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Hydraulic Laboratory Report HL-2019-05

Cle Elum Spillway Energy Dissipation Basin Splitter Wall Configurations

1:52 Scale Physical Model Study

U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
Hydraulic Investigations and Laboratory Services Group
Denver, Colorado

July 2019

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14. ABSTRACT
As part of ongoing construction activities relating to the Cle Elum dam fish passage and protection projects a splitter wall dividing the energy dissipation basin into two parts is required. A cost savings gravity wall design was recommended by the design team which adds significant concrete to the energy dissipation basin and reduces the overall volume of the basin to dissipate energy but would save both time and construct costs. Concerns regarding the performance of the basin with the gravity wall in place were raised. A 1:52 scale physical model was used to analyze the effects of both the gravity wall and the originally designed splitter wall to determine the hydraulic performance of both features and if they pose any hydraulic issues. Results show that either splitter will function hydraulically with minimal impacts to the existing structures.

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July 2019

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The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Acknowledgments

The author would like to acknowledge the hydraulic investigations and laboratory services group construction staff and the assistance provided by Tracy Vermeyen and Matthew Klein in some of the data collection.

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Executive Summary

As part of ongoing construction activities relating to the Cle Elum dam fish passage and protection projects a dividing wall is required in the energy dissipation basin to isolate outlet works discharges from the entrance and exit of the fish passage facilities. The original design was a vertical splitter wall around 3.5-ft-thick. A cost savings gravity wall design was recommended by the design team that would save significant time and construction costs but adds significant concrete to the energy dissipation basin and reduces the overall volume of the basin to dissipate energy. Concerns regarding the performance of the basin with the gravity wall in place were raised by some members of the design team. A 1:52 scale physical model was proposed to analyze the effects of both the gravity wall and the originally designed splitter wall to determine the hydraulic performance of both features and if they pose any hydraulic or scour concerns.

This report summarized the physical model results. Three configurations of the energy dissipation basin were modeled including the as-built basin, the basin with the splitter wall and the basin with the gravity wall. The model was operated at flows up through the maximum 40,000 ft^3/sec design capacity of the spillway for each configuration. Bed elevation contour maps were created before the tests were operated and after each configuration was operated at each flow for 1-hour model time (7.2 hours real time). Results show that either configuration of the dividing wall will function hydraulically with minimal impacts to the existing structures. Slight scour occurred at the toe of the gravity wall where it starts to extend beyond the basin's apron. To prevent this slight scour from potentially causing concerns it is recommended that a 3-foot-deep cutoff wall be added to the existing design of the gravity wall.

Background

Cle Elum Dam, located on the Cle Elum River about 8 miles northwest of Cle Elum, Washington USA was built in 1933. The dam was originally constructed without fish passage facilities. The dam expanded a natural lake that historically supported Sockeye, Coho, and spring Chinook salmon with other resident fish populations. Construction of the dam blocked historical access to the lake and upstream habitat for anadromous salmonids and has impacted the salmon runs in the Yakima River basin.

Fish recovery efforts have been in effect since the 1980s. Starting in 2003, the U.S. Bureau of Reclamation (Reclamation) made significant strides in providing fish passage on many Reclamation facilities in the Yakima River basin. Cle Elum dam was selected for a major construction project adding upstream and downstream fish passage at the dam. Construction began in 2015 with roadways and bridges and is projected to continue through 2025.

During a 2014 physical modeling effort, a splitter wall in the stilling basin was designed to separate outlet work flows from the fish passage entrance and exit (Hanna, 2015). Subsequently, to save construction time and costs, it was suggested to redesign the original splitter wall as a gravity wall. This re-designed wall takes additional volume in the energy dissipation basin compared to the original vertical splitter wall that was tested in the model study. Reducing the volume of the basin may prevent the basin from functioning as originally designed. The Reclamation design team approached the Hydraulic Investigations and Laboratory Services group to analyze the potential implications of constructing a gravity wall instead of the original splitter wall. Due to the large footprint of the proposed gravity wall and the corresponding reduced volume of the energy dissipation basin, a physical model of the basin was recommended to ensure that the energy dissipation basin would still function as originally designed.

Model Description

Model Objectives

The 1:52 Cle Elum Dam energy dissipation basin model study focused on the following objectives:

- Evaluate the hydraulics in the energy dissipation basin for three configurations:
  - As built conditions (to verify the performance of the existing basin)
  - Proposed vertical splitter wall (see drawings 33-D-60282 through 33-D-60287 in Appendix A)
  - Proposed gravity wall (see drawing 33-D-60285b in Appendix A)
- Suggest modifications to the basin if:
  - The basin does not perform adequately to protect the downstream channel
  - If scour develops around the structures that might impact their structural integrity.
- For each configuration evaluate flows of:
  - 5,000 ft^3/sec
  - 10,000 ft^3/sec
  - 20,000 ft^3/sec
  - 40,000 ft^3/sec
- For each configuration evaluate the extent and location of any scour that occurs in the downstream river channel.

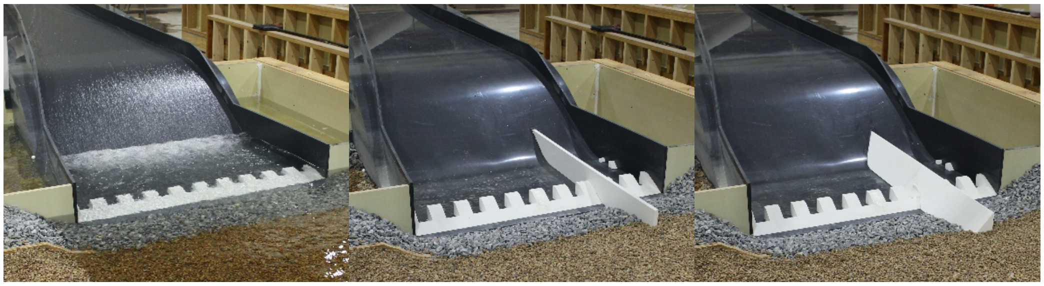


Figure 1. The three energy dissipation basin configurations tested in the physical model, as built (left), splitter wall (center), gravity wall (right).

Model Scale

Similitude between the model and the prototype is achieved when the ratios of the major forces controlling the physical processes are equal in the model and prototype. Since gravitational and inertial forces typically dominate open channel flow, Froude-scale similitude was used to establish a kinematic relationship between the model and the prototype. The Froude number is defined as

$$F_r = \frac{v}{\sqrt{gd}}$$

where v = velocity, g = gravitational acceleration, and d = flow depth. When Froude-scale similitude is used for a 1:52 scale, the following relationships exist between the model and prototype where the r subscript refers to the ratio of model to prototype:

Length ratio:	$L_r = L_{model}/L_{prototype} = 1:52$
Pressure ratio:	$P_r = L_r = (52) = 1:52$
Velocity ratio:	$V_r = L_r^{1/2} = (52)^{1/2} = 1:7.21$
Time ratio:	$T_r = L_r^{1/2} = (52)^{1/2} = 1:7.21$
Discharge ratio:	$Q_r = L_r^{5/2} = (52)^{5/2} = 1:19498.80$

A critical component of this model is the riprap and the downstream rock channel. In order to most appropriately model these features geometric scaling was selected due to the large size of the riprap and channel rock. Scaling the rock features in this way makes the density of the rock in the model slightly higher than it should be, but the scour mechanisms of non-cohesive particle transport are similar between the prototype and the model. This approach was considered adequate for the intended model purpose.

Model Features

A 1:52 scale physical hydraulic model was tested at Reclamation's Hydraulics Laboratory in Denver, Colorado to ensure that the energy dissipation basin of the Cle Elum dam spillway would function as originally intended. The model was constructed of wood and plastic materials and represented part of the upstream reservoir, the entrance channel, crest, piers (Figure 2), spillway chute with training walls (Figure 3), energy dissipation basin (Figure 4), and the downstream river to the existing gauging station.

Prototype bed material sizes downstream of the stilling basin transition from 12- to 36-in angular riprap to 6-in nominal rounded river rock. To size the riprap in the model simple geometric scaling was used. Accordingly, 0.25- to 0.75-in angular gravel and 0.125-in pea gravel were used to model the downstream river channel. Topography templates were created from LiDAR and bathymetry data provided by the TSC design team and were used to represent the geometry of the downstream channel. Once the topography was leveled between templates the top two inches of the templates were removed and filled with material to provide a uniform bed without templates impacting the flow and turbulence. The light grey/blue color material in Figure 4 is the zone of angular riprap represented as gravel and the brown/yellow colored material is the river rock represented by pea gravel.

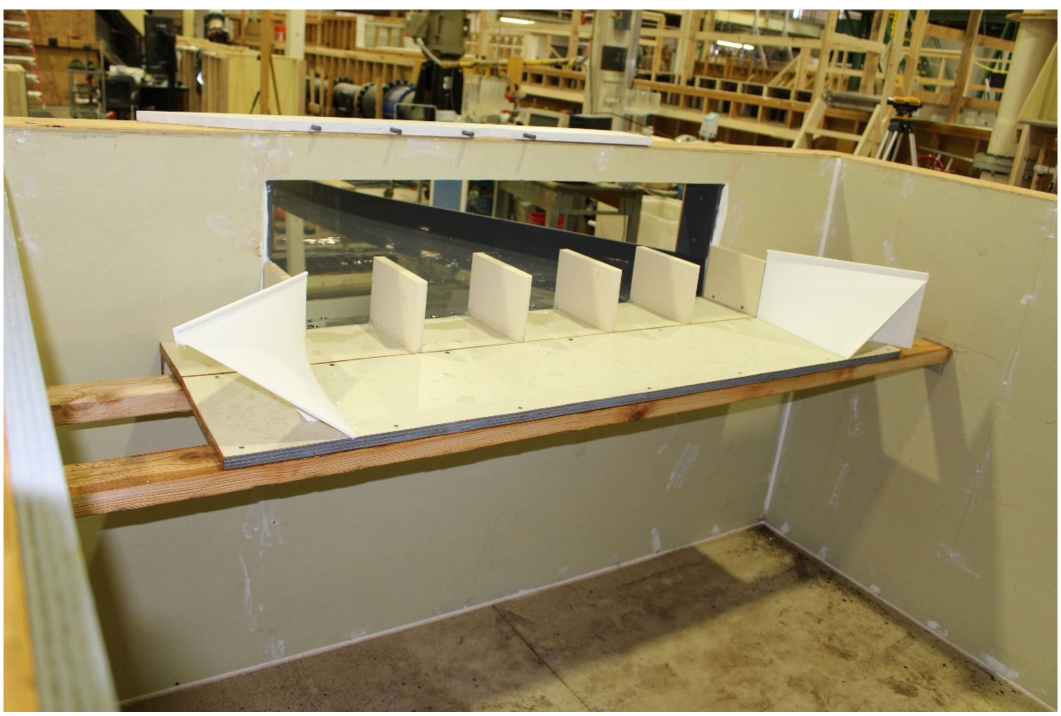


Figure 2. Photograph of upstream reservoir, entrance channel, crest and piers of the Cle Elum spillway model (flow will be from lower right to upper left).

