NE Manley Road & Culvert Project

Clark County, WA

Alternatives Analysis

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Executive Summary

This alternative analysis studied the various options regarding replacements of the three culverts along NE Manley Road. Each of the three culverts has varying site constraints that dictate various solutions. The culverts are identified as the southern, middle, and northern culverts respectively. A summary of the parameters and constraints are as follows:

Roadway: At all three locations, the roadway will be widened several feet and the horizontal and vertical profiles are expected to not change significantly.

Geotechnical: The soils at all three sites appear to be competent for the new culvert foundations. The roadway embankment fill will be removed and replaced.

Wetlands: Other than the stream channel proper, the only wetlands present at all three sites were at the southern culvert location. The impacts to those wetlands will be small but may require mitigation.

Stream and Fish Passage: WDFW guidelines based on the Bank Full Width show that new culvert spans in the range of 18 to 20 feet are needed for each culvert. The stream reconstruction planned at the north and southern culvert locations is straight-forward, but at the middle culvert, an additional 150 feet or so of stream will be reconstructed to lower the gradient.

Flood Concerns: The culvert sites do not lie within a flood plain. However, removal of the middle and southern culverts will cause a slight rise downstream – and have possible minor impacts to the neighboring properties.

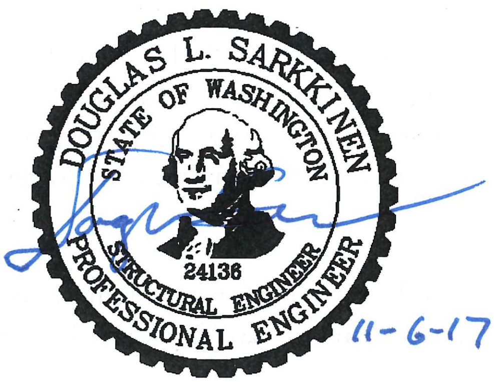
Culvert Replacement Types: For the southern and middle culverts, three types of culverts were reviewed, including two types of steel plate arches and a precast concrete three sided structure. The steel plate arches are less expensive but take longer to construct. The options for the northern culvert were limited due to vertical clearance, so a bridge option and a three sided concrete culvert option were studied. The three sided concrete culvert option was least expensive and faster to construct.

Construction Scheduling: Two constraints for construction are the limited 8 week in-water-work window and the requirement for only closing the road for one culvert at a time. A comparison study was performed looking at the impacts of constructing all three culverts over one season or two seasons.

Preferred Alternate:

The recommended or preferred alternate is to construct all three culverts in one season using accelerated construction methods. This will entail the use of precast concrete three sided culverts with precast wing walls and footings for the northern and southern culverts, and a steel plate arch with MSE or wire basket retaining walls for the middle culvert. This alternate has comparative overall project costs but has the least impact to the environment and to the neighbors and traveling public.

Endorsement



Project Background

NE Manley Road & Culvert Repair Project is located northwest of the City of Battle Ground in Clark County, WA. It includes the length of NE Manley Road from its intersection with NE 82nd Avenue (at the north end) to its intersection with NE 244th St (at the south end of the project). NE Manley Road is classed a rural minor collector and serves as a bus route for the Battle Ground School District. NE Manley Road crosses Daybreak Creek at three locations within the project limits. The purpose of the project is to improve the roadway safety through additional guardrail, adjusting the alignment, and improving the culvert crossings for Daybreak Creek.

This alternatives analysis provides the background and basis for the culvert alternatives developed to assist the County in decision making for preferred alternatives at each crossing. After a preferred selection is completed, Clark County and Otak will proceed with design development to the 50% draft level. General information is reviewed below, and each site is presented in depth in the following sections of this report.

Work Completed to Date

Work completed on the project to date has been performed to supplement available information and further inform this Alternatives Analysis. This work includes:

- Topographic survey of the site including stream hydraulic cross sections, wetland boundaries and utility locates
- Preliminary layout of revised roadway alignment
- Preliminary stream hydraulics analysis, including field review and hydraulic modeling
- Geotechnical soil borings and preliminary soil property analysis

Roadway

Clark County is providing the roadway engineering for this project, including geometrics, pavement design, curbs and guardrail design, and stormwater management.

Southern Culvert

Description

The southern culvert is located at a meander bend in Daybreak Creek. Previous reports indicate that the existing culvert is prone to being partially clogged by debris and is classified as a partial fish passage barrier. The culvert is a 36 inch diameter round corrugated metal pipe approximately 74 feet long. The inlet and outlet are both characterized by large pools within the stream channel. The culvert is in moderate condition with visible corrosion below the springline.

Roadway

The proposed roadway alignment will closely match existing. The roadway pavement cross section, including lane widths, will closely match existing conditions with the addition of a gravel shoulder and guardrail on each side of the roadway. Proposed finish grade will be raised less than 0.5 ft.

Crossing Alignment and Span

The existing culvert follows a natural stream alignment skewed relative to the roadway by approximately 22 degrees. The proposed replacement will match this same alignment. Notably some culvert options presented, particularly steel options, a skewed alignment will require some additional embankment construction around the culverts to create a balanced fill condition on both sides of the culvert.

Construction

It is proposed to fully close the roadway while the existing culvert is removed and the new culvert is installed. This will facilitate the required stream bypass installation to isolate the work area. This bypass can be installed in a deep trench or be pumped across the roadway embankment on the south approach to the culvert. The surrounding site topography is a flat plane with the stream channel incised through it: excavation can be completed by laying-back the slope with no need for additional shoring. The timing of the construction will largely be governed by the In Water Work Window (IWWW). For this site it is anticipated that the IWWW will be July 1st and August 31st.

Hydraulics

Description

The stream at the most southern crossing is fairly flat with fully incised steep banks. The substrate present is primarily fine-grained sediment and some gravel. The existing culvert crossing is a 36 inch corrugated metal pipe (CMP) culvert. Sediment has collected inside of the culvert on the upstream end and heavy siltation is present upstream of the culvert. This is caused in part by break in the pipe slope creating a sag located towards the middle of the culvert. A scour pool is present immediately downstream of the existing culvert. Dense vegetation is present along the banks with some trees are protruding into the channel.

Hydraulic Analysis

The hydraulic analysis was performed using the United States Army Corps of Engineers (USACE) HEC-RAS 5.0.3. A one dimensional model was used to evaluate existing conditions and proposed conditions. The proposed model predicted a 100-year flood elevation of 212.7 feet at the upstream end of the culvert.

A scour analysis has been completed for design of the culvert foundation by determining the required sour depth for revetment. The analysis was carried out following the Federal Highway Administration (FHWA) Evaluating Scour at Bridges (HEC-18) manual. Local scour was not computed since the culvert abutments will be protected with adequately sized riprap. Scour depths were estimated for the 100- and 500-year peak discharges. The 100-year and 500-year scour depths were calculated to be zero feet. The footings will be embedded by a minimum of 1 foot. Once the preferred alternative is selected the exact embedment will be determined based on dimensions of the proposed culvert, minimum required span, and cover.

Geomorphic Measurements

- Bankfull Width (BFW) = 13.8 feet
- Bed Material D_{50} = 24.6 mm
- Upstream Average Channel Slope(existing) = 0.8%
- Culvert Slope (existing) = 0.98%
- Downstream Average Channel Slope (existing) = 0.5%

Fish Passage Design

The following criteria will be used to meet fish passage design requirements:

- Minimum Span Requirement per WDFW requirements is 1.2 times the BFW + 2 ft
- Minimum Span = (1.2 x 13.8) + 2 feet = 18.6 feet

Wetlands

A field survey of the wetlands in the vicinity of the crossing has been completed and extents of the wetlands were staked and subsequently surveyed. Wetlands were identified and delineated on both ends of the culvert and the boundaries of the wetlands extend to the edges of the existing culvert structure. Additionally, some wetland ditches were identified and delineated on both sides of the roadway on the south approach to the culvert.

Geotechnical

A geotechnical boring was conducted at the location of the proposed culvert. The foundations for the culvert are anticipated to be founded in the Troutdale Formation, a gravelly, loosely cemented layer that provides competent bearing capacity. The soils at this crossing site pose little to no adverse seismic effects such as liquefaction. GRI has provided preliminary input for alternative selection; a final report is forthcoming.

Utilities

In the vicinity of this culvert there are overhead lines on both sides of the roadway. These do not have any long-term impacts on the design, but will need to be considered for their impacts on construction. No buried utilities have been surveyed at this time.

Alternatives

Alternates are discussed below; supporting information, including drawings of each alternate with information on the cost estimate can be found in the appendices to this report. Alternates for the south culvert are divided by skew. Alternates 1a, 1b, and 1c are for a square-ended culvert. Alternate 2a is for a skew-ended culvert.

The skewed configuration can be laid out to require little to no additional Right of Way (ROW). The square ended configuration will require purchasing ROW to accommodate the embankment and wingwalls. In any case all options will require a temporary construction easement to provide clearance for the Contractor to access and prepare the site during construction.

Alternate 1a – Precast Concrete Structure with Squared Ends

This alternate is for a precast reinforced concrete three sided structure. The shape for this alternate is a rectangular opening with squared corners. This shape has the advantage of being efficient from a hydraulic design perspective. Footings can be either cast in place or precast concrete footings.

Cost

The relative cost for this option is $483,700. This is the estimated cost for excavation; dewatering for footings and stream diversion, supplying and installing the culvert, stream reconstruction, footings, and headwall; and for backfilling the structure. Costs for removing the existing culvert, Contractor mobilization, contingency etc. are not included.

Constructability

This type of culvert is efficient to construct. The structure arrives to the site in precast segments. Once the segments are placed, then backfilling can begin. The structure is rigid and does not require special consideration for backfill procedure.

Impacts

Due to the proximity of the wetland areas to this structure, this alternate would have permanent impacts on the adjacent wetlands. The squared ends of the culvert would require embankment to be constructed in within the fringes of these wetlands causing further impacts that would require mitigation. This culvert option can be constructed with a 19 foot span which would meet the permitting requirements for fish passage.

Headwalls

For this type of structure, several types of headwall are considered, including precast, cast in place, and a block-type (ultrablock, gabion, or mechanically stabilized earth). For this alternate, a precast wall was priced for comparison; precast headwalls are frequently paired with precast structures to lend a uniform appearance. Additionally, since the installation of the precast headwall is similar to a precast culvert, matching the structure types streamlines the overall construction and can allow for “dry” assembly to verify component fit up and constructability prior to delivery to the site.

Alternate 1b – Single Radius Steel Arch

This alternate is for a single radius, steel plate arch culvert... This type of shape is structurally efficient, which helps make the materials cost efficient; it has the disadvantage of requiring larger span structures to get the same equivalent hydraulic opening compared to a box-type structure. In comparison with the precast concrete alternate, greater care in backfill placement and compaction is also required.

Cost

The relative cost for this option is $370,200. This is the estimated cost for excavation; dewatering for footings and stream diversion, supplying and installing the culvert, footings, and headwall; and for backfilling the structure. Costs such as removing the existing culvert, stream reconstruction, Contractor mobilization, etc. are not included in this number.

Constructability

This type of culvert exchanges efficiency of materials for speed of construction and therefore the construction is not as fast as a precast structure: the structure arrives on site as curved plates that are bolted together on site; the flexible nature of the structure requires backfilling procedure follow strict guidelines and monitoring as specified by the manufacturer.

Impacts

Due to the proximity of the wetland areas to this structure, this alternate would have permanent impacts on the adjacent wetlands. The squared ends of the culvert would require embankment to be constructed in within the fringes of these wetlands. This culvert option can be constructed with a 19 foot span which would meet the permitting requirements for fish passage. Due to the shape of the opening, additional hydraulic modeling would be required to verify the adequacy of a 19 foot structure before the shorter span can be finalized.

Headwalls

For this type of structure, several types of headwall were considered, including precast, cast in place, and a block-type (ultrablock, gabion, or mechanically stabilized earth). Steel plate arches are flexible compared concrete headwalls, therefore a flexible headwall such as an MSE wall or a gabion wall is preferred. For this analysis, a gabion wall option was used for cost estimating; the headwall type will be finalized after a culvert alternate is selected.

