Appendix D

"Sediment Management Plan", dated June 2009,
by The Louis Berger Group, Inc.

Taylor River - Sediment Management Plan

The dam for Taylor River Pond consists of an earthen embankment, a primary spillway (with fishway) to the north of the embankment, and an emergency spillway in the center of the embankment to allow for additional outflows during peak storm events. The primary spillway is covered by a bridge for Route I-95. These structures have deteriorated and require mitigation, with the exception of the embankment.

Taylor River Pond contains an estimated 77,000 CY of sediment that has accumulated since the construction of the dam. Generally, the thickness of sediment that has accumulated in the Taylor River impoundment on top of the former marsh soils since dam construction ranges between <0.5 and 2 feet, with a mean of approximately 1.0 foot. The average sediment thickness was observed as 1 to 2 feet in the lower pond, 0.5 to 1 foot in the midsection of the pond, and 1 to 2 feet in the upper pond (Figure 1). The deposited sediment is fine-grained and organic-rich as a result of the widespread submerged aquatic vegetation in the pond.

The former tidal creek channel is submerged but still distinguishable on pond bathymetry mapping. The channel appears to be fairly narrow and defined based on field investigations. The channel has accumulated sediment at varying rates. More surveying would be needed prior to excavation to determine the width and depth of the channel in greater detail, as well as the amount of sediment within it.

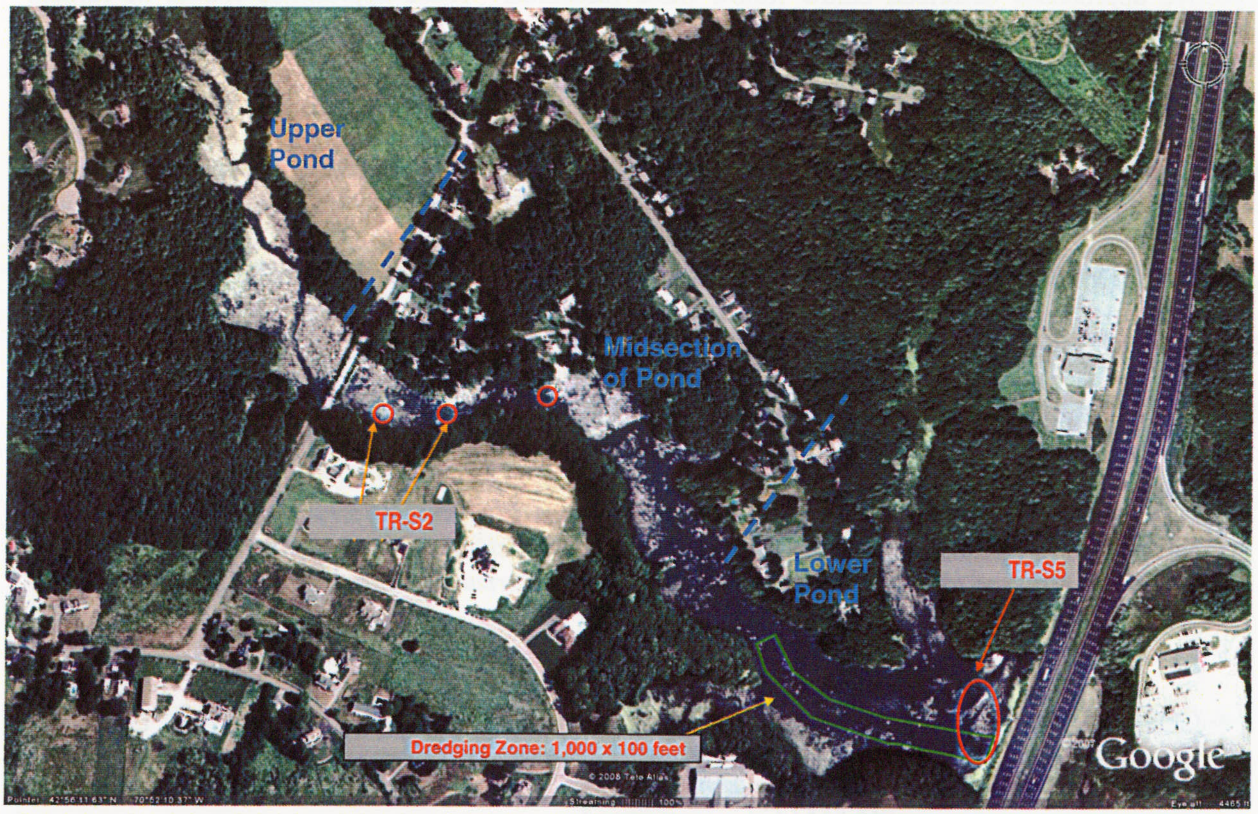


Figure 1: Taylor River Pond. The dredging zone proposed by NHDES is marked in green. The two stations (TR-S2 and TR-S5) mark the locations were sediment samples were collected along transects. In the upper and midsections of the pond, the distribution of the aquatic vegetation in the pond marks the location of the submerged former creek channel.