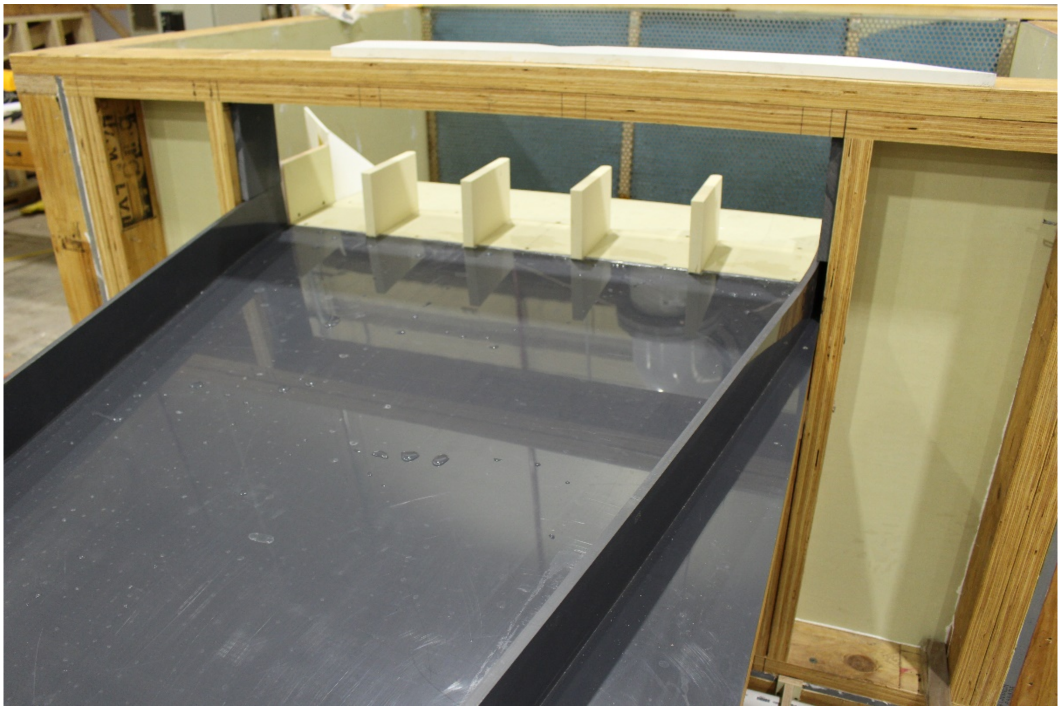


Figure 3. Photograph of entrance channel, crest, piers and upper section of the spillway (flow will be from upper right to lower left).

Figure 4. Photograph of spillway, energy dissipation basin with baffle blocks and gravity wall installed and downstream river channel.

Instrumentation

A 240,000-gallon storage reservoir under the laboratory floor supplied water for the hydraulic model through an automated flow delivery and measurement system. Inflow to the model was measured with venturi meters. A 44,000-pound weigh-tank facility was used to calibrate the laboratory venturi meters at regular intervals to an accuracy of $\pm 0.25\%$.

One piezometer tap was attached to a stilling well (Figure 5) and was equipped with a lory point gauge accurate to 0.001-ft. The piezometer tap was in the center of the downstream channel at the approximate location where the river gauge would be located. This piezometer tap was utilized to set the necessary tailwater in the channel.

Tailwater was set with a downstream adjustable overflow weir (Figure 6).

Figure 5. Photograph of stilling well attached to piezometer tap in the center of the downstream river channel.

Figure 6. Photograph of downstream overflow weir used to set the tailwater depth of the model.

Model Results

For each configuration pre-test bed elevations were collected using a Laser Scanner. The scanner was able to collect a point cloud of the topography and the energy dissipation basin. Four flow rates and corresponding tailwater elevations were established in the model as outlined in Table 1. Each flow was allowed to operate in the model for about 1 hour model time (7.2 hour prototype time) after which the flow was stopped and the energy dissipation basin and downstream topography were drained. Post-test bed elevations were collected using the laser scanner.

Table 1. Flow rates and corresponding tailwater elevations in prototype units that were modeled for each of the three model configurations.

Flow Rate (ft3/sec)	Tailwater Elevation (ft)
5,000	2,113.9
10,000	2,116.2
25,000	2,123.1
40,000	2,130.0

The remainder of this section provides images, pre- and post-test contour maps, and difference contour maps when it provides relevant information for each flow and configuration.

Configuration 1 – As Built

Figure 7 through Figure 10 provide photographs of each of the four flow rates tested for the as built configuration from a right bank and plan view perspective. Figure 11 provides a pre-test contour map of bed elevations in prototype feet and represents the undisturbed bed topography prior to any flow entering the model. Figure 12 provides a post-test contour map of the bed topography in prototype feet. Comparing the two contour plots shows that only a very small amount of surface particles immediately downstream of the baffle blocks mobilized over the duration of the testing, and no scour was present after the testing was completed. The basin functions properly through the design 40,000 ft^3/sec.

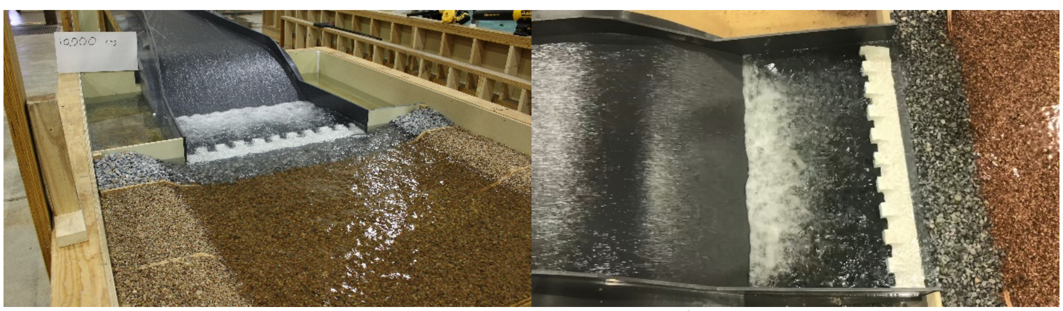


Figure 7. Photographs of as built configuration for 5,000 ft^3/sec the left image is looking from the downstream river right, and the right image is looking at a plan view with flow from left to right.

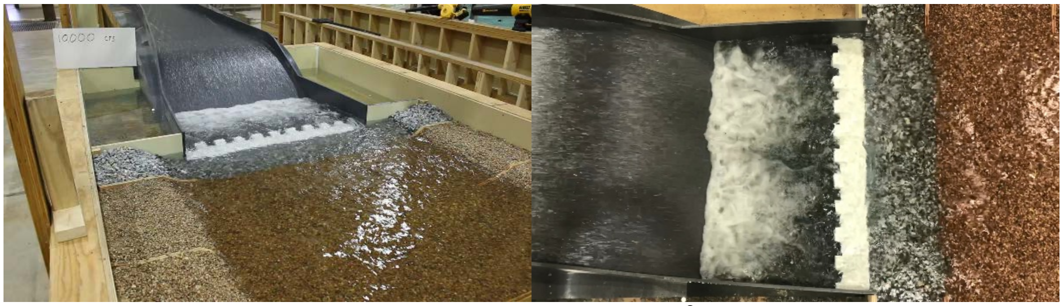


Figure 8. Photograph of as built configuration for 10,000 ft^3/sec, the left image is looking from the downstream river right, and the right image is looking at a plan view with flow from left to right.

Figure 9. Photograph of as built configuration for 25,000 ft^3/sec, the left image is looking from the downstream river right, and the right image is looking at a plan view with flow from left to right.

Figure 10. Photograph of as built configuration for 40,000 ft^3/sec, the left image is looking from the downstream river right, and the right image is looking at a plan view with flow from left to right.

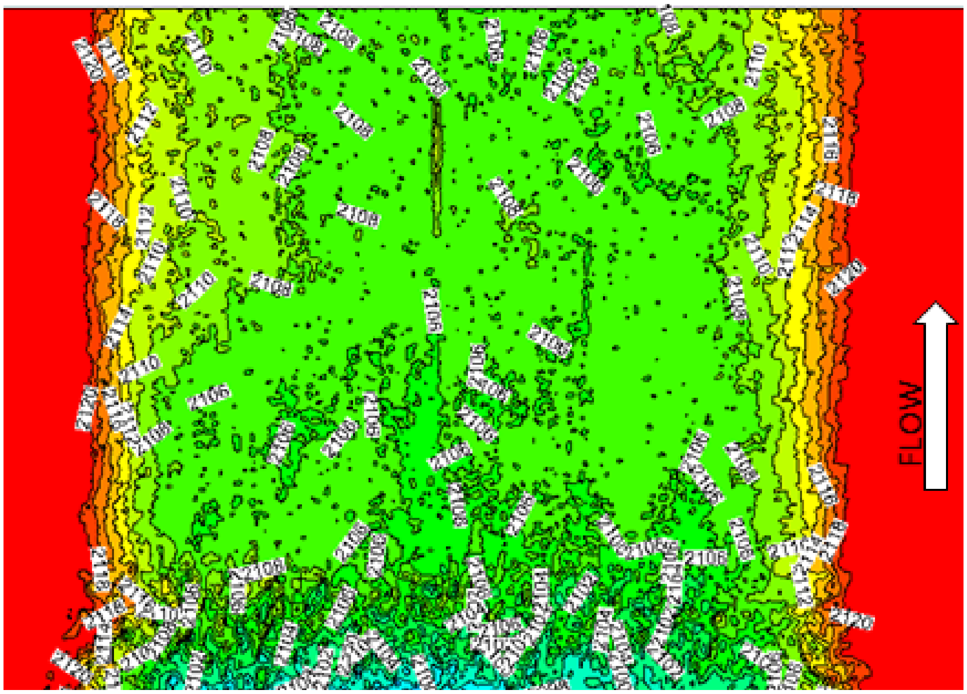


Figure 11. As built configuration pre-test prototype bed elevation contours, flow direction is from the bottom to the top of the image and the contours start just downstream of the energy dissipation basin and extend to the downstream gauge site.

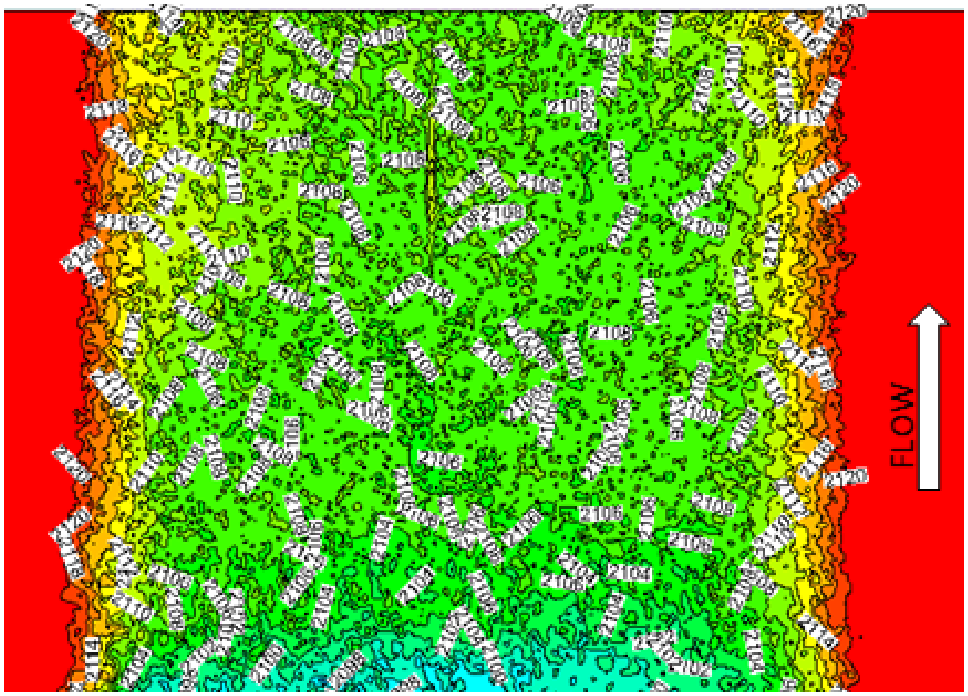


Figure 12. As built configuration post-test prototype bed elevation contours, flow direction is from the bottom to the top of the image and the contours start just downstream of the energy dissipation basin and extend to the downstream gauge site.

Configuration 2 – Splitter Wall

Figure 13 and Figure 14 show the splitter wall installed prior to any flow being introduced into the model. Figure 15 through Figure 18 provide photographs from the right bank and plan view of each of the four flow rates tested for the splitter wall configuration. Figure 19 provides a pre-test contour map of bed elevations in prototype feet and represents the undisturbed bed contours prior to any flow entering the model. Note that the bed had been re-graded after the as-built tests and installation of the splitter wall. Figure 20 provides a post-test contour map of the bed elevations in prototype feet and represents the disturbed bed contours after the model was operated. Comparing the two models shows no difference, which indicates that the bed has not scoured or deposited. Figure 21 is an image taken after the flow drained from the basin, a few rocks are present that have moved upstream onto the apron that extends beyond the energy dissipation blocks. These few rocks are not alarming and indicate that separation off the dissipation blocks is causing an upstream velocity over the riprap section of the downstream channel.

