1.0 BACKGROUND

1.1 Introduction

The Taylor River Pond is located in Hampton Falls and Hampton, NH, just south of the Interstate 95 (I-95) Rest Area and Liquor Store (**Figure 1**). The pond was created by a dam. The earthen embankment of the dam is crossed by Interstate I-95. Taylor River flows out of the pond via a primary spillway (NHDES Dam No. 106.08) into the downstream estuary. The outflow via the spillway is crossed by a bridge (NHDOT Bridge No. 120/102). The I-95 bridge and the primary spillway have deteriorated and require repair.

Taylor River Pond Primary Spillway/ Fishway and I-95 Bridge

In addition to the primary spillway, an emergency spillway exists further south (NHDES Dam No. 106.09). This structure includes a culvert through the earthen embankment. Reportedly the culvert attracts migrating fish during high flows. However, when the high flow recedes, the fish get stranded either immediately below the emergency spillway or within the culvert.

Collectively, the primary spillway, emergency spillway and culvert, and earthen embankment are hereafter referred to as the "Taylor River Pond Dam" or the "Dam".

The Louis Berger Group, Inc. (Berger) was retained by the New Hampshire Department of Transportation (NHDOT) to evaluate the feasibility of replacing the I-95 bridge, and removing or replacing the Taylor River Pond primary spillway, fishway, and emergency spillway/culvert.

1.2 Project Purpose and Goals

This Feasibility Study examined different alternatives for replacing the bridge, and removing or replacing the primary spillway, fishway, and emergency spillway/culvert. The assessment considered transportation, public safety, flood management, water quality, natural and cultural resources, and socioeconomic issues. The Feasibility Study also reviewed several options to restore anadromous fish[1] passage within the affected portion of the Taylor River.

Upstream face of I-95 Bridge

NHDOT indicated that addressing the concerns with the I-95 bridge over the Taylor River is a high priority. The steel sheet-piling wall that supports the reinforced concrete slab bridge is exposed to a corrosive saltwater tidal environment and is heavily rusted. The reinforced concrete slab is also showing signs of deterioration with cracks and spalls.

[1] Anadromous fish are species that live most of their lives in the ocean and return to freshwater to spawn.

The Feasibility Study was based on a review of relevant existing information, collection of additional information in the field and from other sources, and a synthesis of the information for the development of a viable solution for the deteriorated structures.

Specifically, the Feasibility Study included the following components:

- Hydraulic/hydrologic analysis of the Taylor River;
- Fluvial geomorphology;
- Sediment analysis;
- Structural engineering design for the Dam and bridge;
- Bathymetric (depth) measurement in the Taylor River Pond;
- Aquatic/fisheries resources assessment;
- Wetland delineation adjacent to I-95;
- Water quality assessment;
- Socio-economic assessment;
- Recreational use assessment; and
- Archaeological and historical assessments.

This Feasibility Study was completed in conjunction with the NHDOT, NH Department of Environmental Services (NHDES), the Towns of Hampton and Hampton Falls, the NH Fish and Game Department (NHFGD), the National Oceanic and Atmospheric Administration (NOAA) Restoration Center, the U.S. Fish and Wildlife Service (USFWS), American Rivers, and the Piscataqua Regional Estuaries Partnership (PREP). Funding for this study was provided by NHDOT, NOAA, Gulf of Maine Council on the Maine Environment, and the PREP. This group is also referred to as the "Project Partners".

1.3 Taylor River and its Watershed

The watershed boundary of the Taylor River is presented in **Figure 2**. The headwaters of the river start just south of Lamprey Road near the common corporate boundary of Kensington, Hampton Falls, and South Hampton, NH. The river first generally flows south to north through Kensington, then turns northwesterly to southeasterly through the Towns of Hampton Falls and Hampton. It continues underneath I-95 and US Route 1, through the "Hampton Flats" estuary, and finally into the Atlantic Ocean in Hampton.

Several smaller tributaries discharge into the Taylor River, including Grapevine Run and Clay Brook (from the southwest), Old River (from the northeast), and Ash Brook (from the northwest). The Taylor River Pond Dam creates an impoundment that extends approximately 2 miles upstream from I-95 to Old Stage Road. The total watershed area above the Taylor River Pond Dam (upstream from I-95) is estimated to be 7,075 acres.

Three other dams upstream of the Taylor River Pond are on record in the NHDES database:

1. Rice Dam (#106.06): Located just upstream of Old Stage Road, in Hampton, NH.
2. Car Barn Pond Dam (#105.01): Located south of Hampton Road/NH Route 27 on the Old River, in Hampton Falls, NH.

3. Proposed "Taylor River Dam" (#106.13): Located just south (upstream) of Curtis Road on the upper Taylor River, in Kensington, NH. This dam was not built. However, according to NHDES records, existing remains of a former dam, referenced as an "Old Stone Dam", are located at this location, and are included in the NHDES evaluation of the Taylor River Pond Dam.

These upstream dams were included and analyzed by the NHDES Dam Bureau. Measurements and storage information as provided in the NHDES documents were used in the analysis, as described in subsequent sections of this Feasibility Study.

The Taylor River Pond supports spawning of anadromous river herring (blueback herring and alewife) and contains resident freshwater fish species. American eel elvers (juvenile form of this catadromous species[2]) also ascend the Taylor River into the pond.

Normal High Tide Downstream of Taylor River Pond Dam

The river is not listed as a "designated river" under NH Statue RSA 483.10. However, upstream of the Dam, Taylor River is listed by the USEPA (under the Clean Water Act Section 303[d] list) as being impaired for mercury. Downstream of the Dam, the large Taylor River tidal estuary is listed on the 303(d) list as impaired for polychlorinated biphenyls (PCBs), dioxin, and fecal coliform (USEPA, 2009).

1.4 Existing Structures

The base plan developed for this Feasibility Study is presented in **Figures 3** to **6**. The plan shows the existing structures. Data used for the development of the plan consisted of the following:

- Field survey data (Fall 2006): Obtained by the NHDOT from the Rice Dam downstream to the I-95/Taylor River Pond Dam.
- Aerial survey data (Fall 2005): Obtained by Col-East, Inc. for the Taylor River Pond and surrounding area. This data developed in accordance with NHDOT Mapping Standards for use with Microstation/MX. A digital terrain model was developed and 2-foot contours were generated. Digital orthophotos were provided with a pixel size of 0.5 foot.
- Bathymetry survey data (October 2006): Bathymetric contours of Taylor River Pond were developed by HydroTerra based upon soundings collected from October 6 to 14, 2006. The vertical datum was NHDOT HT-2 at 2.78 feet NGVD 1929 at Towle Farm Road. Details of the bathymetry survey are included in **Appendix A**.

Downstream Face of I-95 Bridge

All elevations in this Feasibility Study are referenced to the National Geodetic Vertical Datum of 1929 (NGVD29), as this is the datum of the base plans and reference documents used.

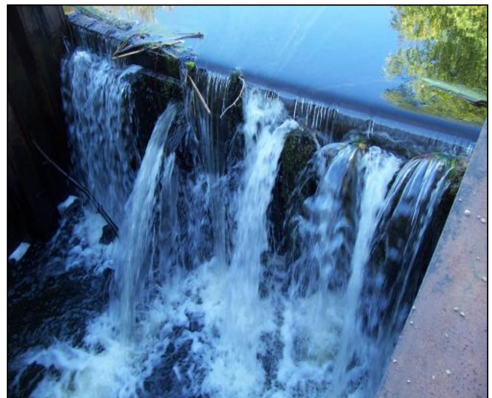
[2] Catadromous species live most of their lives in freshwater and return to the ocean to spawn.

1.4.1 I-95 Bridge

The existing I-95 bridge (Bridge No. 120/102) was originally constructed in 1950 as part of Taylor River Structure No. 5, and was later extended in 1974 as part of a roadway widening for the I-95 Northbound barrel. It currently carries the eight lanes of I-95 over the Taylor River. Upon review of historic US Geological Survey (USGS) plans and review of the original NHDOT design plans for the existing bridge, it is evident that the existing bridge was constructed to the north of the original Taylor River channel. A new, approximately 380-foot-long tidal channel (ranging from 6 to 13 feet deep) was excavated for the bridge to connect Taylor River to the original channel located further to the southeast.

The existing bridge structure is approximately 207 feet long (measured along the relocated Taylor River) and provides a clear opening width of 15 feet. It is comprised of vertical steel sheet piling supporting a cast-in-place reinforced concrete slab and approximately six to eight feet of roadway fill. The NHDOT Bridge Inspection Reports note that the steel sheet piling is heavily rusted with section loss and holes below the waterline. The reinforced concrete slab shows cracking and spalling, and is leaking. The bridge rail, rail transition and approach rail ends do not meet current standards.

1.4.2 Primary Spillway and Associated Structures


Primary Spillway

The primary spillway was constructed in 1950 as part of the I-95 highway bridge over the Taylor River near head-of-tide in Hampton, NH, as waterfowl mitigation requested by the NHFGD. A Denil fishway[3] was installed on the primary spillway in the late 1960s to provide anadromous fish passage. According to the 1948 construction plans, the existing primary spillway was constructed approximately 535 feet north of the historical river channel that divides the Towns of Hampton and Hampton Falls. The total embankment length is estimated to be between 600 and 650 feet. An approximately 180-foot-long channel was also constructed from the existing bridge on the east side of I-95, to the existing tidal channel. According to information from the NHDOT and the NHDES Dam Safety Bureau, and as observed during the September 26, 2006 inspection, the primary spillway, the emergency spillway/culvert, and the fishway have since begun to deteriorate. The deteriorated fishway has resulted in less efficient fish passage.

According to NHDOT and NHDES information and inspections (NHDES November 2004 hydrologic evaluation, January 12, 2005, meeting notes, and January 25, 2005, inspection report, included in **Appendix B**), there are four major components associated with fish passage and access to upstream habitat, as follows:

1. <u>Primary Spillway (NHDES Dam #106.08)</u>: The NHDOT-owned primary spillway is 18.5 feet tall and 50 feet long (embankment to embankment), and blocks fish access to upstream habitat, although this is somewhat mitigated by the existing fishway. The 15.2-foot-wide sheet pile primary spillway and 3-foot-high flashboard bay are deteriorating, with numerous leaks and holes. The top of the sheet pile spillway is at elevation 7.54 feet. The timber flashboards were installed on top of the sheet pile

[3] A Denil fishway is designed with a series of sloped channels and can be constructed with an overall slope of 10 to 25 percent. It contains wooden baffles that are positioned at regular intervals. The fishway has a narrow entrance which creates high water velocity to attract fish. It may also contain resting pools between long segments of the fishway.

spillway to an elevation of 8.55 feet, which is considered the elevation for "normal operation" of the primary spillway.

The I-95 earthen embankment that forms the main part of the Dam is in excellent condition, with a very wide crest, gentle slopes, and no apparent seepage from the downstream slope.

NHDES has recently re-evaluated the Dam and has classified the primary spillway as a "High Hazard Dam", *i.e.*, a dam that has "high hazard potential", as its failure may cause damage to an interstate highway, in accordance with NHDES Env-Wr 101.09(c). As stated in our January 2007 Technical Memorandum, the sheet pile primary spillway and flashboard bay are badly deteriorated, and settlement has been noted at the left abutment adjacent to the sheet pile training wall of the primary spillway. NHDOT owns and manages the Dam and has stated that the primary spillway should be removed or replaced. Repair of the existing primary spillway is not a viable option because this would not address concerns by local residents about flooding of the pond during peak storm events.

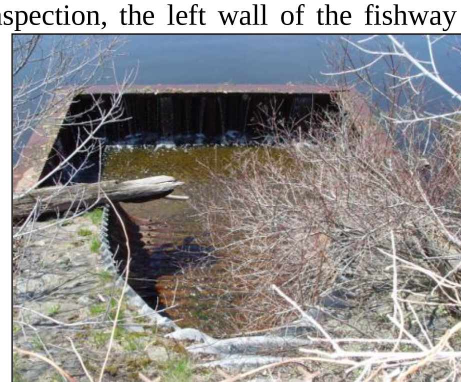
2. Impoundment: The Taylor River Pond Dam has created a freshwater pond covering an area of approximate 47.5 acres. The pond provides spawning and nursery habitat for anadromous and freshwater fish, and nursery habitat for catadromous American eel. There is an approximately 150-foot-long section of free-flowing stream between the Old Stage Road bridge and Rice Dam, based on Berger's September 2006 inspection. This short stream segment may also provide spawning habitat for river herring and nursery habitat for American eel.

Taylor River Pond, as seen from the Dam

A bathymetry survey of the impoundment recorded an average depth of 2 feet within nearshore areas and approximately 9 feet within the confined former channel.

According to two residents that were interviewed, the sediment gives off an odor when the lake level is very low.

3. Fishway: The existing 3-foot-wide Denil fishway was installed in the 1960s. It is currently in poor condition. It has leaks and holes where it is joined to the primary spillway. As stated in the January 2007 memo and according to the July 2, 2004 NHDES inspection, the left wall of the fishway is cracking. Water from the leaks and holes in the fishway attract and confuse migrating fish so that they may be unable to find the entrance to the fishway. The NHFGD operates the fishway and controls water levels in the fishway by using timber stop logs.



Emergency Spillway and Entrance to Culvert

4. Emergency Spillway/Culvert (NHDES Dam #106.09): The Taylor River Pond emergency spillway is a 35.5 foot long by 1.5-foot-wide sheet pile structure with a spillway elevation of 9.03 feet that flows into a 6.1-foot-high by 8.8-foot-wide steel plate pipe-arch culvert. The pipe-arch culvert carries excess water under the I-95 roadway south of the bridge and spillway location. As stated above,

discharge through this culvert attracts migrating fish during high flows. However, fish are stranded either immediately below the emergency spillway or in the culvert when the water level recedes. This spillway is considered a "Significant Hazard Dam" by the NHDES Dam Safety Bureau. A new concrete invert was recently constructed as a measure to repair the deteriorated culvert invert. The interior dimensions were reduced to a height of 5.66 feet and a width of 7.98 feet.

1.4.3 Dam and Fishway Maintenance

The NHDOT is listed as the owner of the Taylor River Pond Dam and has repaired the emergency spillway pipe-arch culvert, as mentioned above. The areas next to I-95 and the earthen embankment are cleared, mowed, and maintained frequently by the NHDOT Turnpike Division. However, according to the NHDOT Highway Division, no other regular maintenance of the structures is performed.

The NHFGD and NHDES maintain the water level of the pond using the existing timber flashboards at the primary spillway. The following is a summary of monitoring and maintenance procedures for the fishway as provided by NHFGD personnel:

- The fishway is monitored and maintained seven days per week, from the end of April through mid/late-June. A 10-minute calibration count is performed on the Smith-Root electronic fish counter to confirm that it is working properly. Once a week the battery in the fish counter within the fishway is changed. River herring are very sensitive to the amount of water flowing through the counting tube, so it is often adjusted as water levels rise/fall. According to the NHFGD, this watershed is very reactive to rain events and rises/falls very erratically. Each day the interior grates of the fishway are cleaned and logs/debris within or against the fishway or spillway are removed.

- Biological samples are taken three times during the spawning run (beginning, middle, and end). The NHFGD attempts to take 150 samples during each event. The Taylor River Pond Dam fishway does not have a trap at the top to hold fish. Therefore, samples must be taken from inside of the fishway using a dip net to catch river herring from between the baffles. This effort requires 2 or 3 people. Usually only 10 to 30 fish are captured each day for sampling. It usually takes many days to complete the sampling.

- Repairs are often made to the wooden structures within the fishway. Each year ice, debris, or rodents damage at least a few baffles. Also, the system of chutes, grates, and boards needed for fish passage periodically need maintenance or replacement. Periodic patching and caulking of the concrete part of the fishway is also required (about every 5 to 7 years). The steel grates on top of the fishway also need periodic replacement, requiring new mounting hardware drilled and hammered into the concrete.

- The fishway is damaged by vandals on an annual basis, mostly when the impoundment level is low. Typically, the lock/chain is cut and boards that allow fish passage are stolen or thrown downstream. Wooden boards or accumulated debris may result in blockage of the fishway. The materials that are damaged or lost are immediately replaced by NHFGD so that the river herring run can continue.

1.4.4 Flooding and Tides

The water elevation in Taylor River Pond is affected by high stormwater runoff volumes and high tidal elevations. In addition, strong persistent wind from the sea can push up tidal waters even further during high tide. The mean high water elevation of Hampton Harbor is 8.63 feet (Town of Hampton, 2009).

Flooding during the May 14 and 15, 2006, storm event ("Mother's Day Flood of 2006") was reported by residents located in the Taylor River Estates development northwest of the existing Dam. According to Mr. Frank Chamberlain (6 Laurel Drive, Taylor River Estates), flood elevations reached approximately 1.5 feet above his first floor. The water started to rise around 8:00 pm on May 14th, reaching its peak in Taylor River Pond around midnight. The midnight peak elevation was likely affected by the high tide at that time (**Figure 7**), slowing the water release from the pond. The water receded later during the night and was low again by 8:00 am on May 15.

During the peak elevation around midnight, water reportedly inundated the two southbound lanes of I-95 by approximately 0.5 foot. This inundation marks the peak elevation of the Taylor River Pond for that flood event. Debris blocking the primary spillway and its downstream channel may have also affected the flood elevation.

2.0 ALTERNATIVES

2.1 Introduction

Berger and its sub-consultant, GEI Consultants, Inc. (GEI) analyzed the following three alternatives:

A. No Action

B. Replacement of I-95 bridge and new spillway/fishway

C. I-95 bridge replacement without spillway.

Issues addressed included the following:

- Effective fish passage (specifically American eel, river herring, and rainbow smelt);
- Rare, threatened, and endangered species located both up- and downstream of the project area;
- Water and sediment quality;
- Fire water supply and water wells for the area surrounding the Taylor River Pond;
- Cultural and historical resources;
- Recreational usage of Taylor River Pond; and
- Other socio-economic issues, including but not limited to, property values that may result from the removal or replacement of Taylor River Pond spillway Dam.

Rehabilitation of the spillway structures was not studied because it would not mitigate the flooding problem of the pond. Also, due to historic upstream flooding of the pond, a larger hydraulic bridge opening was to be analyzed.

