

# Ministry of Forests

## Kettle Valley Rail Trail KV-005 Bridge



### *Condition Assessment Report*

# Ministry of Forests

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March 20, 2023

Ministry of Forests  
Engineering Branch  
441 Columbia Street  
Kamloops, BC  
V2C 2TE

**Alex Soukup, RFT**  
**Engineering Officer, Rail Corridors**

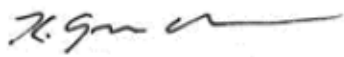
Dear Mr. Soukup:

**Kettle Valley Rail Trail Bridge**  
**KV-005 Condition Assessment Report**

Please find enclosed the KV-005 Bridge Condition Assessment Report. We trust it meets your project requirements. Please let us know if you have any questions.

Yours truly,

**KLOHN CRIPPEN BERGER LTD.**



Kristin Greinacher, P. Eng.  
Project Manager

MKC/CJ/JJ/MRC

## TABLE OF CONTENTS

|       |                                                      |    |
|-------|------------------------------------------------------|----|
| 1     | INTRODUCTION .....                                   | 1  |
| 2     | STRUCTURAL .....                                     | 4  |
| 2.1   | Inspection Observations .....                        | 4  |
| 2.1.1 | Right Abutment .....                                 | 5  |
| 2.1.2 | In-stream Pier .....                                 | 6  |
| 2.2   | Structural Recommendations .....                     | 8  |
| 2.2.1 | Right Abutment .....                                 | 8  |
| 2.2.2 | Pier .....                                           | 8  |
| 3     | HYDROTECHNICAL .....                                 | 9  |
| 3.1   | Hydrology .....                                      | 9  |
| 3.1.1 | Flow Record .....                                    | 9  |
| 3.1.2 | Flood Frequency Analysis .....                       | 10 |
| 3.2   | Hydraulic Model Setup and Validation .....           | 11 |
| 3.2.1 | Software .....                                       | 11 |
| 3.2.2 | Geometry .....                                       | 12 |
| 3.2.3 | Settings and Inputs .....                            | 12 |
| 3.2.4 | Validation .....                                     | 12 |
| 3.2.5 | Sensitivity Check .....                              | 12 |
| 3.3   | Hydraulic Model Results .....                        | 13 |
| 3.4   | Hydrotechnical Recommendations .....                 | 14 |
| 4     | GEOTECHNICAL .....                                   | 16 |
| 4.1   | Existing Conditions .....                            | 16 |
| 4.2   | Slope Stability Analyses .....                       | 17 |
| 4.2.1 | Model Geometry .....                                 | 17 |
| 4.2.2 | Model Parameters .....                               | 18 |
| 4.2.3 | Geogrid Reinforcement .....                          | 19 |
| 4.2.4 | Slope Stability Results .....                        | 19 |
| 4.2.5 | Retaining Wall External and Internal Stability ..... | 20 |
| 4.3   | Geotechnical Recommendations .....                   | 21 |
| 4.3.1 | Riprap Scour Protection .....                        | 21 |
| 4.3.2 | Rockfill Slope .....                                 | 21 |
| 4.3.3 | Riprap Slope .....                                   | 21 |
| 4.3.4 | Retaining Walls .....                                | 21 |
| 4.3.5 | Re-Use of On-Site Soils .....                        | 23 |

|   |                     |    |
|---|---------------------|----|
| 5 | ENVIRONMENTAL ..... | 24 |
| 6 | COST ESTIMATE.....  | 25 |
| 7 | CONCLUSION.....     | 27 |
| 8 | CLOSING.....        | 28 |
|   | REFERENCES.....     | 29 |

### List of Tables

|                                                                |    |
|----------------------------------------------------------------|----|
| Table 3-1: Flood frequency. ....                               | 11 |
| Table 3-2: Existing model results. ....                        | 13 |
| Table 3-3: Riprap sizing using USACE method.....               | 14 |
| Table 4-1: Summary of test pit locations. ....                 | 16 |
| Table 4-2: Summary of soil parameters. ....                    | 19 |
| Table 4-3: Summary of embankment slope stability results. .... | 20 |
| Table 4-4: Internal Stability Analysis Results.....            | 21 |
| Table 6-1: Option 1 Construction Cost Estimate. ....           | 25 |
| Table 6-2: Option 2 Construction Cost Estimate .....           | 25 |
| Table 6-3: Option 3A Construction Cost Estimate.....           | 26 |
| Table 6-4: Option 3B Construction Cost Estimate .....          | 26 |

### List of Figures

|                                                                                                         |    |
|---------------------------------------------------------------------------------------------------------|----|
| Figure 1-1: Map showing location of the KV-005 bridge.....                                              | 1  |
| Figure 1-2: Photo of KV-005 (by others) from 2019 inspection taken looking downstream (south). ....     | 2  |
| Figure 2-1: Timber approach span. ....                                                                  | 4  |
| Figure 2-2: Steel girder main span. ....                                                                | 4  |
| Figure 2-3: Sketch of undermining at right abutment.....                                                | 5  |
| Figure 2-4: Undermining at the upstream corner of right abutment. ....                                  | 5  |
| Figure 2-5: Right abutment back wall at downstream bearing. ....                                        | 6  |
| Figure 2-6: Right abutment back wall (looking upstream). ....                                           | 6  |
| Figure 2-7: Approximate extents of undermined area at the concrete pier. ....                           | 7  |
| Figure 2-8: Photo (by others) of the concrete pier from 2021 survey taken looking upstream. ....        | 7  |
| Figure 2-9: Varying pier cap thickness (looking at left bank). Bridge appears to be superelevated. .... | 7  |
| Figure 3-1: West Kettle River at Westbridge 1975 - 2021 (WSC 08NN003). ....                             | 9  |
| Figure 3-2: Flood frequency analysis.....                                                               | 11 |
| Figure 3-3: HEC RAS cross-section at bridge looking upstream.....                                       | 14 |
| Figure 4-1: Backfill ravelling behind right abutment wall.....                                          | 18 |

### List of Appendices

|              |                            |
|--------------|----------------------------|
| Appendix I   | Test Pit Locations         |
| Appendix II  | Test Pit Logs              |
| Appendix III | Global Stability Results   |
| Appendix IV  | Conceptual Design Drawings |

## 1 INTRODUCTION

The Kettle Valley Rail Trail (KVRT) is a multi-use recreational trail located in the Okanagan-Boundary region of southern British Columbia. The Ministry of Forests, Engineering Branch, Southern Engineering Group (the Ministry), provides and administers engineering services to Recreation Sites and Trails BC for the rail trail program. The Ministry has identified bridge structure KV-005, a 33.7 m long multi-span steel and timber girder bridge with concrete abutments which spans the West Kettle River approximately 20 km south of Beaverdell, for condition assessment and repairs. The location of the KV-005 bridge is provided in Figure 1-1.

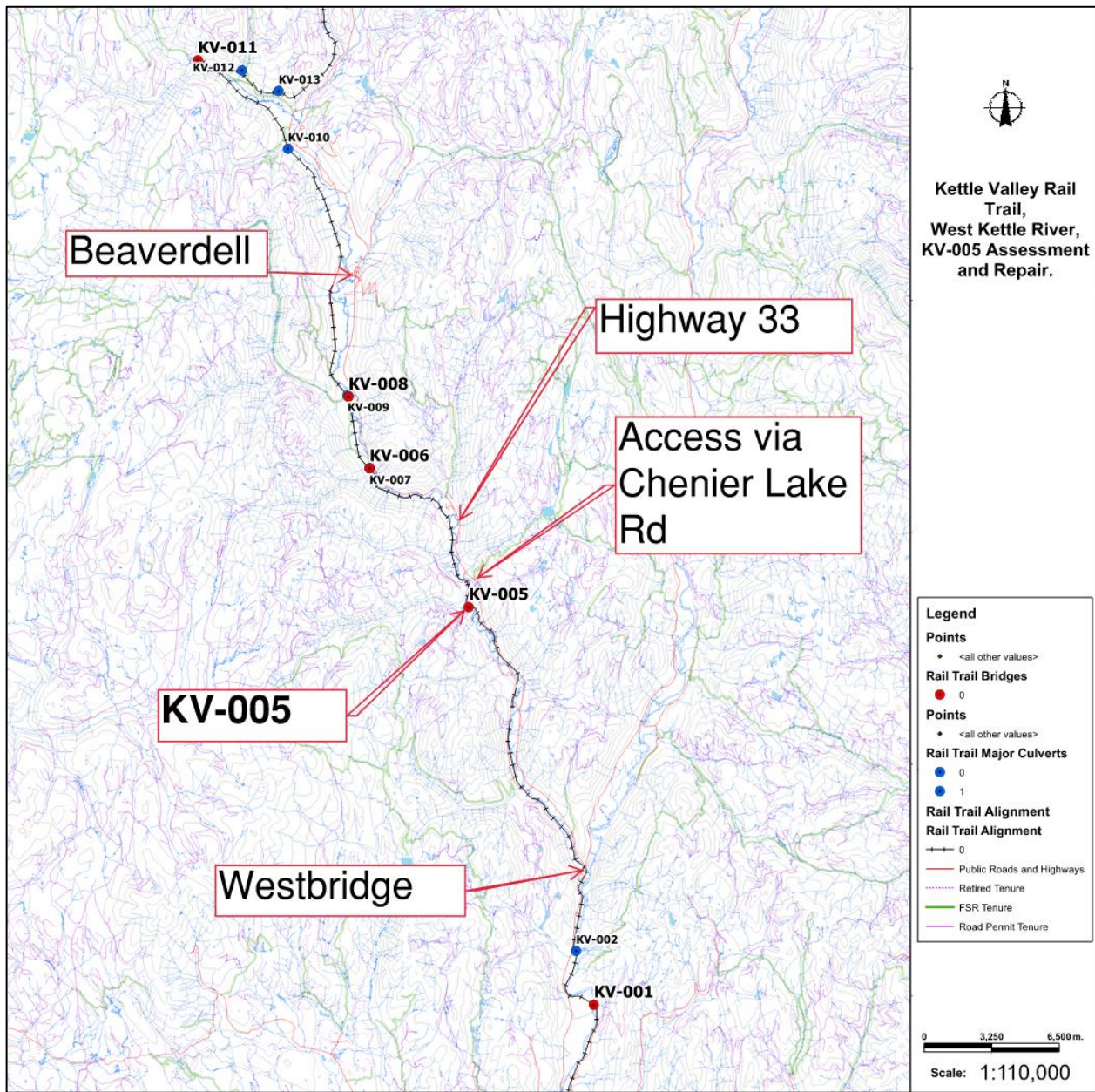


Figure 1-1: Map showing location of the KV-005 bridge.

KV-005 is a rail bridge which was inherited by the Ministry with no accompanying record drawings or geotechnical information and converted for pedestrian use. The bridge has a 26.2 m long main span comprised of twin steel girders supporting a timber deck which extends from the right cast-in-place (CIP) concrete abutment to an in-stream CIP concrete pier. Markings on the steel girders indicate they were likely fabricated in 1956. A skewed 7.5 m long approach span comprised of timber stringers and a timber deck connects the pier to the left CIP concrete abutment. Note that references to the right and left sides of the bridge are as seen looking downstream (south) of the structure.

Recent inspections have revealed undermining at the downstream corner of the pier and right abutment, failure of the right bank approach fills, and erosion of the right bank which extends upstream and downstream of the bridge.

A photo of the bridge layout and scour locations is shown in **Figure 1-2**. A general arrangement drawing produced based on field measurements of the bridge is provided in **Appendix IV**.

