Inter-Fluve, Inc.
Technical Memorandum-FINAL

TO: Beth Lambert, MA DER; Dan Welch, Bostik, Inc.; Josh Ellsworth, Ipswich River Watershed Association; Eric Hutchins, NOAA
FROM: Nick Nelson, Inter-Fluve; Bruce Adams, Weston & Sampson
DATE: June 30, 2011
REGARDING: South Middleton Dam Removal - Refining Costs for Removal and a Fire Suppression Alternative

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1 Executive Summary
Inter-Fluve was contracted by the MA Division of Ecological Restoration (DER) to perform additional studies relating to the proposed removal of South Middleton Dam on the Ipswich River. The goal of this phase of the project was to refine the costs of the replacement fire suppression water system at the Bostik facilities as well as the costs of the design and construction for the removal of the dam. To refine these costs, assumptions were verified with Bostik's fire suppression engineer, design drawings of the dam were analyzed, sediment management options were analyzed, and conceptual restoration renderings were drawn. The key findings from this phase of the project are:

- Estimated cost of the preferred fire suppression alternative: $715,000
- Estimated design and construction costs for dam removal: $280,900
- Off-site disposal of impounded sediments may not be necessary
This technical memorandum details the results of this phase of the project in four primary sections:

- Fire protection alternative - summary of preferred alternative, confirmation of assumptions, and revised cost estimates
- Dam removal design and construction cost estimates - proposed scope of work and associated costs for the necessary future phases for removing the dam; also includes estimated construction costs
- Sediment management - summary of management alternatives for the impounded sediment behind South Middleton Dam
- Conceptual rendering - description of design opportunities and considerations; renderings are in Appendix 2

2 Background

South Middleton Dam is located about 500 ft west of the Boston Street bridge over the Ipswich River in South Middleton (Figure 1). The watershed upstream of the dam is approximately 44 mi², 32% of which is forested land. South Middleton Dam is approximately 110 ft long with a spillway length of about 45 ft; the structural height is 9 ft and the hydraulic height is 7.5 ft (GEI Consultants, Inc., 2006). The impoundment is approximately 0.5 miles long with a maximum pool storage of about 75 acre-ft (GEI Consultants, Inc., 2006). The dam was built in 1900, modified in 1953 and is currently in fair condition (GEI Consultants, Inc., 2006).

In 2010, Inter-Fluve completed a Partial Feasibility Study for the removal of South Middleton Dam. This dam is a complete fish passage barrier and is the most downstream obstruction on the Ipswich River that does not provide opportunities for fish to move up and downstream. One of the primary objectives for removing the dam is to restore the natural riparian habitat and upstream fish passage. Dam removal will improve conditions for blueback herring, alewife, sea lamprey, American eel, American shad, eastern brook trout, white sucker, fallfish, creek chubsucker and the common shiner. Dam removal will also eliminate maintenance costs and safety and liability concerns for the dam owner, Bostik, Inc. The project partners for the Partial Feasibility Study were the Ipswich River Watershed Association (IRWA); MA Division of...
3 Recommendations for Replacement of Fire Protection Flows for the Bostik Facility

The Bostik facility located in Middleton currently takes water for fire protection from an impoundment on the Ipswich River. A vertical turbine pump set over a 14-foot deep wetwell is reported to have capacity to pump 2,000 gallons per minute (gpm) at 80 psi into the fire protection piping network. The network includes fire sprinkler systems within various buildings and fire hydrants on site. With the removal of the dam, the current source of water for fire protection will no longer be available. This will require developing an alternate source of water and replacing the pumped system with a new system that will deliver the required flow and pressure.

For the purpose of this report, we have assumed that the flow requirement for the fire protection system will continue to be 2,000 gpm in the future. According to Mr. Phil Crain, CFPS, of XL Capital Group, fire protection consultant for Bostik, this volume is needed over a duration of three hours, resulting in a total volume requirement of 360,000 gallons. The delivery pressure design point should be between 110 and 125 psi, according to Mr. Crain, which is an increase from the current 80 psi. A design point of about 115 psi is suggested to avoid excessive pressures on the existing piping network. For the purpose of this evaluation, pressures are assumed to be measured from ground level at the lower buildings nearest the river (assumed at 60 feet ground elevation). A pressure of 115 psi at ground elevation of 60 feet is equal to a hydraulic grade line of 325 feet. This pressure should be verified with Bostik’s fire protection consultant prior to any facility design or improvement.

