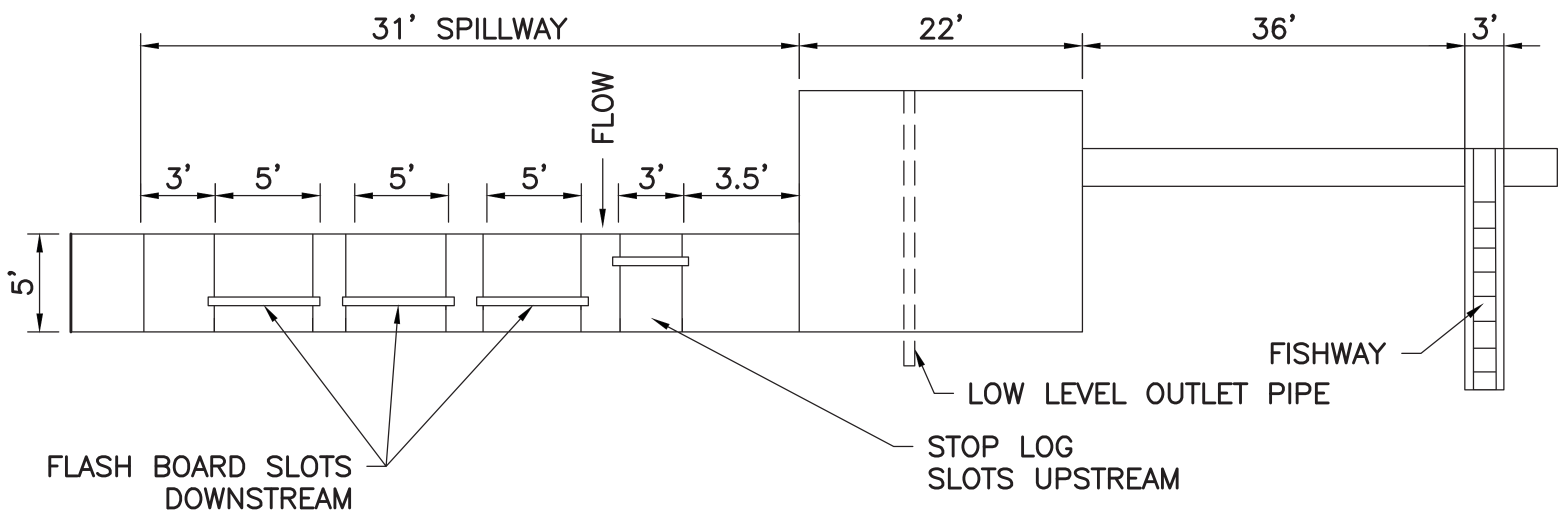
WRIGHT-PIERCE
Engineering a Better Environment



TOWN OF BRISTOL
BRISTOL MILLS FISHWAY IMPROVEMENTS
AERIAL MAP

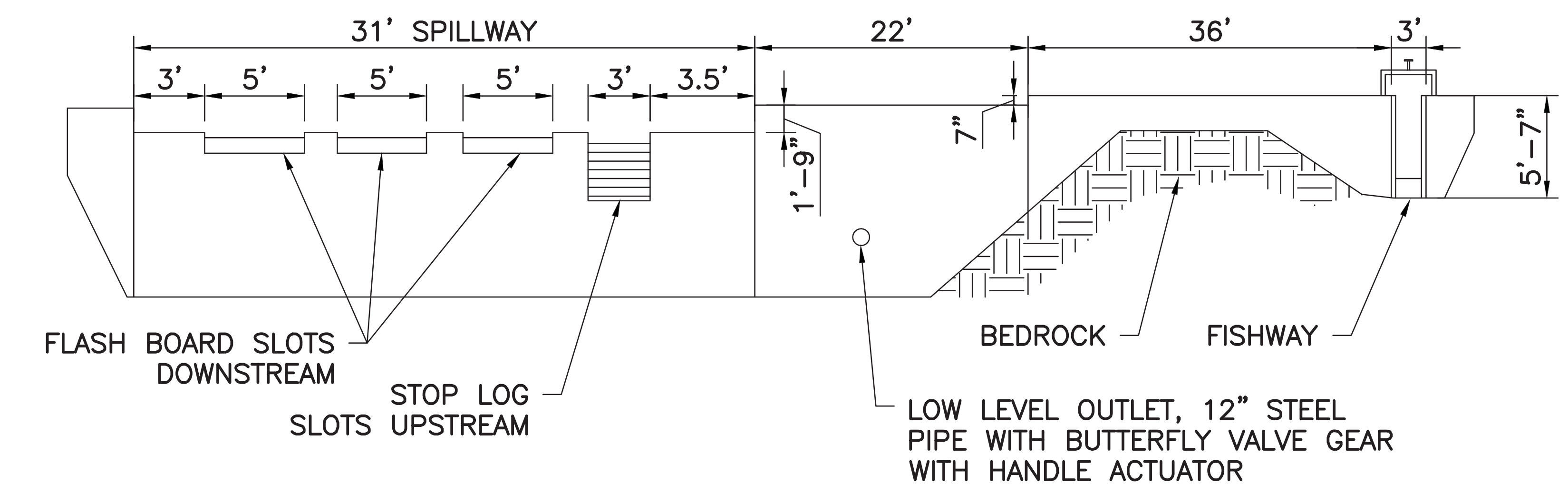
PROJ NO:	DATE:	FIGURE:
12965A	NOV. 2015	2

WRIGHT-PIERCE
Engineering a Better Environment



PLAN VIEW

NTS



DOWNSTREAM ELEVATION

NTS

TOWN OF BRISTOL
BRISTOL MILLS FISHWAY IMPROVEMENTS
DAM ELEVATIONS AND PLAN VIEW

PROJ NO: 12965A
DATE: NOV. 2015
FIGURE: 4

WRIGHT-PIERCE
Engineering a Better Environment

TOWN OF BRISTOL BRISTOL MILLS FISHWAY IMPROVEMENTS BRISTOL, MAINE	WRIGHT-PIERCE Engineering a Better Environment Offices Throughout New England 888.621.8156 | www.wright-pierce.com	DESIGNED BY: JMM CAD COORD: RPB CAD: RPB CHECKED BY: JMM DATE: 5-12-15 APPROVED BY: JMM DATE: 5-12-15 PROJECT NO: 12965A	DRAWING FIG-5
EXISTING CONDITIONS PLAN			

NO	SUBMISSIONS/REVISIONS	APP'D	DATE
1			
2			
3			
4			

APPENDIX A
Photographs

Photo #1 - Overview of Dam from Upstream

Photo #2 – Overview of Dam from Downstream

Photo #3 – Overview of Left Abutment

Photo #4 - Overview of Downstream Face Right Abutment

Photo #5 – Overview Upstream of Spillway Crest

Photo # 6 – Fishway Control Gate on Left Abutment

Photo #7 – Overview Upstream Face Right Abutment

Photo #8 - Downstream Face Left Abutment

Photo #9 – Overview of the Upstream Impoundment

Photo #10 – Overview of the Downstream River

Photo #11 – Left Spillway from Downstream

Photo #12 – Left Spillway from Downstream

Photo #13 – Upstream View of Former Penstock Intake

Photo #14 – Downstream View of Former Penstock with Low Level Outfall

Photo #15 – Voids at Abutment near Penstock Ledge Interface

Photo # 16 – Cracks in Downstream Face Right Side

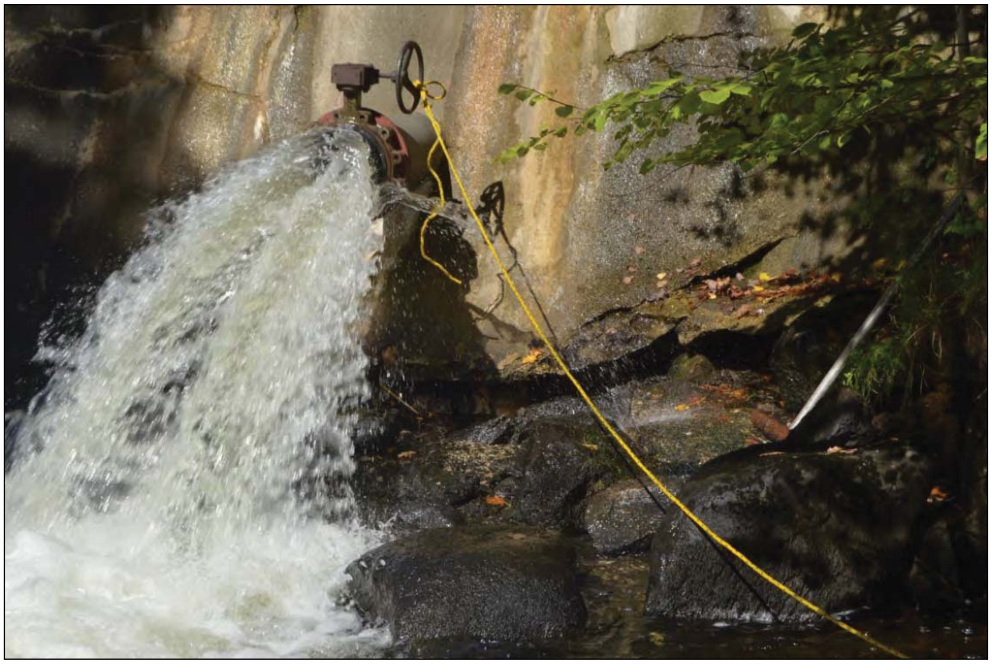


Photo # 17 – Voids at base of Downstream Abutment

Photo 18 – Minor Concrete Erosion At Spillway Crest

Photo #19 – Penstock Intake with Loss of Concrete

Photo #20 – Sluiceway with Concrete Cracking and Exposed Rocks

APPENDIX B
Inspection Checklist

Dam Inspection Checklist

Dam Name:	Bristol Mills Dam	Inspector:	Jan Wiegman, PE
	State Id # 05063 Nat. ID # ME00280		Wright-Pierce
	MEMA # 077	Owner:	Town of Bristol
River/Stream/Lake:	Pemiquid River	Address:	1268 Bristol Road
Current Hazard Potential	High___ Significant ___ Low___	Address:	Bristol, ME 04539
Dam Location (Town)	Bristol Mills Dam	Dam Type:	Concrete and masonry
Date of Inspection:	9/24/2015	Laditude:	43°57.615" Longitude: 69°30.550"
Genreal Comments:	Water level had been drawn down to approximately 35" below crest		
	All stop logs and flash boards were remooved Low level outlet was open		

Item	Yes	No	N/A	Remarks:
1. Crest				
a. Settlement?		X		
b. Misalignment?		X		
c. Cracking?		X		
d. Trees/Brush?		X		
e. Evidence of Major Rehabiliation?				
2. Upstream Slope				
a. Adequate grass Cover?	X			
b. Erosion?		X		
c. Trees/brush on Slope?	X			Left side
d. Longitudinal Cracks?		X		
e. Transverse Cracks?		X		
f. Adequate Riprap Protection?	X			
g. Any Stone deterioration?		X		
h. Visual depressions or buldges?		X		
i. Visual settlements?		X		
j. Debris or trash present?	X			
3. Downstream Slope				
a. Adequate grass Cover?	X			
b. Erosion?	X			On either side of the fishway
c. Trees/brush on Slope?	X			
d. Longitudinal Cracks?	X			
e. Transverse Cracks?		X		
f. Visual depressions or buldges?		X		
g. Visual settlements?		X		
h. Is the tow drain dry?			X	
i. Are drainage well flowing?			X	
j. Are boils present at the toe?				Could not observe toe because back water

Item	Yes	No	N/A	Remarks:
k. is seeppage present?				Toe was partially submerged
l. Soft or spongy zones present?		X		
m. Are foundation toe drains pipes			X	
(1) Broken, bent, or missing?				
(2) corroded or rusted?				
(3) Obstructed?				
(4) Is discharge carring sediment?				
4. Abutment Contacts				
a. Any erosion?		X		
b. Visual differential movement?		X		
c. Any cracks noted	X			Minor cracks noted on both left and right sides
d. Is sepage present	X			Minor seepage noted on left and right contact areas
5. Pricncipal Spillway Inlet				
a. Do concrete surfaces show:				
(1) Spalling?		X		
(2) Cracking?		X		
(3) Erosion?		X		
(4) Scaling?		X		
(5)Exposed rebar?		X		
b. Do Joints show:				
(1) Displacement of offset?		X		
(2) Loss of joint material?		X		Water was flowing in spillway did not see bottom joint
(3) Leakage?		X		
c. Metal Appertenances:			X	
(1) Rust present?				
(2) Broken components?				
(3) Anchor system Secure?				
d. Trashrack operational?				
6. Principal Spillway Conduit				
a. Is the Conduit Concrete?	X			
b. Do concrete surfaces show:				
(1) Spalling?	X			Inside of sluiceway wall
(2) Cracking?	X			inside sluiceway wall
(3) Erosion?		X		
(4) Scaling?		X		
(5)Exposed rebar?		X		
c. Do Joints show:				
(1) Displacement of offset?		X		
(2) Loss of joint material?	X			Inside of the sluiceway walls

Item	Yes	No	N/A	Remarks:
(3) Leakage?		X		
d. Is the conduit metal?		X		
(1) Rust present?				
(2) Protective coatings adequate?				
(3) Is the conduit misaligned?				
e. Seepage around the conduit?		X		
7. Stilling Basin				
a. Do concrete surfaces show:			X	
(1) Spalling?				
(2) Cracking?				
(3) Erosion?				
(4) Scaling?				
(5)Exposed rebar?				
b. Do Joints show:			X	
(1) Displacement of offset?				
(2) Loss of joint material?				
(3) Leakage?				
c. Do energy disapators show:			X	
(1) Signs of deterioration				
(2) Accumulation of Debris				
d. Is the channel:				
(1) Eroding?		X		
(2) Sloughing?		X		
(3) Obstructed?		X		
e. Is discharged water:				
(1) Undercutting the outlet?	X			Voids observed at toe of downstream face left side
(2) Eroding the embankment?		X		
8. Emergency Spillway				
a. Does Concrete spillway show:				
(1) Spalling?		X		
(2) Cracking?		X		
(3) Erosion?		X		
(4) Scaling?		X		
(5)Exposed rebar?		X		
b. Do Joints show:				
(1) Displacement of offset?		X		
(2) Loss of joint material?		X		
(3) Leakage?		X		
c. Is spillway in Rock or Soil?			X	

Item	Yes	No	N/A	Remarks:
(1) Are slopes eroding?				
(2) Are slopes sloughing?				
d. Is the discharge channel :				
(1) Eroding or back cutting?				
(2) Obstructed?				
(3) Is vegetative cover adequate?				
e. Has discharged water:				
(1) eroded the embankment?		X		
(2) Undercut the Outlet?		X		
f. Is weir in good condition?	X			
9. Valves/Gates				
a. Are valves/gates:	X			
(1) Broken or bent?		X		
(2) Corrroded or rusted?		X		
(3) Periodically maintained?		X		As reported by Town
(4) Operational?	X			
b. Is there a low level valve?	X			
c. Is the low level valve operational?	X			Functioning during inspection
10. Area Downstream				
a. Recent downstream development?		X		
b. Seepage or wetness?		X		

Notes:

1. Screen on the low level inlet was temporary and should be made more substantial to keep debris out of inlet area
2. Slight seepage on downstream left side where rock and concrete interface/contact area
3. Minor leakage from cracks around tailrace plug on down stream face
4. Slight leakage along right side contact area
5. Some small trees on penninsula above dam
6. Some erosion alonf outside of walls of fshway
7. Fence and posts along top of dam. Public access to top of dam

APPENDIX C
Previous Reports and References

PREVIOUS REPORTS AND REFERENCES

The following is a list of reports that were located during the file review, or were referenced in previous reports.

1. Inspection of Bristol Mills Dam for the Maine Emergency management Agency by MBP Consulting date May 1998.

2. MEMA Inspection Report #077 Bristol Mills Dam, Bristol, Maine dated 24 August 1999

The following references were utilized during the preparation of this report and the development of the recommendations presented herein.

1. "ER 1110-2-106-Recommended Guidelines for Safety Inspection of Dams", Department of the Army, September 26, 1979

2. "Design of Small Dams", United States Department of the Interior Bureaus of Reclamation, 1987

INSPECTION
OF
BRISTOL MILLS DAM

BRISTOL, MAINE

MAINE EMERGENCY MANAGEMENT AGENCY

MAY 1998

MBP Consulting

PLANNING AND ENGINEERING

INSPECTION OF BRISTOL MILLS DAM

BRISTOL, MAINE

National ID: ME00280 State ID: 05063 MEMA ID: 077

Submitted to:

Maine Emergency Management Agency
Augusta, Maine

Submitted by:

MBP Consulting
Portland, Maine

May 1998

TABLE OF CONTENTS

SUMMARY

Based on review of the project information and the October 8, 1997 field inspection findings, the structures of Bristol Mills Dam are considered to be in fair to poor condition. Although no signs of immediate failure of the dam were observed, there are concerns which may present a threat to the integrity of the dam and public safety. The major concerns are significant seepage through the intake structure, reduced spillway hydraulic capacity after the 1994 restoration work, and inaccessibility of the spillway and sluice stoplogs during flood events. General deficiencies of the project include the absence of written operating and maintenance procedures.

To improve the integrity of the dam and protect the public safety, it is recommended that the Owner of the dam obtain the services of a registered professional engineer to implement the following corrective measures within 1 year of receipt of this report:

1. Reduce seepage through the intake and rehabilitate the deteriorated base of the spillway and old intake structure.
2. Evaluate the effect of the reduced spillway hydraulic capacity on stability of the dam.
3. Provide access to the spillway and sluice stoplogs during flood conditions.

The implementation of these recommendations should include determination of the appropriate spillway design flood based on the dam hazard classification and stability evaluation, as necessary.

To improve operation and maintenance of the dam and adequately respond to emergency conditions threatening the dam and public safety, it is recommended that the Owner implement the following within 1 year of receipt of this report:

1. Repair a void in the east sidewall of the sluice.
2. Repair the deteriorated timber noses of the spillway piers.
3. Operate the spillway and sluice stoplogs on a regular basis.
4. Remove all the sluice stoplogs annually to flush silt and debris.
5. Cut and remove trees and brush from the dam and within 20 feet of the dam abutments.
6. Monitor the dam semi-annually for seepage and changes in condition and record the observations in a monitoring log.
7. Engage a registered professional engineer to conduct a detailed inspection of the dam and appurtenant facilities every 5 years.
8. Establish written operation and maintenance procedures at the dam.

9. Establish an emergency action plan, if necessary, for conditions that could threaten the dam and public safety.

1.0 INTRODUCTION

In accordance with the agreement for professional services between the State of Maine Emergency Management Agency (MEMA) and MBP Consulting (MBPC) dated April 17, 1997, MBPC has performed the inspection of Bristol Mills Dam and prepared the report of the findings. This report contains a review of the project data, results of the visual observation of the project facilities, assessment, and recommendations.

As a follow-up to the recent history of dam failures in Maine, MEMA conducted a brief, statewide inspection in 1996 and 1997 of about 220 dams with significant and high hazard potential identifying the dams requiring detailed inspection and condition evaluation by a professional engineer. The purpose of the 1997 inspection program is to perform a visual inspection and evaluation of significant and high hazard dams, which may threaten the public safety, and recommend corrective measures, if required.

It should be noted that this report does not pass judgement on the safety, hydraulic adequacy, or stability of the dam other than on a visual basis. The purpose of this inspection is to identify those features of the dam which need corrective action and/or further study.

