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Replacement of Main Road Culvert over Konkapot River Conceptual Design Report

Town of Monterey

State Route 23, Monterey, MA

June 25, 2020
GZA File No. 01.0174558.00

PREPARED FOR:
Town of Monterey
Monterey, MA

GZA GeoEnvironmental, Inc.
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June 25, 2020
File No. 01.174558.00

Shawn Tryon,
Director of Operations, Department of Highways, Buildings and Properties
Town of Monterey, MA 01245

Re: Replacement of Main Road Culvert over Konkapot River
Conceptual Design Report
Monterey, Massachusetts

Dear Mr. Tryon:

GZA GeoEnvironmental, Inc. (GZA) is pleased to present to the Town of Monterey the enclosed Conceptual Design Report for the culvert at the crossing of Main Road (State Route 23) and the Konkapot River. The report was prepared in accordance with the Agreement for Professional Services accepted on February 24, 2020. Our report is subject to the Limitations contained in **Appendix A.**

GZA evaluated design alternatives for proposed replacement of the culvert that would reduce flood hazards and potential scour at the stream crossing, as well as an additional alternative for flood risk management upstream of the culvert. The study developed information and data needed to evaluate the problem and propose alternatives for conceptual solution.

GZA appreciates the opportunity to continue to provide engineering services to the Town of Monterey. Please contact Chad Cox at 781-278-5787 or via email at chad.cox@gza.com if you have any questions or concerns.

Very truly yours,
GZA GEOENVIRONMENTAL, INC.

Media Sehatzadeh
Assistant Project Manager

James P. Guarente, P.E.
Consultant/Reviewer

Chad Cox, P.E.
Principal in Charge

Attachments:
Replacement of Main Road Culvert over Konkapot River Conceptual Design Report

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INTRODUCTION

On February 24, 2020, GZA entered into an agreement with the Town of Monterey (The Town) to execute a culvert replacement study associated with Main Road Culvert over Konkapot River in Monterey, Massachusetts. The culvert was identified by the Town as potentially undersized, and therefore, possibly a contributor to flooding in the Monterey Town Hall. This study developed information and data needed to evaluate the problem and propose a conceptual solution. This report and its attachments are subject to the Limitations contained in **Appendix A**.

This study was partially funded by a Municipal Vulnerability Preparedness (MVP) grant from the Commonwealth of Massachusetts. The Berkshire Regional Planning Commission is providing administrative and outreach work as part of the project.

BACKGROUND

The existing culvert is located at the crossing of Main Road (State Route 23) over the Konkapot River, between street address numbers 437 (a house adjacent to the river's left bank) and 435 (Monterey Town Hall). The structure is a 15-foot wide, 10-foot high, about 40-foot long corrugated metal pipe (CMP) arch culvert with a concrete headwall and concrete training walls on the upstream side. On the downstream side, there is concrete wingwall on the left side of the culvert, with riprap on the right river bank. (Note that left and right as used in this report are oriented based on facing downstream.) The road is classified in MassDOT road Inventory as Rural Major Collector or Urban Minor Arterial roadway. The culvert is within a special flood hazard area, Zone A, as delineated by FEMA in Flood Insurance Rate Map 2500300010B, effective June 15, 1981.

Konkapot River flows out of Lake Garfield dam about 0.9 mile upstream of the culvert. Other structures on the Konkapot River include a footbridge about 250 feet upstream of the culvert, and Old Stone Dam about 300 feet downstream of the culvert. Old Stone Dam was measured by GZA to be a 12.6 feet high masonry dam, with an approximately 8-foot wide spillway. The normal pool was observed to be about 2 inches lower than the dam crest at the time of site visit.

The culvert was last inspected by MassDOT in December 2018, and rated to be in satisfactory condition, i.e. 6 out of 10. MassDOT cited 4 deficiencies including exposed wingwall footings, rust in the corrugated metal pipe, coating failure, and isolated cracks. The report is provided in **Attachment B**.

Openness ratio of the existing culvert, i.e. its cross-sectional area by its length, is estimated to be 2.8 feet, which is significantly higher than the minimum recommended openness ratio of 0.82 feet according to the Massachusetts Stream Crossing Standards. The existing pipe arch bottom was observed to be covered in a substrate material generally similar to upstream and downstream natural material to a depth of about 0.5 feet. The Stream Crossing Standards recommend a minimum of 2 feet of cover over culvert bottoms.

In general, the structural condition of the culvert appears to be fair, with no significant deterioration or damage evident to the culvert structure, headwalls, or associated concrete training walls. No significant scour was observed upstream or downstream of the culvert. Utilities which cross the river at the culvert include an underground potable water line and overhead wires.

GZA has reviewed the existing condition survey, photos, field notes from our site visits, and readily available Geographic Information System (GIS) data layers to evaluate the existing site constraints to support the development of alternatives to address flooding issues immediately upstream of the culvert. The following includes a description of the data collected on the project site.

DATA COLLECTION AND DEVELOPMENT

WETLAND DELINEATION

The Project Area inspection and boundary delineation was conducted by GZA field staff in March 2020 in accordance with definitions in the Massachusetts Wetlands Protection Act (WPA) regulations, 310 CMR 10.00 and under Section 404 of the federal Clean Water Act. GZA also conducted a pebble count in a representative location to support performance and analysis of stream characteristics and substrate to be used as a reference, should a replacement crossing design alternative be pursued.

GZA has identified several resource areas subject to protection and/or jurisdiction under the WPA, on or within 100 feet of the Project Area, and has delineated the boundaries of these areas that exist within the Project Area. Refer to the full Wetland Delineation Report included herein as **Attachment C** for further description of the wetland resources associated with the project area, as well as results of the pebble count.

TOPOGRAPHICAL SURVEY

Hancock Associates Inc. of Marlborough, MA, in association with GZA as lead consultant, completed a topographical survey of the culvert. Results of the survey including the area around the roadway and culvert, showing cross sections and longitudinal profile of Konkapot River, are presented in **Attachment D**.

BANKFULL MEASUREMENT

GZA conducted a site visit on March 24, 2020 to assess the natural stream's bankfull conditions and perform bankfull width measurements. To estimate the natural condition, GZA performed the measurements at several locations extending up to approximately 400 feet upstream of the culvert. The locations of the selected measurements were evaluated to be at adequate distances from the culvert and therefore not affected by the backwater from the culvert. Bankfull width at these locations was measured to be 20.5 feet to 21 feet from top of the bank in accordance with North Atlantic Aquatic Connectivity Collaborative (NAACC) guidelines.

GEOTECHNICAL INVESTIGATION

New England Boring Contractors (NEBC) of Brockton, MA, in association with GZA as lead consultant, completed soil borings on April 8 and 9, 2020. GZA personnel coordinated, observed, and logged a total of two test borings. Results of the explorations and recommendations regarding culvert foundation design are summarized in our Geotechnical Report which is included herein as **Attachment F**.

HYDRAULIC AND HYDROLOGIC (H&H) ANALYSES

GZA evaluated the hydrology and hydraulics of Konkapot River in the vicinity of the culvert. River flow rates were generated from the USGS StreamStats Web Application. The results of which are as follows:

Table 1 - Peak Flow Estimates in Konkapot River at Main Road Culvert from StreamStats

Return Period	Estimated Peak Flow from StreamStats (cfs)
2-Year Flood	330
5-Year Flood	566
10-Year Flood	766
25-Year Flood	1,070
50-Year Flood	1,330
100-Year Flood	1,620
200-Year Flood	1,930
500-Year Flood	2,400
Bankfull Flow (1- to 2- Year Flood)	221

GZA developed a one-dimensional hydraulic model of the stream channel in the project area, including the upstream reach within more than 600 feet of the culvert, the culvert, and the downstream reach ending more than 2,600 feet from the culvert, including the downstream Old Stone Dam. The model was created using the U.S. Army Corps of Engineers HEC-RAS computer program. GZA modeled the system under existing conditions to estimate peak water surface elevations resulting from flows related to various flood return periods. GZA also modified the model to assess water surface elevations resulting from hypothetical proposed alternative conditions, including the replacement of the existing CMP arch culvert at Main Road with precast concrete box culverts of various geometries. The assessment of alternatives started with a box culvert of the same width as the existing structure. The box culvert's rectangular shape provides more flow area than the arch-shaped existing culvert. Three-sided, open bottom, pre-cast concrete structures are also an alternative and we judge would perform identically from a hydraulic standpoint. Criteria for evaluating these alternatives are listed in Design Criteria Section. Culverts with additional widths were also modelled.

The results indicate that the existing culvert has enough hydraulic capacity to pass the design flood (25-year flood) without freeboard. This results in backwater upstream of Main Road, including inundation of the Monterey Town Hall building. The house at 437 Main Road has a side adjacent to the left riverbank and can therefore be considered vulnerable to being flooded in general. During floods equal to or larger than 10-year flood, the house at 441 Main Road may be affected by flood waters. During floods equal to or larger than 25-year flood, the house at 445 Main Road may also be subject to flood impacts.

Design alternatives (for a similar open bottom structure) with a span equal to or wider than 16 feet were found to have the hydraulic capacity to pass the design flood with 2 feet of freeboard, per MassDOT requirements. With a 16-foot wide box culvert in place, peak water surface during the design flood is not estimated to reach the lowest ground surface elevation adjacent to Town Hall (elevation 1254.5 feet NAVD88). However, during the 100-year flood, peak water surfaces would result that are approximately 0.5 feet above that elevation. A design alternative with span of 25 feet, which requires modification of the river channel, particularly on the upstream of the culvert, complies with Massachusetts stream crossing standards (MSCS) requirement for minimum span of 1.2 times the bankfull width. The 25-foot span also provides the greatest mitigation of upstream flooding impacts of the alternatives studied. With the 25-foot span alternative in place, the peak 100-year flood elevation in the area of Town Hall is estimated as elevation 1253.5 feet, or approximately 0.5 feet below the lowest exterior grade of Town Hall.

GZA also considered the potential for upstream flood mitigation strategies that do not involve alterations to the existing culvert. The primary alternative that was considered was the construction of linear flood barriers in the form of flood walls / flood levees adjacent to the banks. Water surface elevations generated by the existing conditions model were used to establish the minimum recommended top elevations of the proposed flood barriers.

GZA also evaluated the potential impact of removing Old Stone Dam upon flood elevations upstream of Main Road, assuming the existing culvert would remain in place. The results indicated no significant reduction in flooding upstream of the culvert due to dam removal. However, removal of the dam does decrease peak flood elevations between the culvert and the dam.

Detailed discussion on the H&H analysis performed to evaluate alternatives, including depths and velocities during the flood can be found in **Attachment F** attached herein**.**

DESIGN CRITERIA

As part of work, GZA evaluated the MSCS and MassDOT's LRFD Bridge Manual[1] to establish design criteria for the replacement culvert. As detailed in the section titled Optimum Standards, the MSCS recommends sizing culverts such that the width is 1.2 times the bankfull width, when possible. During field investigations, GZA estimated the bankfull width at the culvert to be approximately 20.5 to 21 feet. This corresponds to a recommended span of 25 feet for the replacement culvert.

Any new or replacement structure with a span of over 10 feet is subject to MassDOT design requirements and review (with respect to the structure being classified as a "bridge"). MGL Chapter 85, Section 35 provides hydraulic, geotechnical, structural, and other design requirements for bridge spans greater than 10 feet. MassDOT classifies Main Road in Monterey as a Rural Major Collector or Urban Minor Arterial. For a roadway with this classification, in accordance with Chapter 85, the proposed culvert shall be designed to convey the 25-year flood and provide at least 2 feet of freeboard. The structure shall also be designed in accordance with AASHTO LRFD for HL-93 Design Loading per Chapter 85 design requirements.[2]

As part of GZA's assessment of potential flood mitigation benefits, GZA considered floods of up the so-called 100-year return period (1% annual recurrence interval). The Federal Emergency Management Agency uses the 100-year flood to establish its Zone A Special Flood Hazard Zones.

STRUCTURE TYPE ALTERNATIVES

With respect to flood risk management options, alternatives ultimately advanced and considered by GZA for this project include:

- **Alternative 1** – Replace existing 15-foot pipe arch culvert with 15-foot wide, 10-foot high box culvert (12 feet total height, including 2 feet embedment), or open-bottom equivalent, to increase the flow area without heavy modification to the training walls upstream;
- **Alternative 2** – Replace existing 15-foot pipe arch culvert with 18-foot wide, 10-foot high box culvert (12 feet total height, including 2 feet embedment), or open-bottom equivalent, with moderate modifications to the channel as

[1] LRFD Bridge Manual, MassDOT, 2013 Edition, Part 1.

[2] Municipal Bridge Projects MGL Chapter 85 Section 35 Review Process Design Requirements and Submittals for New Bridge and Full Bridge Replacement Projects.

needed. This option also includes construction of a 100-foot long berm in front of the Town Hall. The crown elevation of the berm is set at 1256 feet. i.e. at 100-year flood water elevation at the Town Hall;

- **Alternative 3** – Replace existing 15-foot pipe arch culvert with 25-foot wide, 10-foot high box culvert (12 feet total height, including 2 feet embedment), or open-bottom equivalent, with significant modifications to the channel as needed: This option has the span length compliant with MSCS, and provides more-than-adequate freeboard per MassDOT requirements;

GZA also evaluated another potential alternative to provide increased flood risk management upstream of the existing culvert:

- **Alternative 4** – Maintain existing 15-foot pipe arch culvert and provide flood barriers upstream up to 100-year flood level on one or both sides of the bank;

These four alternatives may be combined with acquisition of private properties inundated by the 100-year flood. In particular, the house at 437 Main Rd which has a side adjacent to the left riverbank and can therefore be considered vulnerable to being flooded in general.

With respect to structural and other considerations, the following issues were evaluated:

Utilizing a closed bottom 12-foot high concrete box culvert (including 2 feet embedment) for alternatives 1 through 3. This alternative is estimated to be preferable for smaller sizes when it comes to cost, footprint and constructability, as the precast box culvert can replace the existing culvert without the need for footings. However, for the 18-foot and 25-foot span alternatives, this option is expected to be less preferable because a structure of this span is likely to be outside the common range provided by manufacturers and would require significant modifications to the stream channel.

- Utilizing a three-sided, open bottom pre-cast culvert (rectangular or arch) with the same effective opening size for alternatives 1 through 3. Were this option selected, precast footings could be used to facilitate construction, but it is noted that these footings would need to be placed well below the stream invert to protect against potential scour. These footing excavations would then need to be backfilled with stream substrate, similar to a box culvert. This option is preliminarily evaluated as more likely to be the practical option for the 18-foot and 25-foot span alternative.

- Developing a combination of replacement culverts with hydraulic capacity equal to a 18-foot or 25-foot by 10-foot culvert for alternatives 2 and 3. The potential benefit to this would be to reduce the weight of individual pre-cast culvert segments which may in turn increase the constructability of the culvert replacement by reducing the size of lifting equipment needed at the site. However, this alternative would not be as beneficial with respect to aquatic habitat considerations and likely increase the potential for scour.

- For alternatives 1 through 3, replacement of the existing culvert would be expected to result in significant traffic issues during construction. At minimum, Main Road would be reduced to one-lane with a temporary traffic light controlling traffic traversing the temporary crossing. This condition would last for many months and adds significant costs to the project. A complete closure of the road would accelerate construction and reduce costs but would require a significant detour around the site.

- For alternative 4, sheet piles or concrete structures may be constructed as linear flood barriers. If concrete flood walls were selected, foundation excavation would likely be more extensive and result in a greater impact area than sheeting. Sheeting would have a very narrow footprint but vibration issues would need to be considered

during installation. On the culvert's east side, the barrier's location will likely have to align with existing training wall due to the location of private properties. It is also possible that some portions of the linear flood barriers could be constructed using earthen embankments, which would likely reduce costs.

ENGINEER'S PRELIMINARY OPINION OF PROBABLE CONSTRUCTION COST

GZA prepared a preliminary opinion of probable construction cost for work related to each alternative. The conceptual cost breakdown is included in **Attachment G** and includes work related to, but not limited to, demolition and removal of the existing culvert and concrete headwalls (for alternatives 1 and 2), installation and removal of erosion, sedimentation and water controls, installation of the new precast concrete box culvert and headwalls, road reconstruction, and related earthwork. Note this construction cost estimate does not include final design, permitting, and resident engineering costs during construction. The cost estimate information presented in **Attachment G** is for comparative, or general planning purposes only, and includes a 30 percent allowance for contingencies. Further, since GZA has no control over the labor and material costs required to plan and execute the anticipated work, our estimates were made using our experience and readily available information. Actual costs may vary over time and could be more, or less, than stated. Total preliminary probable construction costs for the four alternatives are as follows:

Table 2 – Engineer's preliminary opinion of construction cost for each design alternative

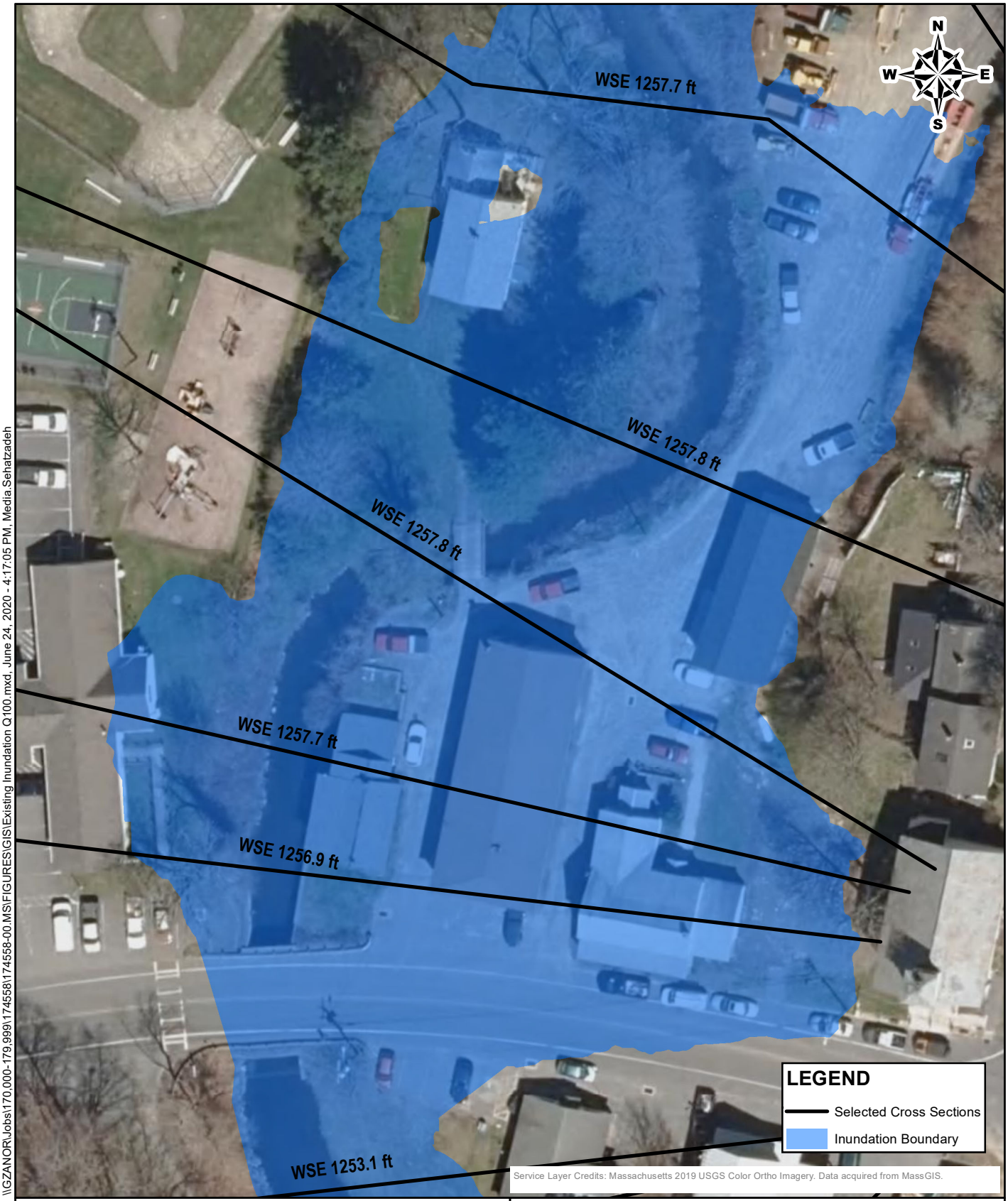
Alternative	Preliminary Probable Construction Cost
Alternative 1 - New 15' Culvert	$1,350,000
Alternative 2 - New 18' Culvert with Berm	$2,100,000
Alternative 3 - New 25' Culvert	$2,400,000
Alternative 4 - Upstream Flood Walls[1]	$1,170,000

Notes: (1) Alternative 4 cost includes flood walls on both sides. If flood protection is limited to the right bank where Town Hall is located, the cost would be anticipated to be reduced to approximately $650,000.
(2) Acquisition of the house at 437 Main Rd is not included in the alternatives. The house is adjacent to the bankline and is valued approximately $250,000 based on rough real estate estimates.

PRELIMINARY CONCEPTUAL DRAWINGS

GZA developed preliminary conceptual plans for the four alternatives discussed above based on data, evaluation, and analyses from the studies described herein. The preliminary plans are included in **Attachment H**. The existing conditions and survey base plan have been developed from a survey of existing features provided to GZA by Hancock Associates, dated March 23, 2020. GZA also prepared an Environmental Constraint Memorandum to identify potential permits required for moving forward, based on the proximity of protected environmental resources through the use of MassGIS databases relative to rare species, drinking water resources, outstanding water resources, etc. to supplement the wetland survey. The Environmental Constraint Memorandum is presented in **Attachment I.**

FIGURES



0 25 50 100

SCALE IN FEET

CULVERT REPLACEMENT AT MAIN ROAD MONTEREY, MA

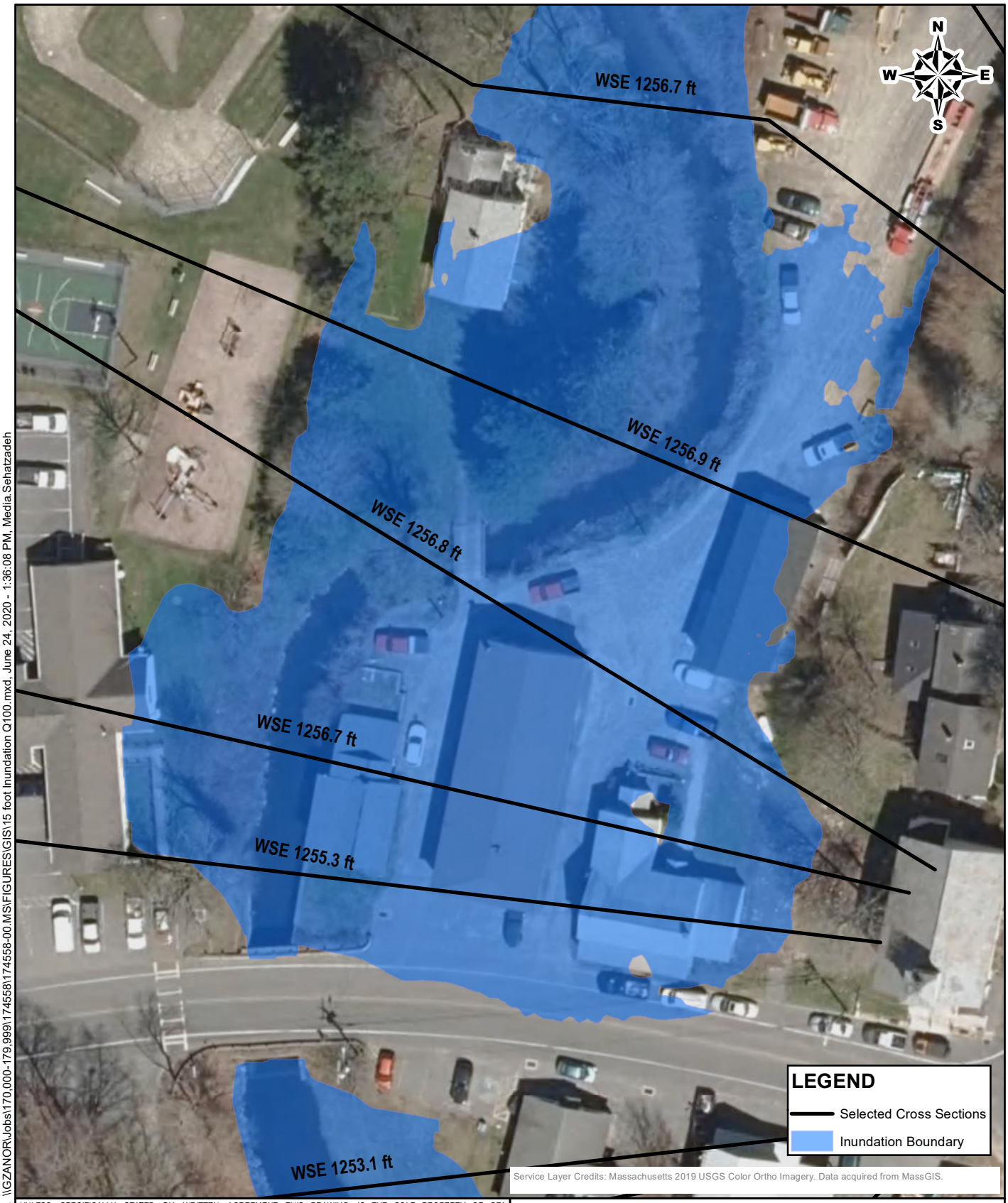
INUNDATION DURING 100-YEAR FLOOD EXISTING CULVERT

PREPARED BY:
GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

PREPARED FOR:
TOWN OF MONTEREY DEPARTMENT
OF PUBLIC WORKS
40 GOULD RD, P.O. BOX 308
MONTEREY, MA 1245

PROJ MGR:	MS	REVIEWED BY:	CWC	CHECKED BY:	JPG
DESIGNED BY:	MS	DRAWN BY:	MS	SCALE:	1 in = 50 ft
DATE:	06/24/2020	PROJECT NO:	01.0174558.00		

FIGURE 1



0 25 50 100

SCALE IN FEET

CULVERT REPLACEMENT AT MAIN ROAD
MONTEREY, MA

INUNDATION DURING 100-YEAR FLOOD
ALTERNATIVE 1 - 15-FOOT WIDE CULVERT

PREPARED BY:
GZA GeoEnvironmental, Inc.
Engineers and Scientists
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PREPARED FOR:
TOWN OF MONTEREY DEPARTMENT
OF PUBLIC WORKS
40 GOULD RD, P.O. BOX 308
MONTEREY, MA 1245

PROJ MGR:	MS	REVIEWED BY:	CWC	CHECKED BY:	JPG
DESIGNED BY:	MS	DRAWN BY:	MS	SCALE:	1 in = 50 ft
DATE:	06/24/2020	PROJECT NO:	01.0174558.00		

FIGURE 2

0 25 50 100
SCALE IN FEET

CULVERT REPLACEMENT AT MAIN ROAD
MONTEREY, MA

INUNDATION DURING 100-YEAR FLOOD
ALTERNATIVE 2 - 18-FOOT WIDE CULVERT

PREPARED BY:
GZA GeoEnvironmental, Inc.
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TOWN OF MONTEREY DEPARTMENT
OF PUBLIC WORKS
40 GOULD RD, P.O. BOX 308
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PROJ MGR:	MS	REVIEWED BY:	CWC	CHECKED BY:	JPG
DESIGNED BY:	MS	DRAWN BY:	MS	SCALE:	1 in = 50 ft
DATE:	06/24/2020	PROJECT NO:	01.0174558.00		

FIGURE 3

0 25 50 100

SCALE IN FEET

CULVERT REPLACEMENT AT MAIN ROAD MONTEREY, MA

INUNDATION DURING 100-YEAR FLOOD ALTERNATIVE 3 - 25-FOOT WIDE CULVERT

PREPARED BY:
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PREPARED FOR:
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OF PUBLIC WORKS
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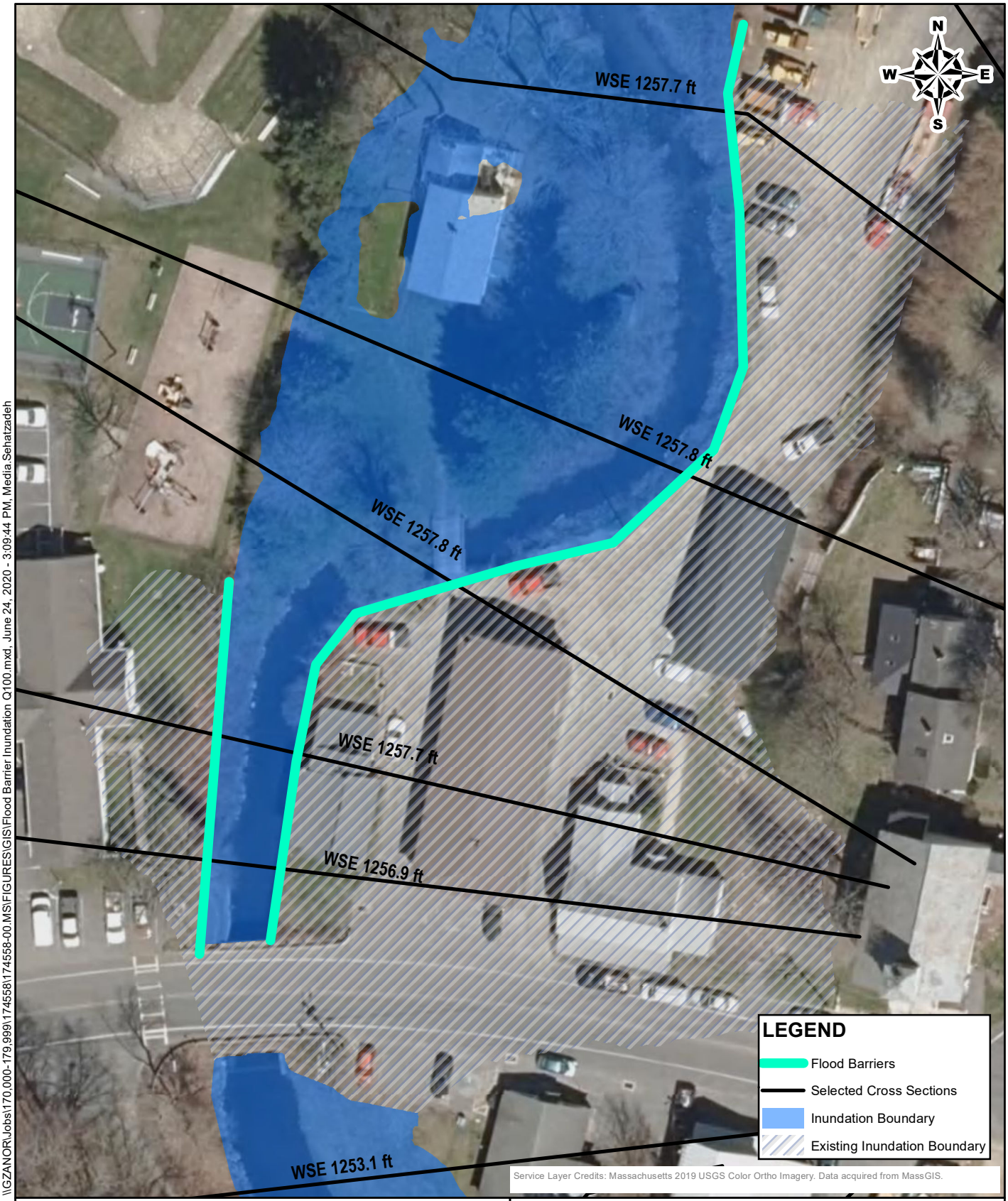
PROJ MGR:	MS	REVIEWED BY:	CWC	CHECKED BY:	JPG
DESIGNED BY:	MS	DRAWN BY:	MS	SCALE:	1 in = 50 ft
DATE:	06/24/2020	PROJECT NO:	01.0174558.00		

FIGURE 4



0 25 50 100
SCALE IN FEET

CULVERT REPLACEMENT AT MAIN ROAD
MONTEREY, MA

INUNDATION DURING 100-YEAR FLOOD
ALTERNATIVE 4 - NEW FLOOD BARRIERS

PREPARED BY:
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TOWN OF MONTEREY DEPARTMENT
OF PUBLIC WORKS
40 GOULD RD, P.O. BOX 308
MONTEREY, MA 1245

PROJ MGR:	MS	REVIEWED BY:	CWC	CHECKED BY:	JPG
DESIGNED BY:	MS	DRAWN BY:	MS	SCALE:	1 in = 50 ft
DATE:	06/24/2020	PROJECT NO:	01.0174558.00		

FIGURE 5

Attachment A – Limitations

ENGINEERING REPORT LIMITATIONS

Use of Report

1. GZA GeoEnvironmental, Inc. (GZA) prepared this report on behalf of, and for the exclusive use of the Town of Monterey, MA (Client) for the stated purpose(s) and location(s) identified in the Report. Use of this report, in whole or in part, at other locations, or for other purposes, may lead to inappropriate conclusions; and we do not accept any responsibility for the consequences of such use(s). Further, reliance by any party not identified in the agreement, for any use, without our prior written permission, shall be at that party's sole risk, and without any liability to GZA.

Standard of Care

2. Our findings and conclusions are based on the work conducted as part of the Scope of Services set forth in the Report and/or proposal and reflect our professional judgment. These findings and conclusions must be considered not as scientific or engineering certainties, but rather as our professional opinions concerning the limited data gathered during the course of our work. Conditions other than described in this report may be found at the subject location(s).
3. Our services were performed using the degree of skill and care ordinarily exercised by qualified professionals performing the same type of services at the same time, under similar conditions, at the same or a similar property. No warranty, expressed or implied, is made.

Subsurface Conditions

4. If presented, the generalized soil profile(s) and description, along with the conclusions and recommendations provided in our Report, are based in part on widely-spaced subsurface explorations by GZA and/or others, with a limited number of soil and/or rock samples and groundwater /piezometers data and are intended only to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized and were based on our assessment of subsurface conditions. The composition of strata, and the transitions between strata, may be more variable and more complex than indicated. For more specific information on soil conditions at a specific location refer to the exploration logs. The nature and extent of variations between these explorations may not become evident until further exploration or construction. If variations or other latent conditions then appear evident, it will be necessary to reevaluate the conclusions and recommendations of this report.
5. Water level readings have been made in test holes (as described in the Report), monitoring wells and piezometers, at the specified times and under the stated conditions. These data have been reviewed and interpretations have been made in this Report. Fluctuations in the groundwater and piezometer levels, however, occur due to temporal or spatial variations in areal recharge rates, soil heterogeneities, reservoir and tailwater levels, the presence of subsurface utilities, and/or natural or artificially induced perturbations.

General

6. The observations described in this report were made under the conditions stated therein. The conclusions presented were based solely upon the services described therein, and not on scientific tasks or procedures beyond the scope of described services or the time and budgetary constraints imposed by the Client.

7. In preparing this report, GZA relied on certain information provided by the Client, state and local officials, and other parties referenced therein available to GZA at the time of the evaluation. GZA did not attempt to independently verify the accuracy or completeness of all information reviewed or received during the course of this evaluation.

8. Any GZA hydrologic analysis presented herein is for the rainfall volumes and distributions and/or return periods stated herein. For storm conditions other than those analyzed, the response of the waterway, impoundment, and drainage structures and network has not been evaluated.

9. Observations were made of the site and of structures on the site as indicated within the report. Where access to portions of the structure or site, or to structures on the site was unavailable or limited, GZA renders no opinion as to the condition of that portion of the site or structure. In particular, it is noted that water levels in the water way and elsewhere and/or flow in or over water conveyance structures may have limited GZA's ability to make observations of underwater portions of the structure. Excessive vegetation, when present, also inhibits observations.

10. In reviewing this Report, it should be realized that the reported condition of the dam is based on observations of field conditions during the course of this study along with data made available to GZA. It is important to note that the condition of any infrastructure system depends on numerous and constantly changing internal and external conditions and is evolutionary in nature. It would be incorrect to assume that the present condition of the system will continue to represent the condition of the system at some point in the future. Only through continued inspection and care can there be any chance that unsafe conditions be detected.

Compliance with Codes and Regulations

11. We used reasonable care in identifying and interpreting applicable codes and regulations. These codes and regulations are subject to various, and possibly contradictory, interpretations. Compliance with codes and regulations by other parties is beyond our control.

12. This scope of work does not include an assessment of the need for items which may be needed to minimize trespass and provide greater security for the facility and safety to the public. An evaluation of the project for compliance with OSHA rules and regulations is also excluded.

Cost Estimates

13. Unless otherwise stated, our cost estimates are for comparative, or general planning purposes. These estimates may involve approximate quantity evaluations and may not be sufficiently accurate to develop construction bids, or to predict the actual cost of work addressed in this Report. Further, since we have no control over the labor and material costs required to plan and execute the anticipated work, our estimates were made using our experience and readily available information. Actual costs may vary over time and could be significantly more, or less, than stated in the Report.

Additional Services

14. It is recommended that GZA be retained to provide services during any future: site observations, explorations, evaluations, design, implementation activities, construction and/or implementation of remedial measures recommended in this Report. This will allow us the opportunity to: i) observe conditions and compliance with our design concepts and opinions; ii) allow for changes in the event that conditions are other than anticipated; iii) provide modifications to our design; and iv) assess the consequences of changes in technologies and/or regulations.

Attachment B – MassDOT Inspection Report

Charles D. Baker, Governor
Karyn E. Polito, Lieutenant Governor
Stephanie Pollack, Secretary & CEO
Jonathan L. Gulliver, Highway Administrator

MassDOT
Massachusetts Department of Transportation
Highway Division

January 11, 2019

Town of Monterey
Board of Selectmen
P.O. Box 308 / 435 Main Road
Monterey, MA 01245

Attn: Shawn Tryon, Highway Superintendent

SUBJECT: SMALL BRIDGE INSPECTION REPORT

M-29-003 (552) ST 23 @ STA 227 / KONKAPOT RIVER Dated: 12/20/18

Dear Mr. Tryon:

As part of the Massachusetts Bridge Inspection Program, MassDOT – Highway Division now also performs inspections of municipally owned bridges whose spans are between 10 feet and 20 feet.

A copy of the recent bridge inspection field report is enclosed for your records for the referenced municipally owned bridge. Repair, rehabilitation or reconstruction of any bridge to address the deficiencies reported is the owner/custodian's responsibility. Chapter 90 funds may be used for these purposes.

Questions regarding the content of the report may be directed to the District Bridge Inspection Engineer, Laurie A. Briggs, at (413) 637-5783.

Sincerely,

Francisca Heming

Francisca R. Heming
District 1 Highway Director

LAB/lab
cc: AKB, LAB, BridgeLen
Enclosure

270 Main Street, Lenox, MA 01240
Tel: (413) 637-5700, Fax: (413) 637-0309
www.mass.gov/massdot

STRUCTURES INSPECTION FIELD REPORT

CULVERT INSPECTION

2-DIST	B.I.N.	BR. DEPT. NO.
01	552	M-29-003

CITY/TOWN	8.-STRUCTURE NO.	11-Kilo. POINT	41-STATUS	90-ROUTINE INSP. DATE
MONTEREY	M29003-552-MUN-BRI	000.000	A:OPEN	DEC 20, 2018

07-FACILITY CARRIED	MEMORIAL NAME/LOCAL NAME	27-YR BUILT	106-YR REBUILT	YR REHAB'D (NON 106)
ST 23 @ STA 227		1970	0000	0000

06-FEATURES INTERSECTED	26-FUNCTIONAL CLASS	DIST. BRIDGE INSPECTION ENGINEER
WATER KONKAPOT RIVER	Major Collector	L. A. Briggs

43-STRUCTURE TYPE	22-OWNER	21-MAINTAINER	TEAM LEADER M. A. Adorno
319 : Steel Culvert	Town Agency	Town Agency	

107-DECK TYPE	WEATHER	TEMP. (air)	TEAM MEMBERS
N : Not applicable	Sunny	0°C	R. MANCARI

TYPE OF CULVERT:

SHAPE:	PIPE ARCH
MATERIAL:	CORRUGATED STEEL
COATING:	GALVANIZED, TAR

BARRELS: (In Meters)

SIZE:	NUMBER:
4.90Wx3.10H	1

	N	S
DEPTH OF COVER (To the nearest tenth of a meter)	1.0	1.0
CURB REVEAL (In millimeters)	N	N

ITEM 62 CULVERT & RETAINING WALLS — 6

I62 (Dive Report): N — I62 (This Report): 6

	Dive Rpt.	This Rpt.	DEF		Dive Rpt.	This Rpt.	DEF		Dive Rpt.	This Rpt.	DEF
1. Roof	N	N	-	7. Protective Coating	N	5	M-P	13. Member Alignment	N	N	-
2. Floor	N	N	-	8. Embankment	N	7	-	14. Deformation	N	7	-
3. Walls	N	N	-	9. Wearing Surface	N	7	-	15. Scour	N	7	-
4. Headwall	N	7	-	10. Railing	N	7	-	16. Settlement	N	7	-
5. Wingwall	N	7	-	11. Sidewalks	N	N	-	17.	N	N	-
6. Pipe	N	6	-	12. Utilities	N	N	-	18.	N	N	-

UNDERMINING (Y/N) If YES please explain: N

COLLISION DAMAGE: *Please explain*
None (X) Minor ( ) Moderate ( ) Severe ( )

LOAD VIBRATION: *Please explain*
None (X) Minor ( ) Moderate ( ) Severe ( )

ITEM 61 CHANNEL & CHANNEL PROTECTION — 7

	Dive Rpt.	This Rpt.	DEF		Dive Rpt.	This Rpt.	DEF
1. Channel Scour	N	7	-	5. Utilities	N	N	-
2. Embankment Erosion	N	7	-	6. Rip-Rap/Slope Protection	N	7	-
3. Debris	N	7	-	7. Aggradation	N	7	-
4. Vegetation	N	7	-				

STREAM FLOW VELOCITY: Tidal ( ) High ( ) Moderate ( ) Low (X)

ITEM 61 (Dive Report): N

ITEM 61 (This Report): 7

93b-U/W INSP DATE: 00/00/0000

APPROACH CONDITION

		DEF
a. Appr. Pavement Condition	7	-
b. Appr. Roadway Settlement	7	-
c. Appr. Sidewalk Settlement	N	-
d.	N	-

WEIGHT POSTING

Not Applicable X

	H	3	3S2	Single
Actual Posting	N	N	N	N
Recommended Posting	N	N	N	N

Waived Date: 00/00/0000 EJDMT Date: 00/00/0000

Signs In Place (Y=Yes,N=No, NR=NotRequired) / Legibility/ Visibility

At bridge E	At bridge W	Advance E	Advance W

ITEM 36 TRAFFIC SAFETY

	36	COND	DEF
A. Bridge Railing	0	7	-
B. Transitions	0	7	-
C. Approach Guardrail	1	7	-
D. Approach Guardrail Ends	0	7	-

ACCESSIBILITY (Y/N/P):

	Needed	Used		Needed	Used
Ladder	N	N	Other:		
Boat	P	N		P	N
Waders	Y	Y			

TOTAL HOURS: 6

PLANS (Y/N): N

(V.C.R.) (Y/N): N

TAPE#:

RATING

Rating Report (Y/N): N

Date: 00/00/0000

Inspection data at time of existing rating
I 62: - Date : 00/00/0000

(To be filled out by DBIE)
Request for Rating or Rerating (Y/N): N

If YES please give priority: HIGH ( ) MEDIUM ( ) LOW ( )

REASON:

X=UNKNOWN N=NOT APPLICABLE H=HIDDEN/INACCESSIBLE R=REMOVED

CITY/TOWN	B.I.N.	BR. DEPT. NO.	8.-STRUCTURE NO.	INSPECTION DATE
MONTEREY	552	M-29-003	M29003-552-MUN-BRI	DEC 20, 2018

REMARKS, PHOTOS & SKETCHES

BRIDGE ORIENTATION

State Route 23 (Main Road) travels east and west. The Konkapot River flows from north to south. This culvert consists of a single corrugated galvanized steel pipe arch barrel supporting fill with an asphalt riding surface. Report notes are taken from south to north, downstream to upstream, in accordance with the 2015 Bridge Inspection Handbook. See photos 1 & 2.

ITEM 62 - CULVERT

Item 62.5 - Wingwall

At both upstream wingwalls, the footings are exposed, full length x up to 6" high, and the weep pipes have failed. See photo 3.

Item 62.6 - Pipe

The bottom portion has begun to rust. The worst conditions are found along the waterline where the pipe has laminated rust and minor section loss. See photos 2 & 4.

Item 62.7 - Protective Coating

Both the tar and galvanizing coatings have failed near and below the waterline. See photos 2 & 4.

Item 62.9 - Wearing Surface

The wearing surface has isolated cracks, up to 5' long x 1/8" wide.

CONDITION RATING GUIDE

	CODE	CONDITION	DEFECTS
	N	NOT APPLICABLE	Use if structure is not a culvert.
G	9	EXCELLENT	No deficiencies.
G	8	VERY GOOD	No noticeable or noteworthy differences which affect the condition of the culvert. Insignificant scrape marks caused by drift.
G	7	GOOD	Shrinkage cracks, light scaling, and insignificant spalling, which does not expose reinforcing steel. Insignificant damage caused by drift with not misalignment and not requiring corrective action. Some minor scouring has occurred near curtain walls, wingwalls, or pipes. Metal culverts have a smooth symmetrical curvature with superficial corrosion and no pitting.
F	6	SATISFACTORY	Deterioration or initial disintegration, minor chloride contamination, cracking with some leaching, or spalls on concrete or masonry walls and slabs. Local minor scouring at curtain walls, wingwalls, or pipes. Metal culverts have a smooth curvature, non-symmetrical shape, significant corrosion or moderate pitting.
F	5	FAIR	Moderate to major deterioration, or disintegration, extensive cracking and leaching, or spalls on concrete or masonry walls and slabs. Minor settlement or misalignment. Noticeable scouring or erosion at curtain walls, wingwalls, or pipes. Metal culverts have significant distortion and deflection in one section, significant corrosion or deep pitting.
P	4	POOR	Large spalls, heavy scaling, wide cracks, considerable efforescence, or opened construction joints permitting loss of backfill. Considerable settlement or misalignment. Considerable scouring or erosion at curtain walls, wingwalls, or pipes. Metal culverts have significant distortion and deflection throughout, extensive corrosion or deep pitting.
P	3	SERIOUS	Any condition described in Code 4 but which is excessive in scope. Severe movement or differential settlement of the segments, or loss of fill. Holes may exist in walls or slabs. Integral wingwalls, nearly severed from culvert. Severe scour or erosion at curtain walls, wingwalls, or pipes. Metal culverts have extreme distortion and deflection in one section, extensive corrosion, or deep pitting with scattered perforations.
C	2	CRITICAL	Advanced deterioration of primary structural elements. Fatigue cracks in steel or shear cracks in concrete may be present or scour may have removed substructure support. Unless closely monitored it may be necessary to close the bridge until corrective action is taken.
C	1	"IMMINENT" FAILURE	Bridge closed. Corrective action may put back in light service.
	0	FAILED	Bridge closed. Replacement necessary.

DEFICIENCY REPORTING GUIDE

DEFICIENCY: A defect in a structure that requires corrective action.

CATEGORIES OF DEFICIENCIES:

M= Minor Deficiency - (Examples include but are not limited to: Spalled concrete, minor to moderate corrosion to steel culverts, minor settlement or misalignment, minor scouring, minor damage to guardrail, etc.)

S= Severe/Major Deficiency - (Examples include but are not limited to: Large spalls, wide cracks, moderate to major deterioration in concrete, considerable settlement, considerable scouring or undermining, extensive corrosion and deflection in steel culverts, etc.)

C-S= Critical Deficiency - A deficiency in a structural component or element of a bridge that poses an extreme hazard or unsafe condition to the public. (Follow-up Critical Deficiency Report must be submitted separately)

URGENCY OF REPAIR:

I = Immediate- [Inspector(s) stay at the bridge until the District Maintenance crew or the responsible Agency crew(if not a State bridge) show up and corrective action is taken.]

A = ASAP- [Action will be taken by the District Maintenance Engineer or the Responsible Agency (if not a State owned bridge) upon receipt of the Inspection Report].

P = Prioritize- [Shall be prioritized by District Maintenance Engineer or the Responsible Party (if not a State owned bridge) and repairs made when funds and/or manpower is available].

CITY/TOWN	B.I.N.	BR. DEPT. NO.	8.-STRUCTURE NO.	INSPECTION DATE
MONTEREY	552	M-29-003	M29003-552-MUN-BRI	DEC 20, 2018

REMARKS

ITEM 61 - CHANNEL AND CHANNEL PROTECTION

Item 61.3 - Debris
At the inlet, the east side has a driftwood stump.

Item 61.6 - Rip-Rap/Slope Protection
At both upstream retaining walls, the footings are exposed, full length x up to 6" high, and the orangeburg type weep pipes have failed. See photo 3.

Item 61.7 - Aggradation
There is a sandbar along the bottom of the pipe, full pipe length x up to 10' wide x up to 1' high.

TRAFFIC SAFETY

Item 36a - Bridge Railing
The railings over the culvert consist of single steel W-beam panels which are continuous with the approaches and mounted on timber posts with timber blockouts, spaced 6' apart.

Item 36b - Transitions
The transitions consist of single steel W-beam panels mounted on timber posts with timber blockouts, spaced 6' apart.

Item 36c - Approach Guardrail
The approach guardrails consist of single steel W-beam panels mounted on timber posts with timber blockouts, spaced 6' apart.

Item 36d - Approach Guardrail Ends
The northwest approach guardrail has a steel terminal end that is not swept.

The remaining approach guardrails have swept steel terminal ends.

Photo Log

Photo 1 : General topside, looking west.
Photo 2 : General underside, looking north.
Photo 3 : Typical retaining wall with exposed footing and failed weep pipes, northwest shown.
Photo 4 : Typical condition of the pipe with rusting near and below the waterline, west shown.

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PHOTOS

Photo 1: General topside, looking west.

Photo 2: General underside, looking north.

CITY/TOWN	B.I.N.	BR. DEPT. NO.	8.-STRUCTURE NO.	INSPECTION DATE
MONTEREY	552	M-29-003	M29003-552-MUN-BRI	DEC 20, 2018

PHOTOS

Photo 3: Typical retaining wall with exposed footing and failed weep pipes, northwest shown.

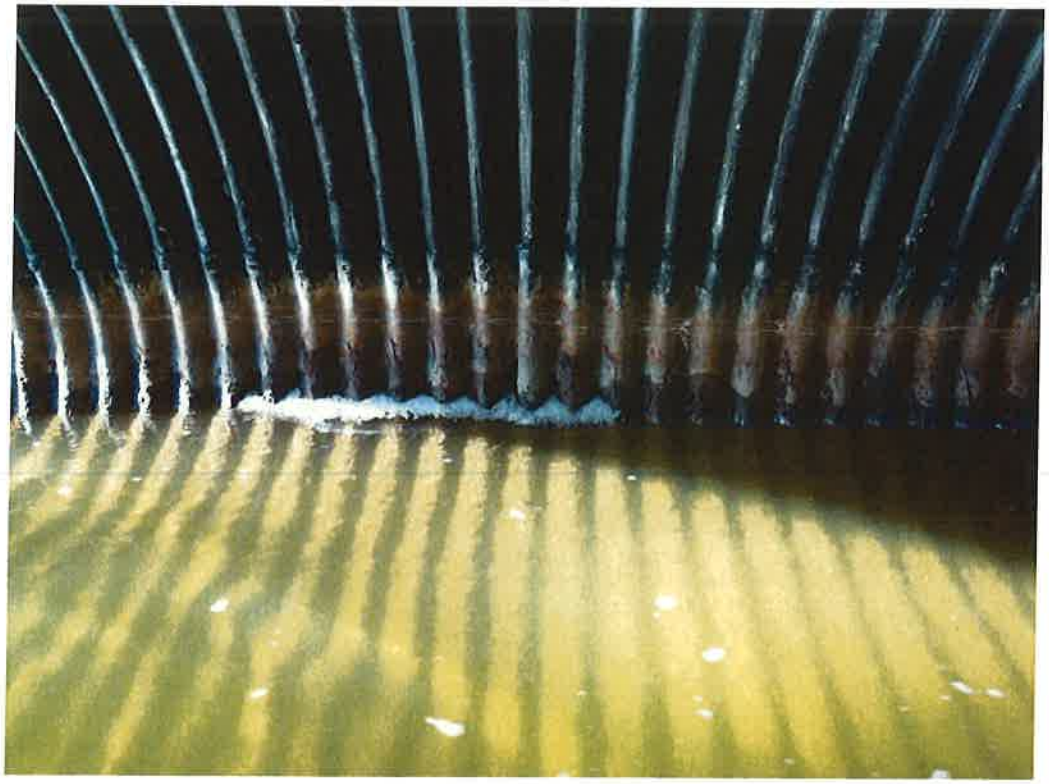

Photo 4: Typical condition of the pipe with rusting near and below the waterline, west shown.

Attachment C – Wetland Delineation Report (including field sketches, data plot information, and representative site photographs)

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GEOTECHNICAL
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April 16, 2020
File No. 01.0174558.00

Via Email (dpw1@montereyma.gov)

Mr. Shawn Tryon
Director of Operations
Town of Monterey Highway Department
P.O. Box 109
Monterey, Massachusetts 01245

Re: Wetland Delineation Report
Main Road over Konkapot River
Monterey, Massachusetts 01245

Dear Mr. Tryon:

GZA GeoEnvironmental, Inc. (GZA) is pleased to provide this letter report detailing the completion of wetland delineation services for the Main Road over Konkapot River culvert in Monterey, Massachusetts (Project Area/Site). The wetland delineation was completed in an approximate 1-acre area surrounding Konkapot River as it crosses under Main Road via an estimated 15-foot concrete and corrugated metal pipe culvert, see **Figure 1**. The culvert crossing is located near the Monterey Town Hall at 435 Main Road. The wetland delineation was performed by a GZA wetland scientist on March 24, 2020. This report is subject to the attached Limitations in **Appendix A**.

The purpose of the delineation work was to evaluate and locate the boundaries of wetlands on the Site. GZA understands that the wetland delineation data will be used to help assess options at the culvert and associated headwall and may be used to support future permitting efforts.