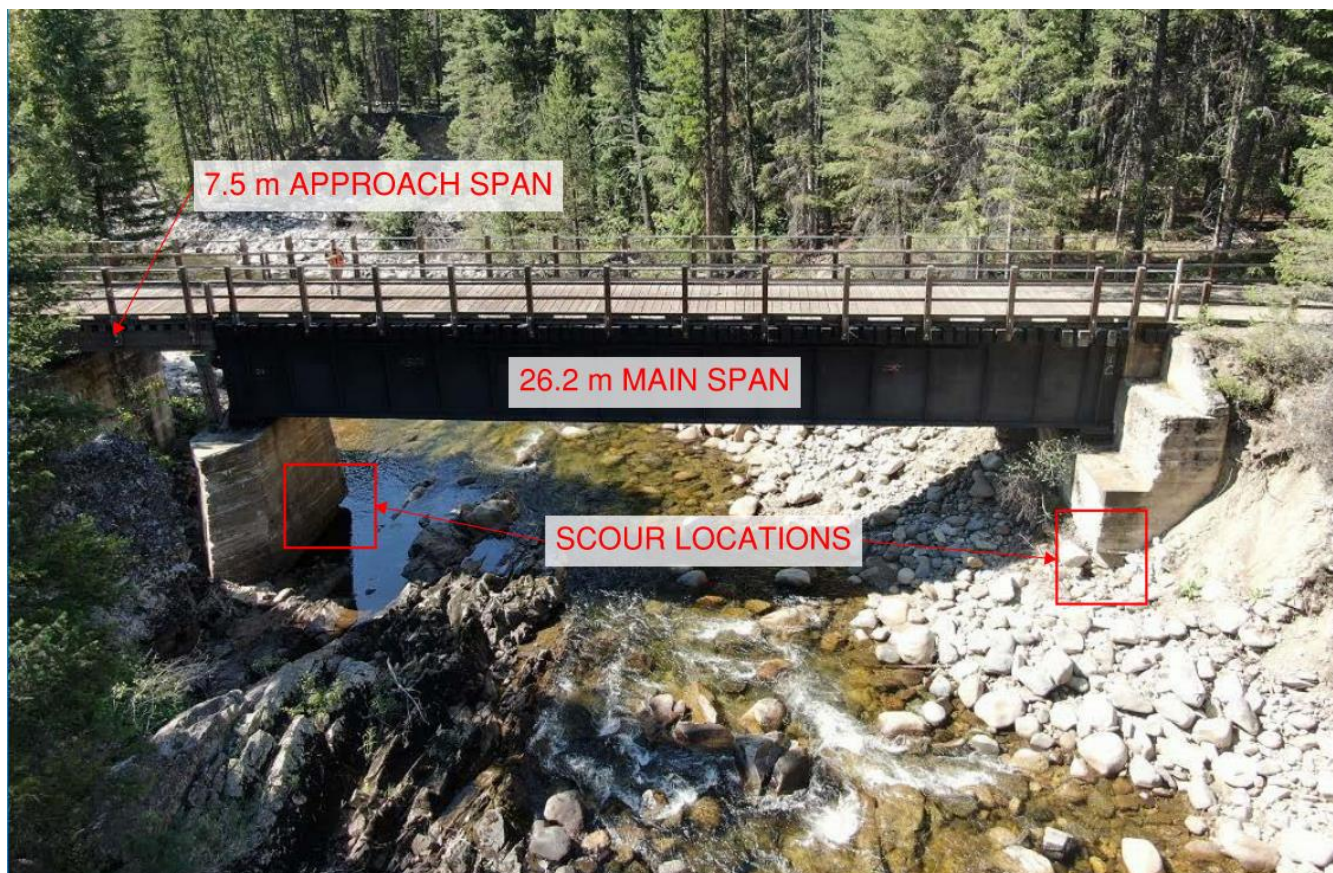


**Figure 1-2: Photo of KV-005 (by others) from 2019 inspection taken looking downstream (south).**

Klohn Crippen Berger Ltd. (KCB) was retained to assess the extent of undermining and provide a repair design for the right bank concrete abutment and the right side of the in-stream pier. The Ministry also requested a repair design to address any in-stream or bank alterations required to mitigate future erosion on both the upstream and downstream sides of the right bank.

Two KCB inspectors performed a walkthrough visual inspection of the KV-005 bridge on December 6<sup>th</sup>, 2022. The inspection took place with approximately 300 mm of snow cover on the ground. The West Kettle River was partially frozen at the edges with steady flow at the center. KCB measured the overall layout of the bridge and completed localized test pitting on the approach fill west of the structure. Drone photogrammetry was used to capture additional bridge features and visible hydrotechnical characteristics of the river immediately upstream and downstream from the bridge. Riprap at the existing bridge located immediately upstream of the KV-005 structure was not reviewed due to snow cover at the time of the inspection. As per the scope of services, the inspection did not include any testing or use of other special equipment.

This condition assessment report provides a summary of existing structural, geotechnical and hydrotechnical conditions based on observations made during the December 2022 inspection, historic geology and river flow information, and information from previous inspections provided by the Ministry. Design recommendations and design drawings for remediation repairs and erosion control options are also included in this report along with a Class 'D' construction cost estimate to implement the repairs.

## 2 STRUCTURAL

### 2.1 Inspection Observations

The KV-005 bridge was inspected for structural deficiencies, with particular focus on the condition of the right cast-in-place (CIP) concrete abutment and the pier, as outlined in the Request for Proposal (RFP). The Ministry initially requested a structural investigation of the “apparent in-sloping of the superstructure”. However, this request was withdrawn as it appears the bridge was constructed with superelevation which accounted for the “apparent in-sloping”.

Due to snow cover, not all components of the bridge were visible at the time of inspection. Snow was removed from the abutments to take measurements. The exposed portions of the left abutment did not show signs of scour; however, the downstream right corner of the abutment was obscured by a snowbank. The left abutment concrete appeared sound and did not show signs of spalling or delamination. Some minor chipping was noted at edges and corners of the abutment.

The timber approach span consists of seven 600 x 200 mm stringers spaced at 560 mm center-to-center. The timber approach span appeared to be in good condition, with minor splitting noted in some members. The timber stringers appeared sound and did not display any visible evidence of rot. The 150 x 150 mm handrail posts are bolted to the exterior stringers. The deck is nailed to timber sleepers supported on 200 x 200 mm transverse ties. At the left abutment, the stringers rest on a timber crib made of four 305 x 305 mm and four 200 x 200 mm members which are bolted to the abutment with angles. At the pier, the stringers sit on four timber columns with cross-bracing and sleepers bolted to the pier with angles.

The main span consists of two 2489 mm (98”) deep steel I-girders with 457 (18”) wide flanges and steel cross-braced diaphragms measuring 3.05 m between inside of webs. The steel on the main span appeared to be in good condition with no visible signs of corrosion. Photos of both spans are shown in **Figure 2-1** and **Figure 2-2**.



**Figure 2-1: Timber approach span.**



**Figure 2-2: Steel girder main span.**

### 2.1.1 Right Abutment

KCB confirmed the location and extents of the undermined upstream corner at the right abutment. The area measured approximately 1.8 m long by 0.96 m wide by 0.85 m deep. A sketch of the undermined area is shown in **Figure 2-3**.

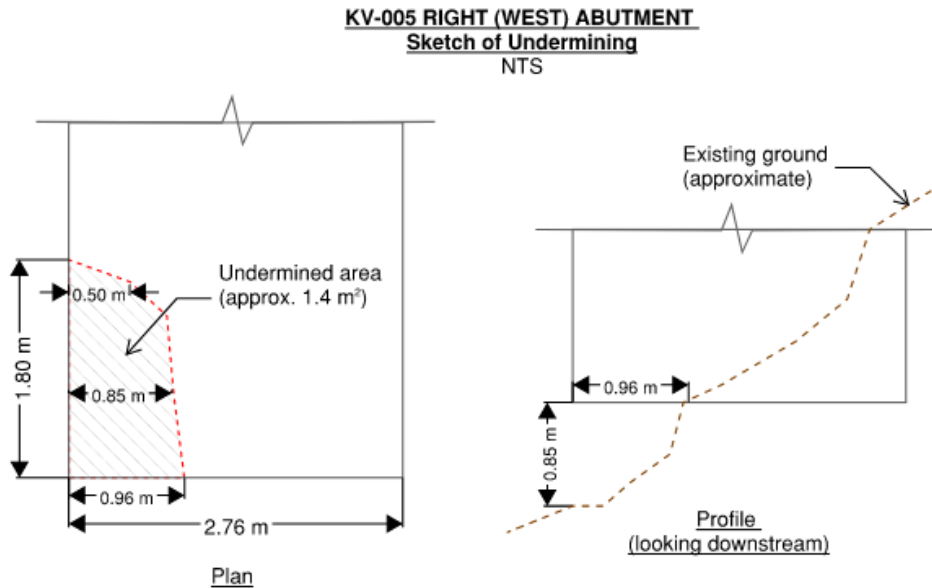


**Figure 2-3: Sketch of undermining at right abutment.**

The upstream edge of the abutment appeared to be resting on two 1 m long x 0.6 m wide/tall rocks, while the surrounding material had scoured away. An annotated photo of the undermining at the right abutment is shown in **Figure 2-4**.

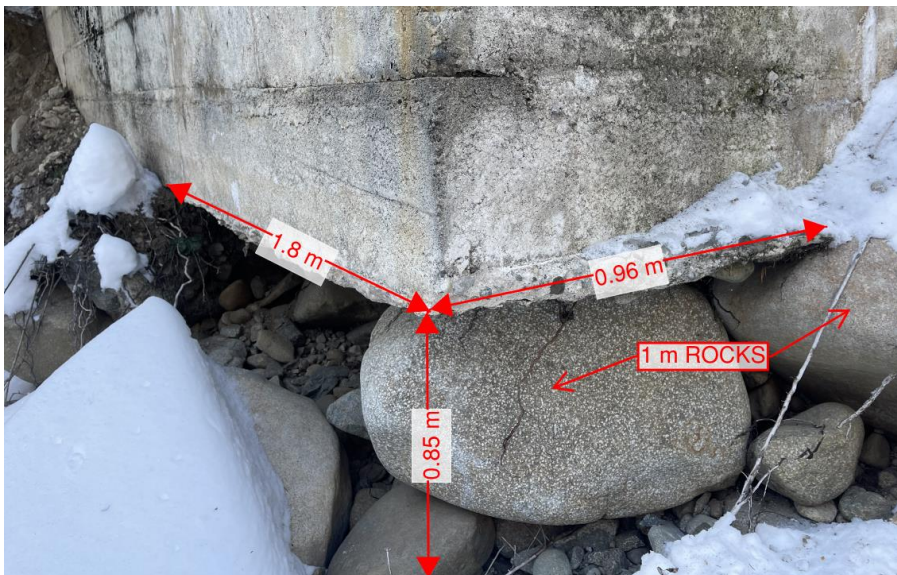


**Figure 2-4: Undermining at the upstream corner of right abutment.**

No significant cracks were observed in the concrete near the undermined area. The concrete on the right abutment appeared sound overall, with some minor chipping, cracking, and honeycombing. No signs of spalling or delamination were visible at the time of inspection. The surface of the back abutment wall appeared rough and uneven, with indentations and exposed aggregate measuring approximately 25 to 100 mm. Photos of the back right abutment wall are shown in **Figure 2-5** and **Figure 2-6**.



**Figure 2-5: Right abutment back wall at downstream bearing.**



**Figure 2-6: Right abutment back wall (looking upstream).**

### 2.1.2 In-stream Pier

The KCB inspection team was able to confirm the presence of undermining at the right downstream corner of the CIP concrete pier. The exact extents of the undermined area could not be measured due to ice and snow accumulation near the pier at the time of inspection. However, based on drone images from the December 2022 KCB inspection and images from a survey by Vast Resource Solutions in 2021, the undermined area was estimated to measure approximately 0.5 m by 0.5 m. Photos showing the approximate extents of the undermining at the right downstream corner of the pier are shown in **Figure 2-7** and **Figure 2-8**.



**Figure 2-7: Approximate extents of undermined area at the concrete pier.**

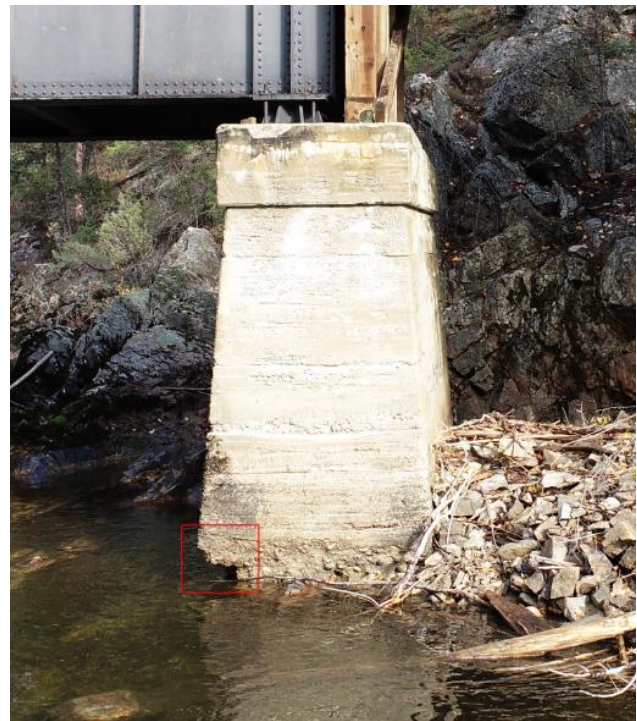


**Figure 2-8: Photo (by others) of the concrete pier from 2021 survey taken looking upstream.**

The pier concrete appeared sound and did not show any signs of spalling or delamination at the time of inspection. Minor cracks and chipping were noted on the surface. KCB noted the thickness of the pier cap varied from the upstream to downstream ends, as shown in **Figure 2-9**. This observation supports the belief that the bridge appeared to have been constructed with superelevation.



**Figure 2-9: Varying pier cap thickness (looking at left bank). Bridge appears to be superelevated.**

## 2.2 Structural Recommendations

### 2.2.1 Right Abutment

Based on the extent of scour noted at the right abutment during the December 2022 inspection, KCB recommends underpinning the undermined area with CIP concrete. Prior to installing formwork, organic and select loose material should be cleared from the area without disturbing the two large rocks which appear to support the upstream edge of the abutment. The rocks can remain in place and will be encased in concrete during the repair. The concrete should be self-consolidating with a minimum compressive strength of 30 MPa at 28 days to facilitate filling all voids in the undermined area. The footprint of the underpinned area should extend beyond the abutment footprint by 150 mm on both faces to allow for sufficient room to pour the concrete. A drawing showing the proposed right abutment repair design is included in **Appendix IV**.

### 2.2.2 Pier

Based on the information available at the time of writing, the scour at the pier is not considered an immediate concern. A rock outcrop runs adjacent to and underneath the bridge at the pier location, and the pier appears to be substantially founded on sound rock. The extent of scour observed at the pier appears to be approximately 2% of the overall footprint based on visual estimates from drone images from the December 2022 KCB inspection and images from the survey by Vast Resource Solutions in 2021.

KCB recommends re-assessing the pier when the water level in the West Kettle River is low. An in-stream assessment is recommended to confirm the actual extents of undermining and determine if the remaining material beneath the pier is susceptible to further scour. If the undermined area exceeds 10% of the pier footprint (approximately 1.4 m<sup>2</sup>), or if significant changes are observed year over year, KCB recommends underpinning the pier with CIP concrete, similar to what is recommended for the right abutment. Until such conditions are met, we recommend confirming the scour extents with an in-stream assessment and monitoring the pier annually for any changes.