Several alternatives and combinations of alternatives were considered for replacing the fire protection supply, as follows:

- Connect to the City of Peabody Main Service water system.
- Connect to the City of Peabody High Service water system.
- Build new on site ground level fire storage facility.
- Reinstate the existing steel elevated water storage facility.
- Build a new steel elevated water storage facility.
- Utilize on-site ponds.

The June 10, 2010 report on Alternatives described and compared each alternative. Building a new ground level fire storage facility was recommended. The recommended system is described below.

**On Site Ground Level Fire Storage Tank** A new tank would be sized to provide water storage for fire protection supply, with or without augmenting supply from the City of Peabody. Full supply would require a large volume for all sprinklers and hydrant hose streams. Typical flow duration for public fire suppression would be three hours for a flow of 2,000 gpm, for a total volume of 360,000 gallons. For the purpose of estimation of a tank volume we have assumed this flow and duration, with an allowance for pump suction volume, for a total of 400,000 gallons capacity. This flow and

2011 Inter-Fluve, Inc.  South Middleton Dam, Ipswich River
duration should be verified, as confirmation of that flow and duration is beyond the scope of this evaluation.

An alternative to the 400,000 gallon ground storage tank would be a smaller tank that would utilize water supply from either or both of the Peabody Systems for refilling the tank during a fire event. The hydraulic model indicates that at least 2,000 gallons could be available from Peabody under normal conditions. To avoid low pressures and disruption in the Peabody Systems during all conditions, we estimate that no more than 800 to 1,000 gpm should be taken from the Main Service and no more than 500 to 700 gpm from the High Service. Supplementing flow from the Peabody Main Service would result in a fire storage tank volume of 250,000 gallons. Additional supplementing with flow from the Peabody High Service would result in a fire storage tank volume 150,000 gallons. 1,000 feet of dedicated 10-inch water main from the water tank to the City water supply at Boston Street would be necessary to allow the supplemental flows to refill the tank during its use.

Since the water in the tank is stored until needed, it must be kept from freezing during the winter. For this reason, the tank should be insulated and the water circulated and heated as necessary. When needed, the water would be pumped to meet the fire demand. Most often, the pumping station would include one engine driven pump and a fire department backup connection. Controls would be automatic.

The tank and pump station should be located near the existing fire protection piping network, and away from existing buildings. The open space close to the existing supply connection and meter from the City of Peabody is an ideal location. It is close to the supply, and at the beginning of the fire protection main loops. This location has been discussed with Mr. Joseph Condon and Mr. Phil Crain and both agreed to the location (Attachment 1).

One water main in the underground piping network should be replaced or paralleled as part of the project. The water main is older 6-inch diameter cast-iron and connects to the supply and several core buildings. We recommend a new 8-inch ductile iron to complete an 8-inch loop of newer piping around the buildings within the site as shown on the attached figure.

**Conclusions** Although a significant fire flow volume is available directly from the City of Peabody water system, 2,000 gpm is not available at the 115 psi pressure desired. For this reason, the flow must be pumped to meet the pressure requirement. To accomplish this, a pumping system with a fire storage tank is needed. Supplementing the volume stored in the tank from at least one of the City of Peabody water distribution systems is also suggested to decrease the size of the storage tank and increase reliability. For the purpose of estimating the probable cost of improvements, we have assumed the following:
• 250,000 gallon insulated fire storage tank with heater and recirculation system. Estimated cost
  $370,000.
• 2,000 gpm at 115 psi single diesel engine pumping system. Estimated cost $250,000.
• 1,000 feet of 8-inch and 50 feet of 12-inch water meter connection from the storage tank to the 8-inch water main in Boston Road. Estimated cost $95,000.

The total estimated cost of the replacement fire protection system is approximately $715,000.

Alternatives include the following:

• Increase the size of the insulated fire storage tank with recirculation system to 400,000 gallon. Estimated additional cost $80,000.
• Decrease the size of the insulated fire storage tank with recirculation system to 150,000 gallon. Estimated reduction in cost $70,000.