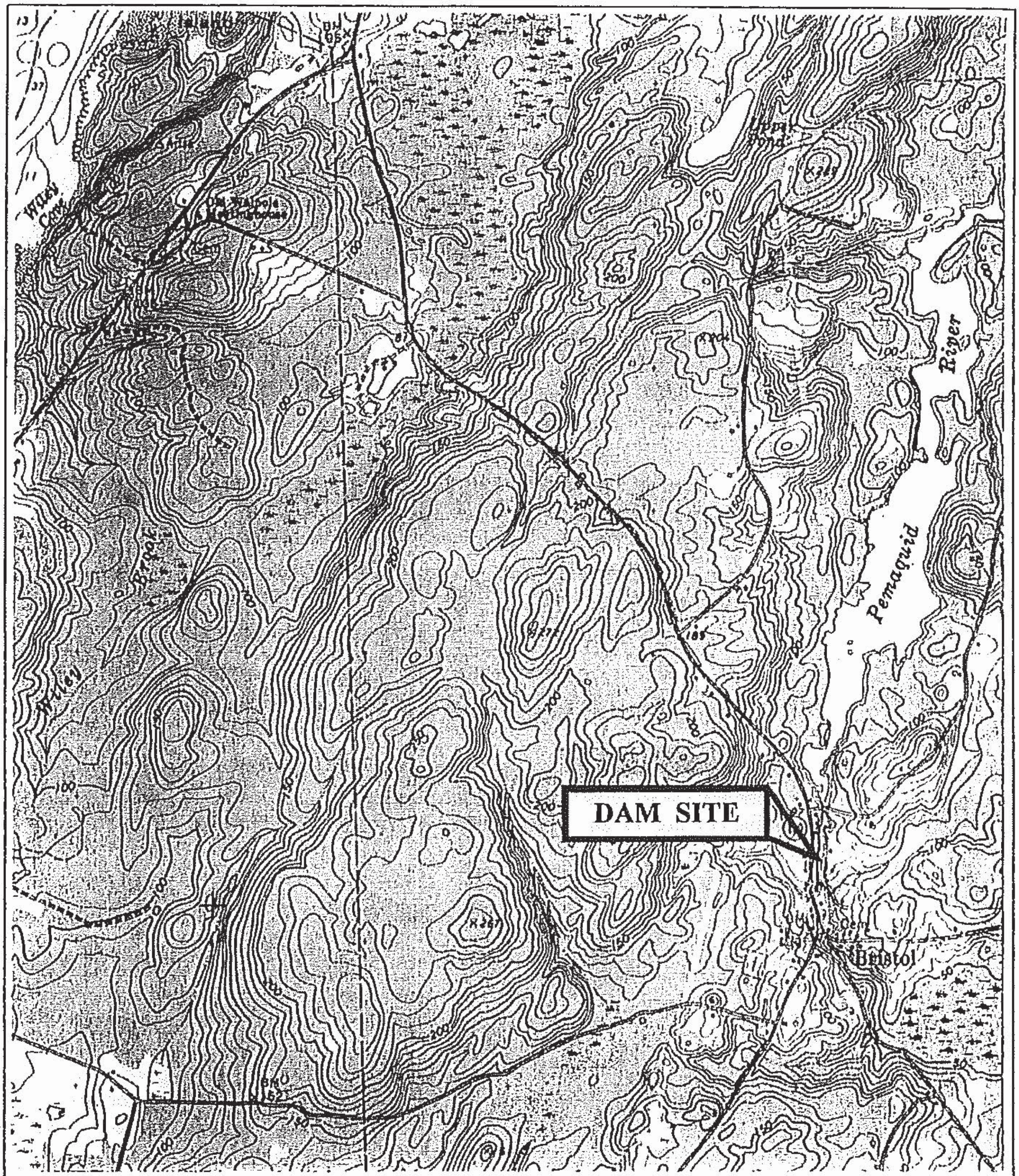
2.0 PROJECT DESCRIPTION

Bristol Mills Dam, also known as Pemaquid River Dam, (National ID # ME00280, State ID # 005063, MEMA ID # 077) is located on the Pemaquid River, in the Town of Bristol, Lincoln County, Maine (Figure 1). Bristol Mills Dam was reportedly built by Lincoln County Electric Company in 1914.

The dam impoundment has a surface area of 2,000 acres and maximum storage of 8,534 acre-feet and is shown on the USGS "Bristol" Quadrangle Map (Figure 1). The dam is classified as an intermediate size structure (the dam height is less than 40 feet, impoundment storage between 1,000 and 50,000 acre-feet) with significant hazard potential[1]. The dam is owned and operated by the Town of Bristol, Maine (Owner).

The 16-foot-high, 110-foot-long concrete gravity dam consists of a spillway, an old intake structure, and an east wall. The dam apparently is founded on bedrock. Rock outcrops were observed along the downstream toe of the dam and at the dam abutments. A field sketch prepared during this inspection shows a plan, downstream view, and sections of the dam (Figure

[1] Significant hazard potential category structures are usually located in predominantly rural or agricultural areas where failure may cause serious damage to isolated homes, secondary highways, or minor railroads; cause interruption of use or service of relatively important public utilities; or cause some incremental flooding of structures with possible danger to human life. (Federal Energy Regulatory Commission. *Engineering Guidelines for Evaluation of Hydropower Projects*, 1991).



BRISTOL MILLS DAM BRISTOL, ME National ID: ME00280 Maine ID: 05063 MEMA ID: 077	N	**FIGURE 1** **LOCATION MAP** USGS Quadrangle "BRISTOL", ME Approx. Scale: 1" = 2000'

2). The following description of the dam is based on the available project information and visual observations during this inspection which included an approximate dimensional survey.

The 36-foot-long spillway is a broad-crested weir with a flat, 5-foot-wide crest and battered upstream and downstream faces. The spillway crest contains three bays separated by 1 feet high, 2 feet wide piers and housing 8-inch-high stoplogs. A 3.3-foot-wide, 3-foot-deep sluice equipped with wooden stoplogs is also incorporated into the spillway crest.

The 20-foot-long old intake structure flanks the east spillway side. The intake was a part of the abandoned hydropower plant and contained a 64-inch steel penstock. The top of the intake is 12 feet wide and is 3 feet above the spillway crest. The structure contains a 12-inch outlet pipe with a valve at the downstream end.

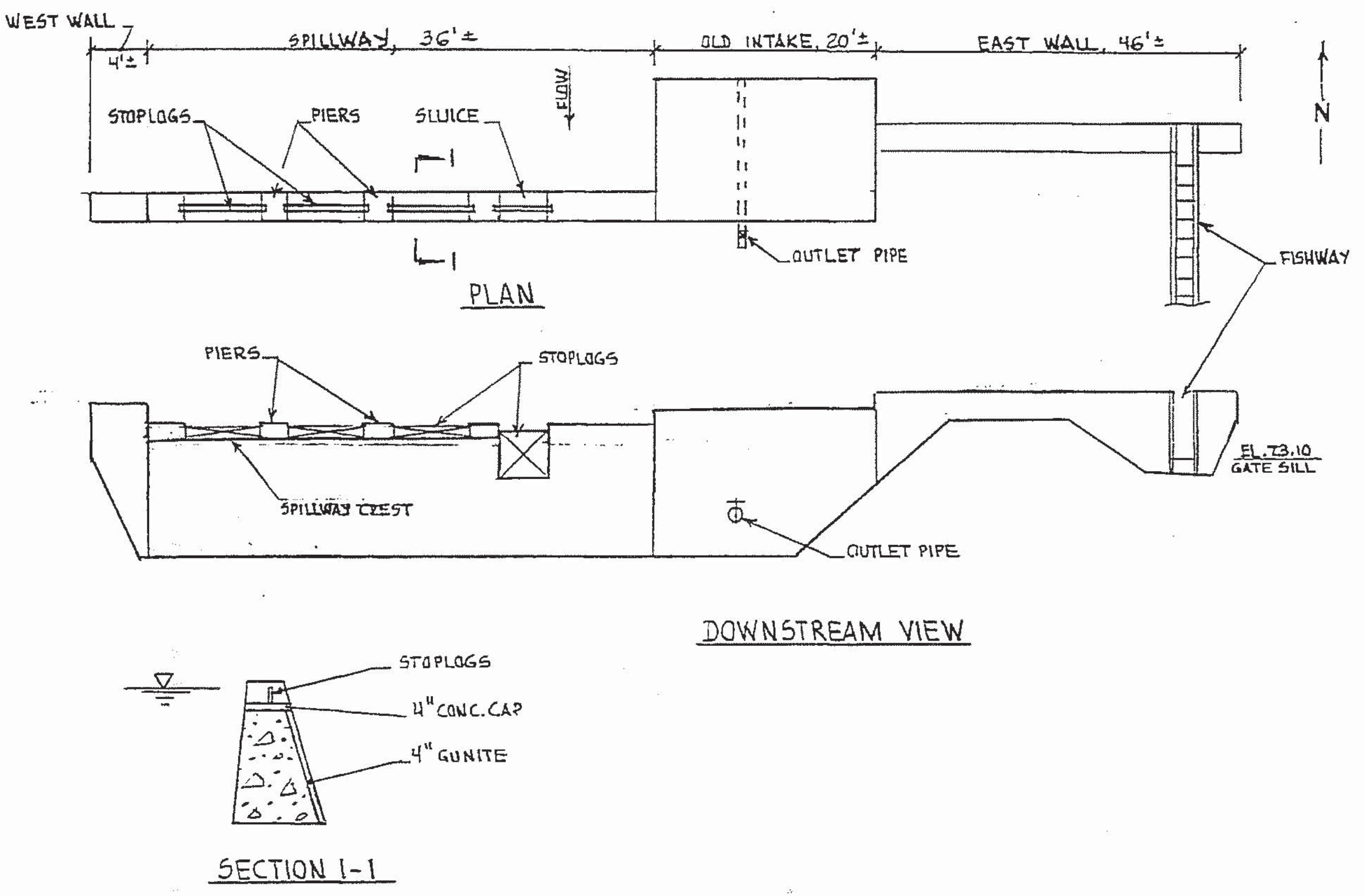
The east wall connects the old intake structure with the east abutment of the dam. The wall is a gravity structure, 2 to 7 feet high, 46 feet long, and 1 to 1.5 feet wide at the top. The wall contains a fishway at the dam abutment operated by the Maine Department of Marine Resources.

3.0 PROJECT INFORMATION

The following project data were available for review and preparation of this report:

- Pemaquid Dam Restoration, Proposed Modification. Five Project Drawings. Applied Engineering, Inc., Wiscasset, Maine, July-August 1994.
- Pemaquid Dam Restoration Project. Notice to Bidders. Applied Engineering, Inc., Wiscasset, Maine, September 1994.
- Bristol Mills Dam. Maine Dams Registration Master Report. Maine Department of Environmental Protection (MDEP), January 23, 1993.
- Bristol Mills Dam Database Sheet. MEMA.
- Bristol Mills Dam Inspection Checklist. MEMA, June 19, 1996.

Significant reconstruction work was conducted at the dam site in 1994. The work included lowering the top of the old intake and installation of a new concrete platform on the top of the intake, installation of a new, 12-inch steel outlet pipe in the old 64-inch steel penstock, and filling the penstock with concrete. A 6-inch concrete cap was removed from the spillway crest and a new concrete cap was installed. Four, 1-foot-high, 2-foot-wide concrete piers were installed over the crest between the sluice and west spillway side. The spillway crest between the sluice and old intake was raised by placement of a 1-foot-high concrete overlay. The downstream face of the spillway and old intake structure was rehabilitated with installation of a 4-inch-thick layer of gunite. The dam restoration work was conducted by Knowles Industrial Services, Portland, Maine.



Bristol Mills Dam, Bristol, ME **Maine Emergency Management Agency** **State Dam Inspection Program**	**Field Sketch:** **Plan, Downstream View, and Sections** Not to Scale	**MBP Consulting** **Portland, ME**	**FIGURE 2**

Appendix A contains project information including the dam datasheets prepared by MEMA and MDEP, and a checklist of the inspection conducted by MEMA.

There were no maintenance records available for review.

4.0 PROJECT OPERATION AND MAINTENANCE

The normal summer pond is reportedly maintained 6 inches above the spillway crest. The typical spring pond level is about 1 inch above the top of the spillway piers with stoplogs in place. The spillway and sluice stoplogs are usually closed and are not used to control the pond level or discharge over the spillway. The fishway gate is operated regularly by a dam keeper.

There were no written operation and maintenance procedures or records available for review on the project events, such as floods, heavy rainfall or ice impact.

5.0 FIELD INSPECTION

The field inspection of the dam was performed on October 8, 1997 by Myron Petrovsky of MBPC assisted by Dwayne Boynton (Owner). The Owner was interviewed at the site on the project data, events, repairs, and operation and maintenance. The inspection was conducted on a sunny day with the ambient temperature about 50 degrees F. At the time of the inspection, the pond level was 0.1 feet above the spillway crest, the spillway and sluice stoplogs were in place, and the fishway gate was open 1.5 feet.

The inspection was performed by visually observing the accessible project structures. The structures, abutments, and downstream discharge channel were observed for signs of weathering, deterioration, erosion, cracking, steel and reinforcement corrosion, movement, seepage, leakage, undermining, vegetation, siltation, and accumulation of debris. Photographs showing the condition of the dam structures at the time of the inspection are presented in Appendix B.

<u>Spillway.</u> The spillway (Photos B-1 and B-2) was inspected with some flow over the crest and wetted downstream surfaces. The crest and upstream face were free from major cracks and deterioration. The pier noses built of 4-inch square timbers showed some splitting and erosion. The downstream face contained a few cracks of shrinkage type with efflorescence. The toe of the spillway at the deepest section was not observed for scour and seepage due to a pool of water. The exposed portion of the base adjacent to the intake was undermined resulting in a loss of contact with rock.

<u>Sluice.</u> The east sidewall of the spillway sluice contained a 6-inch by 8-inch void at the stoplog guide. Flow at an estimated rate of 40 to 60 gallons per minute (gpm) was coming through the void and bypassing the stoplogs. Total leakage through the pressure treated timber sluice stoplogs was 80 to 100 gpm.

Intake. The old intake structure (Photo B-2) exhibited cracks and efflorescence in the 1994 gunite on the downstream face. The base of the structure was significantly deteriorated and undermined to a depth of 2 feet. Two seepage areas were observed at the base. A 2-foot-long area with a flow of 20 to 40 gpm was located immediately west of the 12-inch pipe outlet (Photo B-3). The majority of the flow was coming between the gunite layer and original concrete. The second seepage area was located farther east of the pipe outlet in the exposed base rock. The seepage was about 20 gpm and extended along a 10-foot-length and originated from rock joints and fissures.

East Wall. The east concrete wall (Photo B-4) was in fair condition. The 2 to 7-foot-high wall was dry on the upstream and downstream sides with the wall base mostly located above the pond level. A few cracks of old origin were observed in the downstream face. The area downstream of the wall and dam abutment were overgrown with trees and brush impeding the inspection.

Downstream Channel. The streambed and banks of the downstream discharge channel within 100 feet from the dam were free from debris and large trees which may obstruct movement of water during flood events.

6.0 ASSESSMENT

On the basis of the October 8, 1997 inspection, review of the project data, and the interview with the Owner, the following assessment was made:

1. In general, Bristol Mills Dam appears to be in fair to poor condition. Although no signs of immediate failure of the dam were observed, there are concerns which may present a threat to the integrity of the dam and public safety. The major concerns are significant seepage through the intake structure, reduced spillway hydraulic capacity after the 1994 restoration work, and inaccessibility of the spillway and sluice stoplogs during flood events.

2. Significant concrete deterioration was observed at the base of the spillway and old intake structure rehabilitated in 1994. The deterioration was apparently caused by seepage emanating from the original concrete and exiting behind the gunite layer. The continuous seepage caused detachment of the gunite layer and degradation of the gunite at the base. The base undercutting extended up to 2 feet into the structure. Seepage through the intake was also exiting through the joints and fissures in the base bedrock. Continuing seepage, if left unchecked, may accelerate the process of deterioration of the structure and foundation bedrock which may cause stability problems.

3. The 1994 restorative work improved the overall condition of the dam. However, installation of the concrete piers on the spillway crest and filling the crest between the sluice and intake with the 1-foot-high concrete overlay have caused a reduction of the spillway hydraulic capacity by approximately 15 percent. This reduction in the spillway

capacity may result in overtopping, increased hydrostatic loading on the dam, and stability problems.

4. The spillway and sluice stoplogs are usually in place and not used to control the pond level. Considering the reduction in the spillway capacity, it is important to operate the spillway and sluice stoplogs on a regular basis. The stoplogs are inaccessible during flood events when the spillway piers are overtopped.

5. There are no formal written operation and maintenance procedures in effect to control the impoundment level, routinely inspect the condition of the dam, and regularly provide necessary repairs.

6. There is no emergency action plan (EAP) in effect to respond to emergency conditions threatening the dam and public safety.

7.0 RECOMMENDATIONS

A. Remedial Measures

To improve the integrity of Bristol Mills Dam and protect the public safety, it is recommended that the Owner obtain the services of a registered professional engineer to implement the following corrective measures within 1 year of receipt of this report:

1. Reduce seepage through the intake and rehabilitate the deteriorated base of the spillway and old intake structure.

2. Evaluate the effect of the reduced spillway hydraulic capacity on stability of the dam.

3. Provide access to the spillway and sluice stoplogs during flood conditions.

The implementation of these recommendations should include determination of the appropriate spillway design flood based on the dam hazard classification and stability evaluation, as necessary.

B. Operation and Maintenance

To improve operation and maintenance of the dam and adequately respond to emergency conditions threatening the dam and public safety, the Owner should implement the following within 1 year of receipt of this report:

1. Repair a void in the east sidewall of the sluice.

2. Repair the deteriorated timber noses of the spillway piers.

3. Operate the spillway and sluice stoplogs on a regular basis.

4. Remove all the sluice stoplogs annually to flush silt and debris.

5. Cut and remove trees and brush from the dam and within 20 feet of the dam abutments.

6. Monitor the dam semi-annually for seepage and changes in condition and record the observations in a monitoring log.

7. Engage a registered professional engineer to conduct a detailed inspection of the dam and appurtenant facilities every 5 years.

8. Establish written operation and maintenance procedures at the dam. The procedures should include the following:

   - A schedule and guidelines for maintenance of the impoundment water level.

   - A schedule and guidelines for regular maintenance of the dam facilities such as brush and tree removal, debris control, grass mowing, and repair of deteriorated structures.

   - A schedule and guidelines for inspection and monitoring of the dam and appurtenant facilities including a checklist of inspection items. The inspection of the dam should be conducted semi-annually and immediately after significant floods, heavy rainfall or other major project events. The observation findings should be recorded in a maintenance log.

9. Establish an EAP, if necessary, to provide the following:

   - Identify emergency conditions threatening the dam and public safety.

   - Establish effective response actions to prevent failure of the dam.

   - Reduce loss of life and property damage should failure of the dam occur.

APPENDIX A

PROJECT INFORMATION

Maine Dams

BRISTOL MILLS DAM	05083	ME00280	077	
	S	NR		
UPPER PEMAQUID RIVER BISCAY	BRISTOL	LINCOLN		
BRISTOL, TOWN OF	BENNER, WILLIAM-SELECTMAN			
P. O. BOX 147	BRISTOL	ME	04539	
563-5270	43 57 531	69 30 575		
	N		0	

CN	PFR		6/19/90	N	
110	530	2,000			
0	6,534	0			
11	6,705				
18					

MEMA		N	Y

STATE ID #	CORPS ID #	NAME OF DAM	BODY OF WATER IMPOUNDED	RIVER BASIN
5063	280	BRISTOL MILLS DAM	UPPER PEMAQUID RIVER BISCAY	WEST COASTAL

FERC #: 99999 FERC PROJECT NAME: TOPO MAP: BRISTOL SIZE: 7.5,

DAM LOCATION: BRISTOL COUNTY: LINCOLN GEOCODE: 15050

EXEMPT FROM PAYMENT	IS DAM LEASED	BILL THE OWNER	5 YEAR PAYMENT	AMOUNT PAID CURRENT YEAR	AMOUNT PAID LAST YEAR	REGISTRATION EXPIRES
NO	NO	YES	NO	$100	$64	1994

OWNER OF DAM: BRISTOL, TOWN OF P. O. BOX 147 BRISTOL ME 04539 ( )563-5270
CONTACT PERSON: SELECTMEN

IMPOUNDMENT:

TOTAL VOLUME	SURFACE AREA (ACRES)	CAPACITY (ACRE/FT)	EST CAPACITY (SA X HT X .4)	DRAINAGE AREA (SQ.MI.)	WATER LEVEL SET	YEAR LEVEL SET	EXEMPT FROM SETTING WATER LEVEL
	2,000	8,534	12,300		NO		NO

USAGE: FIRE CONTROL , WILDLIFE

DESCRIPTION:

YEAR BUILT	STRUCTURAL HEIGHT	HYDRAULIC HEIGHT	LENGTH	YEAR OF LAST MAJOR REPAIR	GEN COND	CONSTRUCTION PLANS AVAIL	YEAR LAST INSPECTED	NAME OF INSPECTING ENGINEER	INSP ENGINEER TELEPHONE
	0	16	110		UNK	UNK			

CONSTRUCTION: CONCRETE

OF GATES: TYPES OF MECHANISMS:

HEIGHT	WIDTH	CONDITION	DRAWDOWN AVAILABLE	SPILLWAY LENGTH	SPILLWAY HEIGHT	SPILLWAY ELEVATION	OPERATING FISH PASSAGEWAY	INSTALLED CAPACITY	HYDROMECHANICAL POWER
1.							UP AND DOWNSTREAM	0	0

DEVELOPMENT:
UPSTREAM: DOWNSTREAM: CONCENTRATION - UNKNOWN
NUMBER OF DWELLINGS DEVELOPMENT TYPES -
AROUND IMPOUNDMENT: UNK TYPES OF ROADS -

HAZARD CODE CLASSIFICATIONS:

COE CODE	SCS CODE	DEP CODE
2		

COMMENTS: WATER IMPOUNDED INCLUDES PEMAQUID PONDS

#77

MAINE EMERGENCY MANAGEMENT AGENCY
DAM INSPECTION CHECKLIST

Dam Name: Bristol Mills Dam | Owner: Town of Bristol

River, Stream or Lake: Pemaquid River | Address:

Current Hazard Potential: High __ Significant X Low __ | Address:

Dam Location (Town): Bristol | Dam Type: Concrete

Date of Inspection: 6/19/96 | Latitude: 43°57.631 Longitude: 69°80.575

Pictures 6 & 7

ITEM	YES	NO	N/A	REMARKS
1. Crest				
a. Settlement ?		X		
b. Misalignment ?		X		
c. Cracks ?		X		
d. Trees and Brush ?		X		
e. Evidence of Major Rehabilitation ?	X			If yes, complete Dam Structural Measurement Report
2. Upstream / Downstream Slopes				New left side abutment & cap new fishway
a. Slope Protection ?	X			
b. Erosion / Beaching ?		X		
c. Trees and Brush ?	X			Upstream left side (brush)
d. Visual Settlements ?		X		
e. Sinkholes ?		X		
f. Animal Burrows ?		X		
g. Seepage ?	X			Left side abutment near toe a steady stream of water
h. Toe drains ?	X			
i. Relief wells ?		X		
j. Slides / Slumps ?		X		
3. Abutment Contact				
a. Erosion ?		X		
b. Seeping ?	X			Same as 2g
c. Boils ?		X		
d. Springs ?		X		

APPENDIX B

INSPECTION PHOTOGRAPHS

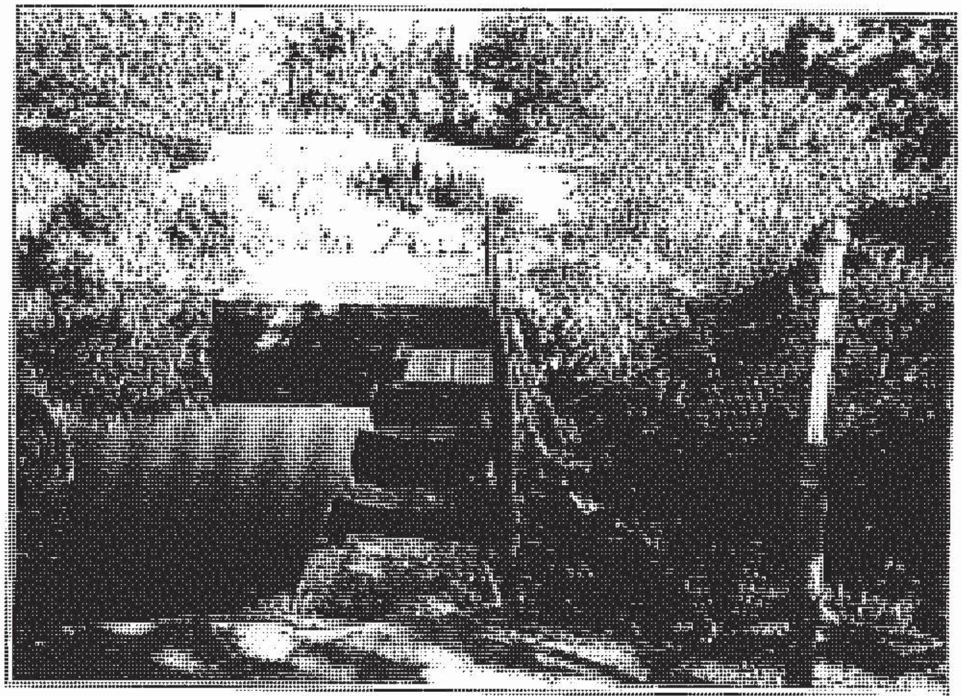


Photo B-1 Bristol Mills Dam.
Spillway and old intake from west abutment. Note concrete piers and stoplogs on spillway crest installed in 1994.

