Site Reconnaissance and Conceptual Designs for Select Stream Barriers

Fitch Basin Dam, Upper & Lower Lynde Basin Dams, and Upper & Lower Spring Basin Dams, Sterling, MA

June 28, 2019

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TABLE OF CONTENTS

INTRODUCTION **3**

EXISTING CONDITIONS **3**

Wekepeke Brook Dams 3

Impoundment and Watershed Characteristics 5

Impounded Sediment 7

Riverine/Riparian Corridor 10

Adjacent Infrastructure 11

Recreational Use 13

Hydrology and Hydraulics 13

Hydrology 13

Existing Conditions Hydraulics – Model Development 13

DAM REMOVAL CONSTRAINTS AND OPPORTUNITIES **14**

Sediment Management 14

Construction Access 14

Hydraulics 14

Infrastructure 17

Ecological Resources 18

Historical Resources 19

DAM REMOVAL APPROACH **19**

Design Concept 19

Design process and scope 20

Design 20

Permitting 21

Cost Estimate 23

Project Schedule 24

REFERENCES **25**

APPENDIX A – CONCEPT DRAWINGS **26**

APPENDIX B – COST ESTIMATE **27**

Introduction

The MA Division of Ecological Restoration (DER) contracted Inter-Fluve in 2019 to perform a site reconnaissance level study for the removal of five dams along tributaries to Wekepeke Brook and identify associated challenges and opportunities. Through this site reconnaissance assessment, Inter-Fluve has collected and analyzed data necessary to complete preliminary hydrology and hydraulic modeling and concept designs, which will allow DER 'to identify candidate dam removal sites that offer significant ecological benefit and reduce risks to public safety.' A team of three Inter-Fluve staff with engineering and geomorphological expertise visited the Wekepeke Brook dam removal sites on April 5 and May 28 of 2019 to collect survey and depth of refusal data and observations of the constraints and opportunities present at the site. The purpose of this memo is to summarize the findings of our field assessment, existing data review, and hydrologic and hydraulic analyses and to present concept designs for a recommended approach to dam removal.

Existing Conditions

WEKEPEKE BROOK DAMS

There are five dams located within the Wekepeke Wildlife Convervation Easment in Sterling, Massachusetts (Figure 1). The dams are on small tributuraies to Wekepeke Brook, which flows into the Nashua River and subsequently to the Merrimack River. The Town of Clinton owns the dams and the surrounding land.

The dams in this study are no longer being used for their intended purpose and range from 3 to about 15 feet in height and several hundred feet in length. The Fitch, Upper and Lower Lynde Dams are jurisdictional, but the Upper and Lower Spring Basin Dams are non-jurisdictional. Upper Spring Basin Dam is inundated by the impoundment of Lower Spring Basin Dam.

Fitch Basin

The Fitch Basin Dam (NID number MA01307) is upstream of Heywood Road and Upper and Lower Lynde Basin at approximately 42.4678 N, 71.7834 W. The basin is currently used for recreational purposes, but was initially the Town of Clinton's municipal water supply. The dam carries a 'Significant' Class II hazard potential rating in poor condition based on the most recent inspection on 8/10/2018 (Lenart Consulting, 2018). According to the Phase I Inspection/Evaluation Report of Fitch Dam (Weston & Sampson Engineers, Inc. 2016), the dam is an earthen embankment that has a structural height of 15 feet, a hydraulic height of 10 feet, and extends 575 feet. The primary spillway is along the left edge (looking downstream) of this embankment. The spillway is an uncontrolled, broad-crested stone masonry weir that is 12.5 feet long and approximately 4 feet below the top of the stone masonry spillway training walls. The crest width ranges from 10 to 17 feet. The upstream embankment slope is between 1.4H:1V and 3.5H:1V. The downstream embankment slope is between 1.4H:1V and 2.5H:1V. Downstream of the spillway, the water flows through a discharge channel into a beaver-impacted stream that eventually flows under Heywood Road and into Upper Lynde Basin.

Upper Lynde Basin

Upper Lynde Dam (NID number 01308) is downstream of Heywood Road and Fitch Basin and upstream of Lower Lynde Basin at approximately 42.4721 N, 71.773 W. The basin is used for recreational purposes, but was initially the Town of Clinton's municipal water supply. The dam carries a 'Significant' Class II hazard potential rating in poor condition based on the most recent inspection on 8/10/2018 (Lenart Consulting, 2018).The dam is a 200-foot earthen dike with a stone masonry primary spillway. The dike has a structural height of 15 feet and crest width of 12 feet. There is a path from the dike to the spillway with trees lining the path. The spillway is an uncontrolled, broad-crested stone masonry weir located on the northeastern side of the impoundment. The weir is about 17.3 feet long and 2.5 feet below the stone masonry training walls. The crest has an elevation of approximately El. 571.9 ft, and a width of approximately 9 feet.

Lower Lynde Basin

Lower Lynde Dam (NID number 02302) is approximately 800 feet downstream of the earthen dike of Upper Lynde Dam at approximately 42.472943 N, 71.774322 W. The dam carries a 'Low Hazard' hazard potential rating in unsafe condition based on information contained in DER bid request BD-19-1046-DER-FWE01-35772. The earthen dam is approximately 225 feet long. The spillway is an uncontrolled, broad-crested stone masonry weir that is approximately 10 feet long and has a hydraulic height of 15 feet. Downstream of the spillway, the stream flows under the access road bridge and then between constructed stone walls for approximately 500 feet. A pump house to the right (looking downstream) of the spillway has been abandoned.

Upper & Lower Spring Basin

The Upper Spring Basin Dam (NID number MA02301) is a former earthen embankment that is now inundated by the Lower Spring Basin Dam (NID number MA02300). The lower dam is located at approximately 42.472822 N, 71.770064 W. These structures are considered non-jurisdictional. The Upper Spring Basin Dam has an elevation of 540.7 ft. Remnants of the stone wall remain exposed on the east side, but the extent of the remaining dam is unknown as it is inundated by the Lower Spring Basin. The Lower Spring Basin Dam is an earthen embankment with a culvert conveying flows and has a hydraulic height of 5 feet. Two pump houses, one on the left side of the embankment and another approximately 275 feet downstream of the dam, have been abandoned.

IMPOUNDMENT AND WATERSHED CHARACTERISTICS

The Fitch Basin impoundment covers approximately 12 acres and has a drainage area of 0.4 square miles. Lower Lynde Basin is downstream of Fitch, with a drainage area of 1.3 square miles and an impounded area of 12.2 acres combined for the Upper and Lower Lynde Basins. The Spring Basin impoundment has an area of 3.8 acres and a watershed area of 0.05 square miles in area. Little development has occurred throughout the watersheds with approximately 66% being made up of forested land (Figure 2) (https://streamstats.usgs.gov/ss/).

Wetland mapping by the Massachusetts Department of Environmental Protection (MassDEP) shows a number of wetland sites near the dams being considered for removal with the watershed being composed of approximately 4% wetland (https://streamstats.usgs.gov/ss/). The channel and floodplain downstream of Fitch Basin Dam is mapped as deciduous wooded swamp, the channel upstream of the Lynde Basins is shown as shrub swamp and marsh, and low-lying areas downstream of Spring Basin Dam are mapped as deep marsh and various types of wooded swamp. In addition to these environmental features of the basin, (https://streamstats.usgs.gov/ss/) the percentage of impervious area is approximately 0.7% and overall developed urban area is 4.3% (https://streamstats.usgs.gov/ss/).