Figure 13. Photograph of splitter wall pre-test image looking from the downstream river right.

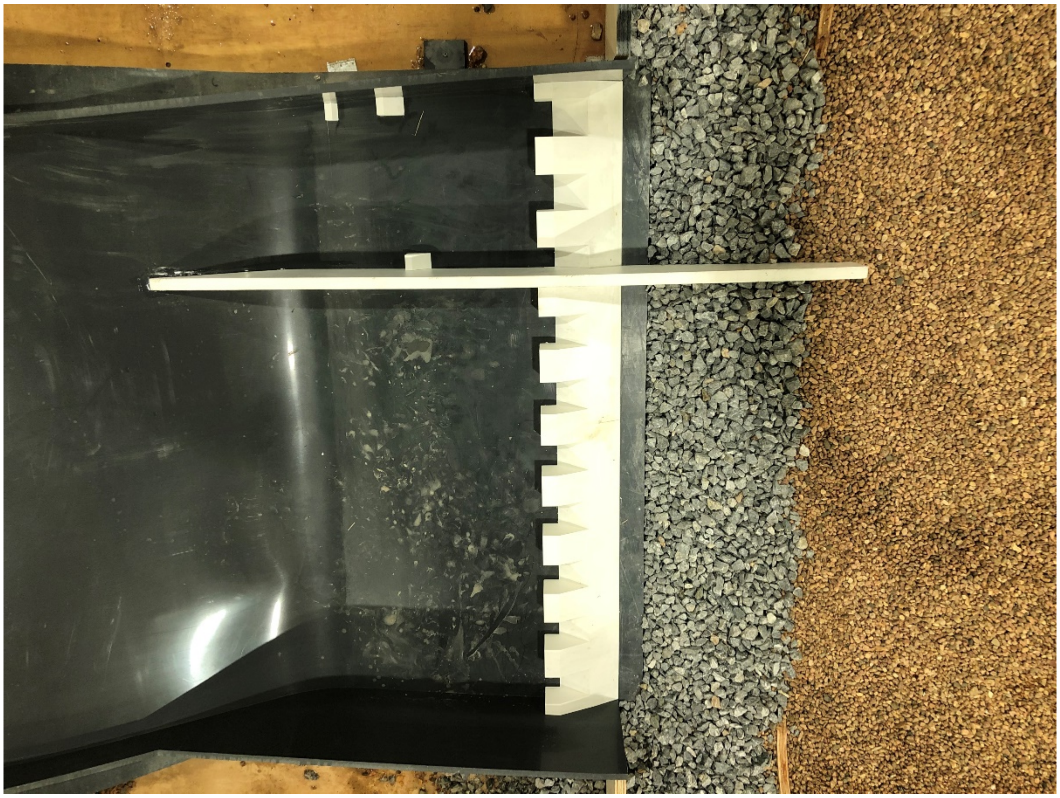


Figure 14. Photograph of splitter wall pre-test plan view the flow is from right to left.

Figure 15. Photograph of splitter wall configuration for 5,000 ft^3/sec, the left image is looking from the downstream river right, and the right image is looking at a plan view with flow from left to right.

Figure 16. Photograph of splitter wall configuration for 10,000 ft^3/sec, the left image is looking from the downstream river right, and the right image is looking at a plan view with flow from left to right.

Figure 17. Photograph of splitter wall configuration for 25,000 ft^3/sec, the left image is looking from the downstream river right, and the right image is looking at a plan view with flow from left to right.

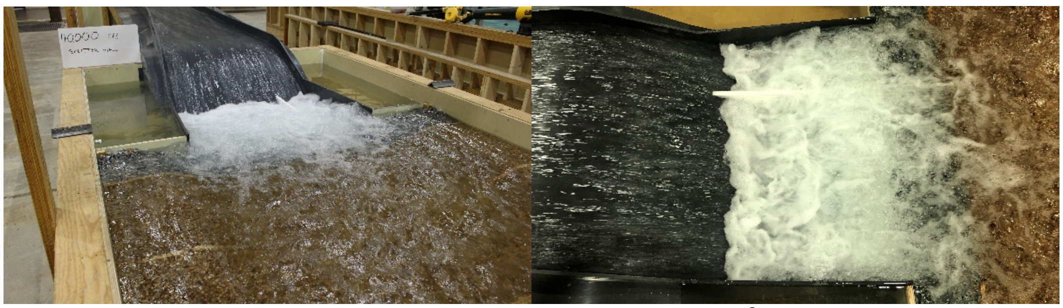


Figure 18. Photograph of splitter wall configuration for 40,000 ft^3/sec, the left image is looking from the downstream river right, and the right image is looking at a plan view with flow from left to right.

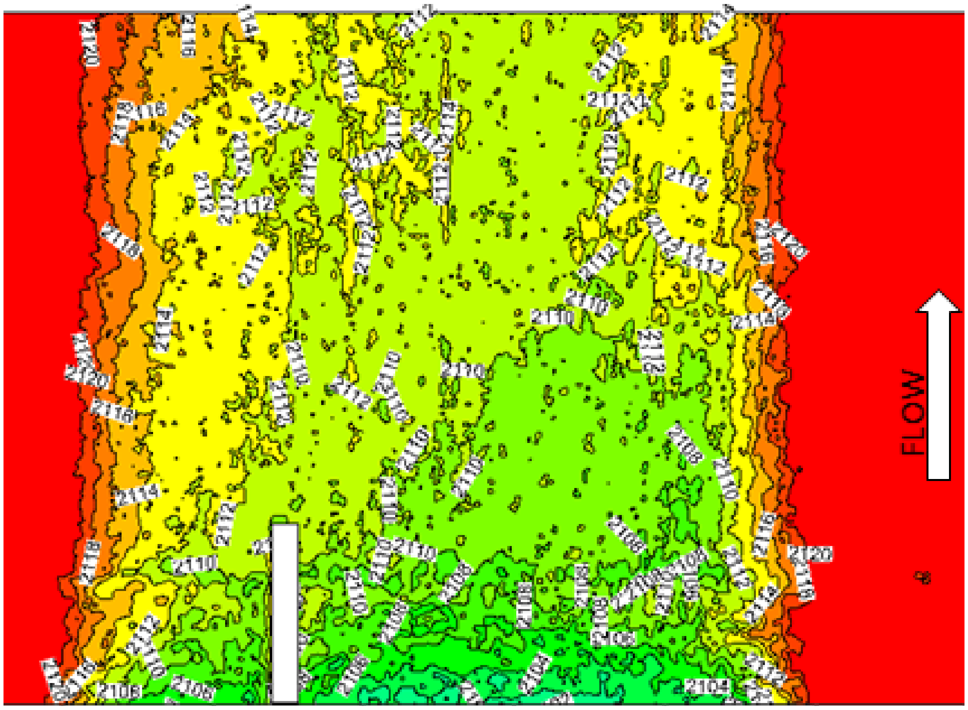


Figure 19. Splitter wall pre-test prototype bed elevation contours, flow direction is from the bottom to the top of the image and the contours start just downstream of the energy dissipation basin and extend to the downstream gauge site.

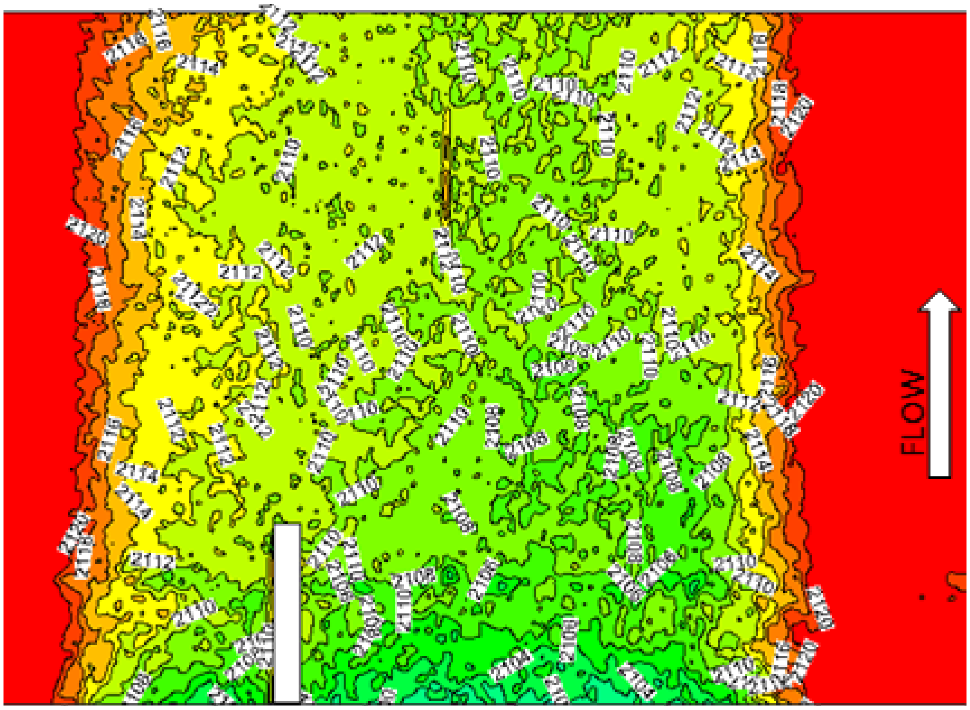


Figure 20. Splitter wall post-test prototype bed elevation contours, flow direction is from the bottom to the top of the image and the contours start just downstream of the energy dissipation basin and extend to the downstream gauge site.


Figure 21. Photograph of splitter wall post-test downstream bed showing that a few rocks moved upstream onto the apron that extends beyond the energy dissipation blocks in the basin.

Configuration 3 – Gravity Wall

Figure 22 and Figure 23 show the gravity wall installed prior to any flow being introduced into the model. Figure 24 through Figure 27 provide photographs from the right bank and plan view of each of the four flow rates tested for the gravity wall configuration. Figure 28 and Figure 29 provide post-test images of the downstream channel after the water was drained from the model. Figure 30 is the pre-test contour map of bed elevations in prototype feet and represents the undisturbed bed contours prior to any flow entering the model. As with the splitter-wall testing, the downstream bed was regraded following the installation of the gravity wall. Figure 31 provides a post-test contour map of the bed elevations in prototype feet and represents the disturbed downstream channel after the simulations were modeled.

Figure 22. Photograph of gravity wall pre-test installation viewed from downstream river right.

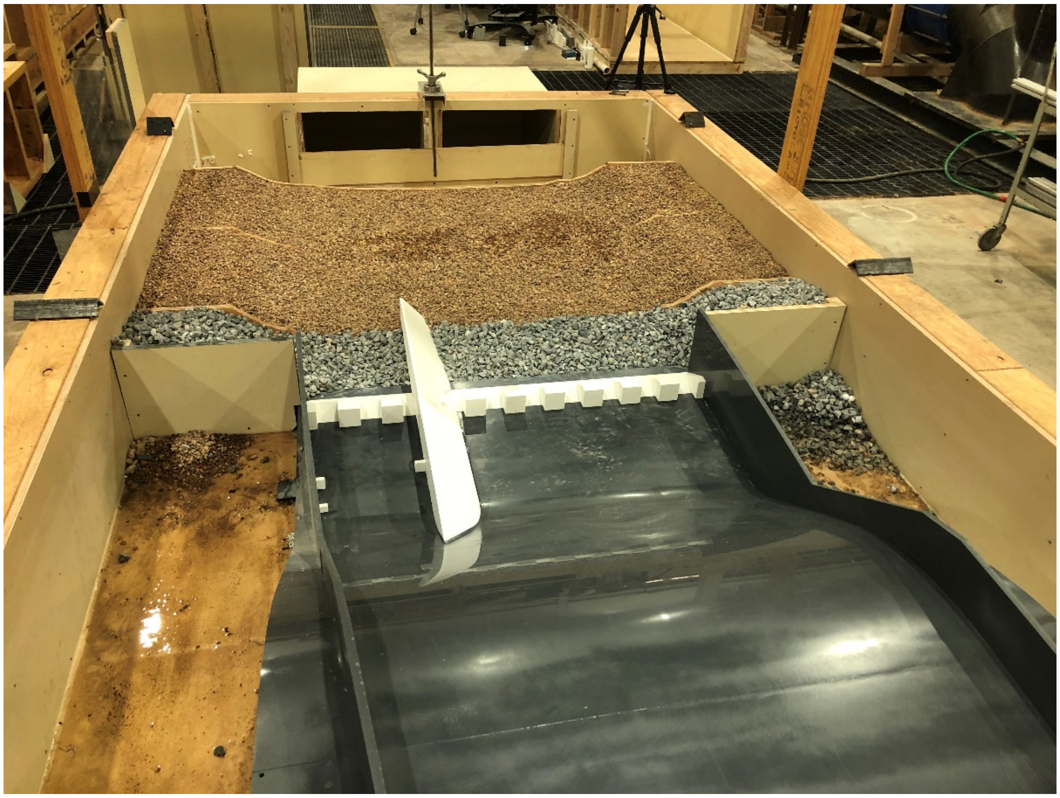


Figure 23. Photograph of gravity wall pre-test installation viewed from upstream center of spillway.