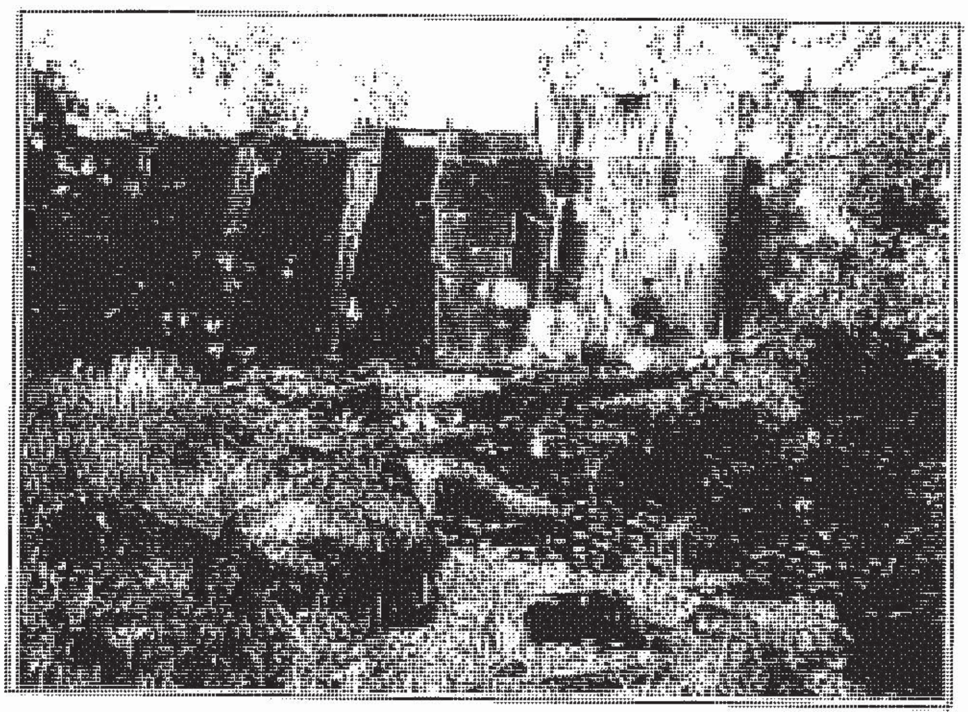


Photo B-2. Bristol Mills Dam.
Downstream face of spillway and old intake with outlet pipe. Note cracks in intake gunite placed in 1994.

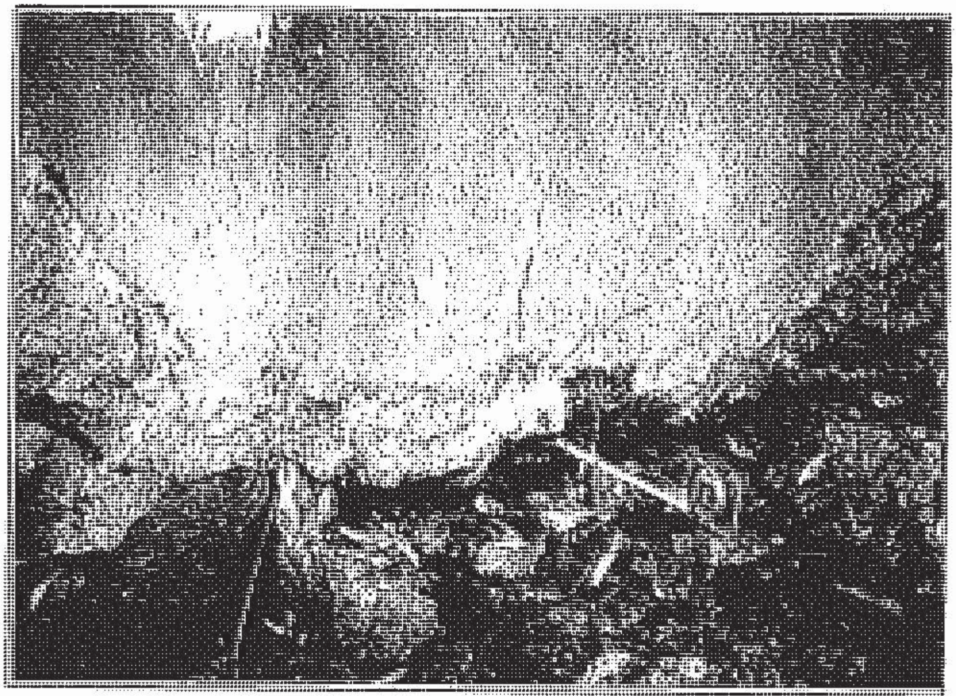


Photo B-3 Bristol Mills Dam.
Old intake. Note deterioration of 1994 gunite and seepage at base.

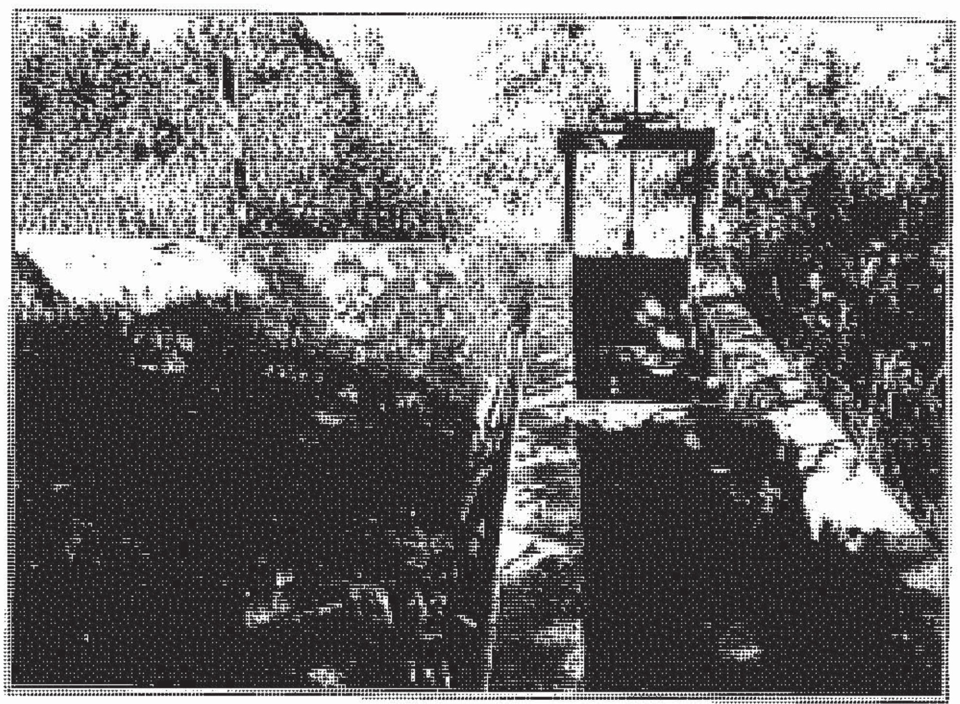


Photo B-4. Bristol Mills Dam.
East wall and fishway. Note crack on downstream face of east wall and vegetation of east abutment.

Angus S. King, Jr.
Governor
State of Maine
(207) 287-3531

Earl L. Adams
Major General
Commissioner
(207) 626-4205

DEPT. OF DEFENSE, VETERANS AND EMERGENCY MANAGEMENT

CAMP KEYES, AUGUSTA, MAINE 04333-0033

December 22, 1999

Office of The Commissioner

Town of Bristol
Attention: Mr. Craig Elliott
P.O. Box 147
Bristol, Maine 04539

RE: Bristol Mills Dam

Dear Mr. Elliott:

Under the provisions of MRSA Title 37B, Chapter 22, "Dam Inspections", dam condition and hazard inspections were carried out by our dam inspector on December 13, 1999, to review the dam hazard rating. The report is attached for your information and contains recommendations by the engineer concerning operation, maintenance, rehabilitation and repairs considered necessary for the safe operation of the dam, which I encourage you to address.

The dam is now classified a "low hazard" dam, and in terms of the law an Emergency Operations Plan is not required.

Should you have any questions, please contact me at 626-4271.

Sincerely,

Earl L. Adams

Earl L. Adams
Major General
Commissioner

10/17/2000
Do not remove from file. Copy for your use

Attachment

Copies Furnished:
Lincoln County Emergency Management Agency
Town of Bristol
Senator Marge Kilkelly
Representative Wendy Pieh

To: The Director, Maine Emergency Management Agency
From: Tony Fletcher, Civil Engineer 1
Date: 13 December 1999

Subject: Dam hazard and condition report.

1. Inspection certificate:

In terms of Maine Revised Statutes Annotated 37B, Chapter 22, a combined downstream hazard and dam condition inspection has been carried out for this dam. Little background material exists on file for this dam. The dam hazard assessment was conducted 2 miles downstream of the dam into the marsh to Boyd pond. Findings and recommendations of both inspections follow. Copies of the report may be sent to the current and new dam owners, the County EMA Director and the Town Manager.

2. Attachments:

A Dam data sheet
B Locality and watershed plan
C Downstream plan
D Drawings and sketches done on site of the dam
E Maine Department of Defense, Veterans and Emergency Management (DVEM) dam checklist
F nil

3. Inspection findings:

3.1 General description of dam, ownership and orders:

3.1.1 Ownership of the dam is vested with the Town of Bristol.
3.1.2 Originally the dam served as a power and water supply dam, but now serves as a recreational lake and possibly for fire water.
3.1.3 The dam is a small, old mill, 12' high (low) head, masonry and concrete structure with a single gated outlat, 75' long, with a short right earth embankment abutment and a 40' left earth dike where the fishway passes through.
3.1.4 The service spillway is a 3' x 5' deep, sluice gate controlled, fishway.
3.1.5 The auxiliary spillway is a partially controlled overspill broad crested weir with stoplog openings and side upstands.
3.1.6 There is no emergency spillway. Under extreme emergency conditions the dam and dikes would be over topped.
3.1.7 The water level is controlled by the stoplogs. Control and operation is in the hands of the owners.
3.1.8 No DEP water level order is in place. There are no dams downstream. Boyd pond lies between the dam and the sea.
3.1.9 A security fence runs the length of the top of the dam but the public are allowed on the wall.

3.2 Condition of dam:

3.2.1 Reservoir upstream of wall: The lake shows some slight shoreline erosion and sedimentation.
3.2.2 Upstream face: The upstream face of the dam appears sound. No debris has collected at the weir.
3.2.3 Crest: The crest of the dam appears to have been rebuilt at some stage.
3.2.4 Downstream: The downstream masonry face shows no deformation and little sign of leakage with some surface deterioration.
3.2.5 Abutments: The dam has 2 sound abutments between the concrete barrage and dikes. No adverse leakage or vegetation evident.
3.2.6 Operation: No dam operation plan exists and the gates, stop logs and draw off are operated as required.
3.2.7 Structures: There are no structures on the dam except a sluice mechanism which is in reasonable repair.
3.2.8 Downstream waterway is rocky with vegetation on the banks.
2.2.9 The dam is under regular surveillance.
3.2.10 No failure or distress seems to have occurred during the historic 1997 flood of record.
3.2.11 The dam is in good serviceable condition. Masonry deterioration is not considered significant. Vegetation growth is minor.
3.2.12 Intermittent minor seepage observed but it did not threaten the structure.
3.2.13 Total leakage through stop logs and flash boards was insignificant.
3.2.14 Results of previous inspection and construction reports are not summarized here.

3.3 Dam hazard classification:

3.3.1 The current classification is "significant" based upon Corps of Engineers inspections, Phase 1, national dam inspection program.
3.3.2 The dam may be defined as small in height and intermediate in capacity. Little or minor damage would be caused if it failed on a Normal day.
3.3.3 If the dam dike failed, the reservoir would empty to about 5' above the riverbed.
3.3.4 The unattenuated 100 year flood is estimated to be 2524 cfs. (attenuation is the reduction in flow as a result of flood storage)
3.3.5 The dam's spillway capacity is 16% of this 100 year flood, but under current conditions the attenuation effects from the lake would keep overflow to a estimated maximum of 2 feet which is a manageable level.
3.3.6 The estimated unattenuated PMF flood is 8387 cfs. The maximum rise in top water level due to PMF flooding is about 6' which would overtop the dike. The estimated flood of record to date is about 1500 cfs. The "probable maximum flood" (PMF) is 6 times this value. Dam breach under PMF conditions would not significantly increase the downstream flood elevations.
3.3.7 The "sunny day breach", based on an assumed width of 3 times the height, is 61 % of the 100 year flood. The sunny day breach would not flood any infrastructure or buildings downstream.
3.3.8 Inspection revealed that there was one lake and no dam downstream, and the stream drained into the sea.
3.3.9 Dam breach under normal and PMF flood conditions would not contribute to significant property damage along the downstream watercourse to the confluence with the sea.

4. Assumptions

4.1 The condition assessment is visual and no testing of materials or detailed calculations were done. No stability analysis was performed and no strength assessments were done of the dam and appurtenances.
4.2 Downstream hydraulic assessments were based on visual inspection only.
4.3 Indicator values of flow and condition are based on ratios defined on Attachment A. The condition index is based on the sum of the Partial indices for each item divided by their sum less 15.

5. Based on the above findings I recommend that:

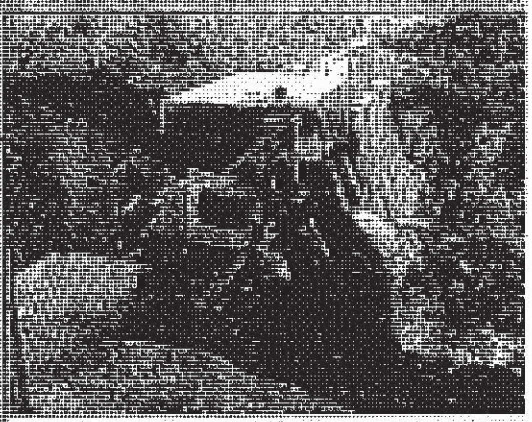
5.1 the dam be reclassified a low hazard dam, and that the condition of the dam be recorded as fair,
5.2 the Owner note the contents of this inspection report,
5.3 the Owner note that the spillway be maintained at a level to accommodate the 100 year flood,
5.4 written "standard operating procedures" (SOP's) be developed for the correct operation and maintenance of the dam
5.6 the new owner carry out voluntary regular dam inspections and report significant findings and dam incidents to this office
5.7 the affected Town and County EMA be notified of these findings and recommendations
5.8 the dam be inspected at minimum every 6 years by this Department.

Tony Fletcher PE
Civil Engineer 1

Stream Crossing Data — Attachment A

077	Bristol Mills		1914	01-06-1997	43	57	601	[illegible]	15 Dec 99
L	Bristol	Lincoln	PPB	MESWA	69	30	575	[illegible]	

Bristol	L	Craig Elliott	[illegible]
P. O. Box 147	Bristol	ME	04539



CS	85	110	14.8	10	2.5
Bedrock	Concrete		11	24	1,600

Concrete mass gravity mill on granite bedrock. Fishway on left bank

Unknown

Natural lake	1,000	2,000	12,000	6000	18,000

0

21	160	13	13	10.00	0.16	10.50	2.8	2,024	6,367	3,646
Upper Pemaquid	60		44	65	15	3,000		400		3,700

		25	2.5	400	.8	steeppass	4	1.5	3	270
15%				0	270					0
15%				0						0
15%	1,500			400	24		1	20	1	24

L	6		no	Bristol	
81%	0			2	0

NR			(738, 104)	0
[illegible]	NR	NR		738 104

N	15 May 00	
	$1,500	SP
MBP		

Dam function to be good in poor condition requiring minor repairs and maintenance.

