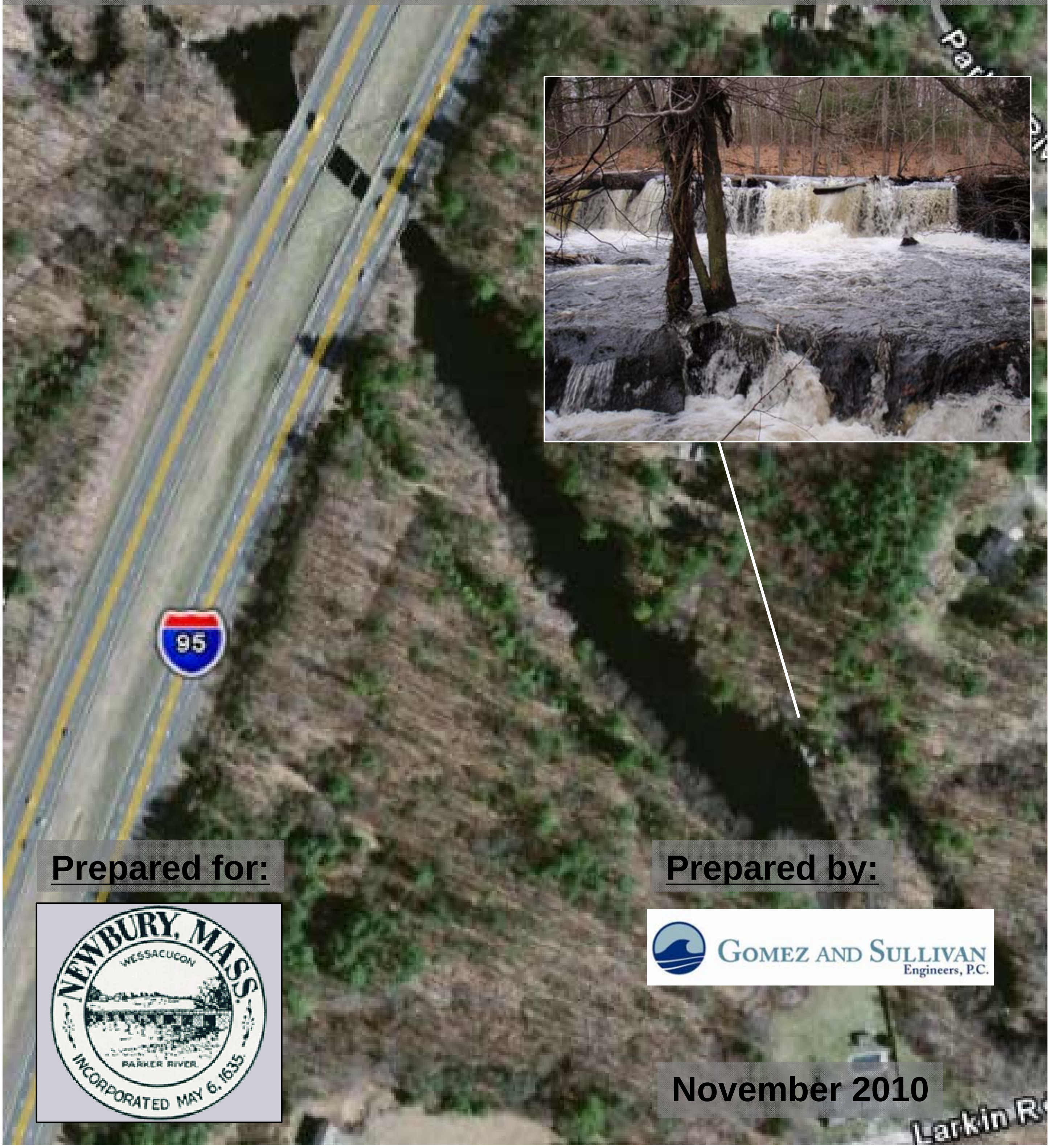
Feasibility Study for the Future Disposition of Larkin Road Dam

Final Report

Volume I of III (Main Text)



Prepared for:

NEWBURY, MASS. WESSACUCON PARKER RIVER INCORPORATED MAY 6, 1635

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Executive Summary

Background

The Larkin Road Dam (LRD), located in the village of Byfield within the town of Newbury, MA, is the second dam upstream from the head-of-tide on the Parker River. The Parker River Basin is a coastal watershed flanked by the Ipswich River to the south and the Merrimack River to the north. The Project consists of an existing dam and associated impoundment, fish ladder, snuff mill building and property around the dam, which is owned by the Town of Newbury. In March 2000, the Massachusetts Department of Environmental Management (now the Massachusetts Department of Conservation and Recreation, MDCR), issued the Town of Newbury a dam inspection report, noting that the dam was "*in poor condition with significant maintenance, operational, and structural deficiencies*". The report required the town to complete various repair work to the dam; however, no repairs were ever conducted. In December 2007, the MDCR reclassified the LRD from previously low-hazard to non-jurisdictional. The non-jurisdictional finding means that the MDCR has no further oversight of the dam.

In June 2007, the Massachusetts Department of Fish and Game Division of Ecological Restoration (DER/Riverways) contracted to conduct a site reconnaissance survey of the dam and to evaluate the merits of potentially removing the LRD. The study supported the State's findings that the dam was in poor condition. The study recommended that a feasibility study be conducted to evaluate the merits of removing the LRD to eliminate an on-going liability, and in a broader perspective, to restore the heavily dammed Parker River to its natural free-flowing condition. Armed with this information, the Newbury Conservation Commission (NCC) secured a grant with the Gulf of Maine Council (GOMC)/National Oceanic and Atmospheric Administration (NOAA). The Town of Newbury, through a town meeting, approved funding to match a portion of the grant.

This feasibility study evaluated the merits of the following alternatives for the future disposition of the LRD:

- status quo- do nothing,
- dam repair or in this case dam replacement (as explained later the condition of the dam was so poor and hydraulically inadequate that dam repair was not a reasonable alternative),
- partial dam removal (spillway section),
- full dam removal including the spillway section and earthen section.

As described later, the town will eventually determine which of these four alternatives is the "preferred" alternative and subsequently advance it to the next stage.

The impacts on wetlands, wildlife, fisheries, recreation and historic resources, infrastructure and flooding were evaluated for each alternative. A separate historic[1] assessment was completed as a stand-alone document. In addition to the impact analysis, order-of-magnitude cost estimates were developed of each alternative.

[1] See Volume III- a separate cultural resources study was conducted by Public Archeological Laboratory.

Project Features

The main project features are described below in upstream to downstream order and are shown in Figures E-1 and E-2. Note that when referring to the left or right side of the river, one is looking in a downstream direction.

- A United States Geological Survey (USGS) gage is located immediately upstream of the impoundment created by LRD. The gage indirectly measures streamflow into the LRD impoundment. The flow data from the gage was used to estimate low, seasonal, and flood flows at the project site.