RESOURCE AREA BOUNDARY DELINEATION AND METHODOLOGY

The Project Area inspection and boundary delineation was conducted by GZA field staff in March 2020 in accordance with definitions in the Massachusetts Wetlands Protection Act (WPA) regulations, 310 CMR 10.00 and under Section 404 of the federal Clean Water Act. The wetland delineation was conducted in a manner that is consistent with both the 1995 Massachusetts Department of Environmental Protection (MassDEP) handbook titled *Delineating Bordering Vegetated Wetlands under the Massachusetts Wetlands Protection Act*[1] *and the* 2012 Regional Supplement to the 1987 Corps of Engineers *Corps of Engineers Wetlands Delineation Manual*[2] *We also reviewed* the National Plant List: 2016 wetlands ratings[3]*, the Field Indicators of Hydric Soils in the United States Version 8.2*[4]*, and the Field Indicators for Identifying Hydric Soils in New England*[5]*.* The observed wetlands were classified in accordance with 310 CMR 10.00 and the *Classification of Wetlands and Deepwater Habitats of the United States – Second Edition*[6] *for Corps jurisdiction.*

[1] 310 CMR: Department of Environmental Protection; Wetlands Protection Act
[2] U.S. Army Corps of Engineers, Environmental Laboratory. 1987. *Corps of Engineers Wetlands Delineation Manual*, Technical Report Y-87-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi
[3] Lichvar, R.W., D.L. Banks, W.N. Kirchner, and N.C. Melvin. 2016. *The National Plant List: 2016 wetland ratings.* Phytoneuron 2016-30: 1-17
[4] United States Department of Agriculture, Natural Resource Conservation Service, 2018. *Field Indicators of Hydric Soils in the United States,* Version 8.2. L.M. Vasilas, G.W. Hurt, and J.F. Berkowitz (eds.). USDA, NRCS, in cooperation with the National Technical Committee for Hydric Soils
[5] New England Hydric Soils Technical Committee. 2019. Version 4. *Field Indicators for Identifying Hydric Soils in New England,* New England Interstate Water Pollution Control Commission, Lowell, Massachusetts
[6] Federal Geographic Data Committee. 2013. *Classification of Wetlands and Deepwater Habitats of the United States*. FGDT-STD-004-2013, 2nd edition. Wetlands Subcommittee, Federal Geographic Data Committee and U.S. Fish and Wildlife Service, Washington, DC

In addition, we reviewed publicly available environmental data on the Massachusetts OLIVER GIS[7] portal including the USDA Natural Resources Conservation Service Soil Survey for Berkshire County (MA) and the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps were used to prepare this wetland delineation report. Descriptions of wetlands delineated within the Project Area are provided in the following sections, and representative photographs are provided in **Appendix B**.

Wetland boundaries were demarcated in the field with pink flagging tied on vegetation. The wetland boundary flags were located after examining the dominant vegetation, soils, and evidence hydrology at several locations within the Project Area.

SITE LOCATION AND DESCRIPTION

The Project Area includes a 15±-foot reinforced concrete and corrugated metal culvert pipe that passes the Konkapot River under Main Road in the east-central portion of the Town of Monterey, see **Figure 1**. The site includes a two lane (single direction) roadway with shoulders and stormwater catch basins. Several stormwater outlets to the river were observed downstream of the culvert.

The existing culvert is located near the Monterey Town Hall at 435 Main Road, Monterey, Massachusetts. The Konkapot River is a MassDEP designated cold-water fishery resource.

The project area is bounded by the Monterey Town Hall to the northwest, the U.S. Post Office to the southeast, and single-family residential parcels to the southwest and northeast.

DESKTOP ANALYSIS

A desktop analysis using MassGIS's OLIVER database preceded the field investigation to identify critical areas on or within 100 feet of the Project Area that would be examined more closely if construction activities are proposed.

Table 1: Critical Environmental Areas as Mapped by MassGIS OLIVER

MAPPED RESOURCES ON OR WITHIN 100 FEET OF THE PROJECT AREA	YES	NO
Areas of Critical Environmental Concern		X
NHESP Certified Vernal Pool		X
NHESP Potential Vernal Pool		X
NHESP Estimated Habitat of Rare Wildlife		X
NHESP Priority Habitat of Rare Species		X
Outstanding Resource Waters		X
FEMA Flood Zones	X	
Surface Water Protection Area		X
Interim Wellhead Protection Area		X
Zone II Wellhead Protection Area		X

The Project Area is located within a mapped FEMA Zone A, 1.0% chance of annual flooding corridor that is coincident with the Konkapot River. In addition, in accordance with regulation 310 CMR 10.59, projects in resource areas must be reviewed for potential adverse effect on specified habitat sites and rare species. Based on the Massachusetts Natural Heritage Atlas 14th Edition, as published in MassGIS[8], no portion of the Site is identified as Priority or Estimated Habitat for Rare Species, or as certified vernal pool habitat.

[7] MassGIS (Bureau of Geographic Information), Commonwealth of Massachusetts EOTSS. OLIVER Interactive Mapping Application. Accessed online at: http://maps.massgis.state.ma.us/map_ol/oliver.php. Accessed 03/10/2020.
[8] MassGIS, Natural Heritage & Endangered Species Program (NHESP). Accessed 03/10/2020.

According to the U.S. Department of Agriculture National Resource Conservation Service (NRCS) Web Soil Survey[9] and the NRCS SSURGO soils data[10], there is one soil unit mapped within the Project Area (*Custom Soil Resource Report for Berkshire County, Massachusetts)*. The mapping unit does not have a hydric soil rating. *Amenia silt loam, 3 to 8 percent slopes* is mapped across the entirety of the Project Area. **Table 2** identifies soils mapped within the Project Area:

Table 2: NRCS Mapped Soils within the Project Area

SOIL UNIT NAME	HYDRIC RATING	ACRES/PERCENT AREA OF PROJECT AREA
Amenia silt loam, 3 to 8 percent slopes	0	100%
	Total Project Acres	0.5

According to the U.S. Fish and Wildlife Service's National Wetlands Inventory[11], only the Konkapot River is mapped as a Water of the United States (WOTUS) within the Project Area. No other WOTUS are mapped within the Project Area.

According the MassGIS's OLIVER database, no state identified wetland polygons were mapped within the Project Area. The Konkapot River is indicated as a perennial stream based upon our review of the USGS topographic map.

WETLAND DELINEATION METHODOLOGY

Determining wetland presence in Massachusetts requires the positive identification of two out of the three wetland parameters: 1) hydrophytic vegetation; 2) hydric soil; 3) and other evidence of wetland hydrology. We offer a detailed description of the site-specific data relative to the three wetland delineation criteria.

The stream boundary was delineated based on indicators of the mean annual high water (MAHW) line described at 310 CMR 10.58(2). The indicators are generally coincident with the criteria for a Bank resource. The wetland flagging demarcates the top or upper limits of the Bank and the flagging also begins the 200-feet Riverfront Area resource that extends landward and parallel to the MAHW line.

VEGETATION

GZA assessed the dominant plant species present within circular plots centered on each sample plot location. The size of the observation plot is based upon the vegetative layer being observed and includes a 30-foot radius plot for tree and vine species, a 15-foot radius plot for shrub and saplings, and a 5-foot radius plot for herbaceous species. The dominant plant species are typically determined using the 50/20 rule[12], which also uses the wetland indicator status for each dominant species based on the Massachusetts subset of the National Wetland Plant List (Lichvar 2016)[13,14]. The Dominance Test was the primary method for determining hydrophytic vegetation. If the Dominance Test failed, the Prevalence Index was used if a sample plot also showed hydrology and hydric soil indicators. At the time of the delineation, ground conditions consisted of approximately 5 inches of snow cover, limiting observations of low-growing herbaceous vegetation.

[9] Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Available online at the following link: https://websoilsurvey.sc.egov.usda.gov/. Accessed 03/10/2020.
[10] USDA. 1989. Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Soil Survey Geographic (SSURGO) Database for Berkshire County, Massachusetts. Available online. Accessed 03/10/2020.
[11] National Wetlands Inventory Wetland Mapped. Available online at the following link: https://www.fws.gov/wetlands/data/mapper.html. Accessed 03/10/2020.
[12] U.S. Army Corps of Engineers, Environmental Laboratory. 1987. *Corps of Engineers Wetlands Delineation Manual*, Technical Report Y-87-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi
[13] Lichvar, R.W., D.L. Banks, W.N. Kirchner, and N.C. Melvin. 2016. *The National Wetland Plant List*: 2016 wetland ratings. Phytoneuron 2016-30: 1-17. Published 28 April 2016. ISSN 2153 733X
[14] Wetland indicator status denotes the likelihood of a plant being found within a wetland. Statuses are defined as follows: obligate wetland (OBL) = >99% chance of being found in a wetland; facultative wetland (FACW) = 67 - 99% chance; facultative (FAC) = 34 - 66% chance; facultative upland (FACU) = 1-33% chance; obligate upland (UPL) = <1% chance; no indicator (NI)= Insufficient information available (not considered in dominance analyses); not on list (NOL)= same as UPL.

SOIL

At each sample plot location, GZA attempted to excavate a soil test bore using a hand soil auger to dig to a depth of 18–20 inches below ground surface (bgs). Areas of refusal were noted. Soil profile characteristics were reviewed to determine whether the soil profile met the definition of a hydric soil indicator as per the Regional Supplement. Soil characteristics were described using standards established by the National Technical Committee on Hydric Soils (version 8.2)[15]. Soil colors were determined using a Munsell Soil Color Chart[16]. In addition, notes recorded any disturbances observed within soil profiles.

HYDROLOGY

Hydrology was largely determined by observing groundwater or saturation within 12 inches bgs. Other primary and secondary criteria were observed within each sample plot and recorded on each data form. In some instances, sample plots were left open for up to 10 minutes to allow groundwater to equalize in the hole. The Northeast Regional Climate Center[17] indicates that Berkshire County, MA is within an area experiencing normal precipitation conditions for the current water year.

CLASSIFICATION OF WETLAND RESOURCES

The wetland resource observed and delineated in the Project Area under the WPA regulations, 310 CMR 10.00 and includes a Bank resource based on the definition provided at 310 CMR 10.54(2). The limits of the Bank resource includes that area along the stream channel that is between the mean high water and the mean low water elevation as determined in the field based upon indicators such as scour lines, obvious change from aquatic to terrestrial plant communities, vegetative drift deposits, and first observable break in slope.

Under the Corps jurisdiction, the wetland delineated in the Project Area includes a Waters of the United States that is more specifically defined as a Land Under Water resource which includes all land within the river that is below the ordinary high water mark.

JURISDICTIONAL WETLAND RESOURCE AREAS – MASSACHUSETTS WETLANDS PROTECTION ACT

Waterway resource area boundaries were identified and delineated in accordance with methods developed by the MassDEP's *Delineating Bordering Vegetated Wetlands Under the Massachusetts Wetlands Protection Act*[18], dated 1995 (the Act), as well as definitions set forth in 310 CMR 10.00. One resource area subject to protection under the Act exists in the Project Area.

BANK (NATURALLY OCCURRING BANKS AND BEACHES) – 310 CMR 10.54

According to 310 CMR 10.54(2), the definition of Bank is "the portion of the land surface which normally abuts and confines a water body. It occurs between a water body and a vegetated bordering wetland and adjacent flood plain, or, in the absence of these, it occurs between a water body and an upland. The upper boundary of a Bank is the first observable break in the slope or the mean annual flood level, whichever is lower."

GZA identified one (1) Bank resource area within the Project Area, which is summarized in **Table 3**, below.

[15] United States Department of Agriculture, Natural Resources Conservation Service. 2018. Field Indicators of Hydric Soils in the United States, Version 8.2. L.M. Vasilas, G.W. Hurt, and J.F. Berkowitz (eds.). USDA, NRCS, in cooperation with the National Technical Committee for Hydric Soils.
[16] Munsell Color (Xrite). 2010. *Munsell Soil Color Charts: with Genuine Munsell Color Chips.* Grand Rapids, MI: Munsell Color.
[17] Northeast Regional Climate Center, Percent of Monthly Precipitation Map. Available online at the following link: http://www.nrcc.cornell.edu/ Accessed 03/10/2020.
[18] 310 CMR: Department of Environmental Protection; Wetlands Protection Act

LAND UNDER WATER BODIES AND WATERWAYS (UNDER ANY CREEK, RIVER, STREAM, POND OR LAKE) – 310 CMR 10.56

According to 310 CMR 10.56(2), the definition of LUWW is "the land beneath any creek, river, stream, pond or lake. Said land may be composed of organic muck or peat, fine sediments, rocks or bedrock."

GZA identified one (1) LUWW resource area within the Project Area, which is summarized in **Table 3**, below.

RIVERFRONT AREA – 310 CMR 10.58

According to 310 CMR 10.58(2), the definition of Riverfront Area is "the area of land between a river's mean annual high water line and a parallel line measured horizontally."

GZA identified one (1) Riverfront Area within the Project Area, which is summarized in **Table 3**, below.

FINDINGS

Upon completion of the wetland delineation of the area that was upstream and downstream of the culvert, we conclude that the Project Area contains three wetland resources under the jurisdiction of the WPA. The three resources include a Bank, LUWW, and a Riverfront Area associated with the Konkapot River. As stated earlier, the Bank and Riverfront Area resources utilize the same delineation boundary, so only one flag series was placed in the Project Area. LUWW typically is not demarcated in the field.

BANK RESOURCE (WETLAND SERIES A)

Wetland Series A (flags A-1 through A-33): This wetland includes the Bank resource associated with the portion of the Konkapot River within the Project Area. Portions of the Bank resource consist of concrete retaining walls directly upstream of the culvert and stone walls directly downstream of the culvert. The remaining portions of Bank are vegetated with both upland and wetland shrub and herbaceous plant species, including silky dogwood (*Swida amomum*), tall goldenrod (*Solidago altissima*), ostrich fern (*Matteuccia struthiopteris*), and various aster species. Invasive plant species observed growing along the banks included Japanese knotweed (*Fallopia japonica*), Asiatic bittersweet (*Celastrus orbiculatus*), and multiflora rose (*Rosa multiflora*). Upstream of the culvert beyond the concrete retaining walls, the stream banks are steep and densely vegetated and the transition from open water to upland is abrupt. The western and downstream bank of the river consists of a stone wall and the eastern bank transitions from open water to a gradually sloped maintained/mown lawn. The portion of the Konkapot River downstream of the culvert is impounded by a dam located approximately 300 feet south of Main Road.

Under the WPA, the Bank resource is expected to support several interests of the WPA regulations, including Wildlife Habitat, Flood Control, Fisheries Protection and Storm Damage Prevention.

LAND UNDER WATER BODIES AND WATERWAYS (LUWW)

The LUWW resource is associated with the Konkapot River. This resource is located below the mean low water line. The limits of this resource were not field delineated, as the LUWW is underwater and typically is not demarcated in the field.

Under the WPA, the LUWW resource is expected to support several interests of the WPA regulations, including Public and Private Water Supply, Ground Water Supply, Flood Control, Storm Damage Prevention, Protection of Fisheries and Wildlife Habitat.

RIVERFRONT AREA (WETLAND SERIES A)

Flags A-1 through A-33 in Wetland Series A demarcate both Bank and MAHW, as the two were coincident. The delineated MAHW line indicates the start of the Riverfront Area, which continues landward 200 feet to a parallel line measured horizontally. The portions of the Riverfront Area within the Project Area consist of the Monterey Town Hall and U.S. Post Office parcels, as well as commercial and residential parcels.

Under the WPA, the Riverfront Area resource is expected to support several interests of the WPA regulations, including Wildlife Habitat, Flood Control, and Storm Damage Prevention.

NWI/MASSDEP MAPPING

The National Wetland Inventory (NWI) maps shows that the portion of the Konkapot River identified within the Project Area as a scrub-shrub wetland, see **Figure 1**. However, since the NWI only shows a rough estimate of the presence and geographic extent of wetland communities in each area, GZA's site-specific wetland delineation provides a more accurate depiction of wetland community type or boundaries within the Project Area. Field delineation within the Project Area identified the Konkapot River as having Bank resources and no associated vegetated wetlands.

MassDEP's OLIVER geographic information database shows no MassDEP mapped wetland polygons within the Project Area[19]. The OLIVER application identifies the Konkapot River as a perennial stream.

Therefore, in GZA's opinion, the wetland delineation completed by GZA on March 24, 2020, provides an accurate and comprehensive account of wetlands and waterways currently within the Project Area.

CONCLUSIONS AND RECOMMENDATIONS

In conclusion, GZA has identified several areas Subject to Protection and/or Jurisdiction under the Massachusetts Wetlands Protection Act, on or within 100 feet of the Project Area, and has delineated the boundaries of these areas that exist within the Project Area. **Table 3** summarizes the resource areas:

Table 3: Resource Area Summary Table

Resource Area	MassDEP Wetland Citation	100-foot Buffer Zone	Approving Authority	Anticipated Federal (USACE) Jurisdiction	Notes
Bank	310 CMR 10.54(2)	Yes	Monterey Conservation Commission & Army Corps of Engineers	Land Under Water	Bank delineation is coincident with MAHW
LUWW	310 CMR 10.56(2)	No	Monterey Conservation Commission	N/A	LUWW is present, but not demarcated in the field
Riverfront Area	310 CMR 10.58(2)	No	Monterey Conservation Commission	N/A	Riverfront Area extends 200 feet landward from the MAHW

[19] MassGIS (Bureau of Geographic Information), Commonwealth of Massachusetts EOTSS. OLIVER Interactive Mapping Application. Accessed online at: http://maps.massgis.state.ma.us/map_ol/oliver.php. Accessed 03/10/2020.

GZA further recommends footprints of disturbance should minimize impacts to the delineated wetlands within the Project Area to the maximum extent practicable.

Very truly yours,

GZA GEOENVIRONMENTAL, INC.

Robin J. Casioppo
Ecologist / Assistant Project Manager

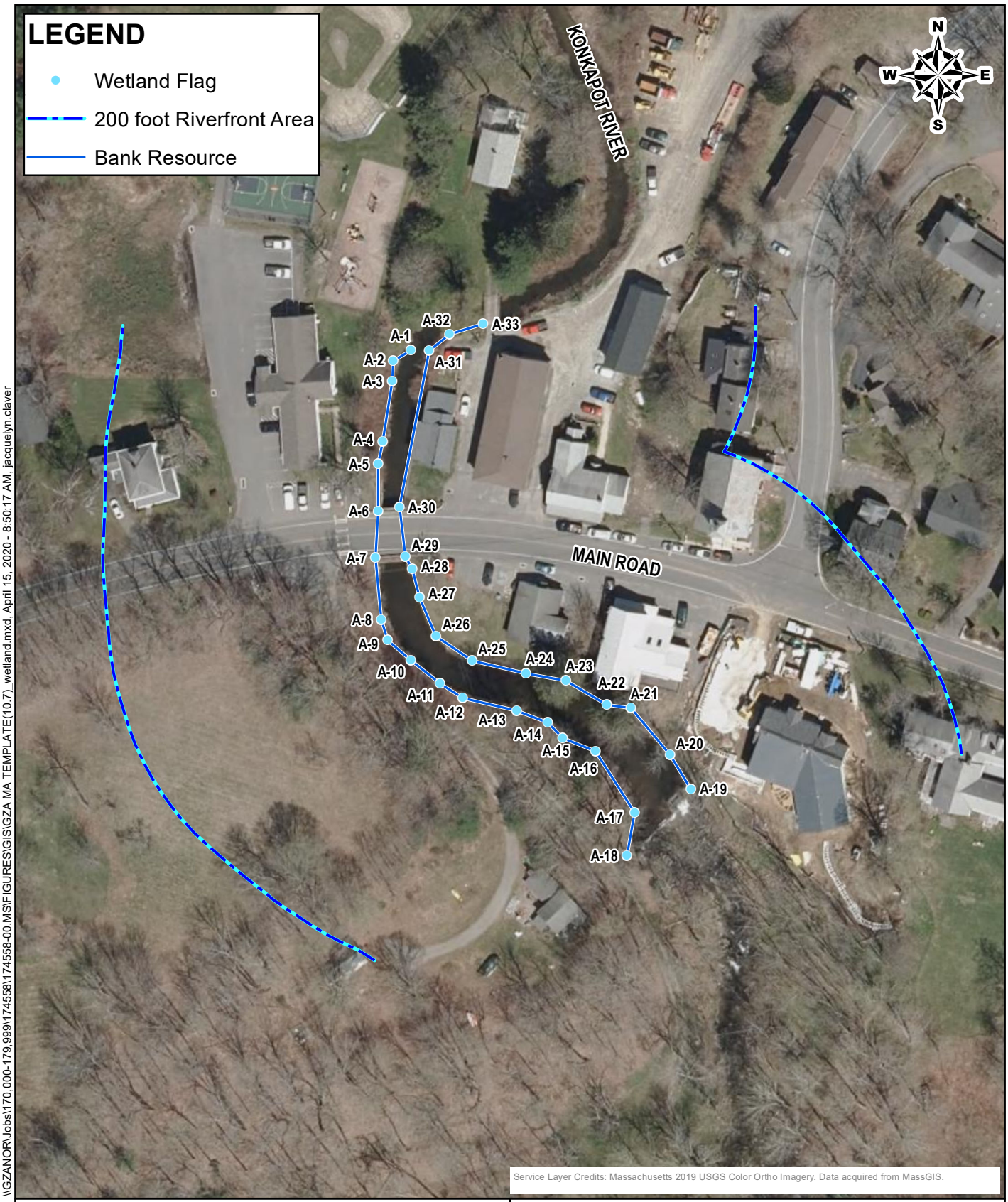
Daniel M. Nitzsche, CPESC, CESSWI, SE
Consultant / Reviewer

Media Sehatzadeh
Assistant Project Manager

Chad Cox, P.E.
Principal-In-Charge

Attachments: Figures
Appendix A – Limitations
Appendix B – Wetland Photos
Appendix C – Pebble Count Data

Figures



0 50 100 200

SCALE IN FEET

CULVERT REPLACEMENT AT MAIN ROAD
MONTEREY, MA

WETLAND RESOURCE MAP

PREPARED BY:
GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

PREPARED FOR:
TOWN OF MONTEREY DEPARTMENT
OF PUBLIC WORKS
40 GOULD RD, P.O. BOX 308
MONTEREY, MA 1245

PROJ MGR: MS	REVIEWED BY: CWC	CHECKED BY: JPG	FIG
DESIGNED BY: JRC	DRAWN BY: JRC	SCALE: 1 in = 100 ft	1
DATE: 04/15/2020	PROJECT NO: 01.0174558.00		

Appendix A – Limitations

USE OF REPORT

1. GZA GeoEnvironmental, Inc. (GZA) has prepared this report on behalf of, and for the exclusive use of Town of Monterey Department of Public Works ("Client") for the stated purpose(s) and location(s) identified in the report. Use of this report, in whole or in part, at other locations, or for other purposes, may lead to inappropriate conclusions; and we do not accept any responsibility for the consequences of such use(s). Further, reliance by any party not identified in the agreement, for any use, without our prior written permission, shall be at that party's risk, and without any liability to GZA.

STANDARD OF CARE

2. GZA's findings and conclusions are based on the work conducted as part of the Scope of Services set forth in the Report and/or proposal, and reflect our professional judgment. These findings and conclusions must be considered not as scientific or engineering certainties, but rather as our professional opinions concerning the data gathered and observations made during the course of our work. Conditions other than described in this report may be found at the subject location(s).

3. GZA's services were performed using the degree of skill and care ordinarily exercised by qualified professionals performing the same type of services, at the same time, under similar conditions, at the same or a similar property. No warranty, expressed or implied, is made.

LIMITS TO OBSERVATIONS

4. Natural resource characteristics are inherently variable. Biological community composition and diversity can be affected by seasonal, annual or anthropogenic influences. In addition, soil conditions are reflective of subsurface geologic materials, the composition and distribution of which vary spatially.

5. The observations described in this report were made on the dates referenced and under the conditions stated therein. Conditions observed and reported by GZA reflect the conditions that could be reasonably observed based upon the visual observations of surface conditions and/or a limited observation of subsurface conditions at the specific time of observation. Such conditions are subject to environmental and circumstantial alteration and may not reflect conditions observable at another time.

6. The conclusions and recommendations contained in this report are based upon the data obtained from a limited number of surveys performed during the course of our work on the site, as described in the Report. There may be variations between these surveys and other past or future surveys due to inherent environmental and circumstantial variability.

RELIANCE ON INFORMATION FROM OTHERS

7. Preparation of this Report may have relied upon information made available by Federal, state and local authorities; and/or work products prepared by other professionals as specified in the report. Unless specifically stated, GZA did not attempt to independently verify the accuracy or completeness of that information.

COMPLIANCE WITH REGULATIONS AND CODES

8. GZA's services were performed to render an opinion on the presence and/or condition of natural resources as described in the Report. Standards used to identify or assess these resources as well as regulatory jurisdiction, if any, are stated in the Report. Standards for identification of jurisdictional resources and regulatory control over them may vary between governmental agencies at Federal, state and local levels and are subject to change over time which may affect the conclusions and findings of this report.

NEW INFORMATION

9. In the event that the Client or others authorized to use this report obtain information on environmental regulatory compliance issues at the site not contained in this report, such information shall be brought to GZA's attention forthwith. GZA will evaluate such information and, on the basis of this work, may modify the conclusions stated in this report.

ADDITIONAL SERVICES

10. GZA recommends that we be retained to provide further investigation, if necessary, which would allow GZA to (1) observe compliance with the concepts and recommendations contained herein; (2) evaluate whether the manner of implementation creates a potential new finding; and (3) evaluate whether the manner of implementation affects or changes the conditions on which our opinions were made.

Appendix B – Wetland Photos

Photo 1. Upstream banks and culvert, facing south. (3/24/20)

Photo 2. East upstream bank, facing south. (3/24/20)

Photo 3. West upstream bank, facing south. (3/24/20)

Photo 4. Upstream culvert headwalls and vegetated bank, facing west. (3/24/20)

Photo 5. Upstream culvert headwalls and vegetated banks, facing north. (3/24/20)

Photo 6. Downstream banks and culvert, facing north. (3/24/20)

Photo 7. Downstream vegetated banks, facing southeast. (3/24/20)

Photo 8. Downstream dam, facing northeast. (3/24/20)

Appendix C – Pebble Count Data

PEBBLE COUNT RESULTS – UPSTREAM OF THE CULVERT

Upstream of the culvert, the particles were categorized as coarse sands with a somewhat even distribution of gravels and cobbles. Sand particles were mostly coarse sands but ranged from silt to very coarse. Gravel particles ranged from fine to coarse. A total of eleven (11) boulders were found ranging from small to very large.

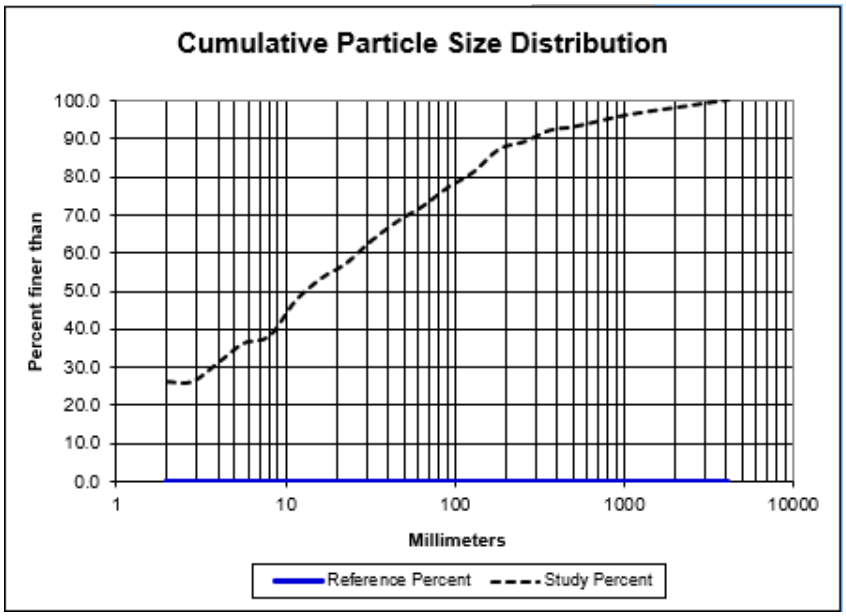


Figure 1 – Upstream of the Culvert

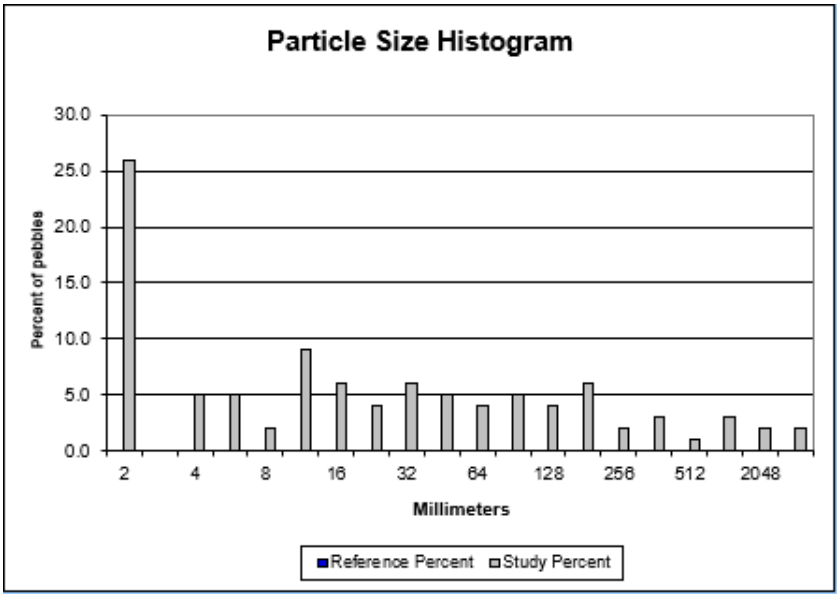


Figure 2 – Upstream of the Culvert

ROSGEN REPRESENTATIVE REACH PEBBLE COUNT

STREAM: Konkapot River, Monterey, MA | **DATE:** 3/24/20

REACH: upstream | **CREW:** PL / RC

PARTICLE TALLY COUNTS BY TRANSECT

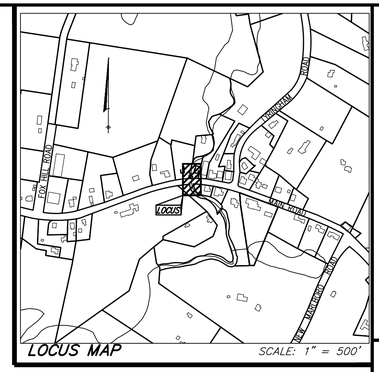
ft	PARTICLE	mm		1	2	3	4	5	6	7	8	9	10	Tot Pool	Tot Riff	Comb Tot	%CUM
	Silt/Clay	< .062	S/C		2	1		1		1			2				
	Very Fine	.062 - .125	S	1	4	1	1						3				
	Fine	.125 - .25	A				1										
	Medium	.25 - .50	N					1	1		1						
	Coarse	.50 - 1.0	D			1		1									
	Vry Coarse	1.0 - 2	S								1	2					
	Very Fine	2 - 4		1							1	2	1				
	Fine	4 - 6	G					1		2	1		1				
	Fine	6 - 8	R	1									1				
	Medium	8 - 12	A				2		2	1	2	1	1				
	Medium	12 - 16	V	1			1	2	1			1				RC	
	Coarse	16 - 24	E				3	1									
	Coarse	24 - 32	L	1			1		3		1						
	Vry Coarse	32 - 48	S	1	1				2	1							
	Vry Coarse	48 - 64		1				1			1	1					
0.21-0.31	Small	64 - 96	C	2				1		1			1				
0.31-0.42	Small	96 - 128	O			1				2	1						
0.42-0.63	Large	128 - 192	B		2	3	1										
0.63-0.84	Large	192 - 256	L								1	1					
0.84-1.26	Small	256 - 384	B	1		2											
1.26-1.68	Small	384 - 512	L		1												
1.68-3.36	Medium	512 - 1024	D			1		1	1								
3.36-6.72	Lrg	1024 - 2048	R							2							
6.72-13.43	Vry Lrg	2048-4096										2					
	Bedrock	>4096	BDRK														

FEATURE SAMPLED

	Length	Proportion	No. Units	Sampled
REACH				
POOL			RC	
RIFFLE				
RUN				

Transect	Feature	Length	Width
1			
2			
3			
4			
5	RC		
6			
7			
8			
9			
10			

Attachment D – Topographical Survey



MASSACHUSETTS STATE PLANE COORDINATE SYSTEM (NAD 83)

NOTES:

1) ELEVATIONS SHOWN HEREON REFER TO THE NORTH AMERICAN VERTICAL DATUM OF 1988 (N.A.V.D. 88) ESTABLISHED BY GPS OBSERVATIONS ON MARCH 21, 2020.

2) UNDERGROUND UTILITIES SHOWN HEREON ARE COMPILED FROM FIELD LOCATIONS OF STRUCTURES AND FROM AVAILABLE RECORD INFORMATION ON FILE AT THE TOWN ENGINEERING OFFICES, TOWN D.P.W., MASS HIGHWAY DEPT. AND UTILITY COMPANIES. OTHER UNDERGROUND UTILITIES MAY EXIST. IT SHALL BE THE RESPONSIBILITY OF THE CONTRACTOR TO VERIFY THE LOCATION, SIZE & ELEVATION OF ALL UTILITIES WITHIN THE AREA OF PROPOSED WORK AND TO CONTACT "DIG-SAFE" AT 811 AT LEAST 72 HOURS PRIOR TO ANY EXCAVATION, DEMOLITION OR CONSTRUCTION.

3) PROPERTY LINES AND STREET LINES SHOWN HEREON ARE FROM MASS GIS DATA. NO BOUNDARY SURVEY WAS PERFORMED.

LEGEND

102	SURFACE CONTOUR
	STONE WALL
	METAL GUARDRAIL
	EDGE OF PAVEMENT
86.75 / 86.25	CURB WITH TOP AND BOTTOM CURB ELEVATION
12" RCP	DRAINLINE WITH PIPE SIZE, MATERIAL & FLOW DIRECTION, CATCHBASIN, MANHOLE & ROUND CATCHBASIN
#181 OHW	EXISTING UTILITY POLE WITH DESIGNATION OVERHEAD WIRES AND GUY POLE
E	ELECTRIC MANHOLE & UNDERGROUND ELECTRIC LINES
	EDGE OF GRAVEL ROAD
98.8 / 93.2	RETAINING WALL WITH TOP AND BOTTOM ELEVATIONS
	BOTTOM OF BROOK
×100.7	THALWEG
×100.7	TOP OF BANK
×100.7	BOTTOM OF BANK
×100.7	SPOT ELEVATION
CMP	CORRUGATED METAL PIPE
CPP	CORRUGATED PLASTIC PIPE
CB	CATCH BASIN
EM	ELECTRIC METER
CU	CONNECTION UNKNOWN
	SIGN
BB	BITUMINOUS BERM
CC	CONCRETE CURB
BIT. CONC.	BITUMINOUS CONCRETE

SCALE: 1" = 10'

0 10 20 40

KONKAPOT RIVER AT MAIN ROAD

Monterey, Massachusetts 01245

PREPARED FOR:

GZA GeoEnvironmental, Inc.

249 Vanderbilt Avenue
Norwood, Massachusetts 02062

HANCOCK ASSOCIATES

Civil Engineers

Land Surveyors

Wetland Scientists

185 CENTRE STREET, DANVERS, MA 01923
VOICE (978) 777-3050, FAX (978) 774-7816
WWW.HANCOCKASSOCIATES.COM

NO.	BY	APP	DATE	ISSUE/REVISION DESCRIPTION

DATE: 5/28/2020 DRAWN BY: RDF
SCALE: 1" = 10' CHECK BY: SRJ

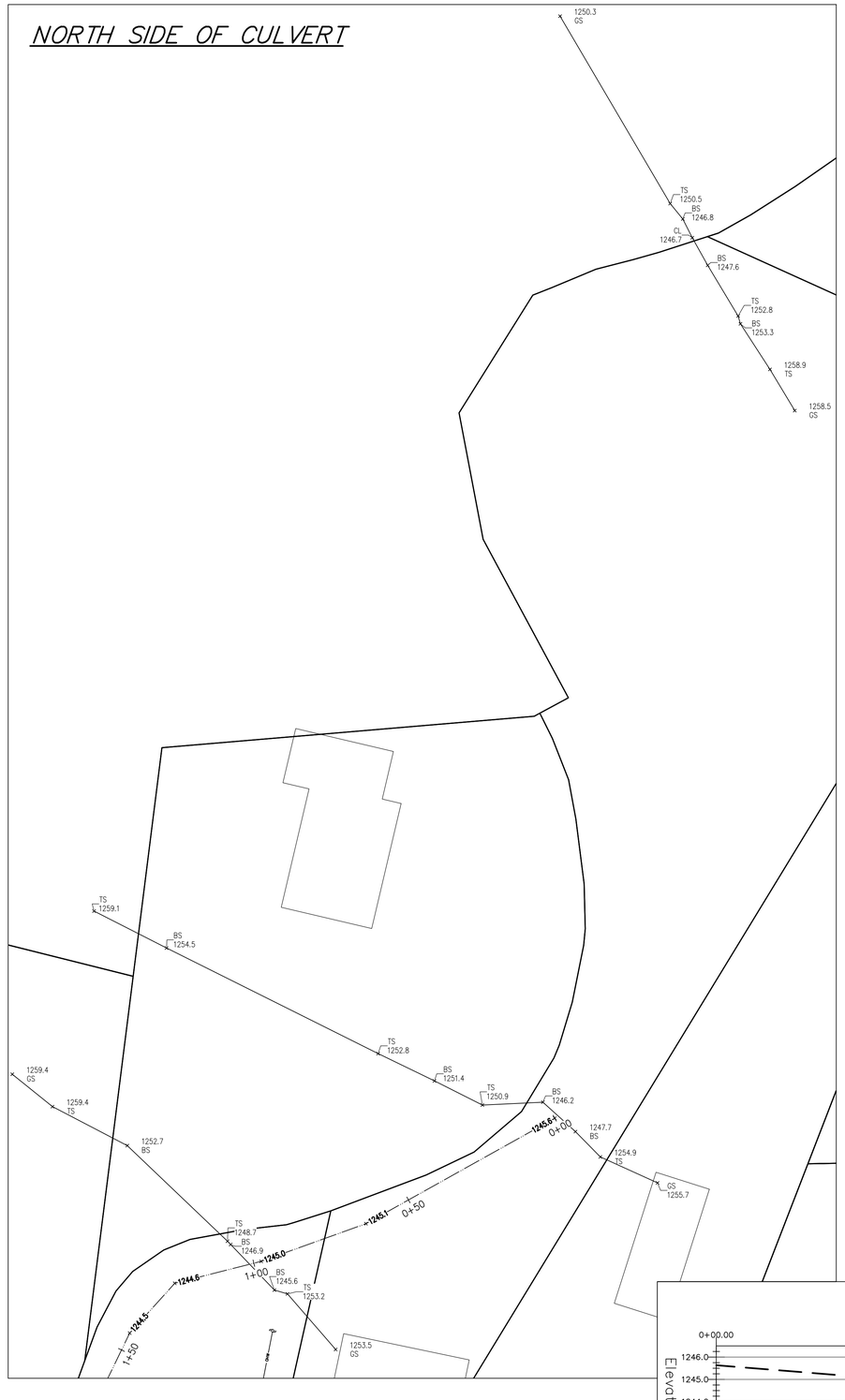
TOPOGRAPHIC PLAN OF LAND IN MONTEREY, MA

PLOT DATE: May 28, 2020 12:02 pm
PATH: F:\Civil 3D Projects\23362-GZA-Monterey\DWG\

DWG: 23362t2.dwg
LAYOUT: EC
SHEET: 1 OF 2

PROJECT NO.: 23362

NORTH SIDE OF CULVERT

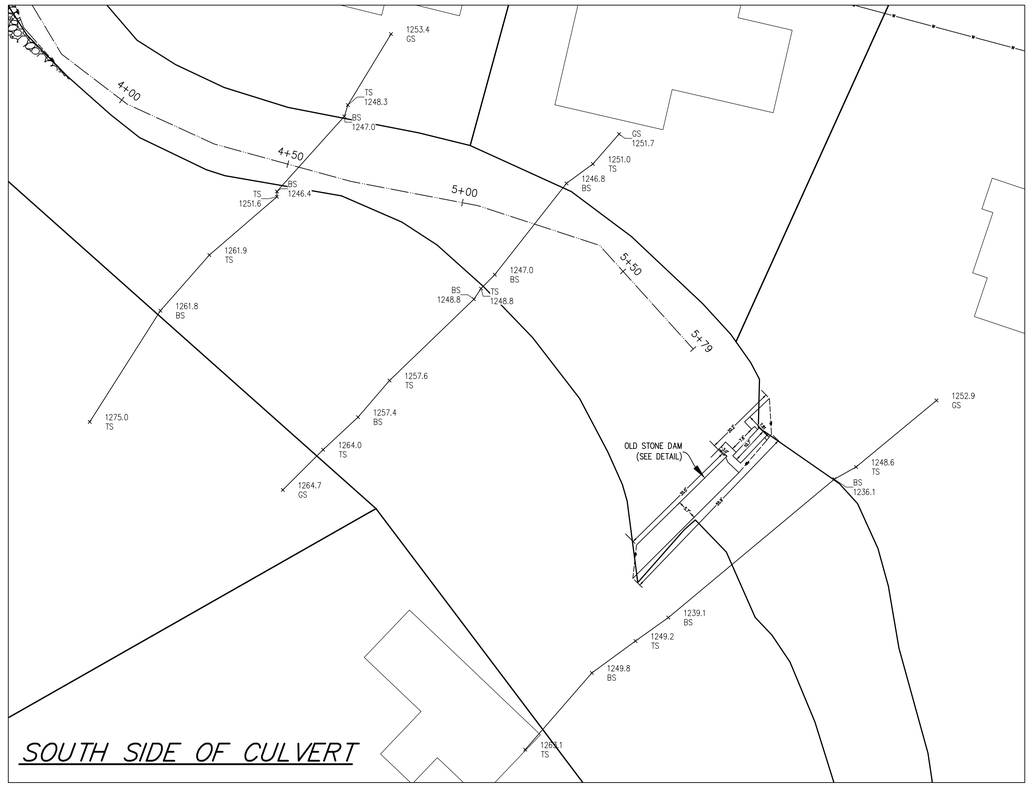


SCALE: 1" = 20'

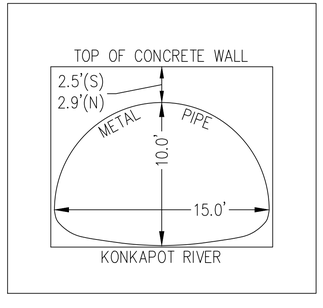
0 20 40 80

MASSACHUSETTS STATE PLANE COORDINATE SYSTEM (NAD 83)

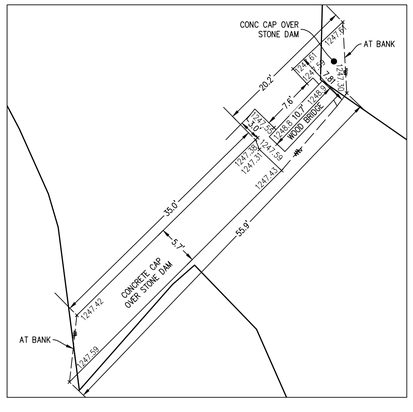
SOUTH SIDE OF CULVERT



DETAIL OF CULVERT DIMENSIONS (NOT TO SCALE)



DETAIL OF OLD STONE DAM (1" = 10')



LEGEND

#181 OHW	EXISTING UTILITY POLE WITH DESIGNATION OVERHEAD WIRES AND GUY POLE
	BOTTOM OF BROOK
× 100.7	THALWEG
× 100.7	SPOT ELEVATION
BS	BOTTOM OF SLOPE
TS	TOP OF SLOPE
GS	GROUND ELEVATION

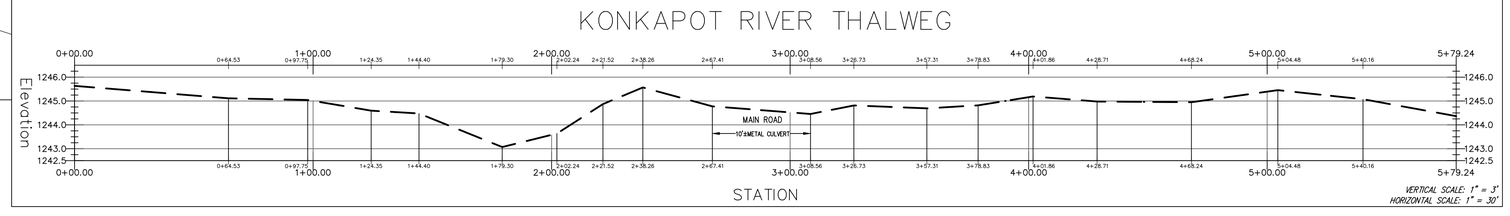
NOTES:

1) ELEVATIONS SHOWN HEREON REFER TO THE NORTH AMERICAN VERTICAL DATUM OF 1988 (N.A.V.D. 88) ESTABLISHED BY GPS OBSERVATIONS ON MARCH 21, 2020.

2) UNDERGROUND UTILITIES SHOWN HEREON ARE COMPILED FROM FIELD LOCATIONS OF STRUCTURES AND FROM AVAILABLE RECORD INFORMATION ON FILE AT THE TOWN ENGINEERING OFFICES, TOWN D.P.W., MASS HIGHWAY DEPT. AND UTILITY COMPANIES. OTHER UNDERGROUND UTILITIES MAY EXIST. IT SHALL BE THE RESPONSIBILITY OF THE CONTRACTOR TO VERIFY THE LOCATION, SIZE & ELEVATION OF ALL UTILITIES WITHIN THE AREA OF PROPOSED WORK AND TO CONTACT "DIG-SAFE" AT 811 AT LEAST 72 HOURS PRIOR TO ANY EXCAVATION, DEMOLITION OR CONSTRUCTION.

3) PROPERTY LINES AND STREET LINES SHOWN HEREON ARE FROM MASS GIS DATA. NO BOUNDARY SURVEY WAS PERFORMED.

KONKAPOT RIVER THALWEG



KONKAPOT RIVER AT MAIN ROAD

Monterey, Massachusetts 01245

PREPARED FOR:

GZA GeoEnvironmental, Inc.

249 Vanderbilt Avenue
Norwood, Massachusetts 02062

HANCOCK ASSOCIATES

Civil Engineers

Land Surveyors

Wetland Scientists

185 CENTRE STREET, DANVERS, MA 01923
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WWW.HANCOCKASSOCIATES.COM

NO.	BY	APP	DATE	ISSUE/REVISION DESCRIPTION

DATE: 5/28/2020 DRAWN BY: RDF
SCALE: 1" = 10' CHECK BY: SRJ

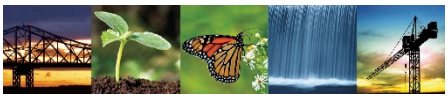
TOPOGRAPHIC PLAN OF LAND IN MONTEREY, MA

PLOT DATE: May 28, 2020 12:02 pm
PATH: F:\Civil 3D Projects\23362-GZA-Monterey\DWG\

DWG: 23362t2.dwg
LAYOUT: EC (2)
SHEET: 2 OF 2

PROJECT NO.: 23362

Attachment E – Geotechnical Report



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Norwood, MA 02062
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F: 781.278.5701
F: 781.278.5702
www.gza.com

June 10, 2020
File No. 01.174558.00

Mr. Shawn Tryon
Director of Operations
Town of Monterey Highway Department
P.O. Box 109
Monterey, MA 01245

Re: Geotechnical Engineering Report
Main Road over Konkapot River
Monterey, Massachusetts 01245

Dear Mr. Tryon:

In accordance with our agreement, dated February 24, 2020, GZA GeoEnvironmental, Inc. (GZA) has prepared this report providing geotechnical recommendations for design and construction of the proposed replacement of culvert carrying Route 23 / Main Road over the Konkapot River in Monterey, MA. This geotechnical evaluation report was prepared to facilitate conceptual design of the culvert, provide data for final design (if culvert replacement is selected), and address certain aspects of the MassDOT Chapter 85 design review and is subject to the limitations attached in **Appendix A**.

Elevations (El.) indicated in this report are in feet and are referenced to the North American Vertical Datum of 1988 (NAVD 88).

BACKGROUND

Our understanding of the project is based on the following information:

- Our correspondence with you;
- "Topographic Plan of Land in Monterey, MA" provided by Hancock Associates, dated April 6, 2020; and
- Readily available on-line information.

This project includes the potential replacement of the existing culvert carrying Route 23 / Main Road over the Konkapot River in Monterey, MA. Refer to the Locus Plan, **Figure No. 1**, for the site location.

The existing culvert consists of a 10-foot tall by 15-foot wide corrugated metal pipe arch with concrete head and channel walls. The elevations at the top of the headwalls are approximately El. 1257 and the invert ranges from approximately El. 1244 to 1245. Top of roadway is at about El. 1256.5.

We anticipate that a replacement culvert would be similar, or larger, in size, and would either be a three-sided box or an arch culvert. Because the culvert structure spans over 10 feet, its replacement is subject to MassDOT design requirements and review (with

respect to the structure being classified as a "bridge") in accordance with MGL Chapter 85, Section 35. We understand that the existing concrete channel walls upstream and downstream of the culvert are likely to substantially remain in place.

SUBSURFACE EXPLORATIONS

A subsurface exploration program was conducted to evaluate subsurface conditions at the site. Approximate boring locations are shown on **Figure No. 2**. Test boring logs are included in **Appendix B**.

TEST BORINGS

Two test borings (designated as B-1 and B-2) were performed to the east and west of the existing culvert by New England Boring Contractors of Brockton, Massachusetts on April 8 and 9, 2020 to evaluate soil conditions in the area of the proposed replacement culvert.

The borings were performed using a truck-mounted drill rig and drive-and-wash drilling methods to depths of 20 to 25 feet below the existing ground surface (bgs), corresponding to approximately El. 1236 feet and El. 1232 feet. Standard Penetration Tests (SPTs) and split spoon samples were generally obtained continuously through the upper 12 feet and at 5-foot intervals thereafter. Split spoon refusals were encountered in boring B-1 at depths of 10.5 feet and 19 feet and in the boring B-2 at a depth of 25 feet. Upon completion, the borings were backfilled with drill cuttings and sand. The roadway surface was patched with cold patch material to match the existing roadway grade.

GZA personnel coordinated, observed and logged each test boring. Boring locations were approximately determined by tape measurements from existing man-made features and elevations were estimated from topographic information prepared by Hancock Associates.

LABORATORY TESTING

Geotechnical laboratory testing included gradation analyses on two granular soil samples and water content and organic content analyses on two organic soil samples collected from the test borings to confirm field classifications and to evaluate engineering properties of the soil and possible reuse of excavated soils during construction.

Laboratory testing was performed by Thielsch Engineering, Inc. of Cranston, Rhode Island. Results are included in **Appendix C**.

SUBSURFACE CONDITIONS

The soil and groundwater conditions described herein are based on the test borings performed as part of this evaluation. Refer to the boring logs included in **Appendix B** for conditions encountered at each boring location.

Local Geology

GZA reviewed subsurface information using the MassGIS Data Viewer to preliminarily evaluate the local subsurface conditions in the project area. The MassGIS data suggests that the majority of overburden soils at the site consist predominantly of glacial till and that bedrock may be shallow. Mass GIS shows that bedrock in the area consists of the Stockbridge Formation, which is beige to dark gray, weathered, quartzose dolomite marble.

GENERALIZED SUBSURFACE CONDITIONS

Based on the borings, subsurface conditions generally consist of asphalt overlying granular fill, organic soils, natural coarse-grained soils (Sand/Sand with Organics) and weathered rock. A general description of the subsurface conditions encountered from the ground surface to bottom of boring is summarized below.

Soil

Asphalt Pavement – Asphalt pavement was encountered at the ground surface in test borings B-1 and B-2. The asphalt pavement was approximately 6 inches thick within the roadway area.

Fill –Fill was encountered in each of the test borings beneath the surficial asphalt pavement layer. The Fill varied from fine to coarse Sand with about 5 to 35 percent inorganic Silt, and about 5 to 35 percent Gravel.

The thickness of the fill layer ranged from approximately 9 to 10 feet. The density of the fill layer ranged from loose to dense with SPT N-values ranging between 7 and 41 blows per foot (bpf) but was generally medium dense with SPT N-Values between 18 and 25 bpf.

Organic Silt/Peat – Approximately 1 foot of peat was encountered beneath the fill layer in boring B-1 and 6.5 feet of Organic Silt/Peat beneath the fill layer in boring B-2. The Organic silt/Peat layer generally consisted of black to brown, Organic Silt or fibrous Peat with 10 to 20 percent Sand, 10 to 20 percent Silt, up to 10 percent Gravel and up to 10 percent of Organics (wood). The density of the organic layer was soft with SPT N-Values ranging between 5 and 8 bpf. A 2-foot thick piece of wood was encountered at the bottom of the organic layer in boring B-1.

Sand with Organics –Sand with Organics was encountered below the Organic Silt/Peat layer in Boring B-1. The 4-foot thick layer of Sand/Sand with Organics generally consisted of gray, fine to coarse Sand with up to 10 percent Gravel, and 10 to 35 percent Silt; gray fine Gravel with up to 35 percent Sand, and up to 10 percent Silt; and black to dark brown, fine to medium Sand with up to 20 percent fibrous Peat or Organic Silt. The density of the Sand/Sand with Organics layer was medium dense with SPT N-values ranging between 20 and 29 bpf.

Decomposed Rock – Approximately 7 feet of Decomposed Rock was encountered in boring B-2 below the organic soils. The fabric of the rock was effectively decomposed into a soil matrix consisting of a very dense, tan, fine to coarse Sand, with 10 to 20 percent Gravel and up to 10 percent Silt.

Weathered Bedrock – Apparent Weathered Bedrock was encountered below the Sand with Organics in boring B-1 at a depth of 17 feet and below the Decomposed Rock in boring B-2 at a depth of approximate 22.5 feet bgs, corresponding to El. 1239 and El. 1234.5, respectively. The thicknesses of the weathered bedrock layer ranged from 2.5 to 3 feet prior to encountering spilt spoon refusal in borings B-1 and B-2 at depths of 20 feet and 22.5 feet bgs, corresponding to El. 1236 and El. 1234.5.

GROUNDWATER

Groundwater was measured in test borings B-1 and B-2 at depths of approximately 8.8 to 9.0 feet below the existing roadway surface, corresponding to approximately El. 1247 to 1248 feet. It should be noted that water was used during drilling operations using drive and wash drilling techniques. Therefore, groundwater levels obtained during or shortly after the completion of drilling are unlikely to represent stabilized conditions and groundwater levels encountered at the site during construction may be different than those reported herein. Groundwater levels are anticipated to be approximately equal to the water level of the adjacent river.

Additionally, seasonal fluctuations in groundwater levels will occur due to variations in precipitation, temperature, season, and other factors different from those existing at the time the measurements were made.

GEOTECHNICAL DESIGN CONSIDERATIONS AND RECOMMENDATIONS

The following geotechnical design recommendations are based on the results of the recent test borings, review of available information provided by the Town, the provisions of the 2017 AASHTO Load and Resistance Factor Design (LRFD) Bridge Design Specifications (referred to as 2017 AASHTO), the 2013 MassDOT LRFD Bridge Manual, and the 2011 AASHTO Guide Specifications for LRFD Seismic Bridge Design with interim revisions through 2015 (referred to as 2011 AASHTO Seismic). These conclusions and recommendations are subject to the limitations in **Appendix A.**

1. Proposed Foundations

Shallow Foundations

The proposed replacement culvert can be supported on spread footings bearing on either the Weathered or Decomposed Bedrock or on ¾-inch Crushed Stone placed over the Weathered or Decomposed Bedrock, after removal of the existing fill and organic soils. Where the footing bears on Crushed Stone or Decomposed Bedrock, consideration should be given to protecting the footing against scour.

The recommended factored bearing resistance for the foundations supported on Crushed Stone over the Decomposed or Weathered Bedrock or on Decomposed Bedrock is 6 kips per square foot (ksf). While the factored bearing resistance for footings bearing directly on Weathered Bedrock would be higher, we recommend all footings be designed for 6 ksf since the actual bearing stratum may vary over the length of the culvert and will not be known until construction.