If no significant changes are observed after 5 years, the monitoring frequency can be reduced to routine 5-year inspections. An inspection should be conducted following any major storm, debris flow, or flooding events.

If the Ministry opts to address the pier undermining at the same time as the other bridge repairs, the area should be underpinned with CIP concrete in a similar manner to the right abutment. We recommend using the same 30 MPa self-consolidating concrete to fill the void below the pier and extending the concrete by 150 mm on both faces to allow for sufficient room to pour the concrete. As the pier is exposed to the freeze-thaw cycles of the West Kettle River, stainless 15M dowels should be installed to connect the new concrete to the existing pier. A temporary cofferdam or similar measures will be required to isolate the repair area from the river for this repair. A drawing showing the proposed pier repair design is included in **Appendix IV**.

### 3 HYDROTECHNICAL

A hydrotechnical assessment at the bridge structure KV-005 was performed to determine erosion protection measures for the right bank and the design flood water level.

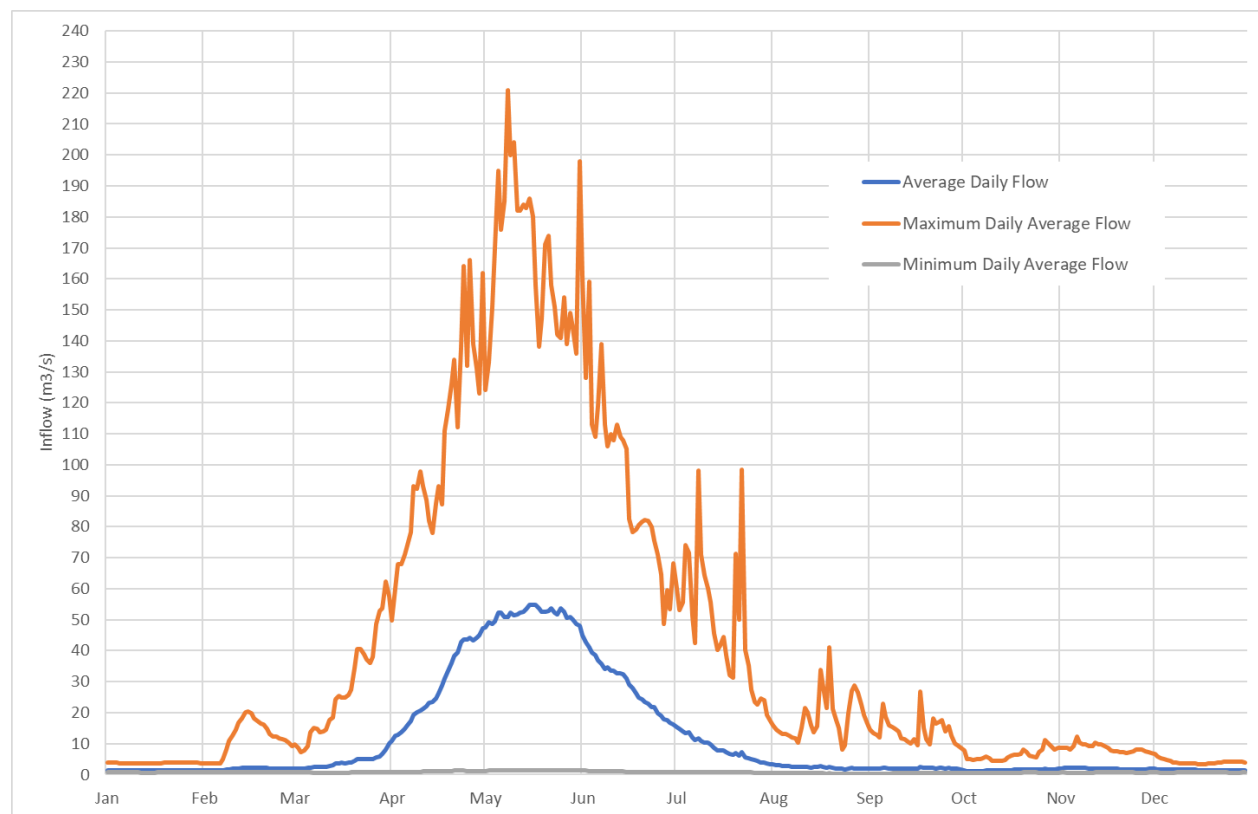
#### 3.1 Hydrology

##### 3.1.1 Flow Record

The Water Survey of Canada (WSC) flow gauge 'West Kettle River at Westbridge (08NN003)' is located on Kettle River approximately 14 km downstream of the bridge. The gauge was established in 1914 and operated until 1921. The gauge was re-established in 1975 and has been operating until the present date.

The available average daily flow record from 1975 to 2021 was used in this assessment, a record of 46 years. Gauge readings are inconsistent during the winter months with gaps in the record due to ice. The maximum, average and minimum daily average flows for the West Kettle River are plotted below for this period.

**Figure 3-1: West Kettle River at Westbridge 1975 - 2021 (WSC 08NN003).**



As the West Kettle River at Westbridge gauge is located 14 km downstream of the bridge, it will include additional catchment area and therefore additional inflows being included for the hydrotechnical assessment of the bridge. No factoring of recorded gauge inflows was used to reduce inflows which is a conservative approach.

### 3.1.2 Flood Frequency Analysis

A flood frequency analysis was performed using the West Kettle River at Westbridge gauge. The maximum daily flow for each year in the period of record was extracted from the flow data set and a statistical analysis was performed using three distributions (Log Pearson III, Gumbel and Log Normal).

A factor of 1.2 was applied to the daily average return period inflows to convert to the peak instantaneous inflow. The factor of 1.2 to account for peak instantaneous was selected based on previous project experience. The Westbridge gauge annual instantaneous extremes record with data available from 2007 to 2020 was compared against the daily average maximum; the selected 1.2 peak instantaneous factor was found to be appropriate for the site.

An additional 20% was applied to the estimated return period flows to account for the predicted increase in runoff as a result of climate change. The guidance provided in BC MoTI Technical Circular T-06/15, available guidelines from EGBC and the Pacific Institute for Climate Solutions (PICS) were considered when selecting the climate change increase.

The three distributions examined provided similar results for the return periods of interest. The Gumbel method was selected as that distribution produced slightly higher inflows. The flood frequency analysis graph is shown in **Figure 3-2** and results are presented in **Table 3-1**.

A 100-year return period was selected for the design flood based on MFLNR Forest Service Bridge Design and Construction Manual - Section 3.11 (MFLNR, 1999).

**Figure 3-2: Flood frequency analysis.**

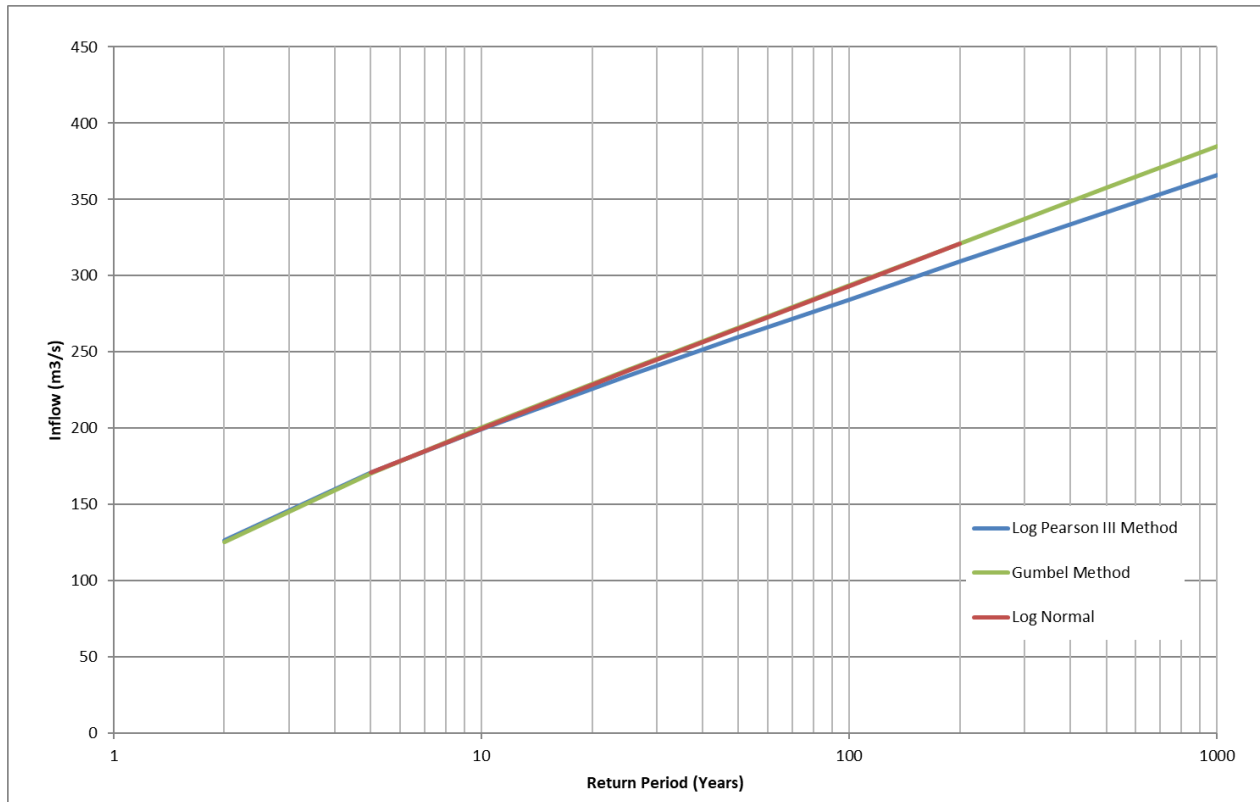


**Table 3-1: Flood frequency.**

| Return Period (Years) | Inflow (m3/s) | Peak Instantaneous Inflow (m3/s) | Peak Instantaneous Inflow (m3/s) with Climate Change Factor (20%) |
|-----------------------|---------------|----------------------------------|-------------------------------------------------------------------|
| 10                    | 200           | 219                              | 262                                                               |
| 25                    | 230           | 260                              | 311                                                               |
| 50                    | 260           | 290                              | 348                                                               |
| 100                   | 280           | 320                              | 384                                                               |
| 200                   | 310           | 350                              | 420                                                               |

## 3.2 Hydraulic Model Setup and Validation

### 3.2.1 Software

KCB developed a hydraulic model of Kettle River at the bridge structure KV-005. We used USACE HEC-RAS v6.2 software, an industry standard software package for modelling river systems in both 1D and 2D.

### 3.2.2 Geometry

The model geometry was developed using topographic and bathymetric survey information from October 2021 gathered by Vast Resource Solutions and photogrammetry obtained from KCB drone imagery, captured during the December 2022 site visit. The available survey information was compiled in AutoCAD Civil 3D to develop a representative surface of the site. The bridge abutments and pier were included in the surface. The girders and bridge deck were not modelled as the design flood water level was below both of those structures.

### 3.2.3 Settings and Inputs

Key model settings and inputs to the model are summarized below.

- The model was set up to analyze unsteady flow with Full Momentum equations;
- The model extents span 150 m upstream and 100 m downstream of the bridge;
- The inflow hydrograph was entered to steadily increase until the design flow was reached and maintained constant;
- Boundary conditions:
  - ◆ Upstream – Flow hydrograph with gradual increase until reaching design flow. Slope set to 0.012 at boundary.
  - ◆ Downstream – Normal depth with slope set to 0.012, selected based on the bathymetric survey sections.
- Manning's n coefficient of 0.04 for the entire surface.
- Mesh size of 0.5 m x 0.5 m.

### 3.2.4 Validation

The model was validated by comparing the modelled water level results to the surveyed high-water mark. The largest average daily inflow experienced for the gauge record was in 2018 with a flow of 319 m<sup>3</sup>/s. KCB assumed that a flow around this 2018 flow represents the high-water mark surveyed. The model results for 300 m<sup>3</sup>/s align with the surveyed high-water mark. At the bridge the high-water mark is approximately El. 701.5 m and the model indicated 701.7 m.

### 3.2.5 Sensitivity Check

KCB conducted a check for sensitivity of the model results to changing Manning's n values. We ran the model for Manning's n values of 0.035 to 0.05, representative of a range of riverbed and embankment conditions for natural streams consisting of gravels, cobbles and few large boulders (Finnemore, 2002). The corresponding variation in flow levels at the bridge was +/- 0.5 m. We selected a manning's n of 0.04 as representative of the river conditions.

### 3.3 Hydraulic Model Results

The model was run for 100-year return period flood of 384 m<sup>3</sup>/s; higher than the validation flow of 300 m<sup>3</sup>/s, for the existing conditions and altered right bank abutment slopes for increased erosion protection.

The model of existing conditions indicated that velocities along the right bank upstream of the bridge are higher than on the left embankment, due to the river alignment. Additionally, the back corner of the pier shows increased velocities. The design flood water level at the bridge for existing conditions is 701.8 m.

**Table 3-2** summarizes the model results for existing conditions at the left and right banks, upstream and downstream of the bridge abutments.