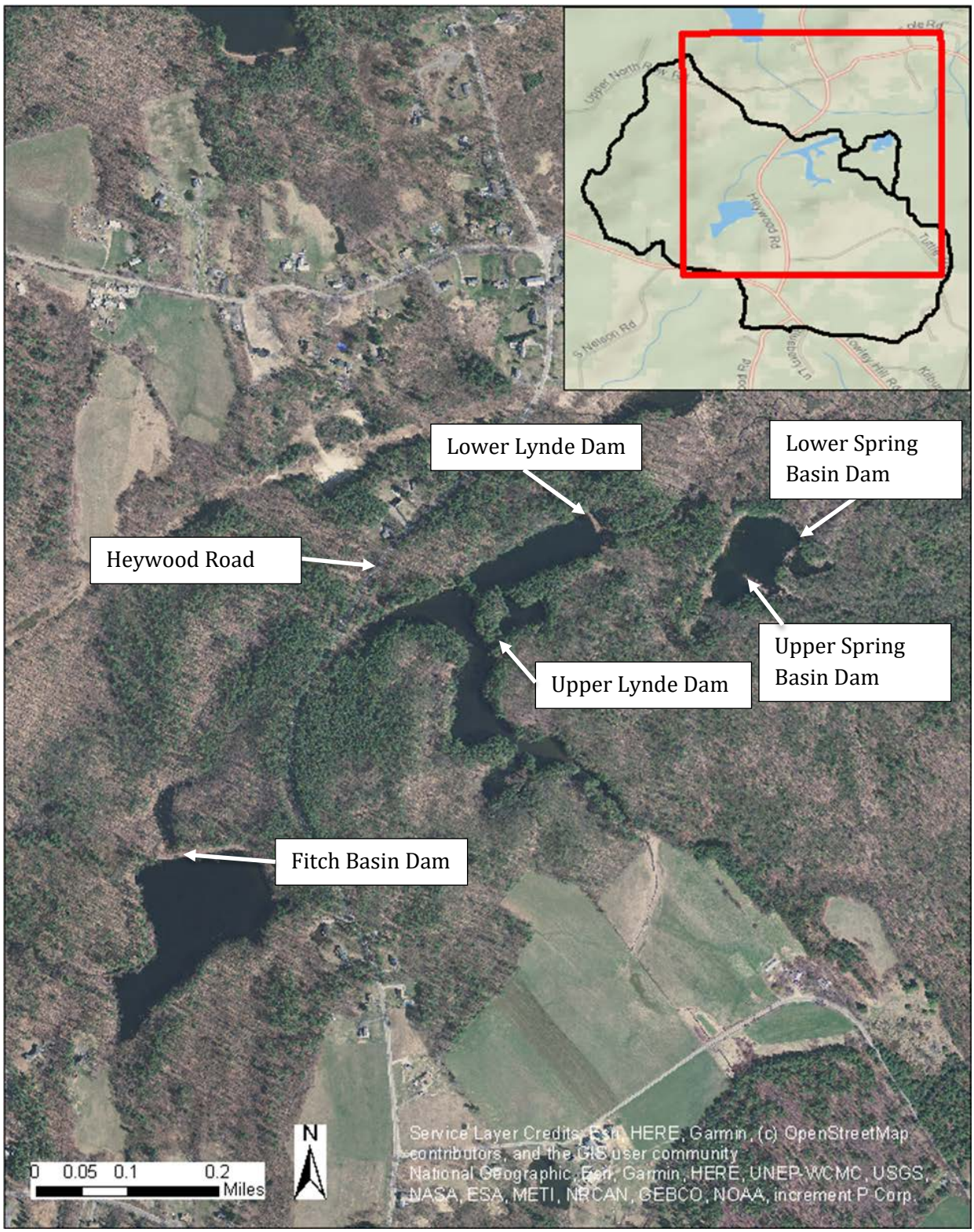


Figure 1. Dams along tributaries to Wekepeke Brook assessed in this study

Figure 2. Looking upstream from the Upper Lynde Dam

IMPOUNDED SEDIMENT

Little sediment has accumulated in the Fitch, Lynde, and Spring Basin impoundments. Sediment volumes were estimated by calculating the volume difference between the existing pond bottom and the depth of refusal surface. We recommend additional surveys in the next phase of design to further refine the volume numbers as the survey in this phase was limited to two cross sections in the Fitch Basin, two cross-sections in the Upper Lynde Basin, three cross-sections in the Lower Lynde Basin, and two cross sections in the Spring Basin.

Sediment Quantity – Fitch Basin

No sediment has accumulated within the surveyed areas of the downstream portion of Fitch Basin (Figure 3). Approximately 3,000 cubic yards (CY) of accumulated sediment and organic material was estimated in the area of survey in the upper portion of Fitch Basin. Much of this material, however, is outside of the likely channel alignment and will not be mobilized following dam removal. We

anticipate less than 300 CY of sediment and organic material moving from this area following dam removal, and we expect this mobile material to deposit in the downstream portion of the Fitch Basin as it will be backwatered from the channel and beaver dams further downstream.

Sediment Quantity – Upper Lynde Basin

Sediment accumulated in select areas in the Upper Lynde Basin. At surveyed locations, approximately 1,100 CY of accumulated material was measured in the upstream portion of the Upper Lynde Basin. The tributary portion of the Upper Lynde Basin had approximately 1,280 CY of sediment accumulation.

Sediment Quantity – Lower Lynde Basin

In the Lower Lynde Basin, a small amount of sediment has accumulated in the area just downstream of the Upper Lynde Dam spillway (approximately 60 CY). The remainder of accumulated sediment in the Lower Lynde Basin was found in the downstream portion of the impoundment (approximately 775 CY).

Between the two Lynde Basins, a total of approximately 3,315 CY of impounded sediment and organic material was estimated. Of this total volume, we anticipate approximately 1,800 CY of material being mobilized throughout these impoundments following both dam removals.

Sediment Quantity – Spring Basin

We identified a few occurrences of impounded sediment in the Spring Basin impoundments, but the material was not widespread enough to calculate volumes. We do not anticipate sediment being mobilized because the pond bottom elevation upstream of the dam is lower than the channel elevation downstream of the dam, suggesting that the area of the current impoundments will likely convert from land under water wetland to bordering vegetated wetland following dam removal.

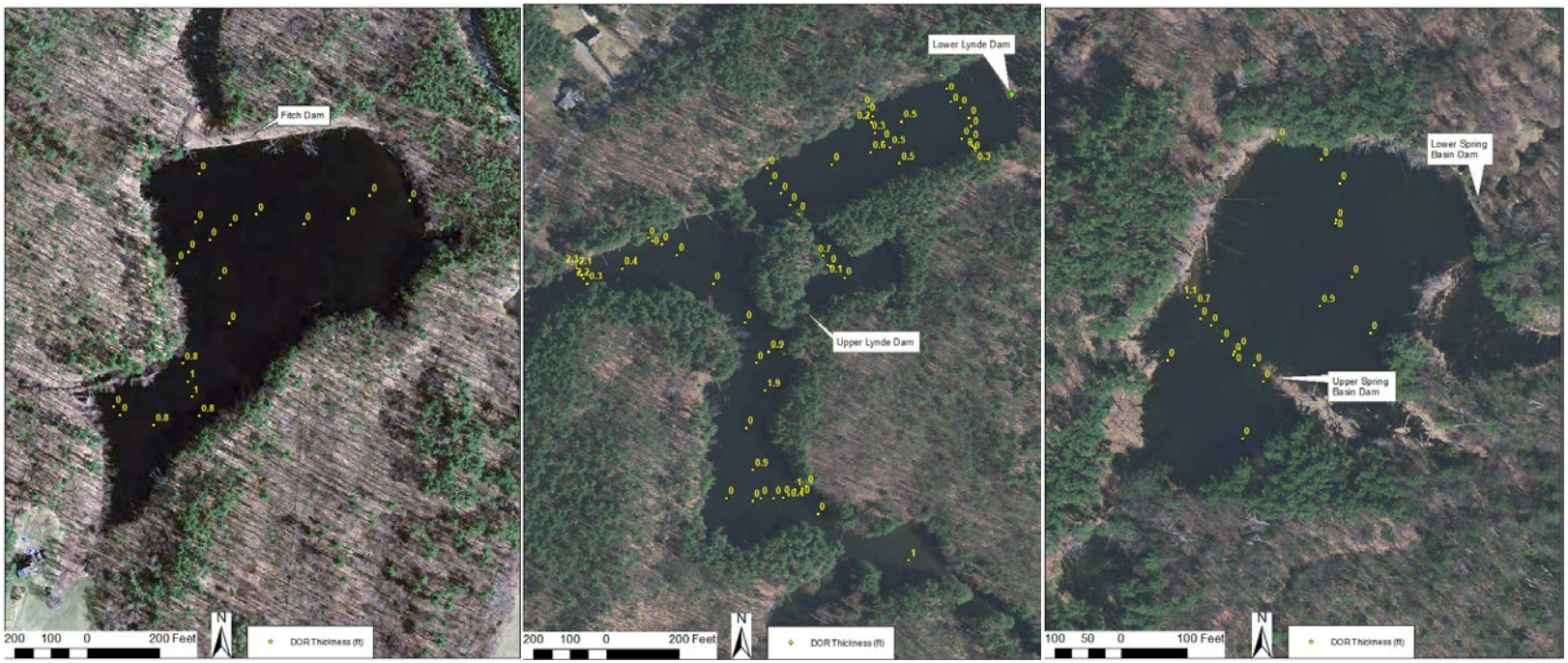


Figure 3. Thickness of the impounded sediment found during the depth of refusal (DOR) survey in each of the impoundments.