The factored resistance is based on a performance factor of 0.45 in accordance with Table 10.5.5.2.2-1 of the AASHTO 2017 (refer to **Appendix D** for calculations). The estimated pressure at bearing elevation from the proposed culvert is assumed similar to the existing pressure, and the footings will bear on Weathered Bedrock or Decomposed Bedrock. However, the footings should be designed for an estimated 1 inch of total settlement and ½ inch of differential settlement to allow for a footing to bear on partly weathered rock and decomposed rock. If this amount of settlement is unacceptable, transition zone should be constructed where the subgrade changes from Decomposed Bedrock to Weathered Bedrock.

Footings should bear at least 4 feet below culvert invert elevation to provide frost protection.

2. Static Lateral Earth Pressure

Static lateral earth pressures of the retained fill and the resultant force per unit width behind the proposed culvert walls should be based on at -rest earth pressure conditions as described in Section 3.11.5.1 of AASHTO 2017. The resultant force, P_o, acts at a height of h/3 above the bottom of the culvert wall. The following soil parameters/assumptions are recommended for calculating P_o:

$$P_o = 0.5 * K_o * \gamma * h^2$$

where:

- γ is the total unit weight of the soil backfill; use 125 pounds per cubic foot (pcf) as recommended by the MassDOT LRFD Bridge Manual 2013;

- h is the height of the proposed embankment height;
- K_o is the at-rest earth pressure coefficient. This parameter is based on a horizontal backfill slope behind the wall and a friction angle of 34 degrees for the soil backfill compacted to 95% of a Modified Proctor Test (ASTM D-1557). We recommend that K_o=0.5 be used at this location.

Where the calculated earth pressure behind the culvert is less than 250 pounds per square foot (psf), it should be increased to approximately 250 psf to account for stresses created by compaction of fill behind the culvert wall. Additional lateral pressures due to vehicular traffic surcharge and seismic loads should be applied as required by AASHTO 2017.

These recommended pressures assume that the culvert walls are backfilled with free draining material such that the water level outside of the culvert is not higher than the water level in the culvert. Alternatively, the culvert should be designed for at rest lateral pressures assuming the effective unit weight of soil plus hydrostatic pressure.

3. Geotechnical Seismic Design Considerations

Site Class

The subsurface profile at this site is representative of Site Class D. This site class is based on SPT N-values obtained from the recent exploration borings in accordance with Section 3.4.2.2 of the 2011 AASHTO Seismic. For a single span bridge type and non-critical/non-essential status, a 1,000-year return period is used for design in accordance with Section 3.4.2.1 of the 2013 MassDOT LRFD Bridge Manual. Based on a Site Class D designation, we recommend the design response spectra for the replacement culvert be constructed using the following parameters:

$As = 0.093g$ $S_{DS} = 0.207g$ $S_{D1} = 0.092g$

where: As is the response spectral acceleration based on Site Class D;

S_{DS} is the design spectral acceleration coefficient at 0.2-second period;

S_{D1} is the design spectral acceleration coefficient at 1.0-second period.

Seismic Design Category

Based on the 1-sec period design spectral acceleration for this site and in accordance with Table 3.5-1 of the AASHTO 2011 Seismic, the culvert may be assigned to Seismic Design Category (SDC) A.

Liquefaction

In accordance with 2011 AASHTO Seismic, any single span bridge or a bridge in SDC A does not require a liquefaction analysis.

Refer to **Appendix E** for a summary of the recommended seismic design parameters.

CONSTRUCTION CONSIDERATIONS

1. Subgrade Preparation

Based on the boring data and a proposed bottom of footing elevation of 1239 to 1240, we anticipate up to about 2 feet of organic soils may be present at bottom of footing. In the event that organics and other unsuitable soils

are found below the bottom of the footing, they should be replaced within the zone of influence. The zone of influence is defined as 1 foot laterally from bottom edge of footing and then sloping down at 1 horizontal to 1 vertical.

In other locations, we anticipate that either Weathered Bedrock or Decomposed Bedrock will be present. Where Weathered Bedrock is present, the footing may be cast directly on the footing. Where Decomposed Bedrock is present, we recommend that the Contractor excavate to at least 1 foot below the bottom of footing with a smooth-edged bucket, taking care not to disturb the subgrade. At least 1 foot of ¾-inch Crushed Stone wrapped in non-woven filter fabric should be placed to help protect the subgrade from disturbance.

Disturbed footing subgrades and/or loose or soft zones should be over excavated to remove loose/disturbed material and replaced with compacted 3/4-inch Crushed Stone wrapped in non-woven geotextile filter fabric. If existing Fill or Organic soils are encountered at the bottom of footing, they should be over-excavated and backfilled to culvert subgrade with compacted ¾-inch Crushed Stone wrapped in non-woven geotextile filter fabric within the zone of influence. Sand with Organics may be encountered down to El. 1239 in the area of boring B-1.

Based on the borings, soils at the bottom of excavation will be susceptible to disturbance during excavation in wet conditions. Excavations should be sequenced and conducted in such a way as to minimize disturbance of subgrades and final excavation to the undisturbed Sand and Weathered Bedrock subgrade should be with a smooth-edged excavator bucket. Equipment should not operate directly on the natural subgrade to limit disturbance.

2. Groundwater and Surface Water Control

The contractor should be prepared to manage and control stream flow and groundwater during foundation excavation and culvert construction, as well as control surface water from entering excavations in order to provide a dry and stable subgrade. The method of dewatering excavations will depend on several factors, including depth of excavation, localized soil conditions encountered, time of year performed, size of the open excavation and the length of time the excavation is left open.

The contractor should be responsible for selecting dewatering methods based on its proposed methods and equipment used for excavation to achieve the desired objectives (that is, maintaining a dry condition at the bottom of the excavation during installation of structures, preparation of stable subgrades, etc.). In addition to diverting stream flow and/or constructing cofferdams to construct the footings, we anticipate that multiple sump pumps will be required to control water during foundation construction. If utilized, local sump pumps should be surrounded by ¾-inch Crushed Stone wrapped in non-woven filter fabric to limit migration of fines. Excavation below the groundwater level may not immediately be evident due to the low permeability silty soil, but over time seepage may become visible on excavation side slopes and/or the side slopes may become unstable and slough. Additionally, the contractor's construction methods will need to include means and measures for temporary diversion of the river to accommodate construction.

Dewatering efforts must satisfy requirements of local, state and federal environmental and conservation authorities.

3. Backfill and Compaction

Backfill for the culvert should consist of free-draining Gravel Borrow fill. Backfill materials should be in accordance with the following table.

Borrow Material	MHD Spec. No.	Use
Gravel Borrow	M1.03.0, Type A	Culvert backfill
Crushed Stone for Foundations	M2.01.1	Beneath footings

Gravel Borrow fill should be placed in loose layers not more than 12 inches in thickness and compacted to at least 95 percent of the maximum dry density as determined by the Modified Proctor Test ASTM D-1557. In confined areas and against the culvert walls, place only 6-inch layers and compact with manually operated, powered vibratory compactor equipment acceptable to the geotechnical engineer. Crushed Stone, for any required depth of more than 12 inches, should be placed in 6-inch layers and compacted to an unyielding surface.

Extra care should be used when compacting adjacent to walls. Only hand-operated rollers or plate compactors weighing not more than 250 pounds should be used within a lateral distance of 5 feet of the back of wall.

4. Temporary Excavation Support

Temporary support of excavation is expected to be required for the construction of the proposed culvert to limit excavation quantities and to help with groundwater control. The following soil properties are recommended for design of temporary excavation support systems:

Layer	Minimum Total Unit Weight (pcf)	Maximum Friction Angle φ
Existing Fill	120	30
Organic Silt/Peat	105	25
Sand/ Sand with Organics	120	32

Groundwater pressure should be considered in the excavation support design.

Temporary earth support systems should be selected by the contractor and designed by an experienced Professional Engineer registered in the Commonwealth of Massachusetts and retained by the contractor. Where excavation sides are cut back and sloped, they should be in accordance with Occupational Safety and Health Administration (OSHA) Construction Industry Standards.

5. Reuse of Excavated Materials

Based on the soil descriptions in the boring logs, it is expected that the existing on-site fill may be reused as Ordinary Borrow below pavement subgrade elevation provided soil is culled of stones greater than 8-inches and debris prior to reuse. On-site soils should not be reused within 3 feet of the back of the culvert or as pavement basecourse. Reuse of onsite soils should be subject to the acceptance of the geotechnical engineer prior to placement. Excavated soil that cannot be reused on-site should be removed from the site in accordance with applicable local, state and federal regulations.

CONSTRUCTION

We trust that the information presented herein is sufficient for your use. During construction, we recommend that GZA be engaged to assist with submittal reviews, as well as perform construction observation and testing services during the earthwork and foundation construction phases of the project, where we would observe the contractor's activities for compliance with recommendations in our geotechnical report and the contract documents.

CLOSING

We appreciate the opportunity to work with you on this project and look forward to receipt of any questions or comments you may have.

Very truly yours,
GZA GEOENVIRONMENTAL, INC.

Heather Audet, P.E.
Senior Project Manager

Mary B. Hall, P.E.
Consultant/Reviewer

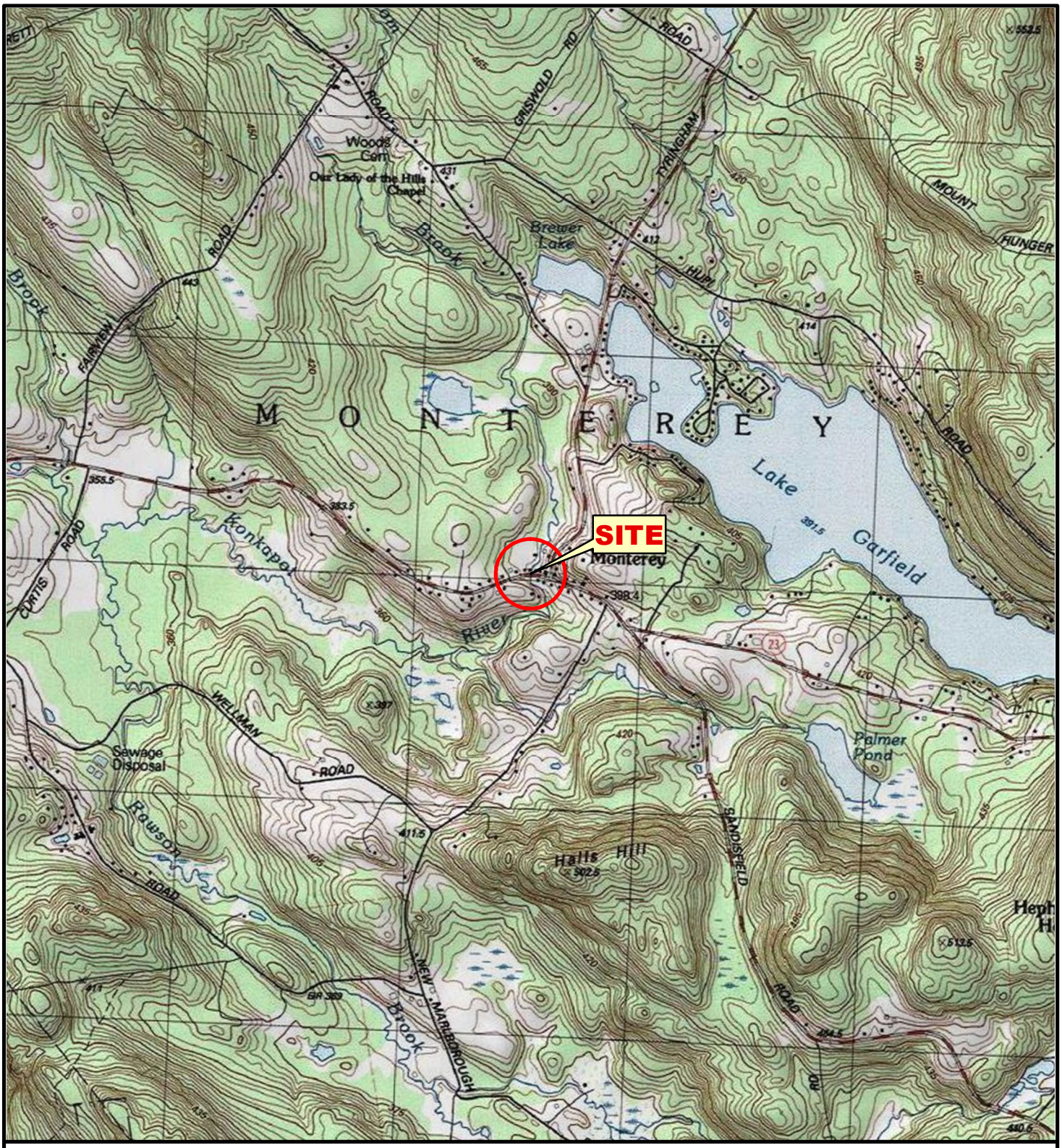
Chad W. Cox, P.E.
Principal-In-Charge

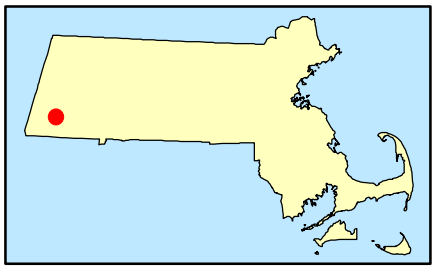
Attachments:

Figures
Appendix A – Limitations
Appendix B – Test Boring Logs
Appendix C – Geotechnical Laboratory Test Results
Appendix D – Calculations
Appendix E – Seismic Design Parameters

J:\170,000-179,999\174558\174558-00.MS\REPORT\Geotech\01 174558 Geotech Memo.docx

Figures





SOURCE : USGS TOPOGRAPHIC QUADRANGLES SCANNED BY THE NATIONAL GEOGRAPHIC SOCIETY & I-CUBED, COPYRIGHT 2011

Data Supplied by : esri

0 1,000 2,000 4,000 6,000

SCALE IN FEET

N W E S

GZA

PROJ. MGR.: HA
DESIGNED BY: HA
REVIEWED BY: MBH
OPERATOR: HA

DATE: 04-29-2020

LOCUS PLAN

JOB NO. 01.0174558.00

MONTEREY CULVERT REPLACEMENT
MAIN ROAD OVER KONKAPOT RIVER
MONTEREY, MASSACHUSETTS

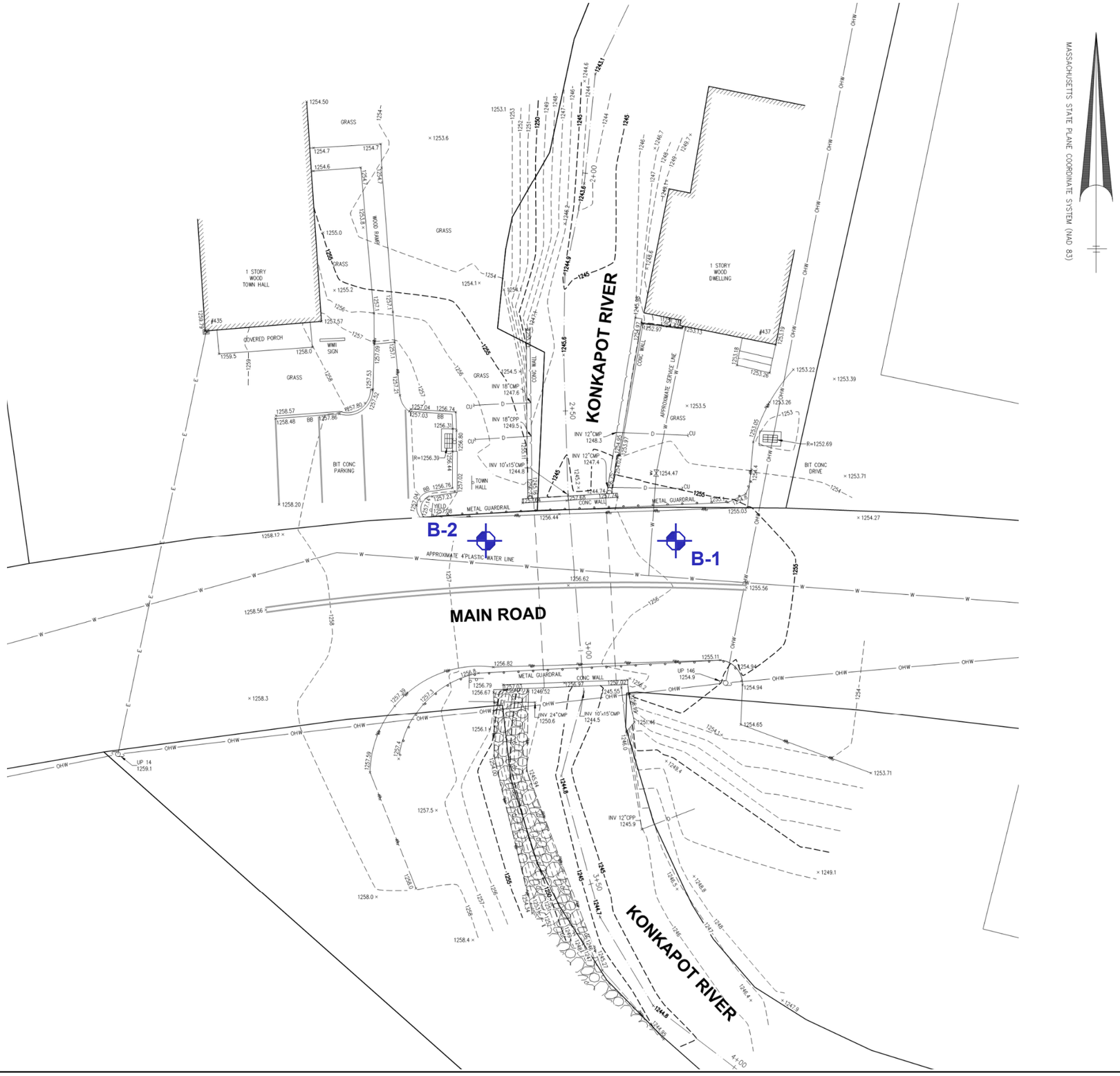
FIGURE NO. 1

LEGEND:

B-1 — INDICATES BORING PERFORMED BY NEW ENGLAND BORING CONTRACTORS ON APRIL 8 AND 9, 2020. LOGGED AND OBSERVED BY GZA PERSONNEL.

GENERAL NOTES:

1. 1. THE BASE MAP WAS DEVELOPED FROM PLANS PROVIDED BY HANCOCK ASSOCIATES ENTITLED "TOPOGRAPHIC PLAN OF LAND IN MONTEREY, MA" DATED APRIL 6, 2020. ELEVATIONS SHOWN HEREIN REFERENCE NAVD88.
2. THE LOCATION OF BORINGS WHERE APPROXIMATELY DETERMINED BY TAPE MEASUREMENTS FROM EXISTING TOPOGRAPHIC AND MAN-MADE FEATURES; THE DATA SHOULD BE CONSIDERED ACCURATE ONLY TO THE DEGREE IMPLIED BY THE METHOD USED.
3. THE PURPOSE OF THIS DRAWING IS TO LOCATE, DESCRIBE, AND REPRESENT THE POSITIONS OF EXPLORATIONS IN RELATION TO THE SUBJECT SITE. THIS DRAWING IS NOT CONSIDERED A LAND SURVEY. THE LOCATIONS SHOWN SHOULD BE CONSIDERED ACCURATE ONLY TO THE DEGREE IMPLIED BY THE METHOD USED.



MASSACHUSETTS STATE PLANE COORDINATE SYSTEM (NAD 83)

OPERATOR: HLA
DATE: APRIL 29, 2020
PROJ MGR: HLA
DESIGNED BY: HLA
REVIEWED BY: MBH

GZA GeoEnvironmental, Inc.

APPROXIMATE SCALE
0' 20' 40'

MONTEREY CULVERT REPLACEMENT
MAIN ROAD OVER KONKAPOT RIVER
MONTEREY, MASSACHUSETTS

EXPLORATION LOCATION PLAN

JOB NO.
01.0174558.00

FIGURE NO.
2

Appendix A – Limitations

USE OF REPORT

1. GZA GeoEnvironmental, Inc. (GZA) prepared this report on behalf of, and for the exclusive use of our Client for the stated purpose(s) and location(s) identified in the Proposal for Services and/or Report. Use of this report, in whole or in part, at other locations, or for other purposes, may lead to inappropriate conclusions; and we do not accept any responsibility for the consequences of such use(s). Further, reliance by any party not expressly identified in the contract documents, for any use, without our prior written permission, shall be at that party's sole risk, and without any liability to GZA.

STANDARD OF CARE

2. GZA's findings and conclusions are based on the work conducted as part of the Scope of Services set forth in Proposal for Services and/or Report, and reflect our professional judgment. These findings and conclusions must be considered not as scientific or engineering certainties, but rather as our professional opinions concerning the limited data gathered during the course of our work. If conditions other than those described in this report are found at the subject location(s), or the design has been altered in any way, GZA shall be so notified and afforded the opportunity to revise the report,as appropriate, to reflect the unanticipated changed conditions .

3. GZA's services were performed using the degree of skill and care ordinarily exercised by qualified professionals performing the same type of services, at the same time, under similar conditions, at the same or a similar property. No warranty, expressed or implied, is made.

4. In conducting our work, GZA relied upon certain information made available by public agencies, Client and/or others. GZA did not attempt to independently verify the accuracy or completeness of that information. Inconsistencies in this information which we have noted, if any, are discussed in the Report.

SUBSURFACE CONDITIONS

5. The generalized soil profile(s) provided in our Report are based on widely-spaced subsurface explorations and are intended only to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized, and were based on our assessment of subsurface conditions. The composition of strata, and the transitions between strata, may be more variable and more complex than indicated. For more specific information on soil conditions at a specific location refer to the exploration logs. The nature and extent of variations between these explorations may not become evident until further exploration or construction. If variations or other latent conditions then become evident, it will be necessary to reevaluate the conclusions and recommendations of this report.

6. In preparing this report, GZA relied on certain information provided by the Client, state and local officials, and other parties referenced therein which were made available to GZA at the time of our evaluation. GZA did not attempt to independently verify the accuracy or completeness of all information reviewed or received during the course of this evaluation.

7. Water level readings have been made in test holes (as described in this Report) at the specified times and under the stated conditions. These data have been reviewed and interpretations have been made in this Report. Fluctuations in the level of the groundwater however occur due to temporal or spatial variations in areal recharge rates, soil heterogeneities, the presence of subsurface utilities, and/or natural or artificially induced perturbations. The water table encountered in the course of the work may differ from that indicated in the Report.

8. Recommendations for foundation drainage, waterproofing, and moisture control address the conventional geotechnical engineering aspects of seepage control. These recommendations may not preclude an environment that allows the infestation of mold or other biological pollutants.

COMPLIANCE WITH CODES AND REGULATIONS

9. We used reasonable care in identifying and interpreting applicable codes and regulations. These codes and regulations are subject to various, and possibly contradictory, interpretations. Compliance with codes and regulations by other parties is beyond our control.

ADDITIONAL SERVICES

10. GZA recommends that we be retained to provide services during any future: site observations, design, implementation activities, construction and/or property development/redevelopment. This will allow us the opportunity to: i) observe conditions and compliance with our design concepts and opinions; ii) allow for changes in the event that conditions are other than anticipated; iii) provide modifications to our design; and iv) assess the consequences of changes in technologies and/or regulations.

Appendix B – Test Boring Logs

TEST BORING LOG

GZA GeoEnvironmental, Inc.
Engineers and Scientists

Monterey Culvert Replacement
Main Road over Konkapot River
Monterey, Massachusetts

BORING NO.: B-1
SHEET: 1 of 1
PROJECT NO: 01.0174558.00
REVIEWED BY: HLA

Drilling Co.: New England Boring Contractors	**Type of Rig:** Truck Rig	**Boring Location:** See Plan	**H. Datum:** See Plan
Foreman: P. Labossiere	**Rig Model:** Failing F-15 Strawn Star	**Ground Surface Elev. (ft.):** 1256	
Logged By: L. Williams	**Drilling Method:** Drive & Wash	**Final Boring Depth (ft.):** 20	**V. Datum:** NAVD88
		Date Start - Finish: 4/8/2020 - 4/8/2020	

Auger/Casing Type:	HW
I.D/O.D.(in):	4"/4.5"
Hammer Weight (lb.):	140
Hammer Fall (in.):	30
Other:	Automatic Hammer

Sampler Type:	Split Spoon
I.D./O.D. (in.):	1.375"/2"
Sampler Hmr Wt (lb):	140
Sampler Hmr Fall (in):	30
Other:	Automatic Hammer

Groundwater Depth (ft.)

Date	Time	Water Depth	Casing	Stab. Time
4/8/20	1330	2.8	17	5 min.
4/8/20	1335	8.8	12	5 min.

Depth (ft)	Casing Blows (ft/min)	Sample No.	Sample Depth (ft.)	Sample Pen. (in)	Sample Rec. (in)	Sample Blows (per 6 in.)	SPT Value	Sample Description and Identification (Modified Burmister Procedure)	Remark	Field Test Data	Stratum Depth (ft.)	Stratum Description	Stratum Elev. (ft.)
		S-1	0.5-2.5	24	12	20 13 12 17	25	S-1: Medium dense, brown, fine to medium SAND, little Gravel, trace Silt, dry.	1		0.5	ASPHALT	1255.5'
		S-2	2.5-4.5	24	18	18 14 15 17	29	S-2: Medium dense, brown, fine to coarse SAND, some Silt, little Gravel, dry.	2				
5		S-3	4.5-6.5	24	12	19 12 13 17	25	S-3: Medium dense, brown, fine to coarse SAND, little Silt, trace Gravel, dry.				FILL	
		S-4	6.5-8.5	24	7	13 4 3 5	7	S-4: Loose, gray, fine to coarse SAND and GRAVEL, little Silt, wet.	3				
		S-5	8.5-10.5	24	12	9 5 3 2	8	S-5: (Top 9") Loose, brown, fine to medium SAND, some Silt, trace Gravel, wet.					
10											10		1246.0'
		S-6	10.5-11.7	14	11	18 48 50/2"	R	S-5: (Bottom 3") Black, fibrous PEAT, little Silt, little fine Sand, trace Wood Debris, wet. S-6: (Top 3") Brown, fine to coarse SAND and GRAVEL, trace Silt, trace Organics, wet. S-6: (Bottom 10") Wood.	4		11	PEAT	1245.0'
												WOOD	
											13		1243.0'
15		S-7	14-16	24	6	37 12 8 13	20	S-7: (Top 3") Black, fine to medium SAND, little fibrous Peat. S-7: (Bottom 3") Medium dense, dark brown, fine to medium SAND, little Organic Silt, trace Organics, wet.				SAND WITH ORGANICS	
											17		1239.0'
									5			WEATHERED BEDROCK	
		S-8	19-19.2	2	2	50/2"	R	S-8: Very dense, tan, fine to coarse SAND, little Gravel, trace Silt.					
20											20		1236.0'
								Bottom of boring at 20 feet.					
25													
30													

REMARKS

1. Ground surface elevation estimated from a plan entitled " Topographic Plan of Land in Monterey, MA", prepared by Hancock Associates and dated April 6, 2020.
2. Asphalt measured 6 inches in thickness.
3. Groundwater observed at 7 feet below ground surface (bgs) in sample S-4.
4. Drilled through a 2-foot-thick piece of wood from 11 to 13 feet bgs.
5. Weathered rock observed in cuttings at 17 feet bgs. Roller bit advanced 3 feet into apparent weathered bedrock.

See Log Key for explanation of sample description and identification procedures. Stratification lines represent approximate boundaries between soil and bedrock types. Actual transitions may be gradual. Water level readings have been made at the times and under the conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the times the measurements were made.

Boring No.: B-1

TEST BORING LOG

GZA GeoEnvironmental, Inc.
Engineers and Scientists

Monterey Culvert Replacement
Main Road over Konkapot River
Monterey, Massachusetts

BORING NO.: B-2
SHEET: 1 of 1
PROJECT NO: 01.0174558.00
REVIEWED BY: HLA

Drilling Co.: New England Boring Contractors	**Type of Rig:** Truck Rig	**Boring Location:** See Plan	**H. Datum:** See Plan
Foreman: P. Labossiere	**Rig Model:** Failing F-15 Strawn Star	**Ground Surface Elev. (ft.):** 1257	
Logged By: L. Williams	**Drilling Method:** Drive & Wash	**Final Boring Depth (ft.):** 25	
		Date Start - Finish: 4/9/2020 - 4/9/2020	**V. Datum:** NAVD88

Auger/Casing Type: HW	**Sampler Type:** Split Spoon	
I.D/O.D.(in): 4"/4.5"	**I.D./O.D. (in.):** 1.375"/2"	
Hammer Weight (lb.): 140	**Sampler Hmr Wt (lb):** 140	
Hammer Fall (in.): 30	**Sampler Hmr Fall (in):** 30	
Other: Automatic Hammer	**Other:** Automatic Hammer	

Groundwater Depth (ft.)

Date	Time	Water Depth	Casing	Stab. Time
4/9/20	1201	6.4	20	30 min.
4/9/20	1206	9.0	15	35 min.

Depth (ft)	Casing Blows (ft/min)	Sample No.	Sample Depth (ft.)	Pen. (in)	Rec. (in)	Blows (per 6 in.)	SPT Value	Sample Description and Identification (Modified Burmister Procedure)	Remark	Field Test Data	Stratum Depth (ft.)	Stratum Description	Stratum Elev. (ft.)
											0.5	ASPHALT	1256.5'
		S-1	0.5-2.5	24	14	20 26 15 11	41	S-1: Dense, brown, fine to coarse SAND, some Gravel, trace Silt, dry.	1				
		S-2	2.5-4.5	24	10	11 11 10 14	21	S-2: Medium dense, brown, fine to medium SAND, little Silt, trace Gravel, dry.	2				
5		S-3	4.5-6.5	24	11	10 9 9 9	18	S-3: Medium dense, brown, fine to medium SAND, little Silt, trace Gravel, wet.				FILL	
		S-4	6.5-8.5	24	6	9 9 11 10	20	S-4: Medium dense, brown, fine to coarse SAND, little Silt, trace Gravel, wet.					
		S-5	8.5-10.5	24	7	5 4 4 3	8	S-5: (Top 5") Loose, brown, fine to coarse SAND, trace Silt, trace Gravel, wet. S-5: (Bottom 2") WOOD.			9		1248.0'
10		S-6	10.5-12.5	24	9	4 2 3 3	5	S-6: Soft, black, Organic SILT, trace Peat, trace Sand, wet.				ORGANIC SILT/PEAT	
15		S-7	14-16	24	4	4 2 4 16	6	S-7: (Top 3") Medium stiff, brown, fibrous PEAT, trace Gravel, Wood Debris, wet. S-7: (Bottom 1") Gray, fine GRAVEL, some fine to coarse Sand, trace Silt, wet.			15.5		1241.5'
20		S-8	19-21	24	14	20 15 14 16	29	S-8: Medium dense, gray, fine to medium SAND, little Silt, trace Gravel, we. (Decomposed Bedrock)				SAND/DECOMPOSED BEDROCK	
									3		22.5		1234.5'
25							R					WEATHERED BEDROCK	
		S-9	25-25	0	0	50/0"		Bottom of boring at 25 feet.			25		1232.0'
30													

REMARKS

1. Ground surface elevation estimated from a plan entitled " Topographic Plan of Land in Monterey, MA", prepared by Hancock Associates and dated April 6, 2020.
2. Asphalt measured 6 inches in thickness.
3. Probable bedrock encountered at 22.5 feet below ground surface (bgs). Roller bit advanced to 24 feet bgs. Split spoon refusal at 25 feet bgs.

See Log Key for explanation of sample description and identification procedures. Stratification lines represent approximate boundaries between soil and bedrock types. Actual transitions may be gradual. Water level readings have been made at the times and under the conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the times the measurements were made.

Boring No.: B-2

Appendix C – Geotechnical Laboratory Test Results

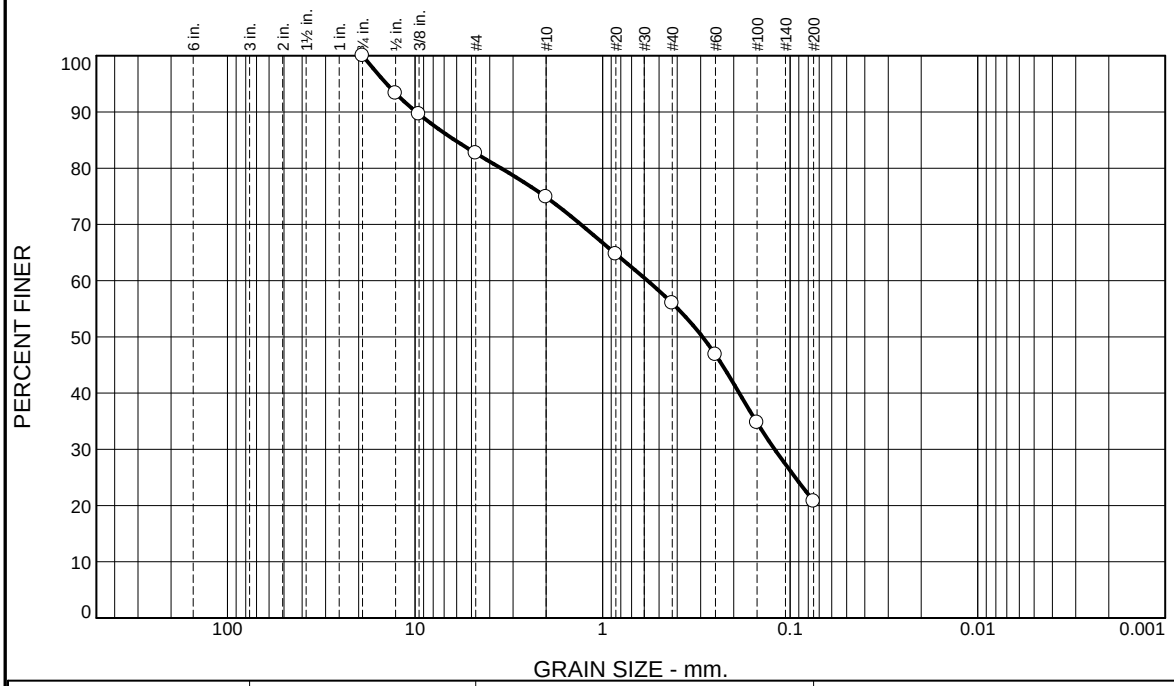
THIELSCH ENGINEERING	14 Rocsam Park Road Braintree, MA 02184 Phone: (781)-848-5184 Fax: (401)-467-2398 thielsch.com *Let's Build a Solid Foundation*	Client Information: GZA GeoEnvironmental, Inc. Norwood, MA PM: Heather Audet Assigned By: Heather Audet Collected By: L. Williams	Project Information: **Monterey Culvert Replacement** **Monterey , MA** GZA Project Number: 01.0174558.00 Summary Page: 1 of 1 Report Date: 04.24.2020

LABORATORY TESTING DATA SHEET, Report No. 7420-D-B006

Boring ID	Sample #	Depth (ft)	Laboratory No.	Identification Tests								Proctor / CBR / Permeability Tests								Laboratory Log and Soil Description
				As Received Water Content %	LL %	PL %	Gravel %	Sand %	Fines %	Org. %	G_s	Dry unit wt. pcf	Test Water Content %	γ_d MAX (pcf) W_{opt} (%)	γ_d MAX (pcf) W_{opt} (%) (Corr.)	Target Test Setup as % of Proctor	CBR @ 0.1"	CBR @ 0.2"	Perme-ability cm/sec	
				D2216	D4318		D6913			D2874	D854			D1557						
B-1	S-2	2.5-4.5	20-S-B180				17.3	61.9	20.8											Light Brown f-c SAND, some Silt, little fine Gravel
B-1	S-5T	8.5-10	20-S-B181				8.0	66.9	25.1											Light Brown f-m SAND, some Silt, trace fine Gravel
B-1	S-5B	10-10.5	20-S-B182	93.4						20.8										Organic Content Only
B-2	S-6	10.5-12.5	20-S-B183	72.6						11.8										Organic Content Only

Date Received *04.17.2020* Reviewed By: Date Reviewed: *04.24.2020*

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	17.3	7.8	18.9	35.2	20.8	

Test Results (D6913 & ASTM D 1140)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
0.75"	100.0		
0.5"	93.3		
0.375"	89.6		
#4	82.7		
#10	74.9		
#20	64.7		
#40	56.0		
#60	46.8		
#100	34.7		
#200	20.8		

* (no specification provided)

Material Description

Light Brown f-c SAND, some Silt, little fine Gravel

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-2-4(0)

Coefficients

D_{90}= 9.8468 D_{85}= 6.1321 D_{60}= 0.5758
D_{50}= 0.2929 D_{30}= 0.1209 D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 4/17/2020 **Date Tested:** 4/22/2020

Tested By: GP

Checked By: Steven Accetta

Title: Laboratory Coordinator

Source of Sample: B-1 **Depth:** 2.5-4.5' **Date Sampled:** 4/13/2020
Sample Number: S-2

Thielsch Engineering Inc.

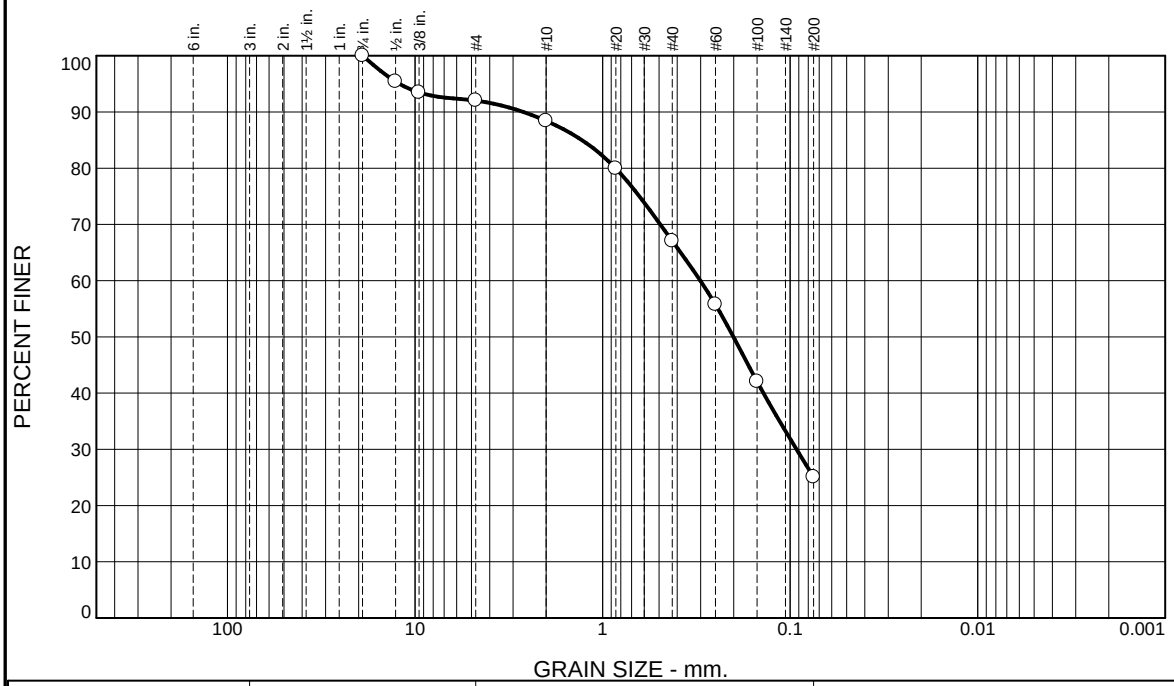
Cranston, RI

Client: GZA GeoEnvironmental

Project: Monterey Culvert Replacement
Monterey, MA

Project No: 01.0174558.00 **Figure** 20-S-B180

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	8.0	3.6	21.4	41.9	25.1	

Test Results (D6913 & ASTM D 1140)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
0.75"	100.0		
0.5"	95.4		
0.375"	93.5		
#4	92.0		
#10	88.4		
#20	79.9		
#40	67.0		
#60	55.7		
#100	42.1		
#200	25.1		

* (no specification provided)

Material Description

Light brown f-m SAND, some Silt, trace fine Gravel

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-2-4(0)

Coefficients

D_{90}= 2.6459 D_{85}= 1.2880 D_{60}= 0.3011
D_{50}= 0.2006 D_{30}= 0.0925 D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 4/17/2020 **Date Tested:** 4/22/2020

Tested By: GP

Checked By: Steven Accetta

Title: Laboratory Coordinator

Source of Sample: B-1 **Depth:** 8.5-10' **Date Sampled:** 4/13/2020
Sample Number: S-5T

Thielsch Engineering Inc.

Cranston, RI

Client: GZA GeoEnvironmental

Project: Monterey Culvert Replacement
Monterey, MA

Project No: 01.0174558.00 **Figure** 20-S-B181

Appendix D – Calculations

Bearing Capacity Evaluation

Project No: 01.174558.00 **Rev. 0**
Project: Main Road over Konkapot River
Location: Monterey, MA
Calculated By: BY **Date:** 4/29/2020
Checked By: HA **Date:** 4/30/2020

Objective: Evaluate the factored bearing resistance for the proposed replacement culvert at Main Road over Konkapot River, Monterey MA. The proposed culvert will be bearing on medium dense, natural, coarse-grained soils (Decomposed Bedrock/Weathered Bedrock) or structural fill placed after the removal of the soft organic layer.

References: 1) AASHTO LRFD Bridge Design Specifications, 7th Edition, 2017.
2) Boring Logs from borings B-1 and B-2.

Assumptions: 1) Assume rigid foundation.
2) Assume strip footing with a dimension of 2 feet wide and 40 feet long and footing embedment depth a minimum of 4 feet (El. 1240).
3) Adjacent finished grades assumed to be relatively flat at footing grade (i.e., no corrections for sloping ground).
4) Vertical or near-vertical loading is anticipated on the culvert, therefore little to no load eccentricity is anticipated. therefore little to no load eccentricity is anticipated. For the purpose of evaluating bearing resistance, assume a load eccentricity of 0-ft.
5) Culvert foundations bearing on the medium dense natural coarse-grained soils (Decomposed Bedrock/Weathered Bedrock) or structural fill placed after the removal of the organic soils.
6) Depth Correction Factor of cohesionless material above bearing elevation dq estimated using AASHTO Table 10.6.3.1.2a-4 based on friction angle of Sand of 32 degrees.
7) Scour depths are unknown at this time.

Analysis: 1. Evaluate the soil stratigraphy:
Soil stratigraphy based on data from recent borings conducted on April 8 and 9, 2020 that were observed and logged by GZA. Boring B-2 was selected as the worst case for analysis.
2. Evaluate soil properties:
Soil properties were based on data from the recent borings.
3. Evaluate the nominal and factored foundation bearing resistance for the proposed strip footing as described in the 2017 AASHTO LRFD Bridge specifications, using equation 10.6.3.1.2a-1, C10.6.3.1.2f-1 and equation 10.6.3.1.1-1.

Results: Results of the bearing resistance analysis are summarized in the table below and in the attached calculation sheets.

Summary of Nominal and Factored Geotechnical Bearing Resistance Analysis

B (ft)	L (ft)	Df (ft)	Nominal Bearing Resistance qn (ksf)	Resistance Factor	Factored Bearing Resistance qr (ksf)
2	40	4	13.1	0.45	5.9

Estimated post-construction elastic and consolidation settlement are anticipated to be negligible. The factored bearing resistance is based on an assumed load eccentricity of 0-ft and should be considered applicable for load cases with eccentricities of 0-ft. If eccentricities are greater than 0-ft, our recommendations should be re-evaluated using higher eccentricity values.

Notes
1) A geotechnical resistance factor of 0.45 in accordance with Table 10.5.5.2.2-1 of 2014 AASHTO for footings in all soils.
2) Proposed footing dimensions, embedment depths are assumed based on the existing culvert.
3) Footing area evaluated taken as footing length times the footing width with little to no eccentricity (assumed an eccentricity of 0-ft).
4) Use 6 ksf for Facatored Bearing Resistance.

Attachments: Bearing Resistance Calculations

GZA
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http://www.gza.com

PROJECT: Main Road over Konkapot River
LOCATION: Monterey, MA
CALCULATED BY BY **DATE** 4/29/2020
CHECKED BY HA **DATE** 4/29/2020

OBJECTIVE: Evaluate the factored bearing resistance for the proposed culvert foundation to be constructed at Main Road over Konkapot River, Monterey, MA.

REFERENCE:
GZA Boring B-2

ASSUMPTIONS AND INPUT

ASSUMPTIONS

- Foundations bear at 4.0-ft below grade (below frost).
- Soil stratigraphy below is based on boring B-2 (worst case). Organic layer in B-1 was over-excavated and replaced with structural fill.
- Proposed conditions: approximately 1-ft of structural fill placed over naturally deposited medium dense Decomposed Bedrock/Weathered Bedrock.
- Use AASHTO 2017 for bearing capacity calculations, Section 10.6.3.1.2f - Two Layered Soil System in Drained Condition to determine Q_n
- Groundwater approximately at grade.

ASSUMED SOIL INPUT PARAMETERS

Layers			Soil Type	N Value (avg)	γ_d	ϕ	c	Assumptions
Top	Bottom	Thickness (ft)			(pcf)	(deg)	(psf)	
0	1	1	Structural Fill	25	125	34	0	Foundation bearing @ 4.0 ft below grade
1	6	5	fine to medium Sand, little Silt	25	120	32	0	Medium dense

CALCULATIONS

- Use AASHTO 2017 to determine bearing capacity. Use Section 10.6.3.1.2f - Two Layered Soil System in Drained Loading
- Assume fully drained condition

DETERMINE THE NOMINAL BEARING CAPACITY

$$q_n = q_2 \, e^{0.67[1+(B/L)](H/B)}$$ Eq. C10.6.3.1.2f-1

- q_2 is the nominal bearing capacity for a fictitious footing of the same size founded on the lower layer of a two-layer system

DETERMINE q_2

			Basis for Assumption (if applicable)
Soil Unit Weight, γ =	120	pcf	See assumed soil stratigraphy and input parameters
Friction Angle of bearing stratum, ϕ =	32	degrees	See assumed soil stratigraphy and input parameters
Cohesion Bearing Capacity Factor, N_c =	35.5		AASHTO Table 10.6.3.1.2a-1
Embedment Bearing Capacity Factor, N_q =	23.2		AASHTO Table 10.6.3.1.2a-1
Unit Weight Bearing Capacity Factor, N_γ =	30.2		AASHTO Table 10.6.3.1.2a-1
Cohesion, c =	0	psf	Assumed for medium dense Sand
Depth to Groundwater, D_w =	0	ft	Assumed groundwater approximately at grade
Poisson's Ratio, υ=	0.30		AASHTO Table C10.4.6.3-1 - Sand
Young's Modulus, E_s =	6.94	ksi	AASHTO Table C10.4.6.3-1 - Sand

FOOTING PARAMETERS

			Basis for Assumption (if applicable)
Footing Length, L =	40	ft	See assumptions.
Footing Width, B=	2	ft	
Df/B=	2.0	ft	
Footing Embedment Depth, D_f =	4	ft	See assumptions.
Footing Eccentricity, e =	0	ft	Assuming footing has little to no eccentricity
Depth from footing bearing to top of lower layer H=	1	ft	

ASSUMED BEARING RESISTANCE FACTOR

		Basis for Assumption (if applicable)
Bearing Resistance Factor, φ_b =	0.45	AASHTO Table 10.5.5.2.2-1 (footing in all soils)

CALCULATIONS

GZA
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PROJECT: Main Road over Konkapot River
LOCATION: Monterey, MA
CALCULATED BY BY **DATE** 4/29/2020
CHECKED BY HA **DATE** 4/29/2020

DETERMINE FACTORED BEARING RESISTANCE, q_r

- Determine effective footing width, B', to account for eccentric loading: (AASHTO eqn 10.6.1.3-1)
- Account for groundwater using factors C_{wq} and $C_{w\gamma}$ using Table 10.6.3.1.2a-2
- Account for sloping ground by replacing N_q and N_γ with factors N_{cq} and $N_{c\gamma}$ in accordance with Section 10.6.3.1.2c, if applicable
- Shape Correction Factors s_c, s_γ, and s_q determined using equation in AASHTO Table 10.6.3.1.2a-3
- Depth Correction Factor of cohesionless material above bearing elevation d_q estimated using AASHTO Table 10.6.3.1.2a-4
- Load inclination factors i_c, i_γ, and i_q assumed to be 1.0 based on unknown loading conditions
- Nominal Bearing Resistance, q_2, determined using equation 10.6.3.1.2a-1

$$q_2 = cN_{cm} + \gamma D_f N_{qm} C_{wq} + 0.5\gamma B' N_{\gamma m} C_{w\gamma}$$

where: $N_{qm} = N_q s_q d_q i_q$

$N_{\gamma m} = N_\gamma s_\gamma i_\gamma$

$N_{cm} = N_c s_c i_c$

- Factored Bearing Resistance, q_r, estimated using equation 10.6.3.1.1-1: $q_r = q_n \varphi_b$

B [ft]	e [ft]	B' [ft]	B'/L	D_f/B'	$C_{w\gamma}$	C_{wq}	N_{cq} (if applicable)	$N_{c\gamma}$ (if applicable)	s_c	s_γ	s_q	d_q
2	0.0	2.0	0.05	2.00	0.5	0.5			1.03	0.98	1.03	1.3

B [ft]	N_{qm}	$N_{\gamma m}$	N_{cm}	q_2 [psf]	**q_n [psf]**	**q_r [ksf]**
2	31.1	29.6	36.7	9,240	**13,136**	**5.9**

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PROJECT: Main Road over Konkapot River
LOCATION: Monterey, MA
CALCULATED BY BY **DATE** 4/29/2020
CHECKED BY HA **DATE** 4/29/2020

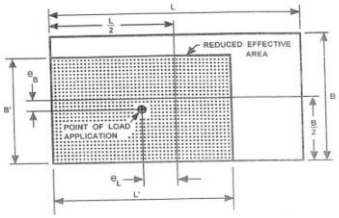
ESTIMATE ELASTIC AND CONSOLIDATION SETTLEMENT

Evaluate the estimated elastic and consolidation settlement due to proposed culvert replacement net loading.

The effective stress beneath the culvert for the post-construction condition is anticipated to be effectively unchanged. Therefore, post-construction elastic and consolidation settlement is anticipated to be negligible.

REFERENCE TABLES/PLOTS

Eccentricity



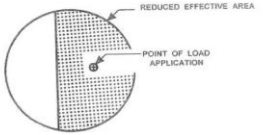


Figure C10.6.1.3-1—Reduced Footing Dimensions

$$B' = B - 2e_B \qquad (10.6.1.3\text{-}1)$$

$$L' = L - 2e_L$$

where:

e_B = eccentricity parallel to dimension B (ft)

e_L = eccentricity parallel to dimension L (ft)

Bearing Capacity Factors

Table 10.6.3.1.2a-1—Bearing Capacity Factors N_c (Prandtl, 1921), N_q (Reissner, 1924), and N_γ (Vesic, 1975)

ϕ_f	N_c	N_q	N_γ	ϕ_f	N_c	N_q	N_γ
0	5.14	1.0	0.0	23	18.1	8.7	8.2
1	5.4	1.1	0.1	24	19.3	9.6	9.4
2	5.6	1.2	0.2	25	20.7	10.7	10.9
3	5.9	1.3	0.2	26	22.3	11.9	12.5
4	6.2	1.4	0.3	27	23.9	13.2	14.5
5	6.5	1.6	0.5	28	25.8	14.7	16.7
6	6.8	1.7	0.6	29	27.9	16.4	19.3
7	7.2	1.9	0.7	30	30.1	18.4	22.4
8	7.5	2.1	0.9	31	32.7	20.6	26.0
9	7.9	2.3	1.0	32	35.5	23.2	30.2
10	8.4	2.5	1.2	33	38.6	26.1	35.2
11	8.8	2.7	1.4	34	42.2	29.4	41.1
12	9.3	3.0	1.7	35	46.1	33.3	48.0
13	9.8	3.3	2.0	36	50.6	37.8	56.3
14	10.4	3.6	2.3	37	55.6	42.9	66.2
15	11.0	3.9	2.7	38	61.4	48.9	78.0
16	11.6	4.3	3.1	39	67.9	56.0	92.3
17	12.3	4.8	3.5	40	75.3	64.2	109.4
18	13.1	5.3	4.1	41	83.9	73.9	130.2
19	13.9	5.8	4.7	42	93.7	85.4	155.6
20	14.8	6.4	5.4	43	105.1	99.0	186.5
21	15.8	7.1	6.2	44	118.4	115.3	224.6
22	16.9	7.8	7.1	45	133.9	134.9	271.8

Groundwater Depth Correction Factors

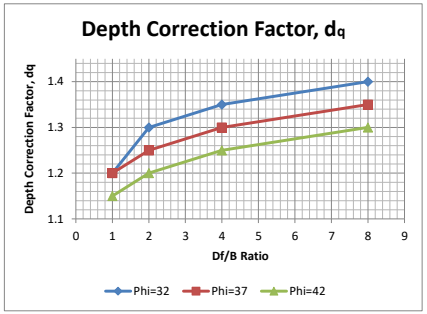
Table 10.6.3.1.2a-2—Coefficients C_{wq} and $C_{w\gamma}$ for Various Groundwater Depths

D_w	C_{wq}	$C_{w\gamma}$
0.0	0.5	0.5
D_f	1.0	0.5
$>1.5B + D_f$	1.0	1.0

Depth Correction Factor

Table 10.6.3.1.2a-4—Depth Correction Factor d_q

Friction Angle, ϕ_f (degrees)	D_f/B	d_q
32	1	1.20
	2	1.30
	4	1.35
	8	1.40
37	1	1.20
	2	1.25
	4	1.30
	8	1.35
42	1	1.15
	2	1.20
	4	1.25
	8	1.30



Shape Factors

Table 10.6.3.1.2a-3—Shape Correction Factors s_c, s_γ, s_q

Factor	Friction Angle	Cohesion Term (s_c)	Unit Weight Term (s_γ)	Surcharge Term (s_q)
Shape Factors s_c, s_γ, s_q	$\phi_f = 0$	$1 + \left(\frac{B}{5L}\right)$	1.0	1.0
	$\phi_f > 0$	$1 + \left(\frac{B}{L}\right)\left(\frac{N_q}{N_c}\right)$	$1 - 0.4\left(\frac{B}{L}\right)$	$1 + \left(\frac{B}{L}\tan\phi_f\right)$

Shape and Rigidity Factors

Table 10.6.2.4.2-1—Elastic Shape and Rigidity Factors, EPRI (1983)

L/B	Flexible, β_z (average)	β_z Rigid
Circular	1.04	1.13
1	1.06	1.08
2	1.09	1.10
3	1.13	1.15
5	1.22	1.24
10	1.41	1.41

Resistance Factors

Table 10.5.5.2.2-1—Resistance Factors for Geotechnical Resistance of Shallow Foundations at the Strength Limit State

Method/Soil/Condition			Resistance Factor
Bearing Resistance	φ_b	Theoretical method (Munfakh et al., 2001), in clay	0.50
		Theoretical method (Munfakh et al., 2001), in sand, using *CPT*	0.50
		Theoretical method (Munfakh et al., 2001), in sand, using *SPT*	0.45
		Semi-empirical methods (Meyerhof, 1957), all soils	0.45
		Footings on rock	0.45
		Plate Load Test	0.55
Sliding	φ_{t1}	Precast concrete placed on sand	0.90
		Cast-in-Place Concrete on sand	0.80
		Cast-in-Place or precast Concrete on Clay	0.85
		Soil on soil	0.90
	φ_{ep}	Passive earth pressure component of sliding resistance	0.50

Appendix E – Seismic Design Parameters

Seismic Site Class Calculation Summary

Project: Main Road over Konkapot River **Project No.:** 174558.00
Location: Monterey, MA
Evaluated By/Date: BY 4/29/2020
Checked By/Date: HA 4/30/2020

Objective: Determine seismic site class by performing calculations in accordance with MassDOT LRFD Bridge Design Manual, which references the AASHTO Guide Specifications for LRFD Seismic Bridge Design (2nd edition, 2011 with interim revisions).