The final tank size and location, pump size and number, pump power source, as well as the location of water main should be confirmed by all involved parties prior to finalizing a design plan.

4 Cost Estimates for Future Phases of Dam Removal Design and Construction

The Phase I Technical Memo provided a scope and cost for an Advanced Feasibility Study. The following cost estimates are based on the information discussed above, past experience with dam removal projects, and the understanding that a minimal design and restoration approach is desirable.

4.1 Design Cost: $122,000
The design tasks for the removal of South Middleton Dam include project management, preliminary designs, permitting, and final designs.

4.1.1 Project Management Cost: $5,700
Project management tasks include regular updates and phone conferences with project partners, timely delivery of invoices, and coordination of the design team to ensure that deliverables are completed on time.

4.1.2 Preliminary Designs Cost: $67,900
Preliminary designs include data collection, hydrology and hydraulics, geotechnical analysis, sediment management, and preliminary designs.

Surveying ................................................................................................................................. Cost: $16,400

• Topographic survey –Complete topographic survey to create a working basemap. The survey will include cross-sections and profile data sufficient to create a continuous project HEC-RAS model for assessment of flood management, fish passage feasibility, sediment management and restoration design. Cross section spacing will reflect local hydraulic conditions and will be sufficient for modeling purposes.
• **Bathymetric survey** – A depth of refusal survey has already been completed. The topographic survey will tie into this depth of refusal survey so above ground and bathymetry data are in one dataset.

Hydrologic and Hydraulic (H&H) Analysis ................................................................. Cost: $8,300

• Existing and proposed topographic data will be integrated with a hydraulic model to develop a plan view of proposed changes under baseflow, 2, 5, 10 and 100 year flood occurrences, and present the HEC-RAS profiles for the 2, 10, 25 and 100 year floods. Modeling will consider recent NOAA recommendations for increased return flood estimates due to climate change.

• Incipient motion analysis – channel and bank stability requirements will be reviewed and refined, sizing and other requirements for stabilization measures such as riprap, bank toe or riffle material will be developed.

• Bridge scour analysis will be conducted at the Boston Street bridge. Cost estimate assumes basic analysis using the hydraulic models created in the above tasks. Use of HEC-18 or other analysis tools would be an additional cost.

Geotechnical Analysis ................................................................................................ Cost: $12,000

• Geotechnical borings (2) will be completed to better understand the underlying soils and geology at the dam location.

Sediment Management ................................................................................................. Cost: $9,900

• *Regulatory Meeting #1* - Meet with DEP to discuss the reuse of Cove sediments in the Cove or Area 5

• *Additional sampling* - If DEP thinks reuse is feasible, collect recommended number of stratified cores and analyze for the recommended contaminants. The cost estimate is based on 4 cores split into two stratigraphic sections - overlying fines and underlying pre-dam material. Two of these cores will be collected in the proposed channel location, the other two in the proposed reuse area of the cove. If Area 5 is the chosen reuse area, additional sampling for PCBs in Area 5 is likely not necessary as hundreds of sediment samples have been collected at this location and tested since the remediation was completed in 2003. Based on preliminary analyses, these cores should be analyzed for metals and PCBs. Also, TCLP should be completed for lead, as lead exceeded the TCLP threshold in one Cove sample.

• *Draft Sediment Management Plan Technical Memorandum* – The sediment management plan will summarize the contaminant data gathered in the task above and will also include the following:
  - Summary of proposed sediment management alternatives.
  - Sediment disposal plan – summary of proposed removal, disposal and/or stabilization of any sediment that is required to be removed and re-used.
  - Regulatory meeting #2 - meet with MA DEP to discuss sediment management alternatives and get feedback. DEP may require additional tests of frozen cores.
• **Final Sediment Management Plan Technical Memorandum** – Based on comments received from project partners and MA DEP, finalize the Sediment Management Plan Tech Memo including the chosen sediment management alternative. The final plan will be sufficient to begin final design and the permitting process.