The former tidal marsh plain is fairly uniform in elevation. At low-flow conditions, and with the wooden stoplogs installed at the primary spillway for the pond, the water depth in the pond is between approximately 3 and 3.5 feet in the lower and mid-pond sections, and between 2 and 3 feet in the upper pond.

The sediments in the pond contain pesticides, as discussed in Section 3.3 of the Feasibility Study. All sediment chemistry investigations were coordinated and approved by NHDES. Based on the findings of the sediment analyses, NHDES concluded that the downstream portions of the Taylor River Pond are impaired for aquatic life and wildlife uses. The sediments do not impair human health, however.

Sediment management measures are required for both Alternative B (Replacement of spillways, fishway, and I-95 bridge) and Alternative C (Spillway removal and bridge replacement). The key measures consist of the following: (1) Excavation of a limited quantity of contaminated sediment (for both alternatives), and (2) Stabilization of exposed marsh plain areas for Alternative C. This sediment management plan is a first-order plan developed for the purpose of developing a preferred alternative.

1.0 EXCAVATION OF CONTAMINATED SEDIMENT

The NHDES decided on measures for addressing the contaminated sediments for both alternatives. The respective approaches described below follow these measures. These approaches should be refined further once a preferred alternative has been selected.

1.1 Alternative A: No Action

The sediment would remain in the Taylor River Pond under this alternative. Similarly, the risk of sediment being mobilized and transported to the downstream estuary remains unchanged.

1.2 Alternative B: Replacement of Spillways, Fishway, and I-95 Bridge

1.2.1 Determination by NHDES (May 19, 2008)

NHDES offered the following two options for this alternative:

- <u>Option A</u>: *"Design and install sediment control so that sediment will not be released downstream during the proposed project. An engineered design needs to meet performance criteria and will be a condition of the NHDES Wetland Permit. This plan shall be reviewed and approved by the NHDES Watershed Management Bureau and Wetlands Bureau prior to construction."*

OR

- <u>Option B</u>: *"Excavate and remove sediment in the impoundment in an area from the furthest point of the impoundment (closest to the dam) moving upstream to Transect TR-S2 (as identified on the approved sampling plan dated November 29, 2006, and as seen below). Based on the following parameters, a minimum of [5,555] CY is to removed :*
  - *i. 1,000 feet along the channel, starting from the lowest portion of the impoundment near the dam and moving upstream,*
  - *ii. 100 feet wide (channel width), and*
  - *iii. 1 ½ feet depth; and,*

Prepare and implement a plan to manage the excavated material which meets the S-1 soil standards (or the soil remediation standards in Table 600-2 in Env-Or 600) either within the right of way controlled by NHDOT or for disposal at an approved landfill. This plan should specify the frequency and parameters for confirmation sampling. This plan should be submitted to the NHDES Hazardous Waste Remediation Bureau for review and approval."

1.2.2 Sediment Management

Alternative B will result in a wider opening underneath I-95 to allow for more water to pass during flood events. This greater volume of passing water will result in greater flow velocities within the Taylor River Pond. The velocity increase in most of the pond is small, thus not expected to result in an increase in erosion of sediment. Thus, Option B offered by NHDES for consideration (*i.e.,* excavation of 1,000 feet along the channel) is not recommended. However, it is anticipated that flow velocities will increase more noticeably in front of the new spillway that is significantly wider than the present spillways. The new spillway is built in an area of the pond that currently experiences very low flow velocities, allowing fine sediment particles to settle out of the water column. These sediments in the immediate area in front of the new spillway would likely erode during peak flow events. Therefore, a small area is recommended to be excavated as allowed under Option A offered by NHDES.

The extent of the zone with increased flow velocities was estimated based on HECRAS model results. These results show that the velocities 200 ft upstream of the new spillway dam (Alternative B) during a 100-year storm are very low (0.5 ft/sec) which would not be sufficient to erode the sediment in the pond. As the water is funneled toward the new spillway, velocities increase.

We recommend the removal of a trapezoidal-shaped apron with a length of 160 feet, and widths of 140 feet along the downgradient side and 60 feet along the upgradient side (Figure 2). This apron includes the 60-foot long and 70-foot wide area of construction for the proposed new spillway and fishway. The remaining 100 feet are excavated to prevent potential resuspension of sediment, and to clear the area for the heavy equipment for the construction of the new spillway.

Key steps for the excavation of the material are expected to be as follows:

- **Preparation of an erosion and sedimentation plan for the construction operations.** This is the responsibility of the Contractor, to be specified in bid documents.

- **Installation of temporary sediment trapping basin downstream of dam:** A sediment trapping basin would be built immediately downstream of the new spillway to be able to capture sediment that may be mobilized from the construction site for the I-95 bridge, and from the sediment excavation area in the pond.

- **Partial dewatering of pond:** The pond would be partially dewatered in order to protect the aquatic resources. The existing primary spillway would be temporarily kept intact.