Alternate 1c – Multiple Radius Steel Arch

This alternate is for a multiple radius, steel plate arch culvert. The shape for this alternate is a sinuous arch. Similar to the single radius arch this type of shape is structurally efficient, which helps make the materials cost efficient; the multiple radius shape has the additional advantage of providing a hydraulically efficient opening when compared to a single radius arch.

Cost

The relative cost for this option is $369,100. This is the estimated cost for excavation; stream diversion and dewatering for the footings; supplying and installing the culvert, footings, and headwall; and for backfilling the structure. Costs such as removing the existing culvert, stream reconstruction, Contractor mobilization, etc. are not included in this number.

Constructability

This type of culvert exchanges efficiency of materials for speed of construction and therefore the construction is not as fast as a precast structure: the structure arrives on site as curved plates that are bolted together on site; the flexible nature of the structure requires backfilling procedure follow strict guidelines and monitoring as specified by the manufacturer.

Impacts
Due to the proximity of the wetland areas to this structure, this alternate would have permanent impacts on the adjacent wetlands. The squared ends of the culvert would require embankment to be constructed in within the fringes of these wetlands.

Headwalls
For this type of structure, several types of headwall were considered, including precast, cast in place, and a block-type (ultrablock, gabion, or mechanically stabilized earth). Steel plate arches are more flexible than concrete headwalls, therefore a flexible headwall such as an MSE wall or a gabion wall is preferred. For this analysis, a gabion wall option was used for cost estimating; the headwall type will be finalized after a culvert alternate is selected.

Alternate 2a – Precast Concrete Structure with Skewed Ends
This alternate is for a precast reinforced concrete three-sided structure. The shape for this alternate is a rectangular opening with square corners. This shape has the advantage of being efficient from a hydraulic design perspective. This alternate differs from Alternate 1a because the ends of the culvert are skewed; this fits the structure within the right of way without permanent easements and reducing the impact to wetlands.

Cost
The relative cost for this option is $506,000. This is the estimated cost for excavation; stream diversion and dewatering for footings; supplying and installing the culvert, footings, and headwall; and for backfilling the structure. Costs such as removing the existing culvert, stream reconstruction, Contractor mobilization, etc. are not included in this number.

Constructability
This type of culvert is efficient to construct. The structure arrives to the site in precast segments. Once the segments are placed, then backfilling can begin. The structure is rigid and does not require special consideration for backfill procedure. Headwalls however become geometrically more complex and comparatively more difficult to install. Additionally, while square ended culvert segments are readily available as an ASTM standard, skewed ends require special design detailing and manufacture, impacting costs.

Impacts
Skewing the ends of the structure allows it to be constructed with no permanent impacts on the adjacent wetlands. The skewed ends will help minimize this impact; additionally, the skewed ends of the culvert require little to no permanent ROW acquisition.

Headwalls
For this type of structure, several types of headwall were considered, including precast, cast in place, and a block-type (ultrablock, gabion, or mechanically stabilized earth). For this

alternate, a precast wall was included in the price; precast headwalls are frequently paired with precast structures to lend a uniform appearance. Additionally, since the installation of the precast culvert is similar to a precast headwall, matching the structure types streamlines the overall construction and can allow for "dry" assembly to verify component fit up and constructability prior to delivery to the site.

Middle Culvert

Description

The middle culvert is located where Daybreak Creek transitions from a steeply sloped and confined streambed to a more gradually sloped and less confined stream channel. The culvert inlet is perched above a small pool. The culvert is a 48 inch diameter round, smooth concrete culvert approximately 77 feet long. The culvert is in moderate condition with a smooth interior and no noted accumulation of debris or sediment within.

Roadway

The proposed roadway alignment will closely match existing. The roadway pavement cross section, including lane widths, will closely match the existing conditions with the addition of a gravel shoulder and guardrail on each side of the roadway. Proposed finished grade in this area will be raised less than 0.5 ft.

Crossing Alignment

The stream channel upstream and downstream of the culvert closely parallels the roadway alignment and the channel turns sharply at the inlet and outlet of the culvert. Some skew was constructed in the current culvert alignment to mitigate these bends. Adding additional skew would increase the length of the culvert significantly with associated costs and additional impacts, to avoid these impacts, the proposed culvert will match the existing alignment for the purposes of this analysis. The downstream channel may be realigned and if so may affect the culvert alignment as design progresses. The proposed alignment is skewed relative to the roadway by approximately 26 degrees. For culvert options presented, particularly steel options, a skewed alignment will require some additional embankment construction around the culverts to create a balanced fill condition on both sides of the culvert, at this site, the narrow channel at the upstream end naturally provides embankment to help balance the culvert backfill.

Construction

It is proposed to fully close the roadway while the existing culvert is removed and the new culvert is installed. This will facilitate the required stream bypass installation to isolate the work area. This bypass can be installed in a deep trench or be pumped across the roadway embankment on the south approach to the culvert. There are several existing slopes in the vicinity of the culvert and some shoring may be required to prevent significant excavation. The timing of the construction will be governed by the In Water Work Window (IWWW). For this site it is anticipated that the IWWW will be between July 1st and August 31st.

Hydraulics

Description

The stream at the middle crossing is relatively steep compared to the other two crossings consisting of cascades and riffles. The substrate present at this crossing is primarily gravels and cobbles with few fine-grained sediments. Evidence of scour and erosion is present immediately downstream of the existing crossing. The erosion is occurring at the culvert outlet and further downstream along the oversteepened road embankment. The existing crossing is a 48 inch CMP culvert. Vegetation includes some lawn, shrubs, and some trees. Large wood is present in downstream of the crossing.

Hydraulic Analysis

The hydraulic analysis was performed using the United States Army Corps of Engineers (USACE) HEC-RAS 5.0.3. A one dimensional model was used to evaluate existing conditions and proposed conditions. The proposed model predicted in a 100-year flood elevation of 132.7 feet at the upstream end of the culvert.

A scour analysis has been completed for design of the culvert foundation by determining the required sour depth for revetment. The analysis was carried out following the Federal Highway Administration (FHWA) Evaluating Scour at Bridges (HEC-18) manual. Local scour was not computed since the culvert abutments will be protected with adequately sized riprap. Scour depths were estimated for the 100- and 500-year peak discharges. The 500-year scour depth was calculated to be 1.30 feet (upstream elevation: 128.1 feet; downstream elevation: 118.4 feet). The footings will be embedded by a minimum of 3 feet. Once the preferred alternative is selected the exact embedment will be determined based on available structure dimensions, minimum required span, and cover constraints.

The existing channel reach is relatively steep. The slope of the existing culvert is steeper than the upstream and downstream channels. Additionally, there is a substantial drop at the outlet of the culvert. The proposed design will work to provide a smooth transition from the upstream channel, through the culvert to the downstream channel, minimizing substantial changes in grade to help protect against hydraulic conditions that would result in a head cut. The steepness of the proposed culvert will necessitate a cascade and pool channel form to provide hydraulic conditions more favorable for fish passage.

Geomorphic Measurements

- Bankfull Width (BFW) = 13.5 feet
- Bed Material D_{50} = 51.4 mm
- Upstream Average Channel Slope(existing) = 5.1%
- Culvert Slope (existing) = 7.53%
- Downstream Average Channel Slope (existing) = 5.8%

Fish Passage Design

The following criteria will be used to meet fish passage design requirements:

- Minimum Span Requirement per WDFW requirements is 1.2 times the BFW + 2 feet
- Minimum Span = (1.2 x 13.5) + 2 feet = 18.3 feet

Flooding

This site is not in a FEMA mapped floodplain. Our HEC-RAS model shows that the proposed 18-foot culvert passes the 100-year flood with ample clearance (5.6-6.8 feet of clearance) to the underside of the culvert. Additionally, hydraulic modeling was performed to examine the flow conditions before and after the culvert replacement. The results show that the existing culvert is a restriction, and when taken out, more flow will occur downstream. The 100-year water surface immediately downstream of the culvert will rise 0.5 feet as a result in the flow increase. Approximately 460 feet downstream of the middle culvert are two smaller twin culverts under a residential driveway. The increase in flood elevation at this location will have diminished to 0.3 feet, so the overall impact is expected to be minor.

We have spoken with the property owner, and he indicated that the culverts have never been overtopped in his recollection. The increase in localized flood risk at the driveway crossing is expected to be small, but nonetheless should be documented.

Wetlands

A field survey of the wetlands was conducted in the vicinity of the crossing and none were encountered at this culvert site.

Geotechnical

A geotechnical boring was conducted at the location of the proposed culvert. The foundations for the culvert are anticipated to be founded in the Troutdale Formation, a gravelly, loosely cemented layer that provides competent bearing capacity. The soils at this crossing site pose little to no adverse seismic effects such as liquefaction. GRI has provided preliminary input for alternatives analysis; a final report is forthcoming.

Utilities

In the vicinity of this culvert there are no utilities that have been located or surveyed at this time.

Alternatives

Alternates are discussed below; supporting information, including drawings of each alternate as well as information on the cost estimate can be found in the appendices to this report. Due to the skewed configuration, constructing the culvert will require purchasing additional ROW to accommodate embankment and wingwalls. The culvert will also require a temporary construction easement to provide clearance for the Contractor to access the site during construction.

Alternate A – Precast Concrete Structure with Squared Ends

This alternate is for a precast reinforced concrete three sided structure. The cross sectional shape for this alternate is a rectangular opening with square corners. This shape has the advantage of being efficient from a hydraulic design perspective. Footings can be cast in place or precast concrete.

Cost

The relative cost for this option is $553,300. This is the estimated cost for excavation; stream diversion; dewatering for the footings; supplying and installing the culvert, stream reconstruction, footings, and headwall; and for backfilling the structure. Costs such as removing the existing culvert, Contractor mobilization, etc. are not included in this number.

Constructability

This type of culvert is efficient to construct. The structure arrives to the site in precast segments. Once the segments are placed, then backfilling can begin. The structure is rigid and does not require special consideration for backfill procedure.

Impacts

Several moderate sized trees may need to be removed to construct the culvert at this location. Mitigation may be required but has not been determined at this time. This culvert option can be constructed with a 19 foot span which would meet the permitting requirements for fish passage.

Headwalls

For this type of structure, several types of headwall were considered, including precast, cast in place, and a block-type (ultrablock, gabion, or mechanically stabilized earth). For this alternate, a precast wall was included in the price; precast headwalls are frequently paired with precast structures to lend a uniform appearance. Additionally, since the installation of the precast headwall is similar to a precast culvert, matching the structure types streamlines the overall construction and can allow for “dry” assembly to verify component fit up and constructability prior to delivery to the site.

Alternate B – Single Radius Steel Arch

This alternate is for a single radius, steel plate arch culvert. This type of shape is structurally efficient, which helps make the materials cost efficient; it has the disadvantage of requiring larger span structures to get the same equivalent hydraulic opening compared to a box-type structure. In comparison with the precast concrete structure, greater care in backfill placement and compaction is also required.

Cost

The relative cost for this option is $429,000. This is the estimated cost for excavation; supplying and installing the culvert, footings, and headwall; and for backfilling the structure. Costs such as removing the existing culvert, stream reconstruction, Contractor mobilization, etc. are not included in this number.

Constructability

This type of culvert exchanges efficiency of materials for speed of construction and therefore the construction is not as fast as a precast structure: the structure arrives as curved plates that are bolted together on site; due to the flexible nature of the structure, the backfilling procedure needs to follow strict guidelines and monitoring as specified by the manufacturer.

Impacts

Several moderate sized trees may need to be removed to construct the culvert at this location. Mitigation may be required but has not been determined at this time. This culvert option can be constructed with a 19 foot span which would meet the permitting requirements for fish passage. If this alternate is selected, additional hydraulic modeling would be required for this structure to verify that the shorter span meets all hydraulic requirements before the span can be finalized.