Preliminary Designs .............................................................................................................................. Cost: $21,300

• *Design plans* - Preliminary (75%) design plans will be based on the conceptual renderings in this report, additional information collected during the survey and regulatory meetings, and discussions with partners. These designs will be permit ready with existing and proposed conditions, resource area calculations, cross sections, design details, design notes, and a vegetation plan

• *Design memo* - A design memo will accompany the designs to explain the proposed designs. Also, this memo will include a preliminary cost of materials estimate.

• *Specifications* - provide technical specifications for the project

4.1.3 **Permitting includes the following tasks:** Cost: $30,400

• Meeting with DEP, the Conservation Commission, MHC, and NHESP to discuss the project and identify any concerns or challenges

• Completion and submittal of the following permits (cost estimate does not include submittal fees, as these will be unknown until preliminary designs are complete):
  o Expanded MEPA ENF; includes MEPA meeting and site, responding to questions
  o MA WPA Notice of Intent; includes wetland delineation, attendance at a Conservation Commission meeting
  o MA DEP 401 Water Quality Certification
  o Chapter 91 Dredging
  o Chapter 253 Dam Safety
  o Section 106 MHC Project Notification Form
  o Section 404 ACOE PGP
  o NPDES-NOI & SWPPP
  o Local building permit for MA Building Code

4.1.4 **Final design includes the following tasks:** Cost: $18,000

• *Final (100%) designs* - incorporate changes made by the project partners and permitting agencies

• *Final design memo* - update the design memo of cost of materials

• *Specifications* - update specifications
4.2 **Construction Cost:** $138,600

- Dam removal (dam demolition, mobilization, moving boulders for bank stabilization, water control, etc.): ......................................................................................................................$44,000
- Removal of 500 CY of Cove sediment to the landfill in Amesbury (includes removal of sediment, detailed grading to shape the channel, transport to Amesbury, and the dumping fees): ..................................................................................................................................$34,000
- 2200 linear ft of FES lift - assumes one lift with rock toe: ..........................................................................................$29,000
- Logs and root wads (~20): .................................................................................................................................$4,000
- Planting - 25 3-gallon trees, 25 2-gallon shrubs, wetland seed mix: .........................................................$4,500
- 20% contingency ..................................................................................................................................................$23,100

- *Additional Cost If Necessary:* Removal of 10,000 CY of channel sediment to the landfill in Amesbury would cost an additional: .................................................................$270,000

4.2.1 **Construction Management/Oversight Cost:** $20,300

- Construction management will include attendance at a pre-bid site visit to answer contractor questions and answering further questions during the bid process
- Oversight will include channel staking and oversight of dam removal and channel creation (assumes 10 days of oversight)

### Cost Summary

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<th>Cost Category</th>
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<td>Project Management</td>
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<td>Preliminary Design</td>
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<tr>
<td>Construction Oversight</td>
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<tr>
<td><strong>TOTAL RESTORATION COST</strong></td>
<td><strong>$280,900</strong></td>
</tr>
</tbody>
</table>

*Additional Cost If Necessary: removal of all impounded sediment to Amesbury landfill* $270,000

**TOTAL (with all sediment removed to a landfill)** $550,900

5 **Sediment Management**

Sediment sampling in 2010 suggested minimal levels of contamination within the main stem Ipswich River upstream of the South Middleton Dam and with slightly higher levels of contamination within the Cove. Initial calculations estimated approximately 10,000 CY of sand within the Ipswich River would need to be removed or passively released downstream with dam removal and restoration of the channel. This volume will be refined once surveys, modeling, and preliminary designs are completed. The small tributary flowing into the Cove from the Bostik...
ponds would need to connect with the main stem Ipswich River through the Cove. Initial calculations estimated approximately 500 CY of sediment within the Cove would need to be removed to extend the channel from its current outlet to the Ipswich River. Various options for managing the Ipswich River sediment and the Cove sediment exist. We will discuss the management options for each area separately below.