Sediment Quality

Due to budget constraints, no sediment sampling was performed as part of this study. Instead, we performed a desktop due-diligence review to determine possible sources of contamination. We reviewed the following data:

- US EPA – No Superfund/Brownfields sites and no National Priorities List sites shown within the watershed.
- MassDEP (USTs) – There are no underground storage tanks identified within the watershed. The nearest upgradient tanks are along Highway 190, about 3 miles away and over high topographic features.
- MassDEP Reportable Release Sites (RRS) – No RRS were found within the watershed. However, two residential releases were listed just south of the watershed boundary along Osgood Road. The spilled materials include aliphatics and home heating oil.
    - RTN 2-0016155 – 2006 – Over 3,000 feet south of the project watershed boundary. A spill of 1400 ug/cubic meter of aliphatics.
    - RTN 2-0015608– 2012 – Approximately a mile south of the project watershed boundary. A spill of 10 gallons of home heating oil.
- Massachusetts Source Water Assessment and Protection Program – No source water sites listed in the watershed.

No direct sources of contamination are identified within these public lists, and potential sources were all found outside of the watershed boundary therefore limiting the likelihood of surface water contamination from these sources. There are low percentages of impervious and developed areas that might facilitate overland transport of contaminants into water bodies. Geologic data found on the MA state GIS web portal (http://maps.massgis.state.ma.us/map_ol/oliver.php) show that surficial geology in the watershed and surrounding area is dominated by glacial till and consists of coarse grained material that is likely to have dominantly vertical groundwater flow paths that would limit the lateral transport of contaminants from distant sources into the watershed. These factors suggest that the risk of substantial contamination appears to be low in the watershed. However, sediment testing may be required in future design phases to confirm this and facilitate permitting of the dam removal project.

RIVERINE/RIPARIAN CORRIDOR

Human and beaver impacts are evident throughout the study area. The backwater of a beaver dam extends to the base of Fitch Basin Dam. Downstream of the beaver dam, past channel manipulation likely for mill dam purposes was observed along much of the remaining channel length to Heywood Road. These channel manipulations included straightening, redirecting the flow of the stream, and channelizing the stream with stone walls in a few locations. When the stream reaches Heywood Road, the channel flows through a 48-foot long corrugated metal pipe and then through a 34-foot

long stone culvert under a dirt road before reaching the Upper Lynde Reservoir. Downstream of the Lower Lynde Dam, the stream is fully channelized by stone walls for approximately 500 feet before meeting the outflow from Spring Basin, joining Wekepeke Brook, and eventually draining into the Nashua River east of Interstate 190.

The stream channels are primarily made up of a gravel and cobble channel bed with aquatic habitat appropriate for production of benthic macroinvertebrates and native fish species. Large wood was observed in the channel having fallen from the adjacent forested floodplain, providing additional stream cover and habitat.

ADJACENT INFRASTRUCTURE

In addition to the five dams in the project area, there is a range of infrastructure throughout the site. Downstream of Fitch Basin Dam, the stream passes through two culverts: one beneath Heywood Road and another under a dirt access road at the upstream end of the Upper Lynde impoundment. As described above, the stream also flows through a constructed channel downstream of Lower Lynde dam (Figure 4).

There are four brick pump houses associated with the dams:

- Lower Lynde Dam - adjacent to the spillway;
- Between Lower Lynde Dam and Lower Spring Basin Dam - along the dirt access road near the end of the stone walls that line the channel;
- Lower Spring Basin Dam - on left side of dam embankment; and
- Downstream of Lower Spring Basin Dam - between the dirt access road and the channel.

In addition, there are remnants of the dam operating infrastructure on the embankment crest of Fitch Basin Dam. The pump houses and remaining dam operational components would be removed as part of the dam removal implementation.

Figure 4. The channelized stream downstream of Lower Lynde Basin Dam

RECREATIONAL USE

The Wekepeke Wildlife Conversation Easement has a trail system that is accessed by the public off of Heywood Road. These trails primarily consist of well-maintained dirt roads. While boating and fishing may occur on the impoundments, these activities were not observed during our site visits.

HYDROLOGY AND HYDRAULICS

Because the Fitch and Lynde impoundments are located on the same stream, they were modeled as one system. Spring Basin Dam was not modeled because it is a non-jurisdictional dam with no nearby infrastructure and is at the headwaters of a small subwatershed.

Hydrology

Wekepeke Brook, and the tributaries studied here, is ungaged; therefore, we used the regional regression equations that are embedded in the USGS StreamStats online software (v. 4.1.3; 2017) to approximate the site hydrology. The program calculates peak discharges using regression equations (Olson, 2014). The hydrology at the site was broken into two parts, the mainstem channel upstream of Fitch Basin Dam at Station 57+25 and the mainstem channel at Upper Lynde Basin Dam at Station 17+21. The results are shown in Table 1.

Table 1. Peak discharges (in cfs) from StreamStats for a range of recurrence intervals at Upper Lynde Pond

Recurrence Interval (Years)	Q2	Q5	Q10	Q25	Q50	Q100	Q500
Mainstem- Upstream	16	27	36	51	63	76	111
Mainstem-Downstream of Tributaries	60	102	136	186	229	275	400

Existing Conditions Hydraulics – Model Development

Cross sections for input into a one-dimensional HEC-RAS model were compiled from a number of sources. Surveyed cross-section data were collected by Inter-Fluve on April 5 and May 28 of 2019. A total of 17 cross sections were surveyed from the upstream portion of Fitch Basin to approximately 300 feet downstream of Spring Basin Dam. There were six cross sections taken at Fitch Basin and 11 cross sections between Upper and Lower Lynde. We defined the cross sections across the dam structures at Fitch Basin (Stn 49+12), Upper Lynde Basin (17+21), and Lower Lynde Basin (Stn 5+35) using point data from the same survey. Fitch Basin Dam and Lower Lynde Dam were modeled as

inline structures with crest elevations of 630 feet and 567 feet, respectively. Upper Lynde Dam was kept as a cross section with a crest elevation of 567 feet.

Dam Removal Constraints and Opportunities

This section explains the constraints and opportunities associated with the removal of the dams on tributaries to Wekepeke Brook based on observations and experience from other, similar projects.

SEDIMENT MANAGEMENT

We recommend drawdown prior to removal of the full vertical extents of the dams to prevent sudden release of water and sediment and to better allow for stabilization of the impoundment by natural vegetation growth. From the depth of refusal survey, sediment depths ranging from 0.5 to 2 feet where found in the impoundments. Approximately 1,790 cubic yards of fine-grained sediment through all impoundments could be mobilized within the primary channel following dam removal. Because we found minimal sediment accumulation and little infrastructure upstream and downstream, passive downstream release of the impounded sediment is proposed. Dam removal and sediment release should be timed to be outside of critical cold-water fish spawning periods. This should be coordinated with the appropriate state and federal agencies in the next design phase if the project moves towards implementation.

CONSTRUCTION ACCESS

Access to Fitch Basin Dam is from Heywood Road on the right side of the impoundment. The dirt road that leads to, and runs on top of, Fitch Basin Dam can be used for access. For Upper and Lynde Basin Dams and Spring Basin Dam, there is access from Heywood Road (further north from Fitch Basin). There is a trail from a parking area to the dams. Lower Lynde Dam is the closest to the trail. Going in the upstream direction leads to Upper Lynde Dam and downstream goes to Spring Basin Dam. The dirt roads could be used for staging, but recreational access would be completely blocked during the construction period. Therefore, we have proposed clearing a small area of trees adjacent to Lower Lynde Dam to provide sufficient staging area. Staging for the Spring Basin Dams is unnecessary as the work will likely take a single day to remove the dam and restore flows.

HYDRAULICS

Following dam removal, a channel will form through the sediment and organic material accumulated at the bottom of the impoundments. Because we are not proposing active sediment removal or channel reconstruction, channel location and dimensions are likely to adjust with time as different flow events migrate through the site, impounded sediment mobilizes downstream, and vegetation establishes. The proposed conditions used in the HEC-RAS model are an approximation of what is likely to occur based on the existing channel grades and dimensions upstream and

downstream of the site, the existing channel and roadway locations, existing topography, and depth-of-refusal data. The gradient of the proposed channel thalweg at the Fitch Basin Dam will be approximately 0.75%, but will decrease upstream of the dam as the pond bottom elevations are lower than the channel bed elevations downstream of the dam. The area upstream of the existing dam will likely convert from land under water wetland to bordering vegetated wetland with the potential for some open water areas to be maintained by the downstream channel bed elevation or downstream beaver dams. The gradient through both Lynde impoundments will be approximately 1.5%, consistent through each impoundment regardless of concurrent dam removal or separate.

The dimensions of the proposed channel were selected to contain the 2-year peak flood discharge and were checked for consistency with average channel dimensions in upstream and downstream reaches. For Fitch and Upper and Lower Lynde Basins, the channel cross section used in the model has a 10-foot bottom width and 10-foot floodplain with banks sloped at 2:1 up to a depth of 3 feet. For Spring Basin, the proposed channel dimensions will have a 5-foot bottom width and a 10-foot floodplain with banks sloped at H2:1V up to a depth of 1.5 feet.