- **Excavation:** The surface sediment would be excavated from the suggested trapezoidal zone (or another zone with redesigned dimensions) within the partially dewatered pond. Excavation would best be conducted in the dry, or at least in standing water, to avoid transport of the resuspended sediment into the downstream estuary. Dry conditions in the excavation area could be achieved with temporary berms placed into the channel and with portable cofferdams (*i.e.*, Aqua Barrier™ or equivalent), as appropriate. Aqua Barriers are modular water-filled cofferdams (Figure 3).

Track-mounted excavation equipment (excavators, trucks) would move on timber-matting or other types of sturdy matting to prevent sinking into the substrate (Figure 4). It may also include the use of a low ground pressure excavator and truck for transport from the excavation location to a laydown area. The excavator may use a longer arm attachment to increase the reach of the equipment to properly extend into the tidal channel and minimize the repositioning of timber mats.

- **Disposal:** The excavated sediment is fine-grained and contains a high percentage of water. There are two options for disposal (1) Approved offsite landfill; or (2) Upland disposal.

  - ***Approved landfill:*** Based on the available chemical results obtained in this study, the sediment from Taylor River Pond would be accepted by landfills in the area (although the sediment is not expected to be usable as cover material). The most suitable landfill would be selected after a preferred alternative has been chosen. Transportation to a landfill would require that the sediment is either first dewatered or stabilized. Dewatering could be done within a bermed dewatering basin or via mechanical devices. Dewatering in a bermed basin would be a slow process given the fine-grained nature of the sediment. An alternative or enhancement to dewatering is stabilization of the sediment by adding polymer, quicklime, or another material. Adding such an amendment to the sediment would reduce the construction time significantly, but would require mechanical mixing of the sediment in a laydown area prior to offsite transportation, which would typically entail the use of a pugmill or mixing system that permits controlled addition of the amendment(s). Contractors often prefer to conduct bench-scale tests of amendments in advance of full-scale operations, so as to establish appropriate mixing ratios and evaluate properties of the amended sediment product. Both, a dewatering area or a laydown area would need to be set up in a manner that would allow loading onto heavy trucks along the perimeter of the dewatering area. Ideally, trucks should have access from the highway which would reduce transportation costs.

    Estimated transportation and disposal costs (per ton) for landfills in the greater vicinity of the Taylor River Pond are presented in Table 1. Final costs will depend on access to the site, nature of the material, volume, and potential use of the material at the landfill. Quotes should be obtained from the potentially suitable landfills.

Table 1: Estimated disposal costs for excavated sediment at landfills in the area

	Round Trip (miles)	Transportation and Disposal (per ton; estimate)
Bethlehem, NH	274	$ 55
Worcester, MA	165	$ 30
Haverhill, MA	46	$ 25
Rochester, NH	60	$ 70

  - ***Disposal at an upland site:*** The sediment could be disposed of at a suitable upland location owned by NHDOT (or another State agency), with appropriate NHDES approvals. The excavated sediment in the pond would not be suitable for beneficial reuse due to its small grain size composition. The ownerships of the properties in the immediate vicinity of the dam are presented in Figure 5 and Table 2. The most suitable location is the area immediately to the north of the dam which is owned by the State of New Hampshire, although disposal could result in temporary odor (*e.g.*, hydrogen sulfide odor) issues for the surrounding community.