Hydraulic analyses of Taylor River were performed for each alternatives. The HydroCAD® v 8.0 by HydroCAD Software Solutions, LLC software was used to analyze the existing spillways. The U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center's River Analysis System (HEC-RAS) hydraulic modeling software (version 3.1.3) was used to model the bridge alternatives with and without a spillway. Section 3.0 of this document contains further explanation of the analysis and results.

2.2 Alternative A: No Action

The alternative of not improving or replacing the existing I-95 bridge and spillway was considered. As stated above, the existing I-95 bridge, Taylor River Pond spillways and fishway are deteriorating. Fish passage efficiency is reduced, and some fish are trapped in the emergency spillway culvert following high flows. As the spillways are considered "high hazards", their failure may cause damage to the interstate highway and adversely impact many of the evaluated resources. Also, debris from a failed spillway could block the pond outlets underneath I-95, causing flooding of surrounding properties and/or I-95. The No-Action Alternative also does not address the flooding issues associated with the I-95 bridge and the Taylor River Pond spillway(s). This alternative is considered the baseline against which the other alternatives were compared.

2.3 Alternative B: Replacement of I-95 Bridge and New Spillway/ Fishway

This alternative consists of the removal of the existing bridge, primary spillway and emergency spillway/culvert. A new opening in the earthen embankment for a new 70-foot-long bridge with a 50-foot-wide spillway (at EL 8.55 feet) and a new fishway (appropriate for the species of concern) would be constructed southerly of the existing location, near the Hampton/Hampton Falls town line.

2.3.1 Proposed Bridge

Under both Alternatives B and C, the existing I-95 bridge would be replaced with a new concrete bridge. Several bridge alternatives were analyzed: a 90-foot-long (abutment to abutment) bridge opening with a 45-foot-wide channel; and an 85-foot-long and a 70-foot-long (abutment to abutment) bridge opening each with a 25-foot-wide channel. The 85-foot-long bridge was evaluated to determine if it was worthwhile to expand the bridge opening to allow for an increase in hydraulic capacity, and still maintain a similar bridge deck depth as the 70-foot-long bridge.

The 70-foot-long and 85-foot-long bridge lengths were evaluated with and without a proposed spillway. Hydraulic analyses were performed to model the channel flow area blocked to the High Monthly Tide (or "spring") surge elevation (EL 7.21 feet) as a downstream boundary condition, in combination with the 100-year freshwater storm (per the Federal Emergency Management Agency (FEMA) records). The flow area below the tide elevation was assumed to be completely blocked by the tide. No storm flow would be allowed to move downstream below this elevation.

The low chord of the bridge under this alternative would be set at the resulting water surface elevation with zero freeboard. The bridge would also be constructed with appropriate sloped abutment embankments and stone scour protection. The upstream channel elevation under the bridge would be set at EL= -0.5 foot to provide a constant channel slope to the downstream side of the proposed bridge.

The results of the evaluation for the 85-foot-long versus the 70-foot-long clear span bridge opening were summarized in the previously submitted "*Additional HEC-RAS Modeling to Set Bridge Low Chord Elevation*" dated September 30, 2008. The resultant water surface elevations for the three bridge openings were similar. Therefore, only the proposed 70-foot-long bridge opening was brought forward in this Feasibility Study.

Folder 1 on the Additional Data CD included with this report**,** contain the model results for the bridge alternatives. A schematic of the proposed 70-foot-long bridge with a new spillway and Denil fishway is included in **Figure 8**.

2.3.2 Proposed Spillway

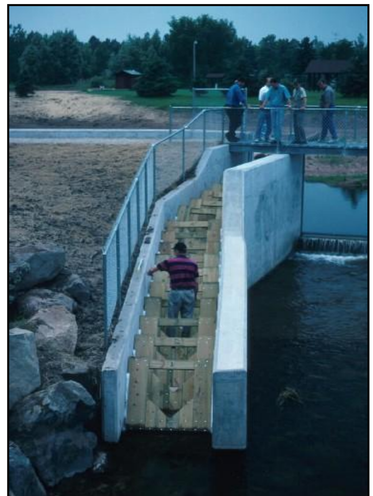
The new bridge and spillway location was selected as it is the approximate historic location of the 25-foot-wide river channel, prior to the construction of I-95, according to the 1948 construction plans. The more southerly location of the new bridge was also chosen to allow NHDOT to construct the bridge in the dry, thus avoiding the difficulties of maintaining the river flow if the existing bridge was replaced at its present location.

In accordance with NHDES Dam Safety Bureau Administrative Rule Env-Wr 101.09, the new spillway would be considered "High Hazard" as its failure would cause "structural damage to an interstate highway which could render the roadway impassable or otherwise interrupt public safety services". Since

this is an existing dam, the design strom is 2.5 times the 100-years storm event. The Probable Maximum Flood (PMF) discharge requirement applies only to new construction of High Hazard dams.
Due to soft underlying soils, the proposed Taylor River Pond spillway would probably be supported on piles that penetrate the "muck" and clay, and bear in sand or till underlying the clay (at EL -45 to -75, or possibly deeper). (See Section 3.2 for more details regarding soils in the project vicinity.) A seepage cutoff wall may be required to be provided along the upstream edges (3 sides) of the structure. The cutoff wall should consist of steel sheet piles driven into the clay soils (EL 0 to -25) or driven through the clay into the underlying sand or till and should be tied into the existing highway embankment. If the sheet piles are driven into the denser soils, then they could serve as both the support piles and the seepage cutoff.

Steel will corrode in a marine environment. This concern needs to be addressed during final design by a combination of embedment in concrete, sacrificial thickness of steel, embedment in soil, and possibly a coating. The details would depend on a number of factors, including the type and layout of the final structure.

The proposed spillway was analyzed at the existing primary spillway elevation of 8.55 feet National Geodetic Vertical Datum of 1929 (NGVD29).



Denil Fishway at Trout Creek Dam, Trout Creek, Ontonagon County, MI

2.3.3 Proposed Fishway

Three fishway options were evaluated for the proposed spillway, as follows:

- Alternative B1: Denil fishway.
- Alternative B2: Alaskan Steep Pass Fishway[5].
- Alternative B3: Rock Ramp Fishway.

The final design of the selected fishway would need to be coordinated and pre-approved by the NHFGD and USFWS. A description for each of these fishway options is provided below.

2.3.3.1 Alternative B1: Denil Fishway

Under this alternative, a new 4-foot-wide Denil fishway with a 30-inch wide downstream entrance would be constructed on the north side of the proposed spillway Dam. Denil fishways are known to be effective fish passage devices for stronger-swimming species such as river herring, American shad, Atlantic salmon, and some riverine species such as suckers. Weaker swimming species such as rainbow smelt or American eel elvers, however, may not be able to traverse a Denil fishway. Eel ramps or eelways have been constructed for the upstream passage of elvers on some New England coastal streams. The inclusion of an eel ramp in the project will be reviewed durign the Final Design stage of the project. The new Taylor River fishway would have a slope of 1:6, a single turning or resting pool, with 30-inches between baffles. Normal water depth within the fishway would be 2 to 4 feet.

The Denil fishway is self-regulating over a range of approximately 2 feet in headwater level. "Stoplogs" would be installed at the upstream and downstream ends of the fishway to allow closure during times of

[5]The Alaskan Steep Pass fishway is a modular prefabricated Denil fishway variant originally designed for remote areas of Alaska.

non-use. The fishway would be constructed as an integral part of the proposed spillway structure and tied to the adjacent I-95 sideslopes of the earthen embankment.

Based on input from Project Partners on fishway options, this is the preferred option for Alternative B. A schematic of this proposed layout is shown in **Figure 8**.

2.3.3.2 Alternative B2: Alaskan Steep Pass Fishway

This is a prefabricated (usually stainless steel) variant of a Denil fishway, originally designed for transport to remote sites in Alaska for salmon passage over natural obstructions. Although the Steep Pass is effective for river herring passage, it has a more limited operating range and may be more susceptible to internal debris problems than the standard Denil fishway. The Steep Pass may also be more subject to damage by river debris during high flow events, because of its lighter-weight steel construction. Because of these potential issues and the NHFGD preference for a standard Denil fishway, this alternative was not evaluated in more detail.

2.3.3.3 Alternative B3: Rock Ramp Fishway

A rock ramp fishway consists of a cobble/boulder ramp typically constructed at the downstream face of the spillway so that water levels in an impoundment are maintained, while providing a more natural-type passage route for migratory fish above the Dam. A rock ramp can be constructed so that a range of species can be accommodated, including weaker swimming species such as American eel elvers. A rock ramp usually consists of a series of small, irregular “step-pools”, at an approximate slope of 20:1, so that fish are able to work their way over the spillway much the same as in a natural riffle area.

For this alternative, the rock ramp would be installed across the full width of the new river channel under the proposed bridge. The upstream end of the rock ramp would be the spillway (and thus would maintain the impoundment), and would be tied into the I-95 sideslope/earthen embankment. For a 13-foot drop in elevation from the pond to the invert downstream of the new bridge, this would require a rock ramp of about 260 feet in length, which would extend beneath the proposed I-95 bridge.

Because of the potential size and cost of this structure, as well as the limited use and experience with the rock ramp design in the Northeastern United States, the rock ramp was not considered a viable fish passage alternative by the NHFGD and USFWS. Therefore, this alternative was not evaluated in more detail.

2.4 Alternative C: I-95 Bridge Replacement without Spillway

Alternative C consists of the removal of the existing I-95 bridge, and the primary spillway/fishway, and emergency spillway/culvert, and the construction of a new concrete bridge located near the historic river channel. This alternative is similar to Alternative B, except it does not include the construction of a new spillway. It does not require a new fishway. Details on the bridge replacement are discussed in Section 2.3.1 above.

3.0 ENVIRONMENTAL ASSESSMENT OF ALTERNATIVES

3.1 Hydraulic Analysis

Hydraulic analyses of the Taylor River and I-95 bridge were conducted using the HydroCAD® and USACE HEC-RAS hydraulic modeling software. The software was used to predict water surface elevations and velocity profiles for the existing and new alternatives. The two models and their respective input and output data for the above alternatives are described below.

3.1.1 HydroCAD® Model Development

The HydroCAD® model software is a hydrograph routing model. It is designed to determine time varying runoff flows, in the form of a hydrograph, as required for the sizing or evaluation of an impoundment outlet structure. For this project, the software's US Department of Agriculture (USDA) Soil Conservation Services (SCS) "SCS TR-20" method for a Type III 24-hour duration storm was used to evaluate the existing primary spillway and emergency spillway/culvert, and the proposed spillway under Alternative B, as stated in Section 2.1 above.

The following data were used to evaluate the surface runoff and hydraulic routing through the Taylor River watershed and the Taylor River Pond Dam:

- Watershed and dam HydroCAD® model data and manual calculations prepared by the NHDES Dam Safety Bureau, dated November and December 2004 (and verified by Berger).
- Fall 2006 NHDOT field survey data for the Rice Dam, Towle Farm Road crossing, and the I-95 Taylor River Pond primary spillway and fishway, bridge, and emergency spillway/culvert.
- Fall 2006 Col-East aerial survey data for the Taylor River Pond and surrounding area.
- 2006 HydroTerra bathymetric survey data for the bottom of the Taylor River Pond.

Towle Farm Road Bridge

The HydroCAD® model input data included weighted Curve Numbers (CNs) based on soil types and ground covers, and times of concentration (T_c) for each sub-catchment based on groundcover and hydraulic type (sheet flow, shallow concentrated flow, etc.), as verified by Berger.

Dimensions and elevations of the three existing upstream dams were taken from the NHDES evaluation to develop the stage-storage rating curves for the storage volumes behind these dam structures. The Col-East, Inc. aerial survey combined with the impoundment bathymetry survey data, and the NHDOT survey data were used to analyze the following existing and proposed Taylor River Pond spillway conditions:

- Alternative A: Existing Conditions with the 15.2-foot-wide primary spillway (EL 8.55 feet) and the existing I-95 bridge over Taylor River; and the 39.7-foot-wide emergency spillway (EL 9.03 feet) with the existing 5.7-foot high by 8.0-foot-wide by 260-foot-long pipe arch culvert in-place (**Figure 9**).

- Alternative B: Proposed Conditions with a proposed 50-foot-wide spillway at the existing elevation (EL 8.55 feet) (**Figures 10** and **11**). This alternative also includes a new 70-foot-long bridge and a new fishway; however, only the proposed spillway conditions were analyzed using the HydroCAD® model.

Alternative C was not analyzed using the HydroCAD® model as it did not include the evaluation of a spillway. Alternative C was evaluated using the HEC-RAS model, as described in Section 3.1.2, below.

The proposed spillway under Alternative B would be constructed near the historical river channel location, as shown on the above referenced figures, just upstream of the proposed I-95 bridge. All spillway alternatives were evaluated for 2-, 10-, 50-, and 100-year storm events, with rainfall depths of 3.1 inches, 4.4 inches, 5.75 inches, and 6.60 inches, respectively.

Table 1 summarizes the results of the HydroCAD® model analysis for the spillway alternatives. The model output reports are presented in **Folder 1** on the Additional Data CD included with this report.

3.1.2 HEC-RAS Model Development

HEC-RAS is designed to perform one-dimensional hydraulic calculations for a full network of natural and constructed channels. The model is intended to calculate water surface elevations for steady, gradually varied flow. The steady flow component of the model is capable of modeling subcritical, supercritical and mixed flow regime water surface profiles. The program utilizes the one-dimensional energy equation. Energy losses are evaluated by friction (Manning's Equation) and contraction/expansion (coefficient multiplied by the change in velocity head). The momentum equation is utilized in situations where the water surface profile is rapidly varied. These conditions include mixed flow regime (*i.e.*, hydraulic jumps), hydraulics of the bridge and evaluating profiles at river confluences.

The prepared Base Plan and supporting data were used to develop a river alignment and hydraulic cross-sections through the reach, starting from the downstream face of Old Stage Road (Station 70+90) to downstream of I-95, within the tidal estuary (Station 1+99).

The hydraulic model river alignment and cross-sections are presented in **Figures 3** through **6**.

The hydrology results from the above HydroCAD® model analysis and HEC-RAS was used to analyze Alternatives B and C for the 2-, 10-, 50-, and 100-year storm events, with the High Monthly Tide (EL 7.21 feet) blocked[7]. A 70-foot-long clear span bridge with a 25-foot-wide channel with a 50-foot-wide spillway set at EL= 8.55 feet and a new fishway were used in this analysis. As stated above, the new structures would be installed close to the location of the former Taylor River historic channel at I-95, just south of the town line (**Figures 10** to **12**).

Tables 2 to **4** summarize analysis results and water surface elevations as modeled, adjacent to the Chamberlain residence and at the upstream side of the proposed I-95 bridge for the proposed 70-foot-long bridge with and without the new spillway (Alternatives B and C, respectively). The model output reports are provided in **Folder 1** on the Additional Data CD included with this report.

[7] The models were run with the channel flow area "blocked" below the elevation of the High Monthly Tide surge elevation, in combination with the freshwater storm event.

3.1.3 Abutter Flood Conditions

The critical storm to review is the High Monthly Tide with the 100-year freshwater storm at the Chamberlain property, adjacent to Taylor River Pond (river Station 4+48). Based on the HEC-RAS model results (see **Tables 2** to **4**), removing the existing Taylor River Pond primary spillway and emergency spillway/culvert, and installing a new bridge, will substantially lower the flood elevation adjacent to the Chamberlain residence. Also, as shown in **Tables 3** and **4**, the water surface elevation just upstream of the proposed bridge (river Station 6+97) is essentially the same for both Alternatives A and B (approximately 12.7 feet). This indicates that the spillway does not influence the water surface elevation under the proposed bridge.

3.2 Geology

Berger's subconsultant GEI obtained and reviewed the necessary available geologic information relative to the bridge replacement options and spillway removal/replacement options for the I-95 bridge and Taylor River Pond Dam. The following sections have been incorporated from information provided by GEI, entitled "Input to Feasibility Study", dated October 23, 2007 (**Appendix C**).

GEI reviewed published information on bedrock and surficial geology from the U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS) soil survey information; and information available from the Geographically Referenced Analysis and Information Transfer, or "GRANIT[8]" website (**Table 1** in **Appendix C**).

3.2.1 Bedrock Geology

Novotny (1969) identified the bedrock in the project area as part of the Kittery Formation, possibly containing slate, phyllite, schist, quartzite, or lime-silicate rock (**Figures 1** and **2** in **Appendix C)**. **Table 1** in **Appendix C** contains an excerpt from the text of the reference that describes the conditions.

3.2.2 Surficial Geology

The surficial geology maps of the Exeter and Hampton quadrangles (Goldsmith, 2001; Koteff, et al., 1989) show interpretations of surficial geology for the western and eastern portions, respectively, of the project area. The interpretations have been incorporated into the mapping available on the GRANIT website to provide a combined picture (**Figure 3** in **Appendix C**). The surficial soils within the Taylor River's historic course and the level areas to either side are identified as salt marsh deposits – partly decomposed organic material mixed or interbedded with estuarine silt, clay, and sand. Soils just upslope from these areas to either side of the river are glaciomarine silt and clay. In the higher elevations, the soils are glacial till.

Goldthwait (1953) described the extent of marine clays in the New Hampshire Seacoast area. He indicated that the clay deposits in the project area follow the course of the Taylor River and underlie the estuarine (salt marsh) deposits and portions of the adjacent glaciomarine (glacially deposited sand, silt, and clay) deposits. He described potential commercial uses of the clay but did not provide geotechnical information.

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[8] The GRANIT website is New Hampshire's statewide geographic information system and contains information on a number of topics, including transportation, geology, land use, and conservation and wetland areas. The website address is: http://www.granit.sr.unh.edu/. The search engine within GRANIT can be accessed directly at: http://www.granit.sr.unh.edu/cgi-bin/load_file?PATH=/data/database/index.html.

3.2.3 Soils

The Rockingham County Soil Survey (U.S. Soil Conservation Service, 1994) provides very detailed information on the soil within 5 feet of the ground surface. It contains aerial photographs with the various map units (areas within which soils are similar) delineated, and the text of the reference contains descriptions of the soils in each unit. These delineations were incorporated into the mapping available on the GRANIT website (**Figure 1** in **Appendix C**). The soil survey information describes the surficial soils along the Taylor River's historic course as "Ipswich mucky peat." The rest of the project area is divided into a number of different map units, but the soils in most of those units are generally described as "sandy loam". **Appendix C** includes more detailed soil descriptions.