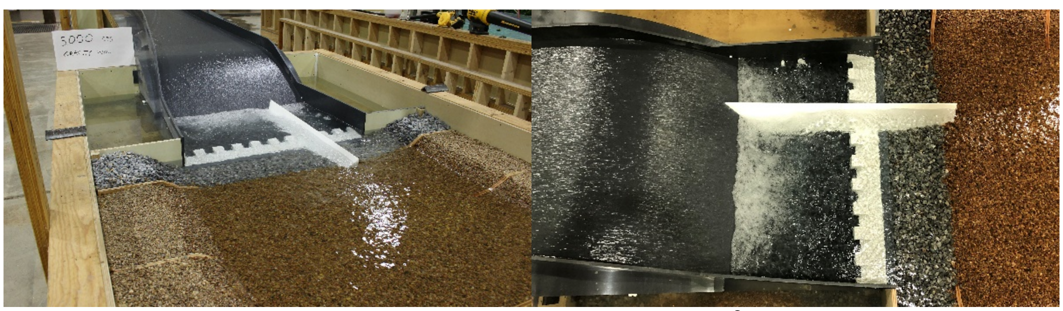


Figure 24. Photograph of gravity wall configuration for 5,000 ft^3/sec, the left image is looking from the downstream river right, and the right image is looking at a plan view with flow from left to right.

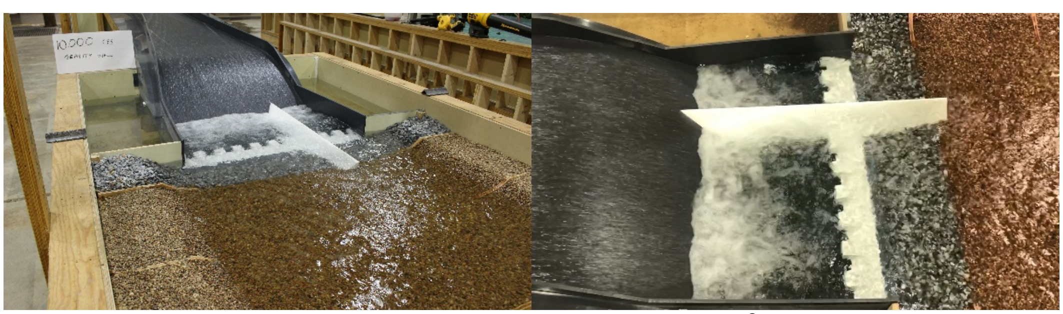


Figure 25. Photograph of gravity wall configuration for 10,000 ft^3/sec, the left image is looking from the downstream river right, and the right image is looking at a plan view with flow from left to right.

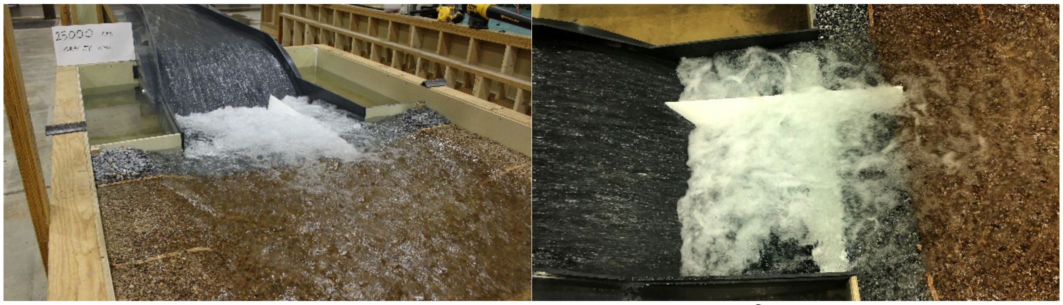


Figure 26. Photograph of gravity Wall configuration for 25,000 ft^3/sec, the left image is looking from the downstream river right, and the right image is looking at a plan view with flow from left to right.

Figure 27. Photograph of gravity wall configuration for 40,000 ft^3/sec, the left image is looking from the downstream river right, and the right image is looking at a plan view with flow from left to right.

Figure 28. Photograph of gravity wall post-test viewed from downstream river right.

Comparing the two models show slight differences at the downstream end of the energy dissipation basin, just downstream of the dissipation blocks. Doing difference mapping between the two sets of contour maps did not result in a good synapsis of where scour and deposition occurred. Photogrammetry was utilized to develop a difference map between the pre- and post-test topography. Figure 32 provides an ortho plan photo of the downstream river channel and the difference map (in feet prototype) side by side. The difference map clearly shows that some of the riprap downstream of the basin was relocated to the apron that extends beyond the energy dissipation blocks in the basin. The rocks that did move up onto the apron were pulled from the toe of the gravity wall just as it transitions from the apron (red circle in Figure 29) and from the right bank side slope. While no rocks were observed to enter the stilling basin, there would still be a slight concern of ball milling leading to damage of the stilling basin apron if it were to be operated for long durations with riprap on the concrete apron.

The area immediately downstream of the stilling basin apron experienced scour depths up to approximately 1 foot deep prototype. While much of this area experienced some scour, the primary scour was concentrated at the joining of the apron and the toe of the gravity wall. To prevent this scour from undermining the gravity wall, it is recommended to install a cutoff wall (a minimum of 3-ft-deep) that extends along the bottom of the gravity wall a distance of at least 10 feet. A cutoff wall already exists at the end of the stilling basin apron.

Figure 29. Photograph of gravity wall post-test viewed from river right, red circle indicates location of scour that should be mitigated with a shallow cutoff wall.

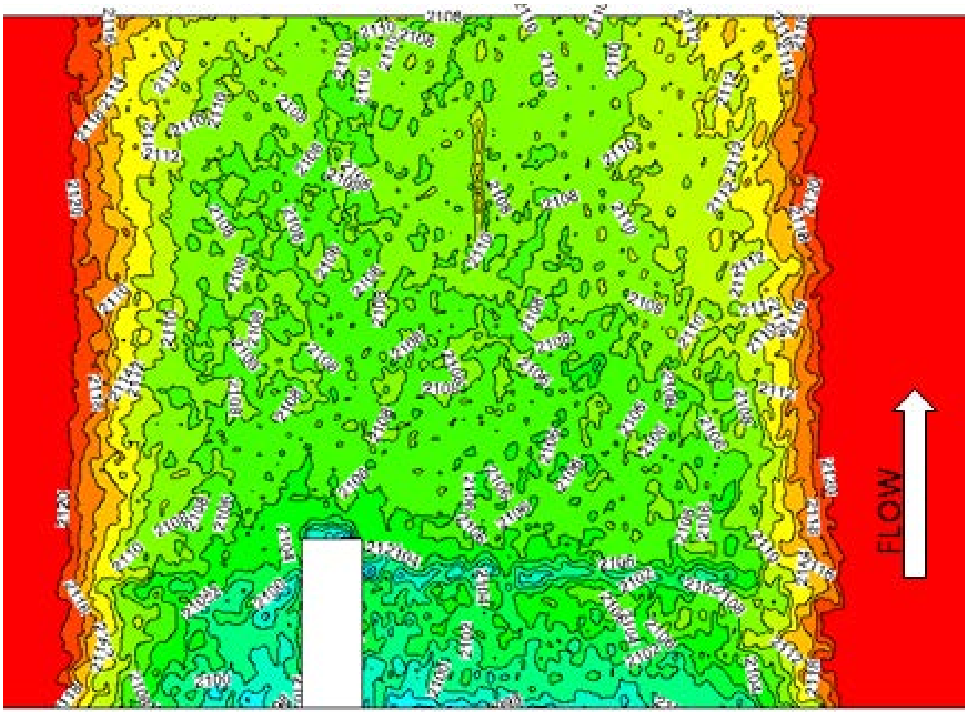


Figure 30. Gravity wall configuration pre-test prototype bed elevation contours, flow direction is from the bottom to the top of the image and the contours start just downstream of the energy dissipation basin and extend to the downstream gauge site.

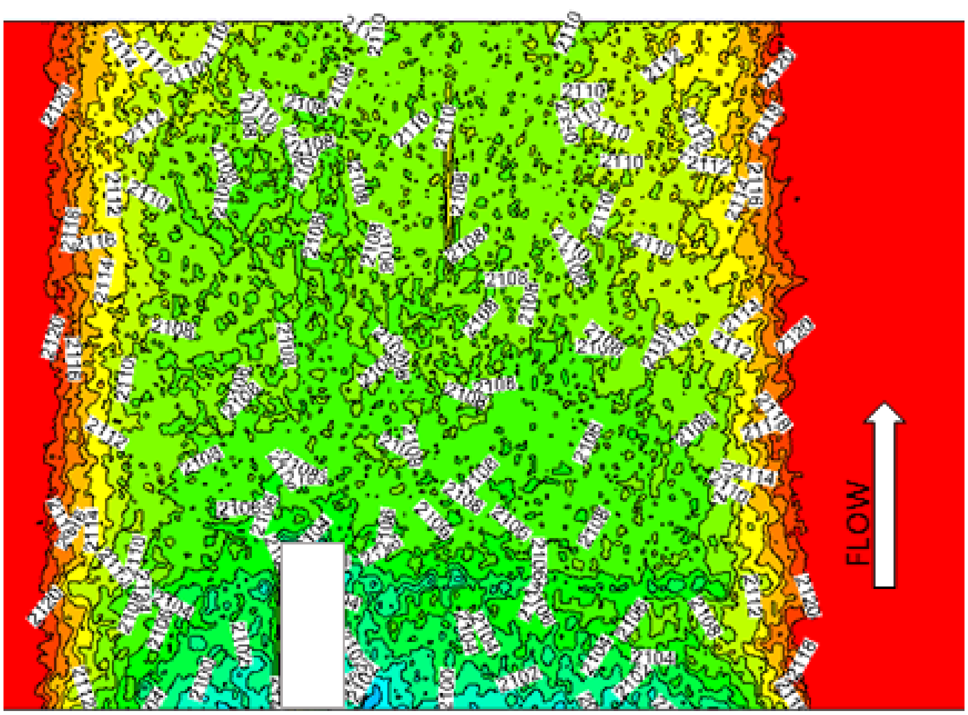


Figure 31. Gravity wall configuration post-test prototype bed elevation contours, flow direction is from the bottom to the top of the image and the contours start just downstream of the energy dissipation basin and extend to the downstream gauge site.