**Table 3-2: Existing model results.**

| Existing Conditions Model |                |           |
|---------------------------|----------------|-----------|
| Location                  | Velocity (m/s) | Depth (m) |
| Right Bank 5 m Upstream   | 4.8 - 5.2      | 2 - 2.5   |
| Left Bank 5 m Upstream    | 2.5 - 4        | 2.8       |
| Right Bank 5 m Downstream | 2.4 - 4.2      | 0.5 - 1.2 |
| Left Bank 5 m Downstream  | 2.2 - 6.0      | 2.5       |

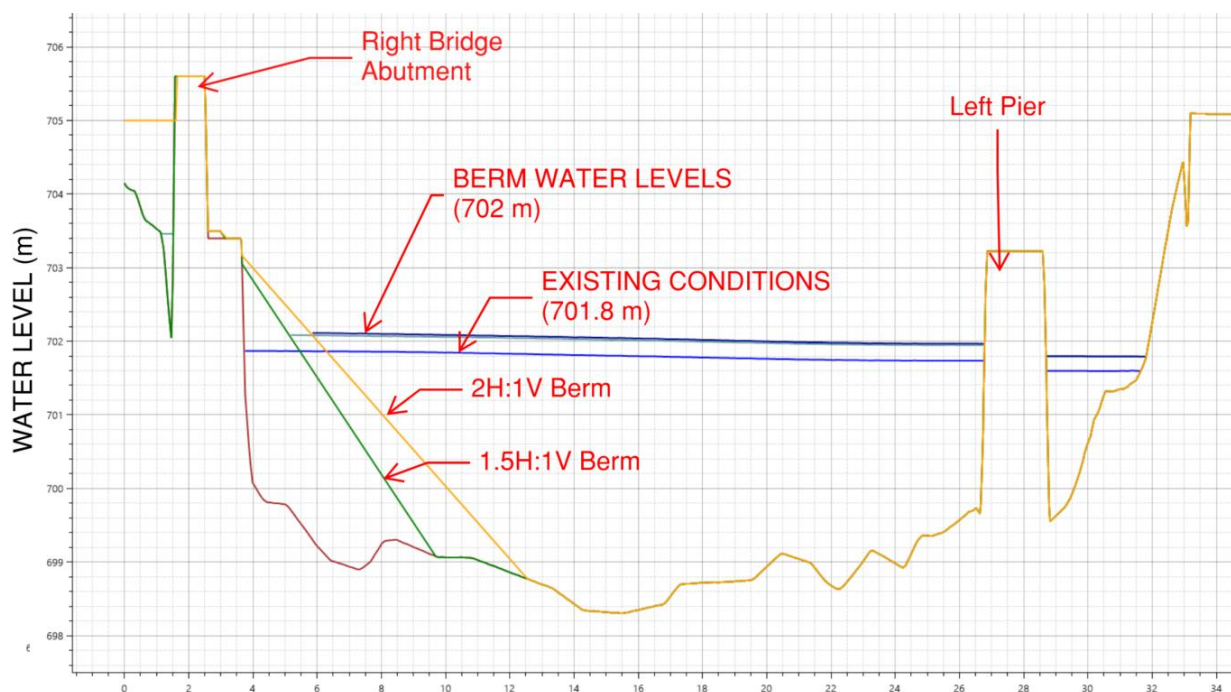
Erosion protection was modelled as an embankment on the right bank as the existing bank slope is approximately a 1H:1V slope that is too steep for riprap placement. The geometry was modified to examine the impact on water levels and flow velocities of embankments with shallower slopes protruding into the main channel. Two embankment slopes were examined for 1.5H:1V and 2H:1V with both embankment crests assumed to be at elevation 703.5 m.

The two potential embankment geometries were run in the model to compare against the existing conditions for the 100-year return period. The two embankment slopes modelled showed that water levels for both are approximately 702.0 m at the bridge. Embankments examined with varying slopes pushing the toe of the riprap slope further into the creek only made minor differences to the water level at the bridge.

The addition of the embankment results in an increase of 0.2 m in water level compared to the existing conditions. The velocities with the addition of the embankments are similar to the existing conditions.

A HEC RAS cross-section at the bridge is shown in **Figure 3-3**.

**Figure 3-3: HEC RAS cross-section at bridge looking upstream.**



### 3.4 Hyrotechnical Recommendations

#### Riprap Sizing

The USACE method was used to determine suitable riprap sizing for the right bank for erosion protection (USACE, 1994). The method was applied for the two different embankment slopes, and an average velocity of 5 m/s.

The results are shown in **Table 3-3**.

**Table 3-3: Riprap sizing using USACE method.**

| Embankment Slope | Velocity (m/s) | D50 (mm) |
|------------------|----------------|----------|
| 1.5 H : 1 V      | 5              | 1200     |
| 2 H : 1 V        | 5              | 780      |

The Ministry guideline states that riprap on stream banks should be normally placed on a slope of 2H:1V (MFLNR, 1999). Additionally, the hydraulic model indicated the selection of the shallower slope 2H:1V embankment had minimal impact on water levels compared to the 1.5H:1V. The selection of a steeper slope will increase the nominal size of riprap required for stability.

Comparing the USACE results to the Ministry guideline riprap sizing table, selecting a maximum allowable velocity of 4.8 m/s is equivalent to 800 mm D50 (MFLNR, 1999). The two methods for selection of riprap size align. KCB recommends that an embankment slope of 2H:1V be selected and

D50 of 800 mm. The 800 mm D50 falls between Class 800 (kg) and 1000 (kg) as per BC Ministry Standard classification, therefore the larger Class 1000 (kg) riprap is selected.

### Riprap Extents

Erosion protection is recommended on the right bank from approximately 15 m upstream and 15 m downstream of the bridge, based on the observed erosion during the site visit and velocities shown in the model. Erosion protection is not required on the left bank as from site observations appears to be exposed bedrock and no on-going erosion.

The riprap should be placed to El. 702.6 m, the 100-year water level plus 600 mm of freeboard.

A drawing showing the proposed riprap design is included in **Appendix IV**.

## 4 GEOTECHNICAL

### 4.1 Existing Conditions

KCB completed a field assessment of the surficial geotechnical conditions at the bridge site as well as performed two (2) test pits to characterize the subsurface soils at the right abutment. Prior to excavating test pits, KCB conducted a BC One Call search for third-party underground to confirm that there were no utilities in the proposed working area. The test pits were excavated using a Hitachi Zaxis 75US excavator operated by Shadow Creek Properties of Midway, BC, contracted directly by the Ministry.

The two test pits were advanced from trail level on the right abutment to the maximum depth achievable by the excavator. The locations of the test pits can be found in **Appendix I**. Soil stratigraphy was logged in the field by KCB's Engineer, test pit logs can be found in **Appendix II**. A summary of test pit information can be found in **Table 4-1**.

**Table 4-1: Summary of test pit locations.**

| Test Pit ID | Date             | Northing (m) <sup>1</sup> | Easting (m) <sup>1</sup> | Termination Depth (m) | Termination Reason |
|-------------|------------------|---------------------------|--------------------------|-----------------------|--------------------|
| TP22-01     | December 6, 2022 | 5461345                   | 351990                   | 2.1                   | Target Depth       |
| TP22-02     | December 6, 2022 | 5461339                   | 351982                   | 1.8                   | Refusal on Boulder |

Notes:

- Coordinates have been estimated from the drone photogrammetry model and are in NAD83, UTM Zone 11.

Both test pits encountered similar soil stratigraphy, the soil stratigraphy was also observable on the banks of the river in areas with no snow cover. The riverbank soils are fluvial deposits that consist predominantly of sand and gravel with cobble and boulder sized rocks. Generally, the percentage of cobbles/boulders making up the soil composition increases with depth. The sand was generally coarse and the gravels, cobbles and boulders were generally sub-rounded to sub-angular which indicate close deposition from material source and medium to high energy deposition environment.

Groundwater was not encountered in either of the relatively shallow test pit excavations. No seepage was observed from the riverbanks and the groundwater table in the vicinity of the bridge site is assumed to be the similar elevation as the river. KCB's site investigation was performed in the winter so groundwater conditions could vary depending on the season.

The left abutment and pier appear to be mostly founded on bedrock but much of the area was obscured by snow at the time of KCB's site investigation which made direct observation difficult in areas. KCB reviewed photos from previous site investigations and publicly available geology maps to better understand bedrock geology at the bridge site. The bedrock in the area has been classified as cretaceous age granites and granodiorites from the Ladybird and Valhalla intrusions in the Okanagan Batholith.

## 4.2 Slope Stability Analyses

Slope stability analyses were performed using GeoStudio Slope/W software to assess the stability of the right bridge abutment where scour has occurred. The analyses considered three (3) slope configurations based on feedback from the Ministry, these included:

- Riprap fill at base with rockfill slope above;
- Riprap fill over height of slope with upper portion steepened; and
- Riprap fill at base with retaining wall above.

For the retaining wall option, either a geosynthetic reinforced soil (GRS) wall or stacked rock wall could be considered. In both cases, it is anticipated that geosynthetic reinforcement will be required in the backfill to achieve global stability requirements.

Assumptions made for the stability analysis included:

- The Morgenstern-Price analysis method using the entry and exit search method to determine the Factor of Safety (FoS) of the critical slip surface.
- No surcharge load was included at the crest of the slope as this area is away from the pedestrian trail and should not experience pedestrian or vehicle traffic.
- Global stability cases considered failure surfaces that entered from the crest of the slope and exit at the toe, representing an overall failure of the abutment slope.
- Local stability cases considered relatively shallow failure surfaces that do not pose a significant threat to overall embankment stability but rather represent surficial raveling.
- Elevations of the piezometric surface was estimated based on site observations and results of the hydrotechnical analysis.
- The target FoS for global stability for normal creek water level (El. 700.0 m) was considered 1.5 while for the 100-year flood event (El. 702.0 m), a minimum FoS of 1.3 was considered as this represents a short-term condition. These target FoS values are considered appropriate for embankment design based on degree of understanding for the site.

### 4.2.1 Model Geometry

A critical cross section of the north side of the right abutment was developed using survey provided by the Ministry supplemented by drone photogrammetry model data. The existing concrete abutment does not close off the abutment slope and backfill material appears to be actively ravelling from behind the abutment as shown in **Figure 4-1**.



**Figure 4-1: Backfill ravelling behind right abutment wall.**

Slope configurations at the right abutment included riprap at the base of the slope to protect against scour. The hydrotechnical analysis indicates that a minimum average riprap block size of 800 mm diameter is required to withstand the flow velocities for the 100-year flood event. Based on the average block size, the minimum true thickness of the riprap layer was taken to be approximately 1.5 m. From a hydrotechnical perspective, a slope of 2H:1V is preferred for riprap placement. The riprap will also be keyed into the riverbed at the toe of the slope.

Above the riprap, the slope can be constructed by rockfill, placed rock fill (PRF) using riprap, GRS wall or stacked rock wall. The final profile of the slope or wall face will be positioned to prevent future loss of backfill material behind the concrete abutment. The maximum slope angle for the rockfill was taken to be 1.5H:1V while for the PRF was taken to be 1H:1V based on discussions with the Ministry. Further discussion on maximum slope angle related to local slope stability is included in Section 4.2.4.

The primary purpose for using the PRF or a GRS wall or stacked rock wall at the top of the abutment slope is to limit the footprint of the riprap in the river compared to a standard rockfill slope. The GRS wall or stacked rock wall will have a near vertical (typically  $>70^\circ$  from horizontal) wall face to close off the abutment wall and prevent backfill from ravelling. To simplify the model, the wall face was conservatively assumed to be vertical.

#### 4.2.2 Model Parameters

The soil strength parameters for the Native River Deposit were developed using a combination of back-analysis from the existing conditions of the right abutment and typical values from literature

based on the soil types observed. The hydrotechnical analysis indicates that an average riprap block size of 800 mm diameter is required to withstand the flow velocities for the 100-year flood event. Strength parameters for the riprap assume that the blocks are relatively angular and placed in a manner that the long-term stability of the embankment will be controlled by the drained strength of the material. The source and quality of rockfill, riprap, and reinforced backfill materials is not currently known so the strength parameters were estimated based on KCB's previous experience using materials with similar characteristics. Due to the uncertainty of the rockfill, riprap, and reinforced backfill strength parameters, a sensitivity analysis was performed to observe effects on global and local stability. The material parameters considered in the stability analyses are summarized in **Table 4-2**.

**Table 4-2: Summary of soil parameters.**

| Material              | Unit Weight (kN/m <sup>3</sup> ) | Model Type   | Anticipated Friction Angle Range (°) | Anticipated Mean Friction Angle (°) |
|-----------------------|----------------------------------|--------------|--------------------------------------|-------------------------------------|
| Native River Deposits | 20                               | Mohr-Coulomb | -                                    | 38                                  |
| Riprap                | 22                               | Mohr-Coulomb | 40 – 50                              | 45                                  |
| Rockfill              | 21                               | Mohr-Coulomb | 35 – 45                              | 40                                  |
| Reinforced Backfill   | 20                               | Mohr-Coulomb | 36 - 40                              | 38                                  |

### 4.2.3 Geogrid Reinforcement

The GRS wall or stacked rock wall would both use layers of geogrid to reinforce the backfill. The geogrid was assumed to have a minimum allowable tensile strength of approximately 18 kN/m and be installed at a maximum of 0.6 m vertical spacing over the wall height. The length of the geogrid was modified until the target FoS for global stability was achieved in the slope stability analysis.

### 4.2.4 Slope Stability Results

A back analysis of the existing right abutment slope was first performed to determine the validity of the soil parameters selected for the Native River Deposits and to assess the current stability of the abutment slopes. The FoS for global stability of the right abutment is slightly above 1, which indicates the slopes are marginally stable. The FoS for local, shallow failure surfaces is less than 1 which indicates the slope is likely to experience ravelling. Based on the results of the back analysis, the material properties were deemed appropriate for analysis of remediation options of the right abutment. A summary of the stability analysis is included in **Table 4-3**. The complete global stability results can be found in **Appendix III**.