3.2.4 NHDOT Geotechnical Information

The following NHDOT bridge drawings and geotechnical information of the project area were also reviewed:

- 1948 drawings for the Taylor River I-95 Bridge (under what is now the southbound I-95 embankment).
- 1953 drawing showing modifications to the Taylor River Pond Dam.
- 1971-72 drawings for the extension of the Taylor River I-95 Bridge under the then proposed (now existing) northbound embankment.
- 1971-72 drawings for a contract (Project P-1235-B, Contract 2) for construction of the current northbound embankment from Route 107 to Towle Farm Road.
- 1971-72 drawings (revised 1975) for the Taylor River Relief Structure (corrugated metal culvert and sheet pile emergency spillway).

Note that an elevation datum is not given on any of the reviewed drawings. It is assumed that the datum was NGVD29, which is about 0.8 foot below the North American Vertical Datum of 1988 (NAVD 1988) in this area. The following information is provided from the above list of drawings:

- 1948 drawings for the Taylor River I-95 Bridge: These drawings included a boring location plan and logs of 21 borings that were drilled to the west of the highway embankment, presumably to identify a location for the bridge. **Appendix C** contains copies of the boring plan, logs, and legend. The information from the borings is summarized as follows:
    - Historic Taylor River Channel: Fifteen of the borings (Borings 1 through 19; no data were available for Borings 4, 6, 9, and 11) were performed in a nearly level area at approximate EL 4 adjacent to the historic Taylor River channel. These borings encountered deposits of very soft organic soils, described as soft peat, peaty silt, silt, and clay, extending to depths of up to 22 feet (EL -18). These soils were underlain by a layer of clay that extended to depths of up to 57 feet (EL -53). The clay was generally very soft to soft, but in places, the upper part of the clay (as much as 10 feet) was stiff to very stiff. In some of the borings, the upper part of the clay layer was found to contain layers of sand or silty sand, with occasional mention of shells or gravel in the logs. The clay was underlain by loose to medium dense fine sand and clay, with some zones containing gravel. This layer ranged from 4 to 20 feet in thickness. Refusal, interpreted on most of the logs as bedrock ("ledge") or a boulder, was encountered just below the sand layer, at depths of about 50 to 70 feet in these borings.

- Lower River Bank: One of the other borings, No. 26, appears to have been drilled up on the river bank, at EL 9, and encountered no soft organic soils at the surface, but instead encountered 14 feet of silty sand with little clay. Below this sand, the boring encountered conditions similar to those in the borings described above: 20 feet of soft clay, underlain by 15 feet of loose to medium dense sand and clay. The top of this sand/clay layer was at EL -25. The boring was stopped, possibly upon refusal, at a depth of 49 feet (EL -40).
- Upper River Bank: The remaining 5 borings (Borings 21, 22, 23, 24, and 25) were drilled higher on the bank to the north of the Taylor River channel. The ground surface was at about EL 13 for these borings. These borings encountered no soft organic deposits. The surficial soils were medium dense to dense sand and silt with little clay, extending to depths of 12 to 15 feet. In three of these borings, the surficial sand was underlain by 2 to 13 feet of soft to medium stiff clay, which was underlain in turn by dense to very dense sand and gravel. In the other two borings, the surficial sand was underlain directly by the dense to very dense sand and gravel. This dense granular soil appears to be different than the sand found beneath the clay in the other borings. The top of the dense granular soil ranged from EL -15 to +1. The borings were stopped at elevations ranging from -22 to -8, though refusal was noted for only one of the borings.

The drawings indicate that the bridge consists of a concrete slab supported by sheet piles driven to elevations varying from -8 to -12, into the dense sand underneath the clay. It appears that the bridge location was selected so that it could be easily founded in the dense sand. The river channel is indicated to be at EL 0, and the underside of the top slab is at EL 8. The bridge span is 15 feet.

- 1953 drawing showing modifications to the Taylor River Pond Dam: The drawing does not include geotechnical information but indicates that the sheet piles making up the primary spillway were to have been driven to elevations varying from -13 to -22. Based on the boring logs described above, these sheet piles would have been driven into the dense sand and gravel underlying the clay. The primary spillway of the Dam is indicated to be at EL 8±, and the non-overflow portions are shown at EL 11. The plan of the Dam appears to be similar to the existing condition. The drawing shows stone fill against the downstream face of the primary spillway, though no stone is now visible in this area. The drawing shows no stoplogs or fishway, as currently exists.

- 1971-72 drawings for the extension of the Taylor River Bridge: One of the drawings includes a boring location plan and logs of three borings. The borings found dense to very dense granular soils and cobbles from the ground surface to refusal at EL -33 to -22. A copy of this drawing is included in **Appendix C**.

  The bridge extension followed the same design as the original bridge, except that all of the sheet piles are shown to be driven to EL -12. The drawings show the Taylor River Pond primary spillway at EL 7.8. They also show proposed rehabilitation of the existing sheet piles, by means of 3/8-inch steel plates attached to the portions of the sheet piles between EL 2.75 and 7.25.

- 1971-72 drawings for a contract (Project P-1235-B, Contract 2) for construction of the current northbound embankment from Route 107 to Towle Farm Road: These drawings do not include a 1,065-foot length where the highway crosses the historic location of the Taylor River. That 1,065-foot portion was apparently in another contract, the drawings for which are not available. Fortunately, the available contract drawings show some information in the Taylor River area, on the highway profiles and cross-sections. The cross-sections show the then-existing ground surface and the bottom of the "muck." They indicate that the muck was to have been excavated within the footprint of the highway embankment and that a sand drainage blanket was to have been placed in the bottom of the excavation before the embankment fill was placed. The muck excavation ranged up to about 30 feet in depth, down to approximate EL -20. No boring logs are included in the drawings.

- 1971-72 drawings (revised 1975) for the Taylor River Relief Structure (corrugated metal bridge and sheet pile emergency spillway): These drawings do not contain boring logs, but they show the foundation for the inlet structure to consist of sheet piles driven to EL -25. The drawings show the emergency spillway crest at EL 9 and a concrete apron downstream of the emergency spillway at EL 6. They also show that the culvert was originally to be located to the south of its present location, in the historic channel of the Taylor River, at Sta. 195+00. The 1975 as-built information indicates that the location was shifted to Sta. 196+50 during construction, to an area where the geotechnical conditions were more favorable. Based on the 1948 boring logs, the current location, which is close to Boring No. 26, is outside of the limits of the soft organic soils and where the soft clay is not as thick. It appears that the sheet piles would have reached the sand/clay layer underlying the soft clay. These drawings also show the sand drainage blanket indicated in the above Project P-1235-B drawings.

3.3 Sediments

The construction of the Taylor River Pond Dam resulted in the deposition of fine-grained sediments within the impoundment. The Taylor River drains largely forested areas, as well as some areas with farmland and rural developments (**Figure 2**). Under the spillway removal alternatives, accumulated sediment would erode in part and be transported into the tidal estuary downstream of the spillway if not properly managed.

Taylor River downstream of the Dam

Removal of spillways typically mobilizes sediments in the associated impoundment (unless mitigation measures are put in place). Mobilized sediments are then transported into downstream water bodies. Downstream impacts could consist of siltation of habitats, physical smothering of organisms, and toxicity impacts for organisms if the sediments contain contaminants at elevated concentrations.

Historically, the watershed of the Taylor River Pond was primarily used for agricultural purposes. It appears that agricultural uses have decreased over time. There are no indications of industrial development aside from a sawmill along Rice Pond. However, Taylor River has a large downstream estuarine system that the USEPA lists on the Clean Water Act Section 303d list for PCBs, dioxin, and fecal coliform. Potential sources for fecal coliform in the estuary include the freshwater component of the Taylor River watershed. Sources for PCBs and dioxin were not investigated but are likely located around the Hampton-Seabrook Marsh and Estuary. The Taylor River watershed is not expected to be a source given its history without industrial development and given the absence of PCBs in the Taylor River Pond sediments (as discussed further below).

Existing data on the sediment characteristics in the Taylor River Pond were not located. Therefore, the sediments were investigated to determine the physical and chemical characteristics of the sediment, and to determine the volume of accumulated sediment in the impoundment since the Dam was constructed. The Rice Dam impoundment was later added to the investigation, as it was recognized that a failure of the Rice Dam could result in mobilization of sediment into the downstream Taylor River Pond and the downstream estuary, under the spillway removal alternatives.

Sediments were investigated for physical and chemical characteristics. Physical characteristics consisted of the accumulated sediment volume and grain size, which was needed to assess the potential mobility of the sediment. Chemical investigations followed the Sediment Triad Approach, as specified in "Evaluation of Sediment Quality Guidance Document" (NHDES, 2005). This approach was developed to assess risks posed to benthic organisms in the sediment using the following sequential steps: (1) sediment chemical analyses; (2) sediment toxicity bioassays in the laboratory; and (3) community assessment in the field.

3.3.1 Physical Characteristics of Sediments

3.3.1.1 Methodology

In the Taylor River Pond, the thickness of accumulated sediment was assessed on December 19, 2006, throughout the impoundment, using a shallow draft boat. The water depth was recorded with a measuring rod that had a 16 x 6-inch wooden plate attached at the end to avoid penetration of the rod into the soft upper sediments layer. The depth to refusal was probed with a graduated 1¼-inch diameter hollow polyvinyl chloride (PVC) pipe. Other probes were tested such as a hollow 1-inch PVC pipe, and a ¾-inch solid steel pipe (stem of a hand auger), but the 1¼-inch pipe was considered best to detect the refusal depth.

The position of each survey location was recorded with a differential Global Positioning System (GPS) with an accuracy of approximately ±6 feet. The entire impoundment was surveyed between the Taylor River Pond Dam at I-95 to approximately 600 feet downstream of the Rice Dam. Most of the impoundment was accessible with the exception of some areas that were covered with a thin sheet of ice. The areas covered with ice included the embayment at the mouth of Grapevine Run. Thickness measurements were collected along various transects in the impoundment, unless shallow water depths or ice coverage prevented access to parts of the impoundment.

The sediment depths in the Rice Dam impoundment were tested on April 6, 2007, using the same approach as for the Taylor River Pond, with the exception of using an aerial photograph for approximate positioning rather than a GPS system.

3.3.1.2 Results – Physical Characteristics

3.3.1.2.1 Taylor River Pond

At many survey locations in the Taylor River Pond, the depth to refusal was well defined. Generally, good refusal was observed in the impoundment, upstream of the Grapevine Run embayment. In the section between the Grapevine Run embayment and I-95, the refusal depth was not as well defined. However, based on observations made during the sediment sampling using a core tube and box corer, Berger feels reasonably comfortable with the recorded observations in this section as well. Specifically, it appears that the uppermost soft sediment layer in this section is underlain by former tidal marsh soil. This type of soil appears to have high root content and is, therefore, softer than the upland soil further upstream in the impoundment. Only the sediment that accumulated since the construction of the Dam was probed, *i.e.*, measurements do not include the deteriorated peat from the filled marsh.

Generally, the thickness of sediment that has accumulated in the Taylor River Pond since the Dam was constructed ranges between <0.5 and 2 feet (**Table 5**; **Figures 13, 13A** and **14** to**16**), with a mean of 1.0 foot, and a median of 0.8 foot. Differences were observed in different sections of the impoundment as follows:

• Narrow upstream portion of impoundment (500 feet south of Old Stage Road bridge to cattail wetland)	0.5 foot
• Upper impoundment (cattail wetland to Towle Farm Road)	1-2 feet
• Mid section of impoundment (Towle Farm Road to Grapevine Run Estuary):	
Channel	<0.5 foot
Shallow sections	0.5 to 1 foot
• Grapevine Run Estuary	n/a *(pond was frozen)*
• Taylor River Estate estuary	0.5 to 1 foot
• Lowermost impoundment, close to I-95	1 to 2 feet

Conceivably, the thickness of accumulated sediment is lower closer to the edges of the impoundment, although a distinct pattern was not observed. Given the comparatively steep topography of the land surrounding the Taylor River Pond, the layer of accumulated sediment may not gradually decrease in thickness toward the edges of the impoundment. Therefore, the full average sediment thickness was used for specific sections of the river for the determination of the total volume of accumulated sediment in the impoundment. Using a mean of 1-foot of accumulated sediment and 47.5 acres for the area of the impoundment, the total estimated volume of accumulated sediment is 77,000 cubic yards.

The sediment distribution throughout the Taylor River Pond appears to be fairly uniform, consisting predominantly of medium sand to clay (**Table 6**). Grain size distributions (Stations TR-S1 to 10) are provided in **Folder 2** on the Additional Data CD included with this report).

3.3.1.2.2 Rice Dam Impoundment

The Rice Dam impoundment is approximately 1,600 feet long (see **Figure 17**). The lower 1,000 feet were surveyed. The impoundment is narrow; much of the surveyed section was only approximately 60 feet wide. The upper section of the surveyed stretch does not contain much accumulated sediment. The substrate is firm without fine-grained sediment. Sediment has accumulated in the lower half of the impoundment but only to an approximate thickness of 0.3 to 0.6 foot. Near the Rice Dam, there was a layer of woody debris that prevented effective penetration into the sediment with a box corer. Nevertheless, using a rod, the sediment thickness seemed to be low as well. The water depth approximately 50 feet upstream from the dam was approximately 8 feet. This elevation was similar to the elevation of the dam, also suggesting that the sediment buildup behind the dam appears to be small. The reason for the apparent lack of sediment is likely the narrow width of the impoundment, resulting in flushing during rainstorm events with high runoff. Peak flow velocities in the Rice Dam impoundment are considerably higher than in the much wider Taylor River Pond.

Aside from the Taylor River, two small unnamed brooks enter the Rice Dam impoundment from the east (**Figure 2**). These brooks may be intermittent streams. The mouth of the smaller brook is located in the upper 1/3 of the surveyed part of the impoundment; it had a discharge rate of approximately 0.5 cubic feet per second (cfs) on April 6, 2007. The second brook enters the impoundment in the mid-section of the impoundment. It had a discharge rate of approximately 1 to 1.5 cfs. The brooks largely drain the adjacent farm and its land to the east. Small sedimentary deltas have formed at their confluence with the Rice Dam impoundment.

In the Rice Dam impoundment, sediment only accumulated in the vicinity of the dam. As in the Taylor River Pond, sediments were fine-grained (medium sand to clay). The grain size distribution for Station TR-S11 is shown in **Folder 2** on the Additional Data CD included with this report).

3.3.2 Chemical Characteristics of Sediments

3.3.2.1 Methodology

3.3.2.1.1 Sediment Chemistry

Sediments that had accumulated since the Dam was built were sampled for chemical analyses, following the Sediment Triad Approach (NHDES, 2005). The first sampling event occurred on November 30, 2006, for sediment chemical analyses. All sampling locations are shown on **Figure 13.**

A total of four sediment samples were collected (**Table 7**). Two samples were collected from within the Taylor River Pond. A third sample was collected just upstream of the pond. In addition, a fourth sample was collected downstream of the Taylor River Pond. All samples consisted of 2 to 3 subsamples that were composited by the laboratory before analysis.

The station locations are listed below (upstream to downstream). The water depths and accumulated sediment depths at each sampling location are presented in **Table 7.**

- ***TR-S1** (Upstream of Taylor River Pond):* The station was located approximately 50 feet downstream of Rice Dam (**Figure 17**). Taylor River is typically free-flowing in this section. On November 30, 2006, the impoundment extended up to the closed Old Stage Road bridge. Subsamples were collected from each of the three islands within the river channel (**Figures 18** and **19**). Samples were collected from the upper 20 centimeters (cm) of the sediment column using a stainless steel spoon.

Taylor River, downstream of Rice Dam

- ***TR-S2** (Mid Section of the Taylor River Pond):* The station was located downstream of the Towle Farm Road bridge (**Figure 20**). Samples were collected from three locations in the central portion of the impoundment and composited in the laboratory. The sampling locations were not within the deeper channel of this section of the impoundment because the thickness of accumulated sediment in the channel was very small. At all three locations, the sediment was collected with a box corer. The sediment was soft, dark, and fine-grained with some roots (**Figure 21**).

- ***TR-S5** (Lower Taylor River Pond):* The station was located close to the earthen embankment (**Figure 22**). Part of the reason for sampling this location was to capture potential contamination from stormwater runoff from I-95. Samples were collected from two locations using a box corer and were composited in the laboratory. The deeper sediments were investigated using a 2.5-inch diameter core tube with core catcher. A third station was cored, but a sample was not collected. As at Station TR-S2, the uppermost sediments were soft, dark, and fine-grained with some roots (**Figure 23**). The sediment was underlain by denser sediment with a high concentration of roots (**Figure 24**); this vegetation appeared to be tidal marsh vegetation that existed prior to the construction of the impoundment. Only the soft uppermost sediments were submitted to the laboratory for analysis.

- ***TR-S4*** *(Downstream of Taylor River Dam):* The station was located approximately 50 to 200 yards to the east of Route I-95 (**Figure 25**). Subsamples were collected at three locations and composited in the laboratory. These three locations were considered as they are expected to reflect I-95 runoff effects (if any) and general background concentrations in the impoundment. The subsamples were collected approximately 1 hour after low tide. The water elevation in the estuary at the time of sampling was approximately at -2.7 feet NGVD29. Subsample 1 of 3 was collected with a core tube between 4 and 10 inches below the water surface. Subsamples 2 of 3, and 3 of 3, were collected approximately 1 to 2 inches above the water surface using a clean stainless steel spoon (**Figures 26** and **27**).

Sediment samples were stored in a cooler with ice. The cooler was collected by the laboratory at the end of the day. The NHDES approved list of parameters and analytical methods used are listed in **Table 5**. A duplicate sample was not collected due to the low number of samples and the homogeneity of the sediment supply. Specifically, the Taylor River to the north supplies most of the sediment that enters the impoundment.

3.3.2.1.2 Sediment Toxicity Bioassays

As a result of the elevated pesticide concentrations detected in the sediments, further samples were collected on April 6, 2007. Samples were analyzed for toxicity, as the second step under the Sediment Triad Approach (NHDES, 2005). Additional grain size samples were also collected at that time. Each sample consisted of two or three subsamples that were composited later in the laboratory. A total of 0.15 cubic feet of sediment were collected at each sampling location using a box corer. The water depths and depths of refusal are listed in **Table 5**. The following samples were collected (upstream to downstream):

- ***TR-S11*** *(Rice Dam Impoundment):* The sample consisted of three subsamples (**Figure 28**). Subsample 1 was collected from the central part of the impoundment, adjacent to the white house on its western shore. Subsamples 2 and 3 were close to each other and were collected from the lower part of the impoundment, approximately 150 feet upstream of the Rice Dam.