- The Route 95 Bridges (northbound and southbound lanes) are located below the USGS gage. The bridges are supported by two vertical abutment walls and footers. The impoundment created by the LRD extends through the bridge opening. Under the partial and full dam removal alternatives, the velocities through the opening will increase and the potential for scouring along the abutment walls and footer was examined. Note that under status quo conditions, scour is present throughout the length of the bridge with a large scour hole is located at the upstream bridge entrance. Review of past Mass Highway reports notes that the footer has been partially exposed due to scour.

- The LRD is approximately 230 feet long and consists of the following main features in a left to right sequence: a) a 65-foot-long left concrete wall, b) a 35-foot-long spillway, and c) a 127-foot-long earthen section with a concrete core wall. Overall, based on three independent (two different consultants and MA Dam Safety) inspections, the spillway and portions of the earthen section are considered to be in poor condition.

- A “fish weir” is located in the Parker River approximately 35 feet below the spillway. The fish weir is a 2-3 foot-high structure constructed of large stone and concrete. It was presumably constructed to preclude fish from moving further upstream toward the spillway, but is intended to “guide” fish to the ladder entrance.

- The entrance to a 140-foot-long fish ladder is located on the right just below the fish weir. The pool-and-weir fish ladder exits at the impoundment. Concerns with the fishway include: a) velocities immediately in front of the entrance can become high precluding fish from entering the ladder, b) because of beaver activity within the LRD impoundment, the fish ladder exit is commonly blocked with debris, thus impacting the amount of water passing down the ladder and impeding fish striving to exit the ladder, and c) fish ladders are not effective at passing all species and life stages of fish.

- A former canal or raceway, integral to the earthen dam, is located to the right of the fish ladder exit. The canal formerly conveyed water to the snuff mill building (located further downstream), where hydropower generation occurred. The gate controlling flow to the former facility is inoperable. The snuff mill building is abandoned, is in extremely poor condition, and is boarded to prevent entrance.

- Between the spillway and the snuff mill building, there is a short section of free-flowing river consisting of riffles (shallow fast moving water) and runs (somewhat deeper moving water). From approximately the snuff mill building downstream and through the Larkin Road Bridge, the Parker River is backwatered (essentially a long pool) due to the most downstream Central Street Dam (the lowermost dam on the Parker River).

- The Larkin Road Bridge is located approximately 920 feet below the spillway. The low chord of the bridge deck is only approximately four feet above the water surface elevation (WSE) under average flows– recall that the Central Street Dam creates a backwater through the Larkin Road Bridge opening.

- Just below the Larkin Road Bridge is the Byfield Water Districts Larkin Road Wells (2 wells, although only one is typically used). The commonly used well (59 feet deep), along with the Forest Street well, provides potable water to residents in Newbury.

Fisheries

The Parker River historically contained a large run of river herring[2]. River herring is an anadromous fish, living part of its life cycle in freshwater as well as the sea. Adult river herring spawn in freshwater in the spring and migrate back to the sea in the fall as juvenile fish. Historical accounts acknowledge the decline of river herring with the construction of numerous dams on the Parker River that blocked fish passage, and hence the natural life cycle of these fish. However, even after construction of fish passage facilities, the number of river herring passing the Central Street Dam has declined considerably between the 1970's and 2009.

River herring counts were conducted at the Central Street Dam from 1972-78 and then again by the Parker River Clean Water Association (PRCWA) from 1997-2009. In 1973, the number of river herring passing the Central Street Dam peaked at 38,102 fish. However, from 2005 to 2009, there have been fewer than 1,000 fish passing Central Street Dam, a considerable decline.

Fish passage facilities of varying vintage are currently present at the six dams on the Parker River mainstem. The Central Street Dam and LRD fish passage structures were listed as in physically fair condition, and "passable" to fish based on a Massachusetts Department of Marine Fisheries 2004 report.

Field Data Collection

As part of this study the following field data was collected:

- A bathymetric map was developed of the impoundment from the LRD to the USGS gage.

- A sediment thickness map was developed of the LRD impoundment. It was estimated that approximately 1,300 CY of deposited sediment is located within the entire impoundment.

- In 2009, sediment samples were obtained at four locations (see Figure E-3) as follows: a) SED-01, on an inside bend of the river upstream of the USGS gage site, b) SED-02, within the impoundment just below the I-95 Bridge, c) SED-03, within the impoundment just upstream of the LRD spillway and d) SED-04, just upstream of the Larkin Road Bridge on an inside bend. In 2010, two additional sediment samples were obtained below the LRD to further assess conditions downstream, including SED-2010-01 and SED-2010-02 (see see Figure E-3).

- A wetland delineation and wildlife/plant inventory of the Parker River between the USGS gage and just below the LRD was conducted.

[2] River herring includes both alewives and blueback herring.

Sediment Findings

Sediment testing was conducted to determine what, if any, potential contaminants could be present. The testing would inform potential sediment management options under the partial or full dam removal alternatives including partial dredging, full dredging, and the natural transport of sediments downstream. Based on due diligence work, which included an evaluation of potential contaminants in the project area and contacting various agencies and the town relative to historic contaminants, the following parameters were sampled: metals, semi-volatile organic compounds (SVOCs), pesticides, polychlorinated biphenyls (PCBs), volatile petroleum hydrocarbons (VPHs), volatile organic compounds (VOCs) and extractable petroleum hydrocarbons (EPHs).

In July 2009, samples were collected at the four locations listed above and the laboratory results were compared to the Massachusetts Upper Concentration Limit Method 1 and the consensus-based screening criteria developed by MacDonald (which includes the threshold effects concentration (TEC) and the probable effects concentration (PEC)). Following the 2009 testing, Project Partners opted to collect two additional samples further below LRD and tested them for the same contaminants as previously with the exception of VOCs and VPHs. The samples were collected in September 2010. The purpose for obtaining samples below the LRD was to determine if allowing sediments within the impoundment to naturally transport would raise levels downstream to above existing levels.

Some definitions are needed to understand and interpret the sediment testing results.

- TEC - Threshold Effects Concentration- TEC values are screening thresholds below which harmful effects on sediment-dwelling organisms is not expected. These concentrations may not necessarily be protective of higher trophic level organisms exposed to bioaccumulating chemicals.

- PEC - Probable Effects Concentration- PEC values are screening thresholds above which harmful effects on sediment-dwelling organisms is expected.

Shown in Table E-1 are only those constituents exceeding the TEC (these are highlighted in yellow) and the PEC (these are highlighted in green).

SED-03 exceeded the TEC for arsenic (10.0 mg/kg), lead (48 mg/kg), mercury (0.22 mg/kg), pyrene (270 ug/kg), benzo(a)anthracene (130 ug/kg), chrysene (220 ug/kg), benzo(b)fluoranthene (290 ug/kg) and total PAH's (1,888 ug/kg). SED-02 also exceeded the TEC for arsenic (10 mg/kg), benzo(b)fluoranthene (160 ug/kg) and lead (50 mg/kg). Note that the exceedences listed above were not excessively over the TEC.