### 5.1 Ipswich River Sediment
Inter-Fluve and DER met with Ken Chin, MA DEP, to discuss the sediment sampling results from 2010 and to discuss possible management options. Because the sediment within the main Ipswich River channel is relatively uncontaminated, with similar levels of contamination as areas downstream, passive downstream sediment release may be an option at this site\(^1\). The initial volume of 10,000 CY estimated to be within the post dam removal channel will be refined following surveys, modeling, and design. Manual removal, transport, and deposit of 10,000 CY of sediment in a landfill would be costly. The transport and deposit at the unlined landfill in Amesbury, MA would cost approximately $270,000. Few other sediment disposal or reuse options are available for this material. The sediment could be reused on the Bostik property, but in discussions with Bostik officials regarding the Cove sediments, there is likely no available location for the disposal of 10,000 CY of sediment. Some contractors prefer to retain material that could be used for fill on other projects. This option could be written into the bid documents as a cost-savings to the Partners if downstream release is not allowable.

### 5.2 The Cove
Based on recommendations from Mr. Chin, Inter-Fluve discussed potential sediment reuse sites for the Cove sediment on the Bostik property that may not trigger the anti-degradation clause in the DEP rules. Inter-Fluve met with Bostik officials and Licensed Site Professionals to discuss the sediment reuse options. The preferred on-site reuse alternative is called Area 5 and is between the north shore of the Upper Pond and the paved driveway (Figure 2)\(^2\). Contamination remediation for PCB-contaminated soils was completed in 2003 at this site, so this location provides an opportunity for sediment reuse as it has been previously disturbed and the contamination levels in the Cove sediments are below those found at this site. In addition, the approximate volume of sediment to be reused would result in only a small increase in elevation at this site.

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\(^1\) Ken Chin, MA DEP, personal communication; March 17, 2011
\(^2\) Dan Welch, Bostik, and Pat King, GEI, personal communication; May 27, 2011; maps provided by GEI
Figure 2: The approximate location of Area 5 (dashed black line) and the portion that could be used for the reuse of Cove sediment (cross-hatching).

In Massachusetts, most dam removal projects are regulated through the 401 water quality program. Severe sediment and soil contamination can potentially trigger several regulatory programs including MA DEP’s 401 water quality program, the Massachusetts Contaminated Sites Program, and EPA’s Toxic Substances Control Act (TSCA) program. The Bostik facility has been the site of several MCP-driven actions as well as PCB remediation overseen by TSCA. Sediment testing to date as well as preliminary conversations with DEP and EPA suggest that neither program would be involved in sediment reuse associated with the dam removal project as long as the reused material has lower contaminant levels than the reuse location\(^3\). The Cove sediments sampled in 2010, 0.01 and 0.12 ppm, are well below the 2 ppm MCP S1 threshold and well below the average concentrations at Area 5 (3.8 ppm). Therefore, EPA’s TSCA program would likely not be involved in evaluating or approving sediment reuse at this site. The alternative to on-site reuse is to remove the sediment for reuse at an offsite landfill. Reuse of the sediment on the Bostik property would reduce construction costs by approximately $19,000. Project Partners may want to discuss on-site versus off-site reuse further if the dam removal project moves forward and additional sampling is completed.

The remediation in Area 5 was completed in 2003 under TSCA regulations. Hundreds of sediment samples were collected following the remediation to determine PCB concentrations. A cleanup target concentration was established at 25 ppm. This target was achieved with all individual samples under 25 ppm and the exposure point concentration (EPC), or average, of all samples being 3.8 ppm\(^4\). The total PCB concentrations from the two samples collected from the

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\(^3\) Beth Lambert, MA DER, personal communication; July 11, 2011  
\(^4\) Pat King, GEI, personal communication; August 1, 2011
Cove in 2010 were 0.01 and 0.12 ppm, well below the average concentration of Area 5. Any Cove sediment reused in this area should have concentrations less than 3.8 ppm. The portion of Area 5 that is currently maintained as lawn would be the best location for reusing Cove sediment. This area is approximately 14,000 ft². Spread out evenly and sloping gently towards the perimeter of Area 5, the reuse of 500 CY of Cove sediment would result in an increase in elevation of approximately 1 to 1.5 ft.

Other options for sediment reuse or disposal include reuse in the Cove area or removal to and disposal in a MA landfill. It is likely that the Cove area will remain in the active floodplain of the Ipswich River. If the hydraulic modeling confirms this, depositing fill in the active floodplain would likely not be advisable or permissible by MA DEP. However, if the accumulated sediments have caused this area to be outside of the active floodplain, reusing the sediment in this area may be permissible as sediments would have similar levels of contamination and would not trigger the 'anti-degradation' ruling. If re-use in the Cove is not permissible, removal to a MA landfill is the other option.