For post-dam removal simulations, we removed the dam structures and modified the channel cross sections to reflect the channel geometry anticipated from observed field conditions and adjusted to accommodate the 2-year flood, and set the slope between the former dam locations (Stn 5+35, Stn 17+21, and Stn 49+21) and the upstream cross section of Fitch Basin (Stn 57+25).

Figure 5 shows the modeled existing (blue) and post-dam removal (green) flood profiles for selected return period events. To aid in model resolution, interpolated cross sections were added where the distance between surveyed cross sections exceeded 50 feet. Figure 5 shows that the dam removal will result in substantially lowered water levels throughout the impoundment areas. Upstream of impoundments and downstream of dams, pre- and post-project water surface elevations are similar with no backwatering effect from the former dam locations.

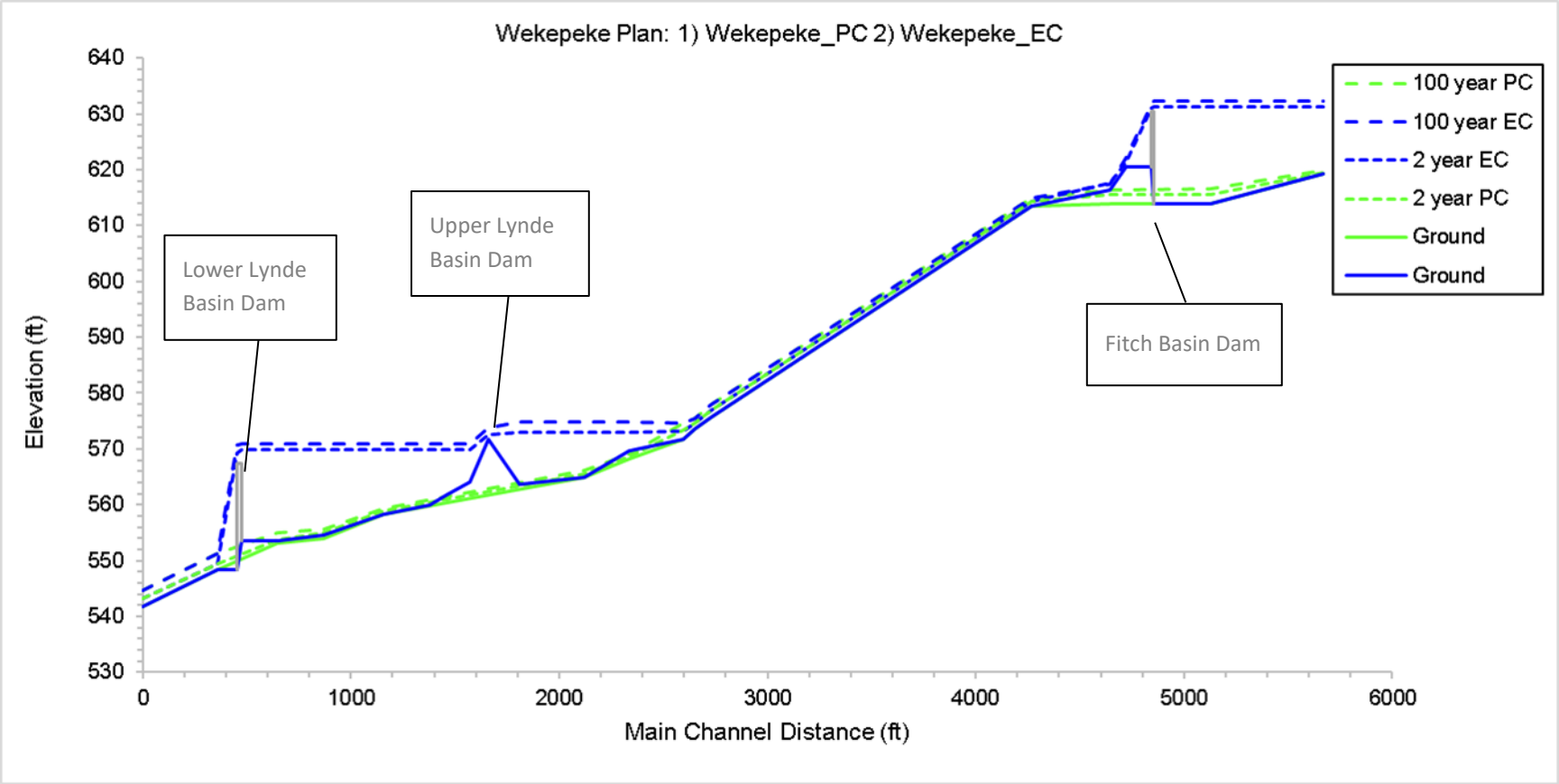


Figure 5. Predicted existing (blue) and proposed (green) dam-out water-surface profiles for the 2-year (dotted) and 100-year (dashed) peak flood events

INFRASTRUCTURE

The main infrastructure around the dams are the pump houses, which are expected to be demolished when the dams are removed. There are also a series of culverts under Heywood Road that bring flows from Fitch Basin into Upper Lynde Basin as well as a small tributary just north of this crossing. While the culverts are well downstream of Fitch Basin Dam, they would need to be monitored during the dam removal as they are at the upstream limits of the Upper Lynde Basin impoundment. The bed substrate is coarse upstream and downstream of the culverts, so scour potential may be limited following dam removal. However, the culverts under the road are old and degraded, so additional modeling and analysis will be necessary in the next design phase to evaluate possible impacts to these crossings with dam removal (Table 2). Based on the minimal sediment expected to be mobilized, the potential for damages or blockages to the culverts is considered low.

The culverts have a range of sizes and composition as shown in Table 2. All of the culverts are undersized relative to anticipated natural bankfull conditions and most appear to have exceeded their design lives and appear to need replacement. The channel just upstream of Heywood Road is approximately 5 feet wide, but this is a channelized section with stone walls on both sides and is not indicative of the channel throughout this reach. Further upstream and closer to Fitch Dam, the channel bankfull width is approximately 17 feet wide. Modeling supports the latter approximation with a bankfull width of 22 feet (top width) predicted to contain the 2-year flood peak.

While the mainstem crossings can be traversed by native fish, water velocities may too great for passage during certain times of year and terrestrial organisms do not have any way of crossing the road safely. While we do not anticipate dam removal having a significant impact on these crossings, replacing them with appropriately-sized culverts and daylighting the culverted section of the tributary through the field would improve organism passage as well as remove liability associated with crossings with obvious degradation.

Table 2. Culvert information for the stream crossings leading to Upper Lynde Basin.			
Culvert Location	Dimensions (inches)	Type	Condition
Mainstem under Heywood Road	42	Corrugated metal pipe	Heavily corroded; may be fish barrier during some flows
Mainstem under dirt road	60x36	Stone masonry	Not falling apart; passable by fish
Tributary under Heywood Road	24	Corrugated metal pipe	Heavily corroded; fish passage barrier; impounds water and sediment upstream
Tributary under grass field (culvert length approximately 150 feet)	24	Ceramic	Broken pieces observed
Tributary under dirt road	Unknown	Unknown, but likely stone masonry if built at similar time as the mainstem crossing at the dirt road	Entrance is under large tree roots, so condition is unknown, but water does appear to move through the culvert

ECOLOGICAL RESOURCES

Wekepeke Brook has been mapped as a Coldwater Fisheries Resource (CFR) by the Massachusetts Division of Fisheries and Wildlife (MADFW). Dam removal is anticipated to improve water quality and increase habitat for species that rely on the coldwater resource. Dam removal and sediment release should be completed outside of fisheries time of year restrictions, which will be determined through coordination with appropriate state agencies.

The extents and nature of the wetland resources upstream of the dams are likely to change following dam removal. Permanent lowering of low-flow water levels may result in conversions from one wetland type (such as land under water wetland) to another (bordering vegetated wetland) or from existing bordering vegetated wetland to uplands. Temporary impacts within the limits of

disturbance at the dam sites themselves are also expected. These impacts and exact wetland extent should be better quantified in future design phases.

HISTORICAL RESOURCES

We reviewed the list of historical sites in Sterling available through the Massachusetts Cultural Resource Information System (MACRIS). Historical resources are included in the register at a number of properties on North Row Road and Heywood Road, although none appear to be within the immediate project area. The presence/absence of historical and cultural resources at the site should be confirmed and coordinated with the Massachusetts Historical Commission and regional Native American tribal authorities as part of a future design phase.

Dam Removal Approach

DESIGN CONCEPT

Full vertical removal of the dams on the tributaries to Wekepeke Brook is proposed. While full removal of the earthen embankments is possible and recommended for full ecological restoration, minimizing removal of the embankments will reduce costs while still providing full fish and wildlife passage and floodplain connectivity. Therefore, we propose the removal of the full vertical extent of the dams, but only partial removal of the embankments.