Headwalls

For this type of structure, several types of headwall were considered, including precast, cast in place, and a block-type (ultrablock, gabion, or mechanically stabilized earth). Steel plate arches require a cast in place concrete collar to transition between the headwall and the culvert structure. Due to the flexible nature of the structure, a flexible headwall such as an MSE wall or a gabion wall is preferred for this type of structure. For this analysis, a gabion wall option was used for cost estimating; the headwall type will be finalized after a culvert alternate is selected.

Alternate C – Multiple Radius Steel Arch

This alternate is for a multiple radius, steel plate arch culvert. The shape for this alternate is a sinuous arch. This type of shape is structurally efficient, which helps make the materials cost efficient; the multiple radius shape has the additional advantage of providing a hydraulically efficient opening when compared to a single radius arch.

Cost

The relative cost for this option is $425,800. This is the estimated cost for excavation; supplying and installing the culvert, footings, and headwall; and for backfilling the structure. Costs such as removing the existing culvert, stream reconstruction, Contractor mobilization, etc. are not included in this number.

Constructability

This type of culvert exchanges efficiency of materials for speed of construction and therefore the construction is not as fast as a precast structure: the structure arrives on site as a stack of curved plates that are bolted together on site; due to the flexible nature of the structure, the backfilling procedure needs to follow strict guidelines and monitoring set forth by the manufacturer.

Impacts

Several moderate sized trees may need to be removed to construct the culvert at this location.

Headwalls

For this type of structure, several types of headwall were considered, including precast, cast in place, and a block-type (ultrablock, gabion, or mechanically stabilized earth). Steel plate arches require a cast in place concrete collar to transition between the rigid concrete headwall and the culvert structure. To avoid this and due to the flexible nature of the structure, a flexible headwall such as an MSE wall or a gabion wall is preferred for this type of structure. For this analysis, a gabion wall option was used for cost estimating; the headwall type will be finalized after a culvert alternate is selected.

Northern Culvert

Description

The northern culvert is located where Daybreak Creek is in a shallow channel in a flat plane. There is a pool formed in the channel upstream of the culvert. The culvert is embedded and has limited access for observation and measurement. The culvert is a 36 inch CMP and is approximately 44 feet long. The condition of the culvert could not be determined due to the embedment of the structure.

Roadway

The proposed roadway alignment will closely match the existing roadway alignment. The roadway cross section, including lane widths, will also match the existing conditions with the addition of a gravel shoulder and guardrail on each side of the roadway. Due to the shallow depth of fill over the new culvert, no guardrail posts may be driven into the fill above the culvert. Instead, the guardrail will transition to precast concrete barrier over the culvert. The current proposed alignment shows the finished grade in this area will be raised approximately 3 feet to accommodate stormwater conveyance. Based on final stormwater design, this pipe may be mounted on the outside of the culvert and eliminate the need for raising the grade.

Crossing Alignment

The stream channel upstream of the culvert closely parallels the roadway alignment and the channel turns sharply at the inlet of the culvert; downstream the channel is approximately perpendicular to the roadway alignment. Minor skew is included in the current culvert to average these upstream and downstream conditions. The alignment is skewed relative to the roadway by approximately 5 degrees.

Construction

During construction, the roadway will be fully closed while the existing culvert is removed and the new culvert is installed. This will require a stream bypass to be installed to isolate the work area. This bypass can be installed in a trench or be pumped across the roadway embankment on the north approach to the culvert. The site is in a flat plain with the stream channel cutting through it: excavation can be completed laying-back the slope with no need for additional shoring. The timing of the construction will largely be governed by the In Water Work Window (IWWW). For this site it is anticipated that the IWWW will be between July 1st and August 31st.

Hydraulics

Description

The stream at the northern crossing is gently sloped and characterized by pools and riffles. The banks are primarily maintained landscaped areas with few trees. A scour pool exists at the downstream end of the culvert. A vegetated island is present immediately upstream of the crossing, separating the main channel from a high flow channel and a manmade berm exists along the north and east edges of the stream and when the berm is overtopped, connects into the East Fork Lewis River floodplain area. The existing road crossing is a 36" CMP culvert. Just upstream of the road crossing is a private driveway crossing with three pipes and they are hydraulically restricted.

Hydraulic Analysis

The hydraulic analysis was performed using the United States Army Corps of Engineers (USACE) HEC-RAS 5.0.3. A one dimensional model was used to evaluate existing conditions and proposed conditions. The proposed model resulted in a 100-year flood elevation of 97.8 feet at the upstream face of the culvert.

A scour analysis was performed to assist with the design of the culvert foundation and determine the required sour depth for revetment design. The analysis was carried out following the Federal Highway Administration (FHWA) Evaluating Scour at Bridges (HEC-18) manual. Local scour was not computed since the culvert abutments will be protected with adequately sized riprap. Scour depths were estimated for the 100- and 500-year peak discharges. The 500-year scour depth was calculated to be 0.2 feet (upstream elevation: 95.1 feet; downstream elevation: 94.3 feet). The footings will be embedded by a minimum of 1 foot. Once the preferred alternative is selected the exact embedment will be determined based on available structure dimensions, minimum required span, and cover constraints.

Geomorphic Measurements

- Bankfull Width (BFW) = 16.1 feet
- Bed Material D_{50} = 42.2 mm
- Upstream Average Channel Slope(existing) = 1.8%
- Culvert Slope (existing) = 1.28%
- Downstream Average Channel Slope (existing) = 4.3%

Fish Passage Design

- Minimum Span Requirement per WDFW requirements is 1.2 times the BFW + 2 feet
- Minimum Span = (1.2 x 16.1) + 2 feet = 21.3 feet

Flooding

Similar to the middle culvert location, this site is also not in a FEMA mapped floodplain. Our HEC-RAS model shows that the proposed 22-foot culvert passes the 100-year flood with limited clearance (1.1-1.8 feet of clearance) to the underside of the culvert. Additionally, hydraulic modeling was performed to examine the flow conditions before and after the culvert replacement. The results show that the existing culvert is a restriction, and when taken out, more stream flow will occur downstream. The 100-year water surface immediately downstream of the culvert will rise by 0.5 feet, but will diminish farther downstream to 0.4 feet.

Approximately 100 feet downstream there is a residential foot bridge and a wooden deck off the back side of a residence. The foot bridge currently gets inundated by high water frequently, as well as the posts for the wood deck. The potential increase in the maximum flood elevation at the deck location is only expected to be 5 inches, which will likely have a minimal impact on the structure.

Wetlands

A field survey of the wetlands in the vicinity of the crossing has been completed and extents of the wetlands were staked and subsequently surveyed. No wetlands were encountered for this culvert site.

Geotechnical

A geotechnical boring was conducted at the location of the proposed culvert. The foundations for the culvert are anticipated to be founded in a soft sandy layer just above the Troutdale Formation, a gravelly, loosely cemented layer that provides competent bearing capacity. The foundation detailing will require overexcavating for the foundations and placing quarry spalls between the top of the Troutdale Formation and the bottom of footing elevation. The soils at this crossing site pose minor adverse seismic effects in the form of liquefaction settlement potential. Overexcavation as described above will mitigate the potential for liquefaction settlement. GRI has provided preliminary input for alternatives analysis; a final report is forthcoming.

Utilities

In the vicinity of this culvert there are overhead lines on both sides of the roadway. These do not present any limitations on the design, but will need to be considered for impacts on construction. No buried utilities have been located or surveyed at this time.

Alternatives

Alternates are discussed below; supporting information, including drawings of each alternate as well as information on the cost estimate can be found in the appendices to this report. Due to the skewed configuration, constructing the culvert will require purchasing additional

ROW to accommodate the embankment and wingwalls. The culvert will also require a temporary construction easement to provide clearance for the Contractor to access the site during construction.

Alternate A – Precast Concrete Structure

This alternate is for a precast reinforced concrete three sided structure. The shape for this alternate is a rectangular opening with square corners. This shape has the advantage of being efficient from a hydraulic design perspective. Footings can be either precast or cast in place concrete.

Cost

The relative cost for this option is $332,900. This is the estimated cost for excavation; stream diversion and dewatering for footings; supplying and installing the culvert, footings, and headwall; and for backfilling the structure. Costs such as removing the existing culvert, stream reconstruction, Contractor mobilization, etc. are not included in this number.

Constructability

This type of culvert is efficient to construct. The structure arrives to the site in precast segments. Once the segments are placed, then backfilling can begin. The structure is rigid and does not require special consideration for backfill procedure.

Impacts

Several moderate sized trees may need to be removed to construct the culvert at this location. This culvert option will be constructed with a minimum 21 foot span to comply with the permitting requirements.

Headwalls

For this type of structure, several types of headwall were considered, including precast, cast in place, and a block-type (ultrablock, gabion, or mechanically stabilized earth). For this alternate, a precast wall was included in the price; precast headwalls are frequently paired with precast structures to lend a uniform appearance. Additionally, since the installation of the precast culvert is similar to a precast headwall, matching the structure types streamlines the overall construction and can allow for "dry" assembly to verify component fit up and constructability prior to delivery to the site.

Alternate B – Slab Bridge

This alternate is for a prestressed, precast slab bridge. The shape for this alternate is a rectangular opening with square corners. This shape has the advantage of being efficient from a hydraulic design perspective.

Cost

The relative cost for this option is $365,000. This is the estimated cost for excavation; stream diversion and dewatering for footings; supplying and installing the deck, footings, and abutments; and for backfilling the structure. Costs such as removing the existing culvert, stream reconstruction, Contractor mobilization, etc. are not included in this number.

Constructability

This type of structure is efficient to construct. The Contractor will excavate and install cast in place abutments, then the precast slabs are arrive on site and are placed on the abutments. This structure will not require any soil cover over the slabs; it will be constructed so that roadway asphalt is installed over the deck after the abutments are backfilled. Approach slabs will be required at either approach to the structure.

Impacts

Several moderate sized trees may need to be removed to construct the culvert at this location. A 21 foot span structure will be required to comply with the permitting requirements.

Headwalls

For this type of structure, no headwalls are required; cast in place abutment walls serve as the wingwalls for the opening.

Longevity

Standard design life of culvert structures is 75 years. Both steel and precast concrete structures meet or exceed this criterion. Beyond a 75 year service life, precast structures can be expected to last nominally longer than steel structures.

Construction Scheduling

The replacement of the three culverts presents two challenges in that there is limited time for the in-water work and that no two culverts can be closed at the same time due to access requirement to adjacent properties.

Regarding the In-Water-Work-Window (IWWW), we have briefly spoken with WDFW, USACE, and NOAA representatives. It appears that the IWWW could be either 8/1 – 8/15, or 7/1 – 8/31, or somewhere in between. NOAA will make the ultimate determination but presently not able to commit to a time without seeing the proposed project. Based on past recent projects in Clark County and on similar streams, we have seen that 8 weeks (7/1 –

8/31) is the typical allotted time for the IWWW. We are recommending that project planning at this time be based on this.

The construction time for replacing a culvert can be highly variable, depending on the size of culvert, site conditions, etc. For example, the recent NW Carty Road Culvert replacement in Clark County had a road closure of around 60 days, with the in-water portion of the work being at least 40 days. On the other end, the recent culvert replacement on NE Borin Rd in Clark County (north of Washougal) was completed with a road closure of only 6 days. There are methods available to accelerate the construction such as requiring two shifts of workers, allowing work 7 days a week, and using culverts that can be installed rapidly.

For this project, we envision two scenarios. The first is to construct the project in two seasons and the second is to use accelerated construction techniques in order to replace all three culverts in the same season. Discussion of each is as follow:

Two Season Construction

This scenario would most likely result in constructing the north and south culvert in one season, and the middle culvert in another season. In this scenario, the most cost effective approach would be to use the least expensive culvert option for each crossing with longer closure times for each. For the first season, the south culvert would be the longer steel plate arch. If the road is closed one or two weeks before the IWWW, this would allow up to 7 weeks of closure (with 5 weeks in the IWWW). This should be ample time for construction, with minimal overtime or weekend work. The second closure would be for the north culvert. If the precast three sided structure is used here, a 5 week closure could be done, with 3 of the first weeks being within the IWWW, with two weeks of closure following to do the final backfill, paving, and guardrail placement. The second season would allow the middle culvert to be replaced, which could be done in 10 weeks, with a week before and after the 8 week IWWW. If you add the costs for each of these options (from the matrices in the appendix) – this totals approximately $1,127,800.