Subsurface Data:

Borings B-1 and B-2, completed by New England Boring Contractors of Brockton, MA on April 8-9, 2020.

Approach: 1) Evaluate if the procedure in AASHTO LRFD Seismic Section 3.4.2.2. for classifying a site. Sites with highly variable subsurface conditions or very large sites may require multiple site class determinations or a site-specific seismic response analysis. Furthermore, classifying a site based on the 100 feet of soil and rock beneath the ground surface may be inappropriate if deep deposits of weak soils are present below 100 feet, or if foundation structures are supported on firm soil or rock below soft soils which can be justified as having little effect on the structure's seismic response.

2) Evaluate if soil properties are known in sufficient detail to determine site class. If data is not known in sufficient detail, AASHTO permits the use of Site Class D, unless conditions for Site Class E or Site Class F are likely to be present.

3) Check for the four categories of Site Class F requiring site-specific evaluation:
- Peats or highly organic clays greater than 10 feet in thickness
- Thick layers (greater than 25 feet) of highly plastic clay (PI > 75)
- Very thick soft/medium stiff clays (greater than 120 feet)

4) Check for existence of greater than 10 feet of soft clay (where s_u < 500 psf, w > 40%, and PI > 20). If these conditions are met, classify as Site Class E.

5) Categorize the site using one of the following three methods:
- $\overline{v}_s$ (Method A) - $\overline{N}$ (Method B) - $\overline{N}_{ch}$ *and* $\overline{s_u}$ (Method C)

If shear wave velocity data are available, they should be used to classify the site. The N and $\overline{s_u}$ methods should only be used if shear wave velocity data is not available, as the correlation between site amplification and these geotechnical parameters is more uncertain (and therefore more conservative) than the correlation with $\overline{v_s}$.

Results: Calculations of the Seismic Site Class based on Method B as described in section 3.4.2.2 of the LRFD Seismic Bridge Design Guide Specifications are attached. Calculations results are summarized in the table below.

Boring ID	B-1	B-2
$\overline{N}$-Value	49.2	35.4
Site Class	D	D

Conclusions: Based on the procedure outlined in section 3.4.2.2 and table 3.4.2.1-1 of the LRFD Seismic Bridge Design Specifications, we recommend that **Site Class D** be used for design based on the limited boring depths.

Based on the criteria speficied in the MassDOT LRFD Bridge Manual, the culvert structure is considered a non-critical/non-essential, conventional bridge. Therefore, seismic design parameters may be developed using the hazard maps contained in AASHTO LRFD Seismic, which are based on a 1,000-year return period event.

Using the seismic design maps provided in Section 3.4.1 of AASHTO LRFD Seismic, we recommend the following seismic design parameters:

S_s = 0.129g	F_a = 1.6	S_{DS} = 0.207g
S_1 = 0.038g	Fv = 2.4	S_{D1} = 0.092g
PGA = 0.058g	F_{PGA} = 1.6	A_s = 0.093g

In accordance with Table 3.5-1 of AASHTO LRFD Seismic, the bridge should be classified in **Seismic Design Category (SDC) A.** We note that for SDC A and for single-span bridges, a liquefaction analysis is not required (AASHTO LRFD Seismic section 3.5).

SPT-Based Seismic Site Class Calculation

Main Road over Konkapot River
Monterey, MA

Calculated By: BY Date: 4/29/2020
Checked By: HA Date: 4/30/2020

INPUT

Exploration ID: **B-1** Ground Surface Elevation: 1256.0 ft Depth of Boring: 20.0 ft

Depth to Bedrock: 20.0 ft

EQUATIONS

$$\overline{N}_{ch} = \frac{\sum_{i=1}^{m} d_i}{\sum_{i=1}^{m} \frac{d_i}{N_i}}$$

where: m = number of layers
d_i = the thickness of all layers between 0 and 100 feet.
d_c = the thickness of any clay layers between 0 and 100 feet.
N_i = the Standard Penetration Resistance (ASTM D 1586) of cohesionless soil layers not to exceed 100 blows/ft as directly measured in the field without corrections.
Note: d_i calculated assuming breaks between sub-layers occur at the midpoint between SPT sample intervals (unless noted otherwise)

CALCULATION

$\overline{N}$ = 49.2

Soil Strata	SPT Interval Depth Top, ft	SPT Interval Depth Bottom, ft	SPT Elevation (mid-interval)	SPT N-value	d_i	d_i / N_i	Comment
Fill	0.5	2.5	1254.5	25	2.5	0.10	
	2.5	4.5	1252.5	29	2.0	0.07	
	4.5	6.5	1250.5	25	2.0	0.08	
Sand	6.5	8.5	1248.5	7	2.0	0.29	
	8.5	10.5	1246.5	8	2.0	0.25	
Peat	10.5	11.7	1244.9	18	2.4	0.13	
Sand w/Organics	14.0	16.0	1241.0	20	6.2	0.31	
Weathered Rock	19.0	100.0	1196.5	100	81.0	0.81	

SPT-Based Seismic Site Class Calculation

Main Road over Konkapot River
Monterey, MA

Calculated By: BY Date: 4/29/2020
Checked By: HA Date: 4/30/2020

INPUT

Exploration ID: B-2 Ground Surface Elevation: 1257.0 ft Depth of Boring: 25.0 ft

Depth to Bedrock: 25.0 ft

EQUATIONS

$$\overline{N}_{ch} = \frac{\sum_{i=1}^{m} d_i}{\sum_{i=1}^{m} \frac{d_i}{N_i}}$$

where: m = number of layers
d_i = the thickness of all layers between 0 and 100 feet.
d_c = the thickness of any clay layers between 0 and 100 feet.
N_i = the Standard Penetration Resistance (ASTM D 1586) of cohesionless soil layers not to exceed 100 blows/ft as directly measured in the field without corrections.
Note: d_i calculated assuming breaks between sub-layers occur at the midpoint between SPT sample intervals (unless noted otherwise)

CALCULATION

$\overline{N}$ = 35.4

Soil Strata	SPT Interval Depth Top, ft	SPT Interval Depth Bottom, ft	SPT Elevation (mid-interval)	SPT N-value	d_i	d_i / N_i	Comment
Fill	0.5	2.5	1255.5	41	2.5	0.06	
	2.5	4.5	1253.5	21	2.0	0.10	
	4.5	6.5	1251.5	18	2.0	0.11	
	6.5	8.5	1249.5	20	2.0	0.10	
Organic Silt/Peat	8.5	10.5	1247.5	8	2.0	0.25	
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Attachment F – Hydrology and Hydraulic Report

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June 10, 2020
File No. 01.174558.00

Mr. Shawn Tryon
Director of Operations
Town of Monterey Highway Department
P.O. Box 109
Monterey, MA 01245

Re: Hydrological and Hydraulic Engineering Report
Main Road over Konkapot River
Monterey, Massachusetts

Dear Mr. Tryon:

In accordance with our agreement, dated February 24, 2020, GZA GeoEnvironmental, Inc. (GZA) has prepared this report providing hydrological and hydraulic analysis for design and construction of the proposed replacement of culvert carrying Route 23 / Main Road over the Konkapot River in Monterey, MA. This hydrological and hydraulic analysis report was prepared to facilitate conceptual design of the culvert, provide data for final design (if culvert replacement is selected), and address certain aspects of the MassDOT Chapter 85 design review and Massachusetts Stream Crossing Standards.[1] This report is subject to the limitations attached in **Appendix A**.

Elevations (El.) indicated in this report are in feet and are referenced to the North American Vertical Datum of 1988 (NAVD 88).

BACKGROUND

GZA's evaluation and conclusions were based on use and review of the following data sources:

- "Topographic Plan of Land in Monterey, MA" provided by Hancock Associates, dated April 6, 2020;
- Latest topographic data available from MassGIS: 1-meter horizontal resolution Digital Elevation Model for Massachusetts – Massachusetts (2015);
- Google Earth aerial imagery;
- Observations during GZA's site visits on March 24, 2020.

[1] Massachusetts Stream Crossing Handbook, Department of Fish and Game, Division of Ecological Restoration, 2nd edition, June 2012.

SITE DESCRIPTION

The existing culvert is located at the crossing of Konkapot River and Main Road, between street address numbers 437 (a house adjacent to the river's left bank) and 435 (Monterey Town Hall). The structure is a 15-foot wide, 10-foot high corrugated metal pipe arch culvert, with a concrete headwall and concrete training walls on the upstream side. On the downstream side, there is concrete wingwall on the left side of the culvert, with riprap on the right river bank. The road is classified in MassDOT road Inventory as *Rural Major Collector* or *Urban Minor Arterial roadway.* The culvert is within a special flood hazard area, Zone A, as delineated by FEMA in Flood Insurance Rate Map 2500300010B, effective June 15, 1981.

Konkapot River flows out of Lake Garfield dam about 0.9 mile upstream of the culvert. Other structures on the Konkapot River include a footbridge about 250 feet upstream of the culvert, and Old Stone Dam about 300 feet downstream of the culvert.

GZA conducted site visit on March 24, 2020 to assess the natural stream's bankfull conditions and perform bankfull width measurements. To estimate the natural condition, GZA performed the measurements at several locations extending up to approximately 400 feet upstream of the culvert. The locations of the selected measurements were evaluated to be at adequate distances from the culvert and therefore not affected by the backwater from the culvert. Bankfull width at these locations was measured to be 20.5 feet to 21 feet from top of the bank in accordance with North Atlantic Aquatic Connectivity Collaborative (NAACC) guidelines.

The footbridge upstream of the culvert was measured to be 18 feet wide at the top and 7.7 feet high from the lowest point in the river's cross section to the bridge's low chord. Old Stone Dam was measured to be a 12.6 feet high masonry dam, with an 8-foot wide spillway. The normal pool was observed to be about 2 inches lower than the dam crest at the time of site visit.

METHODOLOGY

GZA followed the methodology recommended by MassDOT in their LRFD Bridge Manual[2] to perform hydrologic and hydraulic analysis. The design flood for the culvert, during which a minimum of 2 feet freeboard is required, has a return period of 25 years, per MassDOT requirements for culvert on *Rural Major Collector* or *Urban Minor Arterial roadways*. The freeboard per MassDOT definition is measured from the culvert's low chord and is required to allow passage of debris and ice during flood conditions without reduction in the culvert 's hydraulic capacity due to blockage.

GZA estimated flows within Konkapot River at culvert using the USGS StreamStats Web Application. StreamStats estimates flows using regression equations as defined in the National Streamflow Statistics (NSS) Program, a MassDOT recommended hydrologic computational method, based on watershed characteristics, such as drainage area and watershed slope. The potential impact of upstream regulation due to Lake Garfield Dam on peak flood flows at Main Road culvert was conservatively not included in this analysis. Given its size/area, Lake Garfield may provide attenuation of floods, particularly for relatively frequent events.

In support of the hydraulic analysis, GZA developed a one-dimensional hydraulic model of Konkapot River per MassDOT requirements using the United States Army Corps of Engineers' (USACE) Hydrological Engineering Center's River Analysis

[2] LRFD Bridge Manual, MassDOT, 2013 Edition, Part 1.

System (HEC-RAS) model, version 5.0.7. GZA evaluated hydraulic performance for existing and proposed conditions under floods with return period of up to the 500-year flood. Given the nature of flood data available, the hydraulic modeling was performed in steady state, which did not reflect flood attenuation in Konkapot River and potential impact of design alternatives on flooding downstream of Main Road Culvert. The effects of culvert replacement on downstream flood elevations should be evaluated further if the project proceeds.

HYDROLOGIC ANALYSIS

GZA estimated flows within Konkapot River at culvert using the USGS StreamStats Web Application. The contributing watershed was calculated using the program to be 7.36 square miles. The estimated flows are provided in Table 1, below. There are also previous estimates for the peak discharges in Konkapot River at "Upstream of Palmer Pond" (drainage area of 7.13 square miles) available from Flood Insurance Study for town of Monterey in 1980[3]. The FIS 1980 estimates are provided in the same table for comparison. The StreamStats report with overview of the watershed delineated is presented in **Appendix B**.

Table 1 - Peak Flow Estimates in Konkapot River at Main Road Culvert from StreamStats

Return Period	Estimated Peak Flow from StreamStats (cfs)	FIS 1980 Estimates for Comparison (cfs)
2-Year Flood	330	-
5-Year Flood	566	-
10-Year Flood	766	720
25-Year Flood	1,070	-
50-Year Flood	1,330	1,300
100-Year Flood	1,620	1,640
200-Year Flood	1,930	-
500-Year Flood	2,400	2,950
Bankfull Flow (1- to 2- Year Flood)	221	-

[3] Flood Insurance Study for town of Monterey, Massachusetts, Federal Emergency Management Agency (FEMA), December 15, 1980

HYDRAULIC ANALYSIS

HYDRAULIC MODELING

GZA developed a one-dimensional hydraulic model of Konkapot River using the latest HEC-RAS program. The one-dimensional model used cross sections to depict the river and overbanks. GZA developed existing conditions and six proposed conditions models to estimate the water surface profiles and velocities within the river.

The hydraulic model is approximately 3,255 feet long, starting approximately 620 feet upstream of the Main Road culvert and ending approximately 2,635 feet downstream at the confluence with the outflow from Palmer Pond. The downstream boundary condition was set as normal depth at the confluence. Cross sections used in the one-dimensional model were created based on the topographic survey, in combination with elevation data available from MassGIS (Massachusetts 2015).

The extent and overall geometry of the HEC-RAS model is provided in **Appendix C**.

DESIGN ALTERNATIVES

GZA evaluated replacement of the existing corrugated metal pipe arch culvert at Main Road with precast concrete box culvert alternatives with same opening height as existing, plus 2 feet embedment (i.e. sunk into the stream and filled with natural substrate material), per Massachusetts stream crossing standards. The box culvert's rectangular shape provides more flow area than the arch-shape existing culvert. Three-sided, open bottom, pre-cast concrete structures are also an alternative and would perform identically from a hydraulic standpoint. GZA also evaluated reducing tailwater at the Main Road culvert by removing Old Stone Dam. We modelled the existing condition, four design alternatives, and two hypothetical dam removal scenarios as summarized below:

- Existing Condition: 15-foot wide, 10-foot high corrugated metal pipe arch culvert with concrete wingwalls/training walls;
- Design Alternative A: 15-foot wide, 12-foot high box culvert with 2 feet embedment and existing wingwalls/training walls;
- Design Alternative B: 16-foot wide, 12-foot high box culvert with 2 feet embedment and partially modified wingwalls/training walls;
- Design Alternative C: 18-foot wide, 12-foot high box culvert with 2 feet embedment and modified wingwalls/training walls;
- Design Alternative D: 25-foot wide, 12-foot high box culvert with 2 feet embedment, modified wingwalls/training walls and the channel upstream. Alternative D meets requirement of culvert span equal to 1.2 times natural bankfull width, per Stream Crossing Standards;
- Hypothetical Scenario I: Existing Culvert at Main Road, with downstream Old Stone Dam removed;
- And Hypothetical Scenario II: Existing Culvert at Main Road, with downstream Old Stone Dam removed and sediments behind the dam dredged.

RESULTS

Results of hydraulic modeling are summarized in Table 2 below. More detailed results, including river's profile and estimated inundation boundaries are presented in **Appendix D**.

The results indicate that the existing culvert has enough hydraulic capacity to pass the design flood (25-year flood) without freeboard. This results in backwater upstream of Main Road, including inundation of the Monterey Town Hall building. The house at 437 Main Road has a side adjacent to the left riverbank and can therefore be considered vulnerable to being flooded in general. During floods equal to or larger than 10-year flood, the house at 441 Main Road may be affected by flood waters. During floods equal to or larger than 25-year flood, the house at 445 Main Road may also be subject to flood impacts.

Design Alternatives A, B, C and D are anticipated to incrementally reduce flooding upstream of the Main Road culvert. The results indicate that Design Alternative B (16-foot wide box culvert) passes the 25-year flood with 2 feet of freeboard, per MassDOT requirements, and is not expected to result in in flood impacts at Town Hall during the 25-year flood. Alternatives C and D are also expected to have adequate hydraulic capacity to (respectively) pass the 50-year and 100-year floods without inundating the Monterey Town Hall.

Results of hypothetical dam removal scenarios indicate that removing Old Stone dam has little impact on flooding upstream of the Main Road Culvert. This suggests that the Old Stone Dam is not as significant of a hydraulic control for areas upstream of Main Road as the existing pipe arch culvert in place.

Table 2 – Results of Hydraulic Modeling at the Main Road Culvert

Design	Flood Scenario	Flow (cfs)	Maximum WSE Upstream of Culvert* (ft)	Velocity in culvert (ft/s)	Freeboard** (ft)	Depth of Road overtopping (ft)	Change in WSE Upstream of Culvert (ft)***
Existing Condition (15-foot wide pipe arch culvert)	10-year Flood	766	1253.0	6	1.8	0.0	-
	25-Year Flood	1070	1254.7	6	0.1	0.0	-
	50-Year Flood	1330	1256.1	7	-1.3	0.0	-
	100-Year Flood	1620	1256.9	8	-2.1	0.4	-
	500-Year Flood	2400	1258.0	10	-3.2	1.5	-
Design Alternative A (15-foot wide box culvert)	10-year Flood	766	1251.9	6	2.9	0.0	-1.1
	25-Year Flood	1070	1253.1	8	1.7	0.0	-1.6
	50-Year Flood	1330	1254.2	8	0.6	0.0	-2.0
	100-Year Flood	1620	1255.3	9	-0.5	0.0	-1.6
	500-Year Flood	2400	1257.2	11	-2.4	0.7	-0.9
Design Alternative B (16-foot wide box culvert)	10-year Flood	766	1251.7	7	3.1	0.0	-1.3
	25-Year Flood	1070	1252.8	8	2.0	0.0	-1.9
	50-Year Flood	1330	1253.7	9	1.1	0.0	-2.4
	100-Year Flood	1620	1254.8	9	0.0	0.0	-2.2
	500-Year Flood	2400	1254.7	14	0.1	0.0	-3.3
Design Alternative C (18-foot wide box culvert)	10-year Flood	766	1251.4	7	3.4	0.0	-1.6
	25-Year Flood	1070	1252.2	9	2.6	0.0	-2.5
	50-Year Flood	1330	1252.9	10	1.9	0.0	-3.2
	100-Year Flood	1620	1253.7	11	1.1	0.0	-3.2
	500-Year Flood	2400	1255.5	13	-0.7	0.0	-2.6
Design Alternative D (25-foot wide box culvert)	10-year Flood	766	1251.5	5	3.3	0.0	-1.5
	25-Year Flood	1070	1252.3	6	2.5	0.0	-2.4
	50-Year Flood	1330	1252.9	6	1.9	0.0	-3.2
	100-Year Flood	1620	1253.5	7	1.3	0.0	-3.4
	500-Year Flood	2400	1254.9	9	0.0	0.0	-3.2
Hypothetical Scenario I (dam removal)	10-year Flood	766	1253.0	6	1.8	0.0	0.0
	25-Year Flood	1070	1254.7	6	0.1	0.0	0.0
	50-Year Flood	1330	1256.1	7	-1.3	0.0	0.0
	100-Year Flood	1620	1256.9	7	-2.1	0.4	0.0
	500-Year Flood	2400	1258.0	10	-3.2	1.5	0.0
Hypothetical Scenario II (dam and sediment removal)	10-year Flood	766	1252.8	6	2.0	0.0	-0.1
	25-Year Flood	1070	1254.6	6	0.2	0.0	-0.1
	50-Year Flood	1330	1256.1	7	-1.3	0.0	-0.1
	100-Year Flood	1620	1256.9	7	-2.1	0.4	-0.1
	500-Year Flood	2400	1258.0	10	-3.2	1.5	0.0

* For reference, minimum channel elevation upstream of the culvert is el. 1244.8, Main road is at el. 1256.5, and the culvert's low chord is at el. 1254.8 in all design scenarios.

** Negative value corresponds to submerged inlet; *** Change in WSE is in reference to the existing conditions

CONCLUSION

Results of the hydraulic analysis indicate that the existing culvert at Main Road has the capacity to pass the design flood, but without freeboard. This may result in flooding of structures upstream of Main Road, including Monterey Town Hall.

GZA evaluated replacement of the existing corrugated metal pipe culvert with precast concrete box culvert alternatives with the same opening height as the existing opening, plus 2 feet of embedment per Massachusetts stream crossing standards. Design alternatives (or a similar open bottom structure) with a span equal to or wider than 16 feet have the hydraulic capacity to pass the design flood with 2 feet of freeboard, per MassDOT requirements, and prevent inundation of the Town Hall during this flood. Design alternative with span of 25 feet, which requires modification of the river channel upstream of the culvert, complies with Massachusetts stream crossing standards requirement for minimum span of 1.2 times bankfull width. The 25-foot span also provides the greatest mitigation of upstream flooding impacts of the alternatives studied.

GZA also evaluated the potential impact of removing Old Stone Dam upon flood elevations upstream of Main Road, assuming the existing culvert would remain in place. The results indicated no significant reduction in flooding upstream of the culvert due to dam removal; However, removal of the dam does decrease peak flood elevations between the culvert and the dam.

GZA recommends additional study in the final design phase to evaluate potential flood attenuation in Lake Garfield upstream of the culvert, potential increase in flood flows and water surface elevation downstream of the culvert as result of increased culvert size, as well as scour analysis for the proposed culvert design.

CLOSING

We appreciate the opportunity to work with you on this project and look forward to receipt of any questions or comments you may have.

Very truly yours,
GZA GEOENVIRONMENTAL, INC.

Media Sehatzadeh
Assistant Project Manager

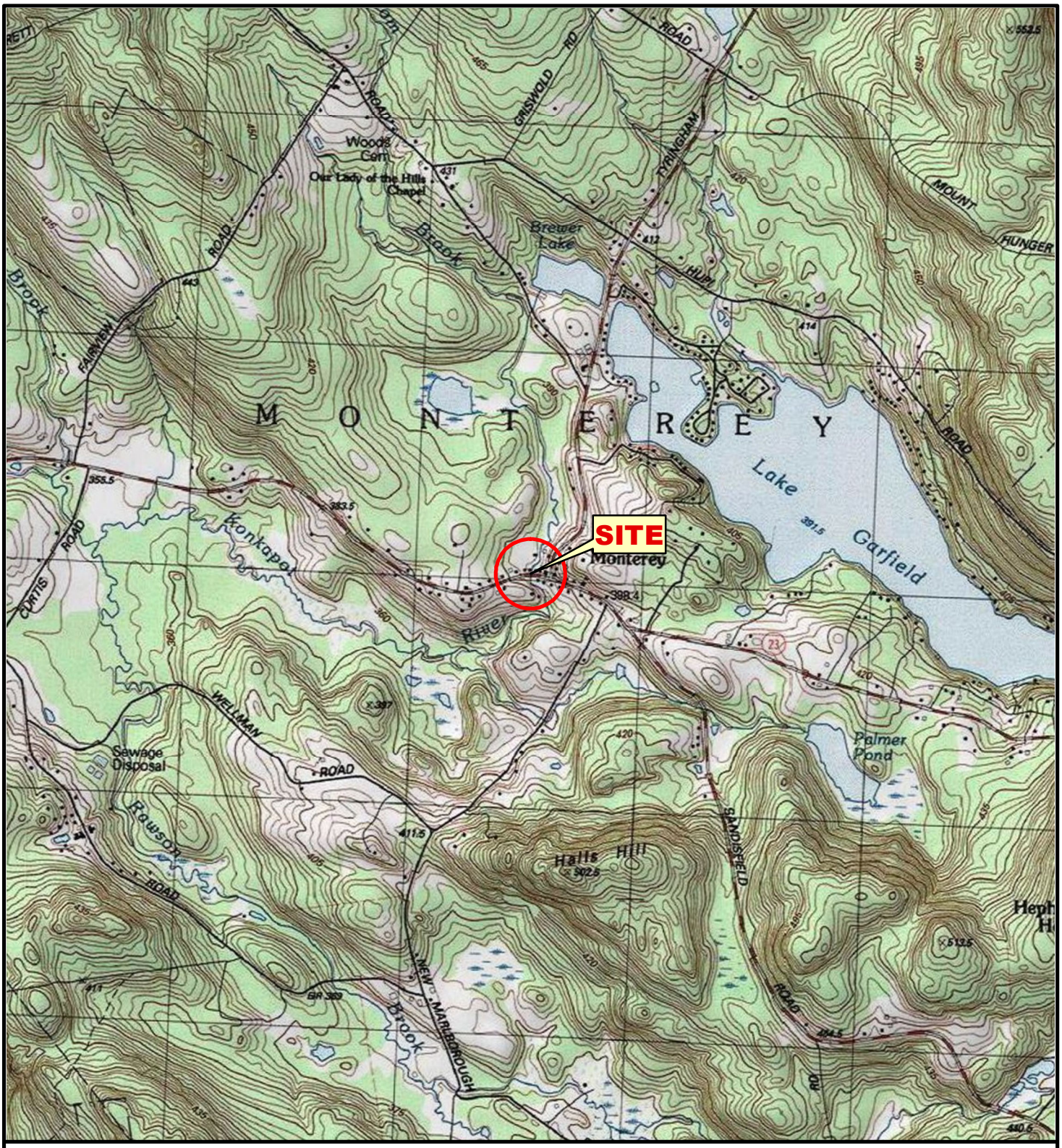
David M. Leone, P.E.
Consultant/Reviewer

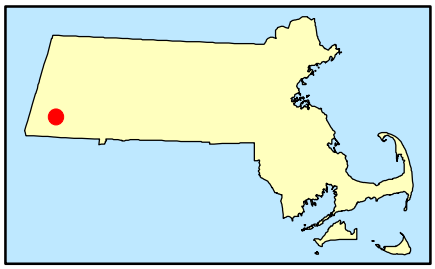
Chad W. Cox, P.E.
Senior Principal

Attachments:

Figures: Locus Plan
Appendix A – Limitations
Appendix B – USGS StreamStats
Appendix C – HEC-RAS Model Extents
Appendix D – HEC-RAS Model Results

Figures





SOURCE : USGS TOPOGRAPHIC QUADRANGLES SCANNED BY THE NATIONAL GEOGRAPHIC SOCIETY & I-CUBED, COPYRIGHT 2011

Data Supplied by : esri

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SCALE IN FEET

N W E S

GZA

PROJ. MGR.: HA
DESIGNED BY: HA
REVIEWED BY: MBH
OPERATOR: HA

DATE: 04-29-2020

LOCUS PLAN

JOB NO. 01.0174558.00

MONTEREY CULVERT REPLACEMENT
MAIN ROAD OVER KONKAPOT RIVER
MONTEREY, MASSACHUSETTS

FIGURE NO. 1

Appendix A – Limitations

USE OF REPORT

1. GZA GeoEnvironmental, Inc. (GZA) prepared this report on behalf of, and for the exclusive use of Town of Monterey (Client) for the stated purpose(s) and location(s) identified in the Report. Use of this report, in whole or in part, at other locations, or for other purposes, may lead to inappropriate conclusions; and we do not accept any responsibility for the consequences of such use(s). Further, reliance by any party not identified in the agreement, for any use, without our prior written permission, shall be at that party's sole risk, and without any liability to GZA.

STANDARD OF CARE

2. Our findings and conclusions are based on the work conducted as part of the Scope of Services set forth in the Report and/or proposal, and reflect our professional judgment. These findings and conclusions must be considered not as scientific or engineering certainties, but rather as our professional opinions concerning the limited data gathered during the course of our work. Conditions other than described in this report may be found at the subject location(s).

3. Our services were performed using the degree of skill and care ordinarily exercised by qualified professionals performing the same type of services at the same time, under similar conditions, at the same or a similar property. No warranty, expressed or implied, is made.

SUBSURFACE CONDITIONS

4. If presented, the generalized soil profile(s) and description, along with the conclusions and recommendations provided in our Report, are based in part on widely-spaced subsurface explorations by GZA and/or others, with a limited number of soil and/or rock samples and groundwater /piezometers data and are intended only to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized, and were based on our assessment of subsurface conditions. The composition of strata, and the transitions between strata, may be more variable and more complex than indicated. For more specific information on soil conditions at a specific location refer to the exploration logs. The nature and extent of variations between these explorations may not become evident until further exploration or construction. If variations or other latent conditions then appear evident, it will be necessary to reevaluate the conclusions and recommendations of this report.

5. Water level readings have been made in test holes (as described in the Report), monitoring wells and piezometers, at the specified times and under the stated conditions. These data have been reviewed and interpretations have been made in this Report. Fluctuations in the groundwater and piezometer levels, however, occur due to temporal or spatial variations in areal recharge rates, soil heterogeneities, reservoir and tailwater levels, the presence of subsurface utilities, and/or natural or artificially induced perturbations.

GENERAL

6. The observations described in this report were made under the conditions stated therein. The conclusions presented were based solely upon the services described therein, and not on scientific tasks or procedures beyond the scope of described services or the time and budgetary constraints imposed by the Client.

7. In preparing this report, GZA relied on certain information provided by the Client, state and local officials, and other parties referenced therein available to GZA at the time of the evaluation. GZA did not attempt to independently verify the accuracy or completeness of all information reviewed or received during the course of this evaluation.

8. Any GZA hydrologic analysis presented herein is for the rainfall volumes and distributions stated herein. For storm conditions other than those analyzed, the response of the site's spillway, impoundment, and drainage network has not been evaluated.

9. Observations were made of the site and of structures on the site as indicated within the report. Where access to portions of the structure or site, or to structures on the site was unavailable or limited, GZA renders no opinion as to the condition of that portion of the site or structure. In particular, it is noted that water levels in the impoundment and elsewhere and/or flow over the spillway may have limited GZA's ability to make observations of underwater portions of the structure. Excessive vegetation, when present, also inhibits observations.

10. In reviewing this Report, it should be realized that the reported condition of the culvert is based on observations of field conditions during the course of this study along with data made available to GZA. It is important to note that the condition of a culvert depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the culvert will continue to represent the condition of the culvert at some point in the future. Only through continued inspection and care can there be any chance that unsafe conditions be detected.

11. The hydrologic analysis presented is for the climate conditions stated herein. For hydrologic or climate conditions other than those analyzed, the response of the system has not been evaluated. Conditions are subject to change over time.

12. The flow data developed for this project was based on limited available publicly available data. The hydrologic evaluation developed for this project is also simplified in nature. Additional investigation, data collection, and resources are needed to develop a refined and calibrated water balance model for future watershed planning which can adequately consider the various climatological, hydrologic, natural resources / aquatic habitat, and human-made factors related to the hydrologic cycle.

COMPLIANCE WITH CODES AND REGULATIONS

13. We used reasonable care in identifying and interpreting applicable codes and regulations. These codes and regulations are subject to various, and possibly contradictory, interpretations. Compliance with codes and regulations by other parties is beyond our control.

14. This scope of work does not include an assessment of the need for fences, gates, no-trespassing signs, repairs to existing fences and railings and other items which may be needed to minimize trespass and provide greater security for the facility and safety to the public. An evaluation of the project for compliance with OSHA rules and regulations is also excluded.

COST ESTIMATES

15. Unless otherwise stated, our cost estimates are for comparative, or general planning purposes. These estimates may involve approximate quantity evaluations and may not be sufficiently accurate to develop construction bids, or to predict the actual cost of work addressed in this Report. Further, since we have no control over the labor and material costs required to plan and execute the anticipated work, our estimates were made using our experience and readily available information. Actual costs may vary over time and could be significantly more, or less, than stated in the Report.

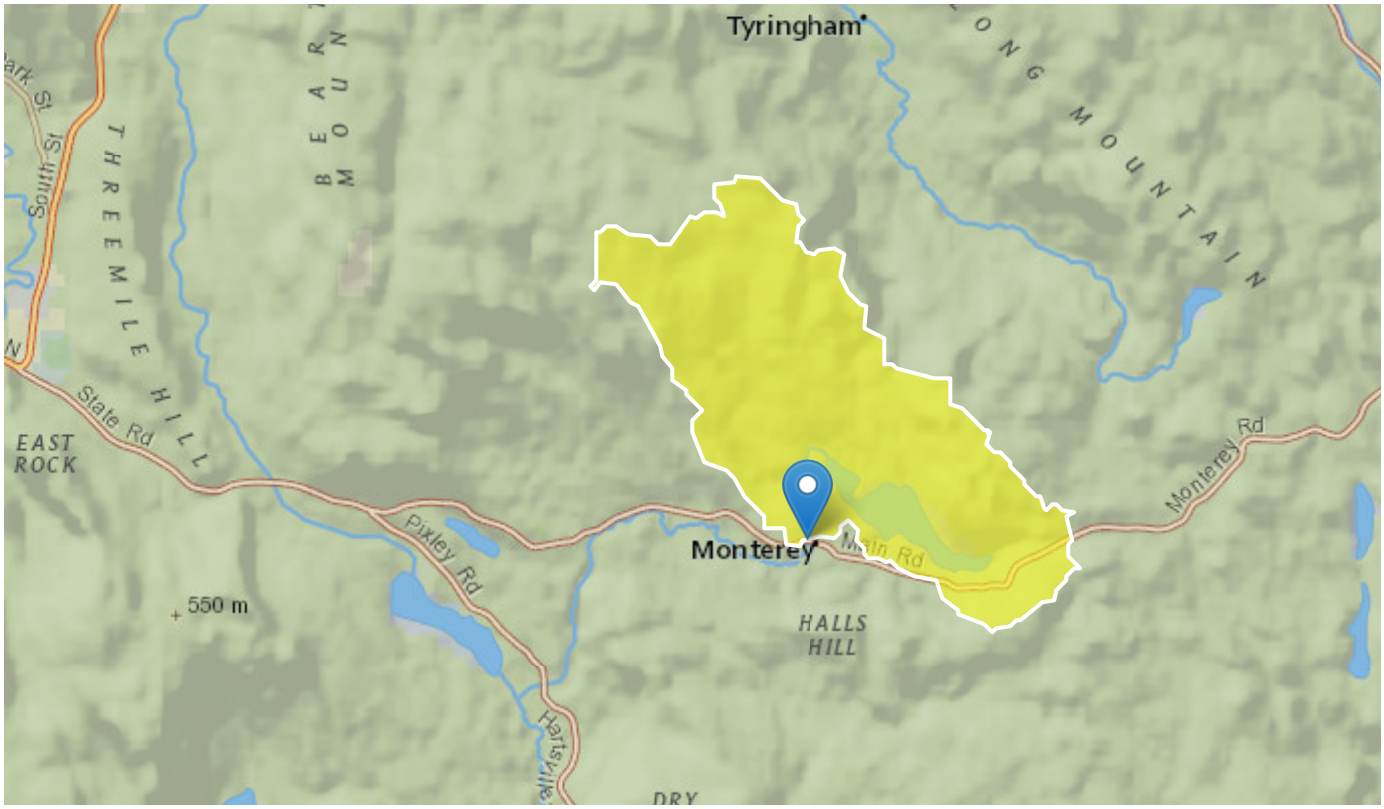
ADDITIONAL SERVICES

16. It is recommended that GZA be retained to provide services during any future: site observations, explorations, evaluations, design, implementation activities, construction and/or implementation of remedial measures recommended in this Report. This will allow us the opportunity to: i) observe conditions and compliance with our design concepts and opinions; ii) allow for changes in the event that conditions are other than anticipated; iii) provide modifications to our design; and iv) assess the consequences of changes in technologies and/or regulations.

Appendix B –USGS StreamStats

StreamStats Report

Region ID: MA
Workspace ID: MA20200429173415649000
Clicked Point (Latitude, Longitude): 42.17948, -73.21343
Time: 2020-04-29 13:34:31 -0400



Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	7.36	square miles
DRFTPERSTR	Area of stratified drift per unit of stream length	0	square mile per mile
MAREGION	Region of Massachusetts 0 for Eastern 1 for Western	1	dimensionless
BSLDEM250	Mean basin slope computed from 1:250K DEM	6.556	percent
PCTSNDGRV	Percentage of land surface underlain by sand and gravel deposits	0	percent

Parameter Code	Parameter Description	Value	Unit
FOREST	Percentage of area covered by forest	85.75	percent
BSLDEM10M	Mean basin slope computed from 10 m DEM	10.244	percent
ELEV	Mean Basin Elevation	1540	feet
LC06STOR	Percentage of water bodies and wetlands determined from the NLCD 2006	7.33	percent
ACRSDFT	Area underlain by stratified drift	0	square miles
CENTROIDX	Basin centroid horizontal (x) location in state plane coordinates	58852.4	meters
CENTROIDY	Basin centroid vertical (y) location in state plane units	884266.7	meters
CRSDFT	Percentage of area of coarse-grained stratified drift	0	percent
LAKEAREA	Percentage of Lakes and Ponds	5.87	percent
LC11DEV	Percentage of developed (urban) land from NLCD 2011 classes 21-24	6	percent
LC11IMP	Average percentage of impervious area determined from NLCD 2011 impervious dataset	0.34	percent
MAXTEMPC	Mean annual maximum air temperature over basin area, in degrees Centigrade	12.2	feet per mi
OUTLETX	Basin outlet horizontal (x) location in state plane coordinates	58455	feet
OUTLETY	Basin outlet vertical (y) location in state plane coordinates	882425	feet
PRECPRIS00	Basin average mean annual precipitation for 1971 to 2000 from PRISM	48.2	inches
STRMTOT	total length of all mapped streams (1:24,000-scale) in the basin	9.67	miles
WETLAND	Percentage of Wetlands	5.17	percent

Flow-Duration Statistics Parameters[Statewide Low Flow WRIR00 4135]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	7.36	square miles	1.61	149
DRFTPERSTR	Stratified Drift per Stream Length	0	square mile per mile	0	1.29
MAREGION	Massachusetts Region	1	dimensionless	0	1
BSLDEM250	Mean Basin Slope from 250K DEM	6.556	percent	0.32	24.6

Flow-Duration Statistics Flow Report[Statewide Low Flow WRIR00 4135]

PII: Prediction Interval-Lower, PIu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PII	PIu	SE	SEp
50 Percent Duration	7.32	ft^3/s	3.94	13.5	17.6	17.6
60 Percent Duration	4.67	ft^3/s	1.93	11.2	19.8	19.8
70 Percent Duration	2.98	ft^3/s	1.27	6.95	23.5	23.5
75 Percent Duration	2.34	ft^3/s	1.01	5.34	25.8	25.8
80 Percent Duration	1.71	ft^3/s	0.724	3.96	28.4	28.4
85 Percent Duration	1.32	ft^3/s	0.518	3.29	31.9	31.9
90 Percent Duration	0.895	ft^3/s	0.345	2.27	36.6	36.6
95 Percent Duration	0.586	ft^3/s	0.203	1.63	45.6	45.6
98 Percent Duration	0.396	ft^3/s	0.118	1.25	60.3	60.3
99 Percent Duration	0.297	ft^3/s	0.0838	0.992	65.1	65.1

Flow-Duration Statistics Citations

Ries, K.G., III,2000, Methods for estimating low-flow statistics for Massachusetts streams: U.S. Geological Survey Water Resources Investigations Report 00-4135, 81 p. (http://pubs.usgs.gov/wri/wri004135/)

Low-Flow Statistics Parameters[Statewide Low Flow WRIR00 4135]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	7.36	square miles	1.61	149

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
BSLDEM250	Mean Basin Slope from 250K DEM	6.556	percent	0.32	24.6
DRFTPERSTR	Stratified Drift per Stream Length	0	square mile per mile	0	1.29
MAREGION	Massachusetts Region	1	dimensionless	0	1

Low-Flow Statistics Flow Report[Statewide Low Flow WRIR00 4135]

PII: Prediction Interval-Lower, PIu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PII	PIu	SE	SEp
7 Day 2 Year Low Flow	0.604	ft^3/s	0.196	1.79	49.5	49.5
7 Day 10 Year Low Flow	0.261	ft^3/s	0.0664	0.958	70.8	70.8

Low-Flow Statistics Citations

Ries, K.G., III,2000, Methods for estimating low-flow statistics for Massachusetts streams: U.S. Geological Survey Water Resources Investigations Report 00-4135, 81 p. (http://pubs.usgs.gov/wri/wri004135/)

August Flow-Duration Statistics Parameters[Statewide Low Flow WRIR00 4135]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	7.36	square miles	1.61	149
BSLDEM250	Mean Basin Slope from 250K DEM	6.556	percent	0.32	24.6
DRFTPERSTR	Stratified Drift per Stream Length	0	square mile per mile	0	1.29
MAREGION	Massachusetts Region	1	dimensionless	0	1

August Flow-Duration Statistics Flow Report[Statewide Low Flow WRIR00 4135]

PII: Prediction Interval-Lower, PIu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PII	PIu	SE	SEp
August 50 Percent Duration	1.4	ft^3/s	0.559	3.46	33.2	33.2

August Flow-Duration Statistics Citations

Ries, K.G., III,2000, Methods for estimating low-flow statistics for Massachusetts streams: U.S. Geological Survey Water Resources Investigations Report 00-4135, 81 p. (http://pubs.usgs.gov/wri/wri004135/)

Probability Statistics Parameters[Perennial Flow Probability]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	7.36	square miles	0.01	1.99
PCTSNDGRV	Percent Underlain By Sand And Gravel	0	percent	0	100
FOREST	Percent Forest	85.75	percent	0	100
MAREGION	Massachusetts Region	1	dimensionless	0	1

Probability Statistics Disclaimers[Perennial Flow Probability]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

Probability Statistics Flow Report[Perennial Flow Probability]

Statistic	Value	Unit
Probability Stream Flowing Perennially	0.972	dim

Probability Statistics Citations

Bent, G.C., and Steeves, P.A.,2006, A revised logistic regression equation and an automated procedure for mapping the probability of a stream flowing perennially in Massachusetts: U.S. Geological Survey Scientific Investigations Report 2006–5031, 107 p. (http://pubs.usgs.gov/sir/2006/5031/pdfs/SIR_2006-5031rev.pdf)

Bankfull Statistics Parameters[Bankfull Statewide SIR2013 5155]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	7.36	square miles	0.6	329

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
BSLDEM10M	Mean Basin Slope from 10m DEM	10.244	percent	2.2	23.9

Bankfull Statistics Flow Report[Bankfull Statewide SIR2013 5155]

PII: Prediction Interval-Lower, PIu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	SEp
Bankfull Width	35.2	ft	21.3
Bankfull Depth	1.77	ft	19.8
Bankfull Area	61.9	ft^2	29
Bankfull Streamflow	221	ft^3/s	55

Bankfull Statistics Citations

Bent, G.C., and Waite, A.M.,2013, Equations for estimating bankfull channel geometry and discharge for streams in Massachusetts: U.S. Geological Survey Scientific Investigations Report 2013–5155, 62 p., (http://pubs.usgs.gov/sir/2013/5155/)

Peak-Flow Statistics Parameters[Peak Statewide 2016 5156]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	7.36	square miles	0.16	512
ELEV	Mean Basin Elevation	1540	feet	80.6	1948
LC06STOR	Percent Storage from NLCD2006	7.33	percent	0	32.3

Peak-Flow Statistics Flow Report[Peak Statewide 2016 5156]

PII: Prediction Interval-Lower, PIu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PII	PIu	SEp
2 Year Peak Flood	330	ft^3/s	157	692	42.3
5 Year Peak Flood	566	ft^3/s	265	1210	43.4
10 Year Peak Flood	766	ft^3/s	350	1680	44.7

Statistic	Value	Unit	PIl	PIu	SEp
25 Year Peak Flood	1070	ft^3/s	469	2440	47.1
50 Year Peak Flood	1330	ft^3/s	562	3150	49.4
100 Year Peak Flood	1620	ft^3/s	658	3960	51.8
200 Year Peak Flood	1930	ft^3/s	761	4910	54.1
500 Year Peak Flood	2400	ft^3/s	896	6440	57.6

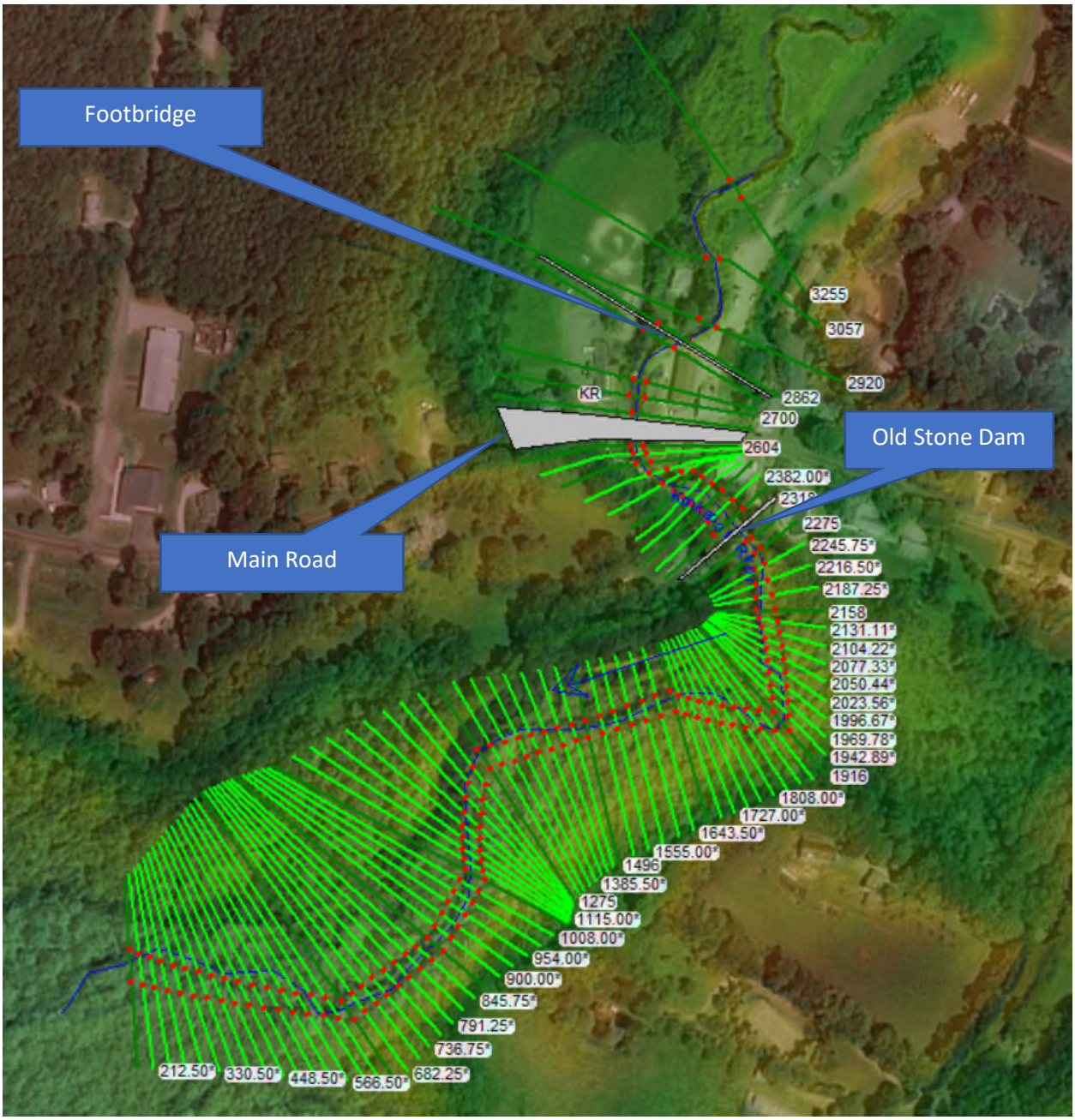
Peak-Flow Statistics Citations

Zarriello, P.J.,2017, Magnitude of flood flows at selected annual exceedance probabilities for streams in Massachusetts: U.S. Geological Survey Scientific Investigations Report 2016–5156, 99 p. (https://dx.doi.org/10.3133/sir20165156)

Application Version: 4.3.11

Appendix C – HEC-RAS Model Extents

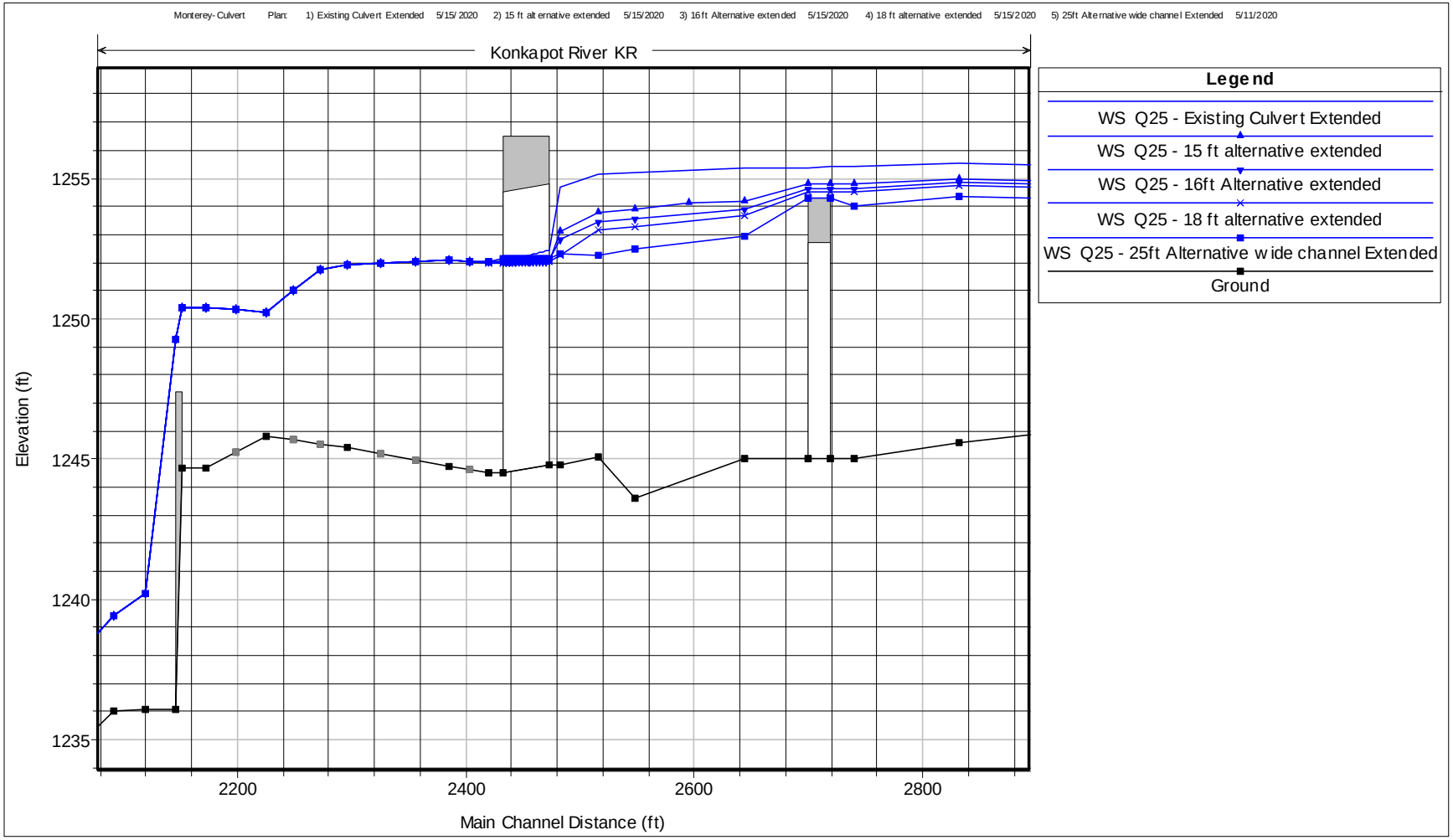
HEC-RAS Model Extent



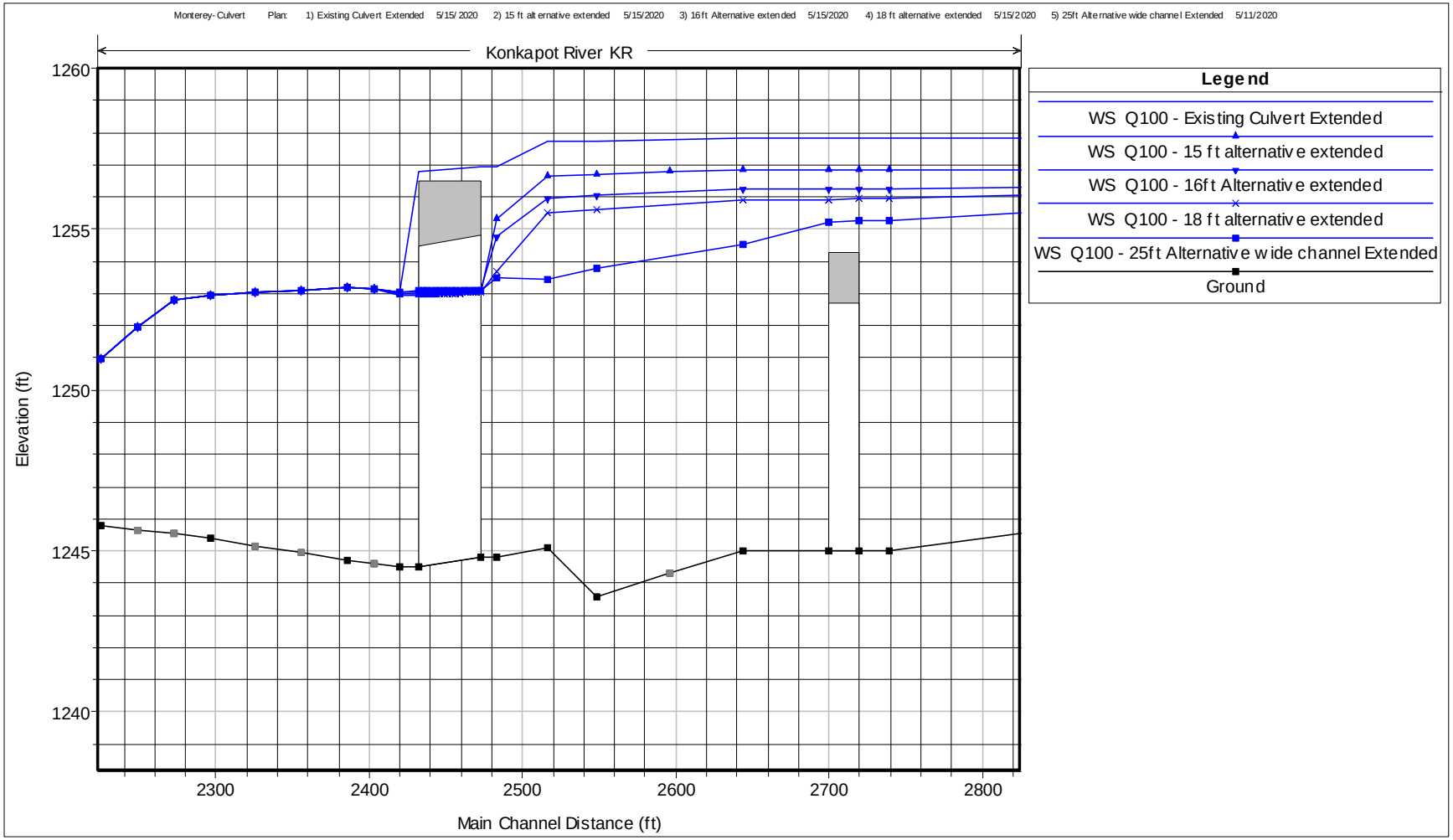
Appendix D – HEC-RAS Model Results

HEC-RAS Results

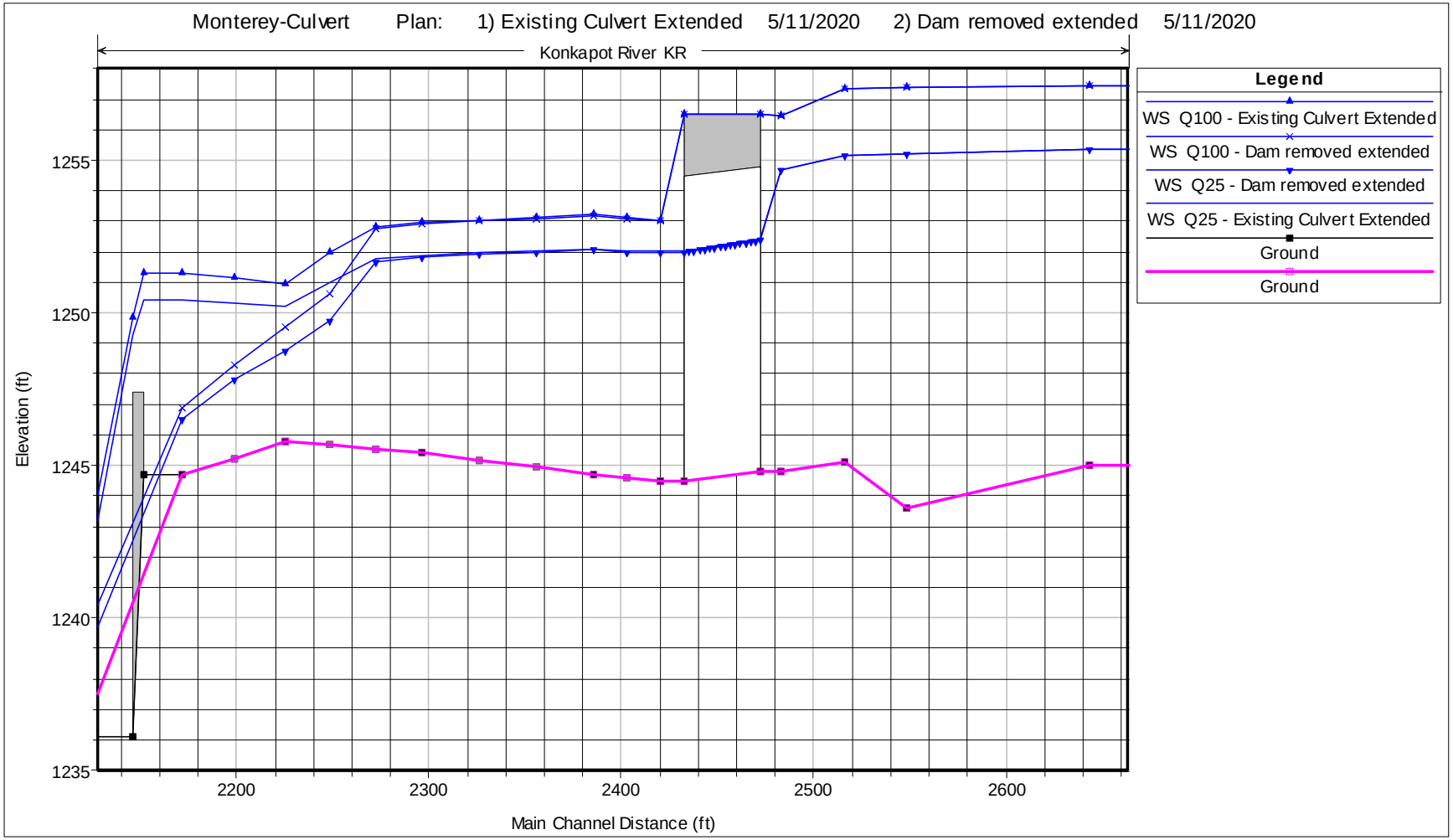
Main Road Culvert profile for existing condition vs design alternatives A through D (spans of 15, 16, 18, and 25 feet, respectively) during 25-year flood