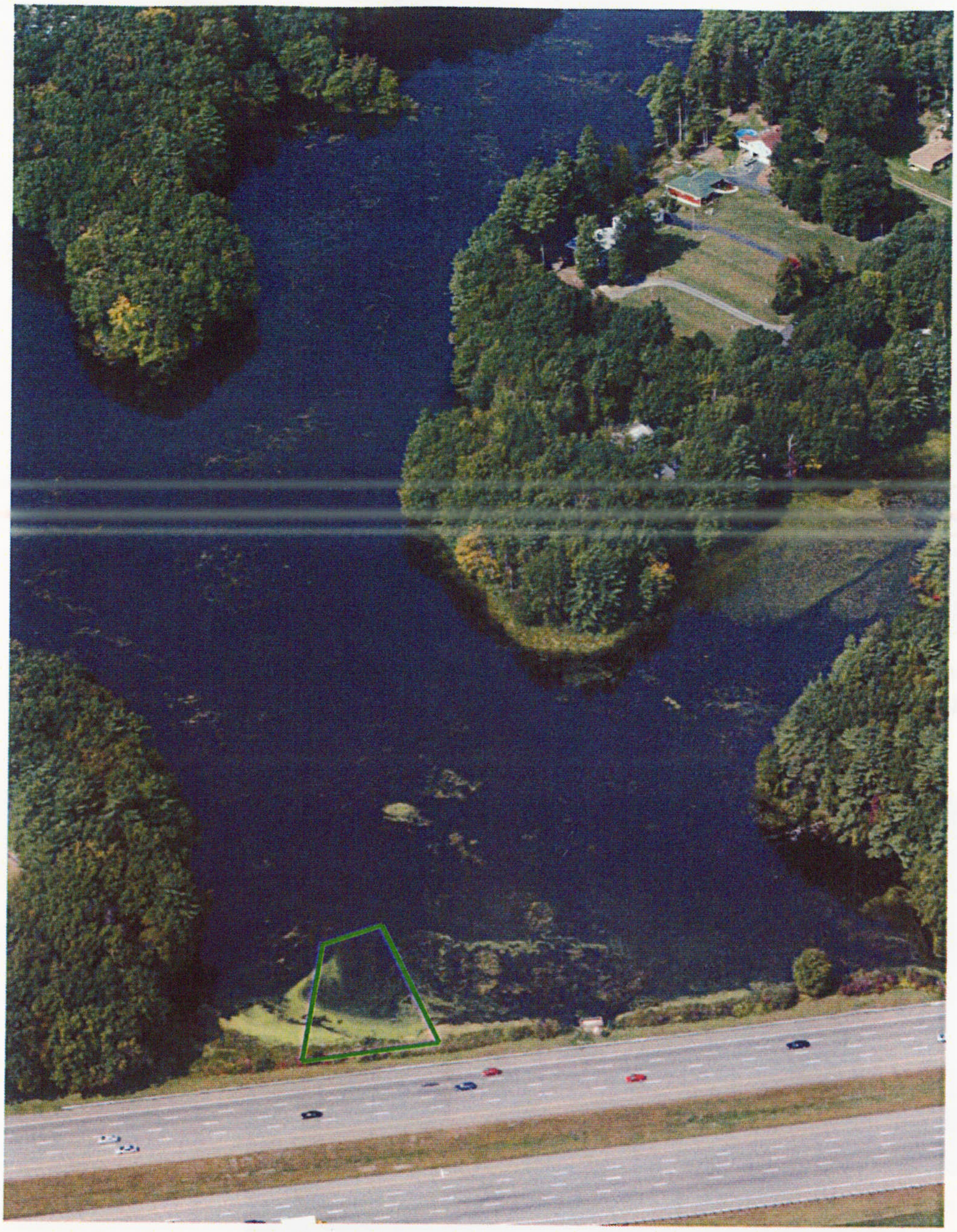


Figure 2: Taylor River Pond, with approximate area of excavation for Alternative B.

Figure 3: Example of portable cofferdams (Aqua Barrier™) used for work in a pond (Source: http://www.aquabarrier.com).

Figure 4: Example of timber matting with excavator and low ground pressure truck, operating in a marsh restoration project (Source: The Louis Berger Group, Inc.).

Figure 5: Ownership of properties near the dam.

Table 2: Ownership of property in the vicinity of the dam

	Map	Block	Property in Study Area	Property Owner	Owner Mailing Address	Town	State	Zip Code
A	171	1	I 95 Southbound	State of New Hampshire Liquor Commission	Storrs St	Concord	NH	03301
B	5	53-9 53-10	6 Swain Dr	Taylor River Farm	6 Swain Dr	Hampton Falls	NH	03844
C	5	57	Brown Rd E/S	NH State Housing Finance Authority	24 Constitution Dr	Bedford	NH	03102
D	9	2		Barbara Batchelder	290 Wadleigh Falls Rd Bldg 207	Newmarket	NH	03857
E to I	172	9	I 95 Northbound	State of New Hampshire	PO Box 483	Concord	NH	03302

Another option is the State-owned land to the east of the liquor store along the northbound lane of I-95. Other appropriate upland sites at a greater distance from the site may also be available. Some dewatering of the sediment may be needed if a selected site is located on the east side of Route I-95 as the sediment would be transported over public roads.

After a period of consolidation of the sediment, the site would be replanted. The soil is expected to be fertile, as it consists largely of topsoil from the surrounding watershed, including former agricultural fields. Further, the sediment contains a comparatively high concentration of organic matter.

- **Water treatment:** Dewatering of the sediment would occur by infiltration into the ground, surface water discharge, and evaporation. Depending on the nature of the underlying sediment at potential disposal sites in the area, infiltration of the dewatered liquid into the ground may be limited. Water draining from the dewatering basin or the laydown area via surface water runoff would be tested to determine if it requires treatment. At this time, we anticipate that suspended solids should be allowed to settle in a settling basin, but that the water quality would otherwise be adequate to allow for discharge to the estuary. If the water is too contaminated to be discharged to the estuary, it would require physical or chemical treatment prior to discharge. Treatment of the dewatered liquid would be incorporated into the permitting for the project.

Given the smaller volume of excavated sediment, on-site disposal of the sediment under Alternative B appears to be feasible, specifically considering that the land to the north of the embankment is owned by the State of New Hampshire.

1.2.3 Cost Estimates

Cost estimates were developed for the apron with the following dimensions: Length 160 feet; width at the base of 140 feet; width at the upstream end of 60 feet; excavation depth of 1.5 feet. These dimensions result in a total sediment volume of approximately 1,200 CY, including 35% overexcavation and excavation at laydown areas, etc. Landfill disposal is estimated to cost $270,000 to $350,000 (Table 3). Disposal on a nearby upland site is estimated to cost $200,000. These costs are first-order estimates that would need to be refined after selection of the preferred alternative.