One Season Construction

This scenario would require close coordination between all three culvert replacement sites, with work efforts overlapping. In order to do this, the north and south culverts would need to be precast three sided concrete structures with precast footings and wing walls. The middle culvert would still be a steel plate arch with MSE or Hilfiker headwalls, as the deep cuts and wall configurations make a precast culvert option difficult and expensive. In addition, two shifts would be needed to accommodate this work, along with work on the weekends. A proposed construction schedule for this scenario is included in Appendix C.

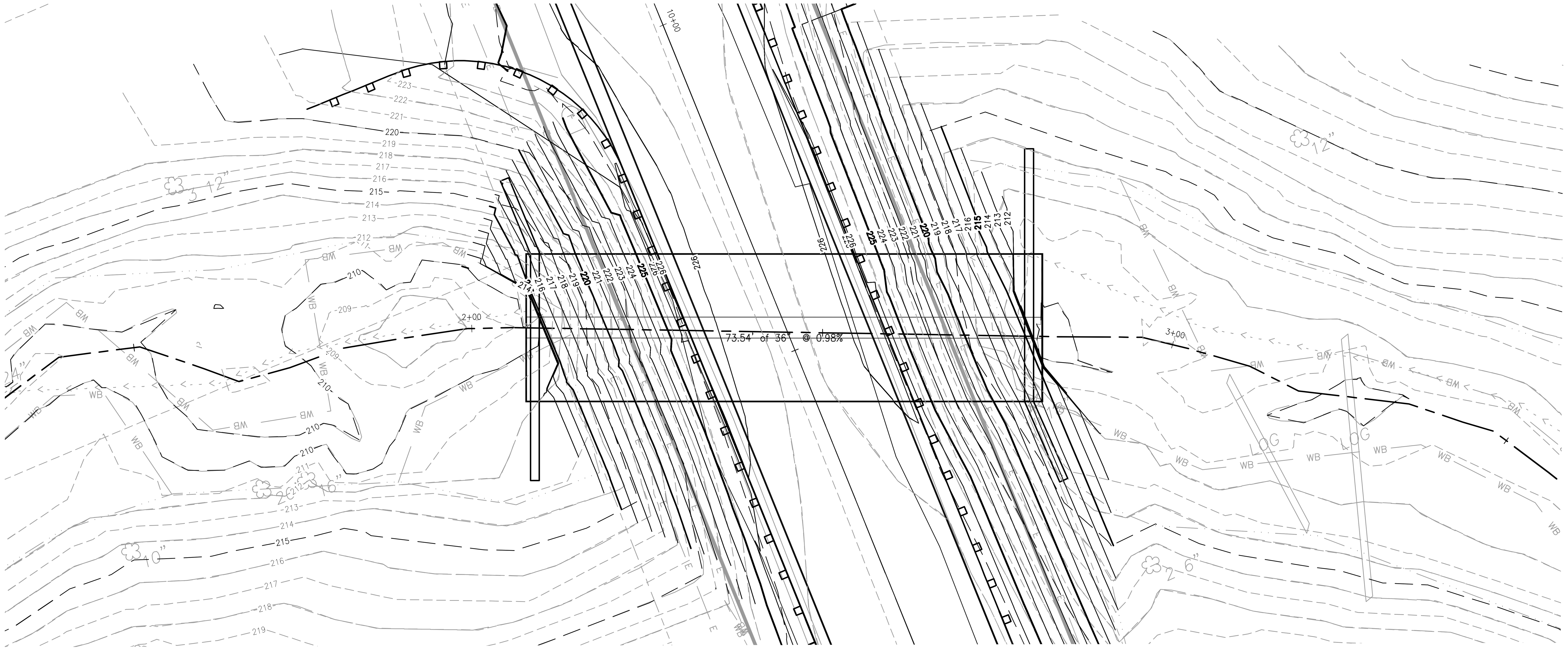
The costs for this option would be a total amount (from the matrices in the appendix) of $1,242,400, plus an additional 10% for acceleration and double shifting.

However, if this scenario can save an entire construction season, there is significant project savings, both for the contractor and the owner. The savings for the contractor is an additional mobilization and demobilization along with overhead costs for an additional 6 to 9 months. It is difficult to assign exact costs for this, but an estimated amount for both of these would be in the range of $100,000. The savings for the owner would be project administration and inspection costs, which could be in the range of $50,000 to $80,000.

Preferred Alternative

After review of the site conditions, impacts to the environment, road closure impacts, and cost, it is our opinion that the preferred alternative for the project would be to use one construction season using accelerated construction techniques. Even though the actual construction costs may be slightly higher with this alternative, there should be an overall reduction in total project cost. And it is significantly less disruptive for the adjoining property owners and the traveling public. Additionally, from an environmental sensitivity standpoint, there is substantial less risk to the stream as it would only involve work during one IWWW rather than two.

Appendix A:
30% Structure Drawings



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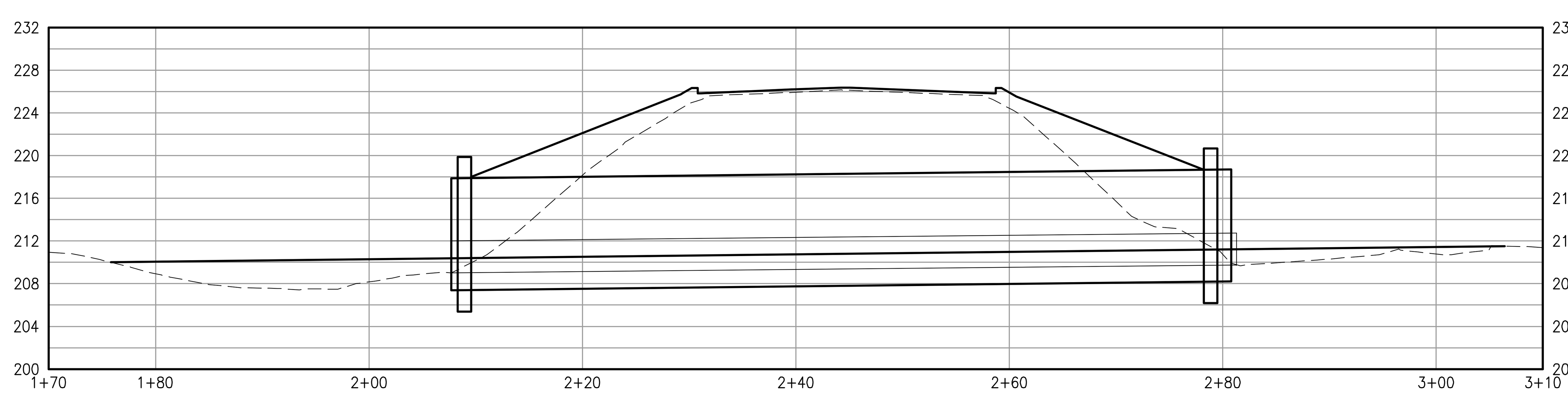

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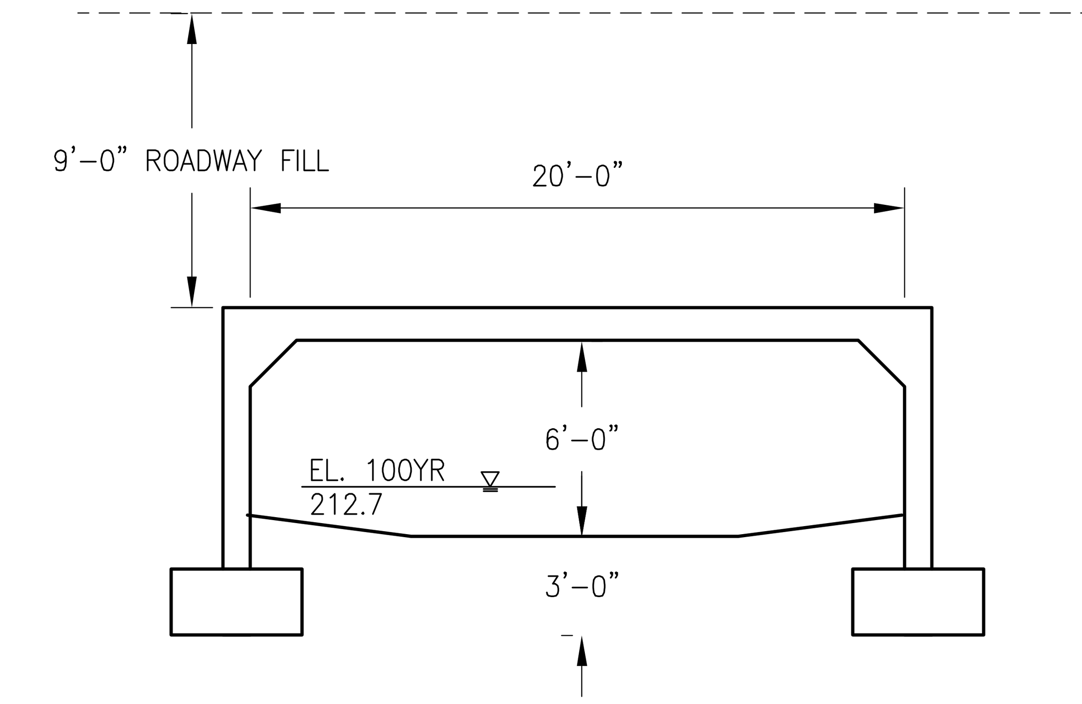

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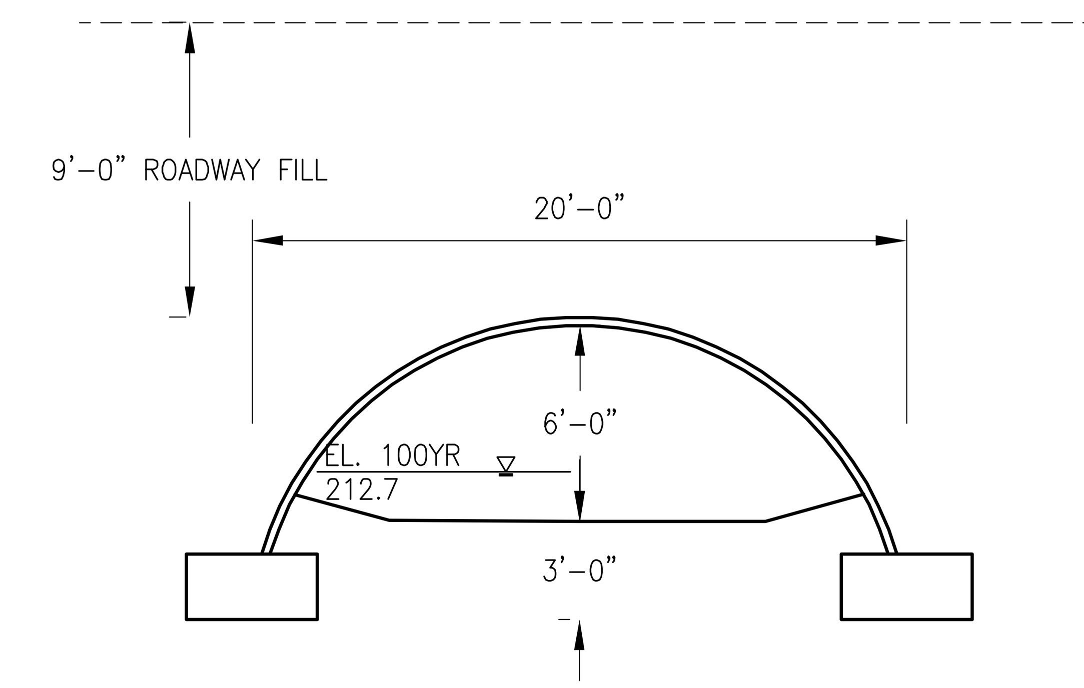