**Table 4-3: Summary of embankment slope stability results.**

| Stability Case                                         | Normal Water Level<br>FoS | 100-Year Flood Level<br>FoS |
|--------------------------------------------------------|---------------------------|-----------------------------|
| Existing Conditions - Global                           | 1.13                      | 1.06                        |
| Existing Conditions - Local                            | 0.70                      | 0.68                        |
| Riprap Fill at Base with Rockfill Slope Above - Global | 1.58                      | 1.51                        |
| Riprap Fill at Base with Rockfill Slope Above - Local  | 1.30                      | 1.30                        |
| Riprap Fill at Base with PRF Slope Above – Global      | 1.46                      | 1.42                        |
| Riprap Fill at Base with PRF Slope Above – Local       | 1.02                      | 1.02                        |
| Riprap Fill at Base with Retaining Wall Above – Global | 1.50                      | 1.45                        |
| Riprap Fill at Base with Retaining Wall Above – Local  | 1.30                      | 1.30                        |

The stability analysis indicates that satisfactory global FoS can be achieved for the different proposed slope configurations for both normal water level and 100-year flood water level scenarios. The riprap fill over the height of the slope arrangement is marginally below FoS of 1.5 but considered acceptable. Calculated FoS for local failure surfaces was lower than the global case FoS but generally high enough that that surficial ravelling should not be an issue on the slopes. Dependent on the riprap quality and how it is placed/compacted, there could be increased ravelling potential if constructed to 1H:1V slope and may require the slope to be constructed at a shallower angle.

The sensitivity analysis indicates that the global stability results are not appreciably influenced by the strength parameters of the rockfill, riprap or reinforced backfill. The global failure surfaces occur primarily through the Native River Deposits so the material properties of the proposed construction materials do not have a significant influence on stability. In terms of local failure surfaces, the FoS is more sensitive to changes in strength parameters for the rockfill, riprap or reinforced backfill. For the lower range of friction angles, the FoS approaches 1 meaning surficial ravelling could occur.

The maximum retaining wall height considered in the scenario where a GRS retaining wall is placed above the riprap fill is a maximum 2.0 m adjacent to the concrete abutment. For a retaining wall of 2.0 m in height the minimum geogrid length required to achieve the target FoS for global is 2.0 m measured from the back of the wall face.

#### 4.2.5 Retaining Wall External and Internal Stability

External and internal stability analysis for the retaining wall above the riprap base was assessed using the software program MSEW Version 3.0 by ADAMA Technologies in general conformance with the FHWA MSE wall design guideline. The software also analyzes for bearing resistance at the base of the wall system using an equivalent footing method.

The retaining walls were modelled with the uniaxial geogrid, Miragrid 3XT, with the reduction factors provided by the manufacturer. The uniaxial geogrid was modelled 2.0 m long measured from the back of the wall face as determined by the global stability analysis. Parameters used in the MSEW model for the retained fill (Native River Deposits), reinforced fill and foundation material (riprap or rockfill) are provided in **Table 4-2**. Based on the MSEW results, the retaining arrangement satisfies bearing capacity, direct sliding, eccentricity, geogrid strength and pullout resistance requirements. Internal stability results are summarized in **Table 4-4**.

**Table 4-4: Internal Stability Analysis Results**

| Failure Mode                        | Capacity to Demand Ratio (CDR) <sup>1</sup> |
|-------------------------------------|---------------------------------------------|
| Bearing Capacity                    | 3.77                                        |
| Foundation Interface Direct Sliding | 2.05                                        |
| Overturning                         | 3.08                                        |
| Geogrid Strength                    | 2.19 <sup>2</sup>                           |
| Geogrid Pullout Resistance          | 5.7 <sup>2</sup>                            |
| Geogrid Direct Sliding              | 1.15 <sup>2</sup>                           |

Notes: 1. CDR > 1 required to meet stability requirement for each failure mode.  
2. Value presented represents the lowest calculated CDR for a single geogrid layer.

## 4.3 Geotechnical Recommendations

### 4.3.1 Riprap Scour Protection

Riprap sizing and extent recommendations for scour protection are provided in Section 3.4 of this report. The quality of riprap rock source should be confirmed by the Engineer prior to placement. Before riprap installation commences, loose materials should be removed from the slope and depressions filled with material from surrounding area. Riprap should be machine placed to interlock rocks with larger rocks placed at the base of the riprap fill. We understand that the Ministry has identified a potential riprap source near the project site which can be used to supply the riprap.

### 4.3.2 Rockfill Slope

The rockfill placed above the riprap base at a maximum 1.5H:1V slope should consist of high quality, well-graded sound rock containing no more than 15% by volume rock larger than 150 mm. Rockfill shall be constructed in horizontal lifts not greater than 700 mm. Material shall be spread evenly in each layer so that the larger particles are well distributed, and the intervening spaces are filled with smaller sizes. Each fill layer is to be uniformly compacted by a vibratory drum roller, if space allows, or plate tamper with the number of passes required to achieve adequate compaction as determined on site by the Engineer.

### 4.3.3 PRF (Riprap) Slope

The PRF placed above the riprap base at a maximum 1H:1V slope should consist of Class 100 (kg) riprap as per BC Ministry Standard classification riprap or larger diameter. The quality of riprap rock source should be confirmed by the Engineer prior to placement. Before riprap installation commences, loose materials should be removed from the slope and depressions filled with material from surrounding area. Riprap should be machine placed to interlock rocks with larger rocks placed at the base of the riprap fill.

### 4.3.4 Retaining Walls

The primary retaining wall types considered for the abutment repair are a GRS wall and a stacked rock wall. Both options would likely require similar extents of geosynthetic reinforcement in the

backfill zone. The stacked rock wall could be considered as a gravity wall if the base width of the stacked rock wall was equivalent to the height.

A leveling/filter pad 300 mm in thickness should be placed on top of the riprap base prior to construction of the retaining wall to prevent backfill migration into the open voided riprap. Wick drains, a drainage layer and/or drain pipe should be placed near the base or behind the retaining wall to prevent water pressure build-up in the backfill. The reinforced backfill used in retaining wall construction and the coarse Native River Deposits are both considered free draining so water pressure build-up within the retaining wall is not likely even without drainage elements.

The reinforced backfill should consist of a well graded BC Ministry of Transportation and Infrastructure (MoTI) Select Granular Sub-base (SGSB) with no greater than 5% of the material by weight passing the 0.075 mm (#200) sieve (BC MoTI, 2020). The backfill material should be placed in lifts of 150 mm and compacted to 95% standard Proctor corrected maximum density (ASTM D698 and D4718). The material should be free of frozen and/or organic soils.

The GRS wall should be constructed with a wrapped face to retain the soil within the reinforced zone. The facing material should be a geotextile consisting of Miramesh GR or equivalent with a minimum of 1.0 m embedment into the reinforced zone as measured from the back face of the wall. The geotextile should be placed on the outside of the wrapped face to minimize UV and environmental damage. The geotextile should have a minimum of 500 mm overlap, or as per manufacturer recommendations. To assist with construction, it is recommended galvanized welded wire mesh form work be placed in advance of placing the geogrid, geotextile and reinforced soil backfill. The form work should consist of 4 gauge steel with 100 mm x 100 mm openings with a minimum of 100 mm overlap. Alternatively, the facing of the GRS wall could be designed by a proprietary supplier to be a stone face or vegetated face.

The geogrid used to reinforce the retaining wall should have a minimum allowable tensile strength of 18 kN/m over the design life of the structure. The minimum geogrid length should be 2.0 m as measured from the back face of the retaining wall and a face anchorage length of 1.0 m as measured from the back face of the retaining wall. The geogrid should be placed perpendicular to the GRS wall face. Geogrid should be placed end-to-end in the parallel direction with no overlap, or as per manufacturers recommendation.

A minimum of 150 mm of compacted soil cover should be placed prior to construction equipment being permitted to travel over the geogrid, or as per manufacturers recommendations.

Individual rock blocks used in the stacked rock wall option should have a weight exceeding 90 kg and be greater than 450 mm diameter in all dimensions. Rocks should be roughly rectangular, tabular or cubic in shape. Rounded rocks should not be used. Rocks should be intact and massive with no open fractures, foliation or other planes of weakness. Rocks must be high quality, hard and resistant to weathering. No continuous vertical or horizontal joints are allowed in the construction of the wall. Care must be taken during construction to produce rock layers with good contact between adjacent rocks, especially on the front face of the wall. KCB has not reviewed the quarry source identified by

the Ministry near the bridge to determine whether rocks are suitable for a stacked rock retaining wall.

KCB recommends the use of GRS walls over a stacked rock wall due to the challenges of providing adequate Quality Control and Quality Assurance with the variable nature of the contact surface between boulders that form the stacked wall facing. The quality of construction and long-term stability requirements of a stacked rock wall is generally more challenging to achieve than a GRS wall. Additionally, the handling and placement of rock blocks in the constricted area adjacent to bridge abutment could be difficult.

Backfill placed and sloped above the retaining wall could be prone to erosion from surface water run-off dependent on the gradation of the material used. The slope should be seeded following completion of construction to allow vegetation to be established.

#### 4.3.5 Re-Use of On-Site Soils

Excavated soil volumes generated during construction at the right abutment are anticipated to be minimal. The soil excavated from the right abutment could potentially be re-used as reinforced backfill for the retaining wall but this would require processing/screening on site to remove deleterious materials (e.g. organics and rootlets) and achieve the specified MoTI SGSB gradation.

The sub-rounded to sub-angular cobbles and boulders encountered in the test pits and observed on the bank are not considered appropriate for rockfill or PRF slope construction. Sources of suitable rockfill could potentially be developed by the contractor on site but KCB did not identify any appropriate sources during our site investigation.

Excavated material classified as suitable for re-use by KCB should be handled and stored in a manner to prevent saturation, contamination by unsuitable soil sources or any form of deterioration. Materials deemed suitable for re-use during initial excavation may be later deemed unsuitable if not handled or stored in an appropriate manner.

## 5 ENVIRONMENTAL

The requirements for concrete works outlined in the Construction Environmental Management Plan (CEMP) from DWB Consulting Services and their associated costs should be considered when planning the repairs. Per the CEMP, water must be prevented from coming in contact with uncured or partially cured concrete to prevent contamination of the stream (DWB Consulting Services Ltd., 2022). The CEMP also states areas where there will be in-stream work must be isolated and dewatered, that a fish salvage must be carried out prior to isolating and dewatering, and that downstream river flows and water quality must be maintained at all times. Performing concrete repair work at low water levels is therefore recommended to reduce the possibility of contaminating the river, minimize the impact of in-stream work, and maximize the working area available on the shores. The CEMP identifies the reduced risk work window for known fish species in the West Kettle River between July 22<sup>nd</sup> and October 31<sup>st</sup>. This window coincides with typical annual low water levels in the river, according to hydrometric data from Westbridge station (08NN026). KCB recommends executing the right abutment repairs and in-stream pier repairs or assessment in this window to take advantage of the low water levels.

Appendix E of the CEMP provides examples of instream erosion and sediment control best practices. Based on previous experience with similar projects and site access constraints, KCB expects the sand bag/gravel bag technique will be used for site isolation during riprap placement. The actual isolation method will be as determined by the Contractor.

The Contractor awarded the repair work should consider the costs associated with the requirements of the CEMP.

## 6 COST ESTIMATE

Based on the geotechnical recommendations provided in Section 4.3, KCB has identified four slope stabilization options for the KV-005 bridge:

- Option 1 – Rockfill slope with riprap at base.
- Option 2 – PRF (riprap) slope with riprap at base.
- Option 3A – GRS retaining wall with riprap at base.
- Option 3B – Stacked rock retaining wall with riprap at base.

To assist with the selection of a slope stabilization option and to help the Ministry decide whether to complete the pier repair work as part of this project, KCB has prepared Class 'D' construction cost estimates for each option, including a 30% contingency to account for uncertainty in pricing. The cost estimates are shown in **Tables 6-1, 6-2, 6-3 and 6-4**. The unit rates are based on recent construction pricing in BC, the Alberta Transportation 2023 unit price averages report, and cost data from RSMeans.