Fitch Basin

For Fitch Basin Dam, there will be a slow drawdown of the impoundment to minimize mobilization of sediment. The current spillway will be filled with cut material from the removal of the earthen dam. The proposed design has the new alignment of the stream flowing to the right (looking downstream) of its current path. The footbridge will be moved or reconstructed to allow pedestrian access across the new stream alignment. While there was no clear disposal site for the excavated materials, coordination with the Town should occur to identify possible disposal sites to minimize construction costs. It is possible that the excavated materials could be placed on the upstream or downstream side of the remaining embankment in upland areas, essentially widening the existing dirt path slightly. This could be done while minimizing vegetation removal.

Upper Lynde Basin

For Upper Lynde Basin Dam, approximately 75 to 100 feet of the earthen berm will be removed to allow the likely historical alignment of the stream to flow in its natural course. The banks will be sloped at 2H:1V and tied into the existing ground. Trees that are removed from the embankment can be used for in-channel and floodplain habitat. The primary spillway further to the east will be removed to allow the tributary to flow freely and join the mainstem past the existing embankment.

Excavated soils could be placed along the upstream and downstream edges of the remaining earthen berms so material will not have to be disposed of off-site.

Lower Lynde Basin

Lower Lynde Dam will also be removed as well as the pump house on the right side of the spillway. Similar to the Upper Lynde Dam, approximately 75 to 100 feet of the dam embankment could be removed to provide channel and floodplain connectivity. At the edges of the floodplain, the embankment will be sloped at 2H:1V to the existing ground. Excavated soils could be placed along the upstream and downstream edges of the remaining earthen dam so material will not have to be disposed of off-site.

Spring Basin

The Upper and Lower Spring Basin Dams will also be removed. The Lower Spring Basin Dam will have 40 feet of the embankment removed to open up the floodplain and pathway for the channel. No channel or bank stabilization is needed for Lower Spring Basin Dam and passive downstream release of impounded sediment is proposed. An area along the hillslope east of the dam was identified as the likely source of earth material used to build the dam. This could be used to dispose of the excavated soils when removing the dam. The pump houses next to the spillway and downstream will also be removed. Upon removal of the Lower Spring Basin Dam, the impact of the Upper Spring Basin Dam on flow will be evaluated. If impacts are minimal or non-existent, no excavation will be required; if this dam is blocking fish passage, the portion of the dam in the channel will be removed.

DESIGN PROCESS AND SCOPE

Design

Based on our work to date, we have found no technical issues that would prevent progression of the dam removals into the next stages of design and permitting. Given the relatively simple design approach and relatively low risk of infrastructure, environmental, and other impacts with appropriate mitigation in place, we recommend a streamlined approach as follows:

- Preliminary 30% Design – In this first phase, basic sediment sampling and analyses would be carried out to determine the quality of impounded sediment and confirm the proposed sediment management approach. Additional survey and depth of refusal data would also be collected and utilities searches carried out so that earthwork volumes can be firmed up and cost estimates and modeling refined. Finally, other reconnaissance level surveys necessary for determining permitting requirements should be carried out if needed. We recommend a pre-application meeting with permitting agencies at the end of the 30% design phase to review the plans and collect feedback prior to progressing the designs.

- Draft 100% Design – Our present assessment of site conditions and design concepts suggests that frequent progress submittals may not be required. We recommend proceeding directly from 30% design to a draft 100% design submission that would be utilized for permit applications. This design phase would likely involve developing design details, wetland delineations, documenting regulated resource area impacts, and drafting technical specifications.
- Permitting – The details of the anticipated permitting needs of the project are outlined in the next section.
- Final 100% Design – The designs would be finalized following receipt of the permits. Permit conditions would be incorporated into the final bid package consisting of the drawings, technical specifications, and up-front sections of the project manual.

Permitting

The typical environmental permits will be required for the removal of these dams. Work for all dams should be incorporated into a single set of permits, rather than submitting permits for each dam separately. While the permitting process can be complicated, a number of very helpful resources have been developed to help project proponents through the permitting process:

- MassDEP, 2007 - Dam Removal and the Wetland Regulations - provides information about permitting issues and review considerations http://www.mass.gov/dep/water/resources/dampol.pdf
- Executive Office of Energy and Environmental Affairs, 2007 - Dam Removal in Massachusetts: A Basic Guide for Project Proponents - provides information of the dam removal process including feasibility studies, the permitting process, and funding opportunities http://www.mass.gov/eea/docs/eea/water/damremoval-guidance.pdf
- MassDOT has a number of documents useful for permitting including a permit table with general permit thresholds and a permit timeline document http://www.mhd.state.ma.us/default.asp?pgid=content/environ/envpublications02&sid=about
- MA Division of Ecological Restoration - MA DER staff developed a document that summarizes the permits and the permitting process for most restoration and dam removal projects. This is not meant as guidance from a regulatory agency, but is a useful tool based on years of collective experience with DER.

For restoration and dam removal projects, we have found it beneficial to approach agencies in advance of a filing to discuss any issues or concerns that may arise, such that these can be addressed prior to the filing of permit applications. This can be done through an informal interagency meeting involving all project partners (i.e., pre-application meeting) or through consultation with individual regulatory agencies. In addition, we recommend that the project partners engage the MA Historical

Commission (MHC) early in the project planning through the completion of a Project Notification Form in order to address the potential for historical or archaeological issues that may arise and to determine if further investigation and or permitting/approvals will be required.

The following permits are likely necessary for the removal of the dams analyzed here:

- Massachusetts Environmental Policy Act (MEPA) Environmental Notification Form (ENF);
- WW26 Combined Chapter 91 Dredge Permit and 401 Water Quality Certification (MassDEP);
- Chapter 253 Dam Safety (Department of Conservation and Recreation);
- Project Notification Form (Massachusetts Historical Commission);
- Section 404 authorization (Army Corps of Engineers); and
- Wetlands Protection Act Ecological Restoration Notice of Intent – Sterling Conservation Commission and MassDEP.

Massachusetts Environmental Policy Act

Projects with state funding or state permits will require review through the Massachusetts Environmental Policy Act (M.G.L. c. 30 §§ 61 through 62H, inclusive) or MEPA. Thresholds requiring review under MEPA are described in the regulations at 301 CMR 11.03, and typically the scope of the review is confined to the land uses and the thresholds which are triggered. Multiple thresholds will likely be exceeded for the removal of these dams, including the removal of a jurisdictional dam.

The ENF review process is takes approximately five weeks from the date of filing until the Secretary of EEA issues a Certificate); however, preparation of a subsequent EIR generally takes considerable additional time and effort if required. Dam removal projects of this nature are typically submitted as an Expanded ENF (EENF) with an EIR waiver request, where the project is likely to cause minimal harm to the environment and those impacts are well documented and understood as part of the EENF submittal process.

WW26 Combined Chapter 91 Dredge Permit and Section 401 Water Quality Certification

Because of impacts to river bank, land under water, and wetlands, the project will need to undergo permitting under Section 401 of the federal Clean Water Act (33 U.S.C. 1251, et seq.) for a Water Quality Certification (WQC) as well as under the Public Waterfront Act (M.G.L. Ch. 91) and its regulations at 310 CMR 9.00, both issued by MassDEP. These can be combined into a single permit under WW26.

Jurisdictional Determination, Chapter 253 Permit with the Massachusetts Office of Dam Safety

A Massachusetts Chapter 253 Dam Safety Permit is required for work that alters a jurisdictional dam structure beyond normal maintenance activity. This will be required for the removal of Fitch Basin Dam and the Upper and Lower Lynde Basin Dams.

MHC Project Notification Form

The Massachusetts Historical Commission (MHC) will be notified of the proposed project boundaries so they can make a determination of the need for more detailed historical and archaeological surveys.

Authorization under Massachusetts Programmatic General Permit - Section 404 Army Corps of Engineers

The proposed project will also require authorization from the Corps under Section 404 of the federal Clean Water Act for alterations to waters of the United States. Dam removal projects are covered under provisions in the Massachusetts Programmatic General Permit (PGP) that allow for projects involving the restoration of streams and wetlands and/or aquatic habitat restoration to be reviewed and approved under a Category 2 (PGP). Along with the PGP application, proper notification must be made to the Massachusetts Historical Commission (MHC) and regional Tribes. A pre-application meeting with the Corps is encouraged.

Massachusetts Wetlands Protection Act

As the project will involve alterations to wetland resource areas and/or associated buffer zones, the project partners will be required to file an Ecological Restoration Notice of Intent (NOI) application with the Sterling Conservation Commission, copied to the regional office of the Massachusetts Department of Environmental Protection (MassDEP). Projects must meet the performance standards under the Wetlands Protection Act regulations at 310 CMR 10.00 for impacts to the various resource areas (anticipated for this project to include Bordering Vegetated Wetland (BVW), Inland Bank, Land Under Waterbodies and Waterways, and Riverfront Area).