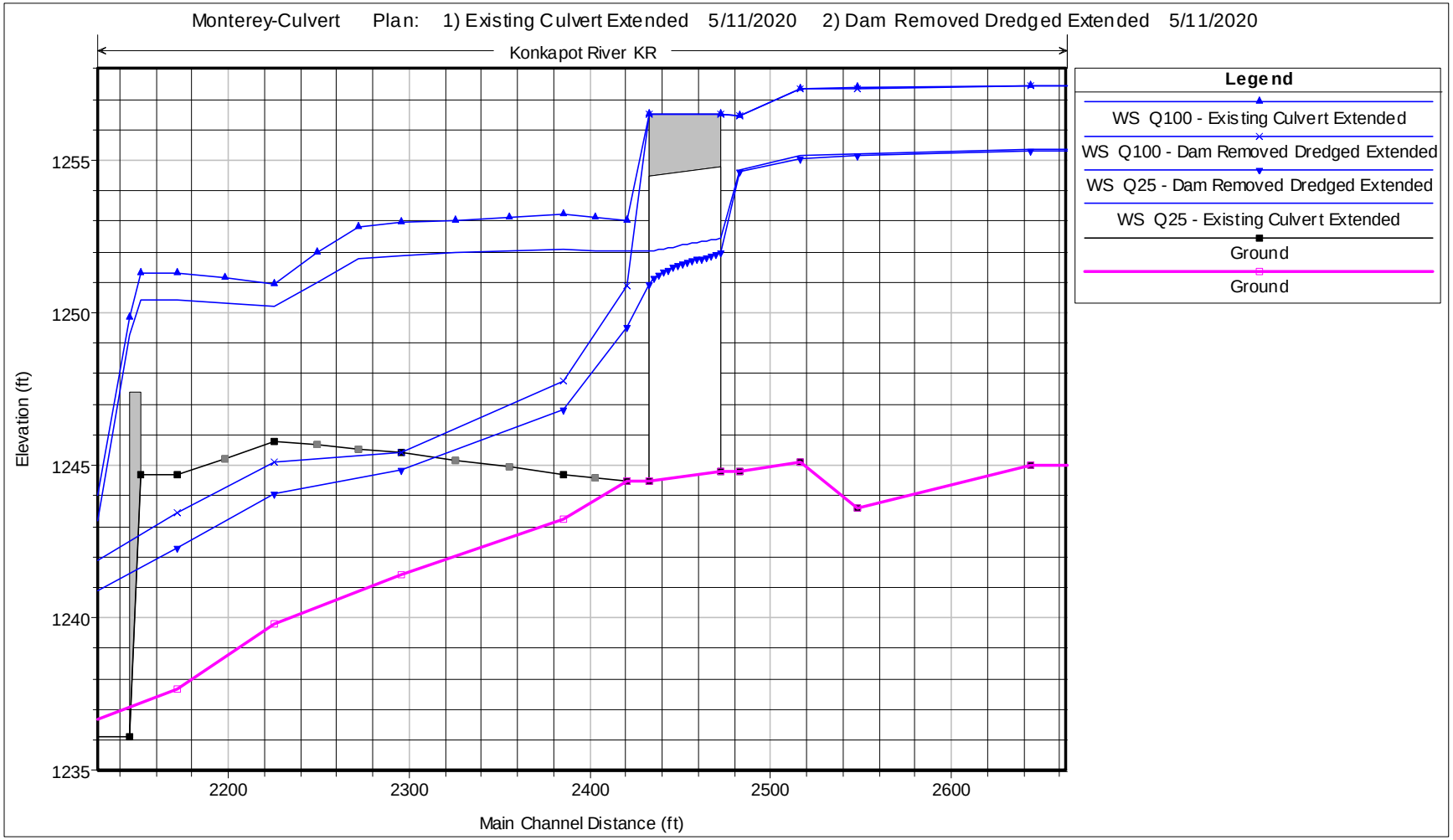
Main Road Culvert profile for existing condition vs design alternatives A through D (spans of 15, 16, 18, and 25 feet, respectively) during 100-year flood



Main Road Culvert profile for existing condition vs hypothetical dam removal scenario I during 25-year and 100-year flood

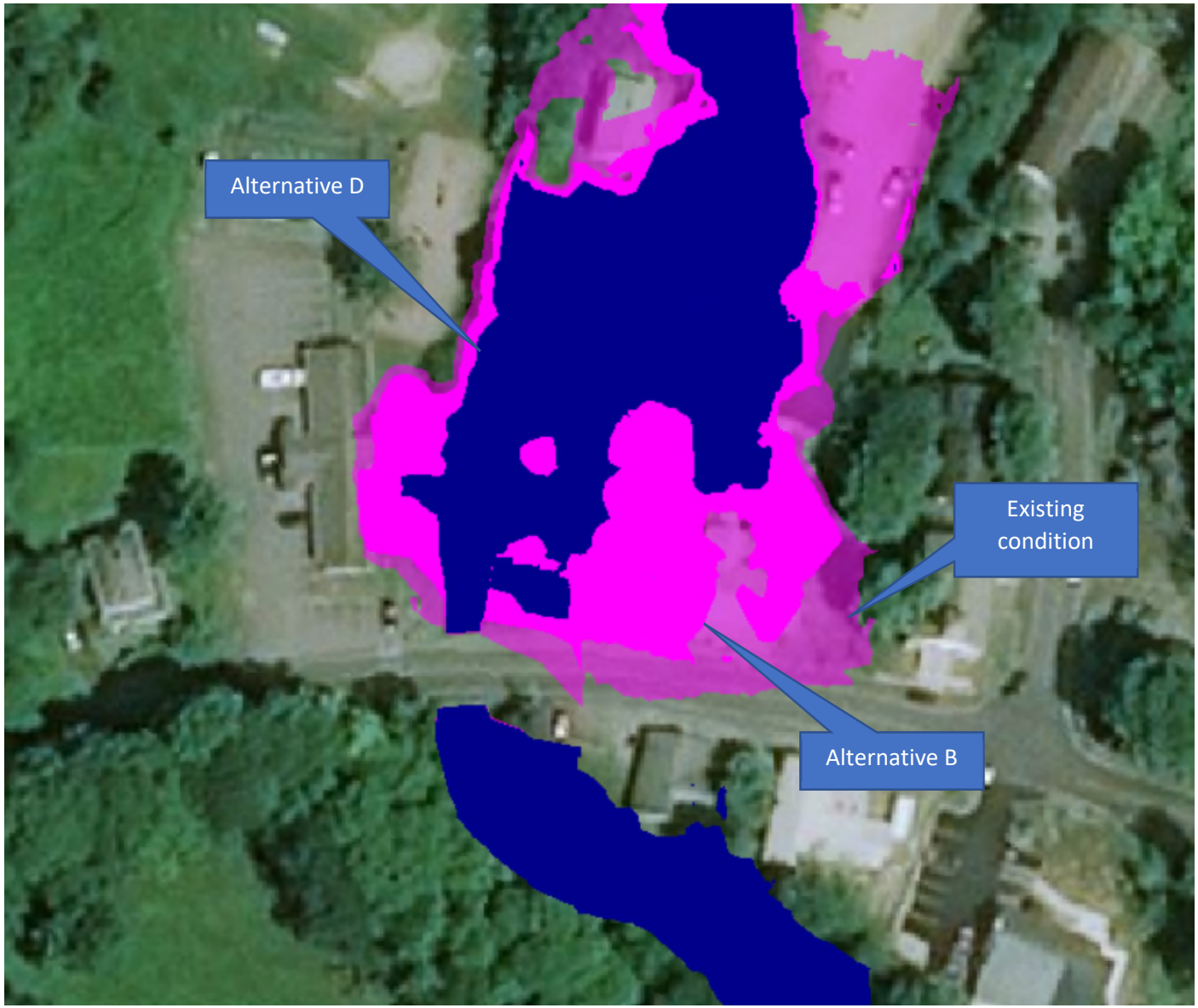


Main Road Culvert profile for existing condition vs hypothetical dam removal scenario II (with sediment removal/dredging) during 25-year and 100-year flood



Estimated inundation boundary for existing condition vs alternative B and D during 25-year flood

Estimated inundation boundary for existing condition vs alternative B and D during 100-year flood



Full HEC-RAS results for existing condition, design alternatives A through D and hypothetical dam removal scenarios I and II

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KR	3255	Q2	Existing Culvert	330	1246.66	1251.54	0.000674	2.66	158.53	116.11	0.27
KR	3255	Q2	Alternative A	330	1246.66	1251.48	0.000726	2.74	151.3	113.21	0.27
KR	3255	Q2	Alternative B	330	1246.66	1251.47	0.000736	2.76	149.94	112.81	0.28
KR	3255	Q2	Alternative C	330	1246.66	1251.46	0.000738	2.76	149.65	112.73	0.28
KR	3255	Q2	Alternative D	330	1246.66	1251.46	0.000739	2.76	149.5	112.68	0.28
KR	3255	Q2	Dam Removal I	330	1246.66	1251.53	0.000684	2.68	157.12	115.54	0.27
KR	3255	Q2	Dam Removal II	330	1246.66	1251.47	0.000738	2.76	149.74	112.75	0.28
KR	3255	Q5	Existing Culvert	566	1246.66	1253.11	0.000311	2.23	421.82	201.68	0.19
KR	3255	Q5	Alternative A	566	1246.66	1252.84	0.000417	2.47	367.74	196.39	0.22
KR	3255	Q5	Alternative B	566	1246.66	1252.76	0.000461	2.57	351.56	194.53	0.23
KR	3255	Q5	Alternative C	566	1246.66	1252.72	0.000479	2.61	345.1	193.66	0.23
KR	3255	Q5	Alternative D	566	1246.66	1252.66	0.000518	2.69	332.32	191.75	0.24
KR	3255	Q5	Dam Removal I	566	1246.66	1253.09	0.000316	2.24	418.89	201.53	0.19
KR	3255	Q5	Dam Removal II	566	1246.66	1252.98	0.000361	2.35	396.67	200.34	0.2
KR	3255	Q10	Existing Culvert	766	1246.66	1254.58	0.000134	1.78	730.99	216.57	0.13
KR	3255	Q10	Alternative A	766	1246.66	1253.96	0.000233	2.18	597.55	212.27	0.17
KR	3255	Q10	Alternative B	766	1246.66	1253.82	0.000268	2.29	567.89	211.3	0.18
KR	3255	Q10	Alternative C	766	1246.66	1253.74	0.00029	2.36	551.13	210.71	0.19
KR	3255	Q10	Alternative D	766	1246.66	1253.56	0.000345	2.51	514.9	208.08	0.2
KR	3255	Q10	Dam Removal I	766	1246.66	1254.57	0.000135	1.79	728.75	216.5	0.13
KR	3255	Q10	Dam Removal II	766	1246.66	1254.46	0.000148	1.85	705.87	215.8	0.14
KR	3255	Q25	Existing Culvert	1070	1246.66	1255.84	0.000105	1.8	1009.6	226.58	0.12
KR	3255	Q25	Alternative A	1070	1246.66	1255.41	0.000139	1.99	914.04	222.46	0.14
KR	3255	Q25	Alternative B	1070	1246.66	1255.3	0.000151	2.04	889.21	221.6	0.14
KR	3255	Q25	Alternative C	1070	1246.66	1255.23	0.000159	2.08	872.92	221.03	0.15
KR	3255	Q25	Alternative D	1070	1246.66	1254.95	0.000195	2.24	812.46	219.07	0.16
KR	3255	Q25	Dam Removal I	1070	1246.66	1255.83	0.000106	1.8	1007.75	226.51	0.12
KR	3255	Q25	Dam Removal II	1070	1246.66	1255.8	0.000108	1.81	1001.75	226.25	0.12

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KR	3255	Q50	Existing Culvert	1330	1246.66	1257.14	0.000077	1.73	1312.11	240.04	0.11
KR	3255	Q50	Alternative A	1330	1246.66	1256.16	0.000134	2.09	1082.22	229.59	0.14
KR	3255	Q50	Alternative B	1330	1246.66	1256.01	0.000146	2.16	1048.43	228.23	0.14
KR	3255	Q50	Alternative C	1330	1246.66	1255.92	0.000154	2.2	1028.88	227.4	0.15
KR	3255	Q50	Alternative D	1330	1246.66	1255.67	0.000181	2.32	971.62	224.91	0.16
KR	3255	Q50	Dam Removal I	1330	1246.66	1257.13	0.000078	1.73	1311.02	239.98	0.11
KR	3255	Q50	Dam Removal II	1330	1246.66	1257.1	0.000079	1.74	1303.7	239.58	0.11
KR	3255	Q100	Existing Culvert	1620	1246.66	1258.08	0.000073	1.8	1541.92	249.51	0.1
KR	3255	Q100	Alternative A	1620	1246.66	1257.25	0.000109	2.07	1339.23	241.48	0.13
KR	3255	Q100	Alternative B	1620	1246.66	1256.82	0.000136	2.23	1235.89	236.33	0.14
KR	3255	Q100	Alternative C	1620	1246.66	1256.6	0.000153	2.32	1185.97	234.09	0.15
KR	3255	Q100	Alternative D	1620	1246.66	1256.27	0.000185	2.49	1107.69	230.52	0.16
KR	3255	Q100	Dam Removal I	1620	1246.66	1258.07	0.000073	1.8	1540.42	249.43	0.1
KR	3255	Q100	Dam Removal II	1620	1246.66	1258.05	0.000074	1.81	1534.31	249.11	0.1
KR	3255	Q200	Existing Culvert	1930	1246.66	1258.72	0.000079	1.96	1709.08	285.58	0.11
KR	3255	Q200	Alternative A	1930	1246.66	1258.08	0.000103	2.14	1541.67	249.5	0.12
KR	3255	Q200	Alternative B	1930	1246.66	1257.87	0.000113	2.21	1490.66	246.76	0.13
KR	3255	Q200	Alternative C	1930	1246.66	1257.64	0.000127	2.3	1433.06	244.69	0.14
KR	3255	Q200	Alternative D	1930	1246.66	1256.83	0.000192	2.65	1238.11	236.4	0.17
KR	3255	Q200	Dam Removal I	1930	1246.66	1258.72	0.000079	1.96	1708.98	285.51	0.11
KR	3255	Q200	Dam Removal II	1930	1246.66	1258.71	0.000079	1.96	1705.13	283.19	0.11
KR	3255	Q500	Existing Culvert	2400	1246.66	1259.44	0.000095	2.25	1954.24	387.73	0.12
KR	3255	Q500	Alternative A	2400	1246.66	1259.04	0.000108	2.35	1808.96	334.41	0.13
KR	3255	Q500	Alternative B	2400	1246.66	1259	0.00011	2.36	1794.99	328.73	0.13
KR	3255	Q500	Alternative C	2400	1246.66	1259.05	0.000108	2.34	1811.62	336.54	0.13
KR	3255	Q500	Alternative D	2400	1246.66	1257.63	0.000197	2.86	1431.6	244.64	0.17
KR	3255	Q500	Dam Removal I	2400	1246.66	1259.45	0.000095	2.25	1956.18	387.79	0.12
KR	3255	Q500	Dam Removal II	2400	1246.66	1259.44	0.000095	2.25	1954.57	387.74	0.12

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KR	3057	Q2	Existing Culvert	330	1246.2	1250.8	0.004709	5.83	57.75	27.06	0.66
KR	3057	Q2	Alternative A	330	1246.2	1250.56	0.006691	6.48	51.45	25.84	0.77
KR	3057	Q2	Alternative B	330	1246.2	1250.47	0.007736	6.77	49.1	25.39	0.83
KR	3057	Q2	Alternative C	330	1246.2	1250.43	0.00818	6.88	48.24	25.22	0.85
KR	3057	Q2	Alternative D	330	1246.2	1250.36	0.009147	7.12	46.55	24.89	0.89
KR	3057	Q2	Dam Removal I	330	1246.2	1250.76	0.004954	5.92	56.79	26.86	0.68
KR	3057	Q2	Dam Removal II	330	1246.2	1250.44	0.008004	6.84	48.57	25.28	0.84
KR	3057	Q5	Existing Culvert	566	1246.2	1252.57	0.001976	5.45	122.14	45.56	0.47
KR	3057	Q5	Alternative A	566	1246.2	1252.08	0.00311	6.3	101.19	41.24	0.58
KR	3057	Q5	Alternative B	566	1246.2	1251.9	0.003756	6.69	93.65	39.35	0.63
KR	3057	Q5	Alternative C	566	1246.2	1251.81	0.004112	6.88	90.27	38.41	0.66
KR	3057	Q5	Alternative D	566	1246.2	1251.59	0.005198	7.4	82.16	36.13	0.73
KR	3057	Q5	Dam Removal I	566	1246.2	1252.54	0.002017	5.48	121.09	45.39	0.47
KR	3057	Q5	Dam Removal II	566	1246.2	1252.36	0.002391	5.79	112.87	44.05	0.51
KR	3057	Q10	Existing Culvert	766	1246.2	1254.2	0.001009	4.85	206.13	56.79	0.35
KR	3057	Q10	Alternative A	766	1246.2	1253.36	0.001858	5.93	160.68	51.18	0.47
KR	3057	Q10	Alternative B	766	1246.2	1253.14	0.002218	6.29	149.41	49.67	0.51
KR	3057	Q10	Alternative C	766	1246.2	1253	0.002485	6.52	142.62	48.72	0.54
KR	3057	Q10	Alternative D	766	1246.2	1252.65	0.003361	7.2	125.91	46.16	0.61
KR	3057	Q10	Dam Removal I	766	1246.2	1254.19	0.001018	4.87	205.41	56.7	0.36
KR	3057	Q10	Dam Removal II	766	1246.2	1254.06	0.001115	5.01	197.92	55.84	0.37
KR	3057	Q25	Existing Culvert	1070	1246.2	1255.42	0.000938	5.31	283.29	70.25	0.35
KR	3057	Q25	Alternative A	1070	1246.2	1254.88	0.001297	5.92	246.49	64.83	0.41
KR	3057	Q25	Alternative B	1070	1246.2	1254.74	0.001395	6.05	237.78	61.33	0.42
KR	3057	Q25	Alternative C	1070	1246.2	1254.64	0.001485	6.18	231.67	60.46	0.44
KR	3057	Q25	Alternative D	1070	1246.2	1254.24	0.001919	6.72	208.31	57.03	0.49
KR	3057	Q25	Dam Removal I	1070	1246.2	1255.41	0.000943	5.32	282.58	70.15	0.35
KR	3057	Q25	Dam Removal II	1070	1246.2	1255.38	0.000961	5.35	280.3	69.83	0.36
KR	3057	Q50	Existing Culvert	1330	1246.2	1256.76	0.000729	5.25	397.29	101.26	0.32

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KR	3057	Q50	Alternative A	1330	1246.2	1255.55	0.001347	6.44	292.39	71.59	0.42
KR	3057	Q50	Alternative B	1330	1246.2	1255.35	0.001515	6.7	277.94	69.52	0.45
KR	3057	Q50	Alternative C	1330	1246.2	1255.22	0.00163	6.87	269.37	68.38	0.46
KR	3057	Q50	Alternative D	1330	1246.2	1254.84	0.002038	7.39	244.11	63.37	0.51
KR	3057	Q50	Dam Removal I	1330	1246.2	1256.75	0.000731	5.26	396.74	101.09	0.32
KR	3057	Q50	Dam Removal II	1330	1246.2	1256.71	0.000745	5.3	393.03	100.19	0.32
KR	3057	Q100	Existing Culvert	1620	1246.2	1257.7	0.000672	5.42	553.38	201.04	0.31
KR	3057	Q100	Alternative A	1620	1246.2	1256.66	0.001138	6.52	387.76	99.37	0.4
KR	3057	Q100	Alternative B	1620	1246.2	1256.08	0.001531	7.2	333.18	83.82	0.46
KR	3057	Q100	Alternative C	1620	1246.2	1255.8	0.001739	7.49	310.59	77.53	0.48
KR	3057	Q100	Alternative D	1620	1246.2	1255.24	0.002394	8.33	270.59	68.55	0.56
KR	3057	Q100	Dam Removal I	1620	1246.2	1257.69	0.000675	5.43	551.81	200.95	0.31
KR	3057	Q100	Dam Removal II	1620	1246.2	1257.66	0.000689	5.47	545.3	200.57	0.32
KR	3057	Q200	Existing Culvert	1930	1246.2	1258.37	0.000626	5.48	691.59	208.84	0.31
KR	3057	Q200	Alternative A	1930	1246.2	1257.45	0.001122	6.87	502.91	198.42	0.4
KR	3057	Q200	Alternative B	1930	1246.2	1257.19	0.001252	7.12	453.34	175.35	0.42
KR	3057	Q200	Alternative C	1930	1246.2	1256.88	0.001437	7.45	410.15	111.95	0.45
KR	3057	Q200	Alternative D	1930	1246.2	1255.57	0.002805	9.31	293.79	71.79	0.61
KR	3057	Q200	Dam Removal I	1930	1246.2	1258.37	0.000626	5.48	691.44	208.84	0.31
KR	3057	Q200	Dam Removal II	1930	1246.2	1258.35	0.000633	5.5	687.82	208.73	0.31
KR	3057	Q500	Existing Culvert	2400	1246.2	1259.09	0.000626	5.74	849.02	232.9	0.31
KR	3057	Q500	Alternative A	2400	1246.2	1258.56	0.000861	6.51	731.02	210.08	0.36
KR	3057	Q500	Alternative B	2400	1246.2	1258.5	0.000894	6.6	718.26	209.67	0.37
KR	3057	Q500	Alternative C	2400	1246.2	1258.57	0.000855	6.49	733.4	210.15	0.36
KR	3057	Q500	Alternative D	2400	1246.2	1255.9	0.003685	11	318.81	80.43	0.71
KR	3057	Q500	Dam Removal I	2400	1246.2	1259.1	0.000624	5.73	850.47	233.21	0.31
KR	3057	Q500	Dam Removal II	2400	1246.2	1259.09	0.000626	5.74	849.3	232.96	0.31
KR	2920	Q2	Existing Culvert	330	1245.6	1250.75	0.00119	3.41	96.68	32.27	0.35

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KR	2920	Q2	Alternative A	330	1245.6	1250.48	0.001533	3.75	88.09	30.96	0.39
KR	2920	Q2	Alternative B	330	1245.6	1250.36	0.001707	3.9	84.68	30.42	0.41
KR	2920	Q2	Alternative C	330	1245.6	1250.32	0.001781	3.96	83.37	30.21	0.42
KR	2920	Q2	Alternative D	330	1245.6	1250.23	0.001944	4.09	80.73	29.79	0.44
KR	2920	Q2	Dam Removal I	330	1245.6	1250.71	0.001234	3.46	95.4	32.08	0.35
KR	2920	Q2	Dam Removal II	330	1245.6	1250.34	0.001751	3.93	83.88	30.3	0.42
KR	2920	Q5	Existing Culvert	566	1245.6	1252.6	0.000685	3.38	192.54	67.3	0.28
KR	2920	Q5	Alternative A	566	1245.6	1252.12	0.001006	3.86	161.79	60.21	0.34
KR	2920	Q5	Alternative B	566	1245.6	1251.93	0.001182	4.08	150.49	57.39	0.36
KR	2920	Q5	Alternative C	566	1245.6	1251.84	0.001278	4.19	145.35	56.06	0.37
KR	2920	Q5	Alternative D	566	1245.6	1251.6	0.001568	4.48	132.73	52.65	0.41
KR	2920	Q5	Dam Removal I	566	1245.6	1252.58	0.000697	3.4	190.99	66.96	0.28
KR	2920	Q5	Dam Removal II	566	1245.6	1252.39	0.000805	3.58	178.91	64.25	0.3
KR	2920	Q10	Existing Culvert	766	1245.6	1254.26	0.000394	3.03	353.93	132.55	0.22
KR	2920	Q10	Alternative A	766	1245.6	1253.42	0.000701	3.74	257.96	96.73	0.29
KR	2920	Q10	Alternative B	766	1245.6	1253.2	0.000817	3.95	237.64	87.28	0.31
KR	2920	Q10	Alternative C	766	1245.6	1253.07	0.000897	4.08	226.4	81.58	0.32
KR	2920	Q10	Alternative D	766	1245.6	1252.72	0.001141	4.43	200.97	69.11	0.36
KR	2920	Q10	Dam Removal I	766	1245.6	1254.24	0.000398	3.04	352.25	132.01	0.22
KR	2920	Q10	Dam Removal II	766	1245.6	1254.11	0.000435	3.14	335.14	126.34	0.23
KR	2920	Q25	Existing Culvert	1070	1245.6	1255.53	0.000312	3.03	542.56	163.69	0.2
KR	2920	Q25	Alternative A	1070	1245.6	1255	0.000455	3.47	459.5	148.41	0.24
KR	2920	Q25	Alternative B	1070	1245.6	1254.86	0.000505	3.6	438.63	145.32	0.25
KR	2920	Q25	Alternative C	1070	1245.6	1254.76	0.000542	3.7	424.12	144.66	0.26
KR	2920	Q25	Alternative D	1070	1245.6	1254.36	0.000719	4.13	367.43	136.84	0.3
KR	2920	Q25	Dam Removal I	1070	1245.6	1255.52	0.000314	3.03	540.92	163.4	0.2
KR	2920	Q25	Dam Removal II	1070	1245.6	1255.49	0.000321	3.06	535.75	162.49	0.2
KR	2920	Q50	Existing Culvert	1330	1245.6	1256.89	0.000206	2.76	787.21	194.21	0.17
KR	2920	Q50	Alternative A	1330	1245.6	1255.72	0.000424	3.59	574.21	169.2	0.24

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KR	2920	Q50	Alternative B	1330	1245.6	1255.52	0.000484	3.77	541.66	163.53	0.25
KR	2920	Q50	Alternative C	1330	1245.6	1255.41	0.000525	3.88	522.44	160.12	0.26
KR	2920	Q50	Alternative D	1330	1245.6	1255.04	0.000684	4.26	465.23	149.52	0.29
KR	2920	Q50	Dam Removal I	1330	1245.6	1256.88	0.000206	2.77	786.16	194	0.17
KR	2920	Q50	Dam Removal II	1330	1245.6	1256.85	0.00021	2.79	779.41	193.2	0.17
KR	2920	Q100	Existing Culvert	1620	1245.6	1257.84	0.000181	2.78	978.31	205.52	0.16
KR	2920	Q100	Alternative A	1620	1245.6	1256.87	0.000308	3.38	783.58	193.52	0.21
KR	2920	Q100	Alternative B	1620	1245.6	1256.32	0.000427	3.8	680.79	183.18	0.24
KR	2920	Q100	Alternative C	1620	1245.6	1256.05	0.000508	4.05	631.22	177.78	0.26
KR	2920	Q100	Alternative D	1620	1245.6	1255.53	0.000715	4.58	542.8	163.73	0.31
KR	2920	Q100	Dam Removal I	1620	1245.6	1257.83	0.000181	2.79	976.88	205.46	0.16
KR	2920	Q100	Dam Removal II	1620	1245.6	1257.8	0.000184	2.8	970.89	205.2	0.16
KR	2920	Q200	Existing Culvert	1930	1245.6	1258.49	0.000185	2.95	1114.35	211.26	0.16
KR	2920	Q200	Alternative A	1930	1245.6	1257.69	0.000277	3.41	948.05	204.19	0.2
KR	2920	Q200	Alternative B	1930	1245.6	1257.44	0.000316	3.58	898.21	201.82	0.21
KR	2920	Q200	Alternative C	1930	1245.6	1257.16	0.000371	3.79	840.62	199.05	0.23
KR	2920	Q200	Alternative D	1930	1245.6	1255.97	0.000758	4.91	617.46	176.25	0.32
KR	2920	Q200	Dam Removal I	1930	1245.6	1258.49	0.000185	2.95	1114.22	211.26	0.16
KR	2920	Q200	Dam Removal II	1930	1245.6	1258.47	0.000186	2.95	1110.9	211.12	0.17
KR	2920	Q500	Existing Culvert	2400	1245.6	1259.2	0.000205	3.25	1269.01	237.59	0.18
KR	2920	Q500	Alternative A	2400	1245.6	1258.72	0.000256	3.52	1163.82	213.31	0.19
KR	2920	Q500	Alternative B	2400	1245.6	1258.67	0.000262	3.55	1152.56	212.85	0.2
KR	2920	Q500	Alternative C	2400	1245.6	1258.73	0.000255	3.51	1165.93	213.4	0.19
KR	2920	Q500	Alternative D	2400	1245.6	1256.55	0.000816	5.36	723	186.66	0.33
KR	2920	Q500	Dam Removal I	2400	1245.6	1259.21	0.000205	3.25	1270.35	238.49	0.18
KR	2920	Q500	Dam Removal II	2400	1245.6	1259.2	0.000205	3.25	1269.3	237.79	0.18
KR	2862	Q2	Existing Culvert	330	1245	1250.69	0.000686	3.09	106.65	42.24	0.26
KR	2862	Q2	Alternative A	330	1245	1250.41	0.000846	3.31	99.69	39.25	0.29

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KR	2862	Q2	Alternative B	330	1245	1250.29	0.000926	3.41	96.84	38.01	0.3
KR	2862	Q2	Alternative C	330	1245	1250.24	0.000961	3.45	95.72	37.53	0.31
KR	2862	Q2	Alternative D	330	1245	1250.15	0.001036	3.53	93.45	36.54	0.32
KR	2862	Q2	Dam Removal I	330	1245	1250.65	0.000706	3.12	105.63	41.8	0.27
KR	2862	Q2	Dam Removal II	330	1245	1250.26	0.000947	3.43	96.16	37.72	0.31
KR	2862	Q5	Existing Culvert	566	1245	1252.49	0.000678	3.72	151.99	61.33	0.27
KR	2862	Q5	Alternative A	566	1245	1252	0.000881	4.06	139.49	56.14	0.31
KR	2862	Q5	Alternative B	566	1245	1251.8	0.000984	4.21	134.54	54.06	0.32
KR	2862	Q5	Alternative C	566	1245	1251.71	0.001038	4.28	132.21	53.09	0.33
KR	2862	Q5	Alternative D	566	1245	1251.47	0.001197	4.48	126.24	50.57	0.35
KR	2862	Q5	Dam Removal I	566	1245	1252.46	0.000686	3.74	151.39	61.08	0.27
KR	2862	Q5	Dam Removal II	566	1245	1252.28	0.000756	3.86	146.61	59.1	0.28
KR	2862	Q10	Existing Culvert	766	1245	1254.07	0.001648	3.88	200.01	110.52	0.4
KR	2862	Q10	Alternative A	766	1245	1253.23	0.000868	4.48	171.1	65.9	0.31
KR	2862	Q10	Alternative B	766	1245	1253	0.000964	4.64	165.18	64.86	0.32
KR	2862	Q10	Alternative C	766	1245	1252.86	0.00103	4.74	161.59	64.27	0.33
KR	2862	Q10	Alternative D	766	1245	1252.5	0.001232	5.03	152.34	61.48	0.36
KR	2862	Q10	Dam Removal I	766	1245	1254.06	0.001676	3.9	198.32	108.81	0.4
KR	2862	Q10	Dam Removal II	766	1245	1253.94	0.000685	4.02	190.55	92.36	0.28
KR	2862	Q25	Existing Culvert	1070	1245	1255.45	0.000719	3.26	428.41	193.94	0.28
KR	2862	Q25	Alternative A	1070	1245	1254.82	0.001412	4.1	311.72	181.38	0.38
KR	2862	Q25	Alternative B	1070	1245	1254.64	0.00174	4.39	279.02	167.84	0.42
KR	2862	Q25	Alternative C	1070	1245	1254.51	0.002022	4.61	257.95	152.22	0.45
KR	2862	Q25	Alternative D	1070	1245	1253.99	0.001313	5.57	192.24	101.63	0.38
KR	2862	Q25	Dam Removal I	1070	1245	1255.44	0.000727	3.27	426.24	193.67	0.28
KR	2862	Q25	Dam Removal II	1070	1245	1255.4	0.000753	3.31	419.44	192.84	0.29
KR	2862	Q50	Existing Culvert	1330	1245	1256.86	0.000314	2.62	728.74	221.12	0.2
KR	2862	Q50	Alternative A	1330	1245	1255.61	0.000946	3.83	460.58	199.55	0.32
KR	2862	Q50	Alternative B	1330	1245	1255.38	0.001187	4.14	415.77	192.38	0.36

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KR	2862	Q50	Alternative C	1330	1245	1255.24	0.001382	4.36	387.91	188.86	0.39
KR	2862	Q50	Alternative D	1330	1245	1254.71	0.002472	5.31	292.23	179.74	0.5
KR	2862	Q50	Dam Removal I	1330	1245	1256.86	0.000316	2.62	727.5	221.07	0.2
KR	2862	Q50	Dam Removal II	1330	1245	1256.82	0.000325	2.65	719.55	220.75	0.2
KR	2862	Q100	Existing Culvert	1620	1245	1257.82	0.000235	2.51	946.14	230.94	0.17
KR	2862	Q100	Alternative A	1620	1245	1256.83	0.000478	3.22	721.51	220.83	0.24
KR	2862	Q100	Alternative B	1620	1245	1256.24	0.00078	3.81	593.6	214.57	0.3
KR	2862	Q100	Alternative C	1620	1245	1255.93	0.001037	4.21	527.18	211.13	0.34
KR	2862	Q100	Alternative D	1620	1245	1255.28	0.001953	5.23	396.72	190.1	0.46
KR	2862	Q100	Dam Removal I	1620	1245	1257.82	0.000236	2.52	944.54	230.88	0.17
KR	2862	Q100	Dam Removal II	1620	1245	1257.79	0.00024	2.54	937.67	230.62	0.18
KR	2862	Q200	Existing Culvert	1930	1245	1258.48	0.000223	2.61	1099.86	239.1	0.17
KR	2862	Q200	Alternative A	1930	1245	1257.67	0.00037	3.11	909.94	229.55	0.22
KR	2862	Q200	Alternative B	1930	1245	1257.41	0.00044	3.3	852.43	227.14	0.23
KR	2862	Q200	Alternative C	1930	1245	1257.12	0.000546	3.55	785.34	224.09	0.26
KR	2862	Q200	Alternative D	1930	1245	1255.75	0.001745	5.32	490.02	209	0.44
KR	2862	Q200	Dam Removal I	1930	1245	1258.48	0.000223	2.61	1099.71	239.09	0.17
KR	2862	Q200	Dam Removal II	1930	1245	1258.46	0.000225	2.62	1095.89	238.9	0.17
KR	2862	Q500	Existing Culvert	2400	1245	1259.19	0.000235	2.86	1275.62	255.28	0.18
KR	2862	Q500	Alternative A	2400	1245	1258.71	0.000302	3.1	1155.04	242.12	0.2
KR	2862	Q500	Alternative B	2400	1245	1258.65	0.000311	3.13	1142.12	241.4	0.2
KR	2862	Q500	Alternative C	2400	1245	1258.72	0.0003	3.1	1157.47	242.25	0.2
KR	2862	Q500	Alternative D	2400	1245	1256.39	0.001507	5.41	625.52	216.93	0.42
KR	2862	Q500	Dam Removal I	2400	1245	1259.2	0.000235	2.85	1277.05	255.38	0.18
KR	2862	Q500	Dam Removal II	2400	1245	1259.19	0.000235	2.86	1275.9	255.3	0.18
KR	2838			Culvert							
KR	2827	Q2	Existing Culvert	330	1245	1250.54	0.000938	2.85	115.69	40.67	0.3

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KR	2827	Q2	Alternative A	330	1245	1250.25	0.001201	3.17	104.17	37.54	0.34
KR	2827	Q2	Alternative B	330	1245	1250.12	0.00133	3.31	99.69	36.25	0.35
KR	2827	Q2	Alternative C	330	1245	1250.08	0.001384	3.37	97.97	35.75	0.36
KR	2827	Q2	Alternative D	330	1245	1249.98	0.001501	3.49	94.54	34.71	0.37
KR	2827	Q2	Dam Removal I	330	1245	1250.5	0.000972	2.9	113.95	40.21	0.3
KR	2827	Q2	Dam Removal II	330	1245	1250.1	0.001362	3.35	98.64	35.95	0.36
KR	2827	Q5	Existing Culvert	566	1245	1252.19	0.000741	2.87	197.13	58.16	0.27
KR	2827	Q5	Alternative A	566	1245	1251.65	0.001115	3.38	167.59	52.49	0.33
KR	2827	Q5	Alternative B	566	1245	1251.44	0.001322	3.62	156.48	50.2	0.36
KR	2827	Q5	Alternative C	566	1245	1251.32	0.00145	3.75	150.74	48.97	0.38
KR	2827	Q5	Alternative D	566	1245	1251.05	0.001808	4.11	137.81	46.08	0.42
KR	2827	Q5	Dam Removal I	566	1245	1252.16	0.000755	2.89	195.65	57.89	0.28
KR	2827	Q5	Dam Removal II	566	1245	1251.96	0.00088	3.07	184.15	55.74	0.3
KR	2827	Q10	Existing Culvert	766	1245	1253.48	0.000499	2.76	278.98	67.6	0.23
KR	2827	Q10	Alternative A	766	1245	1252.71	0.000925	3.35	228.97	63.63	0.31
KR	2827	Q10	Alternative B	766	1245	1252.45	0.00112	3.6	212.64	60.92	0.34
KR	2827	Q10	Alternative C	766	1245	1252.29	0.001263	3.78	202.79	59.18	0.36
KR	2827	Q10	Alternative D	766	1245	1251.85	0.001758	4.31	177.89	54.54	0.42
KR	2827	Q10	Dam Removal I	766	1245	1253.46	0.000503	2.76	278.07	67.51	0.24
KR	2827	Q10	Dam Removal II	766	1245	1253.35	0.000546	2.84	270.57	66.75	0.24
KR	2827	Q25	Existing Culvert	1070	1245	1255.35	0.000268	2.47	535.66	191.6	0.18
KR	2827	Q25	Alternative A	1070	1245	1254.22	0.000598	3.25	343.5	125.49	0.26
KR	2827	Q25	Alternative B	1070	1245	1253.87	0.000747	3.52	306.97	80.44	0.29
KR	2827	Q25	Alternative C	1070	1245	1253.64	0.000867	3.7	290.49	68.97	0.31
KR	2827	Q25	Alternative D	1070	1245	1252.92	0.001507	4.42	242.15	64.51	0.4
KR	2827	Q25	Dam Removal I	1070	1245	1255.34	0.000269	2.48	534.15	191.42	0.18
KR	2827	Q25	Dam Removal II	1070	1245	1255.29	0.00028	2.51	523.94	190.21	0.18
KR	2827	Q50	Existing Culvert	1330	1245	1256.85	0.000153	2.18	852.6	221.02	0.14
KR	2827	Q50	Alternative A	1330	1245	1255.47	0.00038	2.98	558.78	194.43	0.22

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KR	2827	Q50	Alternative B	1330	1245	1255.01	0.000529	3.34	472.67	183.99	0.25
KR	2827	Q50	Alternative C	1330	1245	1254.71	0.000663	3.6	418.02	179.68	0.28
KR	2827	Q50	Alternative D	1330	1245	1253.71	0.001281	4.53	295.1	69.55	0.38
KR	2827	Q50	Dam Removal I	1330	1245	1256.84	0.000153	2.18	850.93	220.95	0.14
KR	2827	Q50	Dam Removal II	1330	1245	1256.82	0.000156	2.19	845.24	220.73	0.14
KR	2827	Q100	Existing Culvert	1620	1245	1257.81	0.000131	2.19	1069.1	230.81	0.13
KR	2827	Q100	Alternative A	1620	1245	1256.83	0.00023	2.67	847.18	220.8	0.17
KR	2827	Q100	Alternative B	1620	1245	1256.24	0.000334	3.04	718.71	214.48	0.21
KR	2827	Q100	Alternative C	1620	1245	1255.89	0.000422	3.29	645.08	210.5	0.23
KR	2827	Q100	Alternative D	1620	1245	1254.52	0.001132	4.58	386.09	153.16	0.36
KR	2827	Q100	Dam Removal I	1620	1245	1257.81	0.000131	2.19	1068.48	230.79	0.13
KR	2827	Q100	Dam Removal II	1620	1245	1257.77	0.000134	2.21	1060.38	230.48	0.14
KR	2827	Q200	Existing Culvert	1930	1245	1258.47	0.000133	2.32	1223.52	238.96	0.14
KR	2827	Q200	Alternative A	1930	1245	1257.66	0.000202	2.69	1034.52	229.48	0.17
KR	2827	Q200	Alternative B	1930	1245	1257.4	0.000233	2.82	976.2	227.03	0.18
KR	2827	Q200	Alternative C	1930	1245	1257.1	0.000278	3	907.42	223.9	0.19
KR	2827	Q200	Alternative D	1930	1245	1255.3	0.0009	4.51	527.1	190.59	0.33
KR	2827	Q200	Dam Removal I	1930	1245	1258.47	0.000133	2.32	1223.34	238.95	0.14
KR	2827	Q200	Dam Removal II	1930	1245	1258.45	0.000134	2.33	1219.46	238.76	0.14
KR	2827	Q500	Existing Culvert	2400	1245	1259.18	0.000149	2.59	1398.19	255.01	0.15
KR	2827	Q500	Alternative A	2400	1245	1258.69	0.000185	2.78	1276.75	241.86	0.16
KR	2827	Q500	Alternative B	2400	1245	1258.64	0.000189	2.8	1265.81	241.26	0.16
KR	2827	Q500	Alternative C	2400	1245	1258.7	0.000184	2.78	1278.46	241.96	0.16
KR	2827	Q500	Alternative D	2400	1245	1256.34	0.000689	4.4	739.79	216.04	0.3
KR	2827	Q500	Dam Removal I	2400	1245	1259.18	0.000149	2.59	1399.91	255.14	0.15
KR	2827	Q500	Dam Removal II	2400	1245	1259.16	0.000151	2.6	1393.25	254.66	0.15
KR	2732	Q2	Existing Culvert	330	1243.59	1250.49	0.000432	2.7	126.06	31.32	0.22
KR	2732	Q2	Alternative A	330	1243.59	1250.17	0.000551	2.9	116.18	30.4	0.25

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KR	2732	Q2	Alternative B	330	1243.59	1250.06	0.000602	2.98	112.86	30.08	0.26
KR	2732	Q2	Alternative C	330	1243.59	1250.01	0.000626	3.02	111.37	29.94	0.26
KR	2732	Q2	Alternative D	330	1243.59	1249.91	0.000681	3.09	108.34	29.63	0.27
KR	2732	Q2	Dam Removal I	330	1243.59	1250.44	0.000447	2.72	124.69	31.15	0.22
KR	2732	Q2	Dam Removal II	330	1243.59	1250.03	0.000616	3	111.95	29.99	0.26
KR	2732	Q5	Existing Culvert	566	1243.59	1252.07	0.000463	3.39	180.2	37.77	0.24
KR	2732	Q5	Alternative A	566	1243.59	1251.5	0.000646	3.76	159.49	35.05	0.28
KR	2732	Q5	Alternative B	566	1243.59	1251.31	0.000729	3.9	152.69	34.06	0.29
KR	2732	Q5	Alternative C	566	1243.59	1251.19	0.000786	3.99	148.71	33.47	0.3
KR	2732	Q5	Alternative D	566	1243.59	1250.91	0.000943	4.22	139.61	32.53	0.33
KR	2732	Q5	Dam Removal I	566	1243.59	1252.05	0.00047	3.41	179.22	37.65	0.24
KR	2732	Q5	Dam Removal II	566	1243.59	1251.84	0.000529	3.53	171.54	36.67	0.25
KR	2732	Q10	Existing Culvert	766	1243.59	1253.3	0.000453	3.78	243.9	87.48	0.24
KR	2732	Q10	Alternative A	766	1243.59	1252.5	0.000673	4.28	197.61	45.1	0.29
KR	2732	Q10	Alternative B	766	1243.59	1252.23	0.000777	4.47	186.18	38.54	0.31
KR	2732	Q10	Alternative C	766	1243.59	1252.06	0.000855	4.6	179.58	37.69	0.33
KR	2732	Q10	Alternative D	766	1243.59	1251.59	0.001122	5	162.57	35.49	0.37
KR	2732	Q10	Dam Removal I	766	1243.59	1253.29	0.000455	3.79	242.68	86.42	0.24
KR	2732	Q10	Dam Removal II	766	1243.59	1253.18	0.000474	3.83	233.83	69.21	0.25
KR	2732	Q25	Existing Culvert	1070	1243.59	1255.21	0.00031	3.64	483.88	165.66	0.21
KR	2732	Q25	Alternative A	1070	1243.59	1253.97	0.000612	4.66	309.95	109.11	0.29
KR	2732	Q25	Alternative B	1070	1243.59	1253.56	0.000771	5.05	267.27	96.68	0.32
KR	2732	Q25	Alternative C	1070	1243.59	1253.29	0.000889	5.3	242.61	86.39	0.34
KR	2732	Q25	Alternative D	1070	1243.59	1252.46	0.001341	6.01	195.84	44.14	0.41
KR	2732	Q25	Dam Removal I	1070	1243.59	1255.2	0.000311	3.65	482.45	165.57	0.21
KR	2732	Q25	Dam Removal II	1070	1243.59	1255.14	0.000322	3.7	472.75	164.76	0.21
KR	2732	Q50	Existing Culvert	1330	1243.59	1256.76	0.000205	3.28	812.75	252.51	0.17
KR	2732	Q50	Alternative A	1330	1243.59	1255.26	0.000464	4.48	492.41	166.45	0.26
KR	2732	Q50	Alternative B	1330	1243.59	1254.72	0.000634	5.03	404.55	149.28	0.3

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KR	2732	Q50	Alternative C	1330	1243.59	1254.38	0.000759	5.36	357.16	126.15	0.32
KR	2732	Q50	Alternative D	1330	1243.59	1253.12	0.001475	6.71	229.62	62.05	0.44
KR	2732	Q50	Dam Removal I	1330	1243.59	1256.75	0.000206	3.29	810.69	252.26	0.18
KR	2732	Q50	Dam Removal II	1330	1243.59	1256.72	0.000209	3.31	803.77	251.46	0.18
KR	2732	Q100	Existing Culvert	1620	1243.59	1257.74	0.000174	3.2	1073.09	275.84	0.16
KR	2732	Q100	Alternative A	1620	1243.59	1256.68	0.000318	4.07	793.54	250.47	0.22
KR	2732	Q100	Alternative B	1620	1243.59	1256.03	0.000446	4.62	638.15	222.99	0.26
KR	2732	Q100	Alternative C	1620	1243.59	1255.63	0.000559	5.04	555.52	177.07	0.28
KR	2732	Q100	Alternative D	1620	1243.59	1253.81	0.001539	7.29	292.01	103.14	0.46
KR	2732	Q100	Dam Removal I	1620	1243.59	1257.74	0.000174	3.2	1072.25	275.79	0.16
KR	2732	Q100	Dam Removal II	1620	1243.59	1257.7	0.000178	3.23	1062.1	275.1	0.17
KR	2732	Q200	Existing Culvert	1930	1243.59	1258.41	0.000172	3.3	1261.37	286.92	0.16
KR	2732	Q200	Alternative A	1930	1243.59	1257.55	0.000275	3.98	1020.01	272.21	0.21
KR	2732	Q200	Alternative B	1930	1243.59	1257.26	0.000323	4.24	943.68	266.5	0.22
KR	2732	Q200	Alternative C	1930	1243.59	1256.92	0.000393	4.59	853.21	257.4	0.24
KR	2732	Q200	Alternative D	1930	1243.59	1254.56	0.001452	7.52	381.61	138.81	0.45
KR	2732	Q200	Dam Removal I	1930	1243.59	1258.41	0.000172	3.3	1261.16	286.91	0.16
KR	2732	Q200	Dam Removal II	1930	1243.59	1258.39	0.000174	3.31	1256.26	286.74	0.17
KR	2732	Q500	Existing Culvert	2400	1243.59	1259.12	0.000184	3.55	1468.81	293.86	0.17
KR	2732	Q500	Alternative A	2400	1243.59	1258.61	0.000239	3.93	1319.39	288.88	0.19
KR	2732	Q500	Alternative B	2400	1243.59	1258.56	0.000245	3.98	1305.12	288.39	0.2
KR	2732	Q500	Alternative C	2400	1243.59	1258.62	0.000238	3.93	1321.26	288.94	0.19
KR	2732	Q500	Alternative D	2400	1243.59	1255.74	0.001155	7.3	575.58	196.39	0.41
KR	2732	Q500	Dam Removal I	2400	1243.59	1259.13	0.000184	3.54	1470.85	293.93	0.17
KR	2732	Q500	Dam Removal II	2400	1243.59	1259.1	0.000186	3.56	1462.86	293.66	0.17
KR	2700	Q2	Existing Culvert	330	1245.09	1250.45	0.000645	2.95	111.68	26.22	0.25
KR	2700	Q2	Alternative A	330	1245.09	1250.12	0.000813	3.2	103.07	25.79	0.28
KR	2700	Q2	Alternative B	330	1245.09	1250	0.000884	3.29	100.16	25.66	0.29