The only exceedence of the PEC occurred at SED-2010-01, where arsenic (51 mg/kg) exceeded the PEC (33 mg/kg). In addition, SED-2010-01 had exceedences of the TEC for several metals including cadmium (2.6 mg/kg), chromium (54 mg/kg), copper (42 mg/kg), lead (88 mg/kg), mercury (0.19 mg/kg), nickel (44 mg/kg) and zinc (310 mg/kg). SED-2010-01 also had exceedences of the TEC for benzo(b)fluoranthene (160 ug/kg), lindane (27 ug/kg) and total DDTs (95 ug/kg).

SED-2010-02 also had exceedences of the TEC for metal including arsenic (15 mg/kg), and lead (52 mg/kg)

As Table E-1 shows, metals and pesticides (total DDTs) were higher in downstream sample (SED 2010-01) than the impoundment. The impoundment samples slightly exceed downstream mean concentrations for five SVOC variables, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene and total PAHs.

Overall, few analytes in the impoundment samples exceeded the TEC, and none exceeded the PEC. In contrast, the downstream samples – specifically SED-2010-01 and SED-2010-02 — had exceedences of the TEC for metals, SVOCs, and pesticides.

The DER/Riverways provided an opinion on the potential connection between allowing impounded sediments to naturally migrate downstream under the full or partial dam removal and the impacts, if any, on the Larkin Road well (see Appendix N for their memo). DER/Riverways rendered their opinion based on reviewing the Draft Feasibility Report, which included the 2009 sediment sampling results, and their experience on other dam removal projects around Massachusetts. DER/Riverways noted the following in their memo:

- Based upon the sediment quality data (2009 samples), the sediment quality in the impoundment appears to be surprisingly clean.
- The contaminant concentrations found in the impoundment samples are below the most conservative reporting and clean standards (RCCS-1 and S-1/GW-1). The S-1/GW-1 clean-up standards apply to soil and groundwater within drinking water source areas and, as such, are conservative and highly protective. All contaminant concentrations detected in the impoundment samples were well below these numerical standards.
- DEP/Riverways compared the concentrations of metals and PAHs found in the impoundment samples to "background" levels in soils. MassDEP obtained data from various sources documenting "background" metals and PAHs levels in Massachusetts soil, and published these values in the *Guidance for Disposal Site Characterization-In Support of the MCP*. DER/Riverways reported that concentrations of metals and PAHs in the impoundment samples were below these published levels.

Based on the above rationale, the DER/Riverways memo concludes "*Simply put, the very low levels of detected contaminants have no reasonable migratory pathway to cause an impact at the downstream groundwater well. There is also a small amount of material expected to mobilize (< 1,000 CY), and so the overall mass of these contaminants is extremely small".*

Given the DER/Riverways memo, coupled with the sediment testing findings conducted in 2009 and 2010, if full or partial dam removal is considered, it is proposed to allow the impounded sediments to naturally migrate downstream.

Hydraulic Modeling

Hydraulic models of river systems are developed to predict water depths, velocities and water surface profiles under different flow events and conditions (such as dam-in and dam-out[3]). A hydraulic model of the Parker River, from below the Larkin Road Bridge to just above the USGS gage weir, was developed for the following purposes:

- To predict depths and velocities in the LRD Impoundment (including the area where the dam currently sits) under different flows under dam-in and dam-out conditions.

- To determine the range of flows at which sediment in the impoundment becomes mobile and is transported downstream under dam-out conditions.

[3] Dam-out is referenced throughout this document and assumes that the entire spillway (partial dam removal) or the entire spillway and earthen dam (full dam removal) would be removed.

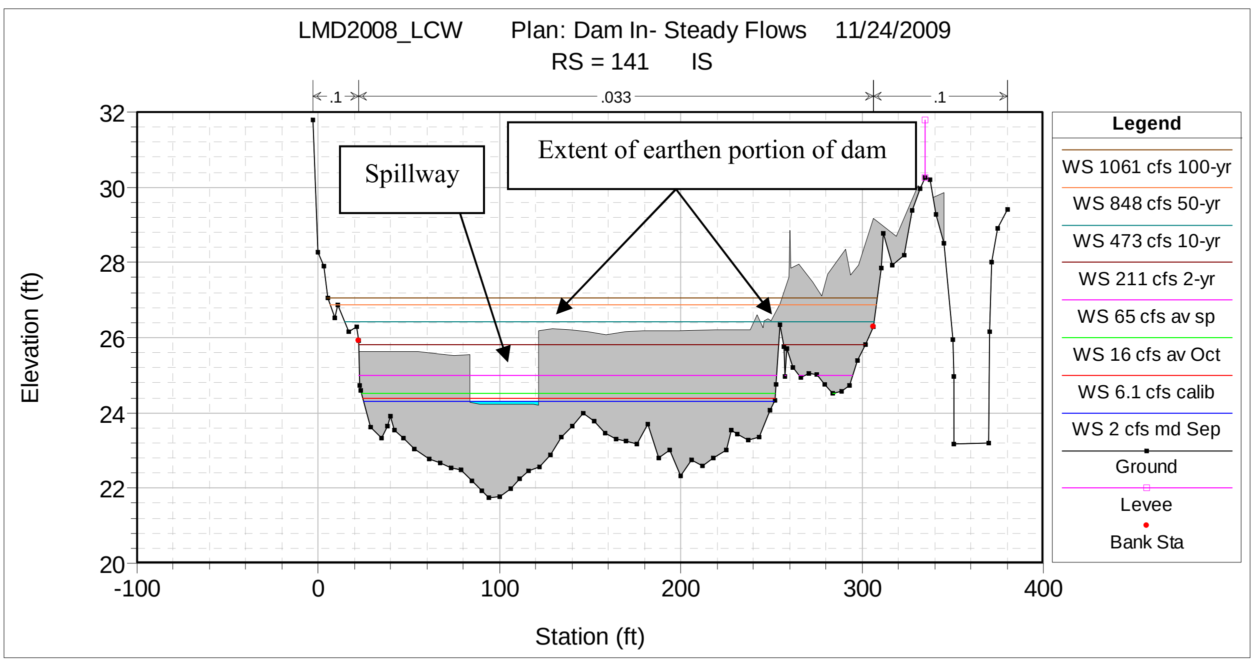
- To determine if water velocities under dam-out conditions could further scour the I-95 Bridge abutments and footers.

- To determine if depths and velocities are sufficient to pass fish under dam-out conditions at the following locations a) through the project area if the dam and fish weir below the dam were removed, b) through the I-95 Bridge opening and c) over the USGS gage weir.

The hydraulic model included numerous surveyed cross-sections starting just above the USGS gage, through the impoundment, at the dam, below the dam, and terminating just below Larkin Road Bridge. The model was calibrated to existing conditions by matching the surveyed water surface elevation (WSEs) measured at the various cross-sections for the given flow (the flow data was available from the USGS gage). In summary, a well-calibrated model was established for dam-in conditions. The major findings of the dam-in model include:

- It was determined that river herring can move upstream through the project area under existing conditions (no vertical or velocity barriers are present), although passage through the fish ladder can be impacted due beavers clogging the exit as described above.