Along with the NOI application materials, all abutters must be notified about the pending project and the date of the public hearing by certified mail, return receipt requested or through Certificate of Mailings. The Conservation Commission public hearing is a forum to describe the project to the Commission and for the Commission to hear public comments on the project.

COST ESTIMATE

A planning level opinion of probable implementation cost is provided in Appendix B. Costs include construction as well as consultant fees for design, permitting, and construction oversight but do not include costs associated with easements or land purchases or other costs incurred by the owner. The cost opinion was developed based on review of construction costs for similar items in past projects and applicable reference cost data. Costs are given in 2019 USD, and the actual implemented cost may vary from this estimate, based on market factors, detailed design development and possible optimization, year of construction, and other factors.

Several assumptions were made in developing costs. Key assumptions include:

- The approach to sediment management will be primarily passive release;
- Material excavated from the embankment portions of the dams will be reused on site; and
- Removal of the pump houses will involve removal of the above ground portions of the structures only, leaving foundations and buried infrastructure in place, and no hazardous materials (e.g., asbestos) will be encountered.

We applied a contingency of 40% to the estimated construction costs to account for uncertainty associated with earthwork volumes, uncertainty associated with the bidding and the construction process, uncertainty or future changes in unit costs, and other scope or design changes that may arise during the design process or as a result of permit conditions.

We have estimated a total project delivery cost (i.e., design, permitting, and construction oversight) based on previous experience with dam removals in Massachusetts and the anticipated duration of construction. We have assumed oversight will only be required during key construction activities such as verifying removal of the full vertical extents of structures. The total cost should be considered an order of magnitude cost; this estimate will be refined in future design phases.

We have also provided order of magnitude costs for implementation of potential culvert replacements and daylighting in the Heywood Road area. We have assumed that the Wekepeke Brook and tributary Heywood Road culverts would be replaced, and the dirt access road culverts would be removed.

Costs at concept level design are based on limited information and therefore have a wide accuracy range. Industry guidance suggests that the accuracy at concept level could be as broad as -50% to +100% or as narrow as -20% to +30% (AACE 2016).

PROJECT SCHEDULE

A basic project schedule for design and permitting based on currently available information is:

- Preliminary 30% Design including pre-application meeting and agency review – 4 months
- Draft 100% Design – 4 months;
- Permitting – 9 to 12 months; and
- Final 100% Design – 2 months.

We anticipate that preliminary 30% design would take approximately four months to complete. The actual timing and duration of the work will depend on site conditions for the additional survey. Commencement of the draft 100% design phase would begin following the pre-application meeting with and 30% design review by permitting agencies. Depending on the time of year, it could take up to a month or more to receive all comments.

The construction period for the dam removals is expected to be approximately one month in duration. The timing of construction will be constrained by time of year restrictions for fish and may depend on the availability of funding.

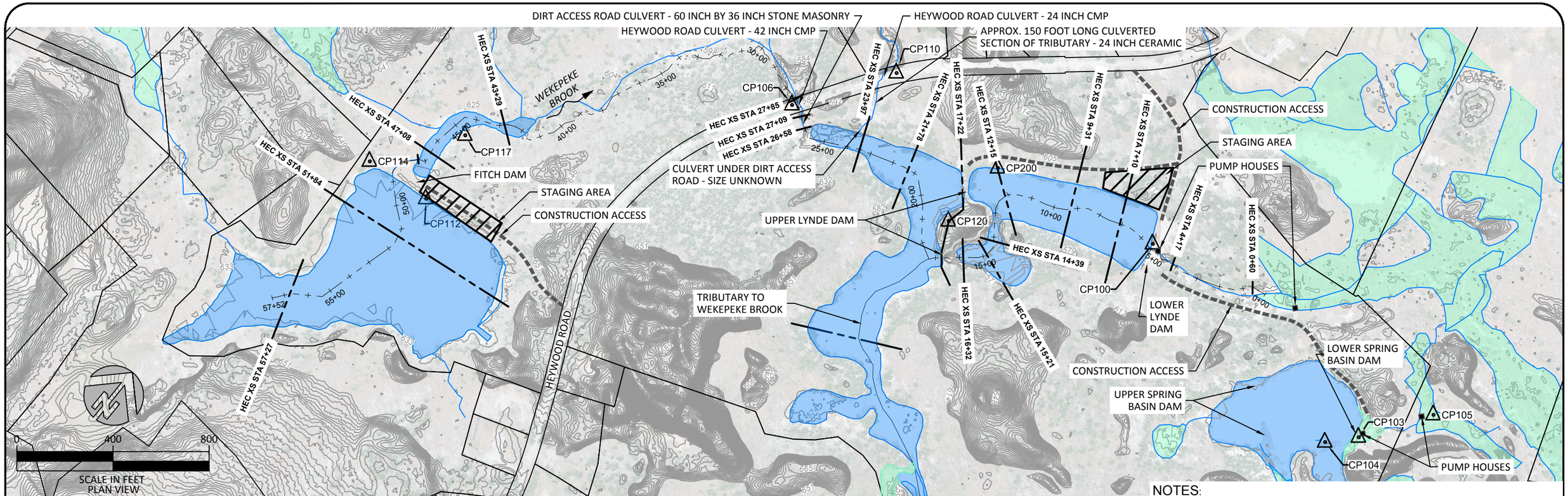
References

[AACE] AACE International, 2016. AACE International Recommended Practice 18R-97. Cost Estimate Classification System – As Applied in Engineering, Procurement, and Construction for the Process Industries. March 1, 2016.

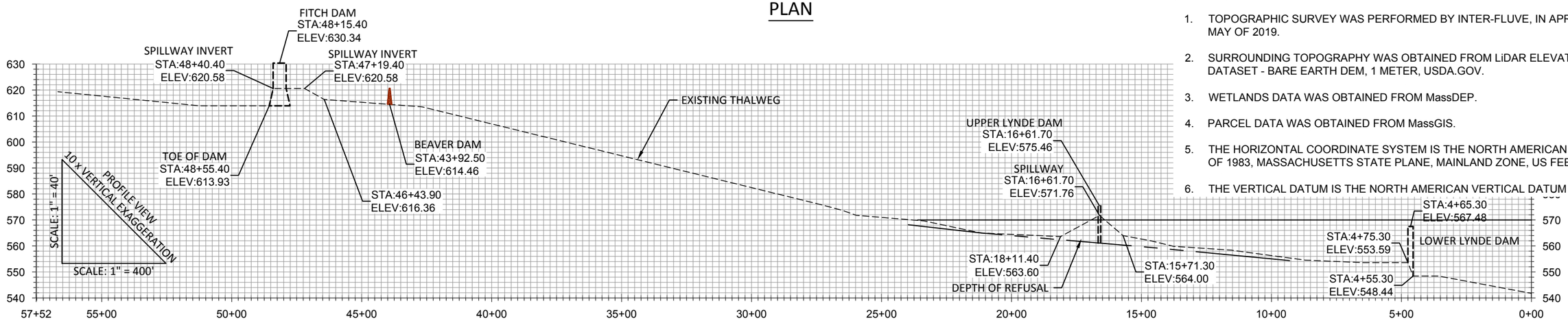
Weston & Sampson Engineers, 2016. Fitch Basin Dam Phase 1 Inspection/Evaluation Report. Prepared for the Town of Clinton. March 2016.

Weston & Sampson Engineers, 2016. Upper Lynde Basin Dam Phase 1 Inspection/Evaluation Report. Prepared for the Town of Clinton. March 2016.

Appendix A – Concept Drawings



PLAN



PROFILE

NOTES:

1. TOPOGRAPHIC SURVEY WAS PERFORMED BY INTER-FLUVE, IN APRIL AND MAY OF 2019.
2. SURROUNDING TOPOGRAPHY WAS OBTAINED FROM LiDAR ELEVATION DATASET - BARE EARTH DEM, 1 METER, USDA.GOV.
3. WETLANDS DATA WAS OBTAINED FROM MassDEP.
4. PARCEL DATA WAS OBTAINED FROM MassGIS.
5. THE HORIZONTAL COORDINATE SYSTEM IS THE NORTH AMERICAN DATUM OF 1983, MASSACHUSETTS STATE PLANE, MAINLAND ZONE, US FEET.
6. THE VERTICAL DATUM IS THE NORTH AMERICAN VERTICAL DATUM OF 1988.