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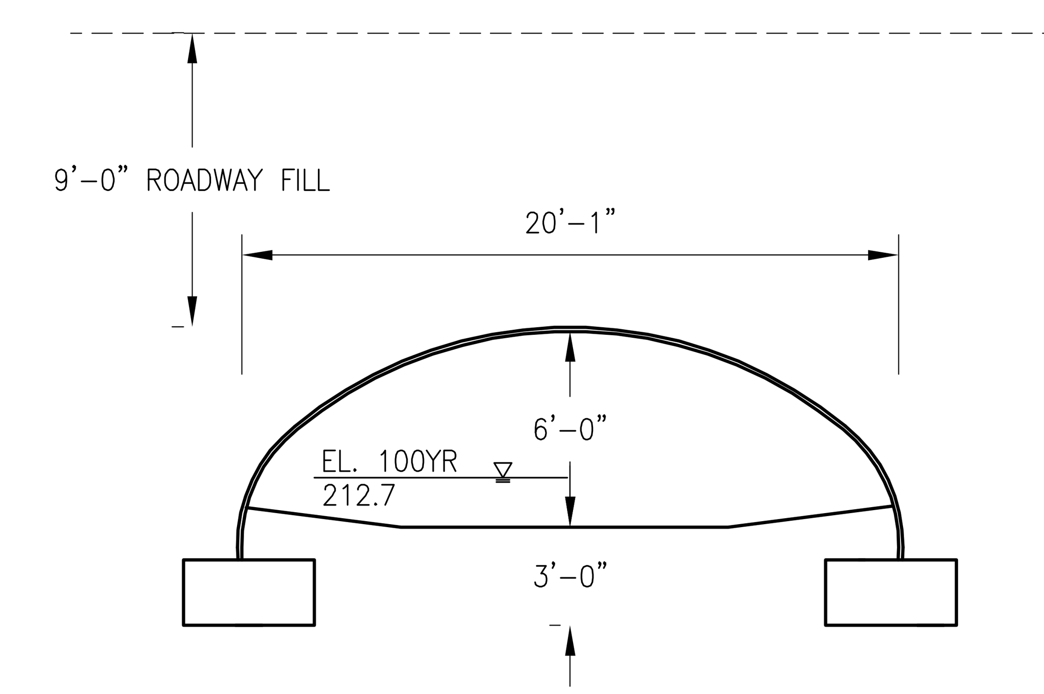
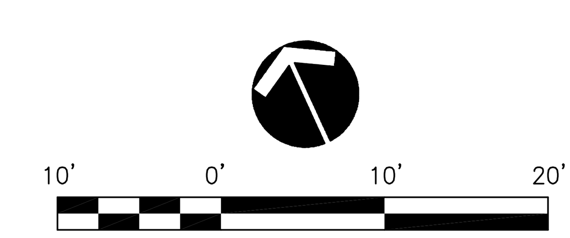


CULVERT OPTION 1C



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TRANSPORTATION PROGRAM

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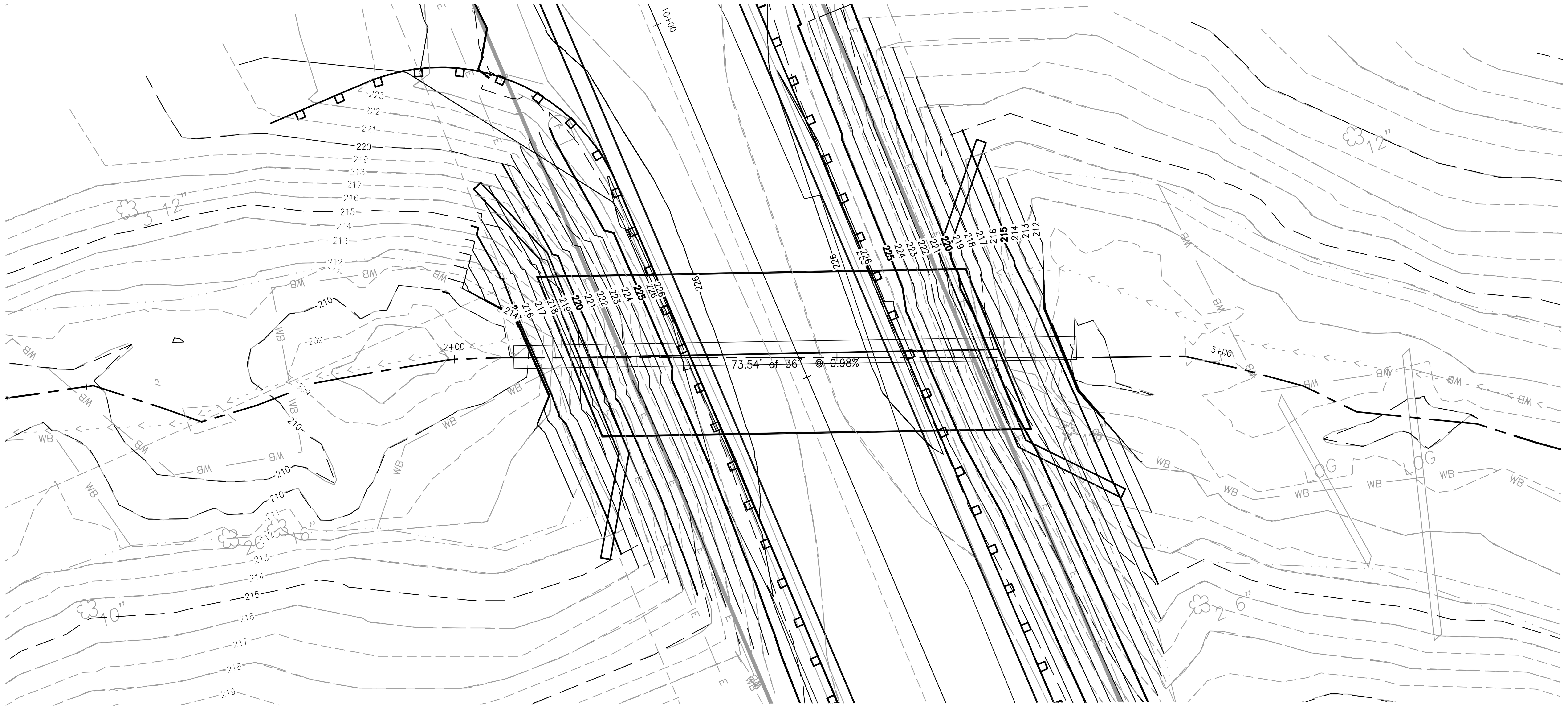

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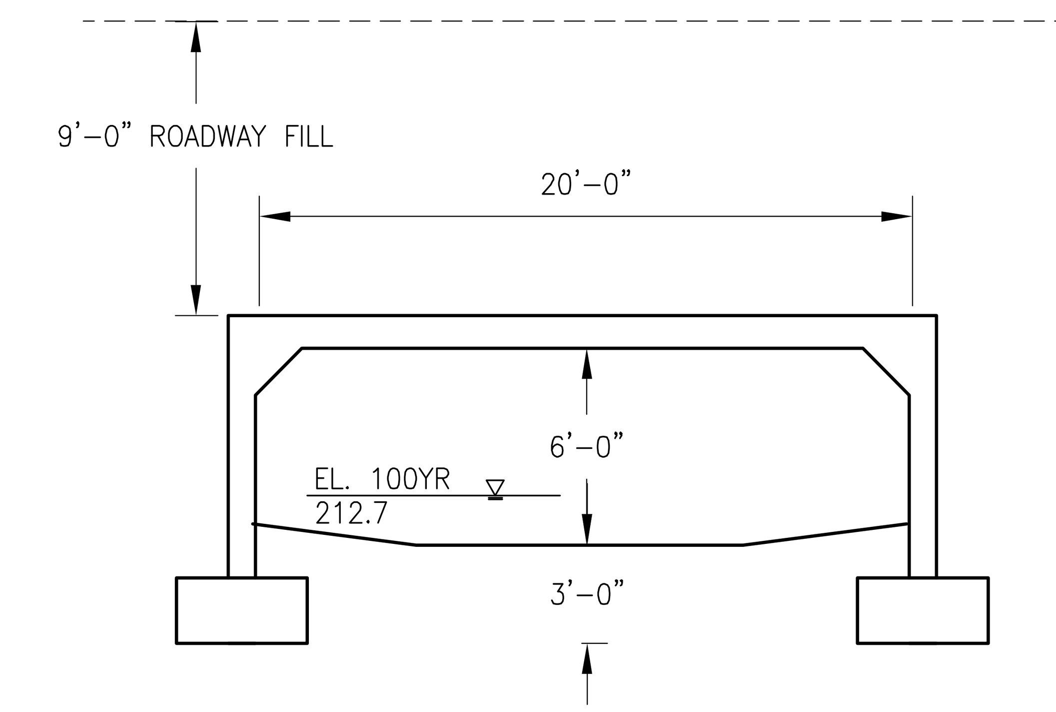

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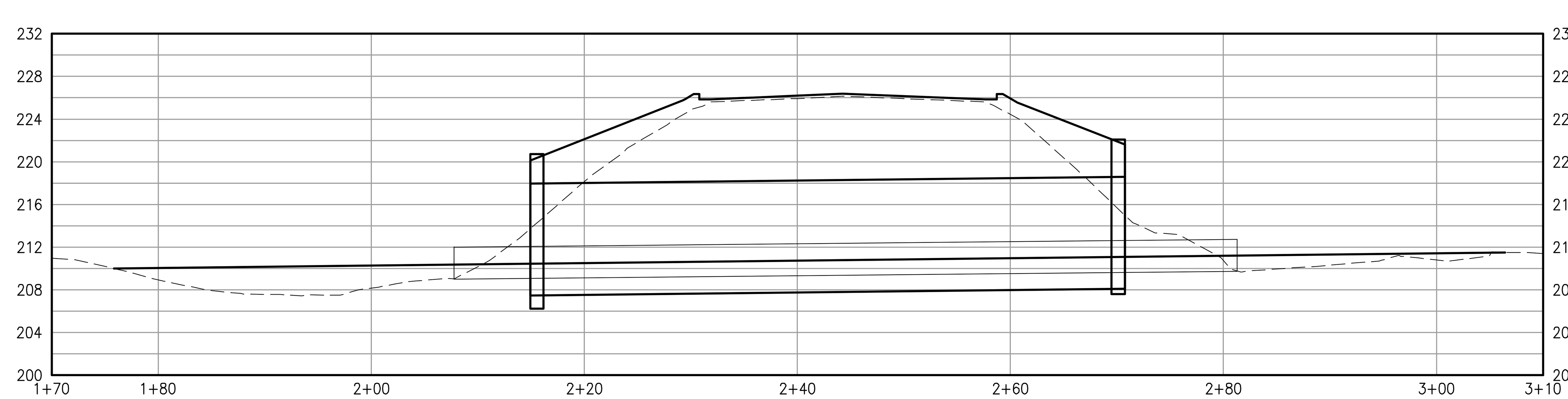