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KR	2700	Q2	Alternative C	330	1245.09	1249.95	0.000919	3.34	98.83	25.59	0.3
KR	2700	Q2	Alternative D	330	1245.09	1249.84	0.000996	3.43	96.09	25.44	0.31
KR	2700	Q2	Dam Removal I	330	1245.09	1250.4	0.000665	2.99	110.5	26.16	0.26
KR	2700	Q2	Dam Removal II	330	1245.09	1249.97	0.000905	3.32	99.35	25.62	0.3
KR	2700	Q5	Existing Culvert	566	1245.09	1252.02	0.000755	3.66	154.61	29.04	0.28
KR	2700	Q5	Alternative A	566	1245.09	1251.43	0.001035	4.1	138.06	27.49	0.32
KR	2700	Q5	Alternative B	566	1245.09	1251.22	0.001165	4.27	132.44	27.22	0.34
KR	2700	Q5	Alternative C	566	1245.09	1251.1	0.001253	4.39	129.07	27.06	0.35
KR	2700	Q5	Alternative D	566	1245.09	1250.8	0.001503	4.67	121.16	26.71	0.39
KR	2700	Q5	Dam Removal I	566	1245.09	1251.99	0.000766	3.68	153.84	28.95	0.28
KR	2700	Q5	Dam Removal II	566	1245.09	1251.78	0.000856	3.83	147.76	27.99	0.29
KR	2700	Q10	Existing Culvert	766	1245.09	1253.25	0.000763	4.01	194.99	38.1	0.28
KR	2700	Q10	Alternative A	766	1245.09	1252.42	0.001132	4.62	166.45	30.7	0.34
KR	2700	Q10	Alternative B	766	1245.09	1252.13	0.001307	4.86	157.82	29.39	0.36
KR	2700	Q10	Alternative C	766	1245.09	1251.94	0.001436	5.03	152.49	28.79	0.38
KR	2700	Q10	Alternative D	766	1245.09	1251.44	0.001879	5.53	138.5	27.51	0.43
KR	2700	Q10	Dam Removal I	766	1245.09	1253.23	0.000769	4.02	194.44	38.04	0.28
KR	2700	Q10	Dam Removal II	766	1245.09	1253.12	0.000814	4.1	190.06	36.03	0.29
KR	2700	Q25	Existing Culvert	1070	1245.09	1255.14	0.000532	3.95	374.38	156.53	0.24
KR	2700	Q25	Alternative A	1070	1245.09	1253.86	0.001097	5.07	227.07	68.85	0.34
KR	2700	Q25	Alternative B	1070	1245.09	1253.44	0.001355	5.43	202.4	42.67	0.37
KR	2700	Q25	Alternative C	1070	1245.09	1253.17	0.00155	5.68	191.92	36.91	0.4
KR	2700	Q25	Alternative D	1070	1245.09	1252.26	0.002386	6.63	161.74	29.82	0.49
KR	2700	Q25	Dam Removal I	1070	1245.09	1255.14	0.000535	3.96	372.97	156.12	0.24
KR	2700	Q25	Dam Removal II	1070	1245.09	1255.07	0.000555	4.01	363.56	153.39	0.25
KR	2700	Q50	Existing Culvert	1330	1245.09	1256.74	0.000308	3.38	711.93	249.44	0.19
KR	2700	Q50	Alternative A	1330	1245.09	1255.15	0.000818	4.9	375.81	156.94	0.3
KR	2700	Q50	Alternative B	1330	1245.09	1254.57	0.001155	5.55	293.44	122.54	0.35
KR	2700	Q50	Alternative C	1330	1245.09	1254.19	0.001422	5.95	253.2	90.86	0.39

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KR	2700	Q50	Alternative D	1330	1245.09	1252.85	0.00277	7.44	180.8	34.65	0.53
KR	2700	Q50	Dam Removal I	1330	1245.09	1256.73	0.000309	3.39	709.82	249.27	0.19
KR	2700	Q50	Dam Removal II	1330	1245.09	1256.7	0.000315	3.41	702.77	248.69	0.19
KR	2700	Q100	Existing Culvert	1620	1245.09	1257.73	0.000245	3.22	971.48	273.35	0.17
KR	2700	Q100	Alternative A	1620	1245.09	1256.64	0.000486	4.22	688.15	247.5	0.24
KR	2700	Q100	Alternative B	1620	1245.09	1255.93	0.000757	5.01	520.43	219.61	0.29
KR	2700	Q100	Alternative C	1620	1245.09	1255.5	0.000985	5.53	432.4	180.61	0.33
KR	2700	Q100	Alternative D	1620	1245.09	1253.44	0.003107	8.23	202.36	42.56	0.57
KR	2700	Q100	Dam Removal I	1620	1245.09	1257.72	0.000246	3.22	970.61	273.33	0.17
KR	2700	Q100	Dam Removal II	1620	1245.09	1257.69	0.000251	3.25	960.38	273.14	0.17
KR	2700	Q200	Existing Culvert	1930	1245.09	1258.4	0.000232	3.26	1156.4	277.24	0.17
KR	2700	Q200	Alternative A	1930	1245.09	1257.52	0.000397	4.04	915.03	272.29	0.22
KR	2700	Q200	Alternative B	1930	1245.09	1257.23	0.000471	4.32	838.08	259.85	0.24
KR	2700	Q200	Alternative C	1930	1245.09	1256.87	0.000593	4.74	745.85	252.14	0.26
KR	2700	Q200	Alternative D	1930	1245.09	1254.04	0.003246	8.86	239.86	76.17	0.59
KR	2700	Q200	Dam Removal I	1930	1245.09	1258.4	0.000232	3.26	1156.19	277.24	0.17
KR	2700	Q200	Dam Removal II	1930	1245.09	1258.38	0.000234	3.27	1151.42	277.11	0.17
KR	2700	Q500	Existing Culvert	2400	1245.09	1259.11	0.000249	3.51	1358.29	294.47	0.18
KR	2700	Q500	Alternative A	2400	1245.09	1258.6	0.000321	3.88	1211.49	279.37	0.2
KR	2700	Q500	Alternative B	2400	1245.09	1258.55	0.00033	3.92	1197.7	278.44	0.2
KR	2700	Q500	Alternative C	2400	1245.09	1258.6	0.00032	3.87	1213.37	279.5	0.2
KR	2700	Q500	Alternative D	2400	1245.09	1255.25	0.002516	8.66	390.71	161.08	0.53
KR	2700	Q500	Dam Removal I	2400	1245.09	1259.12	0.000248	3.51	1360.34	294.54	0.18
KR	2700	Q500	Dam Removal II	2400	1245.09	1259.09	0.000251	3.52	1352.4	293.18	0.18
KR	2666	Q2	Existing Culvert	330	1244.8	1250.33	0.001112	3.7	89.22	18.1	0.29
KR	2666	Q2	Alternative A	330	1244.8	1249.92	0.015795	4.03	81.83	17.96	0.33
KR	2666	Q2	Alternative B	330	1244.8	1249.86	0.001476	4.09	80.76	17.91	0.34
KR	2666	Q2	Alternative C	330	1244.8	1249.79	0.001551	4.16	79.37	17.88	0.35

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KR	2666	Q2	Alternative D	330	1244.8	1249.87	0.000534	2.68	123.12	26.52	0.22
KR	2666	Q2	Dam Removal I	330	1244.8	1250.29	0.001143	3.73	88.36	18.08	0.3
KR	2666	Q2	Dam Removal II	330	1244.8	1249.83	0.001508	4.12	80.16	17.9	0.34
KR	2666	Q5	Existing Culvert	566	1244.8	1251.81	0.001558	4.87	116.32	18.69	0.34
KR	2666	Q5	Alternative A	566	1244.8	1251.06	0.024631	5.52	102.46	18.41	0.41
KR	2666	Q5	Alternative B	566	1244.8	1250.94	0.002361	5.65	100.17	18.34	0.43
KR	2666	Q5	Alternative C	566	1244.8	1250.73	0.002625	5.87	96.47	18.26	0.45
KR	2666	Q5	Alternative D	566	1244.8	1250.85	0.000893	3.79	149.18	26.8	0.28
KR	2666	Q5	Dam Removal I	566	1244.8	1251.78	0.001578	4.89	115.78	18.68	0.35
KR	2666	Q5	Dam Removal II	566	1244.8	1251.55	0.001752	5.08	111.5	18.59	0.37
KR	2666	Q10	Existing Culvert	766	1244.8	1252.96	0.001782	5.55	138.13	19.16	0.36
KR	2666	Q10	Alternative A	766	1244.8	1251.89	0.030555	6.5	117.89	18.76	0.46
KR	2666	Q10	Alternative B	766	1244.8	1251.7	0.002995	6.7	114.31	18.65	0.48
KR	2666	Q10	Alternative C	766	1244.8	1251.37	0.003491	7.08	108.17	18.52	0.52
KR	2666	Q10	Alternative D	766	1244.8	1251.5	0.001184	4.6	166.69	26.99	0.33
KR	2666	Q10	Dam Removal I	766	1244.8	1252.94	0.001793	5.56	137.83	19.15	0.37
KR	2666	Q10	Dam Removal II	766	1244.8	1252.82	0.001883	5.66	135.37	19.1	0.37
KR	2666	Q25	Existing Culvert	1070	1244.8	1254.7	0.001884	6.22	172.31	124.79	0.37
KR	2666	Q25	Alternative A	1070	1244.8	1253.1	0.036516	7.59	141.01	19.24	0.49
KR	2666	Q25	Alternative B	1070	1244.8	1252.8	0.003699	7.92	135.02	19.09	0.53
KR	2666	Q25	Alternative C	1070	1244.8	1252.23	0.004634	8.6	124.36	18.87	0.59
KR	2666	Q25	Alternative D	1070	1244.8	1252.32	0.001608	5.66	189.09	27.24	0.38
KR	2666	Q25	Dam Removal I	1070	1244.8	1254.69	0.00189	6.23	172.1	124.61	0.37
KR	2666	Q25	Dam Removal II	1070	1244.8	1254.62	0.001932	6.27	170.7	123.23	0.38
KR	2666	Q50	Existing Culvert	1330	1244.8	1256.13	0.00176	6.59	208.48	211.62	0.37
KR	2666	Q50	Alternative A	1330	1244.8	1254.14	0.039392	8.26	161.11	24.12	0.51
KR	2666	Q50	Alternative B	1330	1244.8	1253.71	0.004095	8.71	152.69	19.46	0.55
KR	2666	Q50	Alternative C	1330	1244.8	1252.91	0.005464	9.69	137.27	19.14	0.64
KR	2666	Q50	Alternative D	1330	1244.8	1252.92	0.001966	6.48	205.33	27.41	0.42

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KR	2666	Q50	Dam Removal I	1330	1244.8	1256.12	0.001765	6.6	208.18	210.91	0.37
KR	2666	Q50	Dam Removal II	1330	1244.8	1256.08	0.001785	6.62	207.18	208.45	0.37
KR	2666	Q100	Existing Culvert	1620	1244.8	1256.92	0.001974	7.35	239.23	245.78	0.39
KR	2666	Q100	Alternative A	1620	1244.8	1255.34	0.038715	8.71	188.28	164.29	0.51
KR	2666	Q100	Alternative B	1620	1244.8	1254.75	0.004242	9.36	173.43	125.74	0.56
KR	2666	Q100	Alternative C	1620	1244.8	1253.68	0.006138	10.65	152.11	19.45	0.67
KR	2666	Q100	Alternative D	1620	1244.8	1253.5	0.002362	7.32	221.25	27.58	0.46
KR	2666	Q100	Dam Removal I	1620	1244.8	1256.92	0.001977	7.35	239.06	245.72	0.39
KR	2666	Q100	Dam Removal II	1620	1244.8	1256.87	0.002009	7.39	237.06	244.91	0.4
KR	2666	Q200	Existing Culvert	1930	1244.8	1257.34	0.00242	8.34	258.84	253.41	0.44
KR	2666	Q200	Alternative A	1930	1244.8	1255.74	0.047105	9.89	199.53	190.08	0.56
KR	2666	Q200	Alternative B	1930	1244.8	1255.72	0.00428	10	196.28	188.25	0.57
KR	2666	Q200	Alternative C	1930	1244.8	1254.5	0.006558	11.47	168.23	108.14	0.69
KR	2666	Q200	Alternative D	1930	1244.8	1254.06	0.002774	8.15	236.73	28.76	0.49
KR	2666	Q200	Dam Removal I	1930	1244.8	1257.34	0.002421	8.34	258.78	253.38	0.44
KR	2666	Q200	Dam Removal II	1930	1244.8	1257.31	0.002441	8.36	257.63	252.93	0.44
KR	2666	Q500	Existing Culvert	2400	1244.8	1257.5	0.003538	10.18	267.17	256.77	0.53
KR	2666	Q500	Alternative A	2400	1244.8	1255.61	0.076514	12.49	195.74	181.2	0.71
KR	2666	Q500	Alternative B	2400	1244.8	1256.45	0.005111	11.48	219.65	231.51	0.63
KR	2666	Q500	Alternative C	2400	1244.8	1255.44	0.007306	12.82	189.11	170.25	0.74
KR	2666	Q500	Alternative D	2400	1244.8	1254.85	0.003262	9.26	263	135.73	0.54
KR	2666	Q500	Dam Removal I	2400	1244.8	1257.51	0.003523	10.17	267.81	257.02	0.53
KR	2666	Q500	Dam Removal II	2400	1244.8	1257.47	0.003578	10.22	265.42	255.72	0.53
KR	2638			Culvert							
KR	2604	Q2	Existing Culvert	330	1244.5	1249.78	0.00078	3.19	105.16	33.1	0.28
KR	2604	Q2	Alternative A	330	1244.5	1249.78	0.000783	3.19	103.76	33.1	0.28
KR	2604	Q2	Alternative B	330	1244.5	1249.78	0.00078	3.19	105.16	33.1	0.28

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KR	2604	Q2	Alternative C	330	1244.5	1249.78	0.000783	3.19	105.05	33.09	0.28
KR	2604	Q2	Alternative D	330	1244.5	1249.78	0.00078	3.19	105.16	33.1	0.28
KR	2604	Q2	Dam Removal I	330	1244.5	1249.71	0.00083	3.25	102.78	32.73	0.29
KR	2604	Q2	Dam Removal II	330	1244.5	1247.32	0.012046	7.77	42.45	23.14	1.01
KR	2604	Q5	Existing Culvert	566	1244.5	1250.69	0.001123	4.38	137.39	37.58	0.35
KR	2604	Q5	Alternative A	566	1244.5	1250.68	0.001159	4.45	128.64	37.56	0.35
KR	2604	Q5	Alternative B	566	1244.5	1250.69	0.001123	4.38	137.39	37.58	0.35
KR	2604	Q5	Alternative C	566	1244.5	1250.68	0.00113	4.39	137.07	37.54	0.35
KR	2604	Q5	Alternative D	566	1244.5	1250.69	0.001123	4.38	137.39	37.58	0.35
KR	2604	Q5	Dam Removal I	566	1244.5	1250.63	0.001175	4.45	135.06	37.29	0.36
KR	2604	Q5	Dam Removal II	566	1244.5	1248.16	0.010996	9.09	62.26	24.31	1
KR	2604	Q10	Existing Culvert	766	1244.5	1251.28	0.001373	5.23	160.35	40.35	0.39
KR	2604	Q10	Alternative A	766	1244.5	1251.26	0.001459	5.38	144.86	40.27	0.41
KR	2604	Q10	Alternative B	766	1244.5	1251.28	0.001373	5.23	160.35	40.35	0.39
KR	2604	Q10	Alternative C	766	1244.5	1251.26	0.001388	5.25	159.66	40.27	0.4
KR	2604	Q10	Alternative D	766	1244.5	1251.28	0.001373	5.23	160.35	40.35	0.39
KR	2604	Q10	Dam Removal I	766	1244.5	1251.23	0.001415	5.28	158.47	40.13	0.4
KR	2604	Q10	Dam Removal II	766	1244.5	1248.74	0.010778	9.99	76.71	25.17	1.01
KR	2604	Q25	Existing Culvert	1070	1244.5	1252.02	0.001691	6.31	191.73	43.97	0.45
KR	2604	Q25	Alternative A	1070	1244.5	1251.98	0.001874	6.62	165.48	43.8	0.47
KR	2604	Q25	Alternative B	1070	1244.5	1252.02	0.001691	6.31	191.73	43.97	0.45
KR	2604	Q25	Alternative C	1070	1244.5	1252	0.001717	6.35	190.59	43.86	0.45
KR	2604	Q25	Alternative D	1070	1244.5	1252.02	0.001691	6.31	191.73	43.97	0.45
KR	2604	Q25	Dam Removal I	1070	1244.5	1251.98	0.001737	6.37	189.74	43.78	0.45
KR	2604	Q25	Dam Removal II	1070	1244.5	1249.56	0.009924	10.94	98.07	31.63	0.99
KR	2604	Q50	Existing Culvert	1330	1244.5	1252.55	0.001942	7.14	215.48	46.46	0.48
KR	2604	Q50	Alternative A	1330	1244.5	1252.48	0.00223	7.6	179.92	46.11	0.52
KR	2604	Q50	Alternative B	1330	1244.5	1252.55	0.001942	7.14	215.48	46.46	0.48
KR	2604	Q50	Alternative C	1330	1244.5	1252.51	0.001982	7.19	213.72	46.27	0.49

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KR	2604	Q50	Alternative D	1330	1244.5	1252.55	0.001942	7.14	215.48	46.46	0.48
KR	2604	Q50	Dam Removal I	1330	1244.5	1252.5	0.001991	7.2	213.36	46.23	0.49
KR	2604	Q50	Dam Removal II	1330	1244.5	1250.23	0.008765	11.47	120.58	35.35	0.96
KR	2604	Q100	Existing Culvert	1620	1244.5	1253.05	0.002213	7.99	239.16	48.77	0.52
KR	2604	Q100	Alternative A	1620	1244.5	1252.94	0.002646	8.65	193.36	48.25	0.57
KR	2604	Q100	Alternative B	1620	1244.5	1253.05	0.002213	7.99	239.16	48.77	0.52
KR	2604	Q100	Alternative C	1620	1244.5	1252.99	0.002277	8.07	236.49	48.51	0.53
KR	2604	Q100	Alternative D	1620	1244.5	1253.05	0.002213	7.99	239.16	48.77	0.52
KR	2604	Q100	Dam Removal I	1620	1244.5	1253.01	0.002252	8.04	237.53	48.61	0.53
KR	2604	Q100	Dam Removal II	1620	1244.5	1250.89	0.007996	12.01	144.92	38.51	0.94
KR	2604	Q200	Existing Culvert	1930	1244.5	1253.47	0.002585	8.97	260.9	56.02	0.57
KR	2604	Q200	Alternative A	1930	1244.5	1253.33	0.00314	9.76	204.9	51.22	0.63
KR	2604	Q200	Alternative B	1930	1244.5	1253.47	0.002585	8.97	260.9	56.02	0.57
KR	2604	Q200	Alternative C	1930	1244.5	1253.39	0.002678	9.07	256.41	53.92	0.58
KR	2604	Q200	Alternative D	1930	1244.5	1253.47	0.002585	8.97	260.9	56.02	0.57
KR	2604	Q200	Dam Removal I	1930	1244.5	1253.44	0.002619	9.01	259.32	55.48	0.57
KR	2604	Q200	Dam Removal II	1930	1244.5	1251.49	0.007597	12.61	169.08	41.37	0.93
KR	2604	Q500	Existing Culvert	2400	1244.5	1253.96	0.00321	10.41	291.27	73.05	0.64
KR	2604	Q500	Alternative A	2400	1244.5	1253.72	0.004074	11.51	216.92	61.94	0.72
KR	2604	Q500	Alternative B	2400	1244.5	1253.96	0.00321	10.41	291.27	73.05	0.64
KR	2604	Q500	Alternative C	2400	1244.5	1253.85	0.003365	10.57	284.07	67.21	0.66
KR	2604	Q500	Alternative D	2400	1244.5	1253.96	0.00321	10.41	291.27	73.05	0.64
KR	2604	Q500	Dam Removal I	2400	1244.5	1253.96	0.003206	10.41	291.44	73.31	0.64
KR	2604	Q500	Dam Removal II	2400	1244.5	1252.34	0.00711	13.38	205.71	45.38	0.92
KR	2569	Q2	Existing Culvert	330	1244.72	1249.78	0.000543	2.79	137.28	51.77	0.25
KR	2569	Q2	Alternative A	330	1244.72	1249.78	0.000543	2.79	137.28	51.77	0.25
KR	2569	Q2	Alternative B	330	1244.72	1249.78	0.000543	2.79	137.28	51.77	0.25
KR	2569	Q2	Alternative C	330	1244.72	1249.78	0.000543	2.79	137.28	51.77	0.25

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KR	2569	Q2	Alternative D	330	1244.72	1249.78	0.000543	2.79	137.28	51.77	0.25
KR	2569	Q2	Dam Removal I	330	1244.72	1249.7	0.000583	2.86	133.47	51.65	0.26
KR	2569	Q2	Dam Removal II	330	1243.22	1245.29	0.041879	11.22	29.42	24.56	1.81
KR	2569	Q5	Existing Culvert	566	1244.72	1250.71	0.000718	3.7	191.16	62.03	0.29
KR	2569	Q5	Alternative A	566	1244.72	1250.71	0.000718	3.7	191.16	62.03	0.29
KR	2569	Q5	Alternative B	566	1244.72	1250.71	0.000718	3.7	191.16	62.03	0.29
KR	2569	Q5	Alternative C	566	1244.72	1250.71	0.000718	3.7	191.16	62.03	0.29
KR	2569	Q5	Alternative D	566	1244.72	1250.71	0.000718	3.7	191.16	62.03	0.29
KR	2569	Q5	Dam Removal I	566	1244.72	1250.65	0.000756	3.76	187.27	61.62	0.3
KR	2569	Q5	Dam Removal II	566	1243.22	1245.87	0.035741	12.83	44.12	26.44	1.75
KR	2569	Q10	Existing Culvert	766	1244.72	1251.32	0.00083	4.3	230.36	66.22	0.32
KR	2569	Q10	Alternative A	766	1244.72	1251.32	0.00083	4.3	230.36	66.22	0.32
KR	2569	Q10	Alternative B	766	1244.72	1251.32	0.00083	4.3	230.36	66.22	0.32
KR	2569	Q10	Alternative C	766	1244.72	1251.32	0.00083	4.3	230.36	66.22	0.32
KR	2569	Q10	Alternative D	766	1244.72	1251.32	0.00083	4.3	230.36	66.22	0.32
KR	2569	Q10	Dam Removal I	766	1244.72	1251.27	0.000857	4.34	227.35	65.89	0.33
KR	2569	Q10	Dam Removal II	766	1243.22	1246.28	0.033015	13.82	55.41	27.76	1.73
KR	2569	Q25	Existing Culvert	1070	1244.72	1252.11	0.000955	5.04	284.41	71.2	0.35
KR	2569	Q25	Alternative A	1070	1244.72	1252.11	0.000955	5.04	284.41	71.2	0.35
KR	2569	Q25	Alternative B	1070	1244.72	1252.11	0.000955	5.04	284.41	71.2	0.35
KR	2569	Q25	Alternative C	1070	1244.72	1252.11	0.000955	5.04	284.41	71.2	0.35
KR	2569	Q25	Alternative D	1070	1244.72	1252.11	0.000955	5.04	284.41	71.2	0.35
KR	2569	Q25	Dam Removal I	1070	1244.72	1252.06	0.000982	5.09	281.23	70.95	0.36
KR	2569	Q25	Dam Removal II	1070	1243.22	1246.83	0.02901	15.07	71.09	28.68	1.68
KR	2569	Q50	Existing Culvert	1330	1244.72	1252.67	0.001048	5.59	325.47	74.39	0.38
KR	2569	Q50	Alternative A	1330	1244.72	1252.67	0.001048	5.59	325.47	74.39	0.38
KR	2569	Q50	Alternative B	1330	1244.72	1252.67	0.001048	5.59	325.47	74.39	0.38
KR	2569	Q50	Alternative C	1330	1244.72	1252.67	0.001048	5.59	325.47	74.39	0.38
KR	2569	Q50	Alternative D	1330	1244.72	1252.67	0.001048	5.59	325.47	74.39	0.38

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KR	2569	Q50	Dam Removal I	1330	1244.72	1252.63	0.001075	5.64	322.16	74.13	0.38
KR	2569	Q50	Dam Removal II	1330	1243.22	1247.28	0.025826	15.87	84.09	29.01	1.63
KR	2569	Q100	Existing Culvert	1620	1244.72	1253.21	0.001149	6.16	366.67	77.72	0.4
KR	2569	Q100	Alternative A	1620	1244.72	1253.21	0.001149	6.16	366.67	77.72	0.4
KR	2569	Q100	Alternative B	1620	1244.72	1253.21	0.001149	6.16	366.67	77.72	0.4
KR	2569	Q100	Alternative C	1620	1244.72	1253.21	0.001149	6.16	366.67	77.72	0.4
KR	2569	Q100	Alternative D	1620	1244.72	1253.21	0.001149	6.16	366.67	77.72	0.4
KR	2569	Q100	Dam Removal I	1620	1244.72	1253.18	0.001169	6.2	364.18	77.53	0.4
KR	2569	Q100	Dam Removal II	1620	1243.22	1247.78	0.022767	16.54	98.66	29.38	1.57
KR	2569	Q200	Existing Culvert	1930	1244.72	1253.71	0.001263	6.74	412.29	122.49	0.42
KR	2569	Q200	Alternative A	1930	1244.72	1253.71	0.001263	6.74	412.29	122.49	0.42
KR	2569	Q200	Alternative B	1930	1244.72	1253.71	0.001263	6.74	412.29	122.49	0.42
KR	2569	Q200	Alternative C	1930	1244.72	1253.71	0.001263	6.74	412.29	122.49	0.42
KR	2569	Q200	Alternative D	1930	1244.72	1253.71	0.001263	6.74	412.29	122.49	0.42
KR	2569	Q200	Dam Removal I	1930	1244.72	1253.68	0.001281	6.78	408.95	118.72	0.43
KR	2569	Q200	Dam Removal II	1930	1243.22	1248.31	0.020108	17.08	114.26	29.9	1.51
KR	2569	Q500	Existing Culvert	2400	1244.72	1254.24	0.001649	8.05	486.39	145.55	0.49
KR	2569	Q500	Alternative A	2400	1244.72	1254.24	0.001649	8.05	486.39	145.55	0.49
KR	2569	Q500	Alternative B	2400	1244.72	1254.24	0.001649	8.05	486.39	145.55	0.49
KR	2569	Q500	Alternative C	2400	1244.72	1254.24	0.001649	8.05	486.39	145.55	0.49
KR	2569	Q500	Alternative D	2400	1244.72	1254.24	0.001649	8.05	486.39	145.55	0.49
KR	2569	Q500	Dam Removal I	2400	1244.72	1254.25	0.001642	8.04	487.51	145.63	0.49
KR	2569	Q500	Dam Removal II	2400	1243.22	1249.05	0.017453	17.81	143.43	50.74	1.45
KR	2480	Q2	Existing Culvert	330	1245.4	1249.68	0.00102	3	110.1	38.22	0.31
KR	2480	Q2	Alternative A	330	1245.4	1249.68	0.00102	3	110.1	38.22	0.31
KR	2480	Q2	Alternative B	330	1245.4	1249.68	0.00102	3	110.1	38.22	0.31
KR	2480	Q2	Alternative C	330	1245.4	1249.68	0.00102	3	110.1	38.22	0.31
KR	2480	Q2	Alternative D	330	1245.4	1249.68	0.00102	3	110.1	38.22	0.31

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KR	2480	Q2	Dam Removal I	330	1245.4	1249.59	0.001107	3.08	106.97	37.84	0.32
KR	2480	Q2	Dam Removal II	330	1241.4	1243.66	0.017696	7.86	41.96	29.99	1.17
KR	2480	Q5	Existing Culvert	566	1245.4	1250.57	0.001357	3.87	146.12	42.41	0.37
KR	2480	Q5	Alternative A	566	1245.4	1250.57	0.001357	3.87	146.12	42.41	0.37
KR	2480	Q5	Alternative B	566	1245.4	1250.57	0.001357	3.87	146.12	42.41	0.37
KR	2480	Q5	Alternative C	566	1245.4	1250.57	0.001357	3.87	146.12	42.41	0.37
KR	2480	Q5	Alternative D	566	1245.4	1250.57	0.001357	3.87	146.12	42.41	0.37
KR	2480	Q5	Dam Removal I	566	1245.4	1250.5	0.001438	3.96	143.1	42.07	0.38
KR	2480	Q5	Dam Removal II	566	1241.4	1244.12	0.021255	10.11	56	31.12	1.33
KR	2480	Q10	Existing Culvert	766	1245.4	1251.15	0.00159	4.46	171.61	45.13	0.4
KR	2480	Q10	Alternative A	766	1245.4	1251.15	0.00159	4.46	171.61	45.13	0.4
KR	2480	Q10	Alternative B	766	1245.4	1251.15	0.00159	4.46	171.61	45.13	0.4
KR	2480	Q10	Alternative C	766	1245.4	1251.15	0.00159	4.46	171.61	45.13	0.4
KR	2480	Q10	Alternative D	766	1245.4	1251.15	0.00159	4.46	171.61	45.13	0.4
KR	2480	Q10	Dam Removal I	766	1245.4	1251.1	0.001653	4.53	169.24	44.88	0.41
KR	2480	Q10	Dam Removal II	766	1241.4	1244.44	0.023329	11.57	66.2	31.95	1.42
KR	2480	Q25	Existing Culvert	1070	1245.4	1251.9	0.001848	5.18	206.61	49.27	0.44
KR	2480	Q25	Alternative A	1070	1245.4	1251.9	0.001848	5.18	206.61	49.27	0.44
KR	2480	Q25	Alternative B	1070	1245.4	1251.9	0.001848	5.18	206.61	49.27	0.44
KR	2480	Q25	Alternative C	1070	1245.4	1251.9	0.001848	5.18	206.61	49.27	0.44
KR	2480	Q25	Alternative D	1070	1245.4	1251.9	0.001848	5.18	206.61	49.27	0.44
KR	2480	Q25	Dam Removal I	1070	1245.4	1251.84	0.001915	5.25	204.01	48.9	0.45
KR	2480	Q25	Dam Removal II	1070	1241.4	1244.85	0.026435	13.5	79.23	33	1.54
KR	2480	Q50	Existing Culvert	1330	1245.4	1252.43	0.002019	5.7	233.97	52.95	0.47
KR	2480	Q50	Alternative A	1330	1245.4	1252.43	0.002019	5.7	233.97	52.95	0.47
KR	2480	Q50	Alternative B	1330	1245.4	1252.43	0.002019	5.7	233.97	52.95	0.47
KR	2480	Q50	Alternative C	1330	1245.4	1252.43	0.002019	5.7	233.97	52.95	0.47
KR	2480	Q50	Alternative D	1330	1245.4	1252.43	0.002019	5.7	233.97	52.95	0.47
KR	2480	Q50	Dam Removal I	1330	1245.4	1252.38	0.002088	5.77	231.15	52.58	0.48

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KR	2480	Q50	Dam Removal II	1330	1241.4	1245.13	0.029221	15.01	88.6	33.74	1.63
KR	2480	Q100	Existing Culvert	1620	1245.4	1252.94	0.002199	6.23	262.26	60.79	0.5
KR	2480	Q100	Alternative A	1620	1245.4	1252.94	0.002199	6.23	262.26	60.79	0.5
KR	2480	Q100	Alternative B	1620	1245.4	1252.94	0.002199	6.23	262.26	60.79	0.5
KR	2480	Q100	Alternative C	1620	1245.4	1252.94	0.002199	6.23	262.26	60.79	0.5
KR	2480	Q100	Alternative D	1620	1245.4	1252.94	0.002199	6.23	262.26	60.79	0.5
KR	2480	Q100	Dam Removal I	1620	1245.4	1252.9	0.002255	6.28	259.69	59.32	0.5
KR	2480	Q100	Dam Removal II	1620	1241.4	1245.41	0.031852	16.49	98.26	34.49	1.72
KR	2480	Q200	Existing Culvert	1930	1245.4	1253.41	0.00238	6.73	297.38	88.96	0.52
KR	2480	Q200	Alternative A	1930	1245.4	1253.41	0.00238	6.73	297.38	88.96	0.52
KR	2480	Q200	Alternative B	1930	1245.4	1253.41	0.00238	6.73	297.38	88.96	0.52
KR	2480	Q200	Alternative C	1930	1245.4	1253.41	0.00238	6.73	297.38	88.96	0.52
KR	2480	Q200	Alternative D	1930	1245.4	1253.41	0.00238	6.73	297.38	88.96	0.52
KR	2480	Q200	Dam Removal I	1930	1245.4	1253.38	0.002417	6.77	295.11	88.02	0.53
KR	2480	Q200	Dam Removal II	1930	1241.4	1245.73	0.032721	17.61	109.61	35.34	1.76
KR	2480	Q500	Existing Culvert	2400	1245.4	1254.05	0.002413	7.33	357.53	96.4	0.54
KR	2480	Q500	Alternative A	2400	1245.4	1254.05	0.002413	7.33	357.53	96.4	0.54
KR	2480	Q500	Alternative B	2400	1245.4	1254.05	0.002413	7.33	357.53	96.4	0.54
KR	2480	Q500	Alternative C	2400	1245.4	1254.05	0.002413	7.33	357.53	96.4	0.54
KR	2480	Q500	Alternative D	2400	1245.4	1254.05	0.002413	7.33	357.53	96.4	0.54
KR	2480	Q500	Dam Removal I	2400	1245.4	1254.06	0.0024	7.32	358.35	96.46	0.54
KR	2480	Q500	Dam Removal II	2400	1241.4	1246.21	0.032969	18.92	126.84	36.6	1.79
KR	2409	Q2	Existing Culvert	330	1245.8	1248.77	0.013059	3.07	107.47	42.73	0.34
KR	2409	Q2	Alternative A	330	1245.8	1248.77	0.013059	3.07	107.47	42.73	0.34
KR	2409	Q2	Alternative B	330	1245.8	1248.77	0.013059	3.07	107.47	42.73	0.34
KR	2409	Q2	Alternative C	330	1245.8	1248.77	0.013059	3.07	107.47	42.73	0.34
KR	2409	Q2	Alternative D	330	1245.8	1248.77	0.013059	3.07	107.47	42.73	0.34
KR	2409	Q2	Dam Removal I	330	1245.8	1247.34	0.012393	6.6	49.99	37.43	1.01

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KR	2409	Q2	Dam Removal II	330	1239.8	1242.08	0.037169	4.49	73.55	35.28	0.55
KR	2409	Q5	Existing Culvert	566	1245.8	1249.31	0.022303	4.26	132.71	48.06	0.45
KR	2409	Q5	Alternative A	566	1245.8	1249.31	0.022303	4.26	132.71	48.06	0.45
KR	2409	Q5	Alternative B	566	1245.8	1249.31	0.022303	4.26	132.71	48.06	0.45
KR	2409	Q5	Alternative C	566	1245.8	1249.31	0.022303	4.26	132.71	48.06	0.45
KR	2409	Q5	Alternative D	566	1245.8	1249.31	0.022303	4.26	132.71	48.06	0.45
KR	2409	Q5	Dam Removal I	566	1245.8	1247.84	0.013213	8.17	69.26	39.29	1.09
KR	2409	Q5	Dam Removal II	566	1239.8	1242.82	0.041698	5.65	100.1	36.34	0.6
KR	2409	Q10	Existing Culvert	766	1245.8	1249.69	0.027385	5.06	151.44	49.37	0.51
KR	2409	Q10	Alternative A	766	1245.8	1249.69	0.027385	5.06	151.44	49.37	0.51
KR	2409	Q10	Alternative B	766	1245.8	1249.69	0.027385	5.06	151.44	49.37	0.51
KR	2409	Q10	Alternative C	766	1245.8	1249.69	0.027385	5.06	151.44	49.37	0.51
KR	2409	Q10	Alternative D	766	1245.8	1249.69	0.027385	5.06	151.44	49.37	0.51
KR	2409	Q10	Dam Removal I	766	1245.8	1248.21	0.013377	9.12	84	40.65	1.12
KR	2409	Q10	Dam Removal II	766	1239.8	1243.4	0.04205	6.31	121.45	37.17	0.62
KR	2409	Q25	Existing Culvert	1070	1245.8	1250.2	0.0335	6.05	176.9	51.1	0.57
KR	2409	Q25	Alternative A	1070	1245.8	1250.2	0.0335	6.05	176.9	51.1	0.57
KR	2409	Q25	Alternative B	1070	1245.8	1250.2	0.0335	6.05	176.9	51.1	0.57
KR	2409	Q25	Alternative C	1070	1245.8	1250.2	0.0335	6.05	176.9	51.1	0.57
KR	2409	Q25	Alternative D	1070	1245.8	1250.2	0.0335	6.05	176.9	51.1	0.57
KR	2409	Q25	Dam Removal I	1070	1245.8	1248.74	0.012868	10.09	106.03	42.61	1.13
KR	2409	Q25	Dam Removal II	1070	1239.8	1244.1	0.045293	7.25	147.55	38.17	0.65
KR	2409	Q50	Existing Culvert	1330	1245.8	1250.58	0.038614	6.76	196.61	53.37	0.62
KR	2409	Q50	Alternative A	1330	1245.8	1250.58	0.038614	6.76	196.61	53.37	0.62
KR	2409	Q50	Alternative B	1330	1245.8	1250.58	0.038614	6.76	196.61	53.37	0.62
KR	2409	Q50	Alternative C	1330	1245.8	1250.58	0.038614	6.76	196.61	53.37	0.62
KR	2409	Q50	Alternative D	1330	1245.8	1250.58	0.038614	6.76	196.61	53.37	0.62
KR	2409	Q50	Dam Removal I	1330	1245.8	1249.15	0.013205	10.61	125.3	47.53	1.15
KR	2409	Q50	Dam Removal II	1330	1239.8	1244.61	0.047687	7.94	167.52	38.91	0.67

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KR	2409	Q100	Existing Culvert	1620	1245.8	1250.96	0.043297	7.45	217.42	55.89	0.66
KR	2409	Q100	Alternative A	1620	1245.8	1250.96	0.043297	7.45	217.42	55.89	0.66
KR	2409	Q100	Alternative B	1620	1245.8	1250.96	0.043297	7.45	217.42	55.89	0.66
KR	2409	Q100	Alternative C	1620	1245.8	1250.96	0.043297	7.45	217.42	55.89	0.66
KR	2409	Q100	Alternative D	1620	1245.8	1250.96	0.043297	7.45	217.42	55.89	0.66
KR	2409	Q100	Dam Removal I	1620	1245.8	1249.53	0.012981	11.29	143.47	48.82	1.16
KR	2409	Q100	Dam Removal II	1620	1239.8	1245.14	0.05007	8.62	187.99	39.65	0.7
KR	2409	Q200	Existing Culvert	1930	1245.8	1251.32	0.04578	8.12	238.72	62.46	0.69
KR	2409	Q200	Alternative A	1930	1245.8	1251.32	0.04578	8.12	238.72	62.46	0.69
KR	2409	Q200	Alternative B	1930	1245.8	1251.32	0.04578	8.12	238.72	62.46	0.69
KR	2409	Q200	Alternative C	1930	1245.8	1251.32	0.04578	8.12	238.72	62.46	0.69
KR	2409	Q200	Alternative D	1930	1245.8	1251.32	0.04578	8.12	238.72	62.46	0.69
KR	2409	Q200	Dam Removal I	1930	1245.8	1249.92	0.012588	11.86	162.78	50.15	1.16
KR	2409	Q200	Dam Removal II	1930	1239.8	1245.65	0.052275	9.26	208.41	40.38	0.72
KR	2409	Q500	Existing Culvert	2400	1245.8	1251.8	0.049017	9.03	271.23	70.64	0.73
KR	2409	Q500	Alternative A	2400	1245.8	1251.8	0.049017	9.03	271.23	70.64	0.73
KR	2409	Q500	Alternative B	2400	1245.8	1251.8	0.049017	9.03	271.23	70.64	0.73
KR	2409	Q500	Alternative C	2400	1245.8	1251.8	0.049017	9.03	271.23	70.64	0.73
KR	2409	Q500	Alternative D	2400	1245.8	1251.8	0.049017	9.03	271.23	70.64	0.73
KR	2409	Q500	Dam Removal I	2400	1245.8	1250.47	0.012222	12.56	191.1	52.67	1.16
KR	2409	Q500	Dam Removal II	2400	1239.8	1246.36	0.054942	10.1	237.51	41.4	0.74
KR	2355	Q2	Existing Culvert	330	1244.67	1248.81	0.000135	1.28	258.81	74.9	0.12
KR	2355	Q2	Alternative A	330	1244.67	1248.81	0.000135	1.28	258.81	74.9	0.12
KR	2355	Q2	Alternative B	330	1244.67	1248.81	0.000135	1.28	258.81	74.9	0.12
KR	2355	Q2	Alternative C	330	1244.67	1248.81	0.000135	1.28	258.81	74.9	0.12
KR	2355	Q2	Alternative D	330	1244.67	1248.81	0.000135	1.28	258.81	74.9	0.12
KR	2355	Q2	Dam Removal I	330	1244.67	1245.81	0.051744	8.37	39.41	61.38	1.84
KR	2355	Q2	Dam Removal II	330	1237.67	1240.21	0.034219	4.08	80.82	43.92	0.53

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KR	2355	Q5	Existing Culvert	566	1244.67	1249.39	0.000241	1.87	302.75	75.4	0.16
KR	2355	Q5	Alternative A	566	1244.67	1249.39	0.000241	1.87	302.75	75.4	0.16
KR	2355	Q5	Alternative B	566	1244.67	1249.39	0.000241	1.87	302.75	75.4	0.16
KR	2355	Q5	Alternative C	566	1244.67	1249.39	0.000241	1.87	302.75	75.4	0.16
KR	2355	Q5	Alternative D	566	1244.67	1249.39	0.000241	1.87	302.75	75.4	0.16
KR	2355	Q5	Dam Removal I	566	1244.67	1246.09	0.051004	9.72	58.23	71.62	1.9
KR	2355	Q5	Dam Removal II	566	1237.67	1241.14	0.027763	4.58	123.55	47.94	0.5
KR	2355	Q10	Existing Culvert	766	1244.67	1249.82	0.00032	2.29	335.11	75.76	0.19
KR	2355	Q10	Alternative A	766	1244.67	1249.82	0.00032	2.29	335.11	75.76	0.19
KR	2355	Q10	Alternative B	766	1244.67	1249.82	0.00032	2.29	335.11	75.76	0.19
KR	2355	Q10	Alternative C	766	1244.67	1249.82	0.00032	2.29	335.11	75.76	0.19
KR	2355	Q10	Alternative D	766	1244.67	1249.82	0.00032	2.29	335.11	75.76	0.19
KR	2355	Q10	Dam Removal I	766	1244.67	1246.26	0.049378	10.8	70.93	72.57	1.93
KR	2355	Q10	Dam Removal II	766	1237.67	1241.53	0.033246	5.38	142.38	49.56	0.56
KR	2355	Q25	Existing Culvert	1070	1244.67	1250.4	0.000421	2.82	379.12	77.03	0.22
KR	2355	Q25	Alternative A	1070	1244.67	1250.4	0.000421	2.82	379.12	77.03	0.22
KR	2355	Q25	Alternative B	1070	1244.67	1250.4	0.000421	2.82	379.12	77.03	0.22
KR	2355	Q25	Alternative C	1070	1244.67	1250.4	0.000421	2.82	379.12	77.03	0.22
KR	2355	Q25	Alternative D	1070	1244.67	1250.4	0.000421	2.82	379.12	77.03	0.22
KR	2355	Q25	Dam Removal I	1070	1244.67	1246.49	0.047861	12.19	87.8	72.92	1.96
KR	2355	Q25	Dam Removal II	1070	1237.67	1242.28	0.031584	5.92	180.89	52.21	0.56
KR	2355	Q50	Existing Culvert	1330	1244.67	1250.84	0.000492	3.22	413.35	79.65	0.24
KR	2355	Q50	Alternative A	1330	1244.67	1250.84	0.000492	3.22	413.35	79.65	0.24
KR	2355	Q50	Alternative B	1330	1244.67	1250.84	0.000492	3.22	413.35	79.65	0.24
KR	2355	Q50	Alternative C	1330	1244.67	1250.84	0.000492	3.22	413.35	79.65	0.24
KR	2355	Q50	Alternative D	1330	1244.67	1250.84	0.000492	3.22	413.35	79.65	0.24
KR	2355	Q50	Dam Removal I	1330	1244.67	1246.68	0.046563	13.16	101.09	73.08	1.97
KR	2355	Q50	Dam Removal II	1330	1237.67	1242.85	0.030476	6.3	211.11	53.63	0.56
KR	2355	Q100	Existing Culvert	1620	1244.67	1251.28	0.00056	3.63	449.6	83.37	0.26

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KR	2355	Q100	Alternative A	1620	1244.67	1251.28	0.00056	3.63	449.6	83.37	0.26
KR	2355	Q100	Alternative B	1620	1244.67	1251.28	0.00056	3.63	449.6	83.37	0.26
KR	2355	Q100	Alternative C	1620	1244.67	1251.28	0.00056	3.63	449.6	83.37	0.26
KR	2355	Q100	Alternative D	1620	1244.67	1251.28	0.00056	3.63	449.6	83.37	0.26
KR	2355	Q100	Dam Removal I	1620	1244.67	1246.86	0.045581	14.12	114.77	73.24	1.99
KR	2355	Q100	Dam Removal II	1620	1237.67	1243.42	0.029813	6.69	241.99	54.72	0.56
KR	2355	Q200	Existing Culvert	1930	1244.67	1251.71	0.000626	4.02	486.42	87.84	0.28
KR	2355	Q200	Alternative A	1930	1244.67	1251.71	0.000626	4.02	486.42	87.84	0.28
KR	2355	Q200	Alternative B	1930	1244.67	1251.71	0.000626	4.02	486.42	87.84	0.28
KR	2355	Q200	Alternative C	1930	1244.67	1251.71	0.000626	4.02	486.42	87.84	0.28
KR	2355	Q200	Alternative D	1930	1244.67	1251.71	0.000626	4.02	486.42	87.84	0.28
KR	2355	Q200	Dam Removal I	1930	1244.67	1247.05	0.044817	15.03	128.41	73.39	2
KR	2355	Q200	Dam Removal II	1930	1237.67	1244	0.028958	7.05	273.89	55.49	0.56
KR	2355	Q500	Existing Culvert	2400	1244.67	1252.29	0.000716	4.56	539.92	95.26	0.31
KR	2355	Q500	Alternative A	2400	1244.67	1252.29	0.000716	4.56	539.92	95.26	0.31
KR	2355	Q500	Alternative B	2400	1244.67	1252.29	0.000716	4.56	539.92	95.26	0.31
KR	2355	Q500	Alternative C	2400	1244.67	1252.29	0.000716	4.56	539.92	95.26	0.31
KR	2355	Q500	Alternative D	2400	1244.67	1252.29	0.000716	4.56	539.92	95.26	0.31
KR	2355	Q500	Dam Removal I	2400	1244.67	1247.32	0.043569	16.21	148.05	73.62	2.02
KR	2355	Q500	Dam Removal II	2400	1237.67	1244.79	0.028381	7.54	318.23	56.53	0.56
KR	2318			Inl Struct							
KR	2303	Q2	Existing Culvert	330	1236.09	1238.24	0.009213	7.64	55.65	33.82	0.94
KR	2303	Q2	Alternative A	330	1236.09	1238.24	0.009213	7.64	55.65	33.82	0.94
KR	2303	Q2	Alternative B	330	1236.09	1238.24	0.009213	7.64	55.65	33.82	0.94
KR	2303	Q2	Alternative C	330	1236.09	1238.24	0.009213	7.64	55.65	33.82	0.94
KR	2303	Q2	Alternative D	330	1236.09	1238.24	0.009213	7.64	55.65	33.82	0.94

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KR	2303	Q2	Dam Removal I	330	1236.09	1237.07	0.17734	18.97	20.69	26.95	3.59
KR	2303	Q2	Dam Removal II	330	1236.49	1238.46	0.012611	8.41	49.76	32.15	1.09
KR	2303	Q5	Existing Culvert	566	1236.09	1238.8	0.011586	10.06	76.04	39.37	1.1
KR	2303	Q5	Alternative A	566	1236.09	1238.8	0.011586	10.06	76.04	39.37	1.1
KR	2303	Q5	Alternative B	566	1236.09	1238.8	0.011586	10.06	76.04	39.37	1.1
KR	2303	Q5	Alternative C	566	1236.09	1238.8	0.011586	10.06	76.04	39.37	1.1
KR	2303	Q5	Alternative D	566	1236.09	1238.8	0.011586	10.06	76.04	39.37	1.1
KR	2303	Q5	Dam Removal I	566	1236.09	1237.52	0.120648	20.73	33.41	28.97	3.18
KR	2303	Q5	Dam Removal II	566	1236.49	1239.19	0.011702	10.1	75.75	39.29	1.11
KR	2303	Q10	Existing Culvert	766	1236.09	1239.61	0.007732	9.85	113.47	50.07	0.94
KR	2303	Q10	Alternative A	766	1236.09	1239.61	0.007732	9.85	113.47	50.07	0.94
KR	2303	Q10	Alternative B	766	1236.09	1239.61	0.007732	9.85	113.47	50.07	0.94
KR	2303	Q10	Alternative C	766	1236.09	1239.61	0.007732	9.85	113.47	50.07	0.94
KR	2303	Q10	Alternative D	766	1236.09	1239.61	0.007732	9.85	113.47	50.07	0.94
KR	2303	Q10	Dam Removal I	766	1236.09	1237.87	0.098091	21.85	43.83	30.76	2.98
KR	2303	Q10	Dam Removal II	766	1236.49	1240.01	0.007718	9.85	113.55	50.07	0.94
KR	2303	Q25	Existing Culvert	1070	1236.09	1240.22	0.007781	11.03	144.63	52.29	0.97
KR	2303	Q25	Alternative A	1070	1236.09	1240.22	0.007781	11.03	144.63	52.29	0.97
KR	2303	Q25	Alternative B	1070	1236.09	1240.22	0.007781	11.03	144.63	52.29	0.97
KR	2303	Q25	Alternative C	1070	1236.09	1240.22	0.007781	11.03	144.63	52.29	0.97
KR	2303	Q25	Alternative D	1070	1236.09	1240.22	0.007781	11.03	144.63	52.29	0.97
KR	2303	Q25	Dam Removal I	1070	1236.09	1238.38	0.076896	23.1	60.59	35.53	2.76
KR	2303	Q25	Dam Removal II	1070	1236.49	1240.61	0.007788	11.03	144.58	52.29	0.97
KR	2303	Q50	Existing Culvert	1330	1236.09	1240.67	0.007846	11.89	168.55	53.65	0.99
KR	2303	Q50	Alternative A	1330	1236.09	1240.67	0.007846	11.89	168.55	53.65	0.99
KR	2303	Q50	Alternative B	1330	1236.09	1240.67	0.007846	11.89	168.55	53.65	0.99
KR	2303	Q50	Alternative C	1330	1236.09	1240.67	0.007846	11.89	168.55	53.65	0.99
KR	2303	Q50	Alternative D	1330	1236.09	1240.67	0.007846	11.89	168.55	53.65	0.99
KR	2303	Q50	Dam Removal I	1330	1236.09	1238.76	0.067191	24.01	74.64	38.98	2.65

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KR	2303	Q50	Dam Removal II	1330	1236.49	1241.07	0.007844	11.89	168.57	53.65	0.99
KR	2303	Q100	Existing Culvert	1620	1236.09	1241.15	0.007727	12.64	194.97	55.04	1
KR	2303	Q100	Alternative A	1620	1236.09	1241.15	0.007727	12.64	194.97	55.04	1
KR	2303	Q100	Alternative B	1620	1236.09	1241.15	0.007727	12.64	194.97	55.04	1
KR	2303	Q100	Alternative C	1620	1236.09	1241.15	0.007727	12.64	194.97	55.04	1
KR	2303	Q100	Alternative D	1620	1236.09	1241.15	0.007727	12.64	194.97	55.04	1
KR	2303	Q100	Dam Removal I	1620	1236.09	1239.16	0.059341	24.87	92.03	45.72	2.55
KR	2303	Q100	Dam Removal II	1620	1236.49	1241.55	0.007729	12.65	194.95	55.04	1
KR	2303	Q200	Existing Culvert	1930	1236.09	1242.12	0.005444	11.95	249.1	57.21	0.87
KR	2303	Q200	Alternative A	1930	1236.09	1242.12	0.005444	11.95	249.1	57.21	0.87
KR	2303	Q200	Alternative B	1930	1236.09	1242.12	0.005444	11.95	249.1	57.21	0.87
KR	2303	Q200	Alternative C	1930	1236.09	1242.12	0.005444	11.95	249.1	57.21	0.87
KR	2303	Q200	Alternative D	1930	1236.09	1242.12	0.005444	11.95	249.1	57.21	0.87
KR	2303	Q200	Dam Removal I	1930	1236.09	1239.51	0.054857	25.77	108.88	49.73	2.5
KR	2303	Q200	Dam Removal II	1930	1236.49	1242	0.007803	13.46	219.79	56.18	1.02
KR	2303	Q500	Existing Culvert	2400	1236.09	1243.14	0.004521	12.11	308.82	59.22	0.81
KR	2303	Q500	Alternative A	2400	1236.09	1243.14	0.004521	12.11	308.82	59.22	0.81
KR	2303	Q500	Alternative B	2400	1236.09	1243.14	0.004521	12.11	308.82	59.22	0.81
KR	2303	Q500	Alternative C	2400	1236.09	1243.14	0.004521	12.11	308.82	59.22	0.81
KR	2303	Q500	Alternative D	2400	1236.09	1243.14	0.004521	12.11	308.82	59.22	0.81
KR	2303	Q500	Dam Removal I	2400	1236.09	1239.96	0.051122	27.05	131.23	51.35	2.46
KR	2303	Q500	Dam Removal II	2400	1236.49	1242.64	0.007778	14.48	256.01	57.45	1.04
KR	2275	Q2	Existing Culvert	330	1236	1237.96	0.011375	7.9	56.24	39	1.03
KR	2275	Q2	Alternative A	330	1236	1237.96	0.011375	7.9	56.24	39	1.03
KR	2275	Q2	Alternative B	330	1236	1237.96	0.011375	7.9	56.24	39	1.03
KR	2275	Q2	Alternative C	330	1236	1237.96	0.011375	7.9	56.24	39	1.03
KR	2275	Q2	Alternative D	330	1236	1237.96	0.011375	7.9	56.24	39	1.03
KR	2275	Q2	Dam Removal I	330	1236	1237.47	0.03543	11.33	37.98	35.28	1.72

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KR	2275	Q2	Dam Removal II	330	1236	1237.61	0.02446	10.08	43.16	36.55	1.46
KR	2275	Q5	Existing Culvert	566	1236	1238.39	0.015263	10.54	73.67	41.08	1.23
KR	2275	Q5	Alternative A	566	1236	1238.39	0.015263	10.54	73.67	41.08	1.23
KR	2275	Q5	Alternative B	566	1236	1238.39	0.015263	10.54	73.67	41.08	1.23
KR	2275	Q5	Alternative C	566	1236	1238.39	0.015263	10.54	73.67	41.08	1.23
KR	2275	Q5	Alternative D	566	1236	1238.39	0.015263	10.54	73.67	41.08	1.23
KR	2275	Q5	Dam Removal I	566	1236	1237.85	0.041813	14.54	52.08	38.35	1.95
KR	2275	Q5	Dam Removal II	566	1236	1238.09	0.025675	12.45	61.63	39.76	1.56
KR	2275	Q10	Existing Culvert	766	1236	1238.73	0.016572	12.07	87.93	42.14	1.32
KR	2275	Q10	Alternative A	766	1236	1238.73	0.016572	12.07	87.93	42.14	1.32
KR	2275	Q10	Alternative B	766	1236	1238.73	0.016572	12.07	87.93	42.14	1.32
KR	2275	Q10	Alternative C	766	1236	1238.73	0.016572	12.07	87.93	42.14	1.32
KR	2275	Q10	Alternative D	766	1236	1238.73	0.016572	12.07	87.93	42.14	1.32
KR	2275	Q10	Dam Removal I	766	1236	1238.11	0.04541	16.66	62.38	39.86	2.08
KR	2275	Q10	Dam Removal II	766	1236	1238.45	0.025549	13.86	75.95	41.26	1.6
KR	2275	Q25	Existing Culvert	1070	1236	1239.39	0.0141	12.94	116.45	44.11	1.26
KR	2275	Q25	Alternative A	1070	1236	1239.39	0.0141	12.94	116.45	44.11	1.26
KR	2275	Q25	Alternative B	1070	1236	1239.39	0.0141	12.94	116.45	44.11	1.26
KR	2275	Q25	Alternative C	1070	1236	1239.39	0.0141	12.94	116.45	44.11	1.26
KR	2275	Q25	Alternative D	1070	1236	1239.39	0.0141	12.94	116.45	44.11	1.26
KR	2275	Q25	Dam Removal I	1070	1236	1238.46	0.048481	19.19	76.67	41.31	2.21
KR	2275	Q25	Dam Removal II	1070	1236	1239.02	0.021965	14.9	100.22	43.01	1.54
KR	2275	Q50	Existing Culvert	1330	1236	1239.93	0.012457	13.46	140.51	45.15	1.22
KR	2275	Q50	Alternative A	1330	1236	1239.93	0.012457	13.46	140.51	45.15	1.22
KR	2275	Q50	Alternative B	1330	1236	1239.93	0.012457	13.46	140.51	45.15	1.22
KR	2275	Q50	Alternative C	1330	1236	1239.93	0.012457	13.46	140.51	45.15	1.22
KR	2275	Q50	Alternative D	1330	1236	1239.93	0.012457	13.46	140.51	45.15	1.22
KR	2275	Q50	Dam Removal I	1330	1236	1238.75	0.048677	20.78	88.71	42.2	2.26
KR	2275	Q50	Dam Removal II	1330	1236	1239.49	0.019685	15.57	120.49	44.32	1.5