SURVEY CONTROL

PN	EASTING	NORTHING	ELEVATION (FT)
CP100	582100.14	2997502.47	571.23
CP103	583275.01	2997471.94	545.85
CP104	583183.95	2997363.92	544.61
CP105	583445.32	2997748.51	535.37
CP106	580594.76	2996935.45	585.53
CP110	580831.05	2997323.88	590.61
CP117	579663.18	2995936.21	624.36
CP120	581402.90	2997008.25	581.59
CP200	581408.67	2997309.46	569.52
CP112	579717.32	2995630.93	632.02
CP114	579438.57	2995591.34	639.66

LEGEND

- EXISTING CONTOUR
- PARCEL BOUNDARY
- EXISTING MassDEP WETLANDS
- EXISTING SURFACE WATER
- PROPOSED STAGING AREA
- PROPOSED CONSTRUCTION ACCESS

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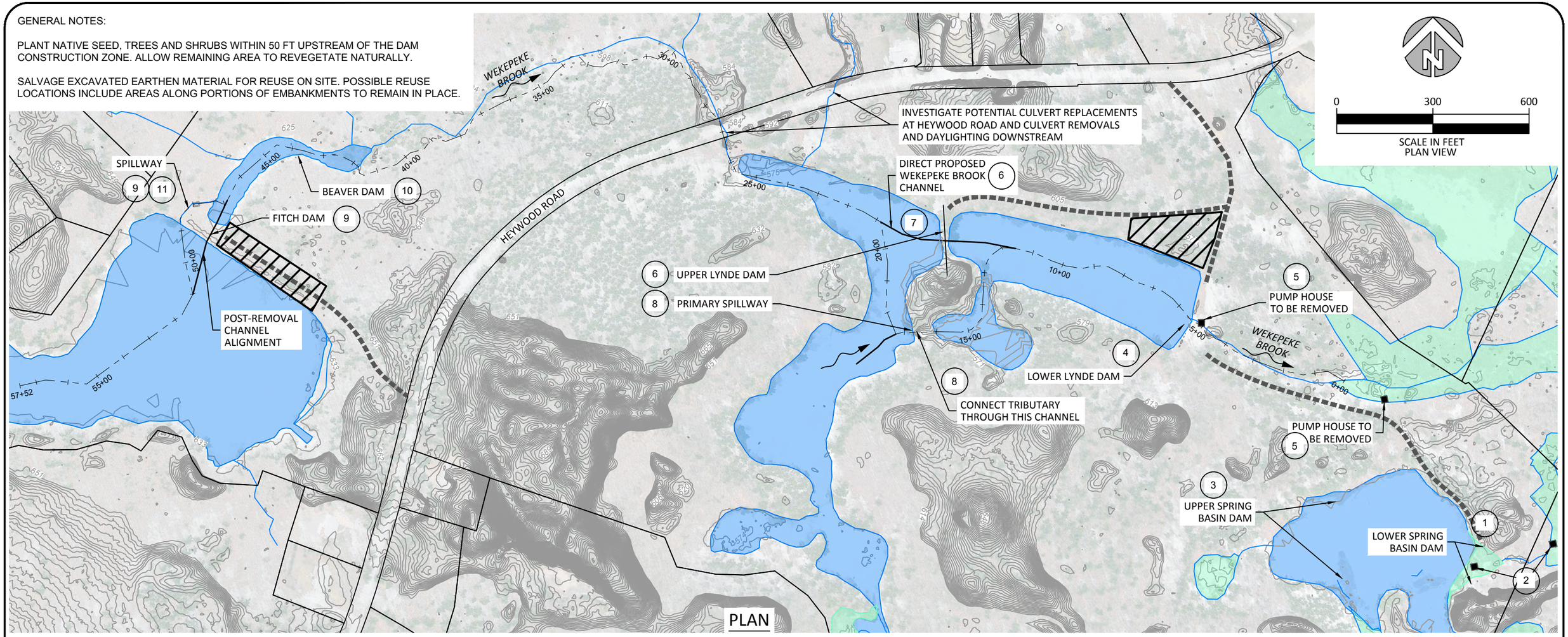
WEKEPEKE BROOK EXISTING CONDITIONS AND PROPOSED CONSTRUCTION STAGING AND ACCESS

GENERAL NOTES:

PLANT NATIVE SEED, TREES AND SHRUBS WITHIN 50 FT UPSTREAM OF THE DAM CONSTRUCTION ZONE. ALLOW REMAINING AREA TO REVEGETATE NATURALLY.

SALVAGE EXCAVATED EARTHEN MATERIAL FOR REUSE ON SITE. POSSIBLE REUSE LOCATIONS INCLUDE AREAS ALONG PORTIONS OF EMBANKMENTS TO REMAIN IN PLACE.



FITCH DAM NOTES:

9 NOTCH DAM AND ALLOW RESERVOIR TO DRAW DOWN. REMOVE FULL VERTICAL EXTENT OF DAM. USE EXCAVATED MATERIAL FOR FILL IN FORMER SPILLWAY.

10 NOTE THAT BEAVER DAMS DOWNSTREAM OF FITCH DAM ELEVATE THE WATER UPSTREAM.

11 MOVE SPILLWAY FOOTBRIDGE TO THE NEW STREAM LOCATION TO MAINTAIN PEDESTRIAN ACCESS.

UPPER LYNDE DAM NOTES:

6 REMOVE 50 FEET OF EARTHEN BERM TO FULL VERTICAL EXTENT, AND SLOPE UP 2:1 TO EXISTING GROUND. DIRECT PROPOSED WEKEPEKE BROOK CHANNEL THROUGH NEW CHANNEL.

7 SALVAGE TREES REMOVED TO ENABLE DAM REMOVAL AND REUSE FOR CHANNEL AND FLOODPLAIN HABITAT PLACEMENT.

8 REMOVE PRIMARY SPILLWAY AND ALLOW TRIBUTARY TO FLOW THROUGH.

LOWER LYNDE DAM NOTES:

4 REMOVE EARTHEN BERM AND SLOPE UP 2:1 TO EXISTING GROUND.

5 DEMOLISH AND REMOVE TWO PUMP HOUSES. FILL ANY HOLES LEFT BY REMOVAL.

SPRING BASIN NOTES:

1 REMOVE 20 FEET OF LOWER SPRING BASIN EARTHEN DAM WITH CONTROLLED, SLOW DRAWDOWN. NO TRAIL/CROSSING NEEDED.

2 DEMOLISH AND REMOVE TWO PUMP HOUSES. FILL ANY HOLES LEFT BY REMOVAL.

3 REMOVE 20 FEET OF FORMER UPPER SPRING BASIN DAM IF PERCHED CONDITION EXISTS AFTER LOWER DAM REMOVAL.

LEGEND

- EXISTING CONTOUR
- PARCEL BOUNDARY
- EXISTING DEP WETLANDS (2005)
- EXISTING IMPOUNDED WATER
- PROPOSED STAGING AREA
- PROPOSED CONSTRUCTION ACCESS

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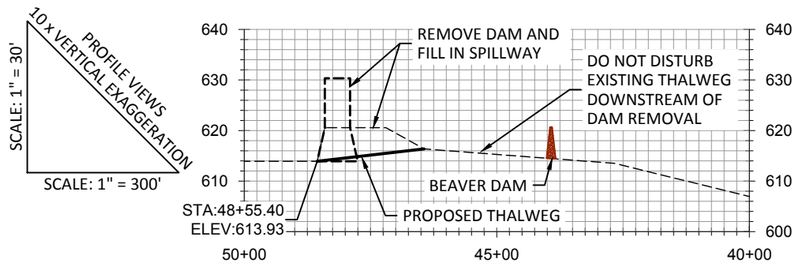
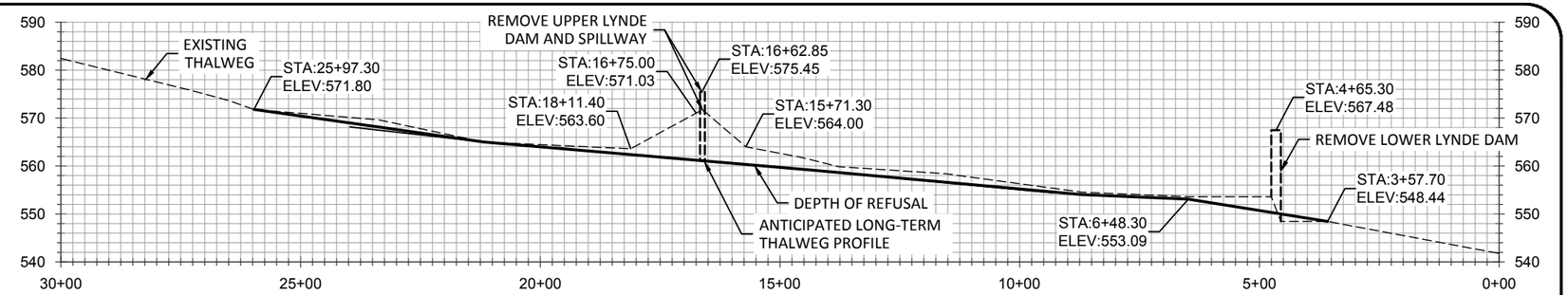
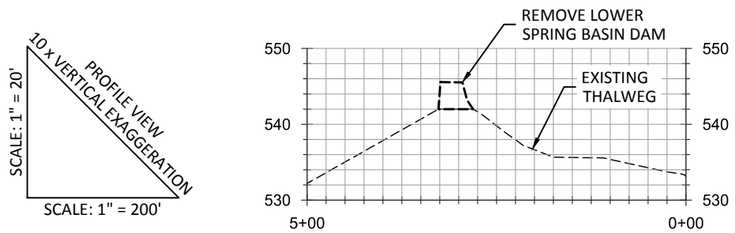
WEKEPEKE PROPOSED CONDITIONS PLAN