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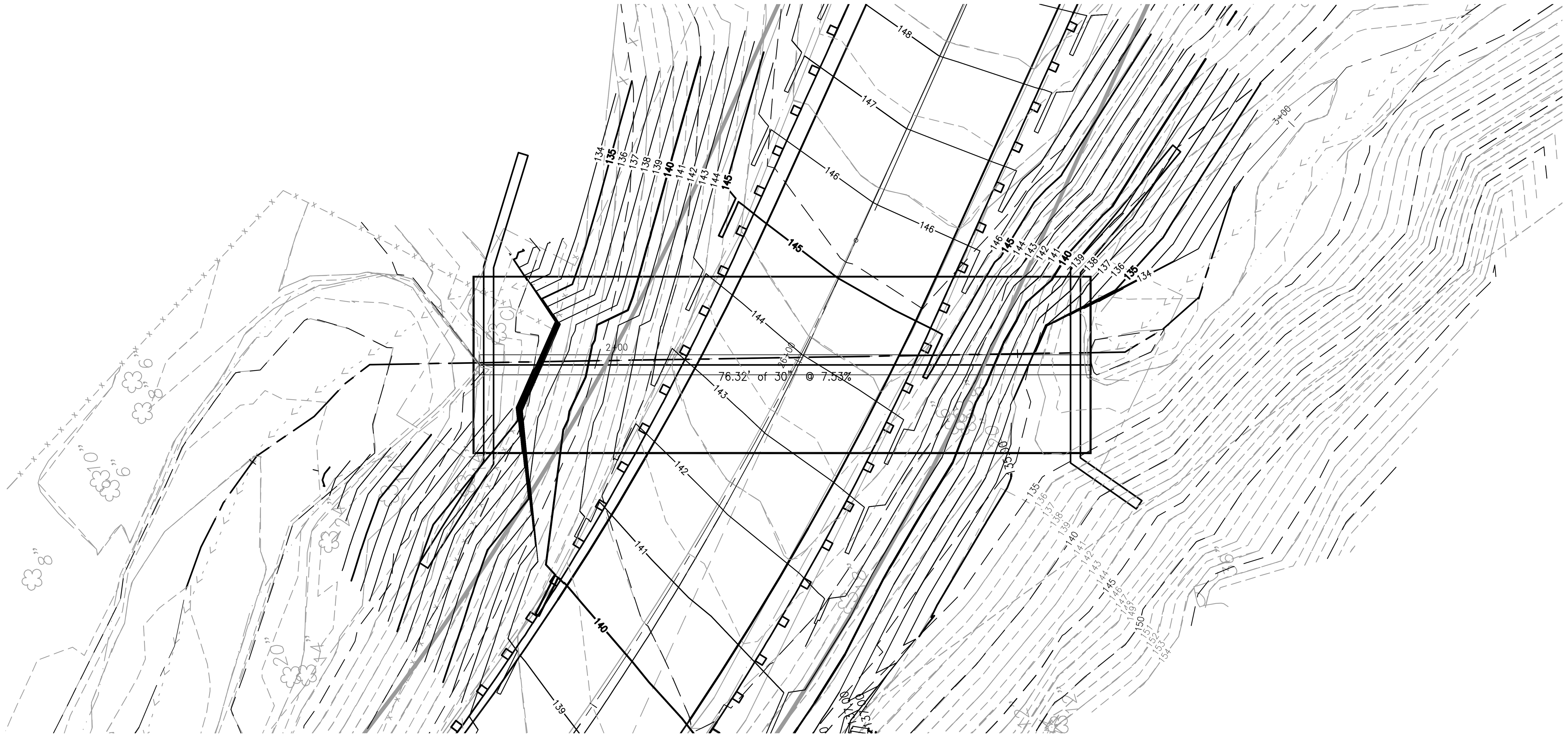

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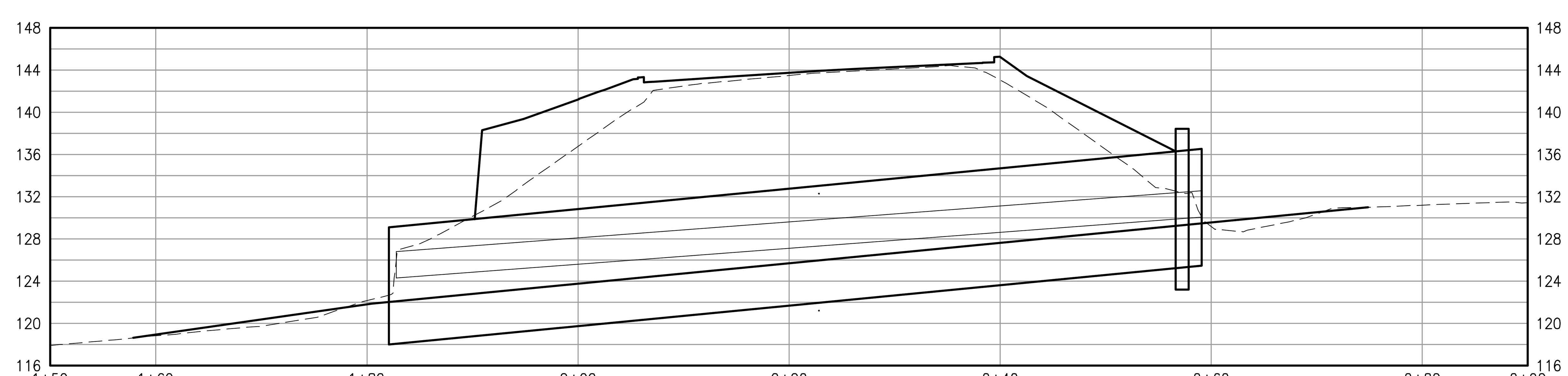

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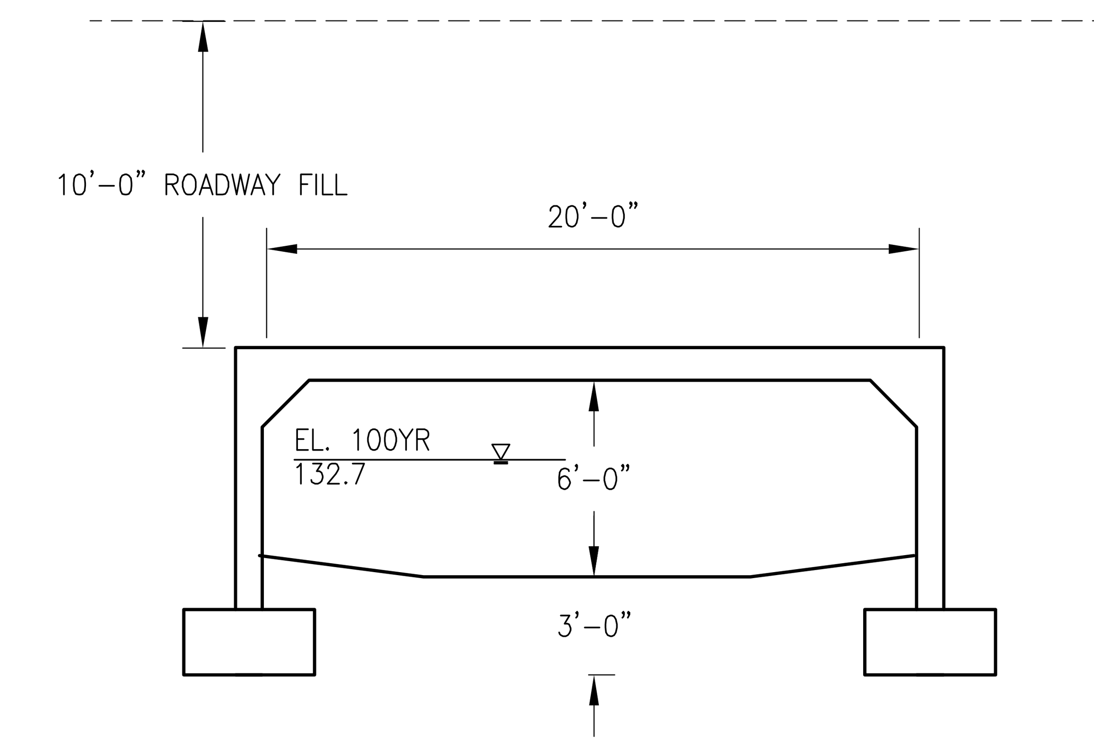

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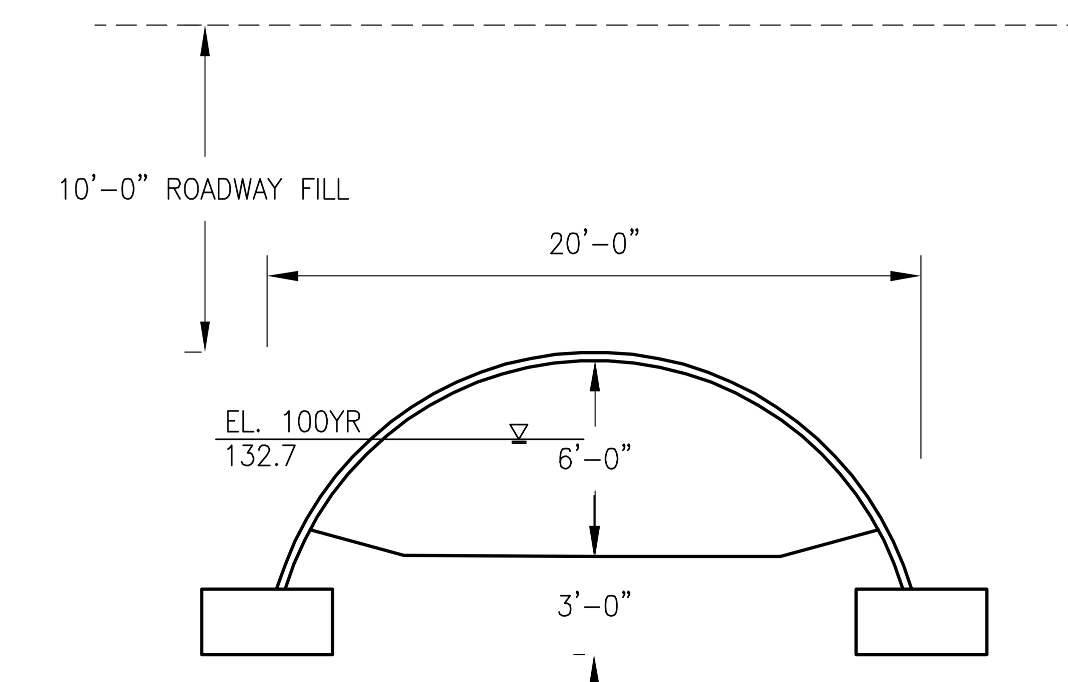

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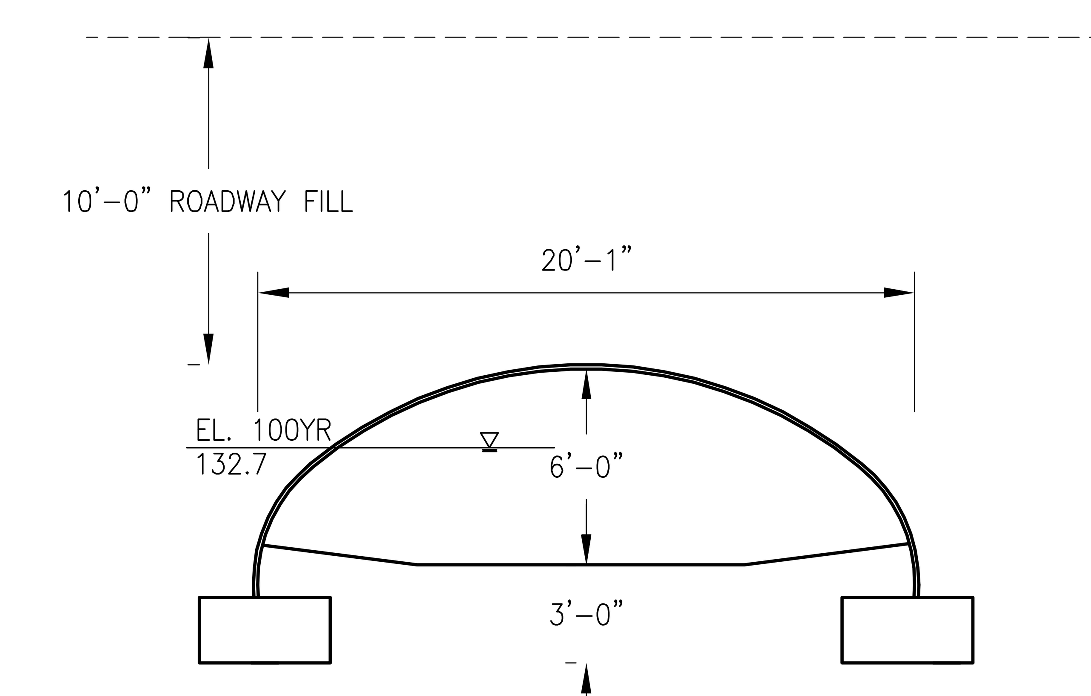

CULVERT OPTION C

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PLAN AND PROFILE – MIDDLE CULVERT