Fishway needs some maintenance

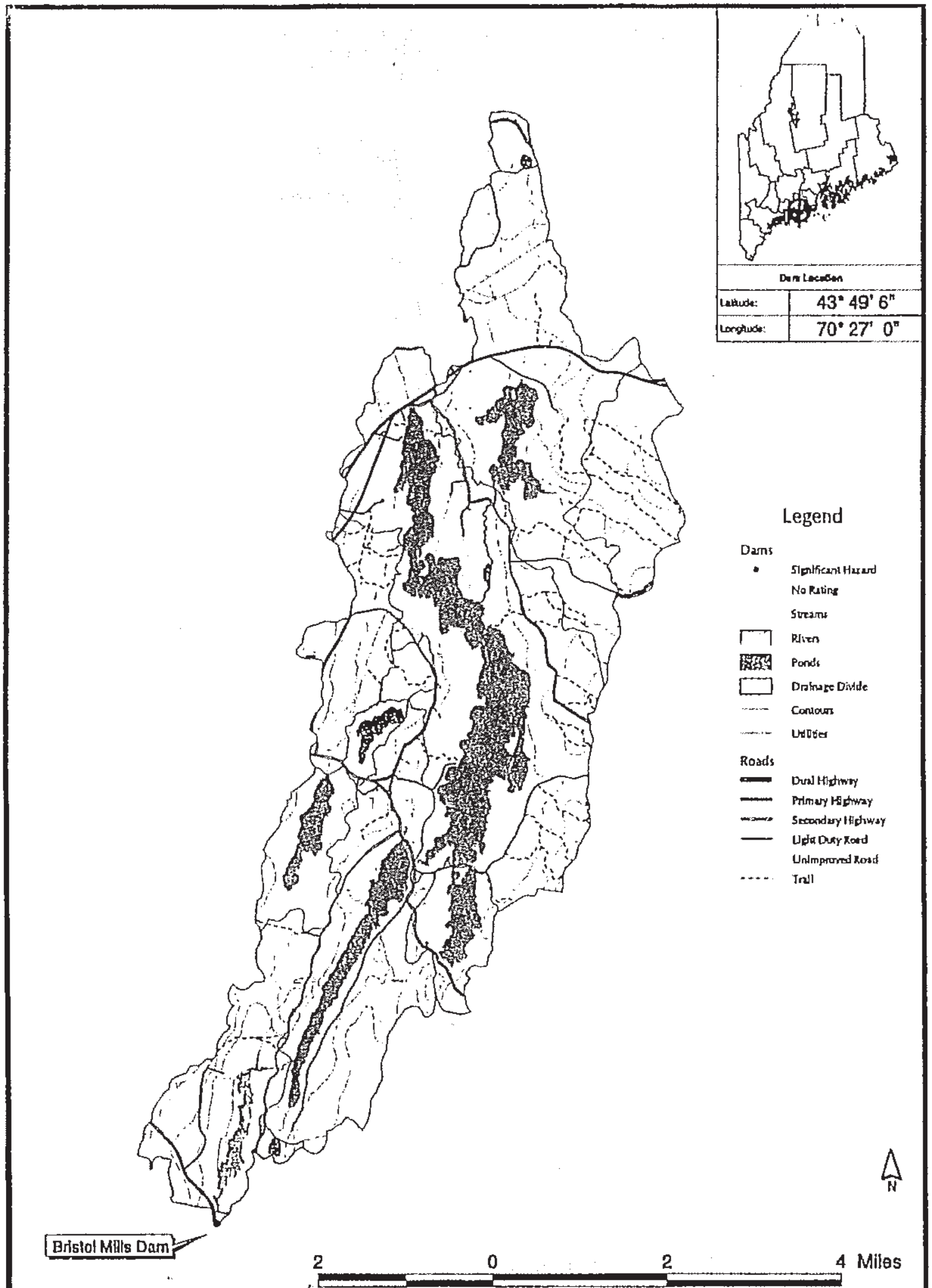
maintenance & repair

good	24 Aug 00	good		5	2025	22 Aug 05

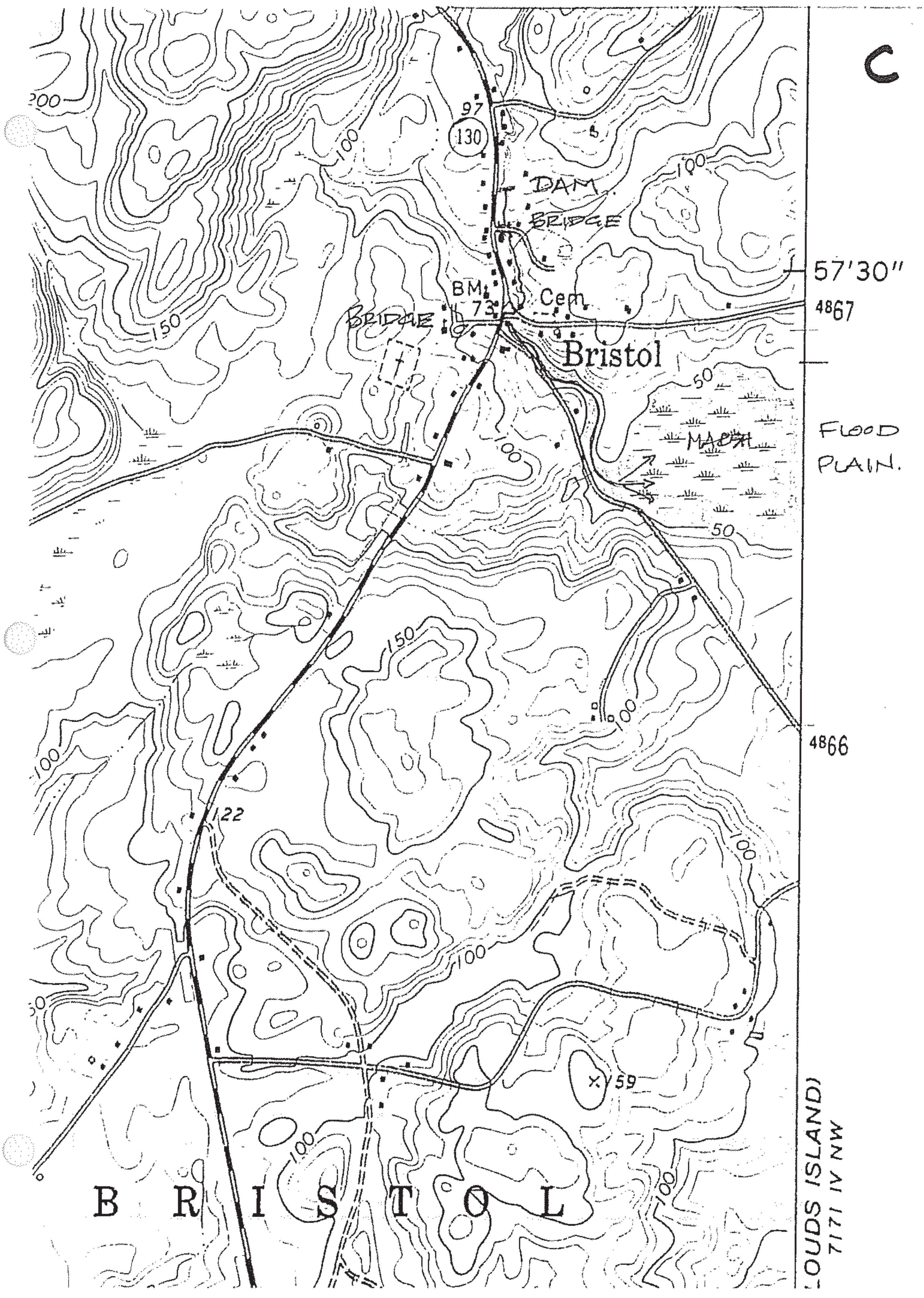
3	3	2	2	2	2	3	1	0
3	2	2	3	3	1	1		57%

maintenance & repair

B

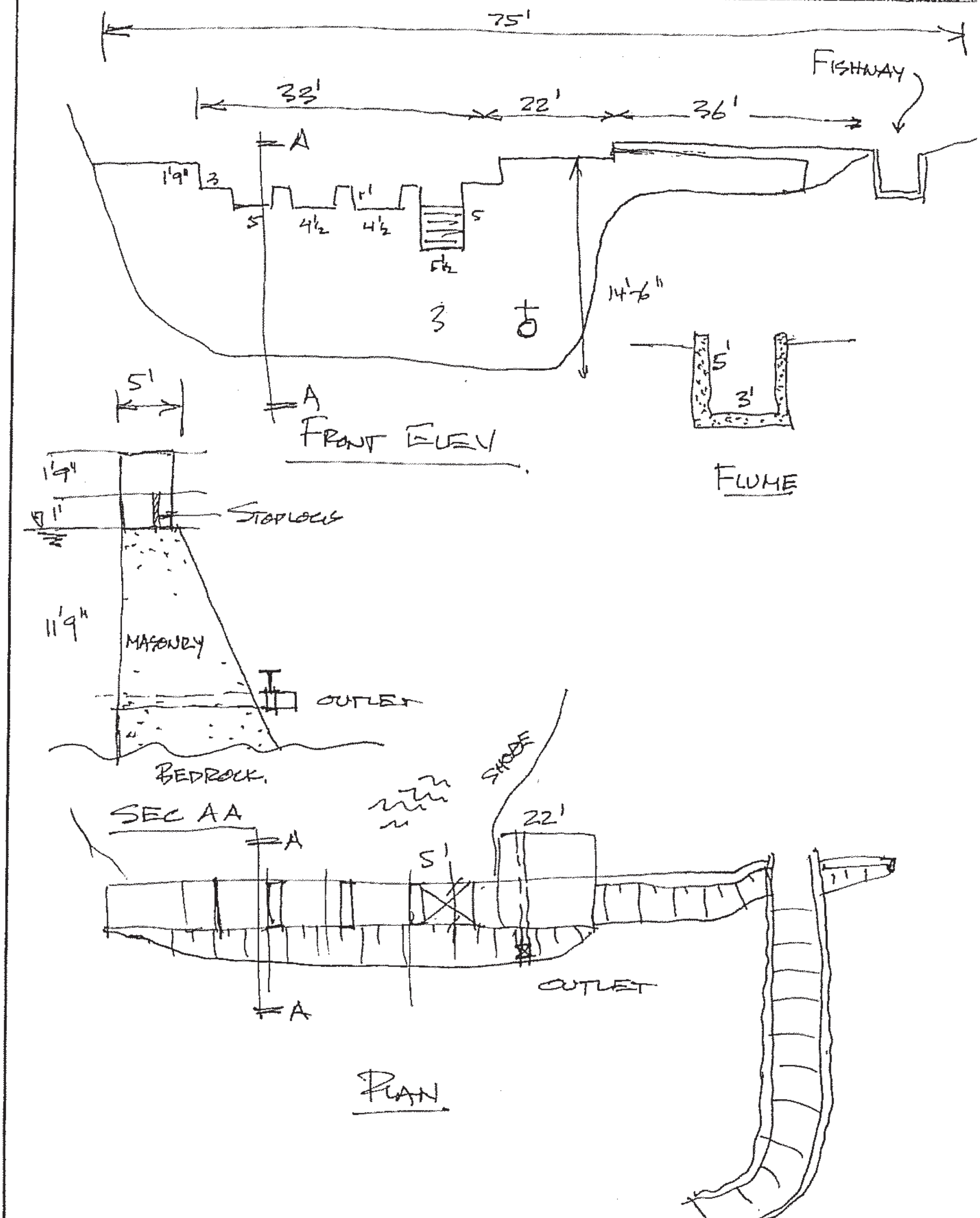


State of Maine, Dam Safety Program		Bristol Mills Dam		Watershed: 31.03 (sq. miles)
Department of Defense, Veterans and Emergency Management [illegible]		Watershed & Impoundment Area		Watercourse: 13.07 (miles)
By: Nathan Howard	Date: 8/16/99	Town: Bristol	Date:	Impoundment: 2658.35 (acres)
Checked:	Date:	County: Lincoln	Amended:	Dwg No: C77/99A



C
200
97
130
100
DAM
BRIDGE
57'30"
4867
BM
73
Cem
BRIDGE
Bristol
150
50
MARSH
FLOOD
PLAIN.
50
150
100
4866
122
100
59
B R I S T O L
LOUDS ISLAND)
7171 IV NW

D



State of Maine, Dam Safety Program Department of Defense, Veterans & Emergency Management 72 SHS, Augusta ME 04333-0072 Tel: (207) 626 7824	#077 BRISTOL MILLS DAM. FIELD SKETCH

By: TF	Date: 14 DEC 99	Town: BRISTOL MILLS	Date 14 DEC 99	Scale: NTS
Checked:	Date:	County:	Amended:	Dwg.No: C77/1

E

MAINE EMERGENCY MANAGEMENT AGENCY
DAM INSPECTION CHECKLIST

Dam Name: Bristol Mills Dam

Owner: Town of Bristol

River, Stream or Lake: Pemaquid River

Address:

Current Hazard Potential: High__ Significant X Low__

Address:

Dam Location (Town): Bristol

Dam Type: Concrete

Date of Inspection: 6/19/96

Latitude: 43°57.631 Longitude: 69°80.575

Pictures 6 & 7

ITEM	YES	NO	N/A	REMARKS
1. Crest				
a. Settlement ?		X		
b. Misalignment ?		X		
c. Cracks ?		X		
d. Trees and Brush ?		X		
e. Evidence of Major Rehabilitation ?	X			If yes, complete Dam Structural Measurement Report
2. Upstream / Downstream Slopes				New left side abutment & cap new fishway
a. Slope Protection ?	X			
b. Erosion / Beaching ?		X		
c. Trees and Brush ?	X			Upstream left side (brush)
d. Visual Settlements ?		X		
e. Sinkholes ?		X		
f. Animal Burrows ?		X		
g. Seepage ?	X			Left side abutment near toe a steady stream of water
h. Toe drains ?	X			
i. Relief wells ?		X		
j. Slides / Slumps ?		X		
3. Abutment Contact				
a. Erosion ?		X		
b. Seeping ?	X			Same as 2g
c. Boils ?		X		
d. Springs ?		X		

E2

ITEM	YES	NO	N/A	REMARKS
4. Appurtenances / Structures				
a. Timbers deteriorated ?			X	
b. Timber fasteners in place ?			X	
c. Crib ballast loss ?			X	
d. Cribs secure ?			X	
e. Concrete condition: Spalling, Cracking, Exposed reinforcement, Loss of Joint filler, Scaling ?	X			Some erosion aroung toe of left side abutment
f. Drains, Weepholes ?		X		
g. Stone displacement / removal ?			X	
h. Gates / Sluices serviceable ?	X			
i. Spillway obstructed / bypassed ?		X		
5. Reservoir				
a. Signs of shoreline instability ?		X		
b. Sedimentation ?		X		
c. Excessive debris ?		X		
d. Ice related problems ?		X		
e. Environmental Concerns ?		X		
f. Other ?				
6. Downstream Channel				
a. Eroding or Backcutting ?		X		
b. Sloughing ?		X		
c. Obstruction ?		X		
7. Emergency Action Plan				
a. Current Plan Posted ?				
b. Alerting and Warning System ?				
c. Certification of last test ?				
d. New development downstream ?				
e. Changed hazard potential ?				

APPENDIX D
Definitions

COMMON DAM SAFETY DEFINITIONS

Orientation

Upstream – Shall mean the side of the dam that borders the impoundment.

Downstream – Shall mean the high side of the dam, the side opposite the upstream side.

Right – Shall mean the area to the right when looking in the downstream direction.

Left – Shall mean the area to the left when looking in the downstream direction.

Dam Components

Dam – Shall mean any artificial barrier, including appurtenant works, which impounds or diverts water.

Embankment – Shall mean the fill material, usually earth or rock, placed with sloping sides, such that it forms a permanent barrier that impounds water.

Crest – Shall mean the top of the dam, usually provides a road or path across the dam.

Abutment – Shall mean that part of a valley side against which a dam is constructed. An artificial abutment is sometimes constructed as a concrete gravity section, to take the thrust of an arch dam where there is no suitable natural abutment.

Appurtenant Works – Shall mean structures, either in dams or separate therefrom, including but not be limited to, spillways; reservoirs and their rims; low-level outlet works; and water conduits including tunnels, pipelines, or penstocks, either through the dams or their abutments.

Spillway – Shall mean a structure over or through which water flows are discharged. If the flow is controlled by gates or boards, it is a controlled spillway; if the fixed elevation of the spillway crest controls the level of the impoundment, it is an uncontrolled spillway.

Size Classification

Large – structure with a height greater than 40 feet or a storage capacity greater than 50,000 acre-feet.

Intermediate – structure with a height between 15 and 40 feet or a storage capacity of 1,000 to 50,000 acre-feet.

Small – structure with a height less than 15 feet and a storage capacity less than 1,000 acre-feet.

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Hazard Classification

High Hazard (Class I) – Shall mean dams located where failure will likely cause loss of life and serious damage to home(s), industrial or commercial facilities, important public utilities, main highway(s) or railroad(s).

Significant Hazard (Class II) – Shall mean dams located where failure may cause loss of life and damage to home(s), industrial or commercial facilities, secondary highway(s) or railroad(s), or cause the interruption of the use or service of relatively important facilities.

Low Hazard (Class III) – Dams located where failure may cause minimal property damage to others. Loss of life is not expected.

General

EAP – Emergency Action Plan – Shall mean a predetermined (and properly documented) plan of action to be taken to reduce the potential for property damage and/or loss of life in an area affected by an impending dam failure.

O&M Manual – Operations and Maintenance Manual; Document identifying routine maintenance and operational procedures under normal and storm conditions.

Normal Pool – Shall mean the elevation of the impoundment during normal operating conditions.

Acre-foot – Shall mean a unit of volumetric measure that would cover one acre to a depth of one foot. It is equal to 43,560 cubic feet. One million U.S. gallons = 3.068 acre feet.

Height of Dam (Structural Height) – Shall mean the vertical distance from the lowest portion of the natural ground, including any stream channel, along the downstream toe of the dam to the lowest point on the crest of the dam.

Hydraulic Height – means the height to which water rises behind a dam and the difference between the lowest point in the original streambed at the axis of the dam and the maximum controllable water surface.

Maximum Water Storage Elevation – means the maximum elevation of water surface which can be contained by the dam without overtopping the embankment section.

Spillway Design Flood (SDF) – Shall mean the flood used in the design of a dam and its appurtenant works particularly for sizing the spillway and outlet works, and for determining maximum temporary storage and height of dam requirements.

Maximum Storage Capacity – The volume of water contained in the impoundment at maximum water storage elevation.

Normal Storage Capacity – The volume of water contained in the impoundment at normal water storage elevation.

Condition Rating

Unsafe – *Major structural****, operational, and maintenance deficiencies exist under normal operating conditions.

Poor – *Significant structural****, operation and maintenance deficiencies are clearly recognized for normal loading conditions.

Fair – Significant operational and maintenance deficiencies, no structural deficiencies. Potential deficiencies exist under unusual loading conditions that may realistically occur. Can be used when uncertainties exist as to critical parameters.

Satisfactory – Minor operational and maintenance deficiencies. Infrequent hydrologic events would probably result in deficiencies.

Good – No existing or potential deficiencies recognized. Safe performance is expected under all loading including SDF.

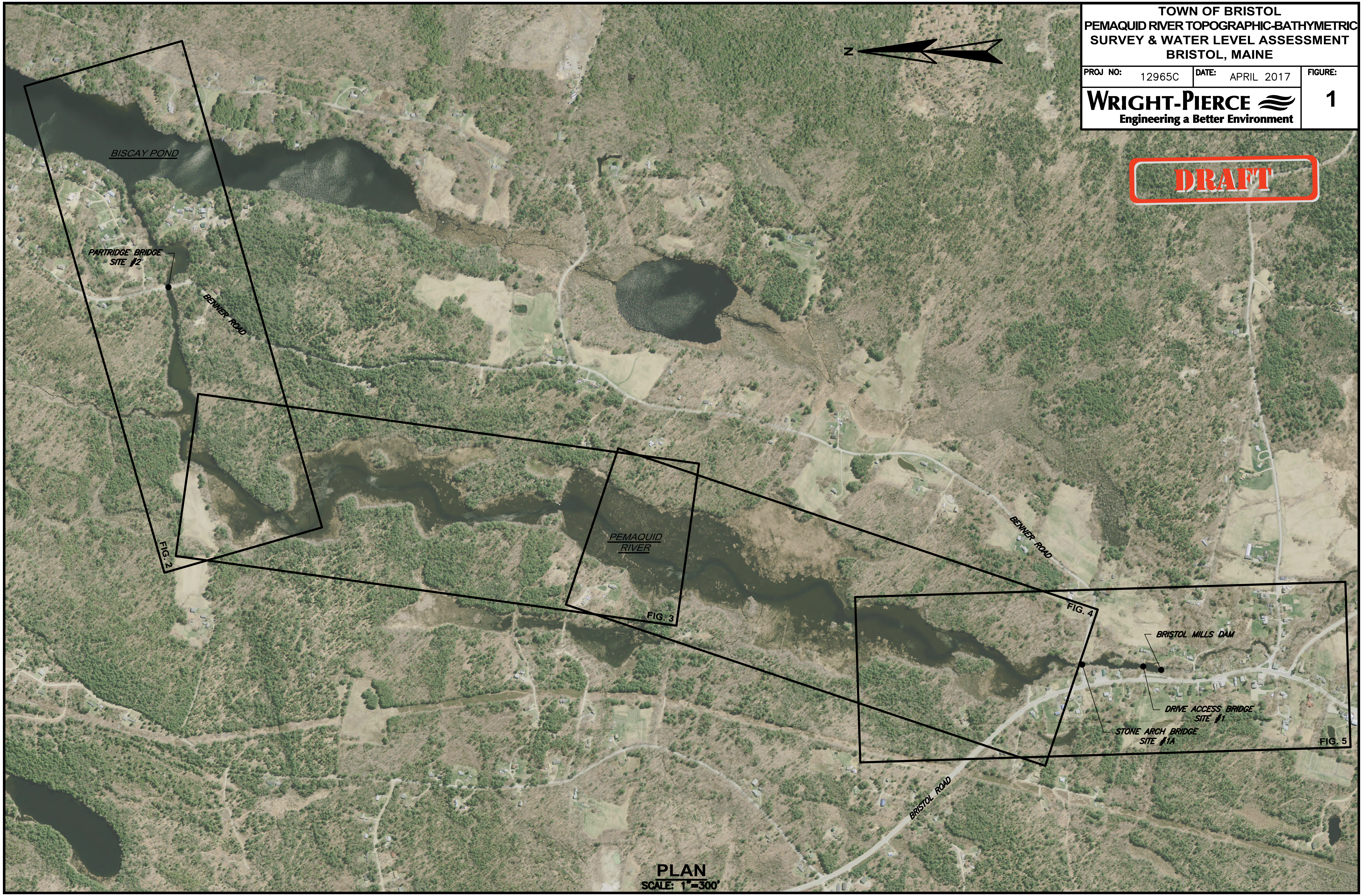
** Structural deficiencies include but are not limited to the following:*

- *Excessive uncontrolled seepage (e.g., upwelling of water, evidence of fines movement, flowing water, erosion, etc.)*
- *Missing riprap with resulting erosion of slope*
- *Sinkholes, particularly behind retaining walls and above outlet pipes, possibly indicating loss of soil due to piping, rather than animal burrows*
- *Excessive vegetation and tree growth, particularly if it obscures features of the dam and the dam cannot be fully inspected*
- *Deterioration of concrete structures (e.g., exposed rebar, tilted walls, large cracks with or without seepage, excessive spalling, etc.)*
- *Inoperable outlets (gates and valves that have not been operated for many years or are broken)*