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KR	2275	Q100	Existing Culvert	1620	1236	1240.58	0.010494	13.71	169.98	46.4	1.15
KR	2275	Q100	Alternative A	1620	1236	1240.58	0.010494	13.71	169.98	46.4	1.15
KR	2275	Q100	Alternative B	1620	1236	1240.58	0.010494	13.71	169.98	46.4	1.15
KR	2275	Q100	Alternative C	1620	1236	1240.58	0.010494	13.71	169.98	46.4	1.15
KR	2275	Q100	Alternative D	1620	1236	1240.58	0.010494	13.71	169.98	46.4	1.15
KR	2275	Q100	Dam Removal I	1620	1236	1239.05	0.048291	22.26	101.65	43.11	2.29
KR	2275	Q100	Dam Removal II	1620	1236	1239.98	0.017677	16.17	142.63	45.24	1.45
KR	2275	Q200	Existing Culvert	1930	1236	1241.1	0.010066	14.46	194.54	47.97	1.14
KR	2275	Q200	Alternative A	1930	1236	1241.1	0.010066	14.46	194.54	47.97	1.14
KR	2275	Q200	Alternative B	1930	1236	1241.1	0.010066	14.46	194.54	47.97	1.14
KR	2275	Q200	Alternative C	1930	1236	1241.1	0.010066	14.46	194.54	47.97	1.14
KR	2275	Q200	Alternative D	1930	1236	1241.1	0.010066	14.46	194.54	47.97	1.14
KR	2275	Q200	Dam Removal I	1930	1236	1239.38	0.046498	23.44	115.91	44.07	2.29
KR	2275	Q200	Dam Removal II	1930	1236	1240.49	0.015929	16.69	166.17	46.23	1.41
KR	2275	Q500	Existing Culvert	2400	1236	1241.9	0.009244	15.3	234.18	51.3	1.12
KR	2275	Q500	Alternative A	2400	1236	1241.9	0.009244	15.3	234.18	51.3	1.12
KR	2275	Q500	Alternative B	2400	1236	1241.9	0.009244	15.3	234.18	51.3	1.12
KR	2275	Q500	Alternative C	2400	1236	1241.9	0.009244	15.3	234.18	51.3	1.12
KR	2275	Q500	Alternative D	2400	1236	1241.9	0.009244	15.3	234.18	51.3	1.12
KR	2275	Q500	Dam Removal I	2400	1236	1239.88	0.042838	24.72	137.96	45.04	2.25
KR	2275	Q500	Dam Removal II	2400	1236	1241.34	0.013211	17.1	206.22	49.01	1.32
KR	2158	Q2	Existing Culvert	330	1231.41	1232.82	0.042727	10.37	31.82	30.93	1.8
KR	2158	Q2	Alternative A	330	1231.41	1232.82	0.042727	10.37	31.82	30.93	1.8
KR	2158	Q2	Alternative B	330	1231.41	1232.82	0.042727	10.37	31.82	30.93	1.8
KR	2158	Q2	Alternative C	330	1231.41	1232.82	0.042727	10.37	31.82	30.93	1.8
KR	2158	Q2	Alternative D	330	1231.41	1232.82	0.042727	10.37	31.82	30.93	1.8
KR	2158	Q2	Dam Removal I	330	1231.41	1232.82	0.042727	10.37	31.82	30.93	1.8
KR	2158	Q2	Dam Removal II	330	1231.41	1232.82	0.042727	10.37	31.82	30.93	1.8

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KR	2158	Q5	Existing Culvert	566	1231.41	1233.22	0.044705	12.6	44.93	33.65	1.92
KR	2158	Q5	Alternative A	566	1231.41	1233.22	0.044705	12.6	44.93	33.65	1.92
KR	2158	Q5	Alternative B	566	1231.41	1233.22	0.044705	12.6	44.93	33.65	1.92
KR	2158	Q5	Alternative C	566	1231.41	1233.22	0.044705	12.6	44.93	33.65	1.92
KR	2158	Q5	Alternative D	566	1231.41	1233.22	0.044705	12.6	44.93	33.65	1.92
KR	2158	Q5	Dam Removal I	566	1231.41	1233.22	0.0449	12.62	44.86	33.64	1.93
KR	2158	Q5	Dam Removal II	566	1231.41	1233.22	0.044766	12.6	44.91	33.65	1.92
KR	2158	Q10	Existing Culvert	766	1231.41	1233.49	0.046686	14.16	54.11	35.04	2.01
KR	2158	Q10	Alternative A	766	1231.41	1233.49	0.046686	14.16	54.11	35.04	2.01
KR	2158	Q10	Alternative B	766	1231.41	1233.49	0.046686	14.16	54.11	35.04	2.01
KR	2158	Q10	Alternative C	766	1231.41	1233.49	0.046686	14.16	54.11	35.04	2.01
KR	2158	Q10	Alternative D	766	1231.41	1233.49	0.046686	14.16	54.11	35.04	2.01
KR	2158	Q10	Dam Removal I	766	1231.41	1233.49	0.046964	14.19	54	35.02	2.01
KR	2158	Q10	Dam Removal II	766	1231.41	1233.49	0.046864	14.18	54.04	35.03	2.01
KR	2158	Q25	Existing Culvert	1070	1231.41	1233.86	0.047233	15.89	67.33	36.96	2.07
KR	2158	Q25	Alternative A	1070	1231.41	1233.86	0.047233	15.89	67.33	36.96	2.07
KR	2158	Q25	Alternative B	1070	1231.41	1233.86	0.047233	15.89	67.33	36.96	2.07
KR	2158	Q25	Alternative C	1070	1231.41	1233.86	0.047233	15.89	67.33	36.96	2.07
KR	2158	Q25	Alternative D	1070	1231.41	1233.86	0.047233	15.89	67.33	36.96	2.07
KR	2158	Q25	Dam Removal I	1070	1231.41	1233.83	0.049798	16.17	66.18	36.79	2.12
KR	2158	Q25	Dam Removal II	1070	1231.41	1233.85	0.04795	15.97	67	36.91	2.09
KR	2158	Q50	Existing Culvert	1330	1231.41	1234.15	0.044438	17.01	78.69	40.91	2.06
KR	2158	Q50	Alternative A	1330	1231.41	1234.15	0.044438	17.01	78.69	40.91	2.06
KR	2158	Q50	Alternative B	1330	1231.41	1234.15	0.044438	17.01	78.69	40.91	2.06
KR	2158	Q50	Alternative C	1330	1231.41	1234.15	0.044438	17.01	78.69	40.91	2.06
KR	2158	Q50	Alternative D	1330	1231.41	1234.15	0.044438	17.01	78.69	40.91	2.06
KR	2158	Q50	Dam Removal I	1330	1231.41	1234.08	0.049788	17.6	75.84	39.85	2.17
KR	2158	Q50	Dam Removal II	1330	1231.41	1234.14	0.045204	17.1	78.25	40.79	2.08
KR	2158	Q100	Existing Culvert	1620	1231.41	1234.46	0.041623	18.03	91.89	44.65	2.04

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KR	2158	Q100	Alternative A	1620	1231.41	1234.46	0.041623	18.03	91.89	44.65	2.04
KR	2158	Q100	Alternative B	1620	1231.41	1234.46	0.041623	18.03	91.89	44.65	2.04
KR	2158	Q100	Alternative C	1620	1231.41	1234.46	0.041623	18.03	91.89	44.65	2.04
KR	2158	Q100	Alternative D	1620	1231.41	1234.46	0.041623	18.03	91.89	44.65	2.04
KR	2158	Q100	Dam Removal I	1620	1231.41	1234.35	0.048794	18.92	87.01	43.43	2.19
KR	2158	Q100	Dam Removal II	1620	1231.41	1234.45	0.042514	18.14	91.22	44.55	2.06
KR	2158	Q200	Existing Culvert	1930	1231.41	1234.76	0.039492	18.99	105.57	45.97	2.03
KR	2158	Q200	Alternative A	1930	1231.41	1234.76	0.039492	18.99	105.57	45.97	2.03
KR	2158	Q200	Alternative B	1930	1231.41	1234.76	0.039492	18.99	105.57	45.97	2.03
KR	2158	Q200	Alternative C	1930	1231.41	1234.76	0.039492	18.99	105.57	45.97	2.03
KR	2158	Q200	Alternative D	1930	1231.41	1234.76	0.039492	18.99	105.57	45.97	2.03
KR	2158	Q200	Dam Removal I	1930	1231.41	1234.62	0.047615	20.11	98.98	45.34	2.21
KR	2158	Q200	Dam Removal II	1930	1231.41	1234.75	0.040101	19.08	105.02	45.92	2.04
KR	2158	Q500	Existing Culvert	2400	1231.41	1235.19	0.036918	20.23	125.58	47.82	2.01
KR	2158	Q500	Alternative A	2400	1231.41	1235.19	0.036918	20.23	125.58	47.82	2.01
KR	2158	Q500	Alternative B	2400	1231.41	1235.19	0.036918	20.23	125.58	47.82	2.01
KR	2158	Q500	Alternative C	2400	1231.41	1235.19	0.036918	20.23	125.58	47.82	2.01
KR	2158	Q500	Alternative D	2400	1231.41	1235.19	0.036918	20.23	125.58	47.82	2.01
KR	2158	Q500	Dam Removal I	2400	1231.41	1235	0.045634	21.59	116.72	47.01	2.21
KR	2158	Q500	Dam Removal II	2400	1231.41	1235.18	0.037338	20.3	125.09	47.77	2.02
KR	1916	Q2	Existing Culvert	330	1226.35	1228.74	0.018147	7.82	42.2	32.73	1.21
KR	1916	Q2	Alternative A	330	1226.35	1228.74	0.018147	7.82	42.2	32.73	1.21
KR	1916	Q2	Alternative B	330	1226.35	1228.74	0.018147	7.82	42.2	32.73	1.21
KR	1916	Q2	Alternative C	330	1226.35	1228.74	0.018147	7.82	42.2	32.73	1.21
KR	1916	Q2	Alternative D	330	1226.35	1228.74	0.018147	7.82	42.2	32.73	1.21
KR	1916	Q2	Dam Removal I	330	1226.35	1228.74	0.018147	7.82	42.2	32.73	1.21
KR	1916	Q2	Dam Removal II	330	1226.35	1228.74	0.018147	7.82	42.2	32.73	1.21
KR	1916	Q5	Existing Culvert	566	1226.35	1229.38	0.016844	8.77	64.53	39.75	1.21

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KR	1916	Q5	Alternative A	566	1226.35	1229.38	0.016844	8.77	64.53	39.75	1.21
KR	1916	Q5	Alternative B	566	1226.35	1229.38	0.016844	8.77	64.53	39.75	1.21
KR	1916	Q5	Alternative C	566	1226.35	1229.38	0.016844	8.77	64.53	39.75	1.21
KR	1916	Q5	Alternative D	566	1226.35	1229.38	0.016844	8.77	64.53	39.75	1.21
KR	1916	Q5	Dam Removal I	566	1226.35	1229.38	0.016844	8.77	64.53	39.75	1.21
KR	1916	Q5	Dam Removal II	566	1226.35	1229.38	0.016844	8.77	64.53	39.75	1.21
KR	1916	Q10	Existing Culvert	766	1226.35	1229.74	0.018755	9.41	82.92	62.78	1.29
KR	1916	Q10	Alternative A	766	1226.35	1229.74	0.018755	9.41	82.92	62.78	1.29
KR	1916	Q10	Alternative B	766	1226.35	1229.74	0.018755	9.41	82.92	62.78	1.29
KR	1916	Q10	Alternative C	766	1226.35	1229.74	0.018755	9.41	82.92	62.78	1.29
KR	1916	Q10	Alternative D	766	1226.35	1229.74	0.018755	9.41	82.92	62.78	1.29
KR	1916	Q10	Dam Removal I	766	1226.35	1229.74	0.018755	9.41	82.92	62.78	1.29
KR	1916	Q10	Dam Removal II	766	1226.35	1229.74	0.018755	9.41	82.92	62.78	1.29
KR	1916	Q25	Existing Culvert	1070	1226.35	1230.06	0.019656	10.86	104.19	67.04	1.36
KR	1916	Q25	Alternative A	1070	1226.35	1230.06	0.019656	10.86	104.19	67.04	1.36
KR	1916	Q25	Alternative B	1070	1226.35	1230.06	0.019656	10.86	104.19	67.04	1.36
KR	1916	Q25	Alternative C	1070	1226.35	1230.06	0.019656	10.86	104.19	67.04	1.36
KR	1916	Q25	Alternative D	1070	1226.35	1230.06	0.019656	10.86	104.19	67.04	1.36
KR	1916	Q25	Dam Removal I	1070	1226.35	1230.06	0.019656	10.86	104.19	67.04	1.36
KR	1916	Q25	Dam Removal II	1070	1226.35	1230.06	0.019656	10.86	104.19	67.04	1.36
KR	1916	Q50	Existing Culvert	1330	1226.35	1230.3	0.020388	11.92	120.37	69.46	1.41
KR	1916	Q50	Alternative A	1330	1226.35	1230.3	0.020388	11.92	120.37	69.46	1.41
KR	1916	Q50	Alternative B	1330	1226.35	1230.3	0.020388	11.92	120.37	69.46	1.41
KR	1916	Q50	Alternative C	1330	1226.35	1230.3	0.020388	11.92	120.37	69.46	1.41
KR	1916	Q50	Alternative D	1330	1226.35	1230.3	0.020388	11.92	120.37	69.46	1.41
KR	1916	Q50	Dam Removal I	1330	1226.35	1230.3	0.020388	11.92	120.37	69.46	1.41
KR	1916	Q50	Dam Removal II	1330	1226.35	1230.3	0.020388	11.92	120.37	69.46	1.41
KR	1916	Q100	Existing Culvert	1620	1226.35	1230.55	0.0206	12.89	141.11	93.77	1.44
KR	1916	Q100	Alternative A	1620	1226.35	1230.55	0.0206	12.89	141.11	93.77	1.44

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KR	1916	Q100	Alternative B	1620	1226.35	1230.55	0.0206	12.89	141.11	93.77	1.44
KR	1916	Q100	Alternative C	1620	1226.35	1230.55	0.0206	12.89	141.11	93.77	1.44
KR	1916	Q100	Alternative D	1620	1226.35	1230.55	0.0206	12.89	141.11	93.77	1.44
KR	1916	Q100	Dam Removal I	1620	1226.35	1230.55	0.020596	12.89	141.12	93.77	1.44
KR	1916	Q100	Dam Removal II	1620	1226.35	1230.55	0.0206	12.89	141.11	93.77	1.44
KR	1916	Q200	Existing Culvert	1930	1226.35	1230.76	0.021761	13.98	161.66	101.69	1.5
KR	1916	Q200	Alternative A	1930	1226.35	1230.76	0.021761	13.98	161.66	101.69	1.5
KR	1916	Q200	Alternative B	1930	1226.35	1230.76	0.021761	13.98	161.66	101.69	1.5
KR	1916	Q200	Alternative C	1930	1226.35	1230.76	0.021761	13.98	161.66	101.69	1.5
KR	1916	Q200	Alternative D	1930	1226.35	1230.76	0.021761	13.98	161.66	101.69	1.5
KR	1916	Q200	Dam Removal I	1930	1226.35	1230.77	0.021591	13.95	162.22	101.79	1.5
KR	1916	Q200	Dam Removal II	1930	1226.35	1230.76	0.021761	13.98	161.66	101.69	1.5
KR	1916	Q500	Existing Culvert	2400	1226.35	1231.01	0.024154	15.6	186.91	108.14	1.61
KR	1916	Q500	Alternative A	2400	1226.35	1231.01	0.024154	15.6	186.91	108.14	1.61
KR	1916	Q500	Alternative B	2400	1226.35	1231.01	0.024154	15.6	186.91	108.14	1.61
KR	1916	Q500	Alternative C	2400	1226.35	1231.01	0.024154	15.6	186.91	108.14	1.61
KR	1916	Q500	Alternative D	2400	1226.35	1231.01	0.024154	15.6	186.91	108.14	1.61
KR	1916	Q500	Dam Removal I	2400	1226.35	1231.01	0.024182	15.61	186.82	108.13	1.61
KR	1916	Q500	Dam Removal II	2400	1226.35	1231.01	0.024158	15.6	186.9	108.14	1.61
KR	1673	Q2	Existing Culvert	330	1220.79	1222.49	0.025888	8.44	39.08	35.44	1.42
KR	1673	Q2	Alternative A	330	1220.79	1222.49	0.025888	8.44	39.08	35.44	1.42
KR	1673	Q2	Alternative B	330	1220.79	1222.49	0.025888	8.44	39.08	35.44	1.42
KR	1673	Q2	Alternative C	330	1220.79	1222.49	0.025888	8.44	39.08	35.44	1.42
KR	1673	Q2	Alternative D	330	1220.79	1222.49	0.025888	8.44	39.08	35.44	1.42
KR	1673	Q2	Dam Removal I	330	1220.79	1222.49	0.025888	8.44	39.08	35.44	1.42
KR	1673	Q2	Dam Removal II	330	1220.79	1222.49	0.025888	8.44	39.08	35.44	1.42
KR	1673	Q5	Existing Culvert	566	1220.79	1222.97	0.025005	9.91	57.09	39.59	1.46
KR	1673	Q5	Alternative A	566	1220.79	1222.97	0.025005	9.91	57.09	39.59	1.46

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KR	1673	Q5	Alternative B	566	1220.79	1222.97	0.025005	9.91	57.09	39.59	1.46
KR	1673	Q5	Alternative C	566	1220.79	1222.97	0.025005	9.91	57.09	39.59	1.46
KR	1673	Q5	Alternative D	566	1220.79	1222.97	0.025005	9.91	57.09	39.59	1.46
KR	1673	Q5	Dam Removal I	566	1220.79	1222.97	0.025005	9.91	57.09	39.59	1.46
KR	1673	Q5	Dam Removal II	566	1220.79	1222.97	0.025005	9.91	57.09	39.59	1.46
KR	1673	Q10	Existing Culvert	766	1220.79	1223.29	0.024481	10.96	70.01	42.66	1.48
KR	1673	Q10	Alternative A	766	1220.79	1223.29	0.024481	10.96	70.01	42.66	1.48
KR	1673	Q10	Alternative B	766	1220.79	1223.29	0.024481	10.96	70.01	42.66	1.48
KR	1673	Q10	Alternative C	766	1220.79	1223.29	0.024481	10.96	70.01	42.66	1.48
KR	1673	Q10	Alternative D	766	1220.79	1223.29	0.024481	10.96	70.01	42.66	1.48
KR	1673	Q10	Dam Removal I	766	1220.79	1223.29	0.024481	10.96	70.01	42.66	1.48
KR	1673	Q10	Dam Removal II	766	1220.79	1223.29	0.024481	10.96	70.01	42.66	1.48
KR	1673	Q25	Existing Culvert	1070	1220.79	1223.67	0.024041	12.45	86.88	44.31	1.52
KR	1673	Q25	Alternative A	1070	1220.79	1223.67	0.024041	12.45	86.88	44.31	1.52
KR	1673	Q25	Alternative B	1070	1220.79	1223.67	0.024041	12.45	86.88	44.31	1.52
KR	1673	Q25	Alternative C	1070	1220.79	1223.67	0.024041	12.45	86.88	44.31	1.52
KR	1673	Q25	Alternative D	1070	1220.79	1223.67	0.024041	12.45	86.88	44.31	1.52
KR	1673	Q25	Dam Removal I	1070	1220.79	1223.67	0.024041	12.45	86.88	44.31	1.52
KR	1673	Q25	Dam Removal II	1070	1220.79	1223.67	0.024041	12.45	86.88	44.31	1.52
KR	1673	Q50	Existing Culvert	1330	1220.79	1223.97	0.023698	13.51	100.24	45.3	1.54
KR	1673	Q50	Alternative A	1330	1220.79	1223.97	0.023698	13.51	100.24	45.3	1.54
KR	1673	Q50	Alternative B	1330	1220.79	1223.97	0.023698	13.51	100.24	45.3	1.54
KR	1673	Q50	Alternative C	1330	1220.79	1223.97	0.023698	13.51	100.24	45.3	1.54
KR	1673	Q50	Alternative D	1330	1220.79	1223.97	0.023698	13.51	100.24	45.3	1.54
KR	1673	Q50	Dam Removal I	1330	1220.79	1223.97	0.023698	13.51	100.24	45.3	1.54
KR	1673	Q50	Dam Removal II	1330	1220.79	1223.97	0.023698	13.51	100.24	45.3	1.54
KR	1673	Q100	Existing Culvert	1620	1220.79	1224.28	0.02324	14.52	115.16	51.1	1.56
KR	1673	Q100	Alternative A	1620	1220.79	1224.28	0.02324	14.52	115.16	51.1	1.56
KR	1673	Q100	Alternative B	1620	1220.79	1224.28	0.02324	14.52	115.16	51.1	1.56

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KR	1673	Q100	Alternative C	1620	1220.79	1224.28	0.02324	14.52	115.16	51.1	1.56
KR	1673	Q100	Alternative D	1620	1220.79	1224.28	0.02324	14.52	115.16	51.1	1.56
KR	1673	Q100	Dam Removal I	1620	1220.79	1224.28	0.02324	14.52	115.16	51.1	1.56
KR	1673	Q100	Dam Removal II	1620	1220.79	1224.28	0.02324	14.52	115.16	51.1	1.56
KR	1673	Q200	Existing Culvert	1930	1220.79	1224.59	0.022678	15.43	132.24	58.11	1.57
KR	1673	Q200	Alternative A	1930	1220.79	1224.59	0.022678	15.43	132.24	58.11	1.57
KR	1673	Q200	Alternative B	1930	1220.79	1224.59	0.022678	15.43	132.24	58.11	1.57
KR	1673	Q200	Alternative C	1930	1220.79	1224.59	0.022678	15.43	132.24	58.11	1.57
KR	1673	Q200	Alternative D	1930	1220.79	1224.59	0.022678	15.43	132.24	58.11	1.57
KR	1673	Q200	Dam Removal I	1930	1220.79	1224.59	0.022656	15.42	132.29	58.13	1.57
KR	1673	Q200	Dam Removal II	1930	1220.79	1224.59	0.022678	15.43	132.24	58.11	1.57
KR	1673	Q500	Existing Culvert	2400	1220.79	1225.01	0.022284	16.66	158.29	67.01	1.59
KR	1673	Q500	Alternative A	2400	1220.79	1225.01	0.022284	16.66	158.29	67.01	1.59
KR	1673	Q500	Alternative B	2400	1220.79	1225.01	0.022284	16.66	158.29	67.01	1.59
KR	1673	Q500	Alternative C	2400	1220.79	1225.01	0.022284	16.66	158.29	67.01	1.59
KR	1673	Q500	Alternative D	2400	1220.79	1225.01	0.022284	16.66	158.29	67.01	1.59
KR	1673	Q500	Dam Removal I	2400	1220.79	1225.01	0.022333	16.67	158.15	67	1.59
KR	1673	Q500	Dam Removal II	2400	1220.79	1225.01	0.022284	16.66	158.29	67.01	1.59
KR	1496	Q2	Existing Culvert	330	1209.62	1211.08	0.059102	12.86	25.66	22.76	2.14
KR	1496	Q2	Alternative A	330	1209.62	1211.08	0.059102	12.86	25.66	22.76	2.14
KR	1496	Q2	Alternative B	330	1209.62	1211.08	0.059102	12.86	25.66	22.76	2.14
KR	1496	Q2	Alternative C	330	1209.62	1211.08	0.059102	12.86	25.66	22.76	2.14
KR	1496	Q2	Alternative D	330	1209.62	1211.08	0.059102	12.86	25.66	22.76	2.14
KR	1496	Q2	Dam Removal I	330	1209.62	1211.08	0.059102	12.86	25.66	22.76	2.14
KR	1496	Q2	Dam Removal II	330	1209.62	1211.08	0.059102	12.86	25.66	22.76	2.14
KR	1496	Q5	Existing Culvert	566	1209.62	1211.58	0.055419	15.08	37.54	24.78	2.16
KR	1496	Q5	Alternative A	566	1209.62	1211.58	0.055419	15.08	37.54	24.78	2.16
KR	1496	Q5	Alternative B	566	1209.62	1211.58	0.055419	15.08	37.54	24.78	2.16

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KR	1496	Q5	Alternative C	566	1209.62	1211.58	0.055419	15.08	37.54	24.78	2.16
KR	1496	Q5	Alternative D	566	1209.62	1211.58	0.055419	15.08	37.54	24.78	2.16
KR	1496	Q5	Dam Removal I	566	1209.62	1211.58	0.055419	15.08	37.54	24.78	2.16
KR	1496	Q5	Dam Removal II	566	1209.62	1211.58	0.055419	15.08	37.54	24.78	2.16
KR	1496	Q10	Existing Culvert	766	1209.62	1211.95	0.055074	16.19	47.31	27.84	2.19
KR	1496	Q10	Alternative A	766	1209.62	1211.95	0.055074	16.19	47.31	27.84	2.19
KR	1496	Q10	Alternative B	766	1209.62	1211.95	0.055074	16.19	47.31	27.84	2.19
KR	1496	Q10	Alternative C	766	1209.62	1211.95	0.055074	16.19	47.31	27.84	2.19
KR	1496	Q10	Alternative D	766	1209.62	1211.95	0.055074	16.19	47.31	27.84	2.19
KR	1496	Q10	Dam Removal I	766	1209.62	1211.95	0.055074	16.19	47.31	27.84	2.19
KR	1496	Q10	Dam Removal II	766	1209.62	1211.95	0.055074	16.19	47.31	27.84	2.19
KR	1496	Q25	Existing Culvert	1070	1209.62	1212.38	0.055167	17.75	60.88	33.81	2.24
KR	1496	Q25	Alternative A	1070	1209.62	1212.38	0.055167	17.75	60.88	33.81	2.24
KR	1496	Q25	Alternative B	1070	1209.62	1212.38	0.055167	17.75	60.88	33.81	2.24
KR	1496	Q25	Alternative C	1070	1209.62	1212.38	0.055167	17.75	60.88	33.81	2.24
KR	1496	Q25	Alternative D	1070	1209.62	1212.38	0.055167	17.75	60.88	33.81	2.24
KR	1496	Q25	Dam Removal I	1070	1209.62	1212.38	0.055167	17.75	60.88	33.81	2.24
KR	1496	Q25	Dam Removal II	1070	1209.62	1212.38	0.055167	17.75	60.88	33.81	2.24
KR	1496	Q50	Existing Culvert	1330	1209.62	1212.67	0.053972	19.11	70.95	35.06	2.26
KR	1496	Q50	Alternative A	1330	1209.62	1212.67	0.053972	19.11	70.95	35.06	2.26
KR	1496	Q50	Alternative B	1330	1209.62	1212.67	0.053972	19.11	70.95	35.06	2.26
KR	1496	Q50	Alternative C	1330	1209.62	1212.67	0.053972	19.11	70.95	35.06	2.26
KR	1496	Q50	Alternative D	1330	1209.62	1212.67	0.053972	19.11	70.95	35.06	2.26
KR	1496	Q50	Dam Removal I	1330	1209.62	1212.67	0.053972	19.11	70.95	35.06	2.26
KR	1496	Q50	Dam Removal II	1330	1209.62	1212.67	0.053972	19.11	70.95	35.06	2.26
KR	1496	Q100	Existing Culvert	1620	1209.62	1212.97	0.05257	20.38	81.85	36.46	2.27
KR	1496	Q100	Alternative A	1620	1209.62	1212.97	0.05257	20.38	81.85	36.46	2.27
KR	1496	Q100	Alternative B	1620	1209.62	1212.97	0.05257	20.38	81.85	36.46	2.27
KR	1496	Q100	Alternative C	1620	1209.62	1212.97	0.05257	20.38	81.85	36.46	2.27

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KR	1496	Q100	Alternative D	1620	1209.62	1212.97	0.05257	20.38	81.85	36.46	2.27
KR	1496	Q100	Dam Removal I	1620	1209.62	1212.97	0.05257	20.38	81.85	36.46	2.27
KR	1496	Q100	Dam Removal II	1620	1209.62	1212.97	0.05257	20.38	81.85	36.46	2.27
KR	1496	Q200	Existing Culvert	1930	1209.62	1213.28	0.051287	21.54	93.04	37.38	2.27
KR	1496	Q200	Alternative A	1930	1209.62	1213.28	0.051287	21.54	93.04	37.38	2.27
KR	1496	Q200	Alternative B	1930	1209.62	1213.28	0.051287	21.54	93.04	37.38	2.27
KR	1496	Q200	Alternative C	1930	1209.62	1213.28	0.051287	21.54	93.04	37.38	2.27
KR	1496	Q200	Alternative D	1930	1209.62	1213.28	0.051287	21.54	93.04	37.38	2.27
KR	1496	Q200	Dam Removal I	1930	1209.62	1213.28	0.051287	21.54	93.04	37.38	2.27
KR	1496	Q200	Dam Removal II	1930	1209.62	1213.28	0.051287	21.54	93.04	37.38	2.27
KR	1496	Q500	Existing Culvert	2400	1209.62	1213.7	0.049501	23.02	109.38	38.68	2.28
KR	1496	Q500	Alternative A	2400	1209.62	1213.7	0.049501	23.02	109.38	38.68	2.28
KR	1496	Q500	Alternative B	2400	1209.62	1213.7	0.049501	23.02	109.38	38.68	2.28
KR	1496	Q500	Alternative C	2400	1209.62	1213.7	0.049501	23.02	109.38	38.68	2.28
KR	1496	Q500	Alternative D	2400	1209.62	1213.7	0.049501	23.02	109.38	38.68	2.28
KR	1496	Q500	Dam Removal I	2400	1209.62	1213.71	0.049427	23.01	109.44	38.69	2.27
KR	1496	Q500	Dam Removal II	2400	1209.62	1213.7	0.049501	23.02	109.38	38.68	2.28
KR	1275	Q2	Existing Culvert	330	1206.62	1208.68	0.013788	7	47.15	35.33	1.07
KR	1275	Q2	Alternative A	330	1206.62	1208.68	0.013788	7	47.15	35.33	1.07
KR	1275	Q2	Alternative B	330	1206.62	1208.68	0.013788	7	47.15	35.33	1.07
KR	1275	Q2	Alternative C	330	1206.62	1208.68	0.013788	7	47.15	35.33	1.07
KR	1275	Q2	Alternative D	330	1206.62	1208.68	0.013788	7	47.15	35.33	1.07
KR	1275	Q2	Dam Removal I	330	1206.62	1208.68	0.013788	7	47.15	35.33	1.07
KR	1275	Q2	Dam Removal II	330	1206.62	1208.68	0.013788	7	47.15	35.33	1.07
KR	1275	Q5	Existing Culvert	566	1206.62	1209.2	0.014943	8.52	66.47	39.34	1.15
KR	1275	Q5	Alternative A	566	1206.62	1209.2	0.014943	8.52	66.47	39.34	1.15
KR	1275	Q5	Alternative B	566	1206.62	1209.2	0.014943	8.52	66.47	39.34	1.15
KR	1275	Q5	Alternative C	566	1206.62	1209.2	0.014943	8.52	66.47	39.34	1.15

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KR	1275	Q5	Alternative D	566	1206.62	1209.2	0.014943	8.52	66.47	39.34	1.15
KR	1275	Q5	Dam Removal I	566	1206.62	1209.2	0.014943	8.52	66.47	39.34	1.15
KR	1275	Q5	Dam Removal II	566	1206.62	1209.2	0.014943	8.52	66.47	39.34	1.15
KR	1275	Q10	Existing Culvert	766	1206.62	1209.52	0.015792	9.66	79.36	40.92	1.22
KR	1275	Q10	Alternative A	766	1206.62	1209.52	0.015792	9.66	79.36	40.92	1.22
KR	1275	Q10	Alternative B	766	1206.62	1209.52	0.015792	9.66	79.36	40.92	1.22
KR	1275	Q10	Alternative C	766	1206.62	1209.52	0.015792	9.66	79.36	40.92	1.22
KR	1275	Q10	Alternative D	766	1206.62	1209.52	0.015792	9.66	79.36	40.92	1.22
KR	1275	Q10	Dam Removal I	766	1206.62	1209.52	0.015792	9.66	79.36	40.92	1.22
KR	1275	Q10	Dam Removal II	766	1206.62	1209.52	0.015792	9.66	79.36	40.92	1.22
KR	1275	Q25	Existing Culvert	1070	1206.62	1209.98	0.015721	10.86	98.88	43.11	1.25
KR	1275	Q25	Alternative A	1070	1206.62	1209.98	0.015721	10.86	98.88	43.11	1.25
KR	1275	Q25	Alternative B	1070	1206.62	1209.98	0.015721	10.86	98.88	43.11	1.25
KR	1275	Q25	Alternative C	1070	1206.62	1209.98	0.015721	10.86	98.88	43.11	1.25
KR	1275	Q25	Alternative D	1070	1206.62	1209.98	0.015721	10.86	98.88	43.11	1.25
KR	1275	Q25	Dam Removal I	1070	1206.62	1209.98	0.015721	10.86	98.88	43.11	1.25
KR	1275	Q25	Dam Removal II	1070	1206.62	1209.98	0.015721	10.86	98.88	43.11	1.25
KR	1275	Q50	Existing Culvert	1330	1206.62	1210.32	0.015993	11.79	113.97	47.27	1.28
KR	1275	Q50	Alternative A	1330	1206.62	1210.32	0.015993	11.79	113.97	47.27	1.28
KR	1275	Q50	Alternative B	1330	1206.62	1210.32	0.015993	11.79	113.97	47.27	1.28
KR	1275	Q50	Alternative C	1330	1206.62	1210.32	0.015993	11.79	113.97	47.27	1.28
KR	1275	Q50	Alternative D	1330	1206.62	1210.32	0.015993	11.79	113.97	47.27	1.28
KR	1275	Q50	Dam Removal I	1330	1206.62	1210.32	0.015993	11.79	113.97	47.27	1.28
KR	1275	Q50	Dam Removal II	1330	1206.62	1210.32	0.015993	11.79	113.97	47.27	1.28
KR	1275	Q100	Existing Culvert	1620	1206.62	1210.6	0.017218	12.91	129.98	66.1	1.35
KR	1275	Q100	Alternative A	1620	1206.62	1210.6	0.017218	12.91	129.98	66.1	1.35
KR	1275	Q100	Alternative B	1620	1206.62	1210.6	0.017218	12.91	129.98	66.1	1.35
KR	1275	Q100	Alternative C	1620	1206.62	1210.6	0.017218	12.91	129.98	66.1	1.35
KR	1275	Q100	Alternative D	1620	1206.62	1210.6	0.017218	12.91	129.98	66.1	1.35

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KR	1275	Q100	Dam Removal I	1620	1206.62	1210.6	0.017218	12.91	129.98	66.1	1.35
KR	1275	Q100	Dam Removal II	1620	1206.62	1210.6	0.017218	12.91	129.98	66.1	1.35
KR	1275	Q200	Existing Culvert	1930	1206.62	1210.84	0.018743	14.06	147.52	79.9	1.42
KR	1275	Q200	Alternative A	1930	1206.62	1210.84	0.018743	14.06	147.52	79.9	1.42
KR	1275	Q200	Alternative B	1930	1206.62	1210.84	0.018743	14.06	147.52	79.9	1.42
KR	1275	Q200	Alternative C	1930	1206.62	1210.84	0.018743	14.06	147.52	79.9	1.42
KR	1275	Q200	Alternative D	1930	1206.62	1210.84	0.018743	14.06	147.52	79.9	1.42
KR	1275	Q200	Dam Removal I	1930	1206.62	1210.84	0.018743	14.06	147.52	79.9	1.42
KR	1275	Q200	Dam Removal II	1930	1206.62	1210.84	0.018743	14.06	147.52	79.9	1.42
KR	1275	Q500	Existing Culvert	2400	1206.62	1211.12	0.02106	15.74	174.26	107.06	1.53
KR	1275	Q500	Alternative A	2400	1206.62	1211.12	0.02106	15.74	174.26	107.06	1.53
KR	1275	Q500	Alternative B	2400	1206.62	1211.12	0.02106	15.74	174.26	107.06	1.53
KR	1275	Q500	Alternative C	2400	1206.62	1211.12	0.02106	15.74	174.26	107.06	1.53
KR	1275	Q500	Alternative D	2400	1206.62	1211.12	0.02106	15.74	174.26	107.06	1.53
KR	1275	Q500	Dam Removal I	2400	1206.62	1211.12	0.021057	15.74	174.27	107.07	1.53
KR	1275	Q500	Dam Removal II	2400	1206.62	1211.12	0.02106	15.74	174.26	107.06	1.53
KR	1035	Q2	Existing Culvert	330	1202.12	1203.65	0.022305	7.76	42.53	39.11	1.31
KR	1035	Q2	Alternative A	330	1202.12	1203.65	0.022305	7.76	42.53	39.11	1.31
KR	1035	Q2	Alternative B	330	1202.12	1203.65	0.022305	7.76	42.53	39.11	1.31
KR	1035	Q2	Alternative C	330	1202.12	1203.65	0.022305	7.76	42.53	39.11	1.31
KR	1035	Q2	Alternative D	330	1202.12	1203.65	0.022305	7.76	42.53	39.11	1.31
KR	1035	Q2	Dam Removal I	330	1202.12	1203.65	0.022305	7.76	42.53	39.11	1.31
KR	1035	Q2	Dam Removal II	330	1202.12	1203.65	0.022305	7.76	42.53	39.11	1.31
KR	1035	Q5	Existing Culvert	566	1202.12	1204.08	0.022201	9.47	59.78	40.38	1.37
KR	1035	Q5	Alternative A	566	1202.12	1204.08	0.022201	9.47	59.78	40.38	1.37
KR	1035	Q5	Alternative B	566	1202.12	1204.08	0.022201	9.47	59.78	40.38	1.37
KR	1035	Q5	Alternative C	566	1202.12	1204.08	0.022201	9.47	59.78	40.38	1.37
KR	1035	Q5	Alternative D	566	1202.12	1204.08	0.022201	9.47	59.78	40.38	1.37

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KR	1035	Q5	Dam Removal I	566	1202.12	1204.08	0.022201	9.47	59.78	40.38	1.37
KR	1035	Q5	Dam Removal II	566	1202.12	1204.08	0.022201	9.47	59.78	40.38	1.37
KR	1035	Q10	Existing Culvert	766	1202.12	1204.4	0.022071	10.55	72.58	41.29	1.4
KR	1035	Q10	Alternative A	766	1202.12	1204.4	0.022071	10.55	72.58	41.29	1.4
KR	1035	Q10	Alternative B	766	1202.12	1204.4	0.022071	10.55	72.58	41.29	1.4
KR	1035	Q10	Alternative C	766	1202.12	1204.4	0.022071	10.55	72.58	41.29	1.4
KR	1035	Q10	Alternative D	766	1202.12	1204.4	0.022071	10.55	72.58	41.29	1.4
KR	1035	Q10	Dam Removal I	766	1202.12	1204.4	0.022071	10.55	72.58	41.29	1.4
KR	1035	Q10	Dam Removal II	766	1202.12	1204.4	0.022071	10.55	72.58	41.29	1.4
KR	1035	Q25	Existing Culvert	1070	1202.12	1204.8	0.022025	11.93	89.73	42.65	1.44
KR	1035	Q25	Alternative A	1070	1202.12	1204.8	0.022025	11.93	89.73	42.65	1.44
KR	1035	Q25	Alternative B	1070	1202.12	1204.8	0.022025	11.93	89.73	42.65	1.44
KR	1035	Q25	Alternative C	1070	1202.12	1204.8	0.022025	11.93	89.73	42.65	1.44
KR	1035	Q25	Alternative D	1070	1202.12	1204.8	0.022025	11.93	89.73	42.65	1.44
KR	1035	Q25	Dam Removal I	1070	1202.12	1204.8	0.022025	11.93	89.73	42.65	1.44
KR	1035	Q25	Dam Removal II	1070	1202.12	1204.8	0.022025	11.93	89.73	42.65	1.44
KR	1035	Q50	Existing Culvert	1330	1202.12	1205.12	0.021574	12.92	103.22	43.87	1.46
KR	1035	Q50	Alternative A	1330	1202.12	1205.12	0.021574	12.92	103.22	43.87	1.46
KR	1035	Q50	Alternative B	1330	1202.12	1205.12	0.021574	12.92	103.22	43.87	1.46
KR	1035	Q50	Alternative C	1330	1202.12	1205.12	0.021574	12.92	103.22	43.87	1.46
KR	1035	Q50	Alternative D	1330	1202.12	1205.12	0.021574	12.92	103.22	43.87	1.46
KR	1035	Q50	Dam Removal I	1330	1202.12	1205.12	0.021574	12.92	103.22	43.87	1.46
KR	1035	Q50	Dam Removal II	1330	1202.12	1205.12	0.021574	12.92	103.22	43.87	1.46
KR	1035	Q100	Existing Culvert	1620	1202.12	1205.43	0.021372	13.94	117.09	45.09	1.48
KR	1035	Q100	Alternative A	1620	1202.12	1205.43	0.021372	13.94	117.09	45.09	1.48
KR	1035	Q100	Alternative B	1620	1202.12	1205.43	0.021372	13.94	117.09	45.09	1.48
KR	1035	Q100	Alternative C	1620	1202.12	1205.43	0.021372	13.94	117.09	45.09	1.48
KR	1035	Q100	Alternative D	1620	1202.12	1205.43	0.021372	13.94	117.09	45.09	1.48
KR	1035	Q100	Dam Removal I	1620	1202.12	1205.43	0.021372	13.94	117.09	45.09	1.48

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KR	1035	Q100	Dam Removal II	1620	1202.12	1205.43	0.021372	13.94	117.09	45.09	1.48
KR	1035	Q200	Existing Culvert	1930	1202.12	1205.75	0.02094	14.85	131.71	46.35	1.5
KR	1035	Q200	Alternative A	1930	1202.12	1205.75	0.02094	14.85	131.71	46.35	1.5
KR	1035	Q200	Alternative B	1930	1202.12	1205.75	0.02094	14.85	131.71	46.35	1.5
KR	1035	Q200	Alternative C	1930	1202.12	1205.75	0.02094	14.85	131.71	46.35	1.5
KR	1035	Q200	Alternative D	1930	1202.12	1205.75	0.02094	14.85	131.71	46.35	1.5
KR	1035	Q200	Dam Removal I	1930	1202.12	1205.75	0.02094	14.85	131.71	46.35	1.5
KR	1035	Q200	Dam Removal II	1930	1202.12	1205.75	0.02094	14.85	131.71	46.35	1.5
KR	1035	Q500	Existing Culvert	2400	1202.12	1206.2	0.020406	16.06	152.91	48.2	1.51
KR	1035	Q500	Alternative A	2400	1202.12	1206.2	0.020406	16.06	152.91	48.2	1.51
KR	1035	Q500	Alternative B	2400	1202.12	1206.2	0.020406	16.06	152.91	48.2	1.51
KR	1035	Q500	Alternative C	2400	1202.12	1206.2	0.020406	16.06	152.91	48.2	1.51
KR	1035	Q500	Alternative D	2400	1202.12	1206.2	0.020406	16.06	152.91	48.2	1.51
KR	1035	Q500	Dam Removal I	2400	1202.12	1206.2	0.020406	16.06	152.91	48.2	1.51
KR	1035	Q500	Dam Removal II	2400	1202.12	1206.2	0.020406	16.06	152.91	48.2	1.51
KR	873	Q2	Existing Culvert	330	1199.62	1201.15	0.015808	7.2	45.83	36.22	1.13
KR	873	Q2	Alternative A	330	1199.62	1201.15	0.015808	7.2	45.83	36.22	1.13
KR	873	Q2	Alternative B	330	1199.62	1201.15	0.015808	7.2	45.83	36.22	1.13
KR	873	Q2	Alternative C	330	1199.62	1201.15	0.015808	7.2	45.83	36.22	1.13
KR	873	Q2	Alternative D	330	1199.62	1201.15	0.015808	7.2	45.83	36.22	1.13
KR	873	Q2	Dam Removal I	330	1199.62	1201.15	0.015808	7.2	45.83	36.22	1.13
KR	873	Q2	Dam Removal II	330	1199.62	1201.15	0.015808	7.2	45.83	36.22	1.13
KR	873	Q5	Existing Culvert	566	1199.62	1201.68	0.01535	8.59	65.89	38.91	1.16
KR	873	Q5	Alternative A	566	1199.62	1201.68	0.01535	8.59	65.89	38.91	1.16
KR	873	Q5	Alternative B	566	1199.62	1201.68	0.01535	8.59	65.89	38.91	1.16
KR	873	Q5	Alternative C	566	1199.62	1201.68	0.01535	8.59	65.89	38.91	1.16
KR	873	Q5	Alternative D	566	1199.62	1201.68	0.01535	8.59	65.89	38.91	1.16
KR	873	Q5	Dam Removal I	566	1199.62	1201.68	0.01535	8.59	65.89	38.91	1.16

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KR	873	Q5	Dam Removal II	566	1199.62	1201.68	0.01535	8.59	65.89	38.91	1.16
KR	873	Q10	Existing Culvert	766	1199.62	1202.03	0.015637	9.64	79.51	40.35	1.2
KR	873	Q10	Alternative A	766	1199.62	1202.03	0.015637	9.64	79.51	40.35	1.2
KR	873	Q10	Alternative B	766	1199.62	1202.03	0.015637	9.64	79.51	40.35	1.2
KR	873	Q10	Alternative C	766	1199.62	1202.03	0.015637	9.64	79.51	40.35	1.2
KR	873	Q10	Alternative D	766	1199.62	1202.03	0.015637	9.64	79.51	40.35	1.2
KR	873	Q10	Dam Removal I	766	1199.62	1202.03	0.015637	9.64	79.51	40.35	1.2
KR	873	Q10	Dam Removal II	766	1199.62	1202.03	0.015637	9.64	79.51	40.35	1.2
KR	873	Q25	Existing Culvert	1070	1199.62	1202.51	0.015186	10.82	99.3	42.07	1.22
KR	873	Q25	Alternative A	1070	1199.62	1202.51	0.015186	10.82	99.3	42.07	1.22
KR	873	Q25	Alternative B	1070	1199.62	1202.51	0.015186	10.82	99.3	42.07	1.22
KR	873	Q25	Alternative C	1070	1199.62	1202.51	0.015186	10.82	99.3	42.07	1.22
KR	873	Q25	Alternative D	1070	1199.62	1202.51	0.015186	10.82	99.3	42.07	1.22
KR	873	Q25	Dam Removal I	1070	1199.62	1202.51	0.015186	10.82	99.3	42.07	1.22
KR	873	Q25	Dam Removal II	1070	1199.62	1202.51	0.015186	10.82	99.3	42.07	1.22
KR	873	Q50	Existing Culvert	1330	1199.62	1202.84	0.015291	11.81	113.49	43.07	1.26
KR	873	Q50	Alternative A	1330	1199.62	1202.84	0.015291	11.81	113.49	43.07	1.26
KR	873	Q50	Alternative B	1330	1199.62	1202.84	0.015291	11.81	113.49	43.07	1.26
KR	873	Q50	Alternative C	1330	1199.62	1202.84	0.015291	11.81	113.49	43.07	1.26
KR	873	Q50	Alternative D	1330	1199.62	1202.84	0.015291	11.81	113.49	43.07	1.26
KR	873	Q50	Dam Removal I	1330	1199.62	1202.84	0.015291	11.81	113.49	43.07	1.26
KR	873	Q50	Dam Removal II	1330	1199.62	1202.84	0.015291	11.81	113.49	43.07	1.26
KR	873	Q100	Existing Culvert	1620	1199.62	1203.19	0.015119	12.72	128.89	44.25	1.27
KR	873	Q100	Alternative A	1620	1199.62	1203.19	0.015119	12.72	128.89	44.25	1.27
KR	873	Q100	Alternative B	1620	1199.62	1203.19	0.015119	12.72	128.89	44.25	1.27
KR	873	Q100	Alternative C	1620	1199.62	1203.19	0.015119	12.72	128.89	44.25	1.27
KR	873	Q100	Alternative D	1620	1199.62	1203.19	0.015119	12.72	128.89	44.25	1.27
KR	873	Q100	Dam Removal I	1620	1199.62	1203.19	0.015119	12.72	128.89	44.25	1.27
KR	873	Q100	Dam Removal II	1620	1199.62	1203.19	0.015119	12.72	128.89	44.25	1.27

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KR	873	Q200	Existing Culvert	1930	1199.62	1203.5	0.015543	13.74	147.74	74.74	1.31
KR	873	Q200	Alternative A	1930	1199.62	1203.5	0.015543	13.74	147.74	74.74	1.31
KR	873	Q200	Alternative B	1930	1199.62	1203.5	0.015543	13.74	147.74	74.74	1.31
KR	873	Q200	Alternative C	1930	1199.62	1203.5	0.015543	13.74	147.74	74.74	1.31
KR	873	Q200	Alternative D	1930	1199.62	1203.5	0.015543	13.74	147.74	74.74	1.31
KR	873	Q200	Dam Removal I	1930	1199.62	1203.5	0.015543	13.74	147.74	74.74	1.31
KR	873	Q200	Dam Removal II	1930	1199.62	1203.5	0.015543	13.74	147.74	74.74	1.31
KR	873	Q500	Existing Culvert	2400	1199.62	1203.86	0.016686	15.21	177.01	88.65	1.38
KR	873	Q500	Alternative A	2400	1199.62	1203.86	0.016686	15.21	177.01	88.65	1.38
KR	873	Q500	Alternative B	2400	1199.62	1203.86	0.016686	15.21	177.01	88.65	1.38
KR	873	Q500	Alternative C	2400	1199.62	1203.86	0.016686	15.21	177.01	88.65	1.38
KR	873	Q500	Alternative D	2400	1199.62	1203.86	0.016686	15.21	177.01	88.65	1.38
KR	873	Q500	Dam Removal I	2400	1199.62	1203.86	0.016686	15.21	177.01	88.65	1.38
KR	873	Q500	Dam Removal II	2400	1199.62	1203.86	0.016686	15.21	177.01	88.65	1.38
KR	655	Q2	Existing Culvert	330	1193.28	1194.96	0.027974	8.12	40.65	68.93	1.44
KR	655	Q2	Alternative A	330	1193.28	1194.96	0.027974	8.12	40.65	68.93	1.44
KR	655	Q2	Alternative B	330	1193.28	1194.96	0.027974	8.12	40.65	68.93	1.44
KR	655	Q2	Alternative C	330	1193.28	1194.96	0.027974	8.12	40.65	68.93	1.44
KR	655	Q2	Alternative D	330	1193.28	1194.96	0.027974	8.12	40.65	68.93	1.44
KR	655	Q2	Dam Removal I	330	1193.28	1194.96	0.027974	8.12	40.65	68.93	1.44
KR	655	Q2	Dam Removal II	330	1193.28	1194.96	0.027974	8.12	40.65	68.93	1.44
KR	655	Q5	Existing Culvert	566	1193.28	1195.35	0.028001	9.97	56.78	82.09	1.51
KR	655	Q5	Alternative A	566	1193.28	1195.35	0.028001	9.97	56.78	82.09	1.51
KR	655	Q5	Alternative B	566	1193.28	1195.35	0.028001	9.97	56.78	82.09	1.51
KR	655	Q5	Alternative C	566	1193.28	1195.35	0.028001	9.97	56.78	82.09	1.51
KR	655	Q5	Alternative D	566	1193.28	1195.35	0.028001	9.97	56.78	82.09	1.51
KR	655	Q5	Dam Removal I	566	1193.28	1195.35	0.028001	9.97	56.78	82.09	1.51
KR	655	Q5	Dam Removal II	566	1193.28	1195.35	0.028001	9.97	56.78	82.09	1.51

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KR	655	Q10	Existing Culvert	766	1193.28	1195.65	0.026665	11.02	69.51	90.66	1.51
KR	655	Q10	Alternative A	766	1193.28	1195.65	0.026665	11.02	69.51	90.66	1.51
KR	655	Q10	Alternative B	766	1193.28	1195.65	0.026665	11.02	69.51	90.66	1.51
KR	655	Q10	Alternative C	766	1193.28	1195.65	0.026665	11.02	69.51	90.66	1.51
KR	655	Q10	Alternative D	766	1193.28	1195.65	0.026665	11.02	69.51	90.66	1.51
KR	655	Q10	Dam Removal I	766	1193.28	1195.65	0.026665	11.02	69.51	90.66	1.51
KR	655	Q10	Dam Removal II	766	1193.28	1195.65	0.026665	11.02	69.51	90.66	1.51
KR	655	Q25	Existing Culvert	1070	1193.28	1196.09	0.024429	12.16	87.97	101.17	1.49
KR	655	Q25	Alternative A	1070	1193.28	1196.09	0.024429	12.16	87.97	101.17	1.49
KR	655	Q25	Alternative B	1070	1193.28	1196.09	0.024429	12.16	87.97	101.17	1.49
KR	655	Q25	Alternative C	1070	1193.28	1196.09	0.024429	12.16	87.97	101.17	1.49
KR	655	Q25	Alternative D	1070	1193.28	1196.09	0.024429	12.16	87.97	101.17	1.49
KR	655	Q25	Dam Removal I	1070	1193.28	1196.09	0.024429	12.16	87.97	101.17	1.49
KR	655	Q25	Dam Removal II	1070	1193.28	1196.09	0.024429	12.16	87.97	101.17	1.49
KR	655	Q50	Existing Culvert	1330	1193.28	1196.42	0.023618	13.05	101.9	107.29	1.49
KR	655	Q50	Alternative A	1330	1193.28	1196.42	0.023618	13.05	101.9	107.29	1.49
KR	655	Q50	Alternative B	1330	1193.28	1196.42	0.023618	13.05	101.9	107.29	1.49
KR	655	Q50	Alternative C	1330	1193.28	1196.42	0.023618	13.05	101.9	107.29	1.49
KR	655	Q50	Alternative D	1330	1193.28	1196.42	0.023618	13.05	101.9	107.29	1.49
KR	655	Q50	Dam Removal I	1330	1193.28	1196.42	0.023618	13.05	101.9	107.29	1.49
KR	655	Q50	Dam Removal II	1330	1193.28	1196.42	0.023618	13.05	101.9	107.29	1.49
KR	655	Q100	Existing Culvert	1620	1193.28	1196.79	0.022076	13.74	117.89	116.94	1.46
KR	655	Q100	Alternative A	1620	1193.28	1196.79	0.022076	13.74	117.89	116.94	1.46
KR	655	Q100	Alternative B	1620	1193.28	1196.79	0.022076	13.74	117.89	116.94	1.46
KR	655	Q100	Alternative C	1620	1193.28	1196.79	0.022076	13.74	117.89	116.94	1.46
KR	655	Q100	Alternative D	1620	1193.28	1196.79	0.022076	13.74	117.89	116.94	1.46
KR	655	Q100	Dam Removal I	1620	1193.28	1196.79	0.022076	13.74	117.89	116.94	1.46
KR	655	Q100	Dam Removal II	1620	1193.28	1196.79	0.022076	13.74	117.89	116.94	1.46
KR	655	Q200	Existing Culvert	1930	1193.28	1198.04	0.009471	11.17	172.74	128.35	1