- The earthen portion of the dam becomes overtopped under flows as low as the 10-year flood. The inset below shows a cross-section at the dam looking in a downstream direction. Earthen dams are not designed to be overtopped; in short, the spillway portion of the LRD is hydraulically undersized. It should be designed to at least pass the 100-year flood. Of concern is over time the earthen portion of the dam will fail.



The hydraulic model was subsequently used to simulate dam-out conditions, under partial and full dam removal. Partial removal assumed the spillway and a small portion of the earthen dam was removed, whereas full removal assumed the entire dam structure (spillway and earthen portion) were removed. The fish weir was also removed. Note that there was were no differences in the hydraulics between the partial removal and full removal, thus the results below are described in general as "dam-out" conditions. The following assumptions and changes were made to the hydraulic model to simulate dam-out conditions:

- The spillway was "replaced" with a river-type cross-section. It was assumed that there is no bedrock directly beneath the existing spillway. By assuming no elevated bedrock is present, higher velocities will occur in the impoundment resulting in greater sediment transport.

- By assuming no elevated bedrock is present, water depths in the former impoundment will be shallower. The depth and velocities from the dam-out hydraulic model were used to a) determine if fish passage through the I-95 Bridge opening is feasible, b) if a vertical barrier to fish passage is present at the USGS gage weir and c) if water velocities and depths are sufficient to pass migrating river herring throughout the entire reach.

The major findings of the dam-out hydraulic modeling effort are described below.

- Shown in Figure E-4 is a profile of the project reach under dam-in and dam-out conditions under a flow of 65 cfs (approximate flow during upstream river herring migration). The profile shows the channel bed elevation, and the WSE under dam-in and dam-out conditions. As the profile shows, under dam-out conditions, the WSE drops approximately 4-6 feet between the former dam and I-95 Bridge.

- Shown in Figure E-5 is a plan view of the project reach under dam-in and dam-out conditions under a flow of 65 cfs. As the plan view shows, under dam-out conditions, the width of the impoundment will shrink to approximately 20-30 feet wide.

- Based on the hydraulic modeling, it appears that river herring will have no velocity barriers through the project area including the "newly" created channel at the former dam location except at the USGS gage. There is a vertical barrier at the USGS gage due to the steep drop in the WSE at the USGS gage (the concrete weir spanning the river) and the WSE immediately below the weir. With the dam removed, the water level immediately below concrete weir drops similar to a short waterfall of approximately 2.7 foot (at 65 cfs). Some modifications to the weir or removal of the weir may be necessary to allow river herring to migrate further upstream. It is recommended that the USGS be consulted to determine if removal of the weir is possible and what other issues could arise from removal.

- The hydraulic model was used to evaluate bridge scour under dam-in and dam-out conditions. As noted above, scour currently exists between the abutments along the length of bridge, with a larger scour hole at the entrance. The hydraulic modeling under dam-in conditions showed greater scour depths than observed[4]. Similarly, the modeling under dam-out conditions showed even greater scour depths – specifically greater than the scour depths predicted by the model under dam-in conditions. If partial or full dam removal is the preferred alternative, further consultation with Mass Highways is recommended to determine if any erosion protection measures are required to protect the abutments and footers.

Sediment Transport Findings

A sediment transport analysis was conducted within the hydraulic model to simulate dam-out conditions and allowing for the natural transport of those sediments within the impoundment. A rough

[4] Note that Mass Highways periodically measures scour at the I-95 Bridge. The magnitude of scour observed in the field is largely dependent on the timing of the field work and previous flow conditions. Presumably the amount of scour would be greater following a high flow event, versus less following normal flow conditions where sediment could "refill" scoured locations.

approximation of the sediment volume deposited below the dam under the 2-year flood was 1,080 CY. The sediment deposition zone has a channel width of approximately 100 feet, whereas the actual channel in this location is around 35 feet (under a 2-year flood the channel width widens considerably and sediments can deposit along the channel fringes). Note that the sediment deposition terminates upstream of the Larkin Road Bridge. Because there is virtually no channel gradient in this reach, it is unclear if the deposited sediments will move further downstream – meaning through the Larkin Road Bridge.

Sediment transport estimates can vary widely and thus a second approximation was made. For this estimate the channel bed profile was used and it was assumed that all of the sediment above the thalweg elevation at the former dam location would be transported downstream. The estimated sediment volume using this simplistic approach was 635 CY.

Infrastructure Findings

Residential housing was developed on Parker River Drive after the LRD was constructed. The houses on this road rely on wells for drinking water. A concern with the partial or full dam removal alternatives is the drop in impoundment water levels and the potential impact to these wells. To investigate this issue, four home owners on Parker River Drive abutting the dam/impoundment were contacted to provide information, including the depth of their well.

Three homeowners responded reporting well depths of 280 feet, 305 feet, and 455 feet. The topography near these homes is around +/-59 feet NGVD. Based on the bathymetric mapping the lowest depth within the impoundment is approximately 14 feet NGVD, while the spillway crest is at approximately 24.2 feet NGVD. The well depths are 200+ feet below the impoundment. Given this, it is not expected that partial or full dam removal would impact those wells in which data was provided.

Alternatives Analysis

A description of each alternative is summarized below.

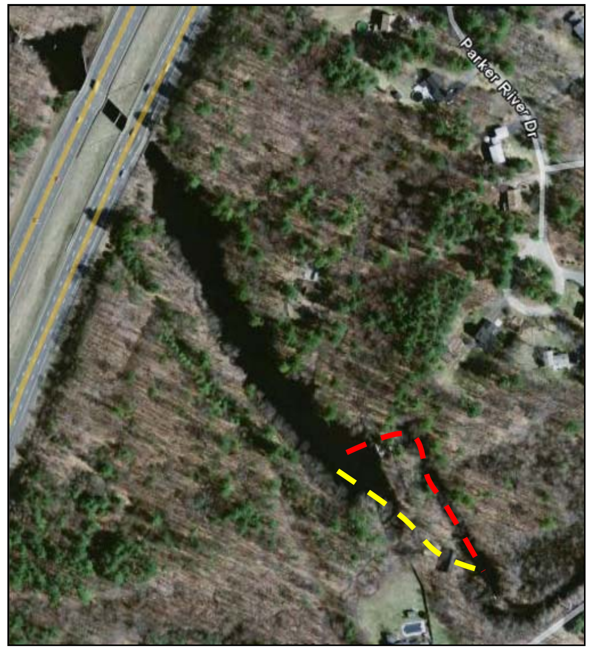
- Status quo or existing conditions- no change from current conditions.

- Dam replacement. The dam is in poor condition and the spillway is hydraulically undersized causing water levels to overtop the earthen portion of the dam under the 10-year flood. Because of these underlying conditions, dam replacement was evaluated in lieu of dam repair. The dam replacement alternative consisted of lengthening the spillway, raising the height of the earthen dam, and installing a low-level gate to allow dewatering. In addition, because raising the height of the earthen dam would render the existing fishway unusable, an Alaskan steeppass fishway was assumed to be constructed. The spillway crest elevation of the new dam was assumed to be at the same elevation of the current dam.