- ***TR-S8*** *(Upper Taylor River Pond):* The station was located approximately 200 feet upstream of the Towle Farm Road Bridge (**Figure 17**). Two subsamples were collected, approximately 30 feet apart.

- ***TR-S7*** *(Mid section of Taylor River Pond; vicinity of TR-S2):* As for sample TR-S2, three subsamples were collected (**Figure 20**).

- ***TR-S9*** *(Downstream of Sample TR-S7):* The station was located approximately 1/3 of the way between Stations TR-S7 and TR-S6 (**Figure 20**). Two subsamples were collected, approximately 30 feet apart. The sample was only analyzed for grain size.

- ***TR-S10*** *(Downstream of Sample TR-S9):* The station was located approximately 2/3 of the way between Station TR-S7 and TR-S6 (**Figure 20**). Two subsamples were collected, approximately 30 feet apart. Only grain size was analyzed.

- ***TR-S6*** *(Lower Taylor River Pond; vicinity of sample TR-S5):* This sample consisted of three subsamples, rather than two subsamples collected for TR-S5 (**Figure 22**).

The toxicity bioassay analyses were conducted by the Envirosystems laboratory in April 2007.

3.3.2.2 Results - Chemical Characteristics

Sediments in Taylor River Pond are organic-rich with total organic carbon (TOC) concentrations ranging between 4 and 8% (**Tables 8** to **10**; **Folder 2** on the Additional Data CD). Sediments in both the Rice Dam impoundment and Taylor River Pond contain pesticides, metals, and polycyclic aromatic hydrocarbons (PAHs) at concentrations that exceed sediment guideline values for both freshwater and marine waters. Pesticides of particular concern are dichlorodiphenyldichloroethane (DDD), dichlorodiphenyldichloro-ethylene (DDE), and dichlorodiphenyltrichloroethane (DDT). Semi-volatile organic compounds (SVOCs), volatile organic compounds (VOCs), and PCBs were not detected, or were detected at concentrations that did not exceed sediment guideline values.

Sediments in the Rice Dam impoundment are organic-rich, with TOC concentrations of 5%. The Rice Dam impoundment also had elevated concentrations of pesticides and PAHs exceeding sediment quality guidelines; although the concentrations were overall lower than in the Taylor River Pond. Lower concentrations could be due to more frequent flushing of the Rice Dam impoundment (due to its narrower width), which would result in sediments of generally more recent age.

The toxicity tests of the freshwater amphipod *Hyalella azteca* showed comparatively high survival and growth in both impoundments, as compared to laboratory control samples (see **Folder 3** on the Additional Data CD included with this report). *Hyalella* is considered epibenthic,[9] burrowing typically to a depth of only about 1 millimeter, according to Mr. Ken Simon from the Envirosystems laboratory. Mr. Simon also stated that *Hyalella* is more sensitive to metals and PAHs, and not as sensitive to pesticides.

The toxicity tests of the freshwater midge *Chironomus dilutus* showed significantly reduced survival in the lower section of the Taylor River Pond near the primary spillway (Station TR-S6), and at Station TR-S11 (Rice Dam impoundment), as compared to the laboratory control sample (see **Folder 3** on the Additional Data CD included with this report). Sample TR-S7 (mid section of the Taylor River Pond) did not have significantly reduced survival rates. Growth was only significantly reduced at Station TR-S6, as compared to the laboratory control sample. *Chironomus* burrows more than 1 or 2 inches into the sediment. The organism is also particularly sensitive to pesticides, among a few other compounds, according to Ken Simon from Envirosystems.

For the Lower Taylor River Pond (at Station TR-S6), the *Chironomus* data (*i.e.*, statistical difference of 20% for survival and 25% for growth, compared to the control sample), warranted further action as specified by the Guidance Document (NHDES, 2005). For the upper Taylor River Pond and the Rice Dam impoundment, the differences were not sufficient to warrant further action.

3.3.3 Fish Tissue Analyses

Fish sampling in the Taylor River Pond was conducted in response to the chemical analyses and toxicity bioassays of the sediments. The objective of the investigation was to assess potential impacts to human health and the aquatic ecosystem.

[9] Epibenthic: Living above the bottom.

3.3.3.1 Field Sampling (Prepared by Cheri Patterson, NHFGD)


Bluegill Sunfish (*Example*)

The NHFGD collected fish between April 25, 2007, and June 25, 2007, for the NHDOT's assessment of the public and wildlife risk associated with contaminants found in the sediment of the Taylor River Pond. An electrofish boat and gill net were utilized to collect fish from the littoral[10]/pelagic[11] and benthic zones, respectively, of the pond. Twelve fish collected from both the littoral/pelagic and benthic zones were filleted for lab analysis to assess the public health risk relating to the known contaminants. In addition, 23 whole fish were collected from the littoral/pelagic zone to assess the associated wildlife risk. All fish collected for lab analysis were equal to or less than 12 inches in length[12]. Each fish retained for analysis was measured, weighed, either filleted or maintained whole and placed in a labeled plastic bag (**Table 11**). These samples were kept in a cooler during field sampling until delivered to the NHDES where they were kept in a freezer until all samples had been collected. Once both littoral/pelagic and benthic samples were collected, they were transferred to the laboratory conducting the analysis (Severn Trent Laboratory [STL], located in Burlington, Vermont) on July 3, 2007.

- On April 25, 2007, electrofish sampling commenced at approximately 10:30 am along the Taylor River Pond's northeast and southern shorelines (**Figure 29**). The species observed during the 2.5-hour sampling period were: American eel (abundant), Eastern chain pickerel, largemouth bass, golden shiner, sunfish (bluegill and redbreasted), and black crappie. The species collected for the risk assessment were Eastern chain pickerel and largemouth bass from the littoral/pelagic zone of the impoundment. The species absent from this sampling were from the benthic zone leading to different methods of collection.

- On May 2, 2007, a fyke net was set approximately 100 feet downstream of Old Stage Road to capture any spring spawning benthic species (*e.g.*, common sucker) that may be utilizing riverine habitat. The 24-hour set produced no fish; however, a hole was found within the net, indicating wildlife had penetrated the net. The net was not reset.

- From May 10 through June 25, 2007, a 100-foot variable mesh (1 3/4", 2", and 2 1/2") gill net was set primarily along the southwestern shore of the Taylor River Pond for benthic fish sampling. The net was checked daily (weather permitting) for benthic fish species. The daily sets were repositioned at various locations within the area indicated in **Figure 29**. The fish encountered in the net were identified and either released alive, or if dead, measured and then discarded. Those processed in the field were only measured while those processed in the office were measured and weighed. Those fish species that were immeasurable due to consumption by snapping turtles were identified and discarded. The only benthic fish species encountered were brown bullhead. The fish filets were processed for lab analysis as noted above and kept at the Region 3 freezer (Marine Fisheries Division) until all twelve samples were collected. The samples were relayed to NHDES for final delivery of all samples to the contracted lab. See **Table 11** for fish species encountered during this sampling period.

[10] Littoral: Littoral is that portion of the lake that is generally less than 15 feet in depth. This is the zone with most of the aquatic plant life (both rooted and floating) in a pond because the high amount of sunlight reaching it allows for significant photosynthetic activity.

[11] Pelagic: The pelagic zone is the descriptive term for the ecological region above the benthos, including the water-column up to the surface.

[12] 12-inch is a standardized length that would be most commonly consumed by either humans or wildlife.

3.3.3.2 Laboratory Analyses

Samples were analyzed for pesticides using EPA Method 8081A. The laboratory provided three data reports, as samples were analyzed in batches of up to 20 samples (**Folder 3** on the Additional Data CD). All laboratory data are summarized in **Table 12**; blank spaces in the table reflect that the compound was not detected at the reporting limit.

The laboratory (STL) completed and provided all the necessary quality control data, which were adequate and complete (reports are included in **Folder 3** on the Additional Data CD). The Case Narratives for the three individual reports (two dated July 27, 2007, and one dated July 31, 2007) described issues encountered with the analyses and their effect on data quality.

- STL utilized a "P" notation in the Analysis Data Sheets (Form 1) which according to the Data Qualifier and Definitions page, has two definitions: (1) "SW-846: Greater than 40% difference for detected concentrations between two GC columns. Unless otherwise specified, the higher of the two values is reported on the Form 1" and (2) CLP SOW: Greater than 25% difference for detected concentrations between two GC columns. Unless otherwise specified, the lower of the two values is reported on the Form 1." The lab utilized the first definition and reported the higher values. There were a total of 39 values with a "P" notation provided on Form 1. Some of the %Differences between the two column runs were high. For example, (1) sample TRF-40: beta-BHC, the reported result was 2.7 micrograms per kilograms (ųg/kg), the confirmatory column result was 0.54 ųg/kg and the %Difference was 400%; and, (2) sample TRF-39: 2,4' dichlorodiphenyldichloroethylene (DDE), the reported result was 1.7 ųg/kg, the confirmatory column was 0.51 ųg/kg the %Difference was 233%. Other %Differences were in the 70-100% range. The difference in concentrations is a result of positive or negative interference during the analysis in the respective GC column. The higher concentrations were reported in the lab and data summary (**Folder 3** on the Additional Data CD; **Table 12**), and used in the data synthesis as a conservative measure.

  The only exception was Heptaclor epoxide in Sample TRF-44 where the lower value was reported (0.46 ųg/kg). According to the lab, there was a large interfering peak in the retention time window for heptachlor epoxide on the RTX-CLPII column that resulted in a high bias for this compound (11 ųg/kg). This was not present on the RTX-CLP column (*i.e.*, 0.46 ųg/kg). Therefore, in this instance, the lower value (RTX-CLP column) was chosen by the lab for reporting.

- In addition, there were compounds with "E" and "D" notations reported. The "E" notation was given to compounds whose concentrations exceeded the upper limit of the calibration range of the instrument for that specific analysis. There was only one value with an "E" notation reported for the study in sample TRF-01 - 4,4' DDE (22 ųg/kg). The "D" notation was for concentrations identified from analysis of the sample at a secondary dilution. Three compounds in sample TRF-01DL: (1) 4,4' DDD (3.4 ųg/kg), (2) 4,4' DDE (21 ųg/kg), and (3) 4,4' DDT (1.1 ųg/kg). The data analyses used the results of sample TRF-01DL, and not the values for sample TRF-01.

3.3.3.3 Results - Fish Tissue and Human Health Assessment (Prepared by Pam Schnepper, NHDES)

The ecological risk of pesticide to benthos, fish, and wildlife in the Taylor River Pond was prepared by Pam Schnepper in a memorandum from September 9, 2007. Aside from a few minor editorial changes, the text in this section was taken directly from the memorandum.

Many organochlorine pesticides have been banned for use in the United States including dichlorodiphenyltrichloroethane (DDT), aldrin, dieldrin, toxaphene, chlordane, and heptachlor. Unfortunately, most organochlorine pesticides break down slowly and can remain in the environment long after application and in organisms long after exposure. Exposure to organochlorines can produce a wide range of acute and chronic health effects, including cancer, neurological damage, and birth defects.

Based on the sediment chemistry analysis, some sediment samples from the Taylor River contained elevated levels of DDT and its breakdown products. In humans, exposure to high levels of DDT has been associated with nervous system stimulation: excitability, tremors and seizures. Additional potential adverse health effects from DDT exposure that have been observed in animals include changes in the lungs, liver, adrenal, reproductive and immunological systems. Although DDT has not been demonstrated to cause cancer in humans, EPA considers DDT to be a probable human carcinogen because DDT and its metabolites have been associated with liver cancer in animals (ATSDR, 2002). Collection of fish from the Taylor River was warranted to determine if the sediment contamination presents a health risk to fish consumers.

NHDES would consider issuing a water-body specific fish consumption advisory if consumption of fish from the Taylor River at the rate of the statewide advisory would result in an exposure that exceeds EPA risk-based levels. The statewide advisory recommends limiting the consumption of freshwater fish due to mercury contamination. Women of childbearing age and children are advised to limit their intake to one six-ounce portion per month. Other adults may eat four portions per month. In addition, because contaminants such as DDT and mercury may bioaccumulate in fish, for fish that eat other fish such as bass and pickerel, only fish that are 12 inches or less should be eaten.

Fish sampling to assess potential organochlorine pesticide contamination was conducted according to the EPA guidance (USEPA, 2000a). Two species were collected for chemical analysis of fillet tissue. The brown bullhead is a bottom feeder, which may have greater contact with contaminated sediment. Largemouth bass represent an upper trophic level predator, which may have higher levels of bio-accumulative toxins such as organochlorines. To be consistent with the consumption limits of the statewide advisory, the length of fish collected was less than 12 inches.

Twelve fillet samples of each species were analyzed by the laboratory (STL). The results as used in the human health analysis are presented in **Table 13**. For calculation of total metabolites, non-detect values were quantified using one-half of the method detection limit. DDT (total) is the sum of DDT, DDE, and DDD congeners. Heptachlor (total) is the sum of heptachlor and heptachlor epoxide. Chlordane (total) is the sum of oxychlordane, trans-nonachlor, cis-nonachlor and gamma chlordane. Summary statistics were generated using USEPA's ProUCL program.

DDT metabolites were detected in all of the fish sampled; additional pesticides, detected at a frequency of greater than 10% in the overall fillet dataset, include dieldrin, and heptachlor and chlordane metabolites. Summary statistics for these compounds are presented in **Table 14**.

The average fillet DDT (total) concentration was 17 ug/kg for brown bullhead and 29 ug/kg for largemouth bass. For comparison, the U.S. Geological Survey's National Water Quality Assessment Plan has assessed DDT contamination in sediments and fish. Analysis of whole fish from 208 different water-bodies that represent mixed land uses (agricultural, undeveloped, and urban areas) detected DDT and its metabolites in 93% of the samples analyzed with a mean DDT(total) concentration of 49.8 ug/kg (Nowell and Crawford, 2003).

New Hampshire fish consumption advisories are based on 95^{th}% upper concentration limit (UCL) fish tissue concentrations. The UCL is a statistical estimation that provides 95% confidence that any individual fish sample will not have a greater concentration. Risk-based fish consumption limits were obtained from EPA guidance (USEPA, 2000b). As **Table 14** shows, the 95^{th}% UCL chemical concentrations for all of the contaminants are below the EPA risk-based consumption limits.

Therefore, consumption of Taylor River fish at the rate recommended in the statewide fish consumption advisory is unlikely to present any appreciable risk of adverse health effects.

3.3.4 Ecological Risk Assessment (Prepared by Lori Siegel, NHDES)

The ecological risk of pesticide to benthos, fish, and wildlife in the Taylor River Pond was prepared by Lori Siegel in a memorandum from September 6, 2007. Aside from a few minor editorial changes, the text in this section was taken directly from the memorandum. References cited in her assessment consisted of the following: Poulsen and Peterson (2006); Sample, Opresko, and Suter (1996); and USEPA (1993).

After careful consideration of the sediment and fish data relevant to the Taylor River Dam site in Hampton/Hampton Falls, NH, Ms. Siegel determined that there is indeed enough ecological risk to warrant limited risk management. Her rationale for this determination was as follows:

- The sediment data has levels of DDT and derivatives that exceed the lower and upper thresholds and bulk sediment bioassays support the toxicity, particularly in the impoundment adjacent to the Dam.

- The fish data indicates the upper 95% confidence level of contaminant concentrations poses risk to birds (using Osprey adults and eggs and Great Blue Herron adults as indicators) (**Table 15**).

Although these analyses reveal an unacceptable ecological risk, the level of those risk factors into decisions regarding the mitigation of that risk. The levels in fish are protective of mammals (using mink as an indicator species) and of fish (using Lake Trout as an indicator species). Furthermore, the risk to birds (adult and egg) assumes a diet consisting of 100% fish from the area of interest. More realistically, birds are ingesting less than that, thereby proportionally reducing that risk.

3.3.5 Impact Analysis

The impact analysis incorporates the findings of the physical and chemical assessments of the studies, as well as the fish tissue and human health assessment (prepared by Pam Schnepper) and Ecological Risk Assessment (prepared by Lori Siegel).

In a memorandum from March 18, 2008, the NHDES determined the following:

> "The Department recognizes that the organochlorine pesticides were unlikely released from any of NHDOT activities but are more likely due to a release of historic agricultural or mosquito control applications. Nonetheless, the presence of the spillways has allowed the pesticides to accumulate in the pond. Accordingly, removal or reconstruction of the spillway could release this contaminated sediment, thereby compromising the integrity of the downstream aquatic environment. Such activity conducted by NHDOT, which requires a Wetlands Permit, thus requires a Water Quality Certificate from the Department's Watershed Management Program. The Water Quality Certificate is to ensure water quality standards will be met during and subsequent to spillway removal or reconstruction work conducted by NHDOT.
>
> Based on the review of the sediment and fish data, the Ecological Risk Program concluded the following in the September 6, 2007 memo: *"....there is indeed enough ecological risk to warrant risk management."* As a result, the [NHDES] will list this portion of the Taylor River as impaired for aquatic life and wildlife uses. Moreover, a list of four (4) recommended actions

was provided to NHDOT for management of this risk as indicated below. Please note the actions noted below … reflect the most updated information based on meetings subsequent to the September 6, 2007 memo:

- Skip the community assessment. With the weight of evidence given by the sediment chemistry and toxicity tests, a community assessment would not alter the determination that the sediment endangers the benthos there. Moreover, if the spillways are indeed removed, then the geochemical conditions would change so much that the community assessment would be irrelevant.

- Remove the sediment that is most contaminated, located adjacent to the spillways. The limits of excavation can either be assumed to extend to the transect on which TR-S2 lies or additional sampling could better delineate the limits of contamination for which removal is warranted.

- Install a temporary stone trap downstream of the spillways during repair or removal work so that any sediment scoured during DOT activities there would be captured. The captured sediment would then need to be removed.

- Install check dams and plant vegetation (consider designs that accomplish both)."

This determination by NHDES from March 18, 2008 was considered in the alternatives assessment for the sediments in the Taylor River Pond. In addition to the determination above, the NHDES memorandum provided specific recommendations regarding the mitigation of sediment for Alternatives B and C. These recommendations were addressed in the conceptual Sediment Management Plan for Alternatives B and C (**Appendix D**). Key recommendations of this Sediment Management Plan are incorporated below.