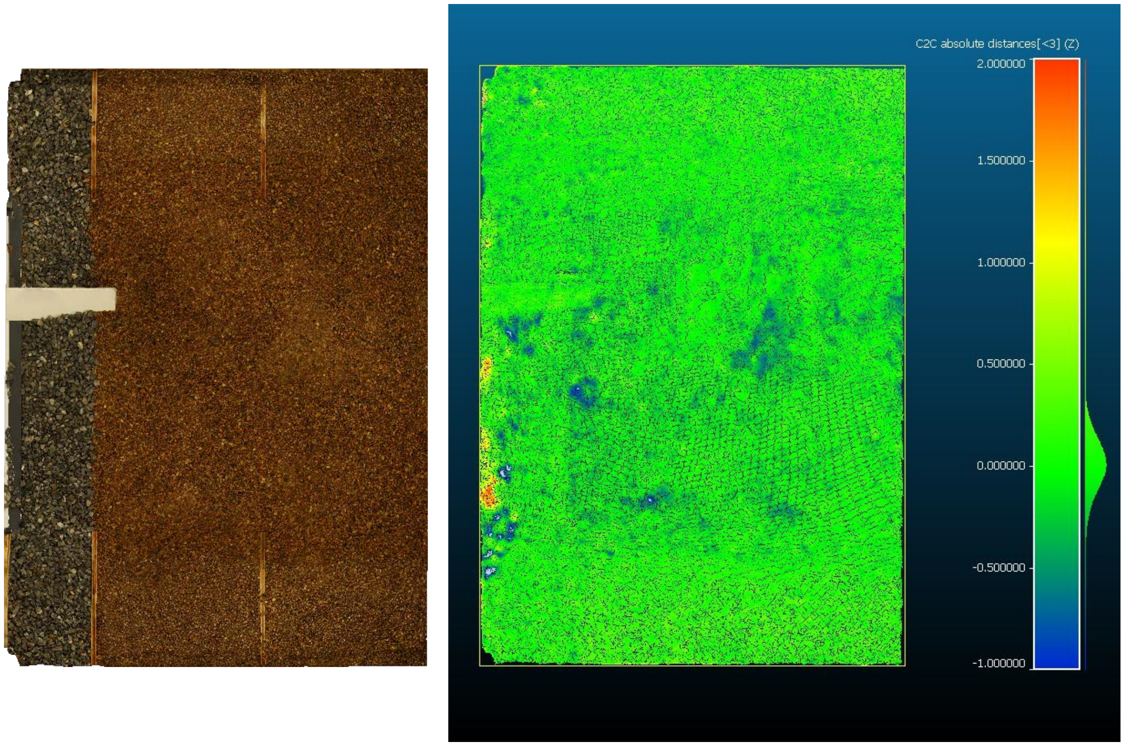


Figure 32. Gravity wall post-test plan view orthophoto (left) with corresponding difference map (right) showing the bed elevation change in prototype feet, deposition is red, scour is blue.

Conclusions

A 1:52 Froude scale physical model of Cle Elum dam spillway and energy dissipation basin was constructed by the Hydraulic Investigations and Laboratory Services Group of the Bureau of Reclamation’s Technical Service Center. The model contained a portion of the upstream reservoir, the spillway crest, piers, chute, training walls, energy dissipation basin and a portion of the downstream river channel. The model was operated at four discharges and three different configurations of the energy dissipations basin including the as-built, splitter wall and gravity wall. Bed elevation contour maps were generated for each of the configurations before and after discharges were modeled. The as-built configuration operated as expected with minimal energy being transferred into the downstream river. The splitter wall configuration did not show significant signs of scour or deposition, a few rocks were pulled from the riprap area onto the basins apron that extends beyond the dissipation blocks. These rocks are not alarming and indicate that the turbulence created by the baffle blocks is causing upstream velocities near the riprap area.

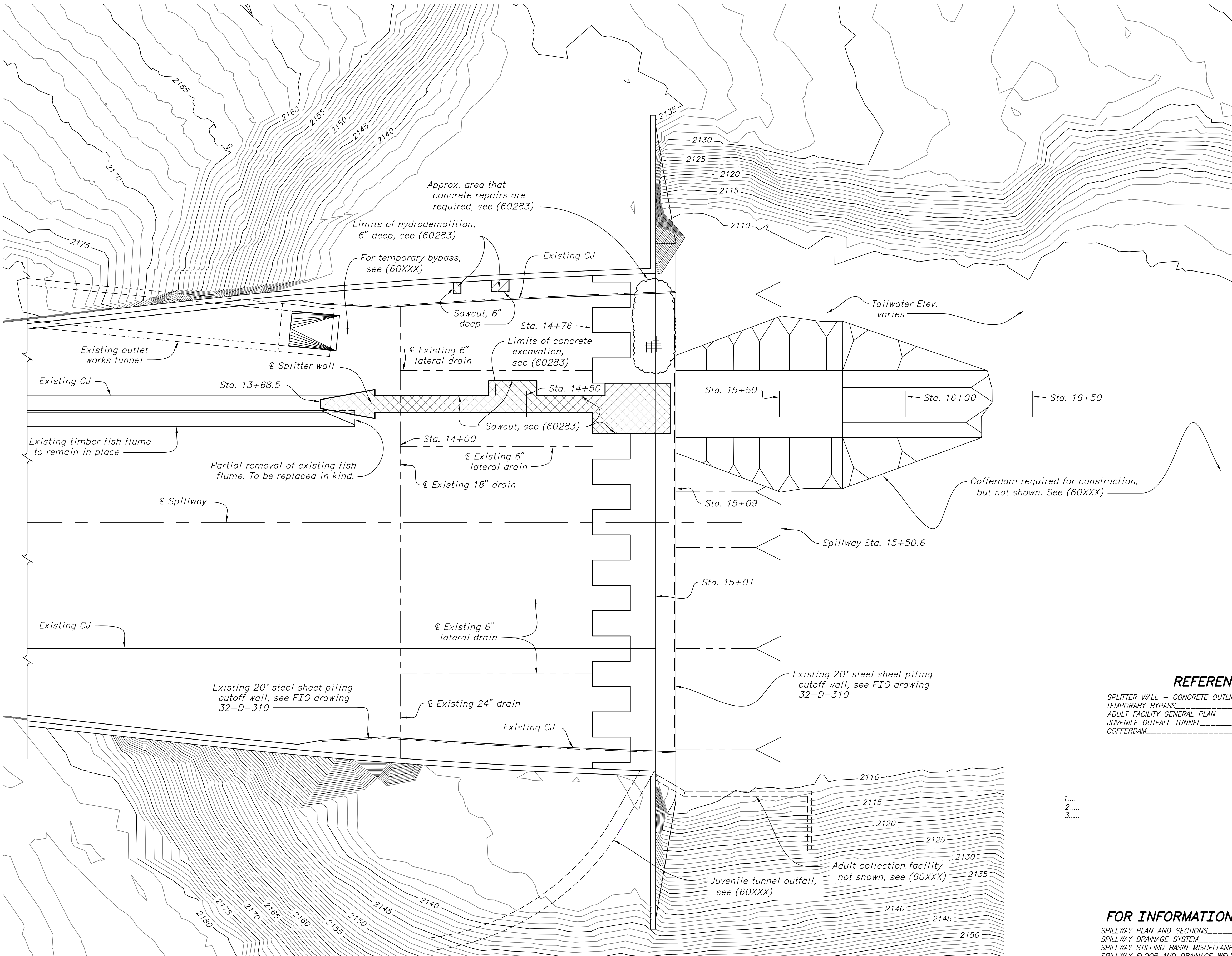
The gravity wall also performed adequately over the range of tests investigated. A slight scour hole was observed at the location where the toe of the gravity wall crossed over the existing stilling basin apron, and a few additional rocks were moved onto the stilling basin’s apron and remained downstream of the baffle blocks. Neither the observed scour nor deposition of rock on the apron is a major concern to the structural integrity. If the gravity wall is the preferred option, it is recommended that a cutoff wall be added to the toe of the wall where it extends past the basin’s apron to prevent the gravity wall from being undermined.

References

Hanna, Leslie (2015), “Hydraulic Model Study of Fish Passage Features Below Cle Elum Dam”, Hydraulic Laboratory Report HL-2015-02. U.S. Bureau of Reclamation, Technical Service Center, Denver CO USA.

APPENDIX A – Draft Design Drawings

The following pages contain the draft design drawings that were used to generate the splitter and gravity walls that were modeled during this study.



STILLING BASIN – PLAN VIEW

20 0 20 40 60
SCALE OF FEET

REFERENCE DRAWINGS

SPLITTER WALL – CONCRETE OUTLINE PLAN AND SECTION___ 33-D-60285
TEMPORARY BYPASS___________________________________ 33-D-60XXX
ADULT FACILITY GENERAL PLAN__________________________33-D-60XXX
JUVENILE OUTFALL TUNNEL____________________________ 33-D-60XXX
COFFERDAM____ 33-D-60XXX

NOTES

1....
2.....
3.....

FOR INFORMATION ONLY (FOI) DRAWINGS

SPILLWAY PLAN AND SECTIONS____________________________32-D-300
SPILLWAY DRAINAGE SYSTEM______________________________32-D-301
SPILLWAY STILLING BASIN MISCELLANEOUS DETAILS ________ 32-D-303
SPILLWAY FLOOR AND DRAINAGE WELL REINFORCEMENT________ 32-D-309
SPILLWAY STILLING BASIN STEEL SHEET PILING CUTOFF________ 32-D-310
DAM–SPILLWAY AND OUTLET WORKS PLAN AND SECTIONS_______32-D-385
MORE DRAWINGS?? ^^VERIFY DRAWING TITLES ^^

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CLE ELUM DAM FISH PASSAGE FACILITY

JUVENILE FACILITY

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APPROVED
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DENVER, CO