- Partial dam removal. This alternative includes removal of the spillway, a portion of the right side of the earthen dam, and the fish weir. The alternative assumes the natural transport of impounded sediments downstream.

- Full dam removal. This alternative includes the removal of the left abutment, spillway, earthen dam and concrete core wall, fishway, raceway or canal, and the fish weir. The alternative assumes the natural transport of impounded sediments downstream.

Each alternative was investigated and the resulting impacts to ecological resources (water quality, fisheries, wetlands, and wildlife), recreation resources, infrastructure (dam, wells, I-95 Bridge and flooding), and, historic/cultural resources was conducted. Shown in Table E-2 is a matrix briefly summarizing the impacts of each alternative.



Note that for this study, the partial and full dam removal alternative assumes that the new channel would remain within the confines of the existing spillway (as shown with the red dashed line). It is possible that prior to construction of the LRD, the river may have bypassed this sharp turn and reconnected more directly with the downstream channel (similar to perhaps the yellow dashed line). The yellow dashed line runs roughly through the raceway and snuff mill building—a more direct route.

If the partial or full dam removal alternative is selected as the preferred alternative, further discussions are needed on an appropriate "breach location". Perhaps further exploration of geologic conditions beneath the entire length of the dam may be warranted. More specifically, ground penetrating radar (GPR) could be used for the purpose of identifying changes in the geology beneath the length of the dam. It is possible that the former channel was located near the raceway and not over the spillway.

One concern with maintaining the current flow path is the potential for creating an eddy and associated erosion along the face of the earthen section of dam (partial removal) or the remaining upland soils (full removal). Specifically, during high flows, there is the potential for scour along the face of the earthen section or upland soils until erosion causes the river to "punch" through the upland area. Obviously such a scenario could have numerous ripple effects including a) erosion of upland soils (no soil testing has ever been conducted in the upland area), b) further sediment deposition of upland material into the river, c) braided channels that could preclude fish passage through the project area, and d) inundation and potential destruction of the snuff mill building.

In short, if partial or full dam removal is considered the preferred alternative, further exploration and discussions are needed relative to the breach location.

Order of Magnitude Costs for Alternatives

Order of magnitude cost estimates were developed for the various alternatives evaluated as summarized below.

Status Quo Alternative

Under status quo conditions, it is assumed that no maintenance or repair work would be conducted. At this juncture the cost estimate for status quo is $0; however, the dam will eventually fail due to no maintenance and overtopping of the earthen section. In the future there could be costs associated with removal of its remains due to failure. Given that there is no immediate action, no permitting has been assumed.

Dam Replacement Alternative

An order-of-magnitude opinion of probable costs was developed for the dam replacement alternative. The major cost items include removal of the existing dam, replacing and widening the spillway, raising the earthen dam, installing a low-level gate and installing an Alaskan steeppass fishway. The following other items were estimated and included in the cost estimate:

- Permitting (including Section 106 process)
- Geotechnical Investigation (Allowance to Perform Borings)
- Engineering Costs
- Construction Phase Services

A 20% contingency was added to the total cost. The order-of-magnitude estimate for the dam replacement alternative, including the contingency, is $645,000.

Partial Dam Removal Alternative

An order-of-magnitude opinion of probable costs was developed for the partial dam removal alternative. The following items were estimated and included in the cost estimate:

- Permitting (including Section 106 process)
- Engineering Costs
- Construction Phase Services

A 20% contingency was added to the total cost. The order-of-magnitude cost for partial dam removal, including the contingency, is $275,000. Note that this estimate assumed the following.

- No erosion control measures are needed at the I-95 Bridge abutments.

- Impoundment sediments would be allowed to naturally transport downstream (no dredging).

- Consultation with the USGS is necessary to determine if they would be willing to modify or remove the concrete weir as it creates a vertical barrier to fish passage under the partial dam removal alternative. Other issues that could arise if the concrete weir were removed would need to be identified. The estimate currently includes no cost associated with removal of this barrier.

- It is assumed that the new channel would pass through the former spillway location.

Full Dam Removal Alternative

An order-of-magnitude opinion of probable costs was developed for the full dam removal alternative. The following items were estimated and included in the cost estimate:

- Permitting (including Section 106 process)
- Engineering Costs
- Construction Phase Services

A 20% contingency was added to the total cost. The order-of-magnitude cost for full dam removal, including the contingency, is $340,000. Note that this estimate includes the same assumptions as noted in the four bullets outlined above for the partial dam removal.

Public Outreach

Prior to initiating this feasibility study, a public meeting was held on June 23, 2009 with Gomez and Sullivan Engineers, P.C. (GSE- the consultant), NOAA, NCC, and DER/Riverways. Letters were sent to abutters, historic groups, town officials and several other parties notifying them of the meeting. The purpose of this meeting was to explain the tasks associated with the study and to address any questions prior to conducting the study.

Following completion of the study, a Draft Feasibility Study was posted on the Newbury town website, and paper copies were provided to the town hall and library. A second public meeting, held on March 30, 2010, included a summary of the draft report findings and request for public input. Again, letters were sent to abutters, historic groups, town officials and several other parties notifying them of the public meeting. Comments on the draft report were received from the Parker River Clean Water Association (PRCWA), Nor'east Chapter of Trout Unlimited, and a Newbury resident who all favored full or partial dam removal. The Byfield Fire Department preferred the dam remain in place and repaired in case a contaminant spill were to occur on Route 95 such that they could deploy equipment to prevent contaminants from passing downstream to the Larkin Road well. Copies of the four letters are provided in Appendix M.

Next Steps

If partial or full dam alternative is considered the preferred alternative, it is recommended that the following next steps be undertaken as the findings could impact the cost of partial or full dam removal.

- Determine if the permitting agencies are amenable to natural sediment transport given the sediment testing findings and sediment transport analysis.

- Provide Mass Highways with the hydraulic analysis and then consult with them to determine the need, if any, for erosion control measures along the bridge abutments to reduce scour.

- Consult with the USGS to determine their willingness to remove the concrete weir that serves as a vertical barrier to fish passage under partial or full dam removal. Also determine if other issues could arise with the removal of the weir.

- Further discussion is needed whether the flow through area should remain in its current location (at the spillway), or a different location. The dam removal design would change considerably if, for example, the flow through area was in the proximity of the raceway.

- Develop an emergency response plan with Town of Newbury Public Safety and other officials to ensure proper and prompt containment of hazardous materials from a spill located at the intersection of Rte. 95 and the Parker River under a no-dam scenario.