To re-use the sediment on site in the Cove or in Area 5, additional sediment sampling would need to be completed to compare the excavated sediments to the proposed re-use locations.

5.3 Landfills
In communications with staff at Waste Management and other operators of landfills, it became clear that most towns no longer operate their own landfills. Many landfills incinerate all material or manage the waste using other methods, but there are few that will accept sediment or soil. Most landfills that accept sediment or soil are owned and operated by Waste Management or other private companies. In order to be reused in a landfill, MA DEP requires that concentrations not exceed the values in Table 1 of Policy # COMM-97-001, Reuse and Disposal of Contaminated Soil at MA Landfills. Policy # COMM-94-007 regulates contaminated sediment, but the values are the same as soil for the lined landfills, and that document does not provide values for unlined landfills.
Contamination levels in the Cove from the sampling in 2010 show levels well below the thresholds for both lined and unlined landfills. However, the sediments would need to be tested for Total Petroleum Hydrocarbons (TPH) and the TCLP analysis for lead, as one sample exceeded the lead TCLP threshold. Assuming these analyses return results similar to the contaminants, reusing the sediment in an unlined landfill in MA is an option. Waste Management owns a landfill in Amesbury, MA, approximately 25 miles from the Bostik property. This is an unlined landfill that is being closed and would accept sediments for reuse. The cost for depositing sediment is $14/ton and the cost for transporting it is an additional $6/ton. The sediment would need to be sufficiently dry as the leaking of water from these trucks is not allowed. Depositing sediment at a lined landfill is typically $10-$15 more expensive per ton.

If TSCA is applicable to these soils, costs for coming into compliance would be approximately $300,000 in addition to transporting the sediment to a different landfill, likely the Turnkey Landfill in NH\(^5\). This landfill is also run by Waste Management and is approximately 60 miles from Bostik. As explained above, we do not expect TSCA to be applicable following MA DER's conversation with EPA staff.

6 Conceptual Rendering

Conceptual renderings provide useful visual representations of the river and floodplain conditions following dam removal. These renderings are schematic or architectural with no engineering details. They are easy to read and understand and present only basic engineering design concepts. No engineering, modeling, or surveying were conducted to complete these renderings.

The conceptual rendering in Attachment 2 shows a restored channel width similar to that downstream of the existing dam and recapturing the historic channel alignment that is evident in

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\(^5\) Pat King, GEI, personal communication; May 27, 2011
the aerial photos and site visits in this narrow impoundment. The channel width will be approximately 45-50 ft with an average bank height of 3-4 ft. The off-channel wetlands, coves, and alcoves will likely no longer contain standing water but may become wetland, floodplain, or high water backwater habitat. The sand that is currently within this channel alignment is underlain by coarse sand in some areas and gravel and cobbles in other areas. The post-removal channel through the impoundment will likely be a relatively slow-moving meandering channel, similar to the existing stream up and downstream of the impoundment. The channel bed at the current dam location is composed of cobbles and has a steeper gradient, so the short reach between the dam and the downstream bridge is likely to remain a riffle.

We have recommended the construction of a small channel in the Cove to connect the channel leaving the Bostik Ponds to the Ipswich River. Reconstructing this channel and stabilizing the banks will help minimize the movement of impounded Cove sediment downstream. A discussion of the sediment management options within the Cove is included below.

The type and extent of bank stabilization will be determined as we move forward with the preliminary designs and come to better understand the channel and bank shear stresses, water velocity, bank heights, channel dimensions, and the allowable channel migration. Although a few minor small outcrops of the Sharpners Pond Diorite do occur in the hills near the dam (see Bedrock Geology Map, Attachment 3), bedrock in the alluvial valley and channel is not apparent and is not indicated on the Surficial Geologic Map (Attachment 4) as being within 5 or 10 ft of the ground surface. Therefore, lateral or vertical stability will not be obtained from existing bedrock. Postglacial floodplain alluvium, consisting of sand, gravel, silt, and some organic material, is indicated for the alluvial valley around the impoundment (Attachment 4). The adjacent hillsides and in the watershed upstream, soils consist of till (sand and some silt), swamp deposits (organic muck and peat), glaciolacustrine fine deposits (very fine sand, silt, and clay), and coarse deposits (gravel). This is consistent with the mostly medium to coarse-grained sand found in the impoundment during the sediment sampling in 2010.