3.3.5.1 Alternative A

There would be no change in the accumulated sediments volume and in the sedimentation pattern in Taylor River Pond under the No Action Alternative. However, in the case of a breach or failure of the spillways, fine-grained sediment accumulated in the pond would be released into the downstream estuary. The release would adversely impact the downstream estuary by smothering organisms, as well as affecting organisms due to the pesticides within the sediment. In addition, the large volume of mobilized sediment may clog some tidal channels. It should be noted that some fine sediments may be transported currently over the Dam during storm events. There is n total containment of the sediment under current condiction.

3.3.5.2 Alternative B

Replacing the I-95 bridge and replacing the spillways with a wider one, would result in higher peak flow velocities in Taylor River Pond during high flow events. Higher flow rates would result in erosion of some of the accumulated sediment in front of the bridge.

Recommendations in the Sediment Management Plan (**Appendix D**) were designed to minimize the mobilization of impaired sediment and transport into the downstream estuary, as requested by the NHDES. In essence, the management plan recommends the removal of accumulated sediment in the impoundment from a small area in front of the proposed bridge. Based on currently available sediment and hydrological information, we recommend the removal of a trapezoidal-shaped apron with a length of 160 feet from the primary spillway, and widths of 140 feet at the edge of the existing Dam and 60 feet along the upgradient side. The removed sediment would be disposed offsite.

We recommend refining the Sediment Management Plan after a preferred alternative has been chosen and a specific construction approach has been developed. It should be noted that replacement of the Dam will not result in total containment of sediment. Similar to current conditions, some sediment transport can be anticipated during storm events.

3.3.5.3 Alternative C

This alternative entails replacement of the I-95 bridge and removal of the existing Taylor River Pond primary spillway/fishway and emergency spillway/culvert, which would lower the channel bed elevation at the location of the existing spillway to -0.5 feet. Given that the average elevation of the sediment surface in Taylor River Pond is 1.0 feet, this alternative will expose the former tidal channel in the impoundment.

The natural reestablishment of the tidal channel will mobilize sediment, unless the accumulated sediment in the channel is excavated prior to opening the current pond area to tidal flows. Erosion would result from tidal flows as high stormwater runoff events. Sediment eroded from the channel during incoming tides would result in partial deposition of sediment on the adjacent tidal marsh; the remainder of the sediment would remain in suspension and be transported downstream during the outgoing tide. Sediment eroded from the channel during the outgoing tides would be transported downstream into the existing estuary.

In addition to the erosion of sediment in the tidal channel, peak flow events in the Taylor River would result in erosion of the fairly unconsolidated, fine-grained sediment from the parts of the area of the impoundment outside of the tidal channel (*i.e.,* the tidal marsh). Hydraulic modeling suggests that during a 100-year storm, water will flow within the footprint of much of the current Taylor River Pond. Flow velocities would exceed those estimated for the erosion of unconsolidated fine-grained sediment**.** Therefore, as a worst-case scenario, a portion of the accumulated sediment (77,000 cubic yards) could be mobilized from the current footprint of the impoundment and transported into the estuary.

These scenarios of sediment mobilization from the tidal channel and tidal marsh assumes the following:

- Vegetation has not yet started to grow on the exposed floor of Taylor River Pond, stabilizing the sediment;
- During construction, no mitigation measures were put in place to stabilize the exposed sediments;
- None of the sediment from the impoundment was excavated and disposed of off-site;
- The causeway for Towle Farm Road does not act as a partial block to sediment erosion from the upper impoundment; and
- Sediments have a high water content and are only partially consolidated. The physical properties will need to be examined further to develop a more definite volume of sediment that would be eroded.

As a result, appropriate sediment mitigation is required for Alternative C. As for Alternative B, the recommendations in the Sediment Management Plan (**Appendix D**) were developed to minimize the mobilization of impaired sediment, as requested by the NHDES. In essence, the management plan recommends removal of accumulated sediment from the currently submerged tidal channel within the lower impoundment, following the determination by the NHDES on March 19, 2008 and June 23, 2009. Removed sediment would be disposed at an offsite location (either a landfill or a location in the vicinity of Taylor River Pond, as discussed further in **Appendix D**). In addition, various steps would be undertaken to stabilize the sediment in the tidal marsh to avoid or minimize erosion of sediment in the downstream estuary.

We recommend refining the Sediment Management Plan after a preferred alternative has been chosen and a specific construction approach has been developed. The goal of such refinements should be to further reduce the volume of sediments that is transported into the downstream estuary in a manner that is both (a) environmentally sound, and (b) cost-effective.

3.4 Groundwater Resources and Wells

This section was prepared by Berger's subcontractor GEI, and represents a summary of their letter reports from October 23, 2007 and July 6, 2009 (attached as **Appendices C** and **E**).

3.4.1 Existing Hydrogeologic Conditions

A review of the bedrock and overburden geologic maps of the area and 1948 borings conducted by NHDOT indicate that the Taylor River is underlain by fine-grained fluvial silt and clay sediments (**Appendix C**). Beneath the fine-grained fluvial sediments lie dense sand and gravel with some silt/clay and then bedrock. The fluvial sediments are likely to have low hydraulic conductivities, especially in the vertical direction. These low hydraulic conductivity materials generally inhibit the ability of water to flow vertically between the surface waters and bedrock. GEI also believes that the basal flow of freshwater in bedrock toward the estuary and ocean and the associated freshwater lens overlying the salt water wedge will limit the potential for intrusion of saltwater into the overlying freshwater zone in the bedrock.

Based on studies conducted along coastal areas in New England **(Table 2** in **Appendix C**), saltwater intrusion at this site is unlikely due to these geologic conditions and the likely low pumping rates associated with residential potable water usage. These studies indicate:

- Little to no saltwater intrusion occurred beyond ¼ mile inland from the ocean; and
- Significantly impacted bedrock potable water supply wells were usually within 200 feet of the ocean and had a direct hydraulic connectivity through bedrock to the ocean.

3.4.2 Water Supply Well Data

To evaluate the potential effects of the proposed project on the wells, GEI obtained available information on the locations and depths of the wells near the Taylor River Pond, and whether the wells are screened in soil or bedrock. Per discussions with representatives of the Towns of Hampton and Hampton Falls, there is no public water service in these towns. The only private water company is Aquarion Water, which serves parts of Hampton. Aquarion's service does not extend west of I-95. Therefore, based on collected information, all water supplies in areas potentially affected by the project are provided by private household wells and community water supply wells.

Since 1984, the State has required submittal of installation data for new water wells, and the NHDES maintains a database of this installation data. In general, the State does not have information on wells installed before 1984, except for wells that are used as public water supply or community wells. Some of the installation data in the State's database has been incorporated into the NHDES GIS system. GEI obtained updated information from the NHDES on water supply wells installed since 1984.

The GIS map provided in **Figure A1** in **Appendix E** shows the private wells located within the study area, generally within ¼-mile of the Taylor River Pond. **Tables 1** and **2** in **Appendix E** show the data summary for wells that are listed in the NHGIS general database for Hampton and Hampton Falls, respectively, and appear to be within ¼-mile of the pond. Some of the well location information is missing, so some of the wells included in these tables may be more than ¼ mile from the pond.

There are wells within ¼ mile of the Taylor River Pond that are not listed in these tables, either because they were installed before 1984 or because the required well installation logs were not submitted to the State. To obtain additional information, GEI visited the Assessor's Office in both Hampton and Hampton Falls to obtain tax maps and generate a list of properties from assessor's records. Property records were also available online for the town of Hampton through the Vision Appraisal website. **Table 3** in **Appendix E** lists properties in Hampton and Hampton Falls that are located within our study area.

GEI prepared a questionnaire to property owners within the study area, including those residents serviced by community wells, to request water supply well information, including the location and depth of the well, the depth of the water below the ground surface, and any analytical test data on water samples from the well. Using the tax assessor's records for Hampton and Hampton Falls, GEI assembled a list of 248 property owners within ¼ mile of the Taylor River Pond, 118 of which are property owners that obtain their water from community wells. The NHDOT sent out the questionnaires to all of the property owners under their letterhead on May 1, 2009. Of the 118 owners who rely on community wells, 24 responded, and of the 130 other owners, 59 responded. Copies of the returned questionnaires are included in **Appendix E**.

Wells being used for public/community water supply are regulated by the State, regardless of the date of installation of the wells. Well locations and laboratory test data are available from the NHDES's "One Stop Program GIS" website. **Figure A2** in **Appendix E** depicts the public water supply well locations from the website, and well data from the website are provided in **Appendix E**. Three active wells (2 wells serving Taylor River Estates and 1 serving the Hemlock Haven mobile home park) are located within ¼ mile of Taylor River Pond. GEI understands that a new well has recently been installed for Hemlock Haven, but is not yet in service.

The community wells and all of the water supply wells in **Appendix E** are identified as bedrock wells. The well depths supplied by the property owners in the questionnaires are nearly all great enough that the wells would extend far into bedrock. GEI expects that wells in the vicinity of the Taylor River for which they do not have information are also typically drawing water from the bedrock and not the overburden. Based on collected data, we expects that the bedrock wells draw water from deep regional bedrock groundwater flow that trends southeast toward the ocean and trends locally toward the estuary. Typical household potable water supply wells in bedrock draw in water at a low rate, because the water contained within the well acts as storage, allowing for a slow, steady flow of water during pumping conditions. Consequently, GEI does not expect a large radius of influence with most of the bedrock wells.

GEI contacted the operators of the community wells to obtain information on typical water withdrawal rates for those wells, but that information was unavailable.

Although none of the wells are specifically indicated to be overburden wells, several of the well depths given in the responses to the questionnaire are small enough that these wells may obtain their water from the overburden rather than the bedrock. Also, one of the property owners indicated that when the level of the Taylor River Pond is low (such as during particularly dry periods or when water is released from the pond), the quantity and quality of their well water decrease. This suggests the possibility of a direct connection between the pond and the well.

A number of the well owners provided analytical data for samples taken from their wells. GEI obtained analytical data for the community wells from the GIS website. None of the data included measurements of salinity, but the concentrations of chloride in the samples were all below EPA drinking water standards and generally well below those standards. This indicates that saltwater intrusion has not occurred to date at these well locations.

GEI also contacted seven local well drillers in the Towns of Barrington, Dunbarton, Henniker, Merrimack, Rollingsford, Sandown, and Stratham, New Hampshire to obtain general information on the wells in the area. None of the representatives GEI spoke to had experience directly within the study area. However, one driller indicated that well depths in the Seacoast area were often about 200 feet, that subsurface conditions encountered generally included clay overlying bedrock, and that yields were typically between 10 and 50 gallons per minute at this depth. Reportedly, no saltwater has been encountered during drilling activities.

3.4.3 Impact Analysis

3.4.3.1 Alternative A

The "no action" alternative for the existing I-95 embankment and Taylor River Pond spillways will have no impact to the existing wells in the project area. Failure of the existing spillway(s) would create, in the short term, a condition similar to Alternative C, for which GEI expects only minor impacts. Repair or replacement of the spillways after failure would restore the existing conditions.

3.4.3.2 Alternative B

Replacing the existing spillways with a wider one at the same elevation as the existing primary spillway should result in no significant change in surface water elevation in the impoundment, except under high flow conditions. Therefore, there would be little to no impact to the surrounding wells.

3.4.3.3 Alternative C

Because the spillways act as a boundary between the freshwater of the Taylor River and seawater of the Atlantic Ocean, removal of the Taylor River Pond spillways would permit the tidal seawater to travel up to approximately 0.6 mile upstream to the Towle Farm Road Bridge, and possibly as much as 1 mile upstream to the Rice Dam. A number of potable water supply wells are located near this stretch of the river, so GEI evaluated the potential for saltwater intrusion to affect these wells following construction of the bridge and removal of the spillways.

If the Taylor River Pond spillways are removed, the width of the estuarine tidal area beyond the I-95 embankment location would be limited by the topographic contours within the Taylor River. The relatively small area covered by the new estuary limits the potential for the Taylor River to become a source of water flow into the underlying overburden and bedrock. In addition, the low hydraulic conductivity of existing glacial marine and fluvial sediments and glacial till would restrict flow of water vertically between the estuary and bedrock.

Based on topographic relief and the limited available information regarding elevation of water in the bedrock wells near the Taylor River Pond, it is expected that water levels in the bedrock are high enough to prevent the flow of estuary water to the bedrock wells, possibly except for the community wells and for wells located very close to the Taylor River Pond (perhaps within 200 feet).

For the overburden, it is expected that in general, the overall flow within the system would be from the freshwater in the overburden into the estuary, thereby inhibiting saltwater intrusion into the overburden aquifer and minimizing the potential effects of lowering the pond on overburden wells. However, anecdotal information from one of the well owners in the questionnaire response indicates that previous lowering of the pond has negatively impacted their well, which is located within 30 feet of the pond. The suggestion in the questionnaire response was that this has happened on multiple occasions. The depth of this well or whether it is an overburden well is not known. It is suspected that it is an overburden well, given that their well responded significantly to short-term changes in the pond level.

The available information regarding the wells in the study area indicates that there are few overburden wells. The GIS information indicates that the depth to bedrock is less than 50 feet in nearly the entire study area. Of the well depths listed in the GIS data and reported in the questionnaire responses, only 6 were less than 100 feet, suggesting that there are very few overburden wells. Also, based on the well depths reported in the questionnaire responses, nearly all of the wells close to the pond are bedrock wells. However, many of the questionnaire responses did not include well depth.

In summary, based on a review of published studies and existing project information, GEI does not anticipate that removal of the spillways would affect the usability of potable water supply wells that draw water from bedrock. Although unlikely, it is possible that individual wells may be connected via bedrock fractures in a more direct way to the Taylor River than is currently known. This scenario is unlikely, because saltwater intrusion rarely occurs this far inland in New England. In general, public/community water supply wells are more likely to be affected than household wells, due to the higher rate of pumping that could draw water from a greater distance. Some of the information obtained from the property owners suggests that a few wells close to the Taylor River Pond may draw water from the overburden. Wells drawing water from the overburden may be more susceptible to negative effects of lowering the pond, either from salt-water intrusion or reduction in recharge from surface infiltration. However, as discussed above, it is expected that there are very few of these wells.

3.5 Infrastructure

Based on information reviewed for this study, there are no utilities or structures, other than the existing I-95 bridge, the Taylor River Pond primary spillway/fishway, and emergency spillway/culvert that will be impacted by the proposed project. However, the peak flow velocities at the Towle Farm Road bridge will likely increase if these structures are removed (Alternative C). Therefore, it is recommended that the impact of higher velocities on the structure footings and abutments be further evaluated during the design phase, should this alternative be selected.

3.6 Fire Fighting Water Supply

3.6.1 Existing Conditions

A fire “dry hydrant” is located on the northwest side of the Towle Farm Road crossing of the Taylor River, in Hampton Falls. This hydrant is used as a water supply for fire trucks. According to July 2008 conversations with the Town of Hampton Falls Fire Chief, the truck pumps have a maximum 15-foot lift capacity, and there have been no problems associated with this hydrant reported. Plans for this installation are not available.

According to the Town of Hampton Fire Chief, there are no dry hydrants on the Hampton side of Taylor River Pond.

3.6.2 Impact Analysis

3.6.2.1 Alternative A

If the existing Taylor River Pond spillways were to remain in-place, the impoundment would also remain. Therefore, the dry hydrant would remain operable. However, if the deteriorated spillway(s) failed, the impoundment would be drained to some unknown elevation, based on the extent of the spillway structural breach. Fire protection from the pond would potentially be impaired following a spillway failure, until repairs were completed.

3.6.2.2 Alternative B

There are minimal variations in surface water elevations between Alternatives A and B. Therefore, there would be no adverse impact on the hydrant's ability to provide adequate water to the fire truck.

3.6.2.3 Alternative C

Under this alternative, Taylor River Pond would essentially be drained, and at normal flows, only small pockets of pooled water will remain. The pond area will be inundated with daily tides; however, there will not be enough storage for use with the aforementioned dry hydrant.

Based on meetings with the Hampton and Hampton Falls fire chiefs on July 2, 2008, two 100,000 gallon underground, concrete fire cisterns would need to be installed to service the residences should this alternative be selected. One cistern would be installed on State-owned property located northeast of the Towle Farm Road crossing of Taylor River (Tax Map 137/Lot 2-A); the other would be constructed at the corner of Towle Farm Road and Brown Road, south west of Taylor River (Tax Map 5/Lot 51-3A). Each cistern would be constructed with appropriate dry hydrant equipment, a gravel or paved fire truck pull-off area, and concrete-filled bollards for traffic protection.

3.7 Socio-Economic Issues

3.7.1 Public Involvement

Two publicly advertised meetings were held with the Select Boards of Hampton (October 16, 2006) and Hampton Falls (November 15, 2006) to introduce the project and identity concerns associated with potential alternatives. There was also a neighborhood meeting at the Boynton's residence, Taylor Estates, on October 11, 2006. Major issues raised during the meetings included potential opportunities to reduce existing flooding problems, potential negative impacts to recreational uses (*e.g.*, fishing and boating) and waterfront property values with the loss of the impoundment, and concerns regarding existing water quality.

In addition to the public meetings, a recreational use survey was completed by 30 individuals and/or households surrounding Taylor River Pond. The survey included a question regarding observed water quality problems, which identified excessive plant/algae growth and foul odors. Twenty of the 30 respondents indicated that they had experienced problems with flooding. The majority of the respondents (23 of 30) were not interested in better public access to the impoundment.

A public informational meeting was held on October 29, 2007, at the Hampton Falls town offices to present the preliminary Draft Feasibility Study results, to obtain further public input and to relay the next steps of the project process. Major issues raised during this meeting included, but were not limited to: the aesthetics with the spillways removed and will the exposed intertidal flats have an odor; the potential impacts to the current fishing environment and other pond recreational activities; potential impacts to property values; and potential impacts to the water table, drinking water wells, and dry hydrants.

Additional Public Informational meetings were held in Hampton Falls on November 10, 2009, in Hampton on March 1, 2010, and in Hampton on June 21, 2010. The intent of the meetings was to present the revised Final Draft Feasibility Study and obtain additional public input, prior to finalizing the document.