**Table 6-1: Option 1 Construction Cost Estimate.**

| Repair              | Item                        | Unit | Price    | Quantity | Total            |
|---------------------|-----------------------------|------|----------|----------|------------------|
| General             | Mobilization                | LS   | \$50,000 | 1        | \$50,000         |
|                     | Environmental Protection    | LS   | \$30,000 | 1        | \$30,000         |
|                     | Temporary Access            | LS   | \$10,000 | 1        | \$10,000         |
| Abutment Repair     | Concrete                    | m3   | \$15,000 | 1        | \$15,000         |
| Pier Repair         | Concrete                    | m3   | \$15,000 | 0.2      | \$3,000          |
|                     | Dewatering                  | LS   | \$50,000 | 1        | \$50,000         |
| Slope Reinstatement | 150 mm Minus Rockfill       | m3   | \$100    | 70       | \$7,000          |
| Scour Protection    | Riprap (Supply and Install) | m3   | \$200    | 680      | \$136,000        |
|                     | Stream Isolation            | LS   | \$60,000 | 1        | \$60,000         |
| Subtotal            |                             |      |          |          | \$361,000        |
| 30% Contingency     |                             |      |          |          | \$108,300        |
| <b>Total</b>        |                             |      |          |          | <b>\$469,300</b> |

**Table 6-2: Option 2 Construction Cost Estimate**

| Repair              | Item                        | Unit | Price    | Quantity | Total            |
|---------------------|-----------------------------|------|----------|----------|------------------|
| General             | Mobilization                | LS   | \$50,000 | 1        | \$50,000         |
|                     | Environmental Protection    | LS   | \$30,000 | 1        | \$30,000         |
|                     | Temporary Access            | LS   | \$10,000 | 1        | \$10,000         |
| Abutment Repair     | Concrete                    | m3   | \$15,000 | 1        | \$15,000         |
| Pier Repair         | Concrete                    | m3   | \$15,000 | 0.2      | \$3,000          |
|                     | Dewatering                  | LS   | \$50,000 | 1        | \$50,000         |
| Slope Reinstatement | Riprap Fill                 | m3   | \$100    | 50       | \$5,000          |
| Scour Protection    | Riprap (Supply and Install) | m3   | \$200    | 640      | \$128,000        |
|                     | Stream Isolation            | LS   | \$60,000 | 1        | \$60,000         |
| Subtotal            |                             |      |          |          | \$351,000        |
| 30% Contingency     |                             |      |          |          | \$105,300        |
| <b>Total</b>        |                             |      |          |          | <b>\$456,300</b> |

**Table 6-3: Option 3A Construction Cost Estimate**

| Repair              | Item                        | Unit | Price    | Quantity | Total            |
|---------------------|-----------------------------|------|----------|----------|------------------|
| General             | Mobilization                | LS   | \$50,000 | 1        | \$50,000         |
|                     | Environmental Protection    | LS   | \$30,000 | 1        | \$30,000         |
|                     | Temporary Access            | LS   | \$10,000 | 1        | \$10,000         |
| Abutment Repair     | Concrete                    | m3   | \$15,000 | 1        | \$15,000         |
| Pier Repair         | Concrete                    | m3   | \$15,000 | 0.2      | \$3,000          |
|                     | Dewatering                  | LS   | \$50,000 | 1        | \$50,000         |
| Slope Reinstatement | Select Sub-Granular Base    | m3   | \$80     | 15       | \$1,200          |
|                     | GRS Retaining wall          | m2   | \$1,400  | 11       | \$15,400         |
|                     | Leveling Pad                | m3   | \$50     | 10       | \$500            |
| Scour Protection    | Riprap (Supply and Install) | m3   | \$200    | 640      | \$128,000        |
|                     | Stream Isolation            | m3   | \$60,000 | 1        | \$60,000         |
| Subtotal            |                             |      |          |          | \$363,100        |
| 30% Contingency     |                             |      |          |          | \$108,930        |
| <b>Total</b>        |                             |      |          |          | <b>\$472,030</b> |

**Table 6-4: Option 3B Construction Cost Estimate**

| Repair              | Item                        | Unit | Price    | Quantity | Total            |
|---------------------|-----------------------------|------|----------|----------|------------------|
| General             | Mobilization                | LS   | \$50,000 | 1        | \$50,000         |
|                     | Environmental Protection    | LS   | \$30,000 | 1        | \$30,000         |
|                     | Temporary Access            | LS   | \$10,000 | 1        | \$10,000         |
| Abutment Repair     | Concrete                    | m3   | \$15,000 | 1        | \$15,000         |
| Pier Repair         | Concrete                    | m3   | \$15,000 | 0.2      | \$3,000          |
|                     | Dewatering                  | LS   | \$50,000 | 1        | \$50,000         |
| Slope Reinstatement | Select Sub-Granular Base    | m3   | \$80     | 15       | \$1,200          |
|                     | Stacked Rock Retaining Wall | m2   | \$1,000  | 11       | \$11,000         |
|                     | Leveling Pad                | m3   | \$50     | 10       | \$500            |
| Scour Protection    | Riprap (Supply and Install) | m3   | \$200    | 640      | \$128,000        |
|                     | Stream Isolation            | m3   | \$60,000 | 1        | \$60,000         |
| Subtotal            |                             |      |          |          | \$358,700        |
| 30% Contingency     |                             |      |          |          | \$107,610        |
| <b>Total</b>        |                             |      |          |          | <b>\$466,310</b> |

The cost estimates are based on information available to date and is only our opinion of the potential cost for budgetary purposes. Actual cost depends on many factors which can change with time, including site and market conditions at the time of construction.

## 7 CONCLUSION

A walkthrough visual inspection of the KV-005 bridge in December 2022 confirmed that there was undermining at the right abutment and downstream corner of the pier, failure of the right bank approach fills, and erosion of the right bank which extends upstream and downstream of the bridge.

Structural repairs are recommended to underpin the undermined area at the right abutment with CIP concrete. KCB recommends an in-stream assessment of the pier to confirm the apparent extents of undermining and determine if the remaining material beneath the pier is susceptible to further scour. The scour at the pier does not appear to require immediate repairs but should be monitored annually for any changes. Should the undermined area exceed 1.4 m<sup>2</sup>, KCB recommends underpinning the pier with CIP concrete. KCB has included a cost to repair the pier undermining as part of this project in case the Ministry elects to do the repairs now.

A hydrotechnical analysis was conducted using a 2D HEC-RAS model for the 100-year return period, accounting for a peak instantaneous flow with a climate change factor of 20%. The model was used to determine the effects of a riprap berm on channel flow and peak high-water levels. KCB recommends that 1000 (kg) riprap be placed at a 2H:1V slope for erosion protection extending approximately 15 m upstream and 15 m downstream of the bridge.

Slope stability analyses was conducted at the right abutment to assess the stability of the abutment slope in its current condition and the improvement to stability for the proposed repair options. The analyses indicates that the right abutment slope is marginally stable (FoS slightly above 1) at present but a FoS close to or exceeding 1.5 can be achieved by all of the proposed repair options.

KCB recommends selecting either Option 2 – PRF (riprap) slope with riprap at base or Option 3A – GRS retaining wall with riprap at base for the right abutment slope reinstatement. Both of these options have a smaller footprint extending into the creek when compared with the other options, so are better from an environmental and constructability perspective. The estimated construction cost for Option 2 is slightly lower than for Options 3A. However, depending on the riprap quality and placement of riprap for Option 2, there could be increased raveling potential if constructed to the 1H:1V slope. Therefore, the Ministry should weigh the cost/benefit of proceeding with Option 2 versus Option 3A.

Once the Ministry has decided which option to select, we will remove all unused information from the Concept Design Drawings included with this report and provide updated drawings that are ready for Tender.

## 8 CLOSING

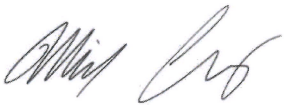
*This report is an instrument of service of Klohn Crippen Berger Ltd. (KCB). The report has been prepared for the exclusive use of the Ministry of Forests for the specific application to the inspection of the KV-005 bridge and may not be relied upon by any other party without KCB's written consent.*

*KCB has prepared this report in a manner consistent with the level of care, skill and diligence ordinarily provided by members of the same profession for projects of a similar nature at the time and place the services were rendered. KCB makes no warranty, express or implied.*

We trust that this report meets your requirements. Please let us know if you have any questions.

Yours truly,

### KLOHN CRIPPEN BERGER



Millar Coveney, E.I.T.  
Structural Engineer



2023-03-20  
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Geotechnical Engineer



Jay Johnson, P.Eng.  
Hydrotechnical Engineer

B.C. Permit to Practice No. 1000171

## REFERENCES

British Columbia Ministry of Transportation and Infrastructure (BC MoTI). 2020. *2020 Standard Specifications for Highway Construction – Volume 1 of 2*. BC MoTI.

DWB Consulting Services Ltd. (2022). *Construction Environmental Management Plan: KV-005 West Kettle River Bridge-Crossing Repair*.

Finnemore. (2002). *Fluid Mechanics with Engineering Applications*. New York, NY.

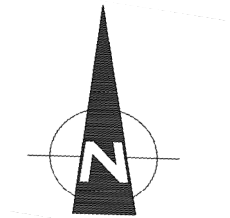
MFLNR. (1999). *Forest Service Bridge Design and Construction Manual*.

USACE. (1994). *EM 1110-2-1601 Eq 3.3*.

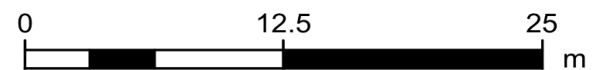
# APPENDIX I

## Test Pit Locations

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 TEST PIT LOCATION



AS A MUTUAL PROTECTION TO OUR CLIENT, THE PUBLIC AND OURSELVES, ALL REPORTS AND DRAWINGS ARE SUBMITTED FOR THE CONFIDENTIAL INFORMATION OF OUR CLIENT FOR A SPECIFIC PROJECT AND AUTHORIZATION FOR USE AND/OR PUBLICATION OF DATA, STATEMENTS, CONCLUSIONS, OR ABSTRACTS FROM OR REGARDING OUR REPORT AND DRAWINGS IS RESERVED PENDING OUR WRITTEN APPROVAL.



|             |  |                                                           |                 |
|-------------|--|-----------------------------------------------------------|-----------------|
| Project     |  | KETTLE VALLEY RAIL TRAIL<br>BRIDGE ASSESSMENT AND REPAIRS |                 |
| Title       |  | TEST PIT INVESTIGATION<br>PLAN DRAWING                    |                 |
| Project No. |  | P10443A01                                                 | Figure No.<br>1 |

## APPENDIX II

### Test Pit Logs

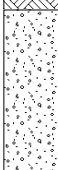
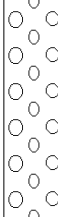
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|                                     |                            |                             |                                             |
|-------------------------------------|----------------------------|-----------------------------|---------------------------------------------|
| Project Number: P10443A01           | Northing: 5461345.0 m      | Easting: 351990.0 m         | Equipment Operator: Shadow Creek Properties |
| Project: KVRT Assessment and Repair | Ground Elevation: 707.0 m  | Logged By: CJ               | Equipment Make/Model: Mechanical Excavator  |
| Location: Near Beaverdell, BC       | Datum: UTM Zone 11, NAD83  | Reviewed by: MC             |                                             |
| Client: MFLNR                       | Date Started: Dec 06, 2022 | Date Finished: Dec 06, 2022 |                                             |

| DEPTH (m) | SAMPLE NUMBER | SAMPLE TYPE | LITHOLOGY SYMBOL | DEPTH / ELEVATION | DESCRIPTION OF MATERIALS                                                                                                                                                                                                                                                                                     | INSTRUMENT/<br>BACKFILL DETAILS | Su (kPa)(top scale) |       |     |                  |
|-----------|---------------|-------------|------------------|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|---------------------|-------|-----|------------------|
|           |               |             |                  |                   |                                                                                                                                                                                                                                                                                                              |                                 | VANE                | FIELD | LAB |                  |
|           |               |             |                  |                   |                                                                                                                                                                                                                                                                                                              |                                 | PEAK                | ◆     | ■   | ▲ UC/2           |
|           |               |             |                  |                   |                                                                                                                                                                                                                                                                                                              |                                 | REMO                | ◇     | □   | △ P.PEN/2        |
|           |               |             |                  |                   |                                                                                                                                                                                                                                                                                                              |                                 | (bottom scale)      |       |     |                  |
|           |               |             |                  |                   |                                                                                                                                                                                                                                                                                                              |                                 | ⊕ % Fines           | Wp %  | W % | W <sub>L</sub> % |
|           |               |             |                  |                   |                                                                                                                                                                                                                                                                                                              |                                 | X-----O-----X       |       |     |                  |
|           |               |             |                  |                   |                                                                                                                                                                                                                                                                                                              |                                 | 50                  | 100   | 150 |                  |
|           |               |             |                  |                   |                                                                                                                                                                                                                                                                                                              |                                 | 25                  | 50    | 75  |                  |
|           |               |             |                  | 0.6               | SAND (SW) and GRAVEL (GW)<br>Some cobbles and boulders, trace rootlets and organics, well graded, max particle size = 300 mm, sub-rounded, brown, dry to moist                                                                                                                                               |                                 |                     |       |     |                  |
| 1         |               |             |                  | 706.4             | SAND (SW) and GRAVEL (GW)<br>Medium to coarse grained sand, cobbley and bouldery, well graded, max particle size = 600 mm, sub-rounded to sub-angular, light brown, dry                                                                                                                                      |                                 |                     |       |     |                  |
| 2         |               |             |                  | 2.1               |                                                                                                                                                                                                                                                                                                              |                                 |                     |       |     |                  |
|           |               |             |                  | 704.9             | Test pit terminated at 2.1 metres.<br>Notes:<br>1) Coordinates are in UTM Zone 11, NAD83 taken from a drone photogrammetry model.<br>2) Test pitting was carried out by Shadow Creek Properties of Midway, BC.<br>3) Termination was at target depth.<br>4) Test pit was backfilled with excavated material. |                                 |                     |       |     |                  |
| 3         |               |             |                  |                   |                                                                                                                                                                                                                                                                                                              |                                 |                     |       |     |                  |
| 4         |               |             |                  |                   |                                                                                                                                                                                                                                                                                                              |                                 |                     |       |     |                  |
| 5         |               |             |                  |                   |                                                                                                                                                                                                                                                                                                              |                                 |                     |       |     |                  |

|                                     |                            |                             |                                             |
|-------------------------------------|----------------------------|-----------------------------|---------------------------------------------|
| Project Number: P10443A01           | Northing: 5488200.6 m      | Easting: 366655.8 m         | Equipment Operator: Shadow Creek Properties |
| Project: KVRT Assessment and Repair | Ground Elevation: 707.0 m  | Logged By: CJ               | Equipment Make/ Model: Mechanical Excavator |
| Location: Near Beaverdell, BC       | Datum: UTM Zone 11, NAD83  | Reviewed by: MC             |                                             |
| Client: MFLNR                       | Date Started: Dec 06, 2022 | Date Finished: Dec 06, 2022 |                                             |