Stabilizing the channel banks after dam removal include the following options:

- No stabilization
- Fabric encapsulated soil (FES) lifts
- Large wood (logs and rootwads)
- Stone salvaged from the dam foundation.

Not installing bank stabilization is likely the best option for much of the impoundment as the relic channel is still apparent through much of the impoundment, the historic banks are intact (based on depth of refusal probing below the sediment and visual observation of the upper banks), and there is no infrastructure that may be at risk due to bank erosion. The channel bed material is coarse grained and short sections of gravel, cobble, and other rock were observed suggesting that the channel bed is intact and risk of channel incision may be low.

In the conceptual renderings, we have included the use of FES lifts between the dam and the channel at the upstream extent of the Cove. However, installing FES lifts may not be necessary if new bank construction is deemed unnecessary in final design. Two main reasons exist for considering active bank stabilization in this area. First, Bostik facilities and property are
relatively close to the channel on the south side and bank stabilization may help prevent short
and long-term bank erosion and undercutting infrastructure, including the pumphouse, paved
roads, Area 2 (Old Tank Farm Area), and Building 2. Immobile riprap observed in the vicinity of
the pumphouse suggests that the toe of the river bank is adequately protected. If the riprap
extends from the dam to the Cove along this south bank, additional stabilization may not be
necessary. Riprap on the north bank, which extends upstream from the dam approximately 68 ft
according to the dam repair design drawings from 1953, may also be sufficient to stabilize the
north bank, again limiting the FES lifts. Second, channel migration through the Cove may not be
desirable considering the sediment contamination issues that have been a concern in the past.
Recent sampling, however, suggest that contamination is minimal (Partial Feasibility Study,
Inter-Fluve, 2010) and long-term channel migration may be acceptable. FES lifts could provide
short-term channel stability until the vegetation takes hold, and FES lifts combined with a rock
toe could provide more long-term stability.

We have recommended one outer bend to contain a complex of logs and root wads. This large
woody habitat complex would both provide natural toe stability on the outside of a meander bend
as the channel flows towards the Cove area and downstream infrastructure. Large wood can
provide toe stabilization long enough for large, soil stabilizing trees to establish. The logs and
root wads would also provide habitat and cover for in-stream aquatic species.

Calculations from the dam repair design drawings from 1953 suggest that more than 160 CY of
boulders lie between the concrete portions of the dam and the channel bed as well as within the
cement abutments. Additional boulders may be below the channel bed, but these would likely
remain in place to minimize excavation costs and provide vertical channel stability. Assuming a
volume of 160 CY, an installation thickness of 4 ft and installation height of 2 ft, these boulders
could provide as much as 500 linear ft of toe stabilization. The length of bank for the tributary
through the Cove and the south bank of the Ipswich River adjacent to the Cove is about 700 ft, so
the boulders could provide non-deformable toe protection for much of this area. Large granite
boulders would not provide a natural aesthetic, but it would provide bank toe stability. If shear
stresses allow, the boulders could be placed low enough to be less conspicuous. A single layer of
FES lifts on top of these boulders would provide sufficient bank height and soil composition for
vegetation regrowth.

To summarize the bank stabilization discussion, much of the impoundment will likely not require
any active bank stabilization. Depending on the flow velocities, shear stresses, and willingness to
allow some channel migration (and potential erosion of Cove sediments), actively stabilizing the
banks adjacent to the Cove and within the Cove may be desirable or necessary. Rock from the
dam could potentially be used for most of this stabilization. One FES lift above this rock would
provide substrate for vegetation and added bank height. Downstream of the Cove, riprap on the
South bank from the Cove to the dam and on the north bank 68 ft upstream of the dam may
provide sufficient bank stability for the Ipswich River. The large woody habitat structure is
optional.