3.7.2 Open Space

Approximately 155 acres of Hurd Farm, straddling the Taylor River in Hampton and Hampton Falls, is protected open space through an agricultural preservation agreement. The agreement, which is held and monitored by the Rockingham County Conservation District, also provides for permanent public recreational access. Funding for the project was a combination of local bond measures, and grants from the federal Coastal and Estuarine Land Conservation Program (CELCP), the USDA Federal Farmland and Ranchland Protection Program (FRPP), and New Hampshire's Land and Community Heritage Investment Program (LCHIP). No federal Land and Water Conservation (6[f]) funding was involved with this purchase. Any potential impacts on properties acquired with 6(f) funds are strictly regulated by the Land and Water Conservation Act. Based on communications with local officials, no other conservation lands abut the impoundment.

3.7.3 Impact Analysis

3.7.3.1 Alternative A

There would be negligible adverse or beneficial short-term impacts with regard to socio-economic issues including property values. Adverse impacts would arise from spillway failure were the structures to fall into further disrepair from lack of maintenance. In addition, if no corrective actions are taken to improve water quality within the pond or watershed, eutrophic conditions will continue and potentially lead to long-term negative impacts. The risk of flooding under this alternative for properties bordering the impoundment presents a further adverse impact.

Should the deteriorated spillway(s) fail, the impoundment would be drained to some unknown elevation, based on the extent of the structural breach. Damage to the land surrounding the primary spillway, as well as to I-95/earthen embankment, could occur due to structural failure. Fish resources and recreational usages of the pond and associated socio-economics would also be adversely affected until the structure(s) were repaired.

3.7.3.2 Alternative B

A properly constructed and maintained bridge and spillway/fishway structure will last many decades. Therefore, the improved fishway should have a positive impact on socio-economics if the river herring runs improve, resulting in larger river herring populations in coastal New Hampshire waters and in the Taylor River and increased utilization of river herring and associated fishery resources (freshwater game fishes in the pond). If, however, water quality conditions in the pond degrade in the future as a result of increased eutrophic conditions, these conditions may offset benefits gained by the improvements in fish passage to the pond.

Additional water quality deterioration in the future could adversely affect the property values over the long term. However, over the short term, no adverse impacts with regard to property values are anticipated.

This alternative will also have adverse impacts as taxpayers or another owner would need to fund the construction of a new spillway and fishway as well as maintain the structures over the long term.

3.7.3.3 Alternative C

The removal of the Taylor River Pond spillways will substantially alter the current habitat characteristics, recreational uses, and scenic views by elimination of the existing impoundment. An assessment of potential impacts on property values is pending further analyses by NHDOT appraiser staff. The existing freshwater aquatic habitat (*i.e.*, the pond) would be converted to intertidal flats and salt marsh, as well as fringing brackish and/or freshwater wetlands, with the narrow Taylor River flowing through the wetlands. The conversion into tidal wetlands upstream of I-95 would benefit the entire downstream estuarine ecosystem through the restoration of former "run-of-river" habitat. The community at-large would also benefit from an increased environmental awareness regarding habitat restoration efforts. The issue of low dissolved oxygen would be eliminated as the impoundment would no longer exist. The loss of the impoundment would likely affect residential shoreline property values.

NHDOT conducted a study relative to impacts to the property values with Alternative C. The report evaluated the River Willow and the Taylor River Estates neighborhoods. A full copy of the report is included in **Appendix F**. The report estimates that a decrease in property values of approximately 5% may be realized for the River Willow neighborhood and approximately 20% may be realized for the Taylor River neighborhood properties directly abutting the water.

3.8 Recreational Use

3.8.1 Existing Conditions

To aid in the identification of important recreational uses of the Taylor River Pond, a Recreational Use Survey was conducted in October 2006, which targeted direct abutters and neighborhoods within sight of the impoundment (**Appendix G)**. Of the approximately 55-60 residences visited, surveys were completed by 30 individuals and/or households. Based on the results of the survey along with observations during data collection and input from local officials, the important recreational uses of the pond, include boat and shore fishing, swimming, boating (canoes and kayaks), and scenic/wildlife viewing (**Figure 30).** Passive recreational uses of scenic and wildlife viewing were the most commonly cited uses by abutters to the Taylor River Pond.

Other uses identified by respondents but not specifically included on the questionnaire included ice fishing, snowmobiling, and skating. When asked about the number of days respondents participated in recreational activities, the activities were equally distributed across all four seasons. This finding further confirms the importance of winter-based recreational activities within the pond.

It is noted that the limited survey does not provide a regional context of current recreational use of the area. The Hurd Farm access can accommodate approximately 15 vehicles. This access affords an excellent opportunity for those who are not direct abutters or residents in the adjacent neighborhoods.

3.8.2 Impact Analysis

3.8.2.1 Alternative A

There would be no immediate effect on existing recreational uses within Taylor River Pond under this alternative. Anadromous or resident freshwater fish populations would remain unchanged. On a longer term basis, however, if no repairs were made to the existing fishway, it would continue to deteriorate and result in lower anadromous fish passage efficiency. The reduction or elimination of the herring run from Taylor River Pond may also affect the resident game species in that less forage (juvenile herring) would be available. This adverse effect to the existing sport fishery could impact boat, shore, and ice fishing opportunities. In addition, if no corrective actions are taken to improve water quality within the pond or watershed, eutrophic conditions would continue and potentially lead to far-term negative impacts to boating, swimming, scenic open water views, and fishing.

If the current pattern of eutrophication of the pond was to continue into the future (assumes that no actions are taken to reverse the current trend), the concentration of submerged and emergent aquatic vegetation would increase. This would result in reduced boating opportunities in the pond and reduced aesthetics (open water views) during the summer months, when vegetation would be most concentrated.

Also, should the deteriorated spillway(s) fail, the impoundment would be drained to some unknown elevation, based on the extent of the structural breach. Damage to the land surrounding the spillway/fishway, as well as to I-95/earthen embankment could occur due to a breach. Fish resources and recreational usages of the pond would be adversely affected until the structures were repaired.

3.8.2.2 Alternative B

The improved fish passage associated with this alternative would have a positive impact on boat, shore, and ice fishing, if the number of forage fish (juvenile herring) for the existing warm water game species increases as a result of increased numbers of herring reaching the pond through an improved fishway. However, the existing eutrophic conditions in the pond would continue or increase over time (without corrective actions), which would have adverse effects on other recreational uses such as boating.

3.8.2.3 Alternative C

Removal of the spillways would substantially alter the current habitat characteristics. The existing freshwater aquatic habitat would be converted to a small freshwater stream meandering through intertidal flats and salt marsh, as well as fringing brackish and/or freshwater wetlands. The loss of an open water pond would substantially change the types of available water-based recreation within the former impoundment. Boat, shore and ice fishing for freshwater fish species would be nearly eliminated. However, the anticipated changes in habitat conditions would lead to new fishing opportunities for coastal/estuarine species.

The restoration of a tidal creek within the impoundment reach would allow for downstream navigation during certain tide cycles with small watercraft such as kayaks, as well as for scenic and wildlife viewing (especially shorebirds) of a different type of habitat (tidal creek and surrounding marsh).

3.9 Water Quality

3.9.1 Existing Conditions

Concern was expressed by the NHDES during early project coordination regarding the potential for low dissolved oxygen (DO) levels within the Taylor River Pond, which could negatively affect fish populations and other aquatic resources. Field observations in the fall of 2006 documented an abundance of submergent and floating vascular plants along with filamentous green algae in many locations. This suggested an abundance of nutrients in the pond. Low DO concentrations were suspected (and previously reported by the NHFGD) in the deeper areas of the pond during the summer months as a result of stratification (the more oxygen-rich upper layer of the water column fails to mix with the deeper oxygen-deficient layer). The deeper area of the pond, however, constitutes a relatively small portion of the total pond area.

The relative shallow and stagnant nature of the pond with its abundance of aquatic plant life suggests eutrophic conditions. The high organic content of the sediment indicate recycling of nutrients back into the water column. Decaying organic matter also reduces the dissolved oxygen content and can cause impacts to other organisms.

To address concern about dissolved oxygen, NHDES deployed a multiprobe datasonde in 12 to 15 feet of water just upstream of the Taylor River Pond primary spillway from August 31 through September 5, 2006, when the water temperature was still relatively warm (over 20°C). NHDES also recorded a temperature/DO profile on August 31 to a depth of 12 feet. Both the datasonde and the DO profile indicated "typical" summertime conditions for a warm water eutrophic pond. The datasonde recorded DO levels generally between 7.0 and 9.0 milligram per liter (mg/l), with a low reading of 5.7 mg/l, well above the state water quality standard for Class B waters of 5 mg/l (**Figure 31**). The DO profile showed relatively high DO levels above state standards from the surface to a depth of 6 feet, with decreasing levels at greater depths to a low of zero DO at the bottom (**Table 16**).

More in-depth DO and nutrient monitoring was conducted in the Taylor River Pond between May and October 2008 (Berger, 2008). Monitoring included vertical profiles at 12 stations throughout the pond during eight sampling events from May to October, as well as continuous monitoring at two stations over 23 days. Water samples for nutrient and chlorophyll *a* analyses were obtained mostly from the upper water column. The *Dissolved Oxygen and Nutrient Conditions in Taylor River Pond* report (Berger, 2009) is included in **Folder 4** of the Additional Data CD.

In summary, the 2008 study found that DO concentrations decrease during the summer well below the regulatory limit of 5 mg/l (**Figure 32**). Lowest concentrations exist in the deeper part of the former river channel; the channel reaches depths of over 10 feet. However, there was considerable spatial variability in the dissolved oxygen concentrations throughout the pond in the summer. This spatial variability could be a result of limited horizontal water exchange due to the shallow water depth in the pond and the dense aquatic vegetation. Other factors are likely freshwater inflow during rainstorms and varying degrees of mixing from wind action in different parts of the pond. The depth of the oxycline (*i.e.*, the interface between zones with higher and lower dissolved oxygen concentrations) appears to fluctuate vertically over time, possibly for the same reasons that cause the spatial variability (**Figure 33**).

Based on nutrient sampling, the limiting nutrient appears to be phosphorus rather than nitrogen, which means that phosphorus concentrations control the degree of growth of the aquatic vegetation. Total phosphorus concentrations were elevated and typically in the eutrophic range (**Table 17**). Chlorophyll *a* concentrations ranged from mesotrophic to eutrophic during the different sampling events. Overall, the low dissolved oxygen concentrations, elevated nutrient concentrations, as well as the high density of floating and submerged aquatic vegetation in the Taylor River Pond verifies eutrophic conditions in the pond in the summer, which has been previously reported.

A pressure transducer and salinity sonde were deployed within the Taylor River downstream of I-95 between September 26 and November 3, 2006 (**Figure 34**). Salinity levels reached 27 parts per thousand (ppt). During periods of high rainfall, the salinity measured at this station was 0 ppt (*i.e.*, freshwater). The salinity data as well as historic topographic maps indicate that an estuarine system would be supported upstream of I-95 if the Taylor River Pond spillways were removed.

3.9.2 Impact Analysis

3.9.2.1 Alternative A

If no action is taken to repair the I-95 bridge and Taylor River Pond spillways, there would be no change in the Taylor River Pond and existing water quality conditions. If no corrective actions are taken to improve water quality within the pond or watershed, eutrophic conditions would continue and potentially result in additional water quality impairments in the future.

However, should the deteriorated spillway(s) fail, the impoundment would be drained to some unknown elevation, based on the extent of the structural breach. This would return the impoundment reach to a riverine habitat without eutrophic conditions, until the structures were repaired.

3.9.2.2 Alternative B

Because the elevation or the operation of the pond is expected to remain unchanged from existing conditions, water quality conditions would be similar to Alternative A, and as noted in Alternative A, there could be additional water quality impairments in the future.

3.9.2.3 Alternative C

The current pond would be eliminated and this reach of the Taylor River would return to a free-flowing coastal stream, likely affected by tidal flows upstream of the I-95 bridge well into the current location of the Taylor River Pond. This would eliminate the shallow eutrophic pond that currently experiences low DO conditions during the summer. After spillway removal, some sediment currently accumulated in the pond would be mobilized and pass downstream as the Taylor River re-establishes a channel within the former pond bed. Once this channel is established, the water quality would likely return to conditions typical of coastal New Hampshire streams within the tidal zone, experiencing fluctuations in water levels and salinity depending on river flow and tidal flows. Water elevations in the Taylor River downstream of the I-95 bridge ranged from about -3 feet to 7 feet NGVD29, indicating that tidal flows would reach well into the former pond (**Figure 35**); the existing primary spillway elevation is at 8.55 feet. The water in the former pond would range from saline to brackish, depending on the amount of rainfall in the Taylor River watershed (**Figure 36**). The current low DO conditions observed in the pond would no longer occur because the Taylor River would revert to a shallow coastal stream dominated by tidal flows without permanent ponding of the water.

3.10 Fisheries

Several sources were researched for historical information and maps regarding natural resources in and along the Taylor River. The primary source of historical information was the Lane Memorial Library, Hampton, NH, website. The NHFGD was also contacted for more recent information (since the 1970s), which included annual anadromous fish reports and annual fish stocking records. The NHFGD also provided a one-page report on the water quality and the fisheries of the pond in 1954. Local property owners on the Taylor River Pond were also interviewed during Berger's site visits, relative to natural resources in the area.

3.10.1 Existing Conditions

3.10.1.1 Recent Diadromous[13] Fisheries Information

The NHFGD provided anadromous fish reports for coastal New Hampshire for 2004, 2005, and 2009, and a 2001 data report on American eel sampling in the Taylor River Pond Dam fishway. These reports indicated that the Taylor River has had a large river herring run (blueback herring and alewife) in years past, but in recent years the run has declined substantially. The NHFGD indicates that the Taylor River is one of two coastal rivers (the other bring the Exeter River) where the spawning runs have indicated a consistent decline over time (**Table 18**).

Two of the lowest river herring counts over the past several years occurred in 2005 and 2006. The NHFGD believes that the lower 2005 and 2006 counts were influenced by high flows that occurred in both springs, including the "Mother's Day Flood" of May 15 and 16, 2006. Counts from 2006 were the

[13] Diadromous species include both anadromous and catadromous species, and are migratory species that historically and currently support important commercial fisheries. River herring are two of the species currently managed by the Atlantic States Marine Fisheries Commission (ASMFC) under the "Fishery Management Plan for Shad and River Herring (*Alosa, spp*.)." The ASMFC also manages the American eel under the "Interstate Fishery Management Plan for American Eel."

lowest counts recorded on all the New Hampshire coastal rivers (combined) since the 1970's, before many of the existing fishways were in operation, with only 147 fish recorded at the Taylor River fishway (although others may have passed upstream undetected). Taylor River fishway counts in 2007 (when the counter was inoperable for 2 weeks) and 2008 were 217 and 976 fish, respectively. The 2008 count was the highest return since 2004.

According to the NHFGD, the species composition of the river herring run is now 95% to 100% blueback herring, although in the early 1990's the run was about 80% blueback herring and 20% alewife, which is a pond spawner (based on communication with the NHFGD on November 6, 2006). In 1976 and 1979, the NHFGD reported that 67 and 99% of the run, respectively, comprised alewife, indicating that there has been a decline in the alewife portion of the run over time, and that spawning conditions in Taylor River Pond may also have declined over time.

The NHFGD also reports that catadromous American eel "elvers" (juvenile eels) migrate upstream in the Taylor River, and that the elver run in the river may be larger than in other New Hampshire coastal rivers. Most years when the NHFGD first prepares the fishway for operation in early spring, hundreds of thousands of elvers must be netted out of the fishway and passed upstream, before fishway operation begins. The NHFGD also hangs a mesh substrate over the primary spillway for upstream eel passage, although passage is not monitored (per communication with the NHFGD on February 6, 2006).

In 2001, the NHFGD placed an "Irish elver ramp" in the fishway to sample the upstream migration. During sampling that occurred from April 22 to June 4, 2001, hundreds of elvers, both "glass" and "brown" stages, were collected. The highest collections occurred in late-April and early-May 2001.

The NHFGD did not report the passage/presence of any other anadromous species in the Taylor River.

The Taylor River may be one of the better systems in the Hampton/Seabrook Estuary with potential for fish restoration because the river has fewer passage barriers than the other rivers, although water quality issues remain. As a result, it is a restoration priority for the NHFGD, which has been working to restore anadromous fish populations to the Taylor River for more than 30 years. Restoration actions have included installing the existing fishway; eliminating in-river harvest of river herring; monitoring fish movement over the fishway; and even netting fish by hand and transporting them over the Taylor River Pond primary spillway.

3.10.1.2 Fish Passage and Potential Upstream Anadromous Fish Habitat

The existing fishway was inspected on September 26, 2006. There was no flow observed through the emergency spillway on the day of the inspection, but there was some flow occurring over the primary spillway, with a flow estimated to be 3 cfs. There is a downstream fish passage chute in the middle of the spillway sheet piles, which was passing water but also appeared to be partially clogged with branches and other woody debris.

The Denil fishway at the existing primary spillway was closed off at the upstream end with stop logs, but there was some leakage flow passing down through the fishway. The water depth at the upstream end of the fishway (in the pond) was approximately 2 feet. As described above, the fishway structure showed signs of concrete erosion at the downstream end, and the steel gratings and access ladder were rusty and corroded.

When the fishway is operating, attraction flow from the fishway enters the narrow channel below the Taylor River Pond primary spillway at right angles to the flow of the river, a considerable design deficiency according to current design standards of the USFWS. Fishway attraction flows should be parallel to river flow. Immediately downstream of the Dam, any significant flow over the primary spillway obliterates the attraction flows from the fishway, making it more difficult for fish to locate the entrance. The NHFGD, however, reports that the fishway does continue to pass fish, even with these noted deficiencies, and the agency has not observed large concentrations of fish delayed downstream of the primary spillway. Any improved fishway design will still require modification of the Taylor River Pond spillway and bridge to provide sufficient space for an improved entrance configuration to meet current design standards.

Downstream of the Taylor River Pond primary spillway and fishway, tidewater extends up to the face of the primary spillway and to the fishway entrance. The tide was relatively low at the time of inspection. There were several riffle areas in the relocated Taylor River channel below the primary spillway, but these riffles are inundated at higher tide levels.