APPENDIX F

Impoundment Topographic and Bathymetric Maps

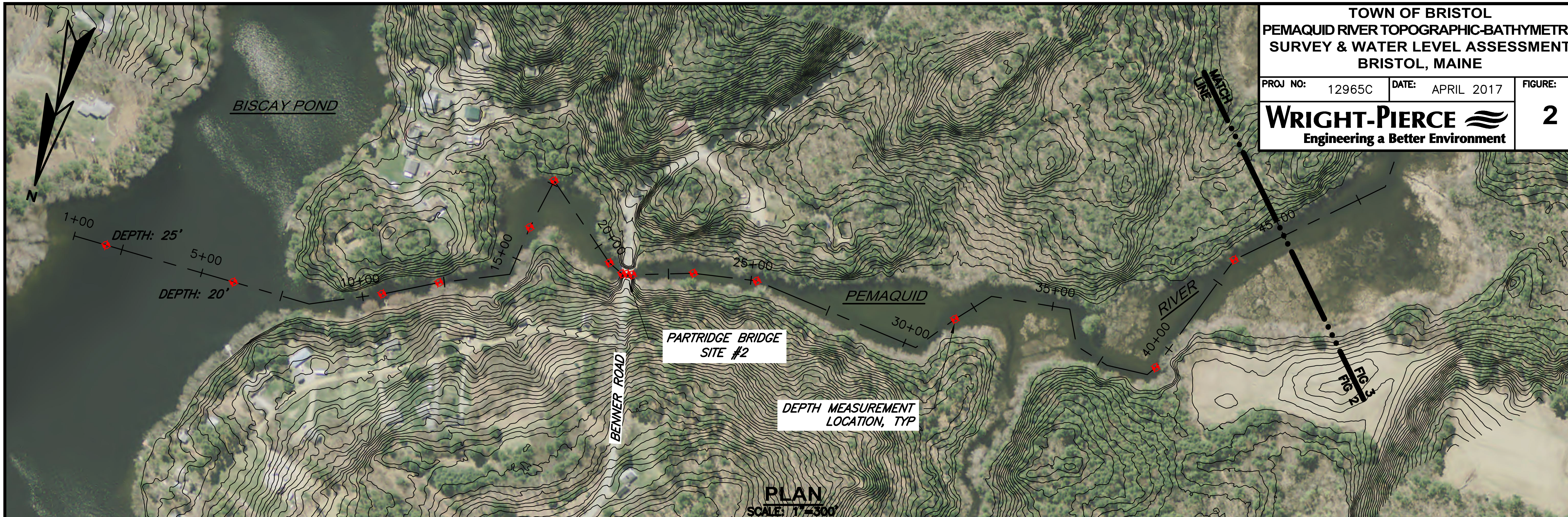
Bathymetric Survey Data for Bristol Mills Dam Impoundment				
Date	PointID	Depth to Substrate	Substrate Description	Notes
9/25/2016	BI1	4.50	hard, unknown if bedrock. Bouldery stones with bedrock exposed on river right (facing downstream).	Confined channel. Trees to river's edge. Notes for trip start: Started canoe trip from town boat launch and paddled upstream to Biscay Pond Outlet. Took measurements from Biscay Pond downstream towards Bristol Mills Dam. Notes on paddle upstream: low water from summer drought. No debris jams except for large active beaver dam under the "Partridge" bridge. Water level above the bridge at the outlet of Biscay Pond was 14" below pollen line on rocks.
9/25/2016	BI2	3.30	hard, unknown if bedrock. Bouldery stones with bedrock exposed on river right (facing downstream).	Confined channel. Trees to river's edge.
9/25/2016	BI3	3.00	River right: hard substrate; bouldery. River left: bank opening to small shallow wetland. Substrate becomes firm with depth	Moving downstream from BI2, becomes deeper than 4.5', then loses depth and has lily pads on river's sides. Becomes sandy moving downstrean towards Partridge bridge, and shallower. About 50ft upstream of bridge, bedrock on river left.
9/25/2016	BI4	3.75	finer substrate, met refusal at a couple inches	Next to bedrock on river left
9/25/2016	BI5	4.50	gravelly, firm	About 20 ft upstream of Partridge bridge.
9/25/2016	BI6	3.70	cobble, gravel	At bridge inlet: active beaver dam.
9/25/2016	BI7	3.20	fines over hard bottom	Center of crossing, beneath bridge.
9/25/2016	BI8	3.00	cobble to gravel with small voids	At bridge outlet. Lots of 3-5' stone placed as part of bridge construction. Depth avg. 3' with some deeper spots.
9/25/2016	BI9	5.40	coarse sand	Becomes shallower, sandy substrate.
9/25/2016	BI10	2.70	fine sand to refusal	About 400ft downstream of bridge.
9/25/2016	BI11	4.00	clay/silt with some fine sand particles and some organic material	River widens into wetlands with lily pads and a deeper channel.
9/25/2016	BI12	5.00	coarse sand, firm	At rocks by Poor Farm Rd. field. Boulders at river right.
9/25/2016	BI13	7.20	old silted in debris and/or beaver dam, exposed at top, silt down to hard refusal	At beaver/debris jam with Poor Farm Rd. field at river right. No sign of bedrock on either shore
9/25/2016	BI14	4.40	silty clay with more organic matter	Location approximate based on notes. Within marsh, no bedrock on either shore.
9/25/2016	BI15	4.00	solid bedrock	Ledge on both sides of shore. Camp with damaged roof is on western shore. Depth about 4' with some higher and lower spots.
9/25/2016	BI16	12.00	hard rock	Immediately downstream of BI15 choke point
9/25/2016	BI17	6.00	silty clay	About a quarter mile downstream from BI15 choke point. This is where the probe got stuck and we had to cut it.
9/27/2016	BI18	7.98	silty	In marsh. About 600 ft downstream of pt. 17
9/27/2016	BI19	7.63	unknown, no longer have a probe, just using lead line	Ledges on west side of river (location where old IFW waterfowl nesting sign is growing into the tree).
9/27/2016	BI20	7.54	unknown	At southest bend in river upstream of neighbors camp. Marshy on both sides of river
9/27/2016	BI21	7.46	unknown	Chokepoint river, uplands and ledge on both banks, where Plummer camp is. Measurement taken on west side of river by overhanging oak.
9/27/2016	BI22	7.54	unknown	About 600ft downstream of pt. 21, upstream of ledge on west shore. Marshy on both sides of river.
9/27/2016	BI23	6.42	hard	Substrate feels hard. On both sides of river: boulders and bedrock. Location about 500ft upstream of boat ramp.
9/27/2016	BI24	3.96	hard	Exposed bedrock on east shore, marsh on west shore. About 75-100ft upstream of boat ramp
9/27/2016	BI25	5.85	hard, gravelly	Adjacent to boat ramp
9/27/2016	BI26	5.69	hard	Directly east of Town Info Center. Bedrock sloping into river on west side, marsh on east side
9/27/2016	BI27	5.77	cobbley	Next to "island" with picnic table. Bedrock on both sides.
9/27/2016	BI28	4.31	hard rock, uneven	At large boulder on top of bedrock on east shore, about 40m upstream of Benner Road Stone Arch (i.e. the southern bridge crossing)
9/27/2016	BI29	4.31	hard rock, uneven	5m upstream of Benner Road Stone Arch (south bridge crossing)
9/27/2016	BI30	5.75	uneven rock	Inside the Benner Road Stone Arch. Bedrock on both sides of river.
9/27/2016	BI31	2.58	uneven rock	5m downstream of Benner Road Stone Arch. Bedrock on both sides, steep drop into river
9/27/2016	BI32	4.04	uneven rock	East and upstream from white house on west bank
9/27/2016	BI33	5.25	hard rock and sand	Behind old mill building with kayaks on floating dock
9/27/2016	BI34	6.17	uneven rock	2m upstream of bridge to Gage house at upstream extent of swimming hole. Bedrock on both sides of river
9/27/2016	BI35	6.08	hard	Under bridge to Gage house
9/27/2016	BI36	9.10	hardish	Directly east of sign on west bank at the swimming hole. Marshy on both shores.
9/27/2016	BI37	10.23	hardish	East of the swimming hole bedrock "beach"
9/27/2016	BI38	11.00	hard	Directly upstream of dam. 16" distance between top of hydrant filter screen and water surface. 33" distance between water surface and top of NW corner of cement platform/pad at penstock of dam.

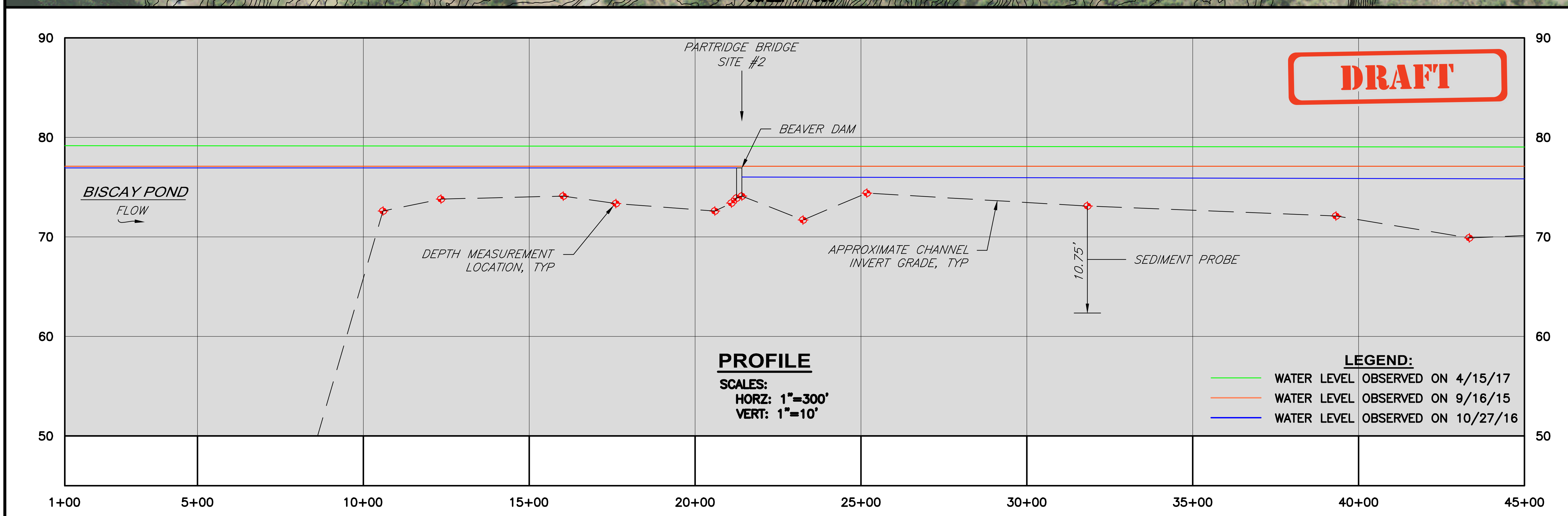

TOWN OF BRISTOL
PEMAQUID RIVER TOPOGRAPHIC-BATHYMETRIC
SURVEY & WATER LEVEL ASSESSMENT
BRISTOL, MAINE
PROJ NO: 12965C
DATE: APRIL 2017
FIGURE: 1
WRIGHT-PIERCE
Engineering a Better Environment
DRAFT
N
BISCAY POND
PARTRIDGE BRIDGE SITE #2
BENNER ROAD
FIG. 2
PEMAQUID RIVER
FIG. 3
BENNER ROAD
FIG. 4
BRISTOL MILLS DAM
DRIVE ACCESS BRIDGE SITE #1
STONE ARCH BRIDGE SITE #1A
FIG. 5
BRISTOL ROAD
PLAN
SCALE: 1"=300'

TOWN OF BRISTOL
PEMAQUID RIVER TOPOGRAPHIC-BATHYMETRIC SURVEY & WATER LEVEL ASSESSMENT
BRISTOL, MAINE

PROJ NO:	DATE:	FIGURE:
12965C	APRIL 2017	2

WRIGHT-PIERCE
Engineering a Better Environment





TOWN OF BRISTOL
PEMAQUID RIVER TOPOGRAPHIC-BATHYMETRIC SURVEY & WATER LEVEL ASSESSMENT
BRISTOL, MAINE

PROJ NO: 12965C	DATE: APRIL 2017	FIGURE: 3

WRIGHT-PIERCE
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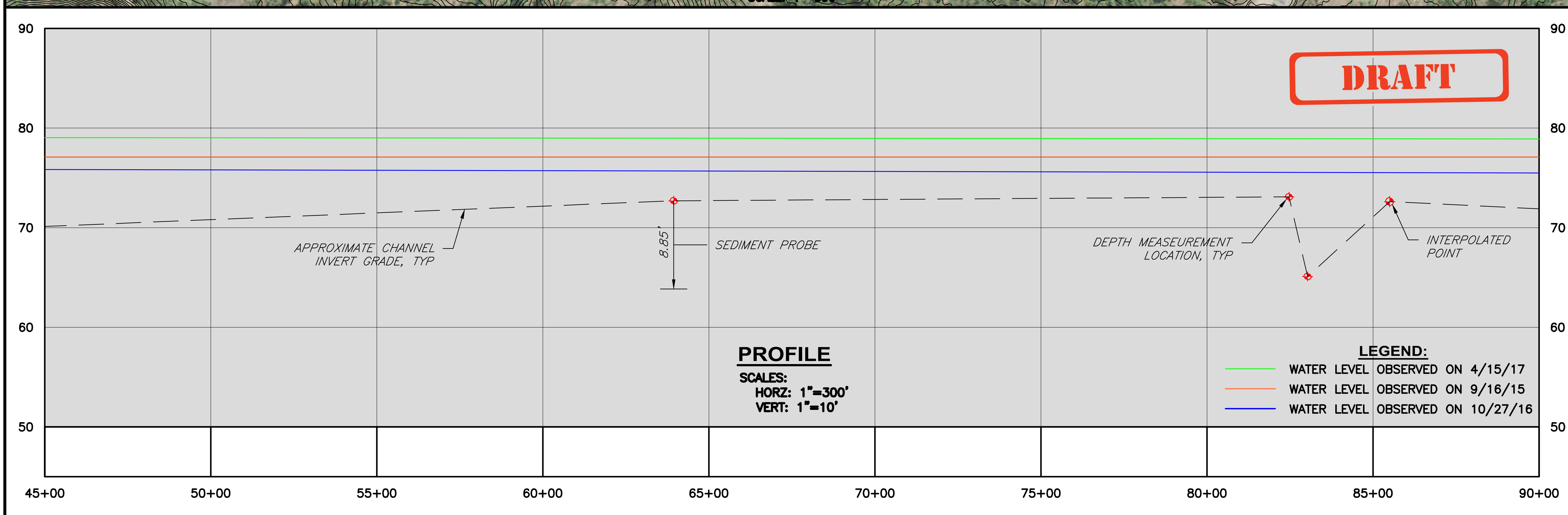
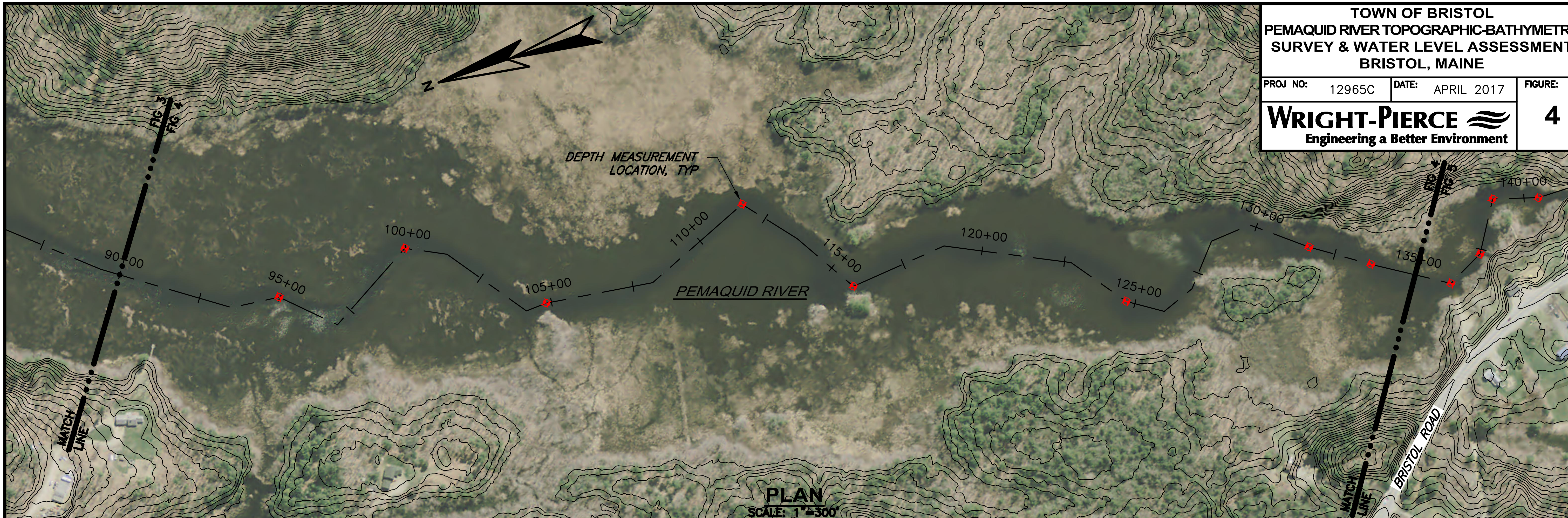


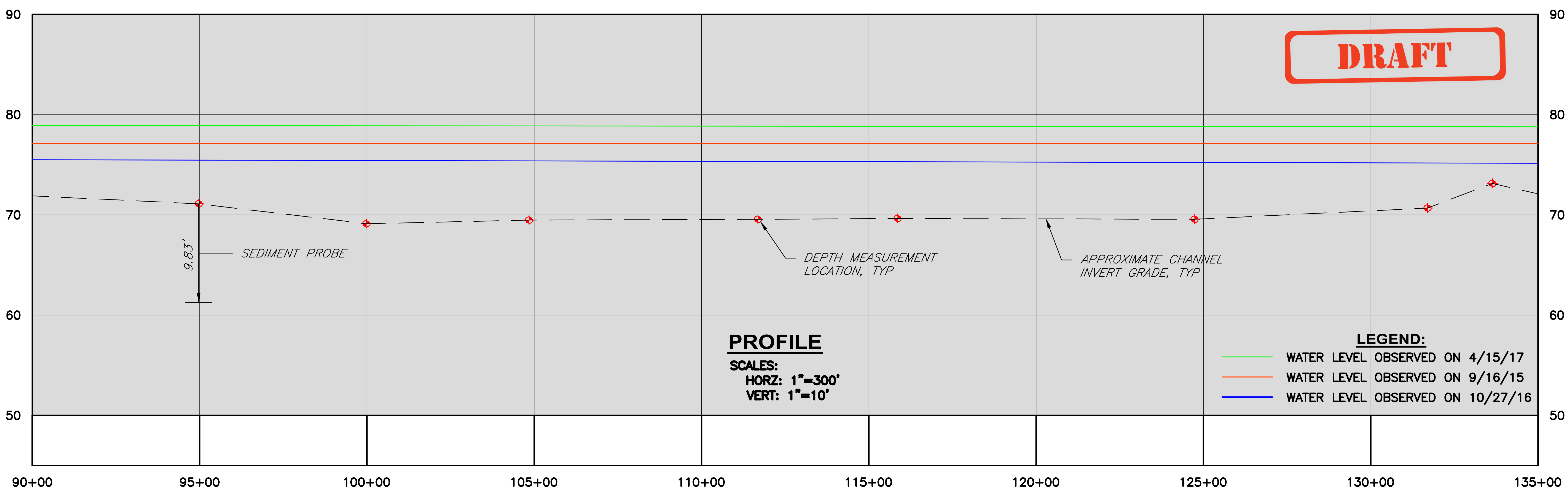
TOWN OF BRISTOL
PEMAQUID RIVER TOPOGRAPHIC-BATHYMETRIC SURVEY & WATER LEVEL ASSESSMENT
BRISTOL, MAINE

PROJ NO:	DATE:	FIGURE:
12965C	APRIL 2017	4

WRIGHT-PIERCE
Engineering a Better Environment



PLAN
SCALE: 1"=300'