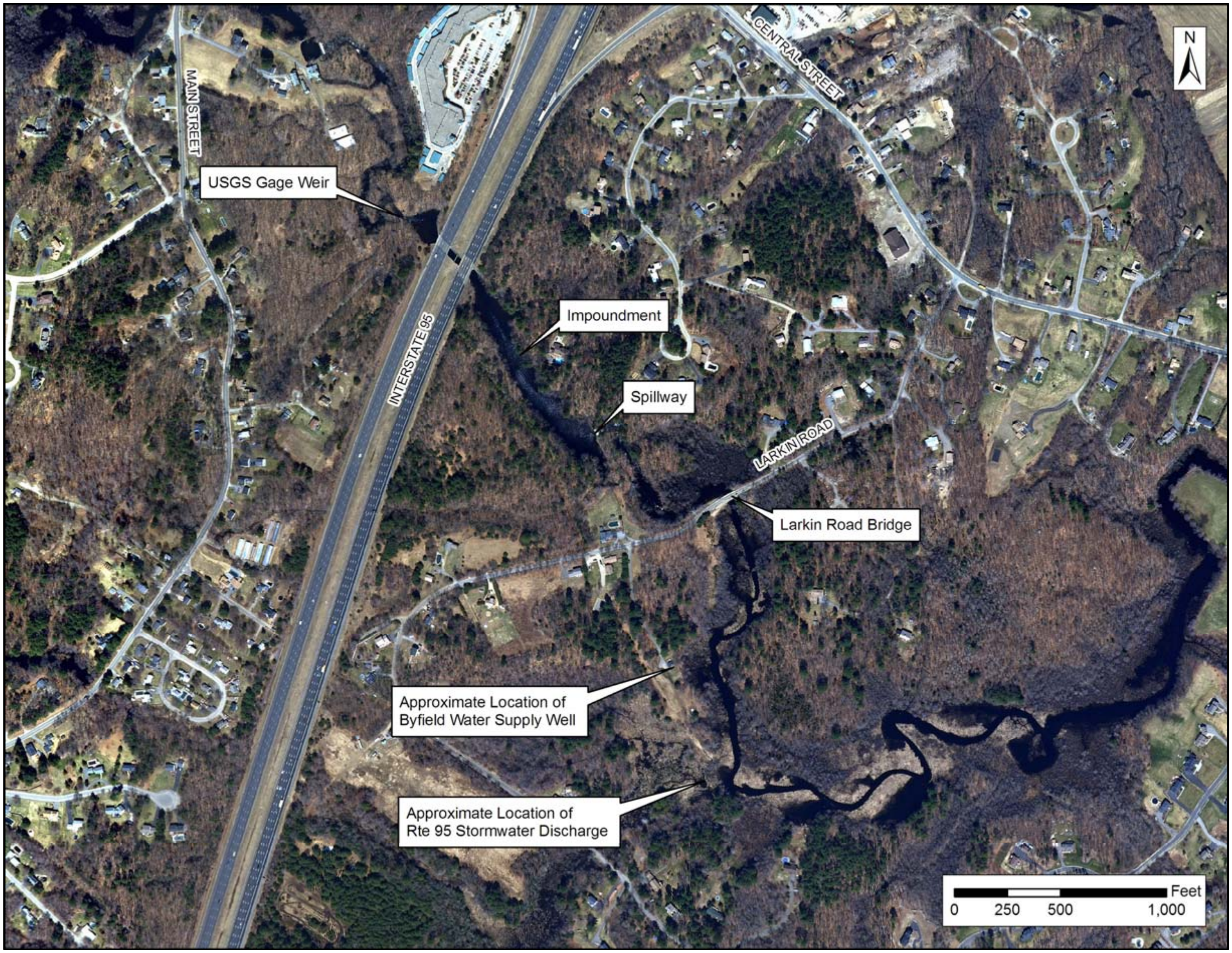


Figure E-1 Project Features

Figure E-2: Dam Features

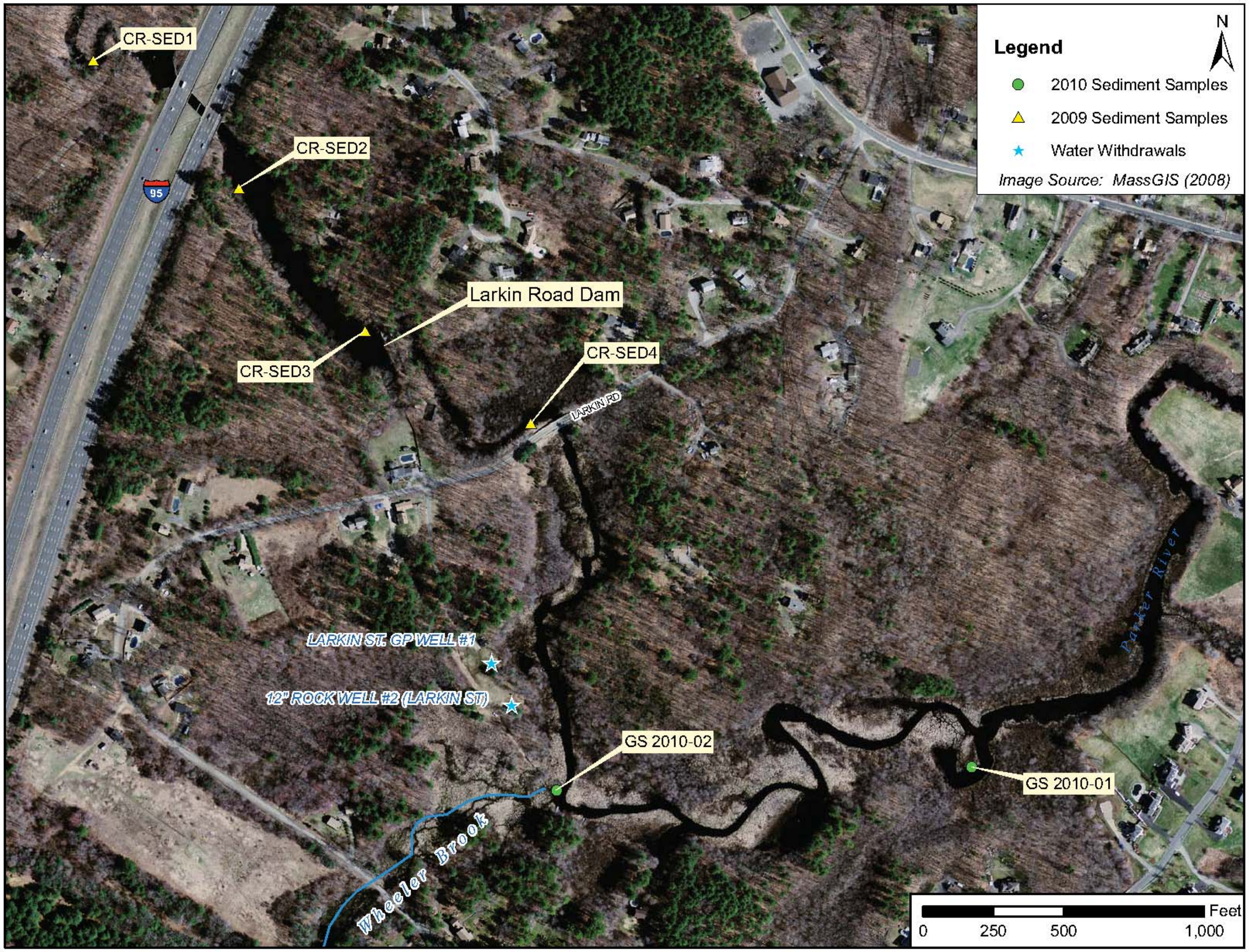


Figure E-3: Sediment Sampling Locations

Table E-1: Larkin Road Dam Sediment Sampling- Detected Analytes and Screening Criteria