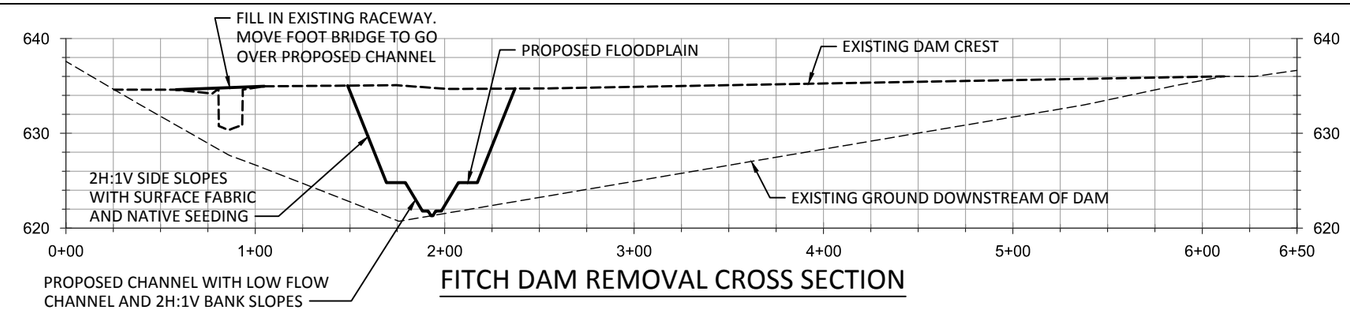
FITCH DAM REMOVAL PROFILE



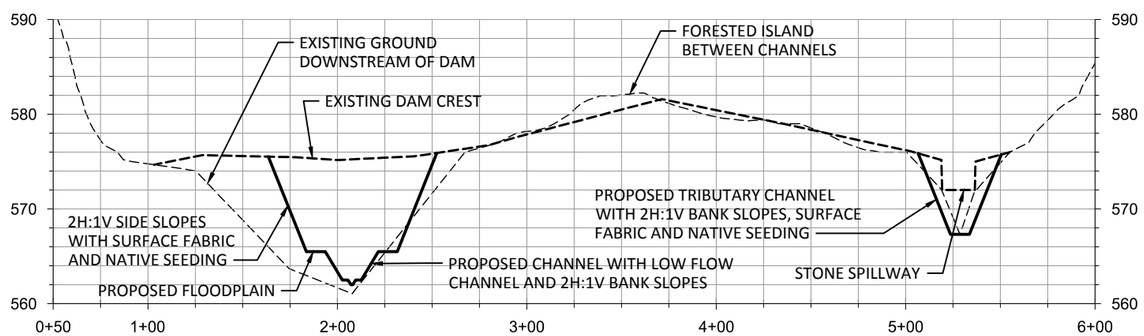
UPPER AND LOWER LYNDE DAM REMOVAL PROFILE



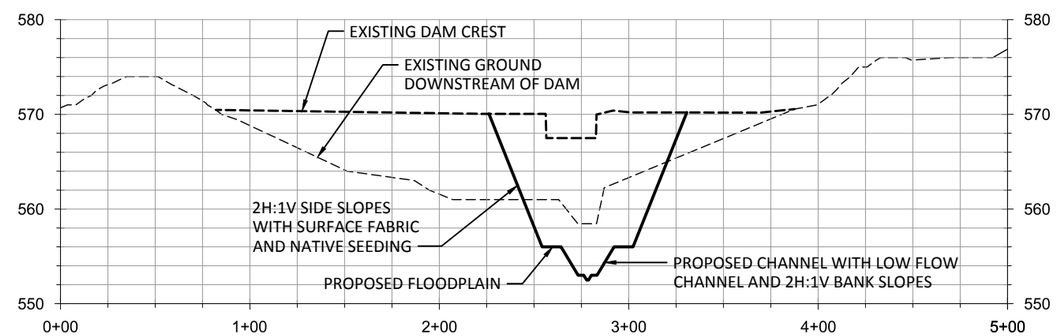
LOWER SPRING BASIN DAM REMOVAL PROFILE



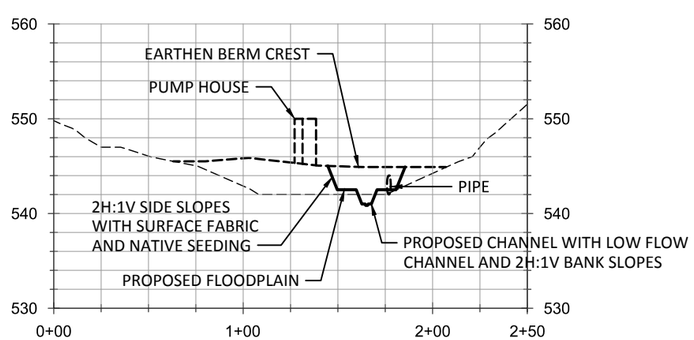
FITCH DAM REMOVAL CROSS SECTION



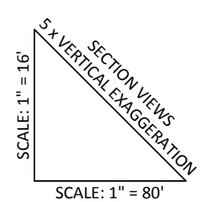
UPPER LYNDE DAM REMOVAL CROSS SECTION



LOWER LYNDE DAM REMOVAL CROSS SECTION



LOWER SPRING BASIN DAM REMOVAL CROSS SECTION



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WEKEPEKE PROPOSED CONDITIONS PROFILES & SECTIONS

Appendix B – Cost Estimate

Wekepeke Brook						
No.	**Item**	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**	**Notes**
Initialization						
1	Mobilization/ Demobilization	1	LS	$ 57,760	$ 57,800	20% of remaining items
2	Erosion, Pollution & Water Control	3	LS	$ 15,000	$ 45,000	With passive release of sediment, this item covers minimal needs for water control, isolated pumping as needed, silt fence, turbitidy curtain. Includes water management for removal of full vertical extents of dam structures.
3	Clearing and grubbing	3	LS	$ 8,000	$ 24,000	Removal of trees along Upper Lynde Dam and placement within the proposed channel and floodplain on either side of the dam. Clearance along access roads.
Dam Removal						
4	Demolition and disposal	1	LS	$ 100,000	$ 100,000	Demolition and disposal of reinforced concrete at the spillways of the Lynde Dams as well as the removal of four gatehouses. Assumes no special disposal conditions (no asbestos, etc.)
5	Excavation and reuse of embankment material	2,350	CY	$ 25	$ 58,800	Excavation and on-site reuse of embankment soil and rock.
Revegetation						
7	Biodegradable erosion control fabric	4,000	SF	$ 3	$ 12,000	Surface fabric on proposed dam edge slopes following removal.
8	Seeding	1	AC	$ 9,000	$ 9,000	Appropriate native seed mix applied to directly impacted areas.
9	Planting	500	EA	$ 80	$ 40,000	Native trees and shrubs in 2-gallon containers
				Construction Subtotal	$ 346,600	
				Contingency (40%)	$ 138,600	
				Project Contruction Total	**$ 485,200**	

Project Delivery Costs	
Design/Permitting (approx. 30% of construction)	$100,000
Construction Observation (approx. 20% of construction)	$69,000
Project Delivery Costs Total	**$169,000**
Total Project Costs	**$654,200**

ALT1	Heywood Road replacement (Wekepeke Brook)	1	LS	$ 500,000	$ 500,000	Assumes culvert less than 10 feet wide. Includes implementation costs.
ALT2	Heywood Road culvert replacement and daylighting of culverted section beneath field (tributary to Wekepeke Brook)	1	LS	$ 750,000	$ 750,000	Assumes culvert less than 10 feet wide. Includes implementation costs.
				Construction Contingency (40%)	$ 500,000	
				Material and Bidding Contingency (20%)	$ 250,000	
				Culvert Total	**$ 2,000,000**	