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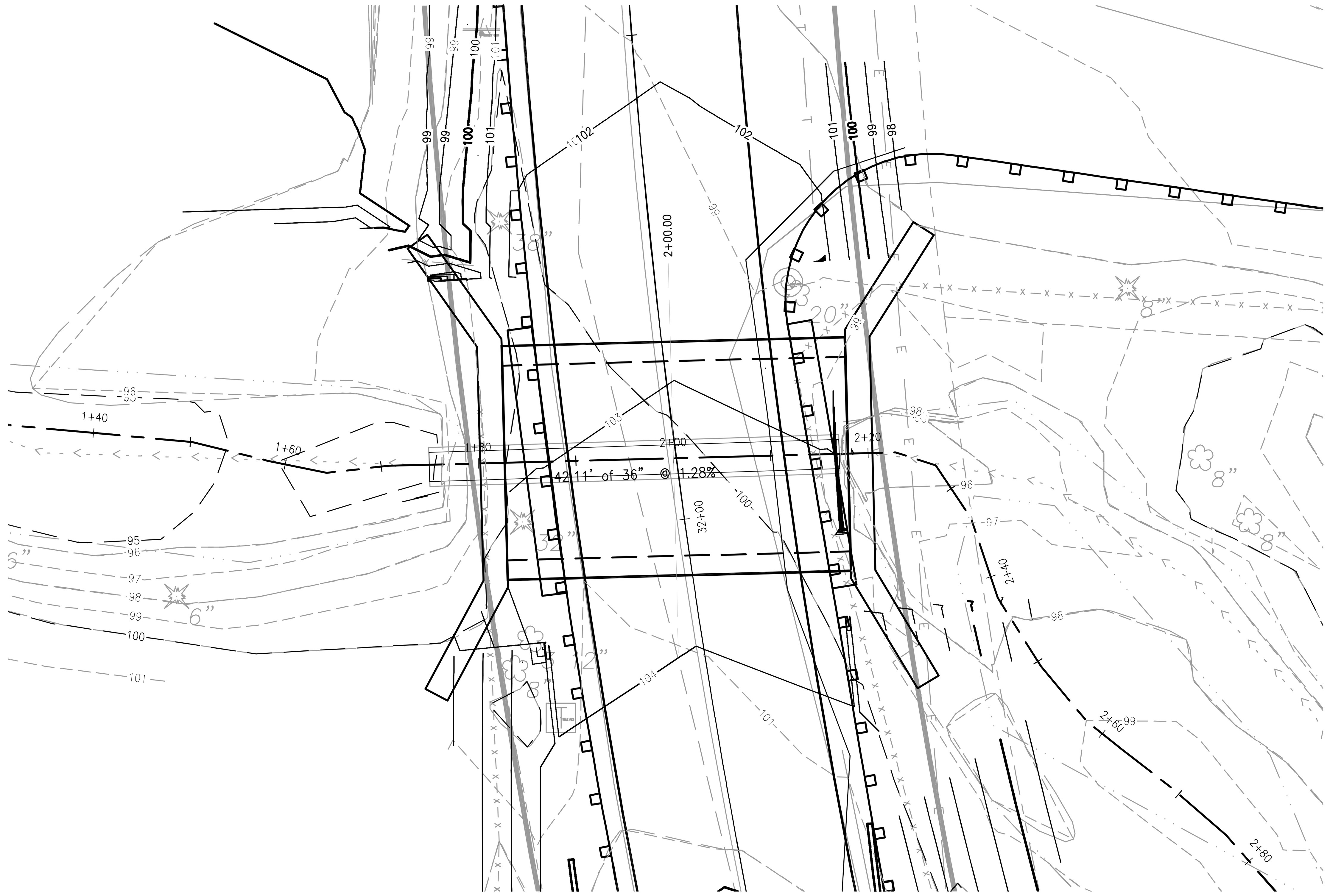

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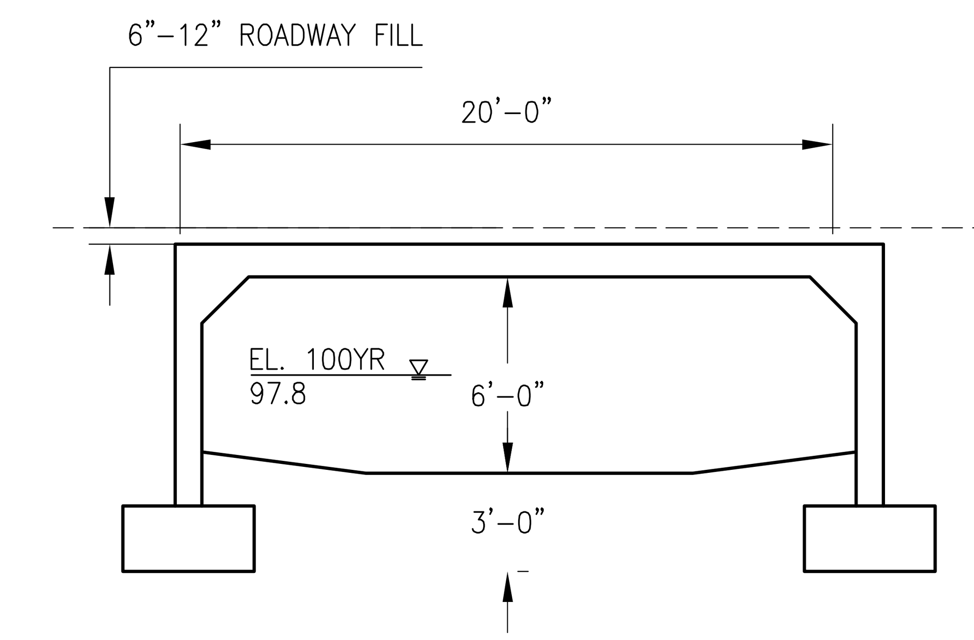

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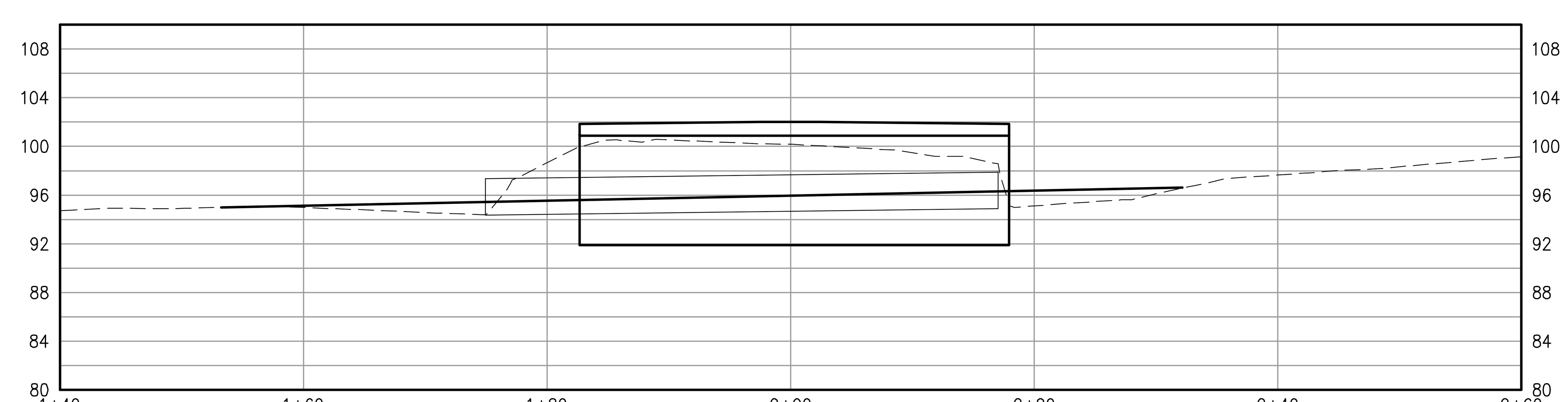

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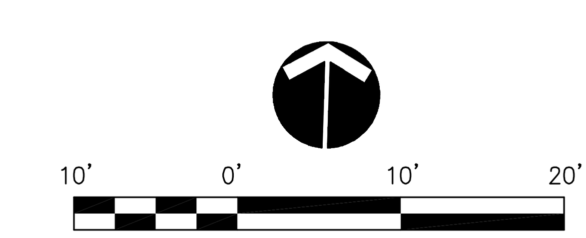

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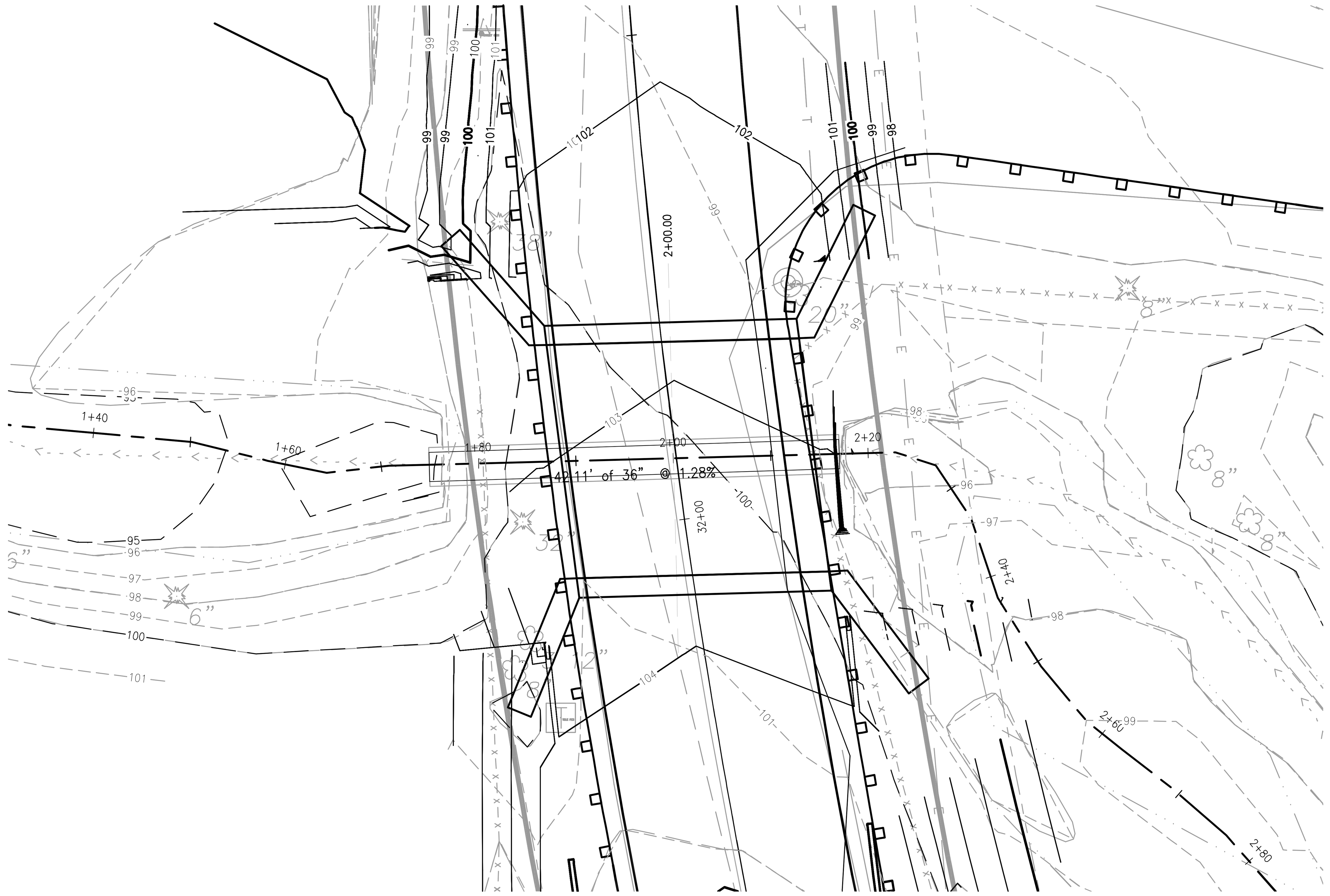