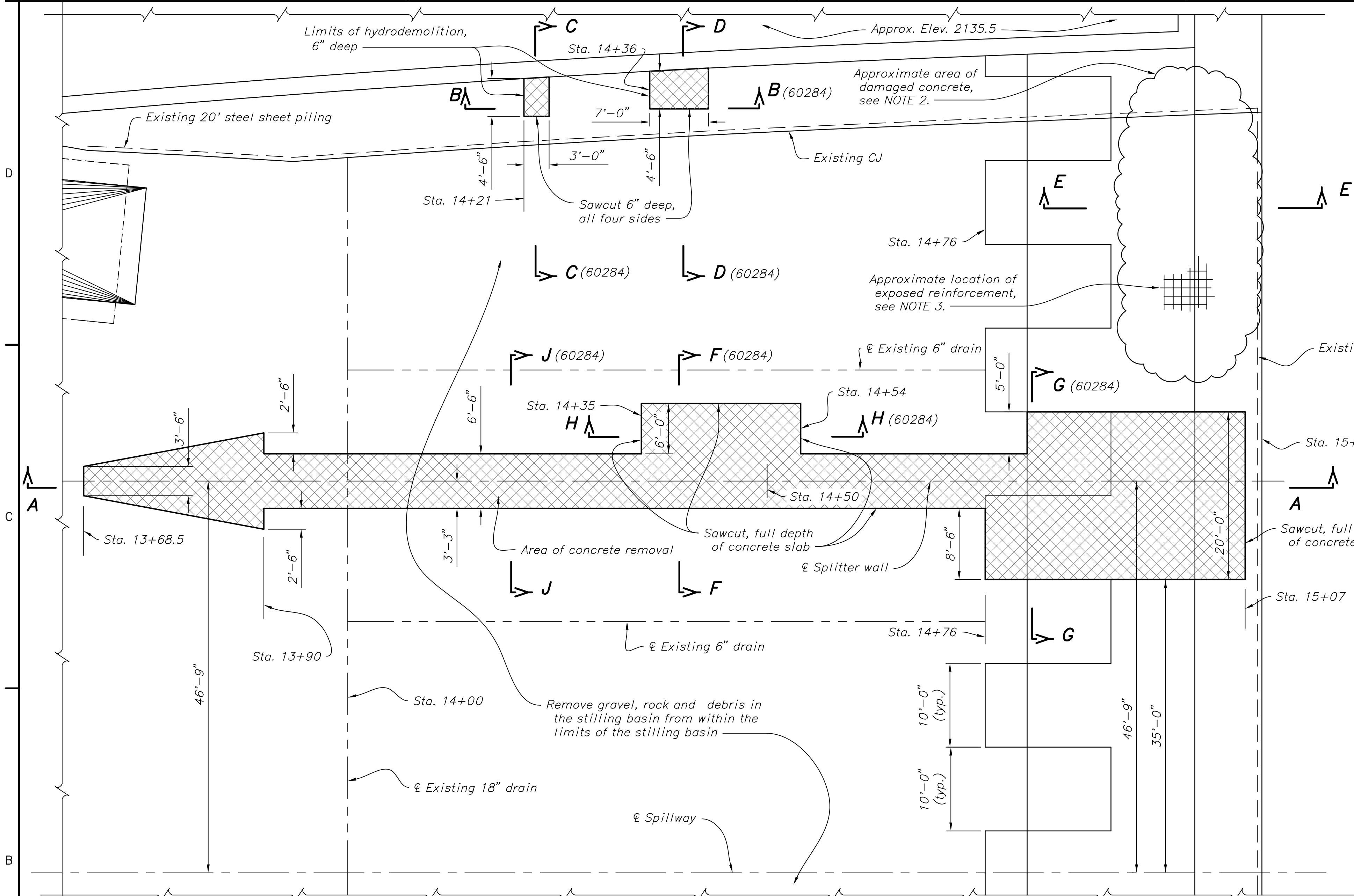
SPLITTER WALL

CONCRETE EXCAVATION AND REPAIR PLAN

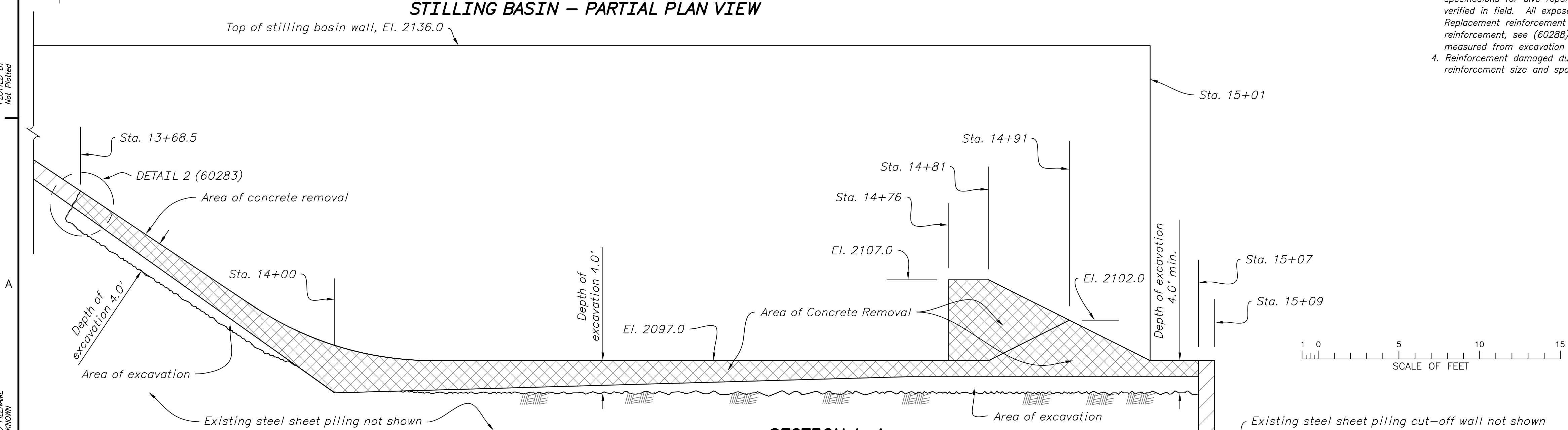
33–D–60282

SHEET 1 OF 3

DATE AND TIME PLOTTED Not Plotted
PLOTTED BY Not Plotted
CAD SYSTEM AUTOCAD
CAD FILENAME UNKNOWN



STILLING BASIN – PARTIAL PLAN VIEW



SECTION A–A

NOTES

1. For additional notes and REFERENCE DRAWINGS, see (60282).
2. Damaged concrete and repair limits are approximate and are shown for reference only. Actual extent of damaged concrete to be verified in field and locations of saw cuts are to encompass entire area of damaged concrete. Repair area to extend 6" horizontally beyond damaged concrete as determined by COR. Carefully excavate concrete beyond damaged section of reinforcement to provide lap splice length for replacement reinforcement. Depth of repair will vary. Depth of excavation dependent upon reaching undamaged concrete and reinforcement.
3. Exposed reinforcement shown for reference only. Reference Division 51 in the specificaions for dive reports. Actual extent of exposed/ damaged reinforcement to be verified in field. All exposed and/or damaged reinforcement must be removed. Replacement reinforcement must be attached to non–yielded / undamaged existing reinforcement, see (60288). Leave a minimum of ((8–inch of existing reinforcement, measured from excavation limits, for verification by COR.))<–Check with Labs.
4. Reinforcement damaged during excavation to be replaced by matching the existing reinforcement size and spacing in accordance with M–47, "Guide to Concrete Repair".

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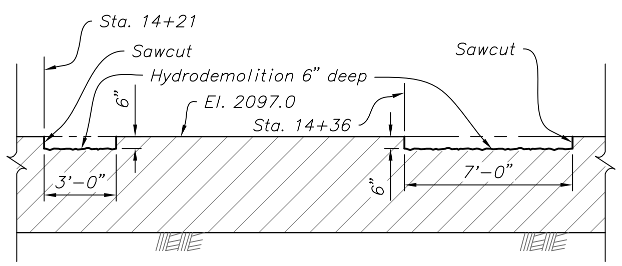
SPLITTER WALL

CONCRETE EXCAVATION AND REPAIR PLAN

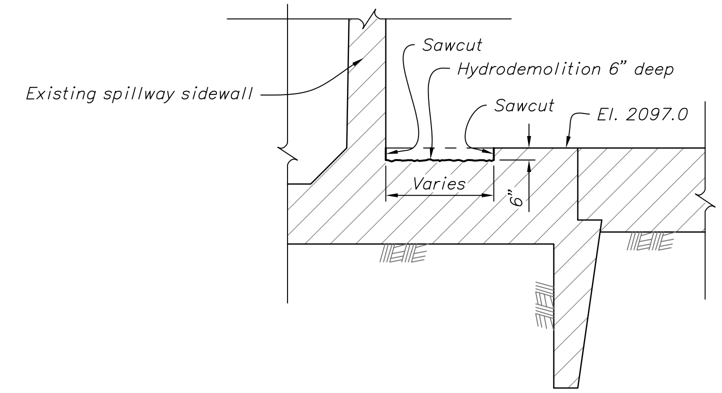
33–D–60283

SHEET 2 OF 3

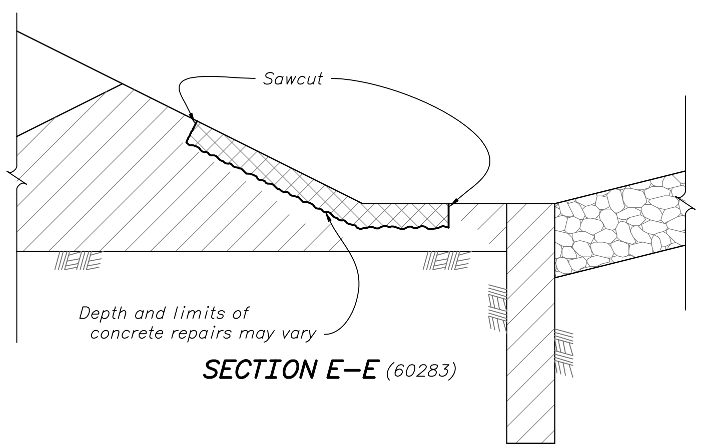
DATE AND TIME PLOTTED Not Plotted
PLOTTED BY Not Plotted
CAD SYSTEM AUTOCAD
CAD FILENAME UNKNOWN



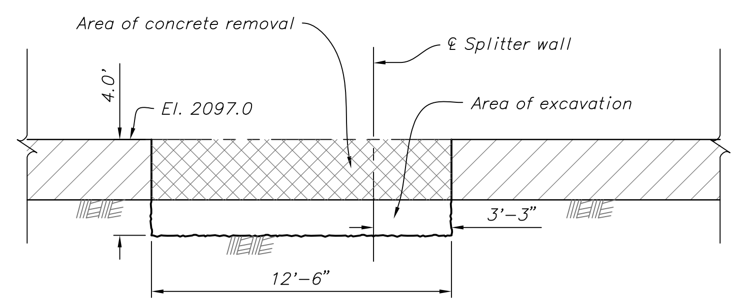
SECTION B–B (60283)



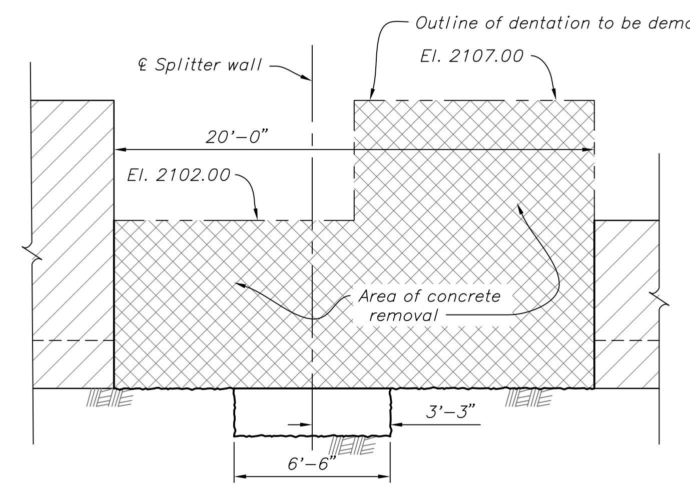
SECTION C–C (60283)
SECTION D–D (60283) (similar)



SECTION E–E (60283)

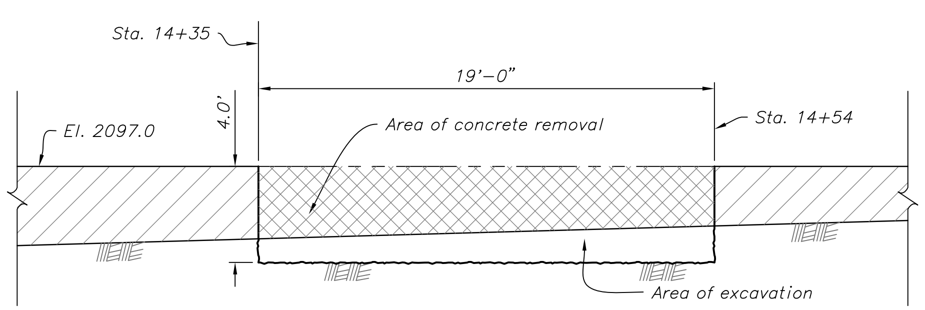


SECTION F–F (60283)

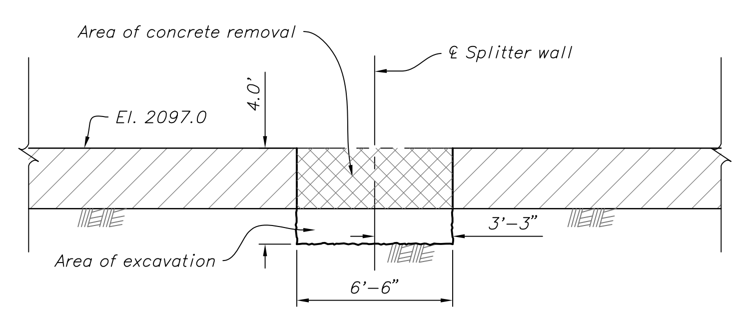


SECTION G–G (60283)
(TYPICAL FROM STA. 14+76 TO STA. 15+07)

1 0 5 10 15
SCALE OF FEET



SECTION H–H (60283)



SECTION J–J (60283)

NOTES

1. For additional notes and REFERENCE DRAWINGS, see (60282).
2. Existing steel reinforcement in the stilling basin not shown.