Table 3: Cost estimate for disposal options

Activity	Unit Costs (per CY)	Alternative B (Replace Spillways, Replace Bridge) Volume (CY): 1,200 — Disposal at Landfill: Low Estimate	Alternative B — Disposal at Landfill: High Estimate	Alternative B — Disposal at Upland Site (within 1/2 mile)	Alternative C (Remove Spillways, Replace Bridge) Volume (CY): 7,000 — Disposal at Landfill: Low Estimate	Alternative C — Disposal at Landfill: High Estimate	Alternative C — Disposal at Upland Site (within 1/2 mile)
Engineering design services, permitting, testing, etc.		$60,000		$60,000	$100,000		$100,000
Excavation and dewatering of sediment *(incl. stop water, laydown area preparation, pumping, surveying, excavation, transportation to laydown area, preparation of disposal area (for upland disposal), mixing with polymer (for offsite disposal) or dewatering*	$75-125 (1)	$150,000		$120,000	$700,000		$525,000
Polymer	$10	$12,000			$70,000		
Transport and disposal of sediment	$35-100 *(2)*	$42,000	$120,000	$10,000	$245,000	$700,000	$30,000
Post-excavation confirmation sediment sampling		$10,000		$10,000	$30,000		$30,000
Total		**$274,000**	**$352,000**	**$200,000**	**$1,145,000**	**$1,600,000**	**$685,000**

(1) Alt. B: $125/CY for disposal at a landfill with required stabilization for longer distance trucking.
$100/CY for disposal nearby (upland). Stabilization with polymer for transportation is not required.
Alt. C: $100/CY for disposal at a landfill with required stabilization for longer distance trucking.
$75/CY for disposal nearby (upland). Stabilization with polymer for transportation is not required.

(2) $35 to $100/CY for trucking and disposal at a landfill (using a conversion factor of 1.4 from CY to tons, which is considered conservative. The factor could be lower due to the high organic matter content in the sediment.) Nearby upland disposal only requires costs for trucking.

1.3 Alternative C: Spillway Removal and I-95 Bridge Replacement

1.3.1 Determination by NHDES (March 19, 2008)

Based on the review of data developed during this project, the NHDES determined the following on March 19, 2008 regarding sediment management:

> *"Excavate and remove sediment in the impoundment in an area from the furthest point of the impoundment (closest to the dam) moving upstream to Transect TR-S2 .... Based on the following parameters, a minimum of [5,555] CY is to be removed:*
>
> *i. 1,000 feet along the channel, starting from the lowest portion of the impoundment and moving upstream,*
> *ii. 100 feet wide (channel width), and*
> *iii. 1 ½ feet depth; and,*
>
> *Provide a plan to manage the excavated material which meets the S-1 soil standards (or the soil remediation standards in Table 600-2 in Env-Or 600) either within the right of way controlled by NHDOT or for disposal at an approved landfill. This plan should specify the frequency and parameters for confirmation sampling. This plan should be submitted to the NHDES Hazardous Waste Remediation Bureau for review and approval.*

The dredging area determined by NHDES is shown on Figure 1. Alternatively, the area proposed by NHDES could be narrower, such as 50 feet instead of 100 feet, based on the dimensions observed in the estuary just downstream of the dam (Figure 6). At the same time, the length of the area proposed by NHDES (*i.e.*, 1,000 feet) only extends halfway to the sampling transect TR-S2 (Figure 1); thus the length could be doubled. Revising the shape in this manner is recommended as most of the sediment that is expected to be mobilized will come from the currently submerged tidal creek channel. Revising the shape of the excavated area would result in a commensurate net volume of excavated sediment.

Figure 6: Taylor River estuary, just downstream of the Taylor River dam. The width of the tidal creek channel and mudflat ranges from 25 to 40 feet.

1.3.2 Sediment Management

The determination by NHDES results in the removal of 5,555 cubic yards of sediment under this alternative. This actual excavated volume would likely be higher due to (a) the potentially higher sediment thickness in the channel, (b) overexcavation due to limitations of accuracy of excavation tools, and (c) excavation of sediment in the laydown area, access path to the channel, and other areas of equipment operation. For the analysis herein, we assumed an additional 25% of excavated material (*i.e.*, a total of 7,000 CY of sediment to be excavated).

Excavation should be conducted during low-flow conditions in Taylor River (*i.e.*, in the summer or early fall). A potential approach for removal of the sediment is described below; this approach requires further refinement and modification if Alternative C is chosen as the preferred alternative. Specifically, the refinement will include more detailed discussions with NHDES. Also, excavation contractors have somewhat different approaches and equipment for a project on this nature. Therefore, a more detailed management plan would need to be developed after Alternative C is chosen, as requested by NHDES (see above) that is appropriate for submission to the NHDES Hazardous Waste Remediation Bureau for review and approval.

The approach used for the removal of the sediment is generally similar to the approach used for Alternative B above, although sediment volumes would be considerably larger. Key steps consist of the following:

- **Preparation of an erosion and sedimentation plan for the construction operations.** This is the responsibility of the Contractor, to be specified in bid documents.