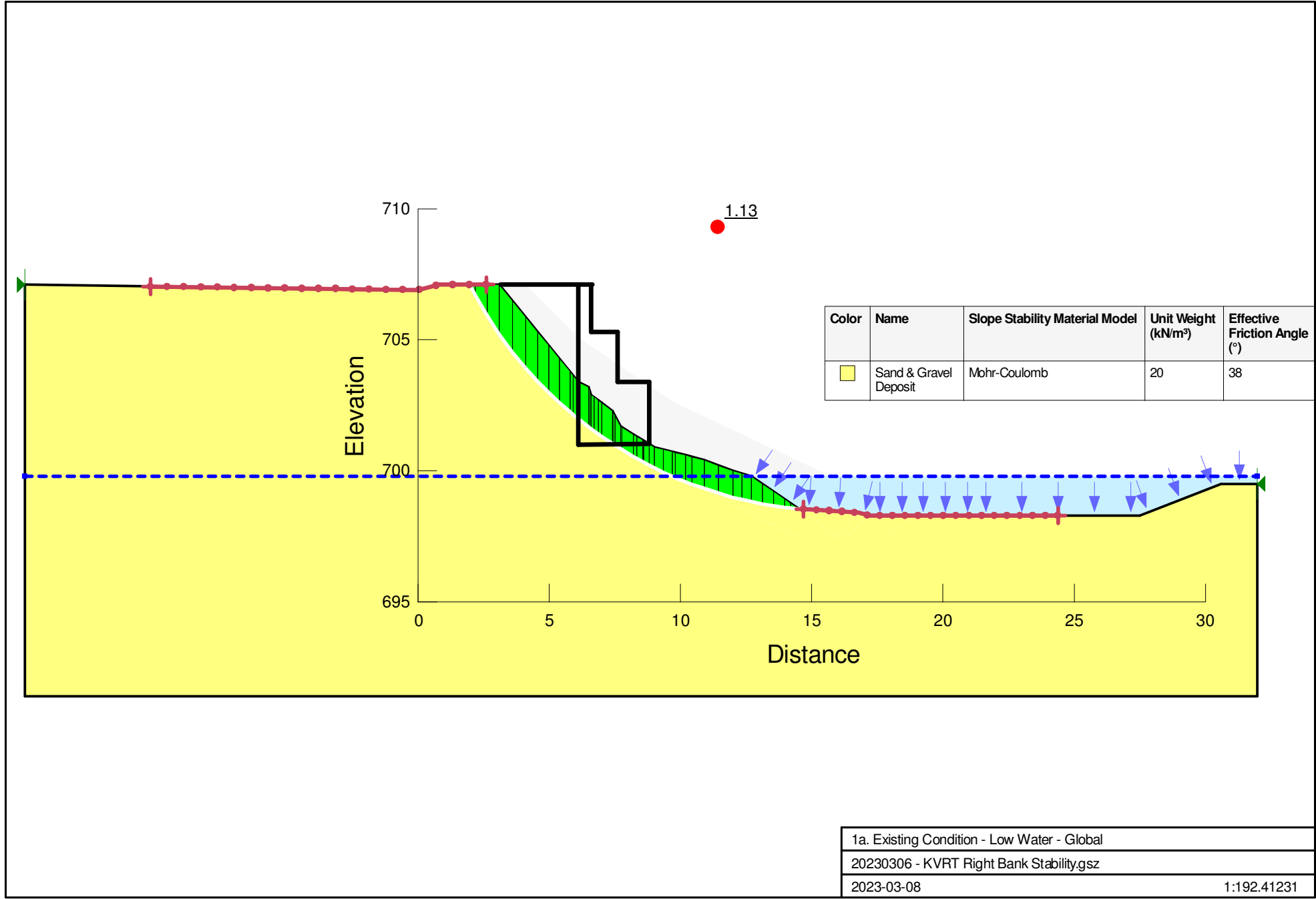
| DEPTH (m)     | SAMPLE NUMBER | SAMPLE TYPE | LITHOLOGY SYMBOL | DEPTH / ELEVATION | DESCRIPTION OF MATERIALS | INSTRUMENT/<br>BACKFILL DETAILS | Su (kPa)(top scale) |       |     |           |
|---------------|---------------|-------------|------------------|-------------------|--------------------------|---------------------------------|---------------------|-------|-----|-----------|
|               |               |             |                  |                   |                          |                                 | VANE                | FIELD | LAB |           |
|               |               |             |                  |                   |                          |                                 | PEAK                | ◆     | ■   | ▲ UC/2    |
|               |               |             |                  |                   |                          |                                 | REMOLD              | ◇     | □   | △ P.PEN/2 |
|               |               |             |                  |                   |                          |                                 | (bottom scale)      |       |     |           |
| ⊕ % Fines     |               |             |                  | Wp %              | W %                      | WL %                            |                     |       |     |           |
| X-----O-----X |               |             |                  |                   |                          |                                 |                     |       |     |           |
| 50            |               |             |                  | 100               | 150                      |                                 |                     |       |     |           |
| 25            |               |             |                  | 50                | 75                       |                                 |                     |       |     |           |

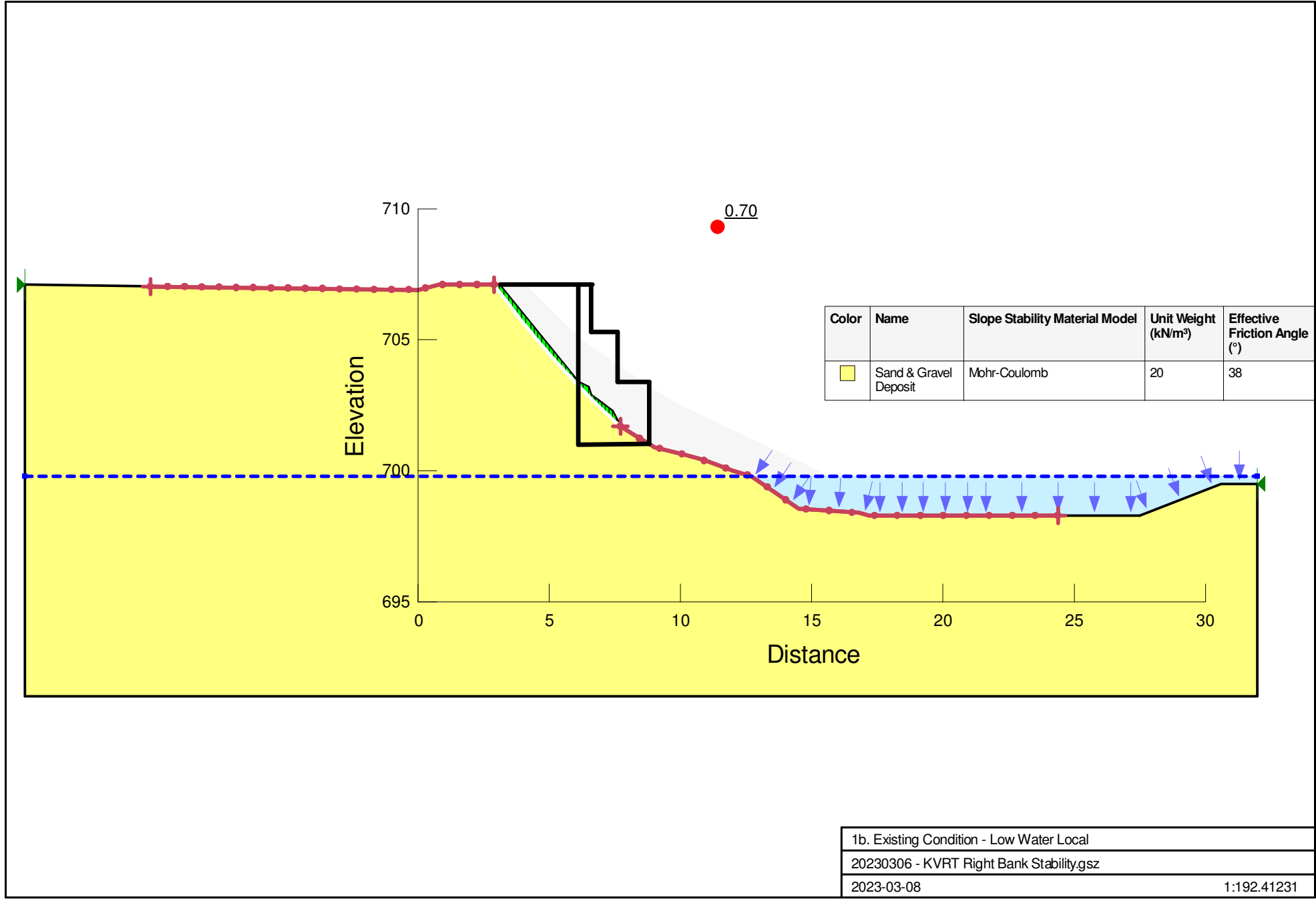
|   |  |  |                                                                                     |       |                                                                                                                                                                                                                                                                                                                    |
|---|--|--|-------------------------------------------------------------------------------------|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 |  |  |    | 0.2   | SAND (SM)                                                                                                                                                                                                                                                                                                          |
|   |  |  |    | 706.8 | Fine to medium grained sand, silty, trace to some cobbles, some organic debris (roots and branches), dark brown, moist [Topsoil]                                                                                                                                                                                   |
|   |  |  |    | 0.9   | SAND (SW) and GRAVEL (GW)                                                                                                                                                                                                                                                                                          |
|   |  |  |    | 706.1 | Medium to coarse grained sand, cobbly, trace boulders, well graded, max particle size = 600 mm, sub-rounded to sub-angular, light brown, dry                                                                                                                                                                       |
| 2 |  |  |   | 1.8   | BOULDERS                                                                                                                                                                                                                                                                                                           |
|   |  |  |  | 705.2 | Cobbly, some sand and gravel, well graded, max particle size = 600 mm, sub-rounded to sub-angular, light brown                                                                                                                                                                                                     |
| 3 |  |  |                                                                                     |       | Test pit terminated at 1.8 metres.<br>Notes:<br>1) Coordinates are in UTM Zone 11, NAD83 taken from a drone photogrammetry model.<br>2) Test pitting was carried out by Shadow Creek Properties of Midway, BC.<br>3) Termination was at refusal on boulder.<br>4) Test pit was backfilled with excavated material. |
|   |  |  |                                                                                     |       |                                                                                                                                                                                                                                                                                                                    |
|   |  |  |                                                                                     |       |                                                                                                                                                                                                                                                                                                                    |
|   |  |  |                                                                                     |       |                                                                                                                                                                                                                                                                                                                    |
| 4 |  |  |                                                                                     |       |                                                                                                                                                                                                                                                                                                                    |
|   |  |  |                                                                                     |       |                                                                                                                                                                                                                                                                                                                    |
|   |  |  |                                                                                     |       |                                                                                                                                                                                                                                                                                                                    |
|   |  |  |                                                                                     |       |                                                                                                                                                                                                                                                                                                                    |
| 5 |  |  |                                                                                     |       |                                                                                                                                                                                                                                                                                                                    |
|   |  |  |                                                                                     |       |                                                                                                                                                                                                                                                                                                                    |
|   |  |  |                                                                                     |       |                                                                                                                                                                                                                                                                                                                    |
|   |  |  |                                                                                     |       |                                                                                                                                                                                                                                                                                                                    |