Parameter/Units	Method	Screening Benchmarks			2009 Impoundment Sample Results		2009 Downstream Sample Results	2009 Upstream Sample Results	2010 Downstream Sample Results	2010 Downstream Sample Results	Impoundment Sample Result Statistics		
		MCP Method 1	Freshwater										
		S1/GW-1	TEC	PEC	SED-02	SED-03	SED-04	SED-01	SED 2010-01	SED 2010-02	Min	Max	Mean
Metals (mg/kg)													
Arsenic	6020	20	9.79	33	11	10	4.6	6.1	51	15			10.5
Cadmium	6020	2	0.99	4.98	ND	ND	ND	ND	2.6	0.75			-
Chromium	6020	30	43.4	111	24	20	16	33	54	23			22
Copper	6020	NC	31.6	149	14	10	7.1	10	42	12			12
Lead	6020	300	35.8	128	50	48	13	12	88	52			49
Mercury	7471	20	0.18	1.06	0.12	0.22	0.049	0.013	0.19	0.11			0.17
Nickel	6020	20	22.7	48.6	18	14	11	ND	44	18			16
Zinc	6020	2,500	121	459	64	62	26	40	310	120			63
SVOC (ug/kg)													
Pyrene	8270	1,000,000	195	1,520	150	270	8.4	ND	190	130			210
Benzo(a)anthracene	8270	7,000	108	1,050	82	130	ND	ND	92	71			106
Chrysene	8270	70,000	166	1,290	120	220	6.7	ND	130	110			170
Benzo(b)fluoranthene	8270	7,000	27.3	13,400	160	290	ND	ND	160	160			225
Total PAHs			1,610	22,800	1,031	1,888	24	6	1,283	1,081			1,460
Pesticides (ug/kg)													
Gamma-BHC (Lindane)	8081	NC	2.37	4.99	ND	ND	ND	ND	27	ND			-
4,4'-DDD	8081	4,000	4.88	28	ND	ND	ND	16	ND	ND			-
4,4'-DDE	8081	3,000	3.16	31.3	ND	ND	ND	9.6	ND	ND			-
4,4'-DDT	8081	3,000	4.16	62.9	ND	ND	ND	ND	ND	ND			-
Total DDTs (Sum of 4,4'-DDE, 4,4'-DDD, 4,4'-DDT)			5.28	572	-	-	-	25.6	95	-			-

- Green shaded values indicate exceedence of PEC.
- Yellow shaded values indicate exceedence of TEC.
- MCP Method 1 S1/GW-1 criteria are applicable only to soil, and are included to assist evaluation of potential upland disposal/reuse of excavated sediment.
- TEC= Threshold Effects Criteria (from MacDonald et al., 2000)
- PEC= Probable Effects Criteria (from MacDonald et al., 2000)
- NC= no criteria
- ND=not detected at the Reporting Limit

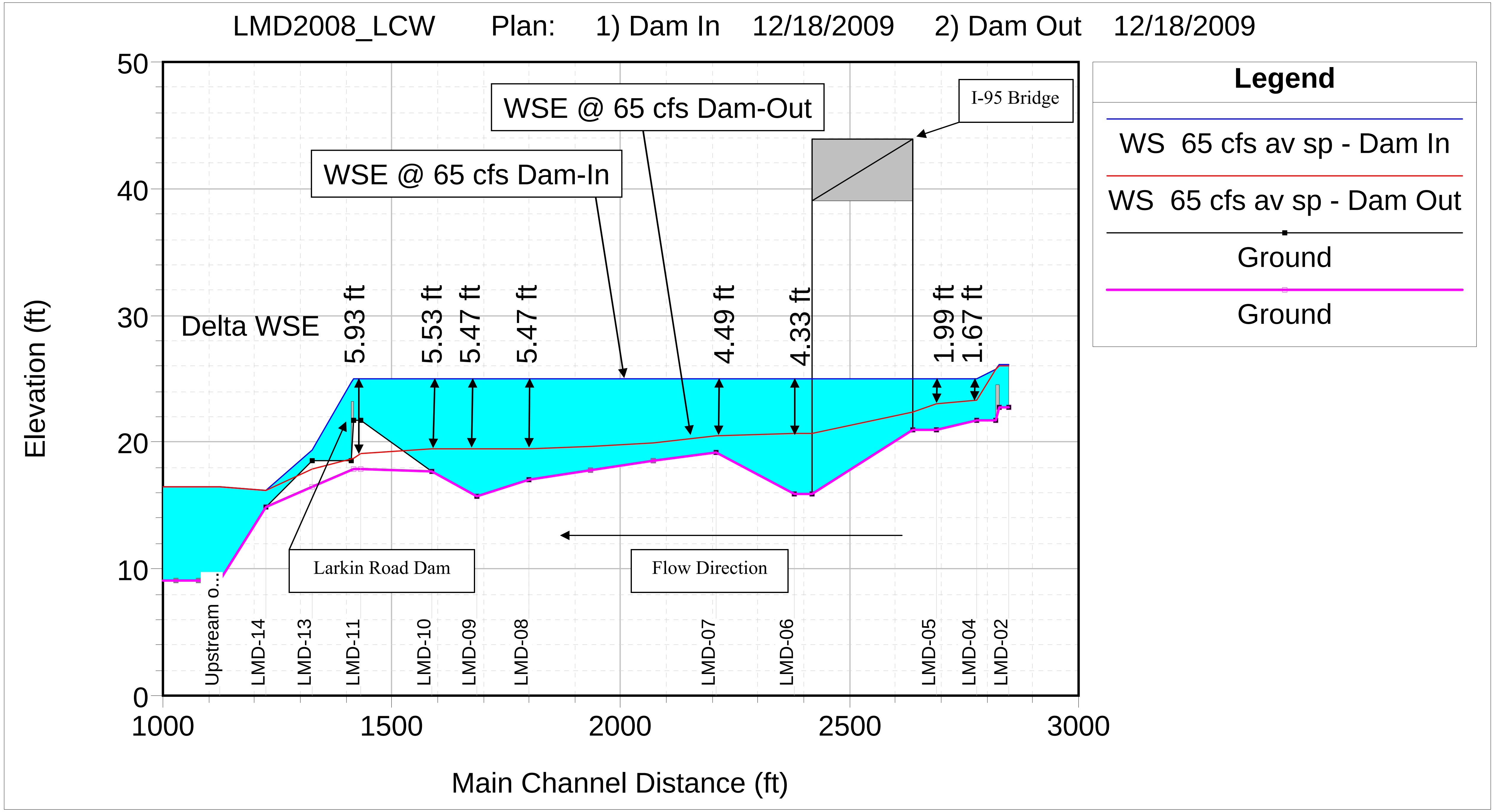


Figure E-4: Larkin Road Dam- Comparison of Water Surface Profile at 65 cfs under Dam-in and Dam-out Conditions