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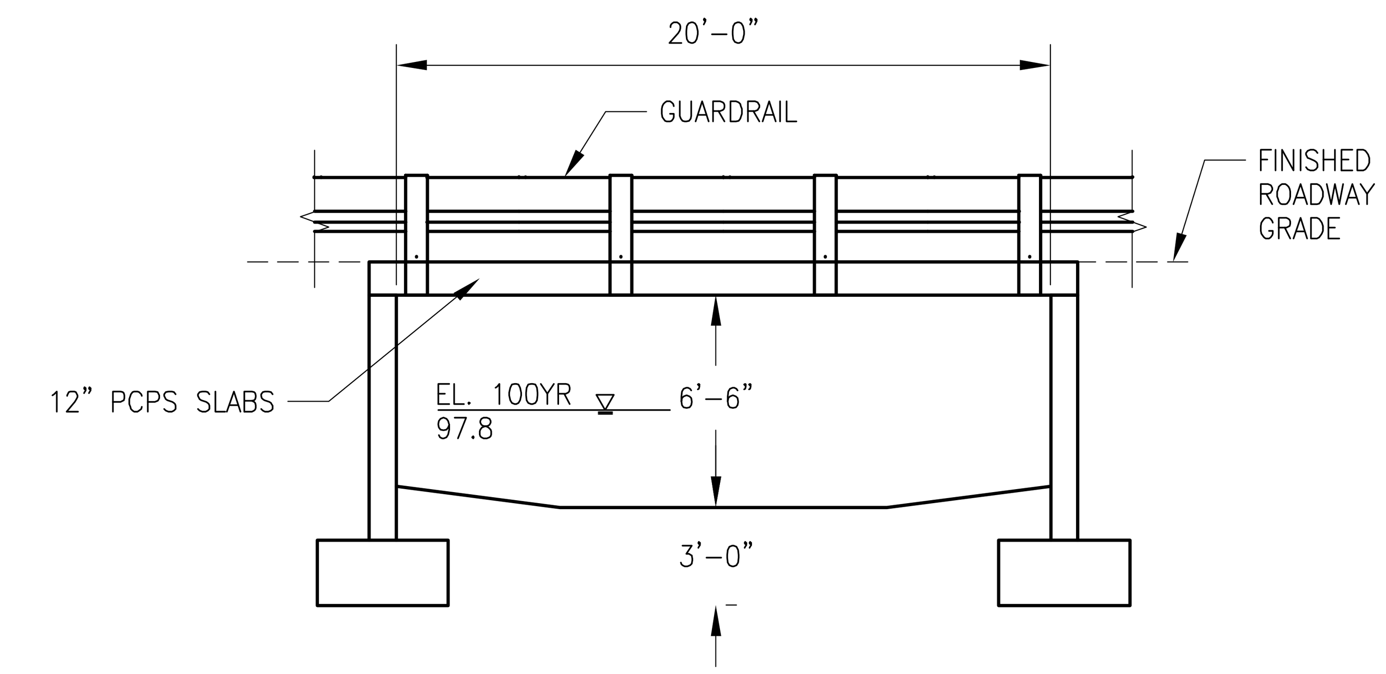

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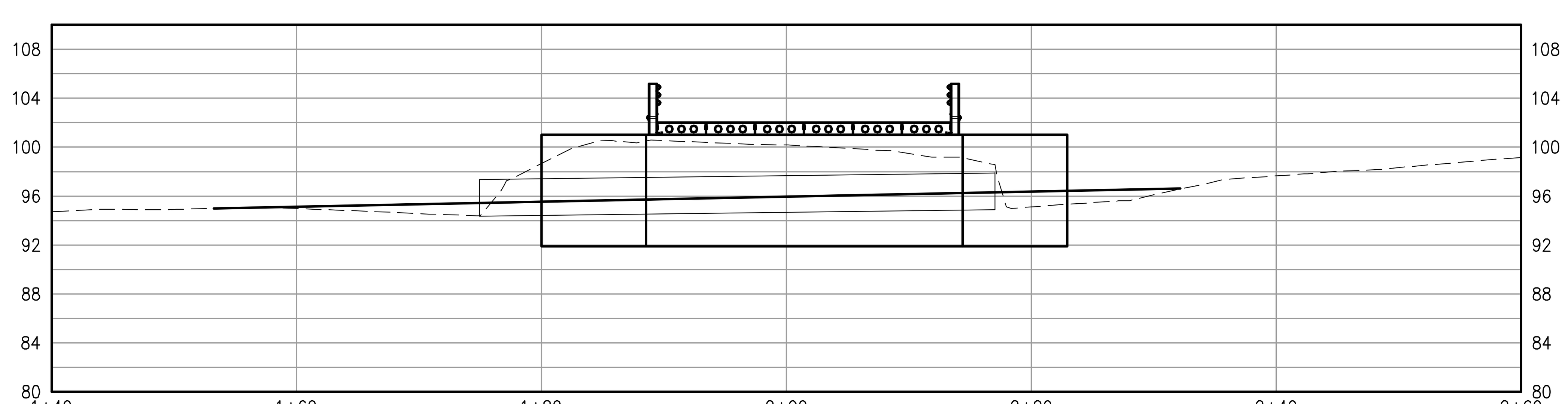

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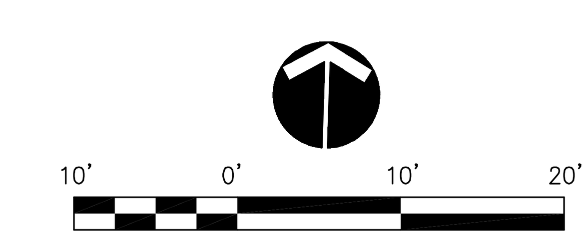

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Appendix B:
30% Cost Estimate

Appendix B - Relative Culvert Cost Comparison

		Southern Culvert Options								
		Alternate 1A -Precast 3-Sided Concrete Box			Alternate 1B -Steel Plate Arch w/ Deep Corrugations			Alternate 1C -Steel High-Profile Plate Arch		
		Quantity	Unit Price	Total	Quantity	Unit Price	Total	Quantity	Unit Price	Total
Temporary Stream Diversion	LS	1	$28,000	$28,000	1	$28,000	$28,000	1	$28,000	$28,000
Dewatering	LS	1	$20,000	$20,000	1	$20,000	$20,000	1	$20,000	$20,000
Structure Excavation	CY	1020	$40	$40,800	1180	$40	$47,200	1180	$40	$47,200
Shoring and Extra Excavation	CY	580	$30	$17,400	630	$30	$18,900	630	$30	$18,900
Backfill	CY	670	$60	$40,200	850	$60	$51,000	820	$60	$49,200
Concrete for footings	CY	70	$600	$42,000	70	$600	$42,000	70	$600	$42,000
Reinforcing steel for footings	LS	1	$16,700	$16,700	1	$16,800	$16,800	1	$16,700	$16,700
Concrete for headwalls	CY			$0	10	$800	$8,000	13	$800	$10,400
Reinforcing steel for headwalls	LS			$0	1	$2,500	$2,500	1	$3,300	$3,300
Wingwalls	SF	670	$80	$53,600	790	$80	$63,200	760	$80	$60,800
Culvert	LF	75	$2,600	$195,000	75	$568	$42,600	75	$568	$42,600
Installation	LS	1	$30,000	$30,000	1	$30,000	$30,000	1	$30,000	$30,000
TOTAL				**$483,700**			**$370,200**			**$369,100**

		Southern Culvert Options		
		Alternate 2A -Precast 3-Sided Concrete Box, Skew Ends		
		Quantity	Unit Price	Total
Temporary Stream Diversion	LS	1	$28,000	$28,000
Dewatering	LS	1	$20,000	$20,000
Structure Excavation	CY	1020	$30	$30,600
Shoring and Extra Excavation	CY	580	$60	$34,800
Backfill	CY	670	$60	$40,200
Concrete for footings	CY	50	$600	$30,000
Reinforcing steel for footings	LS	1	$10,000	$10,000
Concrete for headwalls	CY			$0
Reinforcing steel for headwalls	LB			$0
Wingwalls	SF	760	$80	$60,800
Culvert	LF	56	$3,600	$201,600
Installation	LS	1	$50,000	$50,000
TOTAL				**$506,000**

Appendix B - Relative Culvert Cost Comparison

		Middle Culvert Options								
		Alternate A -Precast 3-Sided Concrete Box			Alternate B -Steel Plate Arch w/ Deep Corrugations					
		Quantity	Unit Price	Total	Quantity	Unit Price	Total	Quantity	Unit Price	Total
Temporary Stream Diversion	LS	1	$32,000	$32,000	1	$32,000	$32,000	1	$32,000	$32,000
Dewatering	LS	1	$20,000	$20,000	1	$20,000	$20,000	1	$20,000	$20,000
Structure Excavation	CY	1410	$40	$56,400	1370	$40	$54,800	1350	$40	$54,000
Shoring and Extra Excavation	CY	920	$30	$27,600	920	$30	$27,600	920	$30	$27,600
Backfill	CY	910	$60	$54,600	1070	$60	$64,200	1030	$60	$61,800
Concrete for footings	CY	70	$600	$42,000	70	$600	$42,000	70	$600	$42,000
Reinforcing steel for footings	LS	1	$17,300	$17,300	1	$17,300	$17,300	1	$17,300	$17,300
Concrete for headwalls	CY			$0	10	$800	$8,000	13	$800	$10,400
Reinforcing steel for headwalls	LS			$0	1	$2,500	$2,500	1	$3,300	$3,300
Wingwalls	SF	980	$80	$78,400	1100	$80	$88,000	1060	$80	$84,800
Culvert	LF	75	$2,600	$195,000	75	$568	$42,600	75	$568	$42,600
Installation	LS	1	$30,000	$30,000	1	$30,000	$30,000	1	$30,000	$30,000
TOTAL				**$553,300**			**$429,000**			**$425,800**

		Northern Culvert Options					
		Concrete Box			Bridge		
		Quantity	Unit Price	Total	Quantity	Unit Price	Total
Temporary Stream Diversion	LS	1	$25,000	$25,000	1	$25,000	$25,000
Dewatering	LS	1	$20,000	$20,000	1	$20,000	$20,000
Structure Excavation	CY	630	$40	$25,200	470	$40	$18,800
Shoring and Extra Excavation	CY	360	$30	$10,800	360	$30	$10,800
Backfill	CY	240	$60	$14,400	190	$60	$11,400
Concrete for footings (abutments)	CY	40	$600	$24,000	60	$1,000	$60,000
Reinforcing steel for footings	LS	1	$10,000	$10,000	1	$15,000	$15,000
Wingwalls	SF	460	$80	$36,800	280	$80	$22,400
Approach Slab	SF	460	$45	$20,700	480	$45	$21,600
Culvert	LF	40	$2,600	$104,000			$0
Installation	LS	1	$40,000	$40,000	1	$40,000	$40,000
Precast Barrier	LF	40	$50	$2,000			$0
12" PCPS Slabs	LF			$0	120	$1,000	$120,000
TOTAL				**$332,900**			**$365,000**

Appendix C:
Preliminary Construction Schedule

NE Manley Rd – Replacements of All Three Culverts in One Season

Task Name	Duration
North Culvert	
Road Closure	**14 days**
Excavation/Shoring	2 days
Stream Isolation Prep	3 days
Install Footings	1 day
Stream Isolation	1 day
Install culvert	2 days
Waterproof	1 day
Backfill	1.5 days
Paving	1.5 days
Guardrail	1 day
Middle Culvert	
Stream Diversion Prep	3 days
Road Closure	**42 days**
Stream Isolation	3 days
Excavation/Shoring	5 days
Install Footings	3 days
Install culvert	4 days
Waterproof	2 days
Retaining walls	12 days
Backfill	7 days
Paving	3 days
Guardrail	3 days
South Culvert	
Stream Diversion Prep	3 days
Road Closure	**21 days**
Stream Isolation	3 days
Excavation/Shoring	4 days
Install Footings	3 days
Install culvert	2 days
Waterproof	1 day
Backfill	5 days
Paving	2 days
Guardrail	1 day