We have suggested wetland planting in the Cove and in the post-removal floodplain area
opposite the channel from the Cove. Revegetating adds cost, but the aesthetic and sediment
stabilization benefits may be desirable. Fifty to 100 trees and shrubs in these areas would
improve the vegetative and habitat diversity and would help to stabilize the fine-grained sediments. Seeding would also help stabilize the finer sediments and channel banks, although an adaptive management approach may be advisable as formerly impounded areas often become rapidly vegetated with the existing seed sources. It should be noted that drained impoundments without active revegetation efforts can often develop nearly 100% coverage by invasive plants if a seed source is nearby and conditions are favorable. Additional wetland vegetation may be desirable in the newly-exposed areas near the house upstream of the Bostik facilities to improve aesthetics as they do have a dock and appear to use the impoundment recreationally in some capacity.

Staging and access are relatively simple for this dam removal project as Bostik owns both sides of the river and there are existing access roads on both sides. A dirt road on the north side exits Boston St and leads to a lightly vegetated area near the dam. On the south side, paved driveways and parking areas encircle the buildings adjacent to the river. Access to the Cove could be accomplished via the Ipswich River if the water flow is being pumped around. Pumping is costly, however, and could be avoided if construction occurs during low water and working in wet conditions is allowed by the permitting agencies. Alternatively, vehicles may be able to cross the tributary on a small road (former railroad bed) in the northwest corner of the Bostik property and make an access road through the forested hillside.
ATTACHMENT 1: Location of proposed above ground water storage tank for fire suppression on the Bostik property.
ATTACHMENT 2: Conceptual rendering of the South Middleton Dam removal.
The Ipswich River restoration consists of three main components:

1. Removal of the South Middleton Dam
2. Stabilization of channel banks
3. Enhancement and restoration of the Ipswich River and associated floodplain wetlands within the former Ipswich River impoundment

**Elevation View: Proposed Conditions**

**Legend**
- Proposed wetland area
- Proposed creek channel
- Proposed pool
- Fabric encapsulated soil lifts
- Proposed plantings
- Proposed staging
- Proposed access

**Plan View Proposed Conditions**

**Conceptual Rendering**

South Middleton Dam removal
Ipswich River
ATTACHMENT 3: Bedrock geologic map of the region around South Middleton Dam.
DESCRIPTION OF LITHOLOGIC UNITS

INTRUSIVE ROCKS

Middletown Intrusive Suite

Granite

White, pink, and biotite granite. Composed mainly of quartz, plagioclase, and少量
biotite. Contains minor amphibole, hornblende, and magnetite. Medium to
coarse-grained, massive to faintly foliated, and rarely porphyry.

Diorite

Gray to black diorite. Composed mainly of plagioclase and hornblende, with lesser
amounts of quartz, biotite, and magnetite. Medium to coarse-grained, massive to
faintly foliated, and rarely porphyry.

Gneiss

Gray to white gneiss. Composed mainly of microcline, plagioclase, and quartz with
minor amounts of biotite and magnetite. Medium to coarse-grained, massive to
faintly foliated.

Mesozoic Intrusive Suite

Diorite

Gray diorite. Composed mainly of plagioclase and biotite, with minor amounts of
hornblende and magnetite. Medium to coarse-grained, massive to faintly foliated,
and rarely porphyry.

Gneiss

Gray gneiss. Commonly possesses an augen texture. Composed mainly of microcline,
plagioclase, and quartz. Medium to coarse-grained, massive to faintly foliated.

Mesozoic Volcanic Suite

Basalt

Dark basalt. Composed mainly of plagioclase and biotite. Medium to coarse-grained,
massive to faintly foliated.

Andesite

Gray to white andesite. Composed mainly of quartz, plagioclase, and biotite.
Medium to coarse-grained, massive to faintly foliated.

EXPLANATION OF SYMBOLS

Bedrock Exposure

Indicated by a colored outline on the map

Lithologic Contacts

Indicates the boundary between different rock units

Structural Symbols

- Structural discontinuities (faults)

Planar Features

- Dip and strike of bedding

Linear Features

- Roads and highways

- Rivers and streams

- Power lines

- Natural and artificial barriers

Additional Information

- Geologic age

- Density of rock units

- Veins and fissures

- Mineralization

-bedrock geologic map of the reading quadrangle, massachusetts

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ATTACHMENT 4: Surficial geologic map of the region around South Middleton Dam. The map was cropped to reduce the file size.