The upstream tributaries and the Taylor River upstream of the Taylor River Pond were inspected for potential anadromous fish spawning habitat. Grapevine Run enters the pond from the southwest and is the largest tributary to the pond. Grapevine Run was observed at the Brown Road crossing and at Swain Drive near the equestrian center. Below Swain Drive, the stream is backwatered from the pond and is narrow and slow-moving. Flow was estimated at about 0.4 cfs on the day of the inspection (September 26, 2006). During the spring, however, higher flows would likely create higher-velocity run conditions and more wetted area and potential herring spawning habitat. Upstream of the Brown Road crossing, the stream was also narrow but with small riffles. The breached remains of a grist mill dam were observed just upstream of Brown Road. The breach leads into an old stone culvert, which is covered by flat boulders. The large wetland above the breached dam contains a small open water area and may provide limited river herring spawning and nursery habitat potential. Without modification to the remains of the former grist mill dam, however, access to the limited spawning habitat above the dam site is likely precluded. The stream flows under Brown Road through two culverts.

Downstream of Brown Road, Grapevine Run is very narrow, and flows quickly through a riffle area to a pipe intake structure, which leads to a small off-stream pond that is used as a source of water for the Fire Department. The narrow stream flows around the perimeter of the pond embankment. Grapevine Run was not observed downstream of the off-stream pond, as the property was posted.

Based on the small size of Grapevine Run, and the barrier at the old grist mill dam, the stream may provide limited river herring spawning habitat, although higher spring flows would enhance any available habitat.

Rice Dam, the next upstream dam on the Taylor River, is constructed of boulders with a concrete cap and abutments made of rock and concrete. It is an obvious barrier to river herring migration, although with the leakage through the dam, is likely passable by American eel elvers. No water was flowing over the dam during our inspections, but was flowing through cracks and crevices. The dam continues to function as a water control structure, with a small pond upstream of the dam. There are several narrow channels (mostly riffles) between the dam and Old Stage Road, where the stream becomes a defined channel before it is backwatered by the Taylor River Pond. An in-depth assessment of existing structural conditions would be needed to accurately evaluate fish passage options at the Rice Dam. Berger did not inspect habitat conditions upstream of the Rice Dam pond.

3.10.1.3 Existing Habitat Conditions and Resident Fishery

The Taylor River Pond is a relatively shallow, 47.5-acre pond, generally less than 10 feet deep, and is eutrophic with a heavy growth of submerged and emergent vegetation. In late summer, much of the water surface is covered with duckweed and other submerged vegetation and there are usually few areas of open water. The NHFGD reports low DO levels and that fish kills have occurred in the pond, although we were unable to locate specific fish kill data. Water quality sampling results from 1954, 1986, 2006, and 2008 show similar results. The surveys reported heavy growth of vegetation, generally adequate DO levels in surface waters (greater than 5 mg/l in the top 5 to 6 feet of the water column), and low or zero DO levels near the bottom (although the 1986 report did not report low DO near the bottom on August 19, 1986). As discussed in Section 3.9, the 2008 survey reported DO concentrations less than the state standard (5 mg/l) in the deeper part of the former river channel in the downstream portion of the pond, and in other shallower areas of the pond, showing considerable spatial variability in the DO concentrations throughout the pond in the summer. We observed no evidence of stress or mortality of resident or anadromous fishes during the 2008 survey, as fishes will typically avoid areas of low DO and select areas with suitable DO.

The 1954 survey noted that the pond contained largemouth bass, chain pickerel, yellow perch, and sunfish, and mentioned that establishment of an alewife run in the Taylor River should improve forage for game fish in the pond. Interviews with local residents indicate that there is an active freshwater fishery for largemouth bass and pickerel. Other species reportedly caught by local residents include American eel, sunfish (including bluegill and pumpkinseed), brown bullhead, smallmouth bass, black crappie, and yellow perch. During most winters, productive ice fishing areas occur in the downstream portion of Taylor Pond, near I-95 (per communication with a member of the New Hampshire Estuaries Project, University of New Hampshire [UNH], on January 23, 2007).

NHFGD stocking records for the Taylor River indicate that NHFGD typically stocks about 200 catchable-size brook trout every spring (April and May) in the Taylor River Pond (per communication with the NHFGD on November 6, 2006). From 1990 through 1993, 3,000 to 5,000 brown trout were annually stocked in Taylor River in an effort to establish a sea run brown trout fishery, but this effort was abandoned.

In 2007, the NHFGD collected resident fish species in the Taylor River Pond, using electrofishing and gill nets, as part of their efforts to assess contaminant levels in fish that reside in the pond (**Table 19)**. Nine species were collected, with the most common species being the eastern chain pickerel (about 37 percent of the catch), followed by the anadromous river herring (14 percent of the catch), largemouth bass (13 percent of the catch), and pumpkinseed (12 percent of the catch). The species composition is typical of small eutrophic ponds in southern New Hampshire, and is consistent with the composition reported in previous surveys of the pond and interviews with local residents.

Aside from the density of the aquatic vegetation observed within the impoundment, the Taylor River Pond appears to support a healthy community of native warm-water fish, as well as the non-native largemouth bass and smallmouth bass. Several juvenile sunfish were observed in nearshore habitat during our October 2006 inspection of the pond, and frequent swirls from larger fish were evident in front of our boat. Residents reported catching large pickerel (up to 25 inches) and largemouth bass (up to 6 pounds) in the impoundment (per communication with UNH on January 23, 2007). Several anglers using car-top boats were fishing in the pond during our October site visit. Minimal shoreline sunfish and bass (centrarchid) spawning habitat was evident, but this is likely due to encroachment of aquatic vegetation, including algae. During the centrarchid nesting season (late spring and early summer), adult fish guarding the nests would likely keep spawning beds free of vegetation and they would be more readily observed. The abundance of submergent vegetation throughout much of the impoundment offers ideal spawning habitat for pickerel, and optimal nursery habitat for pickerel as well as centrarchids. The paucity of open water habitat could limit the amount of available river herring spawning and nursery habitat, although the pond is mostly free of aquatic vegetation during the spring spawning run. Aquatic invertebrates (including hydrophycid caddisflies and mayflies) were common within the gravel/cobble riverbed immediately downstream of Rice Dam, an indication of good water quality in this free-flowing section of the Taylor River not under the influence of Taylor River Pond.

3.10.2 Impact Analysis

3.10.2.1 Alternative A

Under this alternative, no immediate effect on anadromous or resident freshwater fish in the pond would be realized. On a longer-term basis, however, if no repairs are made to the existing fishway, it would continue to deteriorate and result in lower fish passage efficiency and eventually may no longer be operational, although NHFGD would likely attempt to maintain a working fishway. If the fishway became inoperable, fish passage into the Taylor River would be blocked, and the river herring run would likely be significantly reduced, with herring restricted to only the short reach of the river below I-95. The reduction or elimination of the herring run from Taylor River Pond may also affect the resident game species because less forage (juvenile herring) would be available. Reduced forage would result in reduced growth rates and potentially lower game fish populations in the pond, adversely affecting the existing sport fishery for these species. These effects could be avoided if the existing fishway is repaired and improved, but the required improvements to the fishway may not be possible without some modification to the existing primary spillway.

However, should the deteriorated spillway(s) fail, the impoundment would be drained to some unknown elevation, based on the extent of the structural breach. Fish resources in the pond would be adversely impacted as a result of the loss of the pond habitat until the structures were repaired. Anadromous and catadromous fish migration may be temporarily restored in the Taylor River upstream of the Dam, depending on the nature of the breach and whether adequate fish passage conditions occurred.

3.10.2.2 Alternative B

This alternative would likely have little effect on the resident fishery. Even though the wider spillway would result in minimal changes in water surface elevation, the effects on the resident fishery may not be measurable.

The diadromous fishery would be affected by the construction of a new, more efficient fishway for upstream passage of river herring. A new fishway should improve the efficiency of fish passage at the site, allowing more herring to reach the pond and any available habitat in Grapevine Run and in the Taylor River below Rice Dam. The extent of fishway efficiency improvements cannot be quantified, but making the existing habitat available to more river herring should result in a long-term improvement to the river herring population, although this may not occur if the number of herring entering the pond exceeds the carrying capacity of the pond. Based on the typical alewife production for established populations in Maine lakes of 1,700 fish per acre (Walton, 1987), a 47.5-acre pond should support a population of about 81,750 herring, assuming there are no other limitations on the system such as poor water quality. Walton's production figures, however, were for alewife, while the Taylor River herring run is now primarily blueback herring. Historically, the Taylor River supported river herring runs of 200,000 to 400,000 fish (mid to late 1970s), although since 1990 the largest run has been about 85,000 fish, with most years well below that value (**Table 18**). It remains unknown whether the historical fish counts in the Taylor River actually reflect production from just the Taylor River, or instead also reflect the overall abundance of river herring along the New England coast, with large numbers of herring ascending the river when the overall abundance is high along the coast. Research has shown, however, that river herring typically return home to their natal stream, so the large runs of the 1970's, which were comprised of mostly alewife, may have mostly represented Taylor River fish spawned in Taylor River

Pond. The recent run sizes are small, so any increase in the river herring run to the Taylor River should be well within the carrying capacity of the system.

Increasing the number of river herring entering the Taylor River Pond through an improved fishway may also affect the existing resident fishery. Initially, any increase in the production of juvenile herring should benefit the resident game species by increasing the forage base, in turn, benefiting the growth and the health of these species. A large increase in the river herring run into the pond, however, may have some adverse effects on the resident fishery. A large production of juvenile herring could affect the zooplankton population in the pond, as a result of "grazing" by large numbers of juvenile herring. Any reduction in the zooplankton population could, in turn, affect the juvenile life stages of resident species, which also utilize zooplankton as a primary food source. This effect, though, may only be seasonal, occurring during the summer months during the peak abundance period for juvenile herring, and would not be a year-round effect. A large influx of river herring may also affect the nutrient cycle in the pond, by the addition of nitrogen and phosphorous as adult post-spawners die and decompose in the pond. Durbin et al. (1979) noted a significant increase in nutrients in a Rhode Island pond as a result of the influx of large numbers of alewife into the pond. For Taylor River Pond, which already exhibits characteristics of high nutrient levels (excessive aquatic vegetation growth), additional nutrients to the pond could increase eutrophic conditions in the pond resulting in greater growth of aquatic vegetation, fewer areas of open water, and eventually reduction in the amount of suitable fish habitat. As we stated above, however, the current small size of the river herring population makes this scenario seem unlikely in the foreseeable future.

This alternative would also eliminate the approximately 400 feet of "new" Taylor River channel downstream of I-95, which was established when the Taylor River Dam was first constructed and the original river channel was filled in. The original river channel would be re-established and the 400 feet of constructed channel would be filled in, which now consists of a pool and a series of riffles and rapids. This channel serves as the current migration corridor to the existing fishway, and may also support some spawning by river herring. This habitat would be lost but replaced by a new channel about 300 feet long that would pass under the new I-95 bridge. Although this new channel would be engineered to pass flows as efficiently as possible, the channel would also include design features (such as velocity shelters) that would ensure that river herring reach the new spillway and fishway and successfully migrate upstream.

3.10.2.3 Alternative C

This alternative would re-establish the Taylor River as a small coastal stream, with estuarine conditions extending into the former pond bed. Anadromous, catadromous, and estuarine species would have full access to the Taylor River up to Rice Dam and up to the old grist mill dam on Grapevine Creek, the tributary that currently enters the lower end of Taylor River Pond. This would be an advantage over the other alternatives that would provide fish passage via a Denil fishway, which is adequate for river herring and some other species passage, but may not be suitable for passage of rainbow smelt and estuarine species. Although the precise size of Taylor River and the nature of the habitat that would be re-established in the current area of the pond are not known, the river would be a relatively small stream, based on the size of the channel observed immediately below Rice Dam. The river would provide spawning habitat for blueback herring, which comprises the majority of the current river herring run, but would be less suitable for alewife, which are primarily pond spawners, although currently do not successfully use Taylor River Pond. The amount of wetted habitat would be significantly reduced from existing conditions, but the habitat would be riverine and subject to tidal flows, unlike the current freshwater pond habitat. Species such as smelt and American eel, which are currently excluded from the Taylor River or hindered in their upstream migrations, would be able to freely access the river. Tidal estuarine species could use the Taylor River, entering and exiting the river during the tidal cycles, utilizing any newly developed salt marsh for foraging and cover. One sport species of high interest along the New England coast, the striped bass, could be attracted to the Taylor River during the river herring runs and potentially provide a sport fishery in the lower river.

The existing freshwater fishery in the Taylor River Pond would essentially be eliminated with the draining of the pond. Although some of the resident species may continue to occur in small numbers in the restored Taylor River (such as bullhead), those species that prefer or require pond habitat would no longer occur in sufficient numbers to support a recreational fishery. This would include largemouth bass, chain pickerel, and the sunfish species (bluegill, redbreast sunfish, and pumpkinseed). The one species of State concern that reportedly occurs in Taylor River Pond, the banded sunfish, would unlikely occur in the restored Taylor River because of the loss of the pond habitat.

3.11 Listed Species of Concern

3.11.1 Existing Conditions

The USFWS has no federally listed or proposed threatened or endangered species or critical habitat under their jurisdiction at the project location.

The New Hampshire Natural Heritage Bureau (NHNHB) has documented and mapped the occurrences of four state-listed estuarine plant species in two areas of the Hampton River Estuary. The mapped occurrences are located ¾ mile southeast of I-95 and well beyond the limits of the project study area. The NHNHB also reported the occurrence of the banded sunfish (*Enneacanthus obesus*) where Towle Farm Road crosses the pond in 1985. Although banded sunfish is not state-listed, the species is ranked S3 by NHNHB, meaning that the species is "either very rare or local throughout its range (generally 21 to 100 occurrences), or found locally (even abundantly at some of its locations) in a restricted range, or vulnerable to extinction because of other factors." The NHFGD fish collections in 2007, however, did not collect any banded sunfish.

Copies of the USFWS and NHNHB documentation are included in **Appendix H**.

3.11.2 Impact Analysis

3.11.2.1 Alternative A

There would be no impact to the banded sunfish within Taylor River Pond or to the four state-listed estuarine plant species below the impoundment under the No Action Alternative.

3.11.2.2 Alternative B

Impacts to the four state-listed estuarine plant species below the impoundment are not anticipated. An improved fish passage may have a slight benefit to the forage base for the banded sunfish in the form of larval fish. However, the primarily forage base for sunfish is invertebrates.

3.11.2.3 Alternative C

This alternative would substantially alter habitat characteristics by elimination of the impoundment. Existing freshwater aquatic habitat would be converted to intertidal flats and salt marsh, as well as fringing brackish and/or freshwater wetlands. The loss of open water combined with the substantial increase in salinity levels would greatly reduce the amount of suitable habitat for the banded sunfish, with the only potentially suitable habitat limited to the upper reaches of Taylor River immediately below Rice

Dam. This reach, however, may be only marginally suitable with Dam removal because the reach would likely become more riverine in nature.

3.12 Wetlands

3.12.1 Existing Conditions

The Taylor River watershed includes an extensive mosaic of vegetated freshwater wetlands and open water habitat. In fact, four wetland complexes upstream of Taylor River Pond were identified as Prime Wetland candidates under NH RSA 482 (Hampton Conservation Commission and Rockingham County Conservation District, 2004). These areas included portions of the Taylor River in Hampton and Hampton Falls, a portion of Ash Brook and Old River in Hampton and Grapevine Run in Hampton Falls. Below I-95, Taylor River meanders through an extensive salt marsh system associated with Hampton/Seabrook Harbor. Field verification of aquatic resources within the Taylor River Pond during October 2006 by boat, found the embankments to the pond were fairly steep and well defined and lacked a broad transition of emergent marsh and/or wooded wetlands to the upland edge. Historical mapping indicates a meandering tidal creek with estuarine marshes extended well upstream toward Rice Dam prior to construction of the Taylor River Pond Dam.

The wetlands bordering the Taylor River Pond between I-95 and Rice Dam consist of narrow emergent and/or wooded wetland (**Figure 37**). Most of the emergent wetland areas consist of cattails (*Typha* sp.) and are classified as PEMIF in accordance with the US Fish and Wildlife Service Classification System (Cowardin et al., 1979). The majority of the pond consists of extensive beds of submergent and floating vascular plants (L23/4Hh). The deeper portions of the impoundment associated with the center of the former stream channel are limited to submergent aquatic vegetation. In many locations, there was also a layer (sometimes several inches thick) of filamentous green algae evident, suggestive of an abundance of nutrients in the pond. Common submergent and floating vascular plants included floating pondweed (*Potamogeton natans)*, ribbon-leaved pondweed (*Potamogeton epihyhydris),* big-leaved pondweed (*Potamogton amplifolius)*, common elodea (*Elodea Canadensis)*, yellow pond lily (*Nupar lutem)*, coontail (*Ceratophyllum) demersum*, common bladderwort (*Utricularia vulgaris),* water buttercup (*Ranunculus flabellaris)*, duckweed (*Lemna* spp.), and wild celery (*Vallisneria Americana).*

Certified wetland scientists delineated the limits of jurisdictional wetlands along both sides of the I-95 corridor on October 19, 2006 for the project area. A narrow band of common wetland shrubs were found along the toe of the roadway embankment and represent the upper limit of jurisdictional wetlands. The wetland boundary along the eastern embankment generally followed the top of bank associated with the existing channel leading to the bridge under I-95 or the edge of a *Phragmites*-dominated marsh along the edge of an extensive salt marsh just downstream. The adjacent salt marsh is associated with Hampton/Seabrook Harbor. The constructed channel leading to the existing primary spillway and the emergency spillway is largely unvegetated and stone-lined to prevent scour adjacent to the highway.

While this existing freshwater wetland complex currently provides a range of wetland functions including floodflow storage, fish and wildlife habitat, and water quality enhancement, impounded wetlands are not viewed as self-sustaining over the long-term. Without corrective actions that address the existing water quality impairments within the pond or watershed, eutrophic conditions would continue and become more widespread over time. Community functions are also impacted by the existing fragmentation of the Taylor River system which is dependent on the free exchange of sediment, nutrients, organic matter and biota with the ocean and a complexity of habitats to be a long-term self-sustaining wetland complex.

A relatively large wetland within the Taylor River watershed is associated with Grapevine Run, located southwest of the Taylor River Pond. This wetland complex lies upstream of the remains of a grist mill dam. As previously mentioned, this 35-acre wetland complex was identified as a candidate for Prime Wetland designation. The wetland lies significantly higher in elevation (approximately elevation 20 feet) and would not be influenced by any changes in the Taylor River Pond water surface elevation. A large forested wetland located to the west of the I-95 Rest Area also lies within a depression which is substantially higher in elevation than the impoundment and would not be influenced by modifications to the pond water surface elevation.