- **Installation of temporary sediment trapping basin downstream of dam:** A sediment trapping basin would be built immediately downstream of the new spillway to be able to capture sediment that may be mobilized from the construction site for the I-95 bridge, and the sediment excavation area in the pond. The trap would be designed in a manner that allows Taylor River water to pass from the pond area to the estuary without backing up into the pond.

- **Dewatering of pond:** The water from the pond would be drained, while keeping the both existing spillways intact. The outflow would be set up in a manner that prevents tidal waters from entering the pond, using a flap gate or similar device (see Giannico and Souder, 2005, for suggestions). The flap gate should be installed between the base of the primary spillway at an elevation of approximately 7.5 feet. The otherwise intact primary spillway would allow large stormwater flows that exceed the capacity of the flap gate to flow over the spillway, thus avoiding flooding of the construction zone in Taylor River Pond.

- **Excavation:** The surface sediment would be excavated from the required zone (1,000 x 100 x 1.5 feet; or another zone with redesigned dimensions) within the dewatered pond. The excavation would intend to replicate the dimensions of the channel that exists downstream of the dam (Figure 6). Excavation would best be conducted in the dry, or at least in standing water, to avoid transport of the resuspended sediment downstream estuary. This could be accomplished by bypassing the river around the area of excavation. Bypassing could be done in sections, using temporary berms placed into the channel and portable cofferdams (*i.e.*, Aqua Barrier™ or equivalent), as appropriate (Figure 3). River water could be pumped around the isolated excavation area as needed. Alternatively, a temporary channel could be dug parallel to the original channel, after the surface sediments (containing pesticides) were removed for appropriate disposal. Such a temporary channel could be much smaller than the original channel, as it would only be required to accommodate low summer flows.

As for Alternative B, track-mounted excavation equipment (excavators, trucks) would move on timber-matting or other types of sturdy matting to prevent sinking into the substrate (Figure 4). It may also include the use of a low ground pressure excavator and truck for transport from the excavation location to a laydown area. The excavator may use a longer arm attachment to increase the reach of the equipment to properly extend into the tidal channel and minimize the repositioning of timber mats.

- **Disposal:** Options for the disposal of sediment would be similar to options discussed under Alternative B, consisting of approved offsite landfill, or upland disposal.
- **Water treatment:** Water treatment approaches would also be similar to approaches under Alternative B, although the dewatering basin would be considerably larger.

1.3.3 Cost Estimate

Cost estimates for Alternative C are presented in Table 3. Costs are based on an excavated volume of 7,000 CY (i.e., 5,555 CY plus 25%). The option with landfill disposal is estimated to cost $1.1 to $1.6 million. The option with disposal on a nearby upland site is estimated to cost $680,000. As stated previously, these costs are first-order estimates that would need to be refined after selection of the preferred alternative. The cost estimate for the latter option presumes that no engineered capping or long-term monitoring of the disposal site would be required; such additional measures would increase sediment management costs.

2.0 STABILIZATION OF EXPOSED TIDAL MARSH *(for Alternative C)*

2.1 Stabilization Measures

Since the dam was constructed, on average one foot of sediment has been deposited on top of the pre-dam marsh surface. After dewatering the pond, the exposed sediments would consolidate as a result of dewatering and decomposition of roots from freshwater plants. Despite the remaining higher elevation of the tidal flat compared to pre-dam conditions, the intertidal marsh is expected to be largely inundated during high tide similar to pre-dam conditions for the following reasons. Using a rate of 2 mm/year for the average sea level rise for the northern New England coast (NOAA, 2008), the sea level has risen since the construction of the dam in 1950 by approximately 4 to 5 inches, compensating in a sense for part of the added sediment in Taylor River Pond. The high tidal elevation is on average around 5 feet (1.5 m) NGVD 29, ranging from 2.6 to 7.2 feet (0.8 to 2.2 m) during the survey from September to November 2006 (Figure 7). The elevations of the sediment surface of much of the existing pond range from 4 to 6 feet NGVD 29.

With the primary spillway at an elevation of 8.55 ft., the pond area is approximately 47.5 acres. Removal of the spillways exposes the former intertidal marsh within the confines of the Taylor River Pond. As stated in Section 3.13 of the Feasibility Report, as much as 21 acres of fringing inter-tidal salt marsh and mudflats could be restored with the spillway removed. Areas within the impoundment above the anticipated elevation of salt marsh habitat (approximately 5.0 feet NGVD29) would likely convert to a mosaic of forested wetland, shrub swamp, freshwater and brackish marsh.

Tidal flows would likely result in erosion of those parts of the former tidal creek channel that were not excavated. It is reasonable to assume that, over time, the pre-dam channel would largely be scoured out naturally by tidal and freshwater flows. High freshwater flows could also erode some of the sediment on the initially barren marsh. Flow velocities and width of inundation for various storm frequencies at three locations in the dewatered Taylor River Pond area are presented in Table 4. These velocities pertain to ebb tidal conditions, which are higher than at flood tides, due to the freshwater runoff component. These velocities are average velocities across the inundated cross-section. The velocities in the central part of the inundated area (*i.e.*, within the tidal creek channel and along its edges are higher than on the outer parts of the inundated area.