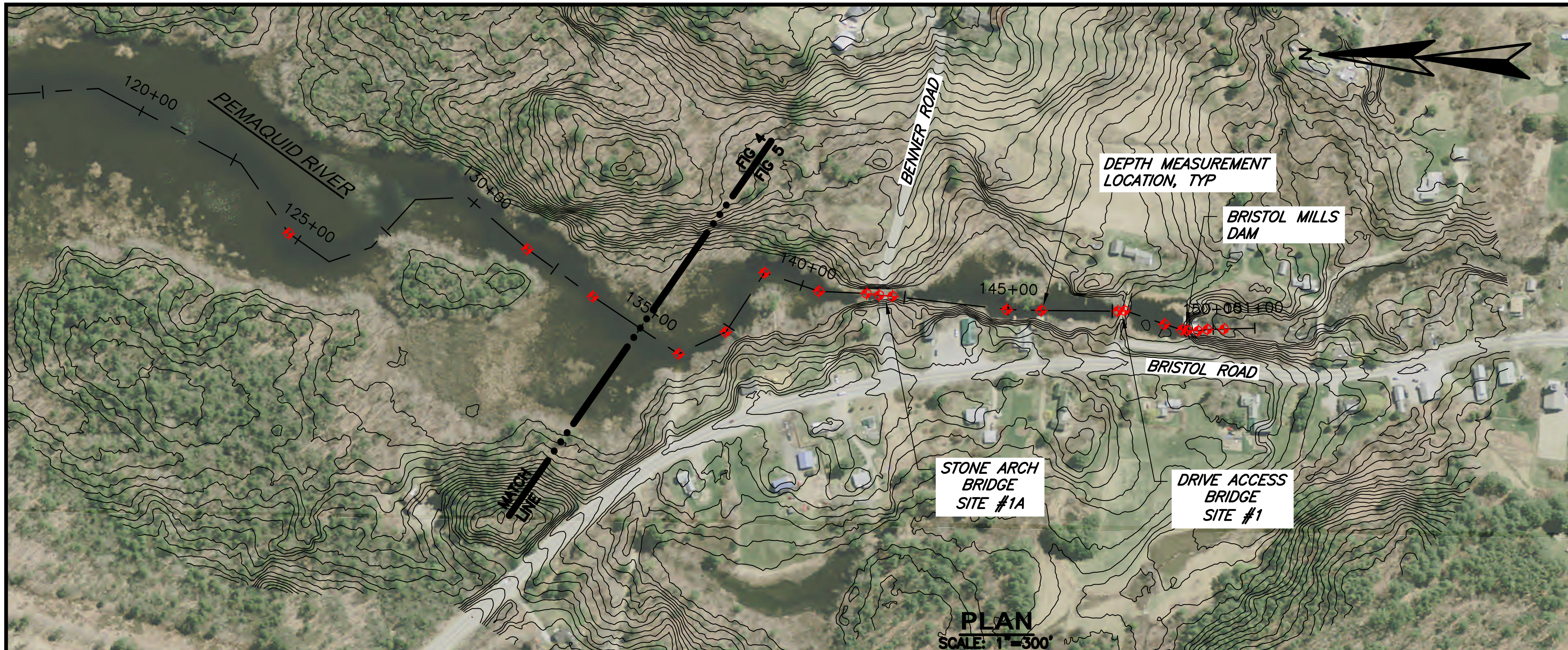


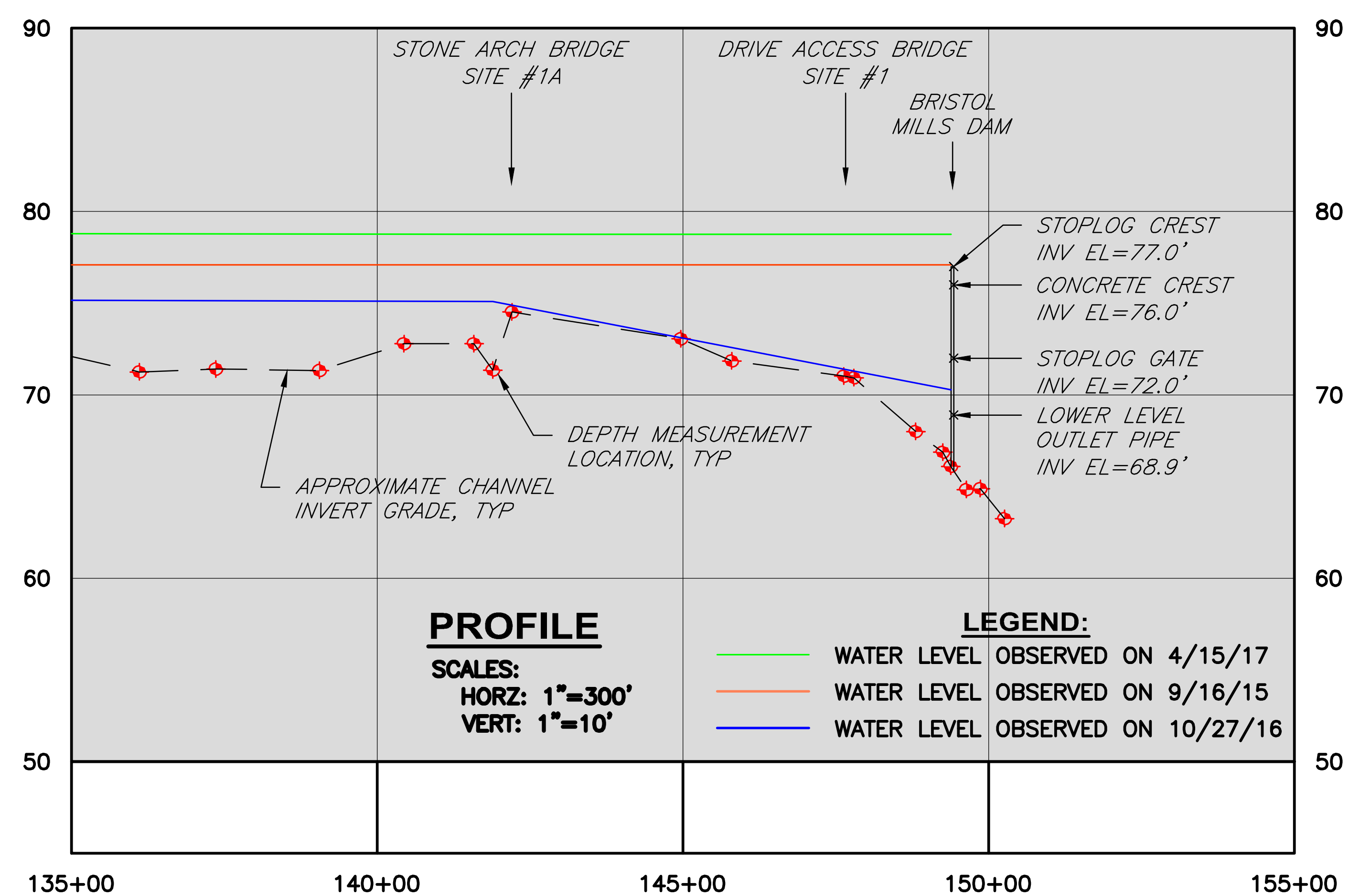
PROFILE
SCALES:
HORZ: 1"=300'
VERT: 1"=10'

TOWN OF BRISTOL
PEMAQUID RIVER TOPOGRAPHIC-BATHYMETRIC SURVEY & WATER LEVEL ASSESSMENT
BRISTOL, MAINE

PROJ NO: 12965C	DATE: APRIL 2017	FIGURE: 5

WRIGHT-PIERCE
Engineering a Better Environment





DRAFT

APPENDIX G

Impoundment Infrastructure Survey Map and Photo Log

CLM W:\GIS_Development\Projects\ME\Bristol\12965B_BristolDamFeasibility\MXDs\FieldPhotos_Mapbook_11x17 - Copy.mxd

Field Photos
Bristol, Maine

PROJ NO:	DATE:
12965	4/21/2017

WRIGHT-PIERCE
Engineering a Better Environment

FIGURE: 1

Field Photos
Bristol, Maine

PROJ NO: 12965 | DATE: 4/21/2017

WRIGHT-PIERCE
Engineering a Better Environment

FIGURE: 2

CLM W:\GIS_Development\Projects\ME\Bristol\12965B_BristolDamFeasibility\MXDs\FieldPhotos_Mapbook_11x17.mxd

Field Photos

Bristol, Maine

PROJ NO:	DATE:
12965	4/21/2017

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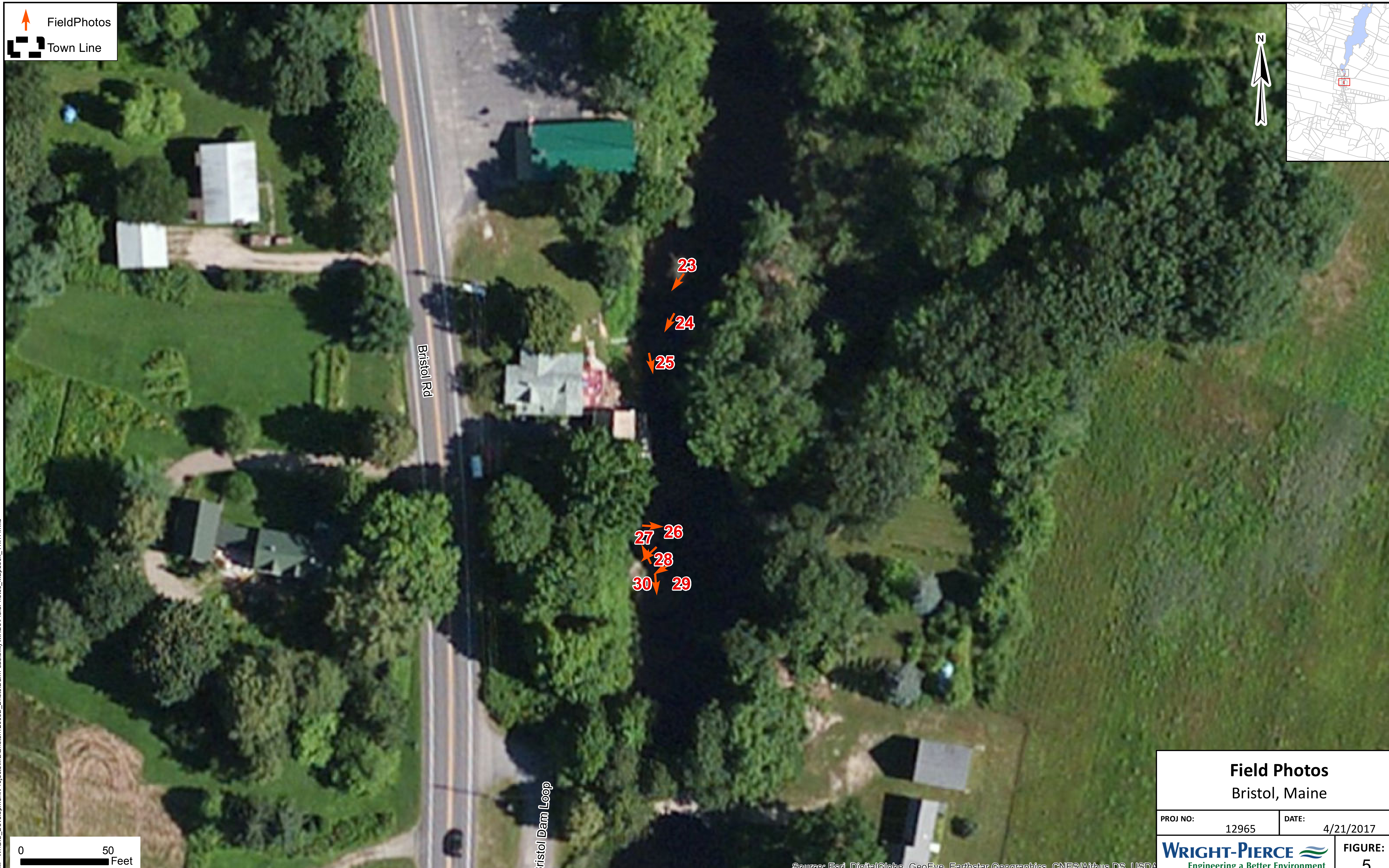
FIGURE: 3

Field Photos
Bristol, Maine

PROJ NO:	DATE:
12965	4/21/2017

WRIGHT-PIERCE
Engineering a Better Environment

FIGURE: 4



Field Photos

Bristol, Maine

PROJ NO:	DATE:
12965	4/21/2017

WRIGHT-PIERCE
Engineering a Better Environment

FIGURE: 5

Bristol Mills Dam Impoundment Infrastructure Survey Photo Log

Photo 1

Photo 2

Photo 3

Photo 4

Photo 5

Photo 6

Photo 7

Photo 8

Photo 9

Photo 10

Photo 11

Photo 12

Photo 13

Photo 14

Photo 15

Photo 16

Photo 17

Photo 18

Photo 19

Photo 20

Photo 21

Photo 22

Photo 23

Photo 24

Photo 25

Photo 26

Photo 27

Photo 28

Photo 29

Photo 30

APPENDIX H

Raw Water Quality Data
(intentionally omitted)

APPENDIX I

Hydrology Calculations

USGS Regression Equations for Rural Unregulated/Ungaged Streams in Maine
(USGS Publication 99-4008)

Project Number:	12965C
Stream Name:	Pemaquid River
Stream Point of Interest:	Bristol Mills Dam
Stream Location:	Bristol, ME

Drainage Area (Km^2):	82.6100
NWI Wetlands w/in Drainage Basin (Km^2):	27.3752
Areal Percentage of Wetlands:	33.1379

	Cubic Meters per Second (cms)			Cubic Feet per Second (cfs)		
Recurrence	Calculated Flows	Average Error Range		Calculated Flows	Average Error Range	
$Q_{2\ (50\%)}$	5.96	8.39	4.24	210.64	296.16	149.77
$Q_{5\ (20\%)}$	8.09	11.48	5.71	285.78	405.52	201.48
$Q_{10\ (10\%)}$	9.51	13.59	6.66	335.82	479.89	235.08
$Q_{25\ (4\%)}$	11.31	16.42	7.79	399.38	579.90	275.17
$Q_{50\ (2\%)}$	12.62	18.54	8.60	445.73	654.77	303.54
$Q_{100\ (1\%)}$	14.07	20.90	9.47	496.74	738.15	334.30
$Q_{500\ (0.5\%)}$	17.26	26.49	11.25	609.40	935.43	397.33

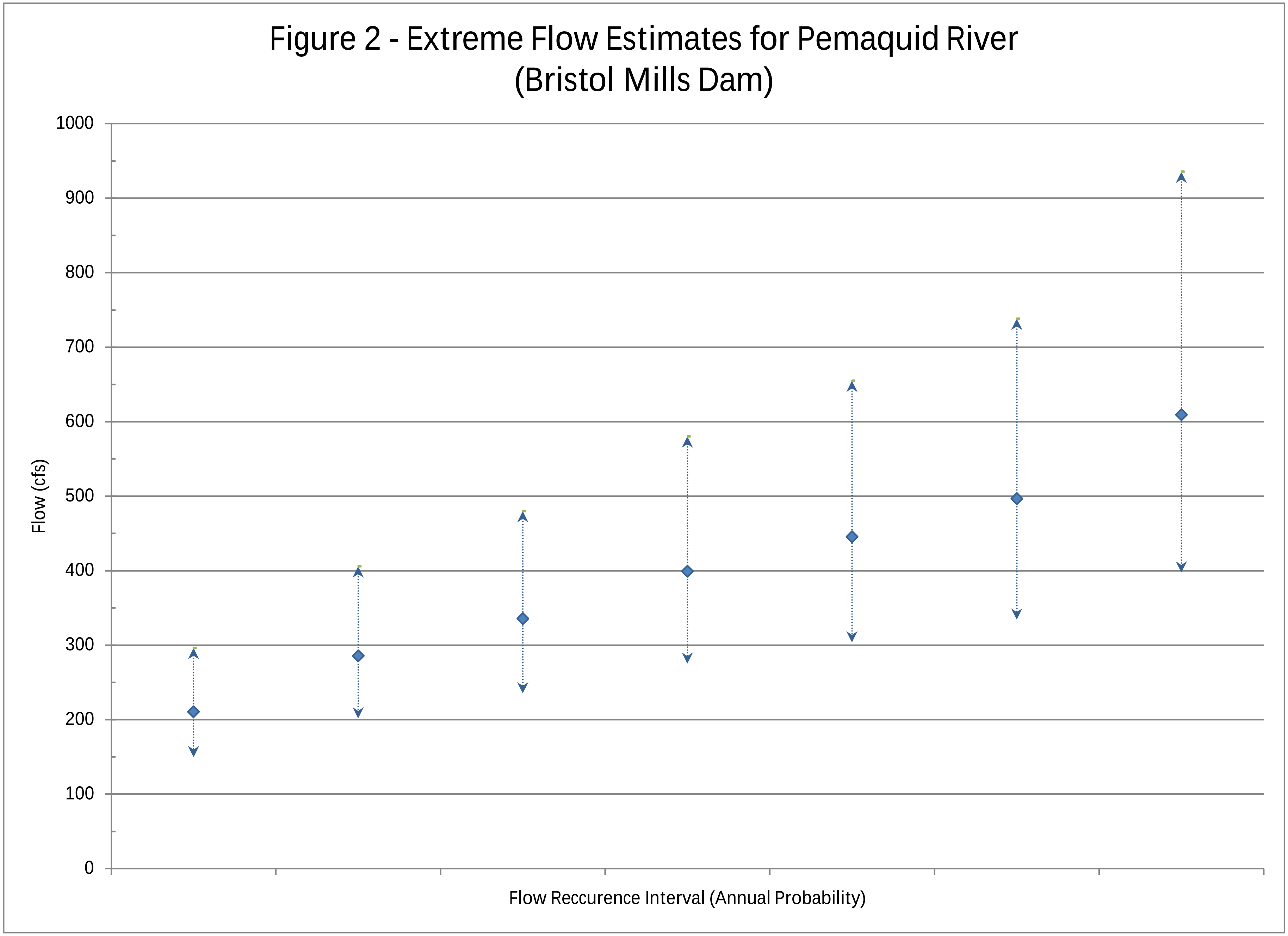


Figure 2 - Extreme Flow Estimates for Pemaquid River
(Bristol Mills Dam)
Flow (cfs)
1000
900
800
700
600
500
400
300
200
100
0
Flow Reccurence Interval (Annual Probability)

USGS Regression Equations for Estimating Monthly, Annual, and Low 7-day, 10-year Streamflows for Ungaged Rivers in Maine (USGS Publication 2004-5026)

Project Number: 12965C
Stream Name: Pemaquid River
Stream Point of Interest: Bristol Mills Dam
Stream Location: Bristol, ME

Watershed Area	31.897	sq.mi.
Sand and Gravel Aquifers	0.0000	decimal fraction within watershed
Distance from Coast	36.640	miles
Mean Annual Precipitation	48.430	inches
Mean Winter Precipitation	11.580	inches

General Regression Estimates

	Flow (cfs)	ASEP		Ave. EYR
$Q_{7,10}$	1.34	0.87	2.04	2.9
$Q_{annual\ mean}$	65.71	60.88	70.93	9.9
$Q_{annual\ median}$	35.58	31.10	40.71	6.9

MEDIAN ESTIMATES

Month	Flow (cfs)	ASEP		Ave. EYR
Jan	48.12	40.37	57.36	8.9
Feb	50.14	43.42	57.91	17.5
Mar	95.57	79.42	115.07	13.3
Apr	170.16	134.77	214.74	3.8
May	56.01	44.59	70.91	3.9
Jun	30.46	23.61	39.84	4.3
Jul	11.22	8.29	15.19	3.6
Aug	7.35	5.24	10.30	3.9
Sep	7.44	5.44	10.17	5.4
Oct	12.65	9.39	17.06	8.3
Nov	39.52	28.10	55.57	4.4
Dec	60.34	52.44	69.39	21.6

MEAN ESTIMATES

Month	Flow (cfs)	ASEP		Ave. EYR
Jan	73.98	66.43	82.41	29.9
Feb	73.09	65.93	80.98	41.2
Mar	146.28	115.56	185.19	7.3
Apr	189.03	159.54	223.82	4.9
May	72.53	61.07	86.17	7.0
Jun	48.55	41.46	56.86	13.1
Jul	20.62	16.64	25.57	8.4
Aug	14.60	11.39	18.72	8.6
Sep	16.40	13.14	20.49	13.9
Oct	33.28	26.86	41.27	17.0
Nov	66.52	54.15	81.76	11.9
Dec	90.39	79.18	103.14	28.9