Figure E-5: Plan View of Larkin Road Dam Impoundment under Dam-in and Dam-out Conditions (Flow= 65 cfs)

Table E-2: Alternatives and Summary Impact Analyses

	Status Quo	Dam Replacement	Partial Dam Removal	Full Dam Removal
Ecological Resources				
Water Quality	The shallow impoundment and residence time causes artificial heating of water. Plant growth in the impoundment likely causes diurnal fluctuations in the dissolved oxygen levels.	The shallow impoundment and residence time causes artificial heating of water. Plant growth in the impoundment likely causes diurnal fluctuations in the dissolved oxygen levels.	Over time, once a riparian zone becomes established along the channel to provide canopy, heating of the water will be reduced. Dissolved oxygen concentrations should increase as water become oxygenated as it moves over substrates. Artificial diurnal fluctuations in the dissolved oxygen concentration will be reduced as plant growth will be limited in a free-flowing river as opposed to an impoundment.	Over time, once a riparian zone becomes established along the channel to provide canopy, heating of the water will be reduced. Dissolved oxygen concentrations should increase as water become oxygenated as it moves over substrates. Artificial diurnal fluctuations in the dissolved oxygen concentration will be reduced as plant growth will be limited in a free-flowing river as opposed to an impoundment.
Fish Passage	River herring passage is likely hindered due to the following: a) under higher flows, velocities immediately in front of the fishway entrance are high, b) beavers clog the fishway exit with debris causing an impediment for fish exiting the ladder and it reduces the flow in the fishway and c) fish ladders are not effective at passing all species, and life stages of fish. Increased maintenance to maintain (clear debris) the fishway.	An Alaskan steeppass is proposed to provide fish passage. Note that steeppasses are not designed to pass all species and life stages of fish, but are limited to those with sufficient swim speeds. Similar to status quo conditions, beavers will remain active and there is concern for clogging of the steeppass. Increased operation and maintenance to maintain (clear debris) the fishway.	No impediments to fish passage through the project reach, except there is a vertical barrier to fish passage at the USGS gage. Modifications or removal of the concrete weir may be necessary to allow all fish to move freely through the project area. Further discussions with the USGS are recommended. There is the potential for beavers to re-dam the free-flowing river to create pond conditions, which may impact fish passage.	No impediments to fish passage through the project reach, except there is a vertical barrier to fish passage at the USGS gage. Modifications or removal of the concrete weir may be necessary to allow all fish to move freely through the project area. Further discussions with the USGS are recommended. There is the potential for beavers to re-dam the free-flowing river to create pond conditions, which may impact fish passage.
Fish Habitat	The impoundment creates limited fish habitat. From the Central Street Dam to the USGS gage the impoundments created by the Central Street Dam and LRD inundates approximately1.62 miles of river, leaving only approximately 0.07 miles of free-flowing river. There is very limited riffle-run habitat.	The impoundment creates limited fish habitat. From the Central Street Dam to the USGS gage the impoundments created by the Central Street Dam and LRD inundates approximately1.62 miles of river, leaving only approximately 0.07 miles of free-flowing river. There is very limited riffle-run habitat.	Habitat diversity will greatly improve. Formerly inundated habitat, including potential spawning habitats, will become available within the former impounded reach. Under the partial dam removal alternative, it was assumed that sediments would be naturally transported downstream. Some of the free-flowing habitat directly below the LRD would be temporarily impacted (covered by sediment) until flows could scour the sediments further downstream.	Habitat diversity will greatly improve. Formerly inundated habitat, including potential spawning habitats, will become available within the former impounded reach. Under the full dam removal alternative, it was assumed that sediments would be naturally transported downstream. Some of the free-flowing habitat directly below the LRD would be temporarily impacted (covered by sediment) until flows could scour the sediments further downstream.
Wetlands/Wildlife	There are two wetlands located adjacent to the impoundment; one on river left just below the I-95 Bridge and one on river right near the dam. Wildlife consists primarily of beavers and common musk turtles. Wildlife and habitat diversity appears limited in this portion of the Parker River.	There are two wetlands located adjacent to the impoundment; one on river left just below the I-95 Bridge and one on river right near the dam. Wildlife consists primarily of beavers and common musk turtles. Wildlife and habitat diversity appears limited in this portion of the Parker River.	Partial dam removal will result in the elimination of slow-moving and standing water habitat. Species most affected by this change are reptiles, amphibians and beaver. It is unlikely the population of musk turtles would continue to exist if the impoundment was converted to a free-flowing river. Land under water would likely revert to wetlands resulting in a net gain of wetlands but loss in open water habitat.	Full dam removal will result in the elimination of slow-moving and standing water habitat. Species most affected by this change are reptiles, amphibians and beaver. It is unlikely the population of musk turtles would continue to exist if the impoundment was converted to a free-flowing river. Land under water would likely revert to wetlands resulting in a net gain of wetlands but loss in open water habitat.
Recreation Resources	Based solely on three site inspections during the spring, summer and winter, there were no recreation activities observed at the project.	Based solely on three site inspections during the spring, summer and winter, there were no recreation activities observed at the project.	Under partial dam removal and under high flows, it may be possible to canoe or kayak through the project area. Angling opportunities may also increase as more diverse fisheries habitat (and fish) become available.	Under full dam removed and under high flows, it may be possible to canoe or kayak through the project area. Angling opportunities may also increase as more diverse fisheries habitat (and fish) become available.
Infrastructure				
Residential Wells	Residents on Parker River Drive utilize wells for drinking water.	Residents on Parker River Drive utilize wells for drinking water.	Because the well depths are so deep (based on three residents abutting the impoundment) partial dam removal should not have an impact on these wells. The wells are located significantly below the impoundment.	Because the well depths are so deep (based on three residents abutting the impoundment) full dam removal should not have an impact on these wells. The wells are located significantly below the impoundment.
Bridge Scour	Scour is already occurring through the length of the bridge opening. A scour hole exists just below the entrance to the bridge. Past Mass Highway reports have indicated exposure of the footer due to scour. Hydraulic modeling showed that the scour depth is greater than documented.	Scour is already occurring through the length of the bridge opening. A scour hole exists just below the entrance to the bridge. Past Mass Highway reports have indicated exposure of the footer due to scour. Hydraulic modeling showed that the scour depth is greater than observed.	Under partial dam removal, water velocities through the bridge will increase. Hydraulic modeling showed that the depth of scour would be greater than the depth of scour under existing modeled conditions. It is recommended that consultation with Mass Highways	Under full dam removal, water velocities through the bridge will increase. Hydraulic modeling showed that the depth of scour would be greater than the depth of scour under existing modeled conditions. It is recommended that consultation with Mass Highways