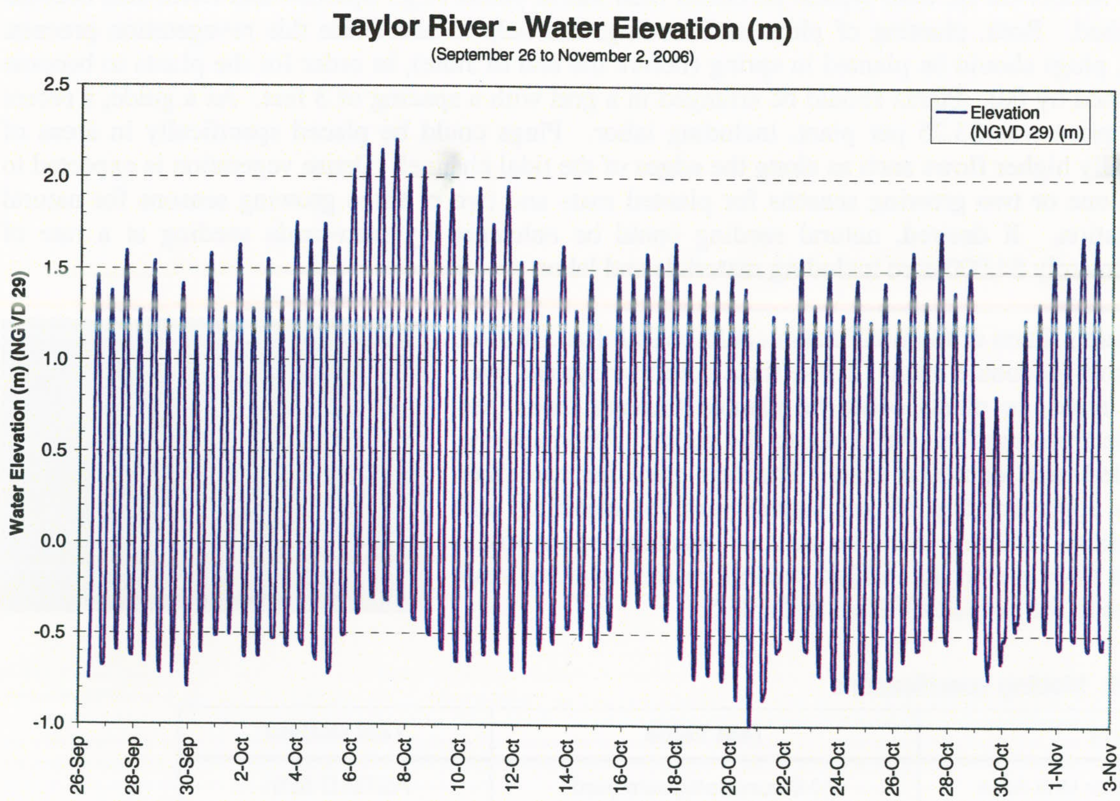


Figure 7: Tidal elevations in Taylor River, just downstream of the dam.

Table 4: Flow velocities in inundated area of Taylor River during various storms.

Storm Frequency	Location					
	500 ft downstream of Towle Farm Road		Midway between Towle Farm Rd and Route I-95		50 feet upstream of Route I-95	
	Width of Flow (feet)	Mean Velocity (f/s)	Width of Flow (feet)	Mean Velocity (f/s)	Width of Flow (feet)	Mean Velocity (f/s)
2-year	183	1.4	55	2.1	40	5.0
10-year	220	1.8	344	2.8	111	4.7
50-year	260	2.2	390	2.8	500	3.2
100-year	274	2.4	411	2.9	545	2.5

These velocities suggest that sediments would be resuspended and transported into the downstream estuary unless the marsh is stabilized, especially along the edges of the tidal creek. Complete tidal inundation would start immediately following the removal of the spillways. The post-dam fine-grained sediment lacks the matting from marsh vegetation that has not yet been reestablished. Recommendations for stabilization are as follows:

- **Seeding:** To a large extent, the exposed sediments would naturally revegetate from seed sources conveyed by tidal waters within the estuary. Initially, the dominant colonization would be by annuals such as *Salicornia* sp. until typical perennial tidal marsh plants (e.g., Spartina and Disticulus become established. Both, planting of plugs and seeding, can help to accelerate this revegetation process. Ideally, plugs should be planted in spring (before the end of June), in order for the plants to become established by fall. Plants should be arranged in a grid with a spacing of 3 feet. As a guide, a recent quoted price was $3.25 per plant, including labor. Plugs could be placed specifically in areas of potentially higher flows such as along the edges of the tidal channel. Dense vegetation is expected to require one or two growing seasons for planted mats and two or three growing seasons for natural revegetation. If desired, natural seeding could be enhanced by man-made seeding at a rate of approximately $4,000/acre including materials and labor.