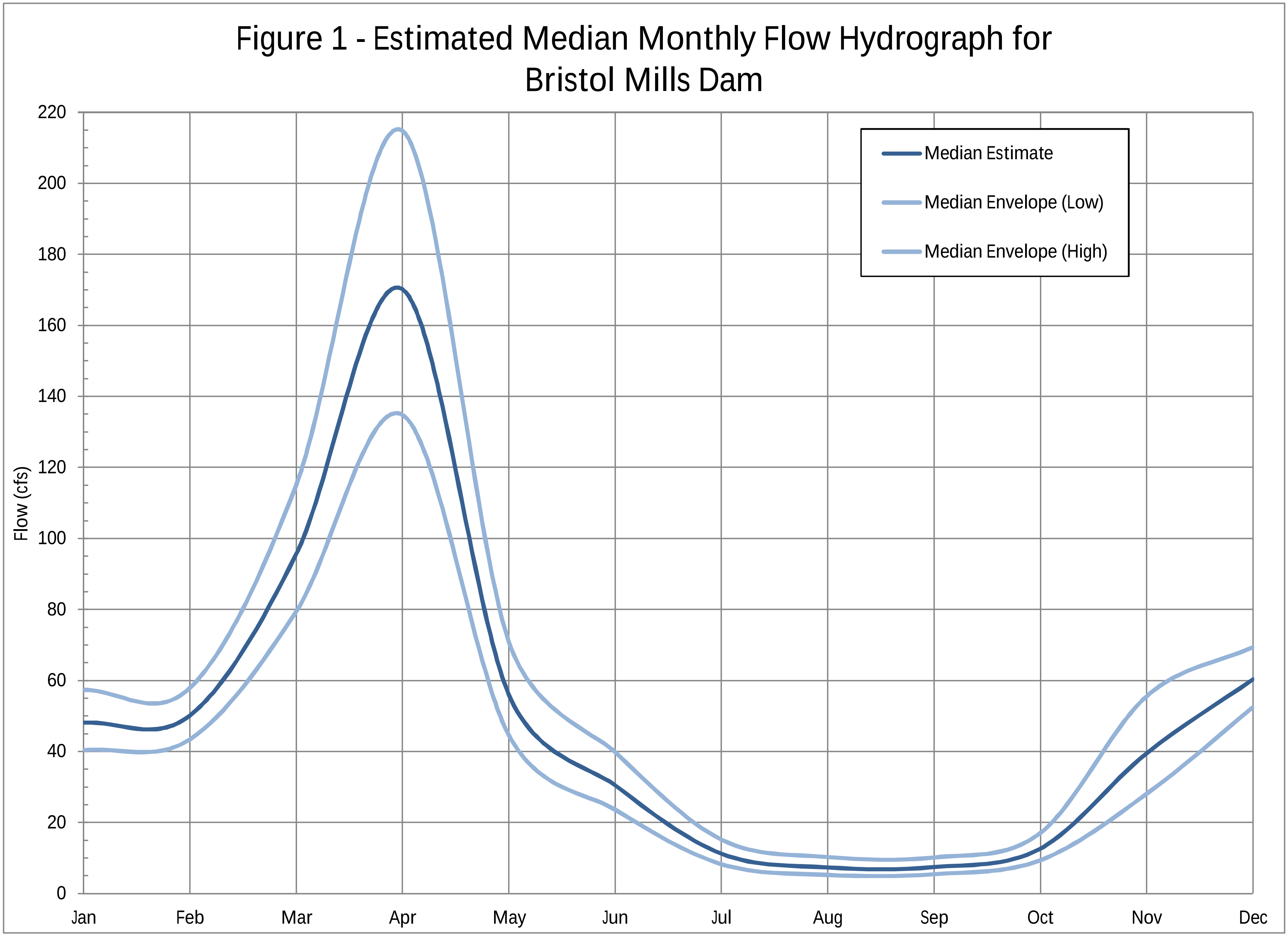


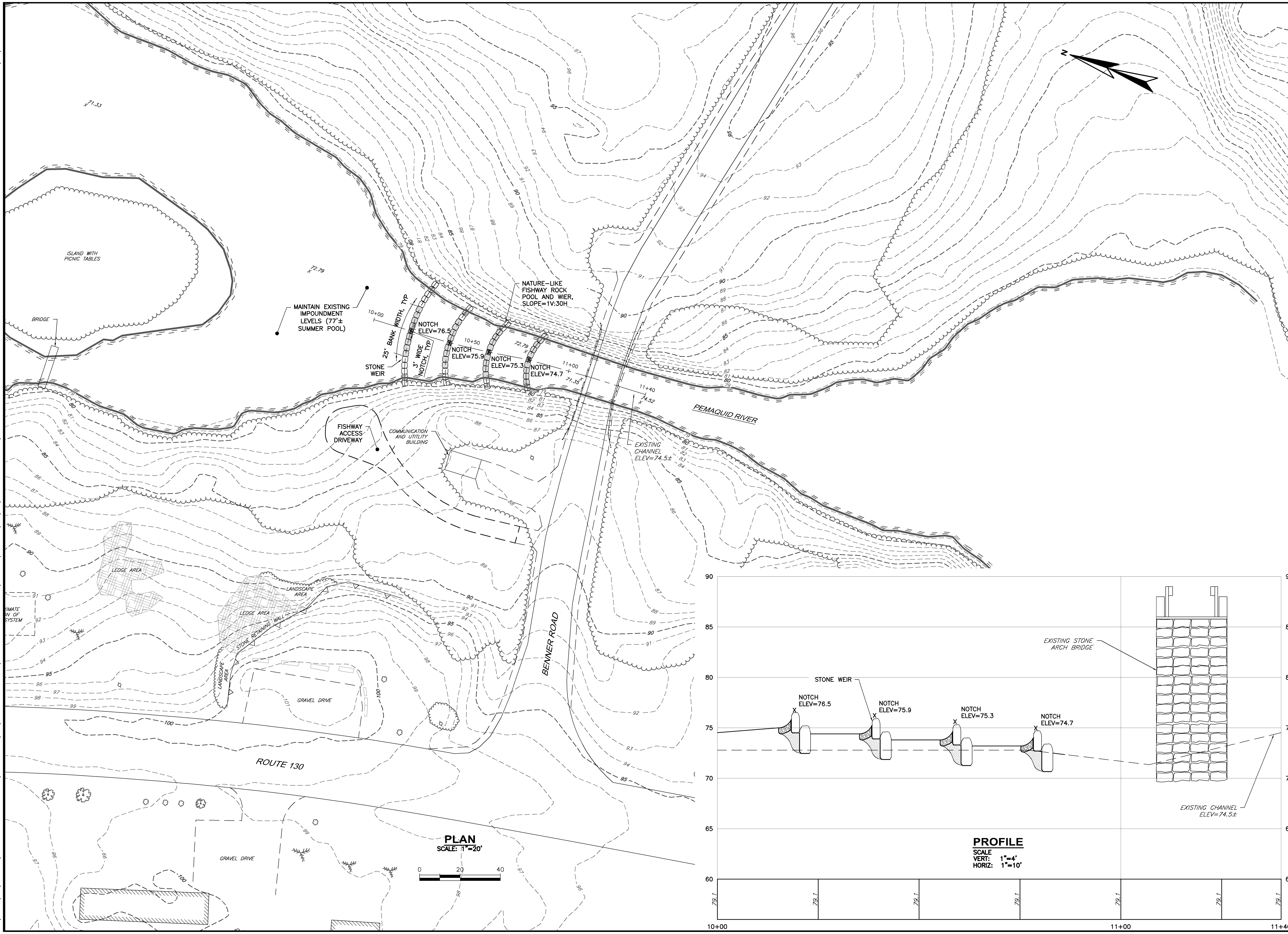
Figure 1 - Estimated Median Monthly Flow Hydrograph for
Bristol Mills Dam
Flow (cfs)
0
20
40
60
80
100
120
140
160
180
200
220
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Median Estimate
Median Envelope (Low)
Median Envelope (High)

APPENDIX J

Lake Level Monitoring Data
(intentionally omitted)

APPENDIX K

Fish Passage Conceptual Plan



LAST SAVED BY: MATT.LAPIERRE 10/20/2017 7:51 AM

G:\DWGS\ME\BRISTOL\12965-BRISTOLMILLSDAM\12965C-FD\CIV\12965C C-3.DWG | 12965C C-3 FISHWAY | 1:4.56 | ---- | 10/20/2017 8:10:27 AM | MATT.LAPIERRE

NO	SUBMISSIONS/REVISIONS	APP'D	DATE

DESIGNED BY: JMM
CAD COORD: RPB
CAD: RPB
CHECKED BY: JMM
DATE:
APPROVED BY: JMM
DATE:
PROJECT NO: 12965C

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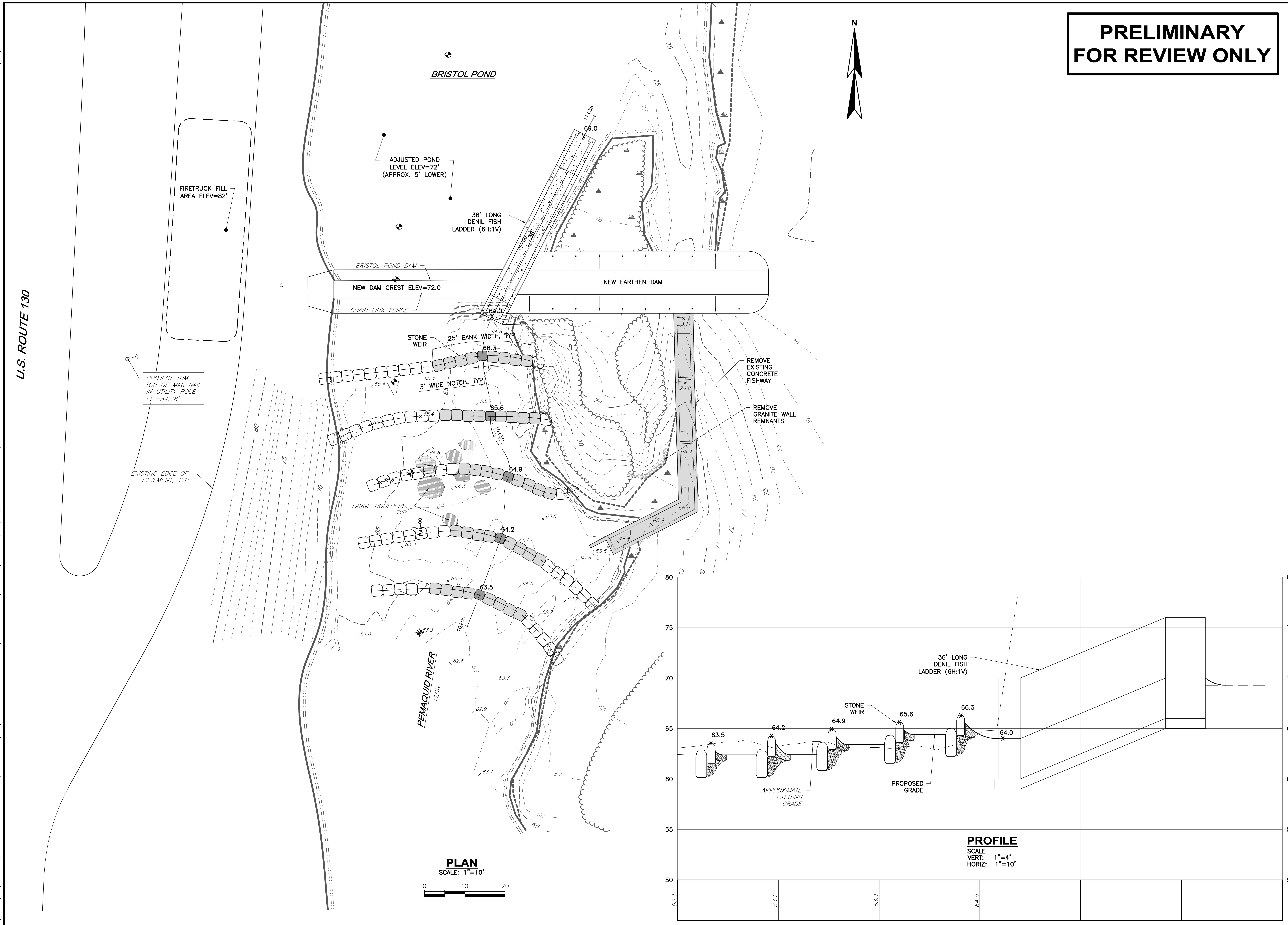
TOWN OF BRISTOL
BRISTOL MILLS DAM
BOAT LAUNCH IMPROVEMENTS
BRISTOL, MAINE

BENNER ROAD BRIDGE FISHWAY PLAN

DRAWING
C-1

PRELIMINARY FOR REVIEW ONLY



TOWN OF BRISTOL
BRISTOL MILLS FISHWAY IMPROVEMENTS
BRISTOL, MAINE

PROPOSED SITE PLAN

DRAWING C-2

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DESIGNED BY: JMM
CAD COORD: RPB
CAD: RPB
CHECKED BY: JMM
DATE: 5-12-15
APPROVED BY: JMM
DATE: 5-12-15
PROJECT NO: 12965A

NO	SUBMISSIONS/REVISIONS	APP'D	DATE
	ISSUED FOR PERMITTING	JMM	5-15

APPENDIX L

Fire Fighting Water Supply Maps

BRISTOL FIRE COMPANY FIRE SUPPRESSION WATER SUPPLY BRISTOL MILLS DAM (E1)		NO.	REVISIONS	APP'D
PROJ NO: 12965C	DATE: MAY 2017	1		
		2		
		3		
WRIGHT-PIERCE Engineering a Better Environment		SITE PLAN		FIGURE: 1

BRISTOL FIRE COMPANY FIRE SUPPRESSION WATER SUPPLY ROUND POND (E2)	NO.	REVISIONS	APP'D
PROJ NO: 12965C DATE: MAY 2017	1		
	2		
	3		
WRIGHT-PIERCE Engineering a Better Environment		SITE PLAN	FIGURE: 2

BRISTOL FIRE COMPANY FIRE SUPPRESSION WATER SUPPLY NORTHERN POINT ROAD (E3)		NO.	REVISIONS	APP'D
		1		
		2		
PROJ NO: 12965C	DATE: MAY 2017	3		
WRIGHT-PIERCE Engineering a Better Environment		SITE PLAN		FIGURE: 3

BRISTOL FIRE COMPANY FIRE SUPPRESSION WATER SUPPLY TRANSFER ROAD (E4)		NO.	REVISIONS	APP'D
		1		
		2		
PROJ NO: 12965C	DATE: MAY 2017	3		
WRIGHT-PIERCE Engineering a Better Environment			SITE PLAN	FIGURE: 4

BRISTOL FIRE COMPANY FIRE SUPPRESSION WATER SUPPLY NEW HARBOR POND (E5)	NO.	REVISIONS	APP'D
	1		
	2		
PROJ NO: 12965C / DATE: MAY 2017	3		
WRIGHT-PIERCE Engineering a Better Environment		SITE PLAN	FIGURE: 5

BRISTOL FIRE COMPANY FIRE SUPPRESSION WATER SUPPLY BRISTOL ROAD, NEW HARBOR (E6)		NO.	REVISIONS	APP'D
		1		
		2		
PROJ NO: 12965C	DATE: MAY 2017	3		
WRIGHT-PIERCE Engineering a Better Environment		SITE PLAN		FIGURE: 6

BRISTOL FIRE COMPANY FIRE SUPPRESSION WATER SUPPLY BRISTOL ROAD (E7)		NO.	REVISIONS	APP'D
		1		
		2		
PROJ NO: 12965C	DATE: MAY 2017	3		
WRIGHT-PIERCE Engineering a Better Environment			SITE PLAN	FIGURE: 7

BRISTOL FIRE COMPANY FIRE SUPPRESSION WATER SUPPLY BRISTOL ROAD (P1)		NO.	REVISIONS	APP'D
PROJ NO: 12965C	DATE: MAY 2017	1		
		2		
		3		
WRIGHT-PIERCE Engineering a Better Environment		SITE PLAN		FIGURE: 8

BRISTOL FIRE COMPANY FIRE SUPPRESSION WATER SUPPLY PARTRIDGE BRIDGE (P2)	NO.	REVISIONS	APP'D
PROJ NO: 12965C DATE: MAY 2017	1		
	2		
	3		
WRIGHT-PIERCE Engineering a Better Environment		SITE PLAN	FIGURE: 9

BRISTOL FIRE COMPANY FIRE SUPPRESSION WATER SUPPLY SPLIT ROCK ROAD (P3)		NO.	REVISIONS	APP'D
		1		
		2		
PROJ NO: 12965C	DATE: MAY 2017	3		
WRIGHT-PIERCE Engineering a Better Environment		SITE PLAN		FIGURE: 10

BRISTOL FIRE COMPANY

FIRE SUPPRESSION WATER SUPPLY

UPPER ROUND POND ROAD (P4)

PROJ NO: 12965C

DATE: MAY 2017

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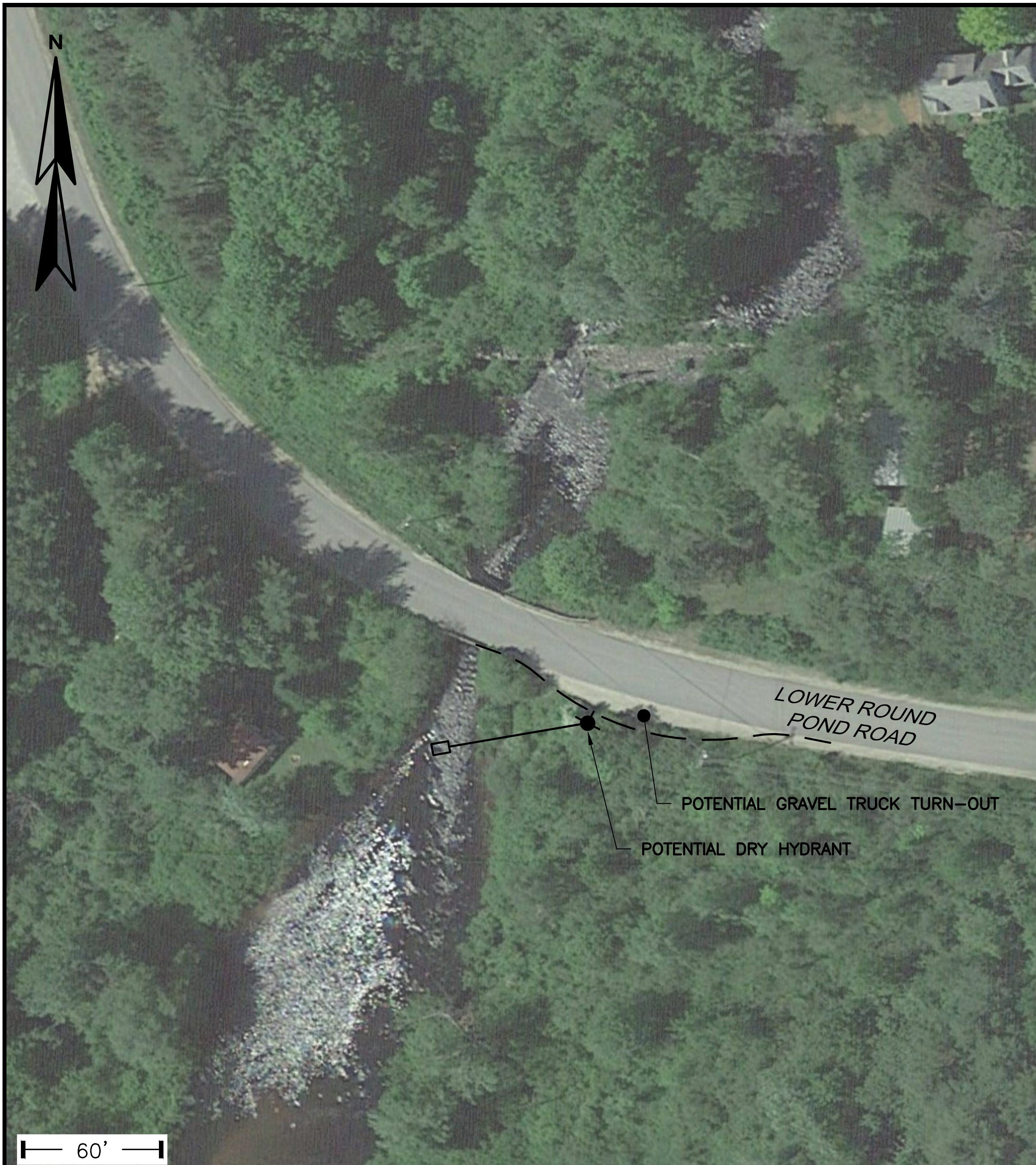
Engineering a Better Environment

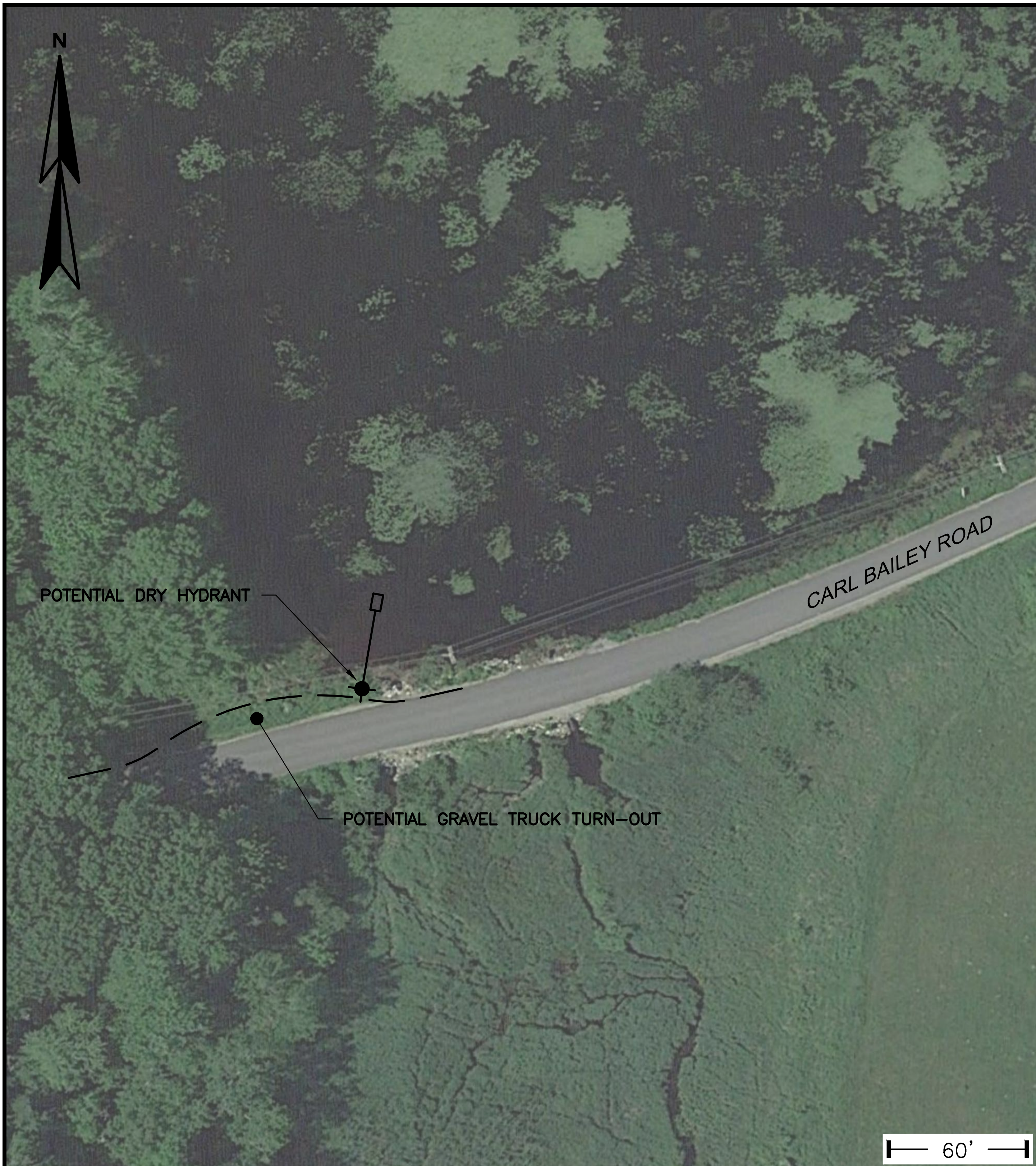
NO.	REVISIONS	APP'D
1		
2		
3		

SITE PLAN

FIGURE: 11



BRISTOL FIRE COMPANY FIRE SUPPRESSION WATER SUPPLY LOWER ROUND POND ROAD (P5)		NO.	REVISIONS	APP'D
		1		
		2		
PROJ NO: 12965C	DATE: MAY 2017	3		
WRIGHT-PIERCE Engineering a Better Environment		SITE PLAN		FIGURE: 12