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SPLITTER WALL

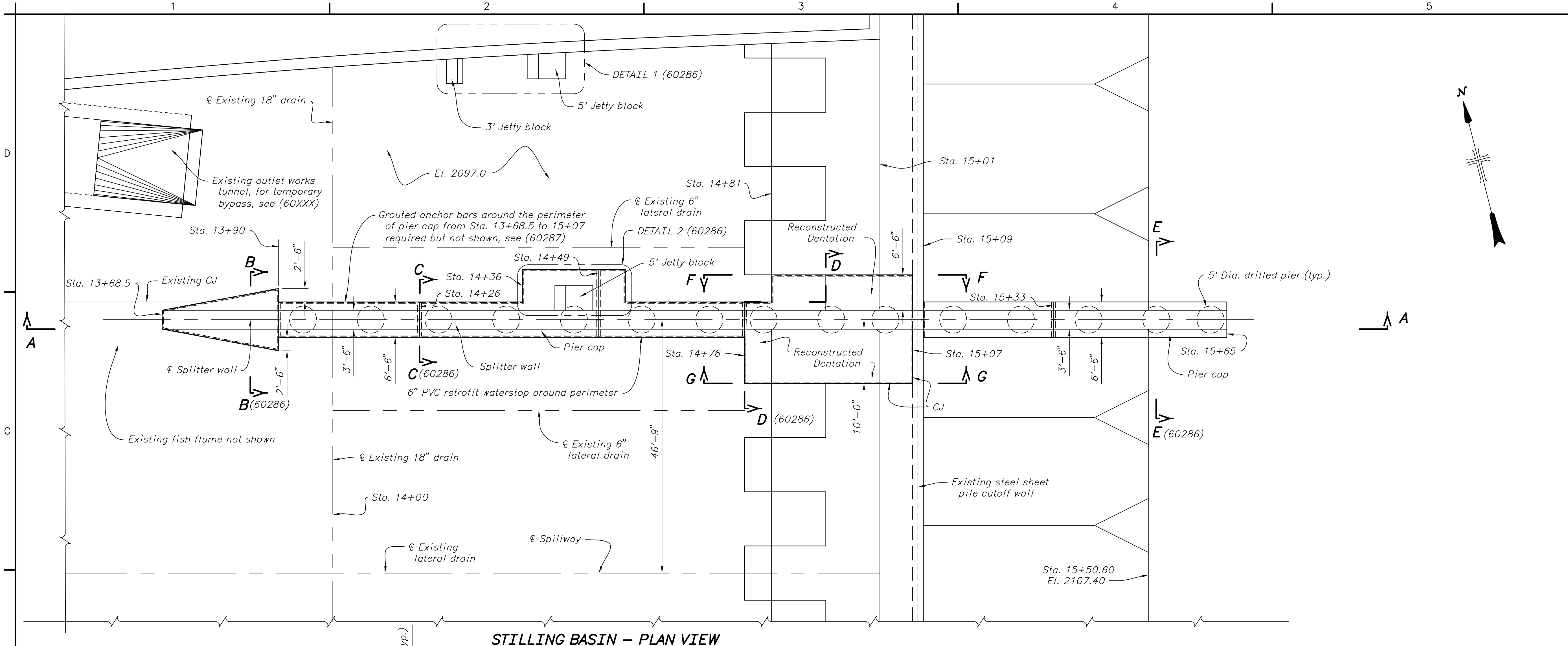
CONCRETE EXCAVATION AND REPAIR PLAN

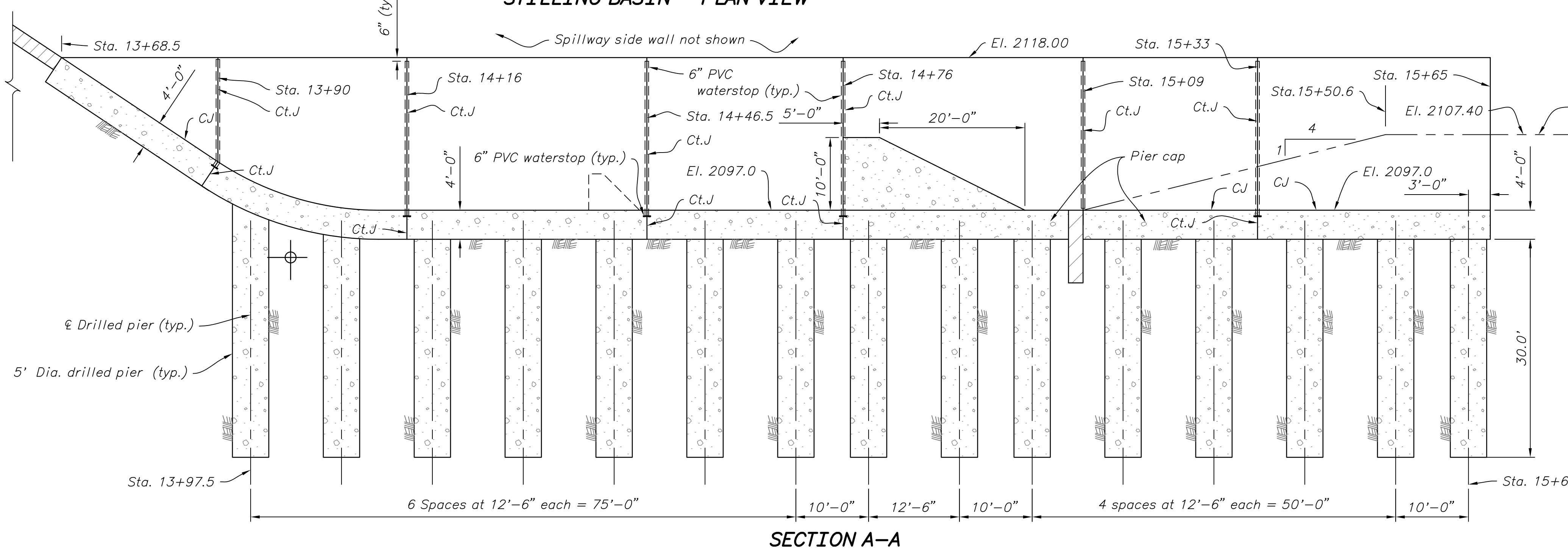
33–D–60284

SHEET 3 OF 3

DATE AND TIME PLOTTED Not Plotted
PLOTTED BY Not Plotted

CAD SYSTEM AUTOCAD
CAD FILENAME UNKNOWN





NOTES

1. For additional concrete outline notes, see 40–D–7012.
2. For additional notes and minimum requirements for detailing reinforcement, see 40–D–6263.
3. Design of concrete reinforcement based on reinforcing steel having a minimum specified yield strength of 60,000 psi. Design of splitter wall and pier cap based on concrete having a minimum compressive strength of 10,000 psi @ 28 days of age. Design of drilled piers based on concrete having a compressive strength of 4,500 psi @ 28 days of age.
4. Chamfer all exposed corners $\frac{3}{4}$" unless otherwise shown, see 40–D–7012.
5. Reinforcement required but not shown.
6. Temporary outlet works bypass not shown, see (60XXX).
7. Anchor bars required, but not shown, see (60287)

REFERENCE DRAWINGS

SPLITTER WALL – CONCRETE EXCAVATION AND REPAIR PLAN	33–D–60282
SPLITTER WALL – REINFORCEMENT	33–D–60288
TEMPORARY BYPASS	33–D–60XXX
ADULT FACILITY GENERAL PLAN	33–D–60XXX
JUVENILE OUTFALL TUNNEL	33–D–60XXX

10 0 10 20 30
SCALE OF FEET

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SPLITTER WALL

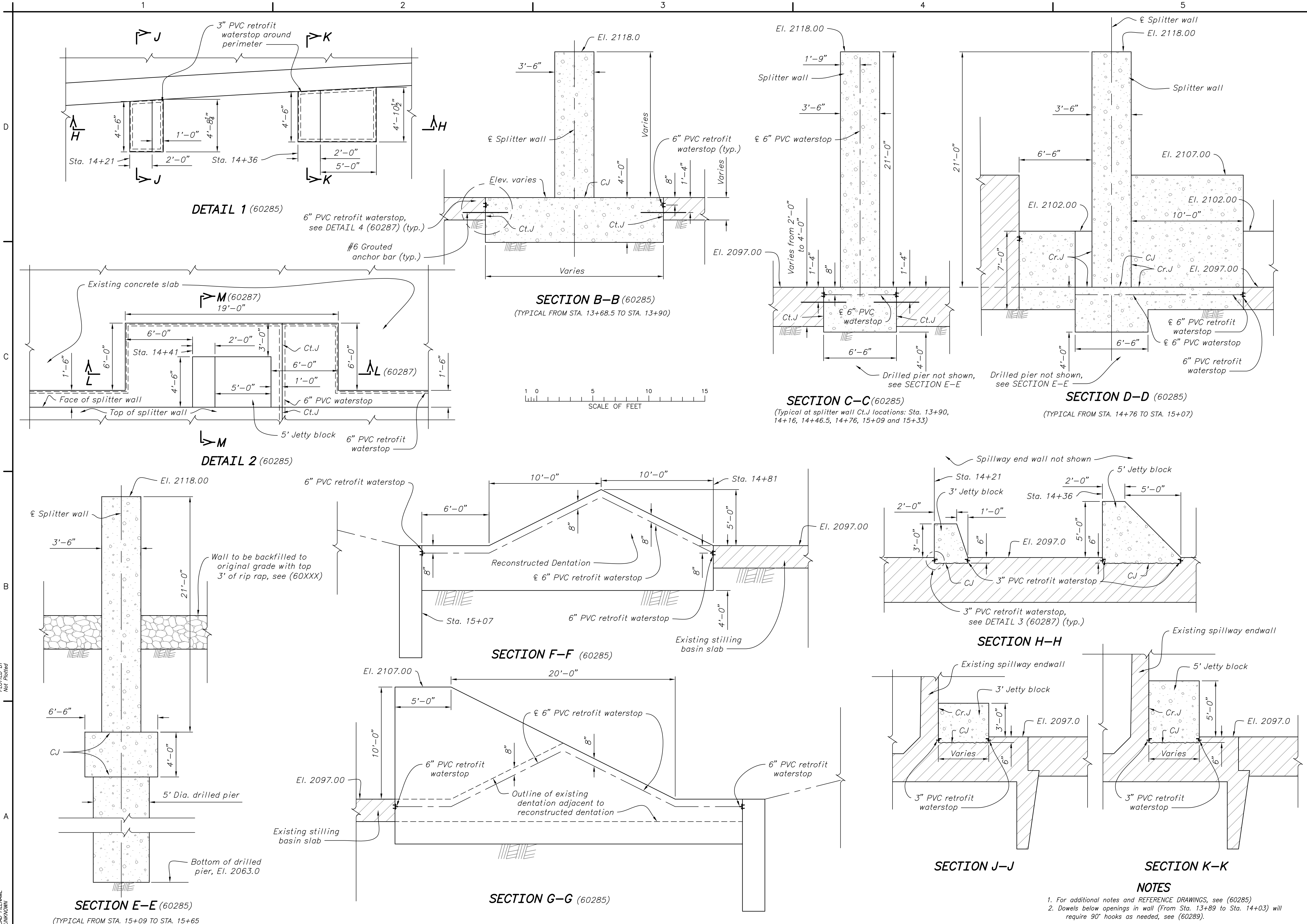
CONCRETE OUTLINE PLAN AND SECTION

33–D–60285

SHEET 1 OF 3

DATE AND TIME PLOTTED Not Plotted
PLOTTED BY Not Plotted

CAD SYSTEM AUTOCAD
CAD FILENAME UNKNOWN



NOTES

1. For additional notes and REFERENCE DRAWINGS, see (60285)
2. Dowels below openings in wall (From Sta. 13+89 to Sta. 14+03) will require 90° hooks as needed, see (60289).