The downstream estuary provides important shellfish resources. The potential for further degradation of water quality over time within the impoundment could lead to shellfish closures in the future.

The habitats within the impoundment, and consequently many of the wildlife species found there, likely are different today when compared to what existed prior to the construction of the Dam. Much of the change in bird occurrence and use likely has been the result in the change of a system dominated by intertidal flats and cordgrass (*Spartina spp.*) to one that currently is dominated by freshwater vegetation. In addition, without corrective actions to improve water quality within the pond, eutrophic conditions would continue and potentially adversely affect forage fish populations that are important seasonal food resources for many birds. Species common to freshwater marsh and wooded wetland habitat include red-winged blackbirds, song sparrows, prairie warblers, common yellowthroats, and grey catbirds. Many of these species are abundant nesters elsewhere in the region. Restoration within the impoundment would permanently alter the current habitat conditions for some of these species and where it is possible, cause them gradually to shift to appropriate habitats higher in the Taylor River system.

Small mammals, such as mice, voles, and shrews are presumed to be very abundant in the wetlands surrounding the impoundment. Larger mammals, such as coyotes, river otters, raccoons, and deer, also utilize the available habitat. The prevalent mammals in the area are generalists, highly adaptable, and likely to move to adjacent habitat unaffected by tidal restoration.

3.12.2 Impact Analysis

3.12.2.1 Alternative A

There would be no immediate (near-term) effect on existing wetland resources within Taylor River Pond under the No Action alternative, as the water levels remain unaffected. If no corrective actions are taken to improve water quality within the pond or watershed, eutrophic conditions would continue and potentially lead to far-term negative impacts to the wetland system fish habitat and recreation functions. The No-Action alternative will continue to fragment the Taylor River system which is dependent on connectivity and complexity of habitats to be a long-term self-sustaining wetland complex.

3.12.2.2 Alternative B

The improved fish passage associated with this alternative would have a positive impact on the wetland system's fish and wildlife habitat functions as the increase in forage fish (juvenile herring) will benefit the existing warm water fishery and fish dependent wildlife. These benefits would be tempered, however, as water quality conditions would be similar to Alternative A, so there could be additional water quality impairments in the future leading to far-term negative fish/wildlife habitat and recreation functions. The replacement of the spillways will continue to fragment the Taylor River system which is dependent on connectivity and complexity of habitats to be a long-term self-sustaining wetland complex.

3.12.2.3 Alternative C

The removal of the spillway(s) would substantially alter habitat characteristics within the Taylor River Pond. As stated previously, existing freshwater aquatic habitat would be converted to intertidal flats and salt marsh, as well as fringing brackish and/or freshwater wetlands. Based on measured salinity levels, tidal datums, existing downstream marsh communities and historical mapping, a meandering tidal creek with estuarine marshes would extend well upstream toward Rice Dam.

Estuarine environments are found along the coast where freshwater from rivers and streams meet and mix with saltwater from the ocean and are among the most productive on earth, creating more organic matter each year than comparably sized areas of forest, grassland, or agricultural land. The tidal, sheltered waters of estuaries also support unique communities of plants and animals, specially adapted for life at the margin of the sea. In addition to supporting a variety of wildlife habitat, salt marsh grasses and other wetland plants found in estuaries help prevent erosion through streambank stabilization, provide storm surge protection, and provide vital pollution control for water draining from upland areas. Within the United States, roughly 50% of the nation's coastal wetlands have been lost and even more have been significantly impacted. In New Hampshire, a substantial effort has been expended to restore tidal wetlands which are much less abundant as compared to freshwater wetland habitats. The NH Wildlife Action Plan identifies salt marsh habitat is an important conservation concern because of its many important values and functions. Many birds use salt marsh habitats for breeding, foraging and roosting, including several species of waterfowl, raptors, wading birds, shorebirds and songbirds. Seasonal use of intertidal and salt marsh habitat also varies, with some species using the salt marsh for breeding and others during migration or the wintering period. Salt marshes provide habitat for several species of special concern in New Hampshire, such as saltmarsh sharp-tailed sparrow, Nelson's sharp-tailed sparrow, and willet (NHFGD, 2005).

Under the assumption that the proposed conveyance under I-95 would not restrict tidal flows during spring tide conditions and elevations within the pond are not substantially influenced by sediment losses or decomposition, as much as 21 acres of fringing intertidal salt marsh and flats could be restored (**Figure 12**). 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. This elevation was derived from biological benchmarks within the downstream reference marsh. A detailed estimate of the total amount and types of habitat conversion is difficult to predict due to an array of environmental conditions influencing initial plant establishment and survival. However, the limits of the existing impoundment are not anticipated to convert to uplands and result in a net loss of wetland area. The loss of open water and changes in vegetation communities would substantially alter the types of functions provided by the wetland system. Some wetland functions associated with the artificially created freshwater impoundment would be impacted by the conversion of this habitat type to inter-tidal salt marsh. However, most of the existing wetland community types are anticipated to remain along the perimeter of the former impoundment but to a lesser extent. Restoration of the Taylor River impoundment would restore a long-term self-sustaining estuarine complex. In addition, the downstream estuarine community would benefit from the restoration of former "run-of-river" habitat. The most common group of mammals found in salt marsh habitats in the New England region are rodents, such as the meadow vole, which are an important prey-species for Northern harriers and other raptors. Other common mammals anticipated to benefit from the restoration of salt marsh habitat include red fox, opossum, chipmunk, and muskrat.

Due the presence of existing invasive species, including purple loosestrife and *Phragmites* within the river system, control measures may be necessary to limit the initial establishment of these aggressive species within the newly exposed substrate. It may also be beneficial to provide streambank stabilization through bioengineering measures involving jute matting and *Spartina* planting and seeding (see **Appendix D**, Sediment Management Plan).

3.13 Cultural and Historic Resources

3.13.1 Area of Potential Effect

The Area of Potential Effect (APE) of the I-95 bridge replacement project extends from below the Old Stage Road bridge downstream approximately 2 miles to the point at which the existing river channel joins the Taylor River's original natural channel, east of I-95 (**Figure 38**). This area encompasses the pond upstream of the Dam, I-95, and the land between the highway embankment and the State Liquor Store property located northeast of the project area.

No historical resources have been recorded in the APE for the potential removal of the spillways, to date. However, the APE may be sensitive for prehistoric archaeological resources, based on a 2006 letter from the New Hampshire Division of Historical Resources (NHDHR) to the Rockingham County Conservation District regarding a location approximately 0.5 mile downstream of the Taylor River Pond Dam.

Town and archaeological site files at NHDHR were reviewed and preliminary on-line background research was conducted at the New Hampshire State Library. Information about the Taylor River Pond, Dam and the I-95 bridge over Taylor River was obtained from NHDOT and from NHDES Dam Safety Bureau.

3.13.2 Existing Conditions

No cultural resources have been formally recorded to-date in the APE. A reconnaissance of the area conducted in October 2006 by foot, vehicle and kayak, located only one resource clearly over 50 years of age, that being I-95 (originally built in 1948-50 as the "New Hampshire Toll Road") and its constituent elements at this location: the Taylor River Pond spillways and the I-95 bridge.

The Taylor River Pond Dam and I-95 bridge were built between 1948 and 1950 in association with construction of the "New Hampshire Toll Road". The embankment section provided the stable ground needed to support the 4-lane highway across the floodplain. The location of the Taylor River Pond primary spillway and the I-95 bridge over Taylor River, at the north end of the embankment (rather than further south), represented a substantial realignment of the stream flow (apparently due to the presence here of dense granular soil that would provide better foundation for the bridge abutments, as discussed in Section 3.2).

The existing bridge is 15 feet wide and approximately 8 feet high, with steel pile sides and a concrete top slab. Beyond the bridge, the realigned stream was accommodated by construction of a short canal that directed the discharge from the bridge back south to join the historical river channel downstream from the highway. In the early 1950s, the spillway appears to have been relocated closer to the bridge, utilizing the existing sheet piling. The concrete fishway was added in the late 1960s to facilitate movement of fish upstream. The New Hampshire Toll Road eventually became part of Interstate 95. With the widening of I-95 in the 1970s, the I-95 bridge over the Taylor River was widened accordingly and the downstream wingwalls rebuilt. At the same time, an emergency spillway and culvert was constructed several hundred feet to the south of the primary spillway to accommodate high flows.

Historically undeveloped, the Hampton side of Taylor River Pond, between I-95 and Towle Farm Road, was gradually built up through the middle and late 20th century, the pond attract people who built seasonal camps and, with increasing frequency, year-round residences. The Hampton Falls side of the impoundment has remained less developed, perhaps as a result of the steep slopes on this side of the river.

The Taylor River Pond primary spillway was built in response to a request from the NH Fish and Game Department for a mitigation measure providing waterfowl resting habitat. In the 1940s "creation of artificial freshwater impoundments in coastal wetland areas was a standard practice" on national wildlife refuges, employed at the urging of sportsmen to provide habitat for "targeted species of waterfowl," particularly Black Duck (PRNWR, undated). This practice also appears to have been adopted by state wildlife management agencies, such as New Hampshire's.

In its Section 106 reviews of this project with NHDOT, the last of which took place on December 17, 2007, NHDHR determined that the Taylor River Pond spillways, fishway, and the I-95 bridge were not eligible for the National Register, based on their materials and lack of significant engineering considerations associated with their construction.

3.13.3 Archaeological Potential

NHDHR files indicate that this area of New Hampshire has documented potential to contain prehistoric archaeological resources. Goodby (2003) has noted that the proximity of upland, estuarine and coastal environments (the first two particular are present in the Taylor River Project area), offered opportunities for subsistence with great diversity, thereby, attracting Native peoples throughout most of the pre-contact period.

Evidence of prehistoric occupation of this area has been documented at six prehistoric sites on the lower Hampton Falls River (east of I-95), and two on the lower Taylor River (also east of I-95). Chiefly artifact collectors recorded all of these sites in the 1970s and 1980s, and temporal and functional information about them is limited. However, site 27-RK-0160 on the Hampton Falls River produced artifacts dated to the mid-late Archaic and mid-late Woodland periods; and Site 27-RK-0055, approximately ½ mile further downstream, is described as a fishing station with artifacts (pestle, cobble weight, stemmed projectile point, and hammer stones) dated to the late Archaic period. The presence of these sites, as well as many others identified in similar environments elsewhere in this area of New Hampshire, lend support to NHDHR's observation (regarding Rockingham County's proposed Marsh Lane Conservation Preserve project on the Taylor River within a mile below I-95) that "the area is considered archaeologically sensitive with regard to Native American site potential" (McConaha to Degnan, June 22, 2006; see **Appendix F**). However, NHDHR's review of the I-95 bridge replacement and spillway removal/replacement project concluded that archaeological investigations were not necessary as long as the water level in the impoundment did not change.

3.13.4 Impact Analysis

3.13.4.1 Alternative A

The no-action alternative would maintain existing conditions and would involve no ground disturbance and no changes to the elevation of the pond or to the existing alignment of the Taylor River above or below I-95. In the event of spillway failure, however, lowering of the water level in the pond could potentially expose previously submerged archaeological resources.

3.13.4.2 Alternative B

Alternative B, which would move the location of the I-95 bridge and the primary spillway southerly to the historic river channel, would result in removal of the existing I-95 bridge, the Taylor River Pond primary spillway, fishway, and emergency spillway structures; none of which are eligible for inclusion in the National Register. Because the pond elevation would remain the same, Alternative B would not affect any archaeological resources that may be present.

3.13.4.3 Alternative C

Alternative C would also relocate the bridge over the Taylor River to the historic channel location, with attendant removal of the existing bridge, primary spillway, and emergency spillway structures. It would also result in draining of the pond, substantial exposure of now-submerged land, and potential effects to archaeological resources from construction activities in undisturbed soils.

Because this alternative would change the water level of the pond, consultation with the NHDHR would be required regarding the need for investigations to locate and identify archaeological resources in the APE. Should National Register-eligible archaeological resources be identified as a result of such investigations, further consultation would be required to determine effects and measures to mitigate any adverse effects on these resources.

4.0 SUMMARY

The purpose of this Feasibility Study was to evaluate various alternatives for replacing the I-95 bridge, spillways and fishway; as an effort to address transportation, public safety, flood management, water quality, and fish passage issues for the Taylor River and impoundment. Twelve conceptual alternatives were evaluated. Nine of these alternatives were determined to not be feasible. The remaining three "primary alternatives" are as follows:

- **Alternative A - No Action:** This alternative would be the continuation of the status quo, with maintenance of the I-95 bridge, primary spillway/fishway, and the emergency spillway/culvert in their current condition. This is the least desirable alternative, as it would not achieve the goals of the project relative to fisheries, flooding, dam safety, and the I-95 bridge. The existing structures are deteriorating, and require repair and/or replacement. The structures are at risk of failure which would adversely affect the natural resources of the area, and possibly place the downstream highway and travelers at risk.

- **Alternative B - Replacement of I-95 Bridge and a New Spillway and Fishway:** This alternative includes the replacement of the existing I-95 bridge with new 70-foot-wide concrete and steel bridge over the Taylor River at a location south of the current bridge, and replacement of the existing spillways with a new 50-foot-wide spillway and a new Denil fishway. The new spillway would provide additional spillway capacity during high-flow conditions which would reduce flood levels in the pond. The new I-95 bridge would replace the existing deteriorating bridge over the Taylor River. A new Denil fishway would improve fish passage into the Taylor River Pond for river herring, allowing the pond and its tributary habitat to be more fully utilized by river herring.

- **Alternative C – I-95 Bridge Replacement with No Spillway:** This alternative would replace the I-95 bridge with a new 70-foot-wide bridge, similar to Alternative B, and remove the existing Taylor River Pond spillways, culverts and fishway. The bridge would be sized to accommodate a 100-year storm event with no freeboard to the low chord of the bridge. This alternative would allow the migration of diadromous and other fish species into the former impoundment area and possibly further upstream without fishway, and would fully alleviate the flooding problem for abutting properties around Taylor River Pond. The existing freshwater pond would be eliminated; instead, the original tidal channel in the existing impoundment area would be restored.

The beneficial and adverse effects of implementing the three primary alternatives on existing baseline conditions for all resource areas studied are summarized below in Table 20 below.

As can be seen in this table, the benefits and adverse effects of the project on the resources studied vary dependent upon the conditions proposed. The various issues discussed in this Feasibility Study, including the estimated costs (discussed in Section 5 below) must be taken into account in the NHDOT's decision-making process for this project.

Table 20 – Summary of Impacts

Resources	**Alternative A No Action**		**Alternative B Replace Bridge & Spillway**		**Alternative C New Bridge with No Spillway**	
	Adverse Impacts	**Beneficial Impacts**	**Adverse Impacts**	**Beneficial Impacts**	**Adverse Impacts**	**Beneficial Impacts**
Flooding	Major	None	Negligible	Moderate	None	Major
Sediment Transport *(1)*	Moderate	None	Minor	None	Moderate	None
Water Wells *(2)*	None	None	None	None	None	None
Dry Fire Hydrants	None	Moderate	None	Moderate	Major	None
Socio-Economic	Moderate	Negligible	Moderate	Minor	Moderate	Moderate
Recreational Use	None	None	Minor	Minor	Moderate	Moderate
Cultural & Historical	None	None	Minor	None	Moderate	None
Water Quality	Moderate *(3)*	None	None	None	Moderate *(4)*	Major *(5)*
Fisheries	Moderate	None	Moderate	Minor	Major	Major
Species of Concern	None	None	None	Minor	Negligible	Moderate
Wetlands	Minor	None	Negligible	None	Moderate	Major

Levels of Impacts:

None: No impact.

Negligible: Impacts would be barely detectable, measurable, or observable.

Minor: Impacts would be detectable, but not expected to have an overall effect on the resource.

Moderate: Impacts would be clearly detectable and could have short-term or long-term,, appreciable effects on the resource.

Major: Long-term or permanent, highly noticeable effects on the resource.

Notes:

(1) Assumes mitigation measures were implemented.
(2) Additional studies required.
(3) There are no impacts, unless a catastrophic failure of the spillway(s) occurs, in which case some of the accumulated sediment in the pond will be washed into the downstream estuary.
(4) Potential water quality impact downstream of estuary from resuspended sediment.
(5) Current low dissolved oxygen conditions will be eliminated but eliminating the pond.

5.0 CONCEPTUAL CONSTRUCTION COST ESTIMATES

A summary of the conceptual costs associated with the alternatives is included in **Table 21, below** for comparison. Based on the impact analysis, Alternatives B and C provide the most environmental and socio-economic benefits.

According to information provided by the NHFGD, the existing fishway annual operation and maintenance costs are estimated as follows:

Personnel Cost:	$10,900
Equipment:	$1,100
Repairs:	$1,500
Dam Registration Fee:	$1500
Total:	**$15,000**

These costs would be maintained for either an existing or proposed fishway, although initially a new fishway may have lower maintenance costs because the structure would be in good condition and not immediately require repairs.

The cost table includes estimated costs for sediment management. A more detailed breakdown of these costs is provided in the Sediment Management Plan (**Appendix D)**.

Table 21 – Conceptual Construction Cost Estimates

Alternative	**Conceptual Construction Cost Estimate**	
Alternative B: Replacement of I-95 Bridge, and a New Spillway and Fishway	Spillway/Culvert Removal	$385,000
	New Spillway	$1,417,000
	New Bridge	$4,840,000
	Sediment Removal and Disposal *	$200,000
	Roadway and Traffic Control	$1,900,000
	Total =	**$8,742,000**
Alternative C: Replacement of I-95 Bridge without Spillway	Spillway/Culvert Removal	$385,000
	New Bridge	$2,251,000
	Sediment Removal and Disposal *	$685,000
	Fire Cisterns	$750,000
	Roadway and Traffic Control	$1,900,000
	Total =	**$8,560,000**

This estimate does not include annual operations and maintenance costs for the new spillway and/or new bridge.

* This cost estimate assumes that the excavated sediment can be disposed of at an upland site adjacent to the Dam. Alternatively, landfill disposal is estimated to *add* the following costs to the listed costs for sediment removal and disposal:

- between $74,000 and $152,000 under Alternative B
- between $460,000 and $915,000 under Alternative C.

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