- **Coir mats:** Parts of the tidal marsh could be stabilized further using coir (coconut) mats. These mats could be spread over seeded areas, or plants could be planted through them (see example from the firm RoLanka to the right). Alternatively, preseeded mats could be used. The unit price for coir fiber mats is approximately $5 per square yard for materials and installation. Matting shall be rolls of machine spun bristle coconut fiber woven into a high strength matrix. Matting shall conform to the properties listed in Table 5.

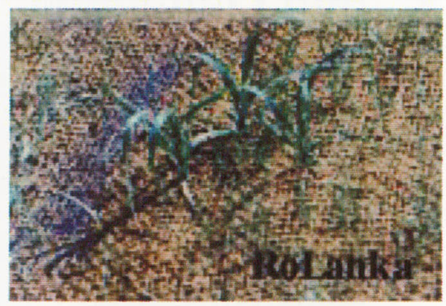
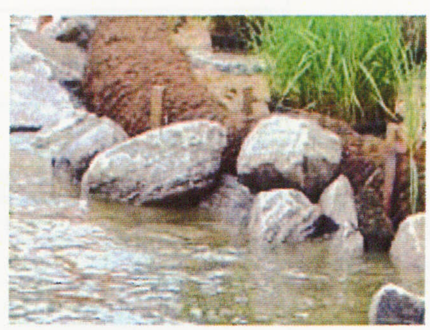


Table 5: Matting specifications

Property	Test Value	Test Method
Mass Per Unit Area	20.6 ounces/square yard	ASTM D 5261
Thickness	0.30 inch	ASTM D 1777
Tensile Strength	1348 x 626 pounds/foot	ASTM D 5035
Elongation	34 percent x 38 percent	ASTM D 5035

- **Natural Fiber Log (Bio-log):** Bio-logs are also made of biodegradable coir fiber. The logs are effective in reducing flow velocities along edges of banks and in trapping and retaining sediment (see photo on the right from a NOAA restoration project in the Chesapeake Bay[1]). At the same time, the needed moisture for plant growth is retained. Natural fiber logs can be molded to fit the bank line, and are anchored by wooden stakes or rock footers. Bio-logs can be planted or covered with plant seeds. The unit price for bio-logs is approximately $6 per linear foot for materials and installation.



[1] https://habitat.noaa.gov/restorationtechniques/public/shoreline_tab2.cfm

- **Flow control:** The spillways should not be removed until the tidal marsh vegetation has been established. This would allow for controlling the tidal flows entering and leaving the former pond area. Flow control should be exercised in a manner that (a) allows saline water to reach the tidal marsh to avoid that undesirable plant communities such as *Phragmites*, and (b) keeps flow velocities low to minimize erosion of sediment from the the still exposed marsh surfaces.

- **Predictive vegetation model:** Predictive vegetation modeling could be done to determine the anticipated plant communities that would become established over a 10-20 year time horizon. This model requires as input elevations, tidal prisms, salinity, and duration of inundation. The model can be a useful tool to guide planting efforts.

The specific approach to be chosen for stabilization of the high marsh sediments will need to be discussed further with NHDES. Ultimately, the preferred approach is a function of the following factors:

- Speed with which the marsh is to stabilize
- Risk tolerance for large storm events and their effects
- Extent of acceptable erosion and transport of sediment into the downstream estuary
- Approach used for excavation and final dimensions of excavated channel
- Available funding.

2.2 Cost Estimate for Restoration

Under Alternative C (Spillway removal and bridge replacement), reasonable first-order restoration costs are estimated to range from **$150,000** to **$250,000**. These costs would include the revegetation of marsh with some seeding/planting of indigenous marsh plants (aside from mostly natural revegetation), and some management to control *Phragmitis* and other nuisance species. Costs may be higher for reasons listed above.

Restoration is not needed for Alternative B (Replacement of spillways, fishway, and I-95 bridge).

3.0 VEGETATING UPLAND SEDIMENT DEPOSIT SITES *(for Alternative C)*

If sediments excavated from the pond are deposited on an upland location, they require some planting after sufficient time of dewatering. The sediment should be sufficiently fertile to support plant growth. Costs for vegetating and landscaping the disposal site depend in parts on the specific planting to be performed. Costs would be higher under Alternative C due to the larger size of the disposal area.

Taller trees would be expensive to install and have a high chance of failure; therefore, it is recommended to plant smaller trees. This applies specifically to the disposal mound which may still be partially unconsolidated, containing comparatively elevated water and organic matter contents. Generally, costs for installation of tree/shrub are approximately $40 per tree for materials and installation assuming trees are in no. 2 container and are 2 ft High and 0.25 to 0.375 inch caliper. Therefore, first-order cost estimates for landscaping and vegetating the upland disposal area are estimated to range from **$20,000 (Alternative B)** to **$100,000 (Alternative C).**

References

Giannico, G. and J.A. Souder, 2005, *Tide Gates in the Pacific Northwest - Operation, Types, and Environmental Effects*. Oregon Sea Grant, Corvallis, Oregon. ORESU-T-05-001.

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