BRISTOL FIRE COMPANY FIRE SUPPRESSION WATER SUPPLY CARL BAILEY ROAD (P6)		NO.	REVISIONS	APP'D
		1		
		2		
PROJ NO: 12965C	DATE: MAY 2017	3		
WRIGHT-PIERCE Engineering a Better Environment			SITE PLAN	FIGURE: 13

BRISTOL FIRE COMPANY FIRE SUPPRESSION WATER SUPPLY TRANSFER ROAD (P7)	NO.	REVISIONS	APP'D
PROJ NO: 12965C / DATE: MAY 2017	1		
	2		
	3		
WRIGHT-PIERCE Engineering a Better Environment		SITE PLAN	FIGURE: 14

BRISTOL FIRE COMPANY FIRE SUPPRESSION WATER SUPPLY BRISTOL ROAD BOAT LAUNCH (P8)		NO.	REVISIONS	APP'D
		1		
		2		
PROJ NO: 12965C	DATE: MAY 2017	3		
WRIGHT-PIERCE Engineering a Better Environment			SITE PLAN	FIGURE: 15

Bristol Fire Service Area
Bristol Fire and Rescue

PROJ NO: 12965B	DATE: 6/13/2017	FIGURE: 1

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APPENDIX M

Ellingwood Park Concept Plans

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NO	SUBMISSIONS/REVISIONS	APP'D	DATE
	PRELIMINARY REVIEW	JMM	10-17
1			
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3			
4			

DESIGNED BY: JMM
CAD COORD: RPB
CAD: RPB
CHECKED BY: JMM
DATE: 10-24-17
APPROVED BY: JMM
DATE: 10-24-17
PROJECT NO: 12965C

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TOWN OF BRISTOL
BRISTOL MILLS DAM
BOAT LAUNCH IMPROVEMENTS
BRISTOL, MAINE

ELLINGWOOD PARK RECREATION ENHANCEMENTS

DRAWING
C-1

NO.	SUBMISSIONS/REVISIONS	APP'D	DATE
	PRELIMINARY REVIEW	JMM	10-17

DESIGNED BY:
CAD COORD: RPB
CAD:
CHECKED BY:
DATE: 10-24-17
APPROVED BY:
DATE: 10-24-17
PROJECT NO: 12965C

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TOWN OF BRISTOL
BRISTOL MILLS DAM
BOAT LAUNCH IMPROVEMENTS
BRISTOL, MAINE

ELLINGWOOD PARK RECREATION AREA
FIRE ACCESS PLAN A

DRAWING
C-2

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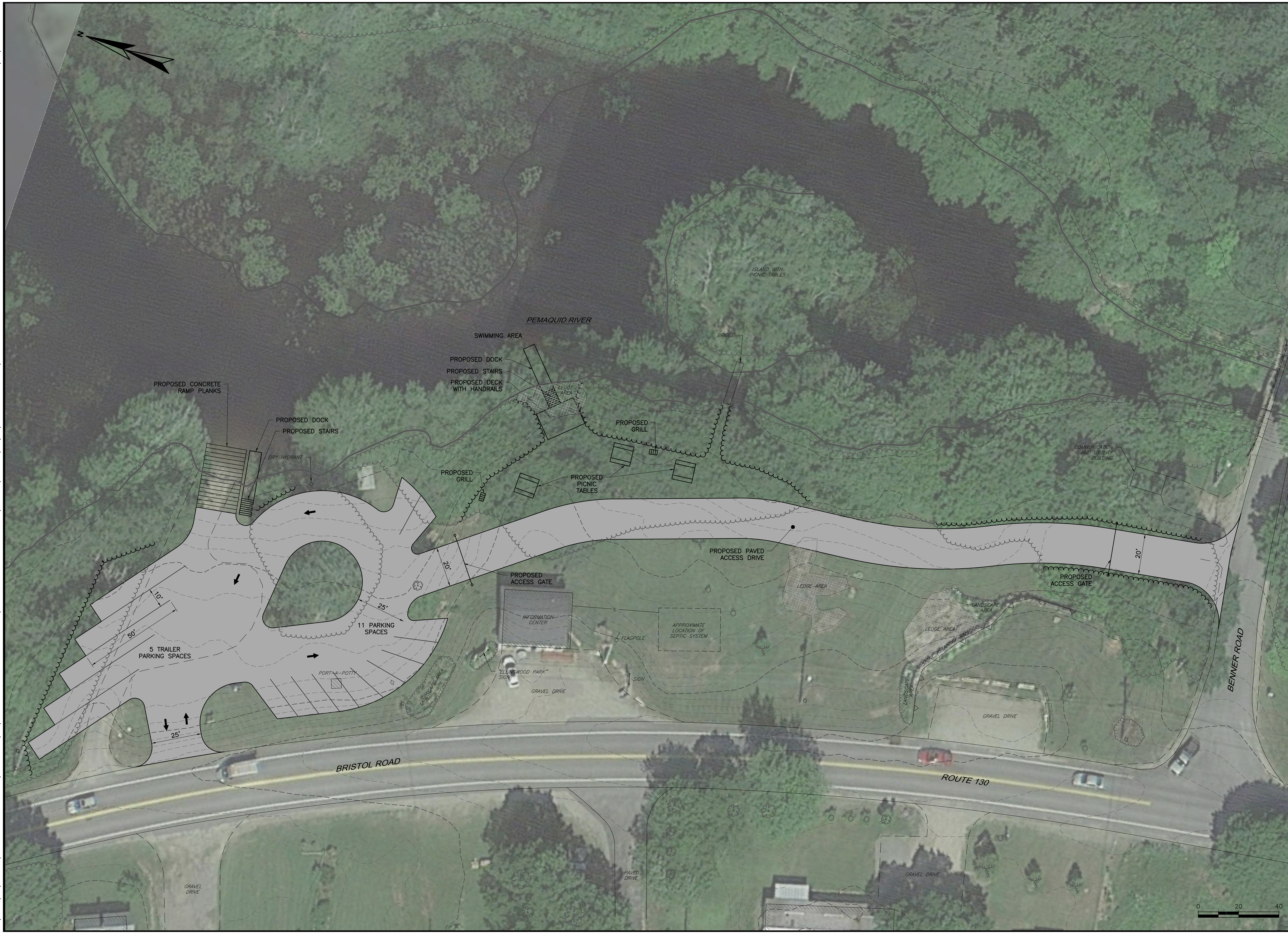

NO.	SUBMISSIONS/REVISIONS	APP'D	DATE
	PRELIMINARY REVIEW	JMM	10-17

DESIGNED BY: JMM
CAD COORD: RPB
CAD: RPB
CHECKED BY: JMM
DATE: 10-24-17
APPROVED BY: JMM
DATE: 10-24-17
PROJECT NO: 12965C

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TOWN OF BRISTOL
BRISTOL MILLS DAM
BOAT LAUNCH IMPROVEMENTS
BRISTOL, MAINE

ELLINGWOOD PARK RECREATION AREA
FIRE ACCESS PLAN B

DRAWING
C-3

APPENDIX N

Cost Estimate Worksheets

BRISTOL MILLS DAM - BRISTOL MILLS, MAINE
June 13, 2017
Fire Suppression Water Supply - Bristol Road (P1)

No.	Description	Unit	Quantity	Unit Price	Total Cost
1	Mobilization/Demobilization	LS	1	$ 10,000.00	$ 10,000.00
2	Gravel Fill	CY	200	$ 35.00	$ 7,000.00
3	Clearing	LS	1	$ 10,000.00	$ 10,000.00
4	Dry Hydrant Installation	EA	1	$ 40,000.00	$ 40,000.00
5	Common Excavation	CY	200	$ 20.00	$ 4,000.00
6	Loam & Seed	LS	1	$ 1,000.00	$ 1,000.00

Subtotal	$ 72,000.00
Engineering, Design, & Contingency (20%)	$ 14,400.00
Total	$ 86,400.00

BRISTOL MILLS DAM - BRISTOL MILLS, MAINE
June 13, 2017
Fire Suppression Water Supply - Partridge Bridge (P2)

No.	Description	Unit	Quantity	Unit Price	Total Cost
1	Mobilization/Demobilization	LS	1	$ 10,000.00	$ 10,000.00
2	Dry Hydrant Installation	EA	1	$ 40,000.00	$ 40,000.00
3	Clearing & Grubbing	LS	1	$ 2,000.00	$ 2,000.00
4	Gravel	CY	300	$ 35.00	$ 10,500.00
5	Common Excavation	CY	50	$ 20.00	$ 1,000.00
6	Loam & Seed	LS	1	$ 1,000.00	$ 1,000.00

Subtotal	$ 64,500.00
Engineering, Design, & Contingency (20%)	$ 12,900.00
Total	$ 77,400.00

BRISTOL MILLS DAM - BRISTOL MILLS, MAINE
June 13, 2017
Fire Suppression Water Supply - Split Rock (P3)

No.	Description	Unit	Quantity	Unit Price	Total Cost
1	Mobilization/Demobilization	LS	1	$ 10,000.00	$ 10,000.00
2	Excavation	CY	100	$ 20.00	$ 2,000.00
3	Gravel Fill	CY	500	$ 30.00	$ 15,000.00
4	Dry Hydrant Installation	EA	1	$ 40,000.00	$ 40,000.00
5	Rip Rap Slope	CY	75	$ 80.00	$ 6,000.00
6	Guardrail Install	LF	300	$ 15.00	$ 4,500.00
7	Loam & Seed	LS	1	$ 1,000.00	$ 1,000.00

Subtotal	$ 78,500.00
Engineering, Design, & Contingency (20%)	$ 15,700.00
Total	$ 94,200.00

BRISTOL MILLS DAM - BRISTOL MILLS, MAINE
June 13, 2017
Fire Suppression Water Supply - Upper Round Pond Road (P4)

No.	Description	Unit	Quantity	Unit Price	Total Cost
1	Dry Hydrant Installation	EA	1	$ 40,000.00	$ 40,000.00
2	Gravel Fill	CY	100	$ 30.00	$ 3,000.00
3	Common Excavation	CY	100	$ 20.00	$ 2,000.00
4	Loam & Seed	LS	1	$ 1,000.00	$ 1,000.00

Subtotal	$ 46,000.00
Engineering, Design, & Contingency (20%)	$ 9,200.00
Total	$ 55,200.00

BRISTOL MILLS DAM - BRISTOL MILLS, MAINE
June 13, 2017
Fire Suppression Water Supply - Upper Round Pond Road (P4)

No.	Description	Unit	Quantity	Unit Price	Total Cost
1	Dry Hydrant Installation	EA	1	$ 40,000.00	$ 40,000.00
2	Common Excavation	CY	150	$ 20.00	$ 3,000.00
3	Gravel Fill	CY	150	$ 30.00	$ 4,500.00
4	Loam & Seed	LS	1	$ 1,000.00	$ 1,000.00

Subtotal	$ 48,500.00
Engineering, Design, & Contingency (20%)	$ 9,700.00
Total	$ 58,200.00

BRISTOL MILLS DAM - BRISTOL MILLS, MAINE
June 13, 2017
Fire Suppression Water Supply - Carl Bailey Road (P6)

No.	Description	Unit	Quantity	Unit Price	Total Cost
1	Dry Hydrant Installation	EA	1	$ 40,000.00	$ 40,000.00
2	Common Excavation	CY	150	$ 20.00	$ 3,000.00
3	Gravel Fill	CY	150	$ 30.00	$ 4,500.00
4	Loam & Seed	LS	1	$ 1,000.00	$ 1,000.00

Subtotal	$ 48,500.00
Engineering, Design, & Contingency (20%)	$ 9,700.00
Total	$ 58,200.00

BRISTOL MILLS DAM - BRISTOL MILLS, MAINE
June 13, 2017
Fire Suppression Water Supply - Transfer Road (P7)

No.	Description	Unit	Quantity	Unit Price	Total Cost
1	Dry Hydrant Installation	EA	1	$ 40,000.00	$ 40,000.00
2	Common Excavation	CY	1100	$ 20.00	$ 22,000.00
3	Gravel Fill	CY	1000	$ 30.00	$ 30,000.00
4	Water Tank	EA	2	$ 200,000.00	$ 400,000.00
5	8" Pipe Installation	LF	450	$ 80.00	$ 36,000.00
6	Loam & Seed	LS	1	$ 1,000.00	$ 1,000.00

Subtotal	$ 529,000.00
Engineering, Design, & Contingency (20%)	$ 105,800.00
Total	$ 634,800.00

BRISTOL MILLS DAM - BRISTOL MILLS, MAINE
June 13, 2017
Fire Suppression Water Supply - Ellingwood Park (P8)

No.	Description	Unit	Quantity	Unit Price	Total Cost
1	Dry Hydrant Installation	EA	1	$ 40,000.00	$ 40,000.00
2	Clearing & Grubbing	LS	1	$ 5,000.00	$ 5,000.00
3	Common Excavation	CY	525	$ 20.00	$ 10,500.00
4	Ledge Removal	CY	30	$ 100.00	$ 3,000.00
6	Loam & Seed	LS	1	$ 1,000.00	$ 1,000.00

Subtotal	$ 59,500.00
Engineering, Design, & Contingency (20%)	$ 11,900.00
Total	$ 71,400.00

BRISTOL MILLS DAM - BRISTOL MILLS, MAINE
October 20, 2017
Fire Suppression Water Supply - Ellingwood Park (P8) - Access Route to Benner Rd.

No.	Description	Unit	Quantity	Unit Price	Total Cost
1	Gravel Driveway	CY	100	$ 30.00	$ 3,000.00
2	Clearing & Grubbing	LS	1	$ 5,000.00	$ 5,000.00
3	Common Excavation	CY	400	$ 20.00	$ 8,000.00
4	Access Gate Installation	EA	2	$ 10,000.00	$ 20,000.00
5	Grass Pavement	SY	750	$ 40.00	$ 30,000.00
6	Loam & Seed	LS	1	$ 1,000.00	$ 1,000.00

Subtotal	$ 67,000.00
Engineering, Design, & Contingency (20%)	$ 13,400.00
Total	$ 80,400.00

Bristol Mills Dam - Bristol, ME
October 20, 2017
Fishway Reconstruction - Included in Option A

No.	DESCRIPTION	UNITS	QUANTITY	UNIT PRICE	TOTAL COST
1	Mobilization/Demobilization	LS	1	$ 10,000.00	$ 10,000.00
2	Erosion Control/loam and seed	LS	1	$ 5,000.00	$ 5,000.00
3	Cofferdamming and dewatering	LS	1	$ 10,000.00	$ 10,000.00
4	Temporary Rock Road (access)	LS	1	$ 25,000.00	$ 25,000.00
5	Demolition and removal including gate	CY	30	$ 100.00	$ 3,000.00
6	Ledge Removal (hammer)	CY	40	$ 300.00	$ 12,000.00
7	Anchor pins into ledge	EA	780	$ 25.00	$ 19,500.00
8	Common Excavation	CY	120	$ 30.00	$ 3,600.00
9	Wrapped Crushed Stone Footing Pads	CY	34	$ 40.00	$ 1,360.00
10	Structural Concrete	CY	107	$ 800.00	$ 85,600.00
11	Perforated Drain	LF	300	$ 65.00	$ 19,500.00
12	Rock/Gravel Fill	CY	200	$ 50.00	$ 10,000.00
13	Cut Fishway at Top	LS	1	$ 1,500.00	$ 1,500.00
14	Drain and Valve	LS	1	$ 2,000.00	$ 2,000.00
15	Baffles	EA	43	$ 250.00	$ 10,750.00
16	Platform	EA	1	$ 4,000.00	$ 4,000.00
17	Stop Logs and Embeds	locations	3	$ 400.00	$ 1,200.00

SUBTOTAL	$ 224,010.00
Contingency (25%)	$ 56,002.50
Engineering & Permitting (10%)	$ 22,401.00
TOTAL	$ 302,413.50

Bristol Mills Dam - Bristol, ME
October 20, 2017
Construction of Nature-Like Fishway At Benner Road - Included in Option B & Option C

No.	DESCRIPTION	UNITS	QUANTITY	UNIT PRICE	TOTAL COST
1	Mobilization/Demobilization	LS	1	$ 20,000.00	$ 20,000.00
2	Temporary Access to Sreambed	LS	1	$ 25,000.00	$ 25,000.00
2	Boulders for Streambed	CY	100	$ 150.00	$ 15,000.00
3	Streambed Construction	SY	150	$ 300.00	$ 45,000.00
4	Erosion/Dewatering Controls	LS	1	$ 15,000.00	$ 15,000.00
5	Loam & Seed	LS	1	$ 5,000.00	$ 5,000.00

SUBTOTAL	$ 125,000.00
Contingency (25%)	$ 31,250.00
Engineering & Permitting (10%)	$ 12,500.00
TOTAL	$ 168,750.00

Bristol Mills Dam - Bristol, ME
October 20, 2017
Fishway Construction at Dam - Included in Option C

No.	DESCRIPTION	UNITS	QUANTITY	UNIT PRICE	TOTAL COST
1	Mobilization/Demobilization	LS	1	$ 25,000.00	$ 25,000.00
2	Streambed Construction	SY	450	$ 300.00	$ 135,000.00
3	Boulders for Weirs	CY	130	$ 150.00	$ 19,500.00
4	Gravel Access (Equipment)	LS	1	$ 25,000.00	$ 25,000.00
5	Erosion/Dewatering Controls	LS	1	$ 25,000.00	$ 25,000.00
6	Loam & Seed	LS	1	$ 10,000.00	$ 10,000.00

SUBTOTAL	$ 239,500.00
Engineering, Design, & Contingency (25%)	$ 59,875.00
TOTAL	$ 299,375.00

Bristol Mills Dam - Bristol, ME
October 20, 2017
Reconstruction of Partial Dam - Included in Option C

No.	DESCRIPTION	UNITS	QUANTITY	UNIT PRICE	TOTAL COST
1	Mobilization/Demobilization	LS	1	$ 30,000.00	$ 30,000.00
2	Demolition & Removal of Material	CY	400	$ 250.00	$ 100,000.00
3	Excavation/Fill	CY	600	$ 35.00	$ 21,000.00
4	Structural Concrete & Rebar for Dam & Fishway	CY	110	$ 800.00	$ 88,000.00
5	Erosion/Dewatering Controls	LS	1	$ 30,000.00	$ 30,000.00
6	Loam & Seed	LS	1	$ 10,000.00	$ 10,000.00

SUBTOTAL	$ 279,000.00
Engineering, Design, & Contingency (25%)	$ 69,750.00
TOTAL	$ 348,750.00

Bristol Mills Dam - Bristol, ME
October 20, 2017
Recreational Alternative - Included in Option B & Option C

No.	DESCRIPTION	UNITS	QUANTITY	UNIT PRICE	TOTAL COST
1	Mobilization/Demobilization	LS	1	$ 20,000.00	$ 20,000.00
2	Clearing/Grubbing	LS	1	$ 5,000.00	$ 5,000.00
3	Excavation	CY	1200	$ 25.00	$ 30,000.00
4	Gravel for Roadway	CY	1200	$ 25.00	$ 30,000.00
5	Pavement for Roadway	SY	1500	$ 35.00	$ 52,500.00
6	Site Amenities	LS	1	$ 5,000.00	$ 5,000.00
7	Concrete for Boat Ramp	CY	50	$ 400.00	$ 20,000.00
8	Wooden Deck and Dock	LS	1	$ 15,000.00	$ 15,000.00
9	Erosion/Dewatering Controls	LS	1	$ 5,000.00	$ 5,000.00
10	Loam & Seed	LS	1	$ 10,000.00	$ 10,000.00

SUBTOTAL	$ 192,500.00
Contingency (25%)	$ 48,125.00
Engineering & Permitting (10%)	$ 19,250.00
TOTAL	$ 259,875.00

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