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KR	655	Q200	Alternative A	1930	1193.28	1198.04	0.009471	11.17	172.74	128.35	1
KR	655	Q200	Alternative B	1930	1193.28	1198.04	0.009471	11.17	172.74	128.35	1
KR	655	Q200	Alternative C	1930	1193.28	1198.04	0.009471	11.17	172.74	128.35	1
KR	655	Q200	Alternative D	1930	1193.28	1198.04	0.009471	11.17	172.74	128.35	1
KR	655	Q200	Dam Removal I	1930	1193.28	1198.04	0.009471	11.17	172.74	128.35	1
KR	655	Q200	Dam Removal II	1930	1193.28	1198.04	0.009471	11.17	172.74	128.35	1
KR	655	Q500	Existing Culvert	2400	1193.28	1198.67	0.009156	11.98	200.52	132.91	1
KR	655	Q500	Alternative A	2400	1193.28	1198.67	0.009156	11.98	200.52	132.91	1
KR	655	Q500	Alternative B	2400	1193.28	1198.67	0.009156	11.98	200.52	132.91	1
KR	655	Q500	Alternative C	2400	1193.28	1198.67	0.009156	11.98	200.52	132.91	1
KR	655	Q500	Alternative D	2400	1193.28	1198.67	0.009156	11.98	200.52	132.91	1
KR	655	Q500	Dam Removal I	2400	1193.28	1198.67	0.009156	11.98	200.52	132.91	1
KR	655	Q500	Dam Removal II	2400	1193.28	1198.67	0.009156	11.98	200.52	132.91	1
KR	183	Q2	Existing Culvert	330	1185.19	1189.01	0.001001	2.44	160.75	124.2	0.31
KR	183	Q2	Alternative A	330	1185.19	1189.01	0.001001	2.44	160.75	124.2	0.31
KR	183	Q2	Alternative B	330	1185.19	1189.01	0.001001	2.44	160.75	124.2	0.31
KR	183	Q2	Alternative C	330	1185.19	1189.01	0.001001	2.44	160.75	124.2	0.31
KR	183	Q2	Alternative D	330	1185.19	1189.01	0.001001	2.44	160.75	124.2	0.31
KR	183	Q2	Dam Removal I	330	1185.19	1189.01	0.001001	2.44	160.75	124.2	0.31
KR	183	Q2	Dam Removal II	330	1185.19	1189.01	0.001001	2.44	160.75	124.2	0.31
KR	183	Q5	Existing Culvert	566	1185.19	1189.64	0.001001	2.93	248.66	157.25	0.32
KR	183	Q5	Alternative A	566	1185.19	1189.64	0.001001	2.93	248.66	157.25	0.32
KR	183	Q5	Alternative B	566	1185.19	1189.64	0.001001	2.93	248.66	157.25	0.32
KR	183	Q5	Alternative C	566	1185.19	1189.64	0.001001	2.93	248.66	157.25	0.32
KR	183	Q5	Alternative D	566	1185.19	1189.64	0.001001	2.93	248.66	157.25	0.32
KR	183	Q5	Dam Removal I	566	1185.19	1189.64	0.001001	2.93	248.66	157.25	0.32
KR	183	Q5	Dam Removal II	566	1185.19	1189.64	0.001001	2.93	248.66	157.25	0.32
KR	183	Q10	Existing Culvert	766	1185.19	1190.06	0.001	3.24	319.13	178.21	0.33

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KR	183	Q10	Alternative A	766	1185.19	1190.06	0.001	3.24	319.13	178.21	0.33
KR	183	Q10	Alternative B	766	1185.19	1190.06	0.001	3.24	319.13	178.21	0.33
KR	183	Q10	Alternative C	766	1185.19	1190.06	0.001	3.24	319.13	178.21	0.33
KR	183	Q10	Alternative D	766	1185.19	1190.06	0.001	3.24	319.13	178.21	0.33
KR	183	Q10	Dam Removal I	766	1185.19	1190.06	0.001	3.24	319.13	178.21	0.33
KR	183	Q10	Dam Removal II	766	1185.19	1190.06	0.001	3.24	319.13	178.21	0.33
KR	183	Q25	Existing Culvert	1070	1185.19	1190.58	0.001001	3.61	415.63	184.89	0.34
KR	183	Q25	Alternative A	1070	1185.19	1190.58	0.001001	3.61	415.63	184.89	0.34
KR	183	Q25	Alternative B	1070	1185.19	1190.58	0.001001	3.61	415.63	184.89	0.34
KR	183	Q25	Alternative C	1070	1185.19	1190.58	0.001001	3.61	415.63	184.89	0.34
KR	183	Q25	Alternative D	1070	1185.19	1190.58	0.001001	3.61	415.63	184.89	0.34
KR	183	Q25	Dam Removal I	1070	1185.19	1190.58	0.001001	3.61	415.63	184.89	0.34
KR	183	Q25	Dam Removal II	1070	1185.19	1190.58	0.001001	3.61	415.63	184.89	0.34
KR	183	Q50	Existing Culvert	1330	1185.19	1190.98	0.001	3.87	488.98	187.77	0.34
KR	183	Q50	Alternative A	1330	1185.19	1190.98	0.001	3.87	488.98	187.77	0.34
KR	183	Q50	Alternative B	1330	1185.19	1190.98	0.001	3.87	488.98	187.77	0.34
KR	183	Q50	Alternative C	1330	1185.19	1190.98	0.001	3.87	488.98	187.77	0.34
KR	183	Q50	Alternative D	1330	1185.19	1190.98	0.001	3.87	488.98	187.77	0.34
KR	183	Q50	Dam Removal I	1330	1185.19	1190.98	0.001	3.87	488.98	187.77	0.34
KR	183	Q50	Dam Removal II	1330	1185.19	1190.98	0.001	3.87	488.98	187.77	0.34
KR	183	Q100	Existing Culvert	1620	1185.19	1191.38	0.001001	4.13	564.09	190.56	0.35
KR	183	Q100	Alternative A	1620	1185.19	1191.38	0.001001	4.13	564.09	190.56	0.35
KR	183	Q100	Alternative B	1620	1185.19	1191.38	0.001001	4.13	564.09	190.56	0.35
KR	183	Q100	Alternative C	1620	1185.19	1191.38	0.001001	4.13	564.09	190.56	0.35
KR	183	Q100	Alternative D	1620	1185.19	1191.38	0.001001	4.13	564.09	190.56	0.35
KR	183	Q100	Dam Removal I	1620	1185.19	1191.38	0.001001	4.13	564.09	190.56	0.35
KR	183	Q100	Dam Removal II	1620	1185.19	1191.38	0.001001	4.13	564.09	190.56	0.35
KR	183	Q200	Existing Culvert	1930	1185.19	1191.77	0.001	4.37	639.66	193.61	0.36
KR	183	Q200	Alternative A	1930	1185.19	1191.77	0.001	4.37	639.66	193.61	0.36

Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KR	183	Q200	Alternative B	1930	1185.19	1191.77	0.001	4.37	639.66	193.61	0.36
KR	183	Q200	Alternative C	1930	1185.19	1191.77	0.001	4.37	639.66	193.61	0.36
KR	183	Q200	Alternative D	1930	1185.19	1191.77	0.001	4.37	639.66	193.61	0.36
KR	183	Q200	Dam Removal I	1930	1185.19	1191.77	0.001	4.37	639.66	193.61	0.36
KR	183	Q200	Dam Removal II	1930	1185.19	1191.77	0.001	4.37	639.66	193.61	0.36
KR	183	Q500	Existing Culvert	2400	1185.19	1192.33	0.001	4.72	751.18	202.7	0.36
KR	183	Q500	Alternative A	2400	1185.19	1192.33	0.001	4.72	751.18	202.7	0.36
KR	183	Q500	Alternative B	2400	1185.19	1192.33	0.001	4.72	751.18	202.7	0.36
KR	183	Q500	Alternative C	2400	1185.19	1192.33	0.001	4.72	751.18	202.7	0.36
KR	183	Q500	Alternative D	2400	1185.19	1192.33	0.001	4.72	751.18	202.7	0.36
KR	183	Q500	Dam Removal I	2400	1185.19	1192.33	0.001	4.72	751.18	202.7	0.36
KR	183	Q500	Dam Removal II	2400	1185.19	1192.33	0.001	4.72	751.18	202.7	0.36

Attachment G – Engineer's Preliminary Opinion of Construction Costs

ENGINEER'S OPINION OF CONSTRUCTION COSTS

MAIN ROAD CONCEPTUAL DESIGN ALTERNATIVES
MONTEREY, MA

Item	Description	Cost Estimate			
		Alternative 1 - New 15' Culvert	**Alternative 2 - New 18' Culvert**	**Alternative 3 - New 25' Culvert**	**Alternative 4 - Upstream Flood Walls**
1	Mobilization / Demobilization	$60,000	$80,000	$80,000	$60,000
2	General Sediment and Erosion Controls	$25,000	$30,000	$30,000	$30,000
3	Temporary Facilities	$25,000	$25,000	$25,000	$25,000
4	Temporary Cofferdams and Water Control	$250,000	$300,000	$300,000	$50,000
5	General Site Preparation	$50,000	$60,000	$60,000	$20,000
6	Demolition / Disposal of Existing Culvert	$35,000	$35,000	$35,000	$0
7	Demoltion / Disposal of Existing River Walls as Needed	$0	$15,000	$15,000	$0
8	New 15'x12' Pre-Cast Concrete Box Culvert and Appurtenances	$250,000	$0	$0	$0
8	New 18'x12' Pre-Cast Concrete Box Culvert and Appurtenances	$0	$270,000	$0	$0
8	New 25'x12' Pre-Cast Concrete Box Culvert and Appurtenances	$0	$0	$350,000	$0
9	Earth Work and Excavation for Installation of New Culvert	$60,000	$100,000	$300,000	$0
10	Cost of Modifying West Upstream Headwall	$0	$75,000	$75,000	$180,000
11	Cost of Modifying East Upstream Headwall	$0	$0	$0	$468,750
13	Stream Channel and Slope Protection	$25,000	$40,000	$40,000	$20,000
14	Utilities Relocation and Restoration	$100,000	$200,000	$200,000	$25,000
15	Site Restoration	$20,000	$30,000	$30,000	$10,000
16	Traffic Control, Police Detail, and Temporary Project Signage	$100,000	$250,000	$250,000	$10,000
17	Roadway Pavement and Restoration	$35,000	$50,000	$50,000	$0
18	Earthwork and Berm Construction	$0	$30,000	$0	$0
	CONSTRUCTION SUBTOTAL	$1,035,000	$1,590,000	$1,840,000	$899,000
	30% CONTINGENCY	$311,000	$477,000	$552,000	$270,000
	GRAND TOTAL	$1,346,000	$2,067,000	$2,392,000	$1,169,000

Attachment H – Preliminary Conceptual Drawings

MAIN ROAD CULVERT
CONCEPTUAL DESIGN ALTERNATIVES

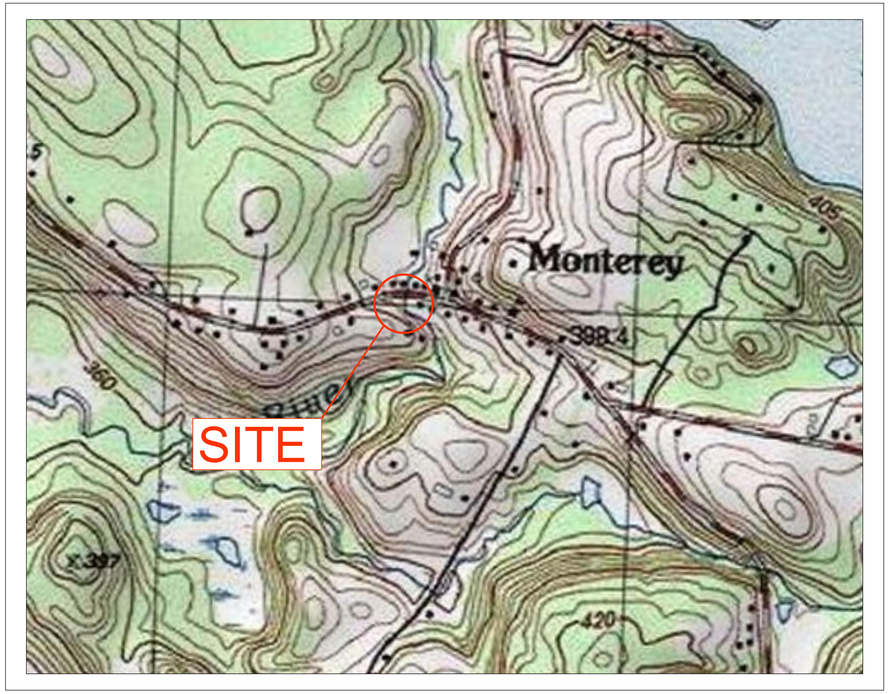
MONTEREY, MASSACHUSETTS

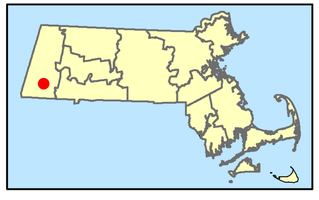
PROJECT OWNER

TOWN OF MONTEREY DPW
40 GOULD ROAD
MONTEREY, MA 01245

PROJECT ENGINEER

GZA GEOENVIRONMENTAL, INC.
249 VANDERBILT AVE.
NORWOOD, MASSACHUSETTS 02062





PROJECT LOCUS MAP

SOURCE: THIS MAP CONTAINS THE ESRI ARCGIS ONLINE USA TOPOGRAPHIC MAP SERVICE, PUBLISHED DECEMBER 2009 BY ESRI RCIMS SERVICES. LAST UPDATED MARCH 2014.

0 250' 500' 1000' 1500'
SCALE IN FEET

NOTE: ALL SCALES APPLICABLE FOR 22"X34" DRAWINGS. USE SCALE BAR FOR ALTERNATE SIZE DRAWINGS.

INDEX OF DRAWINGS

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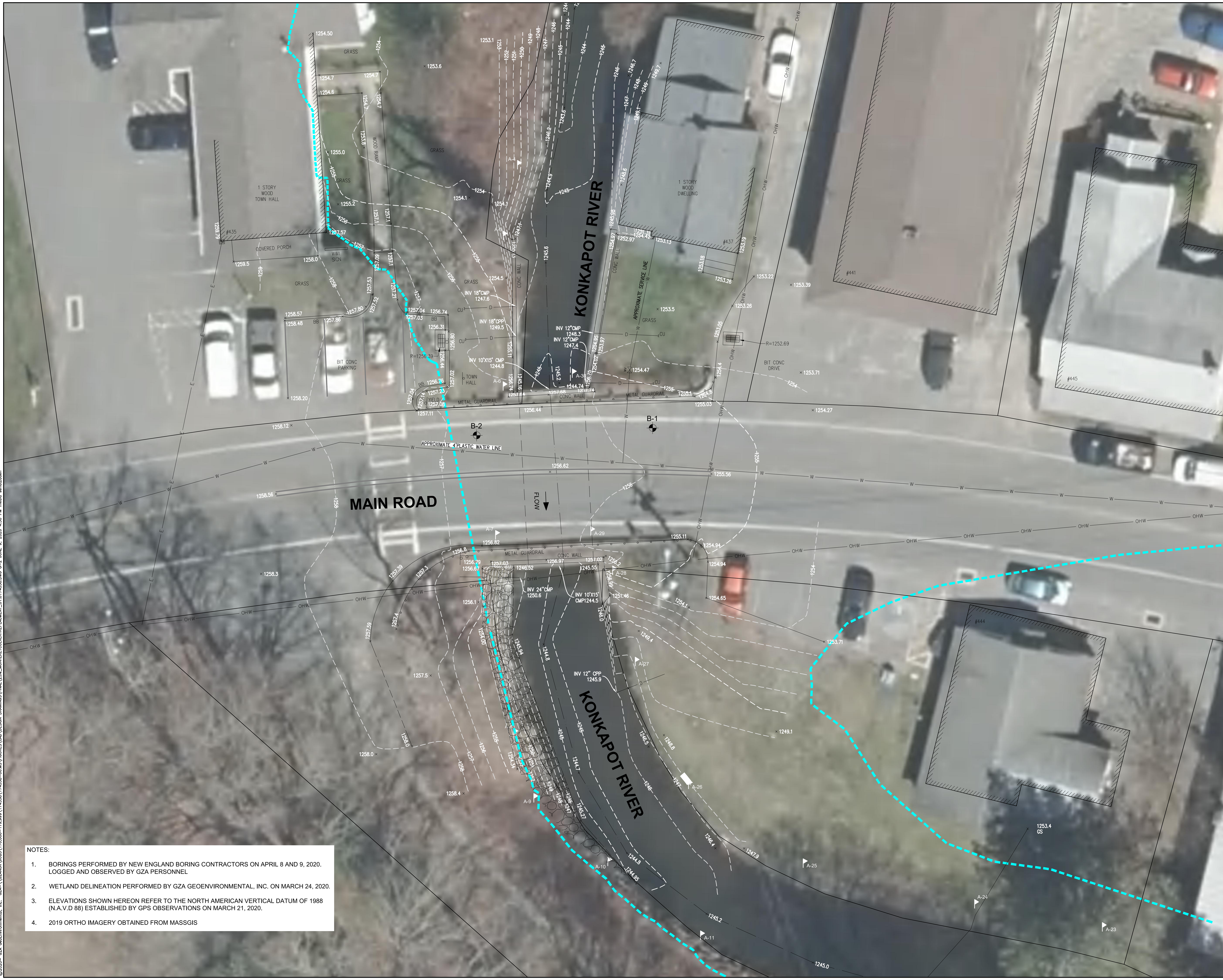
NO.	ISSUE/DESCRIPTION	BY	DATE
1	18' Alternative added	MC	6/5/2020

MAIN ROAD CULVERT CONCEPTUAL DESIGN ALTERNATIVES
MONTEREY, MASSACHUSETTS

TITLE SHEET, SITE LOCUS AND INDEX OF DRAWINGS

PREPARED BY: GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com		PREPARED FOR: MONTEREY DPW 40 GOULD ROAD MONTEREY, MA 01245	
PROJ MGR: MS	REVIEWED BY: CWC	CHECKED BY: CWC	FIGURE G-1
DESIGNED BY: MS	DRAWN BY: MEC	SCALE: AS NOTED	
DATE: JUNE, 2020	PROJECT NO. 01.0174558.00	REVISION NO. 1	



LEGEND

— — 194 — —	EXISTING CONTOUR
X197.75	EXISTING SPOT ELEVATION
197.4 UP33/5	UTILITY POLE
	WETLAND FLAG/ BANK FLAG
GZ-1	APPROXIMATE LOCATION OF BORING
— W —	EXISTING WATER MAIN
— D —	DRAIN LINE
— OHW —	OVERHEAD WIRES
	PROPERTY LINE
	GUARD RAIL
	100-YEAR FLOOD LEVEL
	RIVER THALWEG
	RIPRAP

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0 5 10 20
SCALE IN FEET

NOTES:

1. BORINGS PERFORMED BY NEW ENGLAND BORING CONTRACTORS ON APRIL 8 AND 9, 2020. LOGGED AND OBSERVED BY GZA PERSONNEL
2. WETLAND DELINEATION PERFORMED BY GZA GEOENVIRONMENTAL, INC. ON MARCH 24, 2020.
3. ELEVATIONS SHOWN HEREON REFER TO THE NORTH AMERICAN VERTICAL DATUM OF 1988 (N.A.V.D 88) ESTABLISHED BY GPS OBSERVATIONS ON MARCH 21, 2020.
4. 2019 ORTHO IMAGERY OBTAINED FROM MASSGIS

NO.	ISSUE/DESCRIPTION	BY	DATE

MAIN ROAD CULVERT CONCEPTUAL DESIGN ALTERNATIVES
MONTEREY, MASSACHUSETTS

EXISTING CONDITIONS PLAN

PREPARED BY:
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www.gza.com

PREPARED FOR:
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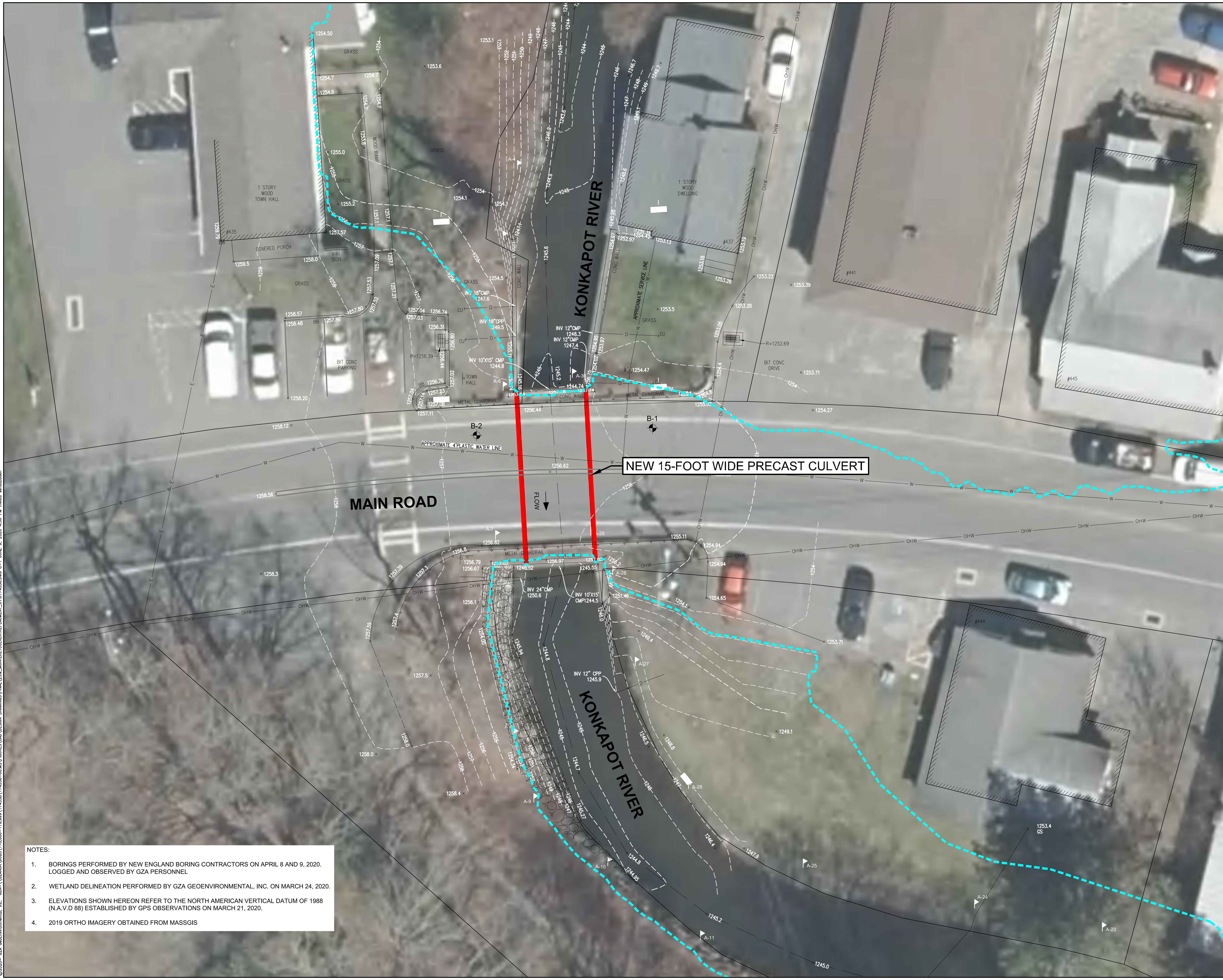
40 GOULD ROAD
MONTEREY, MA 01245

PROJ MGR: MS	REVIEWED BY: CWC	CHECKED BY: MC	FIGURE
DESIGNED BY: MS	DRAWN BY: MEC	SCALE: AS NOTED	G-2
DATE: JUNE, 2020	PROJECT NO. 01.0174558	REVISION NO.	



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LEGEND

- EXISTING CONTOUR
- EXISTING SPOT ELEVATION
- UTILITY POLE
- WETLAND FLAG/ BANK FLAG
- APPROXIMATE LOCATION OF BORING
- EXISTING WATER MAIN
- DRAIN LINE
- OVERHEAD WIRES
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- GUARD RAIL
- 100-YEAR FLOOD LEVEL
- RIVER THALWEG
- RIPRAP

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SCALE IN FEET

NO.	ISSUE/DESCRIPTION	BY	DATE

MAIN ROAD CULVERT CONCEPTUAL DESIGN ALTERNATIVES
MONTEREY, MASSACHUSETTS

ALTERNATIVE 1: 15-FOOT WIDE CULVERT

PREPARED BY:
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Engineers and Scientists
www.gza.com

PREPARED FOR:
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40 GOULD ROAD
MONTEREY, MA 01245

PROJ MGR: MS	REVIEWED BY: CWC	CHECKED BY: MC	FIGURE C-1
DESIGNED BY: MS	DRAWN BY: MEC	SCALE: AS NOTED	
DATE: JUNE, 2020	PROJECT NO. 01.0174558	REVISION NO.	

FLOOD BERM TO MEET EXISTING GROUND AT ELEVATION 1256'

CONSTRUCT NEW FLOOD BERM TO ELEVATION 1256'

CONSTRUCT NEW TRAINING WALL

MODIFY DRAIN PIPES AS NECESSARY

NEW 18-FOOT WIDE PRECAST CULVERT

KONKAPOT RIVER

MAIN ROAD

LEGEND

- EXISTING CONTOUR
- EXISTING SPOT ELEVATION
- UTILITY POLE
- WETLAND FLAG/ BANK FLAG
- APPROXIMATE LOCATION OF BORING
- EXISTING WATER MAIN
- DRAIN LINE
- OVERHEAD WIRES
- PROPERTY LINE
- GUARD RAIL
- 100-YEAR FLOOD LEVEL
- RIVER THALWEG
- RIPRAP

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4. 2019 ORTHO IMAGERY OBTAINED FROM MASSGIS

N

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0 7.5 15 30
SCALE IN FEET

NO.	ISSUE/DESCRIPTION	BY	DATE
1	18' Alternative added	MC	6/5/2020

MAIN ROAD CULVERT CONCEPTUAL DESIGN ALTERNATIVES
MONTEREY, MASSACHUSETTS

ALTERNATIVE 2: 18-FOOT WIDE CULVERT

PREPARED BY:
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Engineers and Scientists
www.gza.com

PREPARED FOR:
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40 GOULD ROAD
MONTEREY, MA 01245

PROJ MGR: MS	REVIEWED BY: CWC	CHECKED BY: MC	FIGURE
DESIGNED BY: MS	DRAWN BY: MEC	SCALE: AS NOTED	C-2
DATE: JUNE, 2020	PROJECT NO. 01.0174558	REVISION NO.	

CONSTRUCT NEW TRAINING WALL

MODIFY DRAIN PIPES AS NECESSARY

NEW 25-FOOT WIDE PRECAST CULVERT

KONKAPOT RIVER

MAIN ROAD

FLOW

B-1

B-2

1 STORY WOOD TOWN HALL

1 STORY WOOD DWELLING

#435

#437

#441

#444

#445

COVERED PORCH

WWI SIGN

WOOD RAMP

GRASS

BIT CONC PARKING

BIT CONC DRIVE

CONC WALL

METAL GUARDRAIL

APPROXIMATE SERVICE LINE

APPROXIMATE 4" PLASTIC WATER LINE

INV 18"CMP 1247.6

INV 18"CPP 1249.5

INV 12"CMP 1248.3

INV 12"CMP 1247.4

INV 10'X15' CMP 1244.8

INV 24"CMP 1250.6

INV 10'X15' CMP1244.5

INV 12" CPP 1245.9

NOTES:

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LEGEND

- EXISTING CONTOUR
- EXISTING SPOT ELEVATION
- UTILITY POLE
- WETLAND FLAG/ BANK FLAG
- APPROXIMATE LOCATION OF BORING
- EXISTING WATER MAIN
- DRAIN LINE
- OVERHEAD WIRES
- PROPERTY LINE
- GUARD RAIL
- 100-YEAR FLOOD LEVEL
- RIVER THALWEG
- RIPRAP

N

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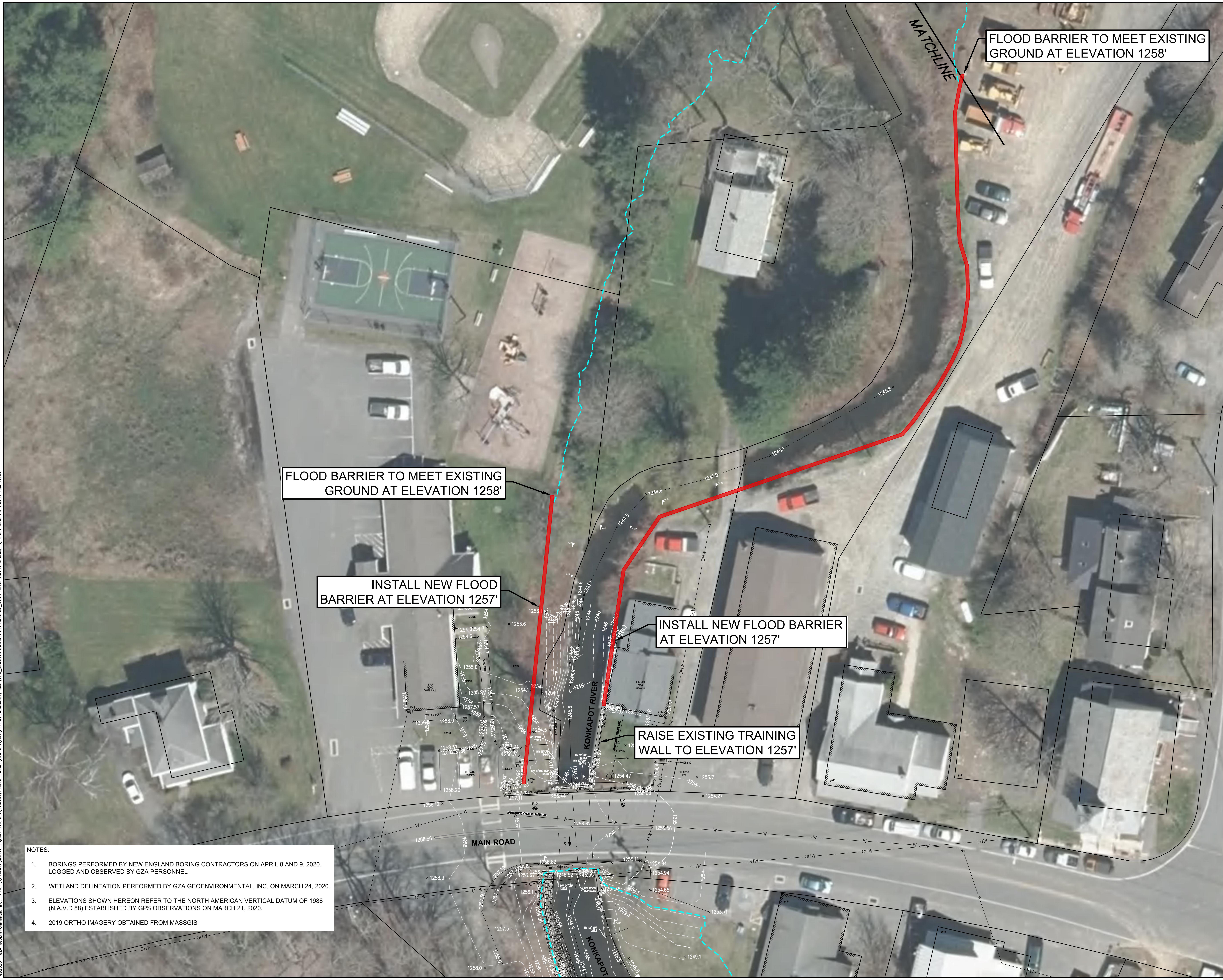
0 5 10 20
SCALE IN FEET

NO.	ISSUE/DESCRIPTION	BY	DATE

MAIN ROAD CULVERT CONCEPTUAL DESIGN ALTERNATIVES
MONTEREY, MASSACHUSETTS

ALTERNATIVE 3: 25-FOOT WIDE CULVERT

PREPARED BY: GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com		PREPARED FOR: MONTEREY DPW 40 GOULD ROAD MONTEREY, MA 01245	
PROJ MGR: MS	REVIEWED BY: CWC	CHECKED BY: MC	FIGURE C-3
DESIGNED BY: MS	DRAWN BY: MEC	SCALE: AS NOTED	
DATE: JUNE, 2020	PROJECT NO. 01.0174558	REVISION NO.	



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LEGEND

- EXISTING CONTOUR
- EXISTING SPOT ELEVATION
- UTILITY POLE
- WETLAND FLAG/ BANK FLAG
- APPROXIMATE LOCATION OF BORING
- EXISTING WATER MAIN
- DRAIN LINE
- OVERHEAD WIRES
- PROPERTY LINE
- GUARD RAIL
- 100-YEAR FLOOD LEVEL
- RIVER THALWEG
- RIPRAP

N

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0 7.5 15 30
SCALE IN FEET

NO.	ISSUE/DESCRIPTION	BY	DATE

MAIN ROAD CULVERT CONCEPTUAL DESIGN ALTERNATIVES
MONTEREY, MASSACHUSETTS

ALTERNATIVE 4: NEW FLOOD BARRIERS

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Engineers and Scientists
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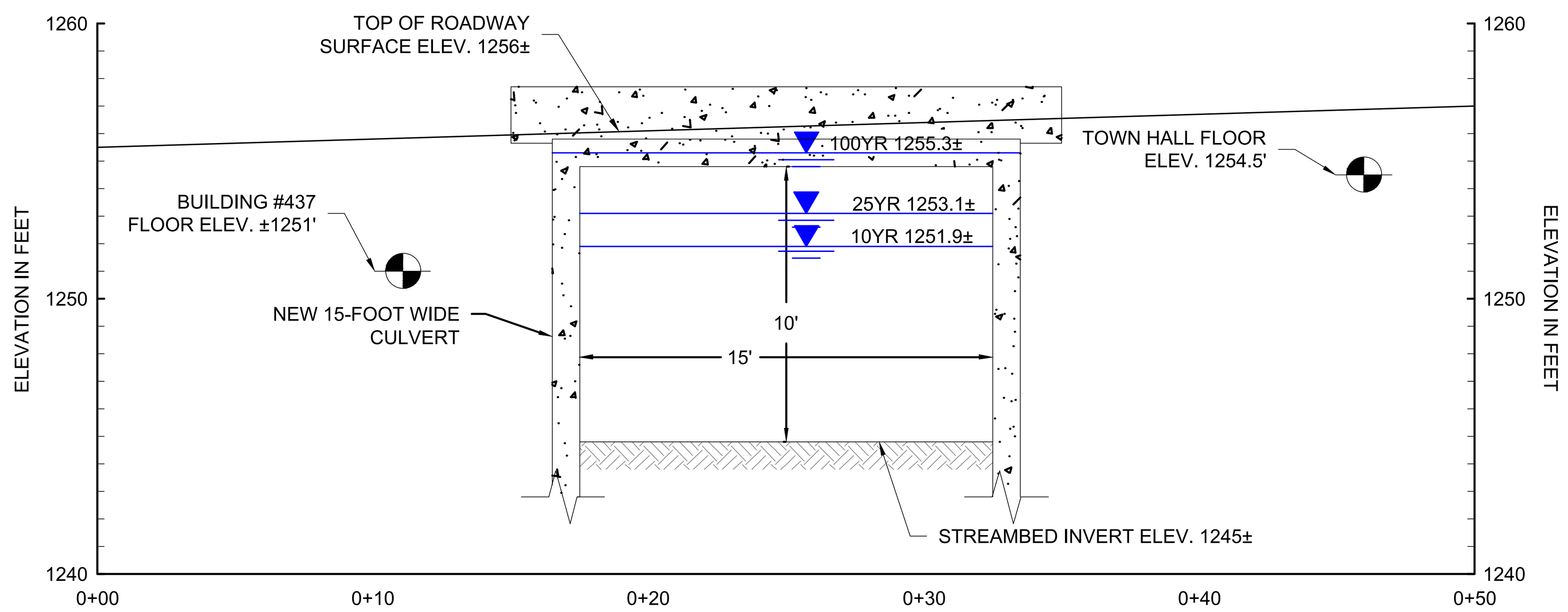
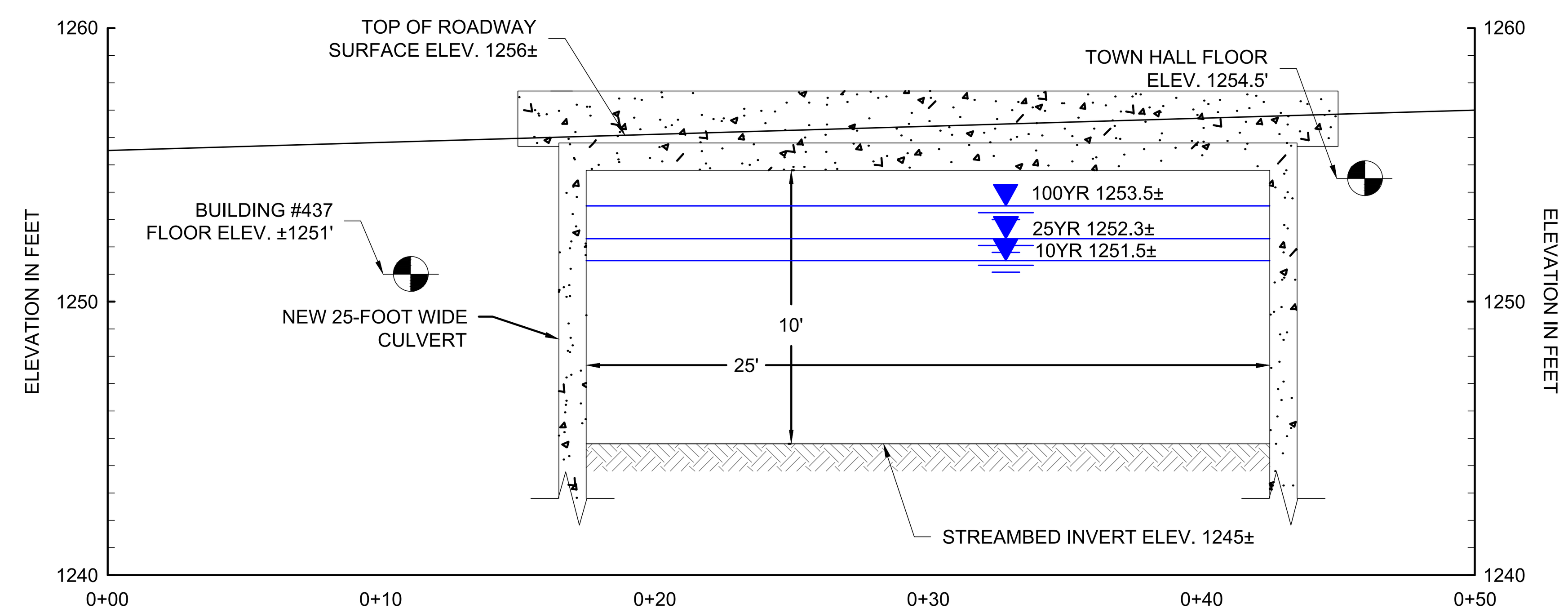
40 GOULD ROAD
MONTEREY, MA 01245

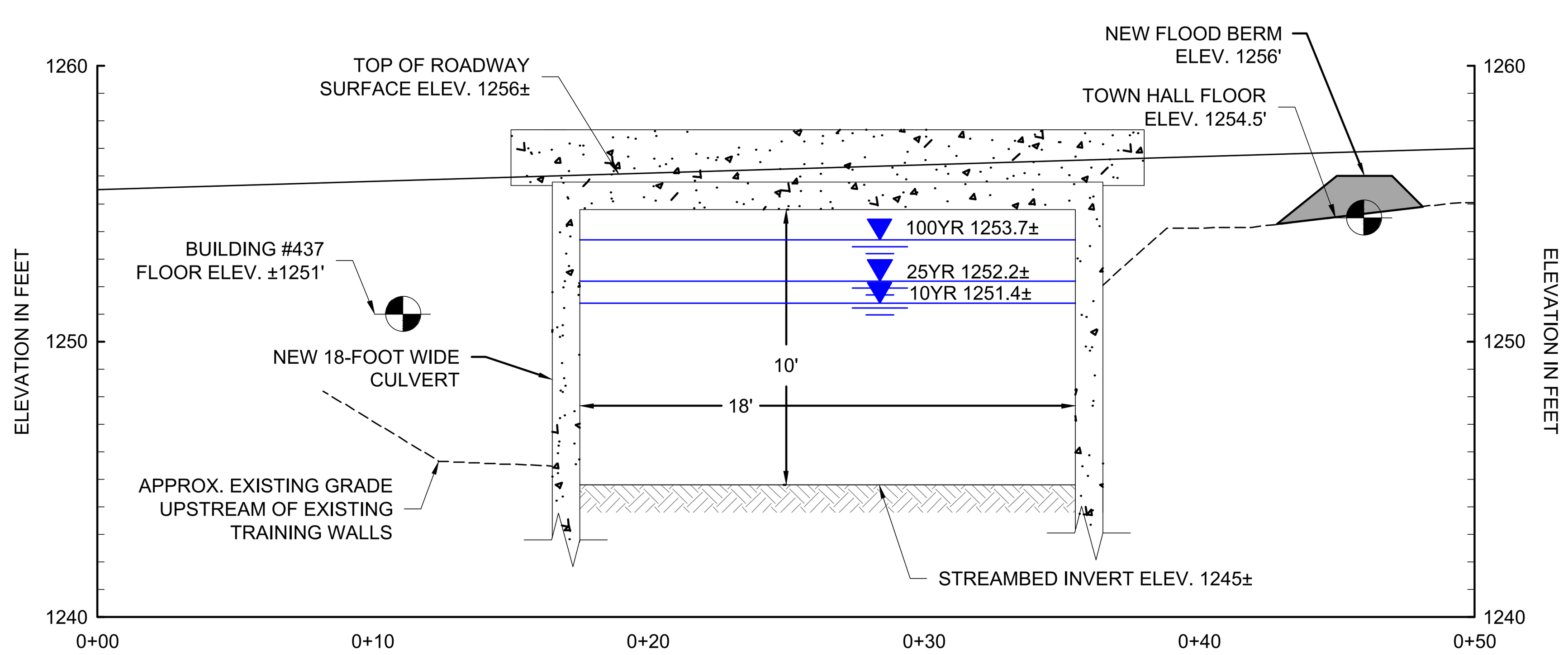
PROJ MGR: MS	REVIEWED BY: CWC	CHECKED BY: MC	FIGURE
DESIGNED BY: MS	DRAWN BY: MEC	SCALE: AS NOTED	C-4
DATE: JUNE, 2020	PROJECT NO. 01.0174558	REVISION NO.	



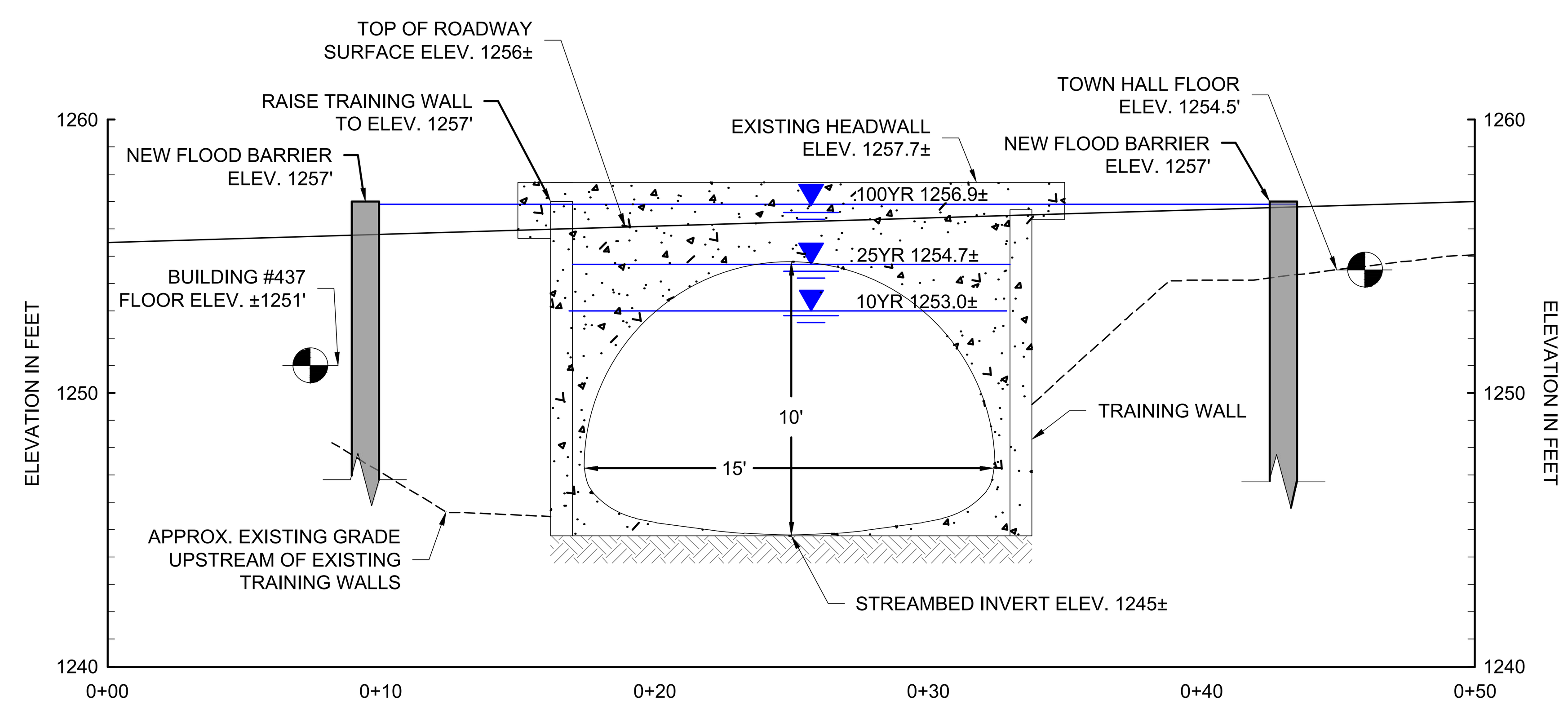
ALTERNATIVE 1 - 15-FOOT WIDE CULVERT



ALTERNATIVE 3 - 25-FOOT WIDE CULVERT



ALTERNATIVE 2 - 18-FOOT WIDE CULVERT



ALTERNATIVE 4 - NEW FLOOD BARRIERS

UPSTREAM CULVERT PROFILES

Flood Elevations at immediately upstream of the culvert

0 2.5 5 10
SCALE IN FEET

PROPOSED DETOUR PLAN

0 625 1250 2500
SCALE IN FEET

NO.	ISSUE/DESCRIPTION	BY	DATE
1	18' Alternative added	MC	6/5/2020

MAIN ROAD CULVERT CONCEPTUAL DESIGN ALTERNATIVES
MONTEREY, MASSACHUSETTS

CULVERT PROFILES AND DETOUR PLAN

PREPARED BY:	PREPARED FOR:
GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com	MONTEREY DPW 40 GOULD ROAD MONTEREY, MA 01245

PROJ MGR: MS	REVIEWED BY: CWC	CHECKED BY: MC	FIGURE
DESIGNED BY: MS	DRAWN BY: MEC	SCALE: AS NOTED	C-5
DATE: JUNE, 2020	PROJECT NO. 01.0174558	REVISION NO.	

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Attachment I – Environmental Constraints Memorandum

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F: 781.278.5702
www.gza.com

M E M O R A N D U M

To: Shawn Tryon

From: Alyssa Noyes, Kimberly Degutis, Media Sehatzadeh, Chad Cox P.E.

Date: May 29, 2020

File No.: 01.0174558.00

Re: Main Road Culvert Replacement Environmental Constraints Memorandum

On February 24, 2020, GZA entered into an agreement with the Town of Monterey (The Town) to execute a culvert replacement study associated with Main Road Culvert over Konkapot River in Monterey, Massachusetts. The culvert was identified by the Town as potentially undersized, and therefore, possibly a contributor to flooding in the Monterey town hall. To supplement the on-site wetland survey performed by GZA on March 24, 2020, GZA also investigated the potential for other protected environmental resources through the use of MassGIS databases including rare species, drinking water resources, outstanding resource waters, etc. Note that preparation of permit applications was not included in the current scope of services proposed by GZA.

This study was partially funded by an MVP grant from the Commonwealth of Massachusetts.

BACKGROUND

The existing culvert is located at the crossing of Main Road (State Route 23) and Konkapot River, between street address numbers 437 (a house adjacent to the river's left bank) and 435 (Monterey Town Hall). The structure is a 15-foot wide, 10-foot high, and about 40-foot long corrugated metal pipe arch culvert, with a concrete headwall and training walls on the upstream side. On the downstream side, there is a single concrete wingwall on the left side of the culvert, with riprap on the right side.

The road is classified in MassDOT road Inventory as Rural Major Collector or Urban Minor Arterial roadway. The culvert is within a special flood hazard area, Zone A, as delineated by FEMA in Flood Insurance Rate Map 2500300010B, effective June 15, 1981.

In support of the design for the removal and replacement of the culvert, or other potential options, GZA has reviewed the existing conditions, site photos, field notes, and readily available Geographic Information System (GIS) data layers to evaluate the existing site constraints to support the project.

WETLAND PROTECTION ACT RESOURCES IDENTIFIED ON SITE

A desktop analysis using MassGIS's OLIVER database preceded the field investigation to identify critical areas on or within 100 feet of the Project Area. Refer to Table 1 below for a summary of our desktop findings.

Table 1: Critical Environmental Areas as Mapped by MassGIS OLIVER

MAPPED RESOURCES ON OR WITHIN 100 FEET OF THE PROJECT AREA	YES	NO
NWI Wetlands		X
MassDEP Wetlands		X
MassDEP Streams	X	
NHESP Certified Vernal Pool		X
NHESP Potential Vernal Pool		X
FEMA Flood Zones	X	
Outstanding Resource Waters		X
Coastal Zone		X
Great Ponds		X
Tidelands		X
NHESP Estimated Habitat of Rare Wildlife		X
NHESP Priority Habitat of Rare Species		X
Areas of Critical Environmental Concern		X
MassDEP Coldwater Fisheries Resource	X	
Wellhead Protection Area (Interim, Zone I, or Zone II)		X

A total of one (1) waterway resource (e.g., stream) was delineated by GZA within the Project Area. The stream boundary was delineated based on indicators of the mean annual high water (MAHW) line. The resource areas associated with the stream boundary for the Konkapot River identified on site are further described in the Wetland Delineation Report (see Attachment B to the Conceptual Design Memorandum).

PERMITTING REVIEW

Based upon GZA's review of available information during the preparation of this design memo, we conclude that wetland resources are present in the Project Site and include MassDEP streams, Federal Emergency Management Agency (FEMA) Flood Zones and Massachusetts Division of Fisheries and Wildlife (DFW) Coldwater Fisheries.

The impacts of the proposed project to Wetlands Protection Act resource areas will determine which permit type is required. GZA assumes that the proposed project will result in less than 5,000 SF of temporary and permanent impacts to the Wetlands Protection Act resource areas. Under this assumption, the permits/reviews likely required for this project would include:

1. Section 404 Permit / Self Verification Notification Form (SVNF) – The United States Army Corps of Engineers (USACE) regulates the discharge of dredged or fill material into waters of the United States and structures or work in navigable waters of the United States under Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act of 1899. Assuming the project will result in less than 5,000 SF of impacts to non-tidal waters of the United States (i.e. disturbance below the Ordinary High-Water Line of the river), GZA would submit a SVNF to the USACE.
2. Order of Conditions (OOC) – Any work within wetlands, waterbodies, or other resources listed within the Massachusetts Wetlands Protection Act (WPA, 310 CMR 10.00) requires an application to be submitted to the local Conservation Commission for their review and approval. Since this project is in the Town of Monterey, the project must also abide by the Monterey non-zoning wetlands by-law. GZA would submit a WPA Form 3 - Notice of Intent (NOI) application to the Monterey Conservation Commission and attend the Conservation Commission public hearing in support of the project and obtain an OOC. Assuming the project will result in less than 5,000 SF

of impacts to wetlands or waterways, the OOC would serve as the MassDEP 401 Water Quality Certification for the project.

3. Chapter 91 Authorization – Any work below the high-water mark of any non-tidal navigable river or stream using public funds is subject to Chapter 91 jurisdiction. This requires a Chapter 91 License/Permit application to be submitted to the MassDEP Waterways Program. GZA would consult with the Waterways Program and submit this application to them.
4. Federal and State Cultural Resources Review – Any project that requires permits from federal or state agencies requires consultation in compliance with Section 106 of the National Historic Preservation Act of 1966 and with the Massachusetts Historical Commission (MHC), which is the office of the State Historic Preservation Officer (SHPO). Other local historical commissions or Tribal Historic Preservation Officers (THPOs) are also consulted. GZA would submit a Project Notification Form (PNF) to the MHC and send consultation letters to interested parties.
5. Federal and State Fisheries Review – The Massachusetts Division of Fisheries and Wildlife (DFW) reviews the project if it is located within a DFW Coldwater Fisheries Resource. Since this project is located within this resource, according to the MassGIS OLIVER database, this review will be required. GZA would send a consultation letter to the DFW so that said review can be undertaken, and potential comments can be addressed.

Should the project result in more than 5,000 SF cumulatively for permanent and temporary impacts to bordering or isolated wetlands, land under water resource, or for some reason the culvert is not able to meet the Massachusetts Rivers and Stream Crossing Standards , then the following permits/review would likely be required:

1. Section 404 Permit – A Pre-Construction Notification (PCN) application would need to be prepared and submitted to the USACE in lieu of a Self-Verification.
2. Section 401 Water Quality Certification (WQC) – An Individual 401 WQC application would need to be prepared and submitted.
3. Massachusetts Environmental Policy Act (MEPA) – This will apply if project impacts result in alteration of 500 or more linear feet of bank along a fish run or inland bank, if an existing structure is expanded in a regulatory floodway, or if project impacts result in alteration of greater than 5,000 SF of wetlands. This requires submitting an Environmental Notification Form (ENF) to the MEPA Office and attending one MEPA scoping meeting.

CONCLUSIONS

GZA has identified state and federally regulated wetland resources on site that will require the filing of several permits depending upon the amount of impacts and the type of regulated resources. The regulated resources identified include wetlands (e.g., Konkapot River), FEMA Flood Zone, and MADFW Coldwater Fisheries.

GZA GeoEnvironmental, Inc.