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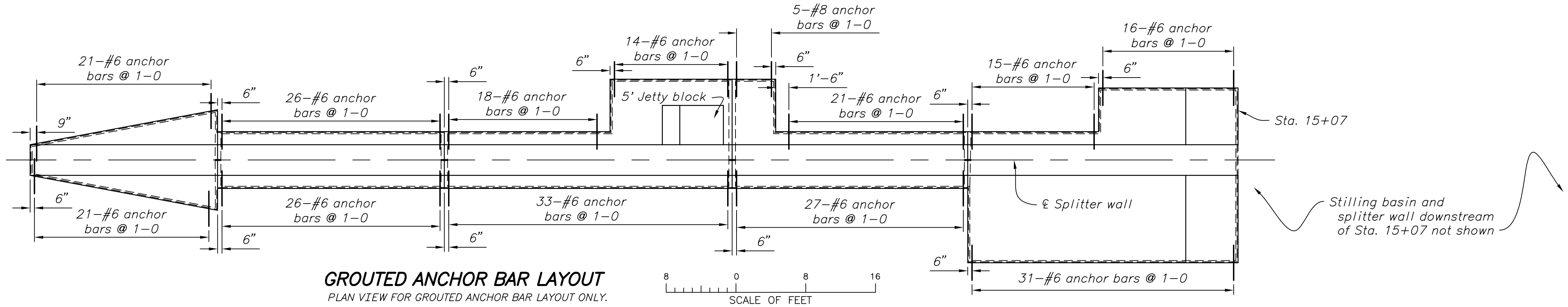
SPLITTER WALL
CONCRETE OUTLINE SECTIONS

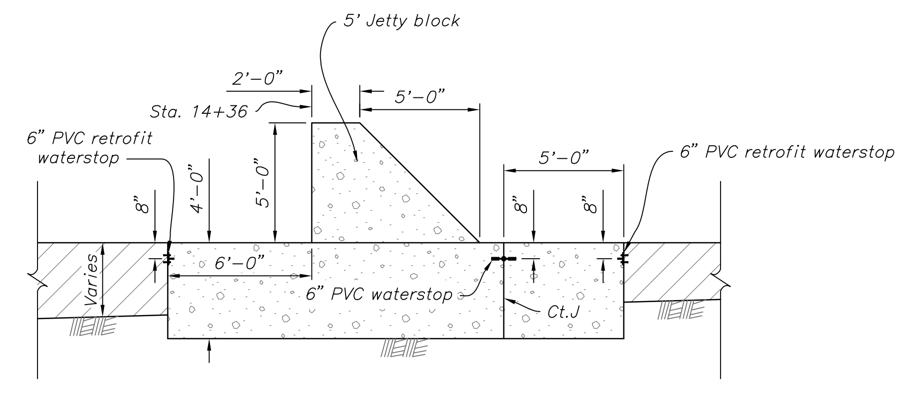
33-D-60286
SHEET 2 OF 3

DATE AND TIME PLOTTED Not Plotted
PLOTTED BY Not Plotted
CAD SYSTEM AUTOCAD
CAD FILENAME UNKNOWN

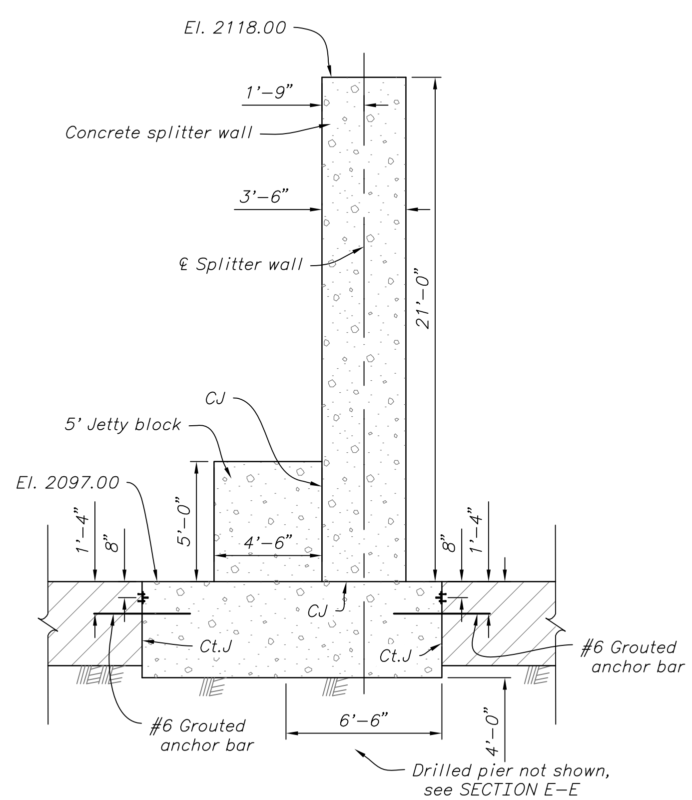


GROUTED ANCHOR BAR LAYOUT

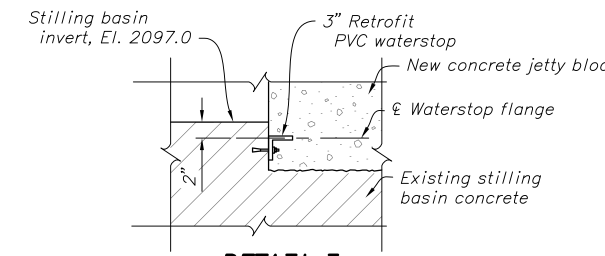
PLAN VIEW FOR GROUTED ANCHOR BAR LAYOUT ONLY.



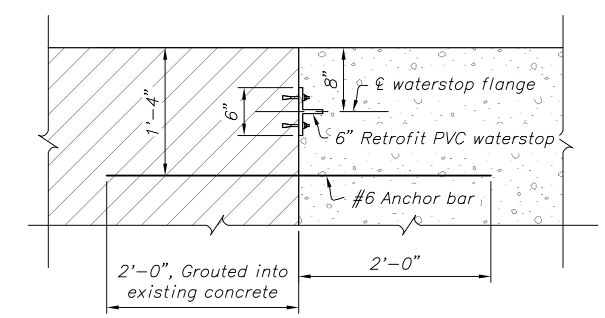
SECTION L–L (60286)



SECTION M–M (60286)



DETAIL 3



DETAIL 4

NOTES

1. For additional notes and REFERENCE DRAWINGS, see (60285)

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SPLITTER WALL

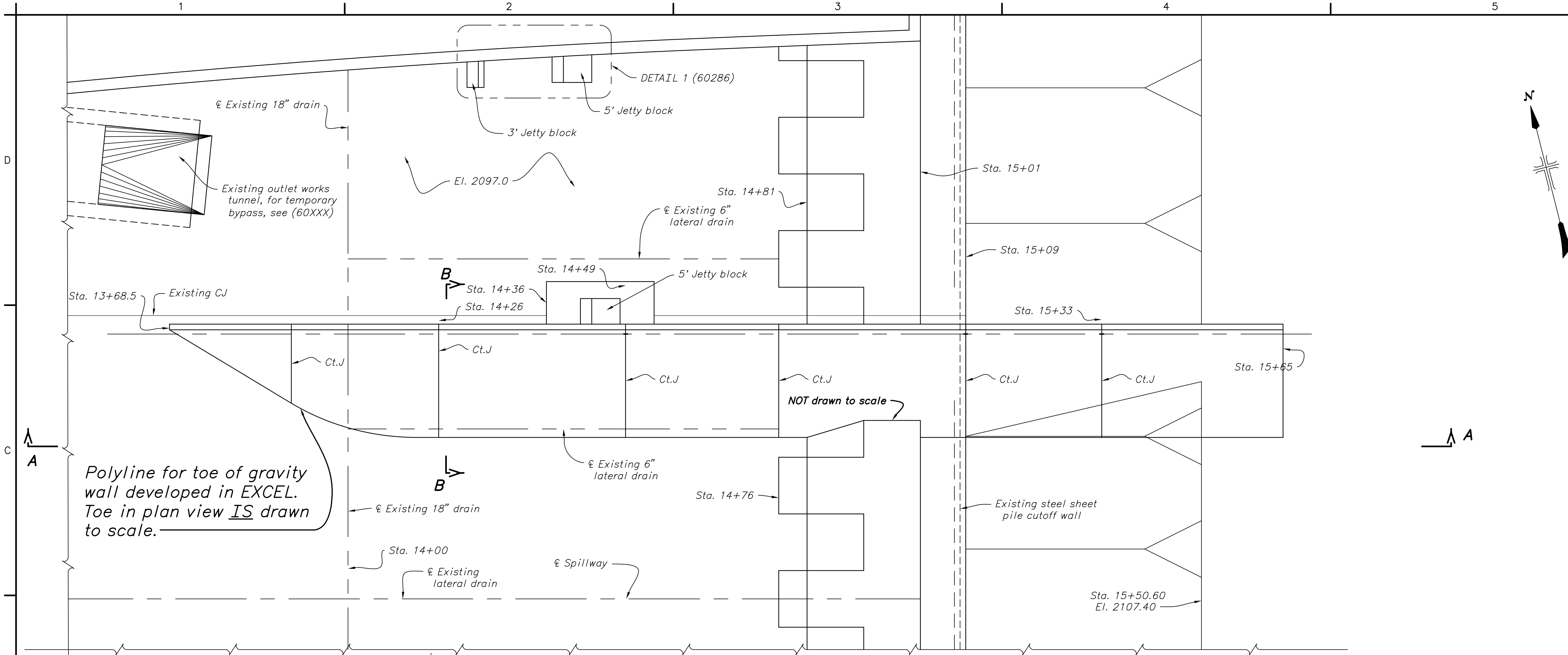
CONCRETE OUTLINE
SECTIONS AND DETAILS

33–D–60287

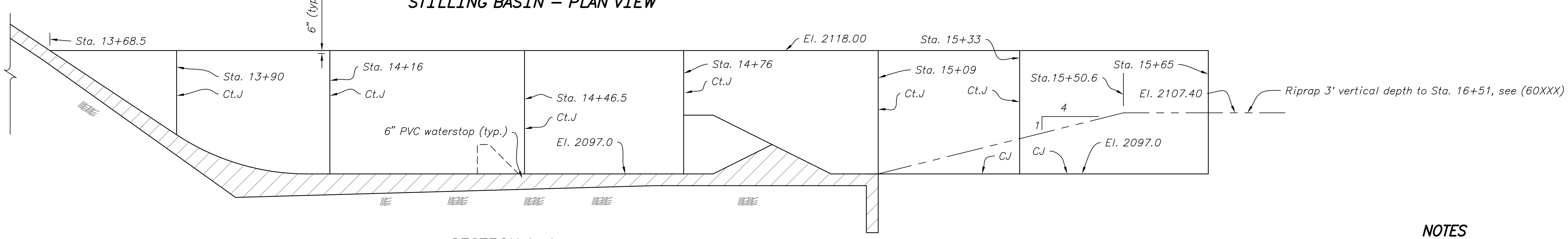
SHEET 3 OF 3

DATE AND TIME PLOTTED Not Plotted
PLOTTED BY Not Plotted

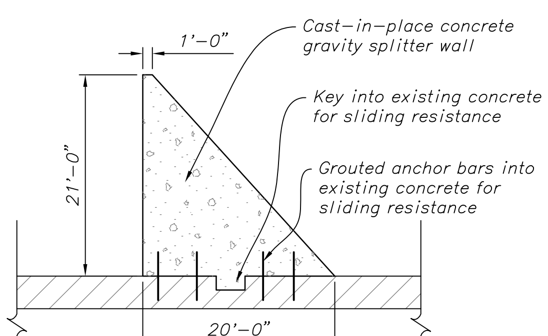
CAD SYSTEM AUTOCAD
CAD FILENAME UNKNOWN



STILLING BASIN – PLAN VIEW



SECTION A–A



SECTION B–B

NOTES

1. For additional concrete outline notes, see 40–D–7012.
2. For additional notes and minimum requirements for detailing reinforcement, see 40–D–6263.
3. Design of concrete reinforcement based on reinforcing steel having a minimum specified yield strength of 60,000 psi. Design of splitter wall and pier cap based on concrete having a minimum compressive strength of 10,000 psi @ 28 days of age. Design of drilled piers based on concrete having a compressive strength of 4,500 psi @ 28 days of age.
4. Chamfer all exposed corners ¾" unless otherwise shown, see 40–D–7012.
5. Reinforcement required but not shown.
6. Temporary outlet works bypass not shown, see (60XXX).
7. Anchor bars required, but not shown, see (60287)

10 0 10 20 30
SCALE OF FEET

REFERENCE DRAWINGS

SPLITTER WALL – CONCRETE EXCAVATION AND REPAIR PLAN__33–D–60282
SPLITTER WALL – REINFORCEMENT________ 33–D–60288
TEMPORARY BYPASS________ 33–D–60XXX
ADULT FACILITY GENERAL PLAN________33–D–60XXX
JUVENILE OUTFALL TUNNEL________ 33–D–60XXX

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SPLITTER WALL

CONCRETE OUTLINE PLAN

33–D–60285

SHEET 1 OF 3

DATE AND TIME PLOTTED Not Plotted
PLOTTED BY Not Plotted
CAD SYSTEM AUTOCAD
CAD FILENAME UNKNOWN