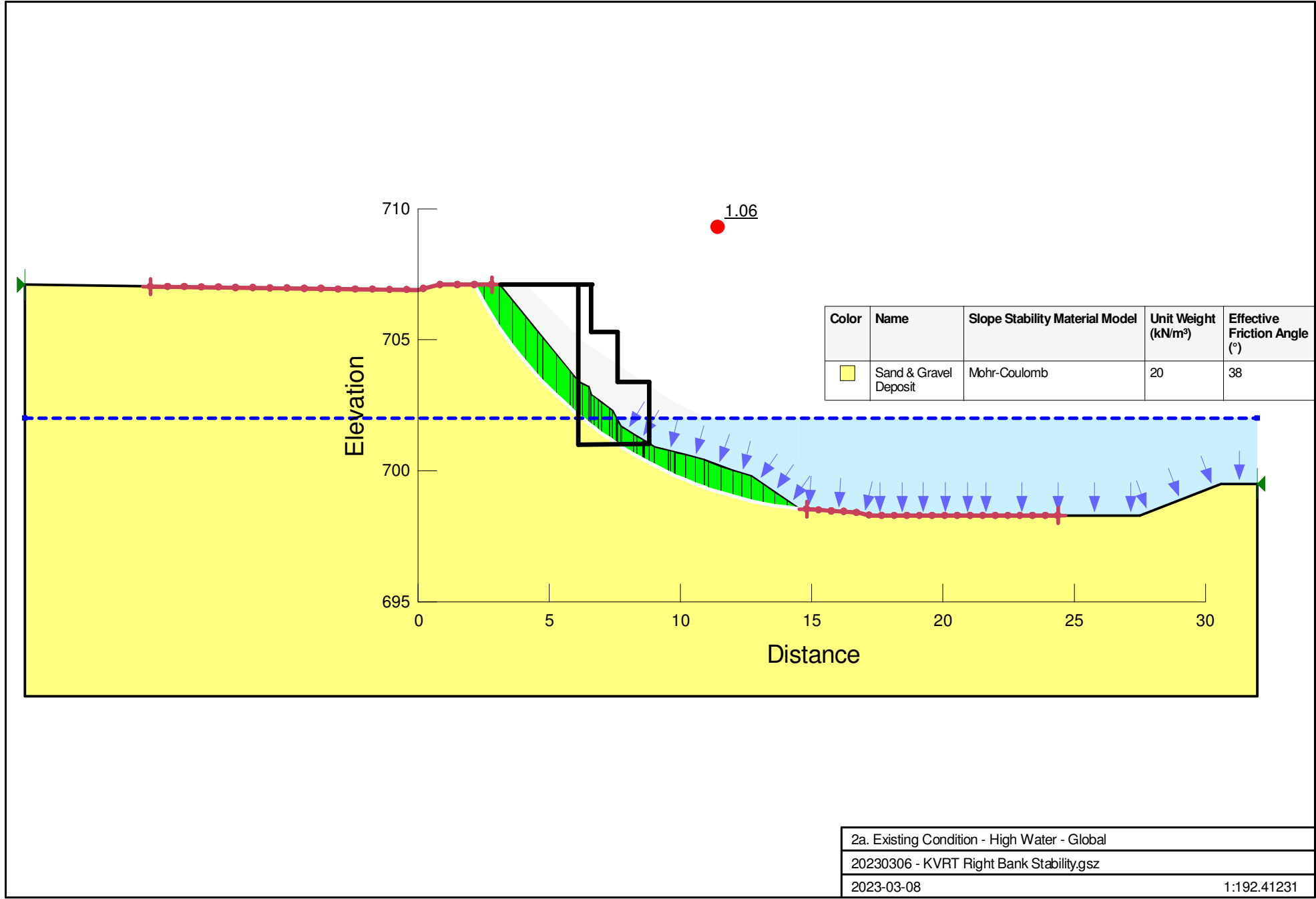
## **APPENDIX III**

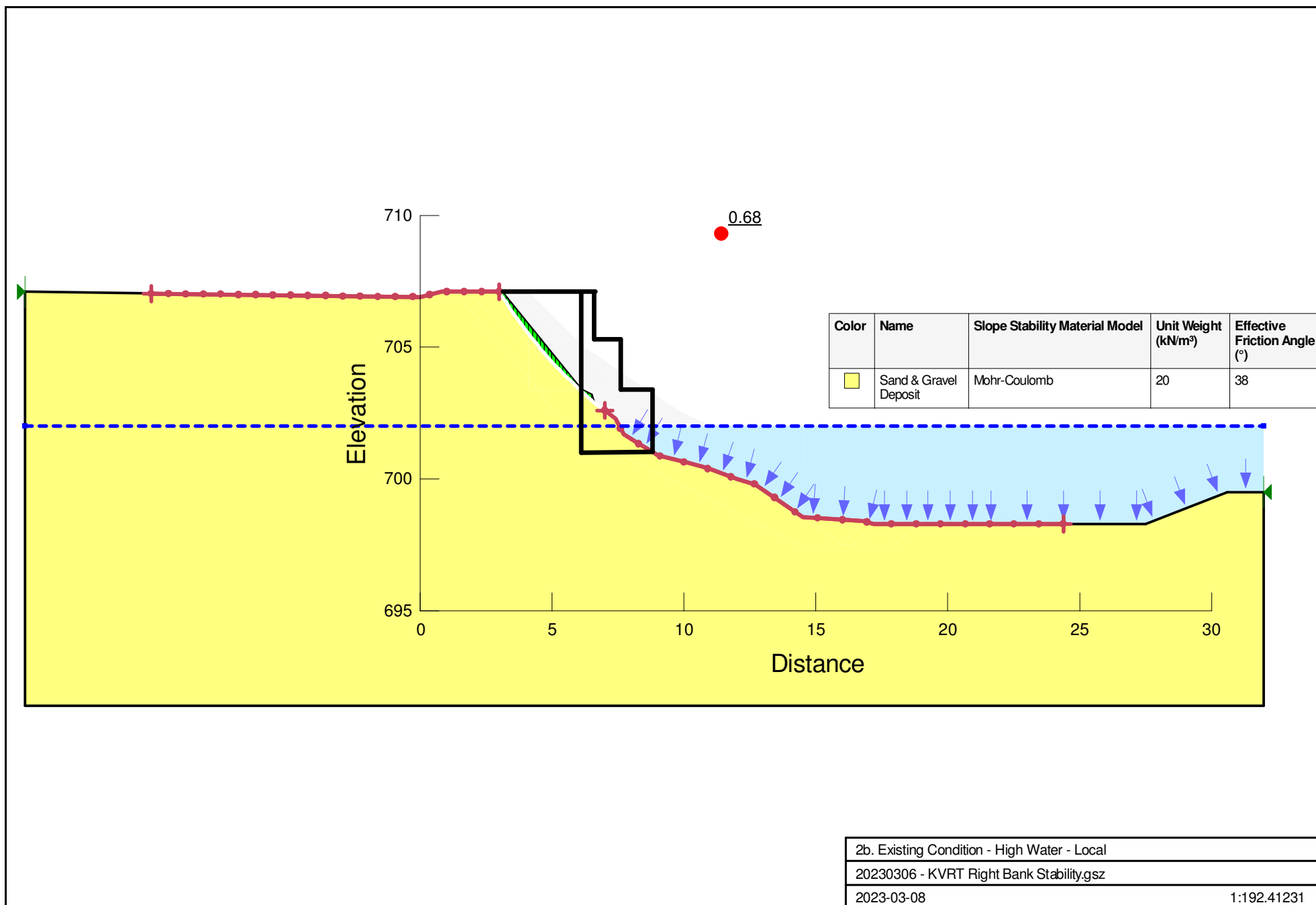
### **Global Stability Results**

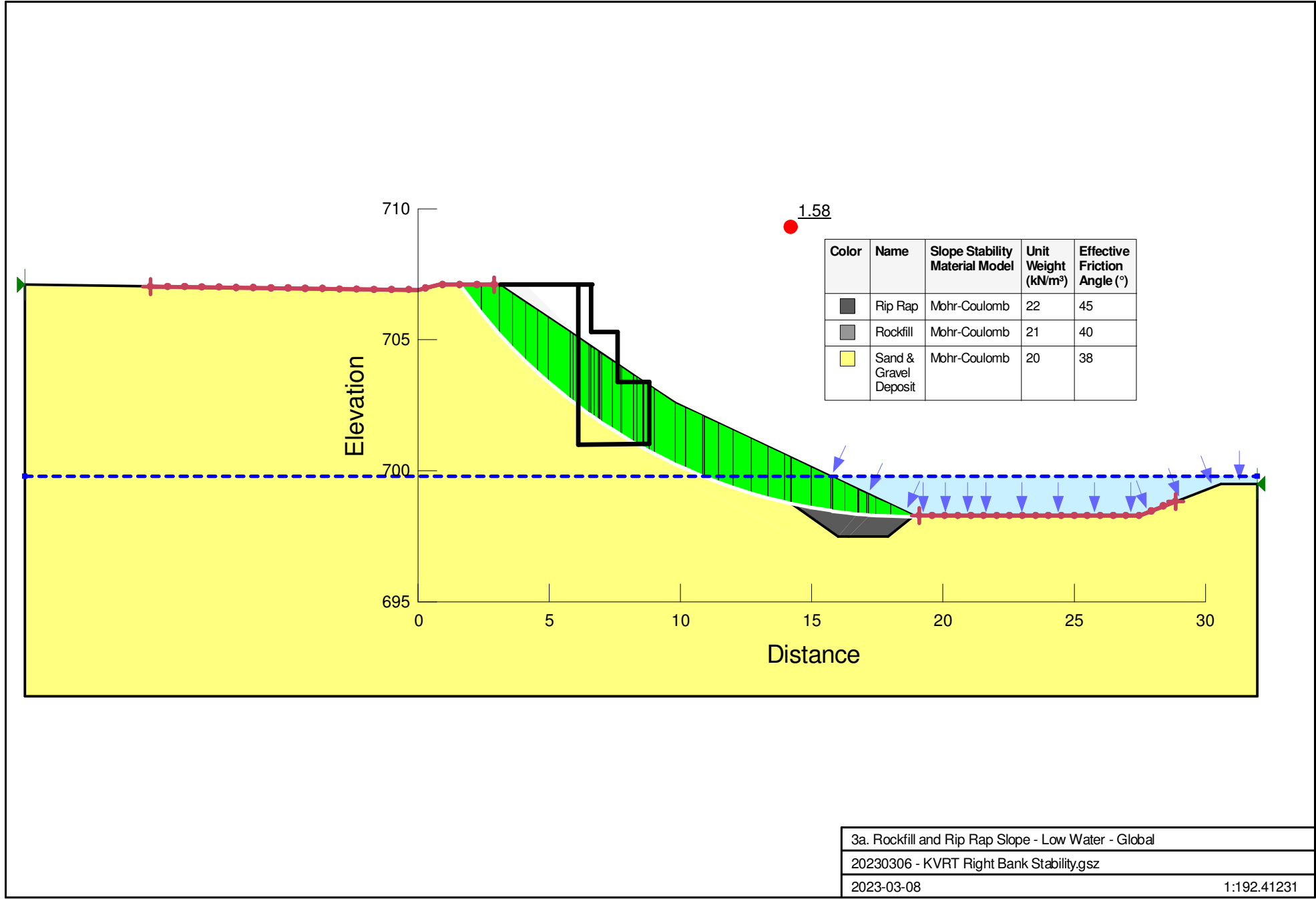
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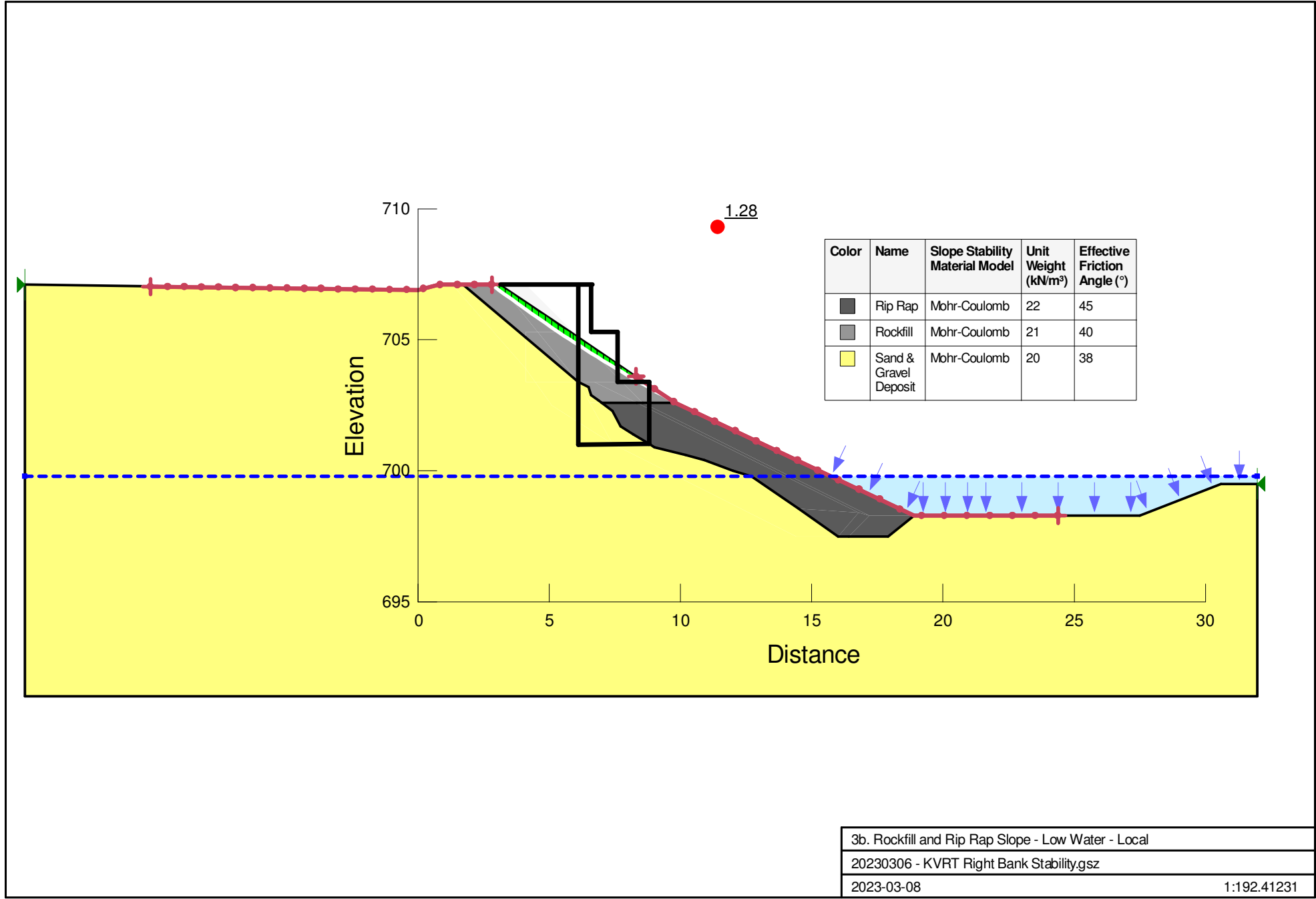


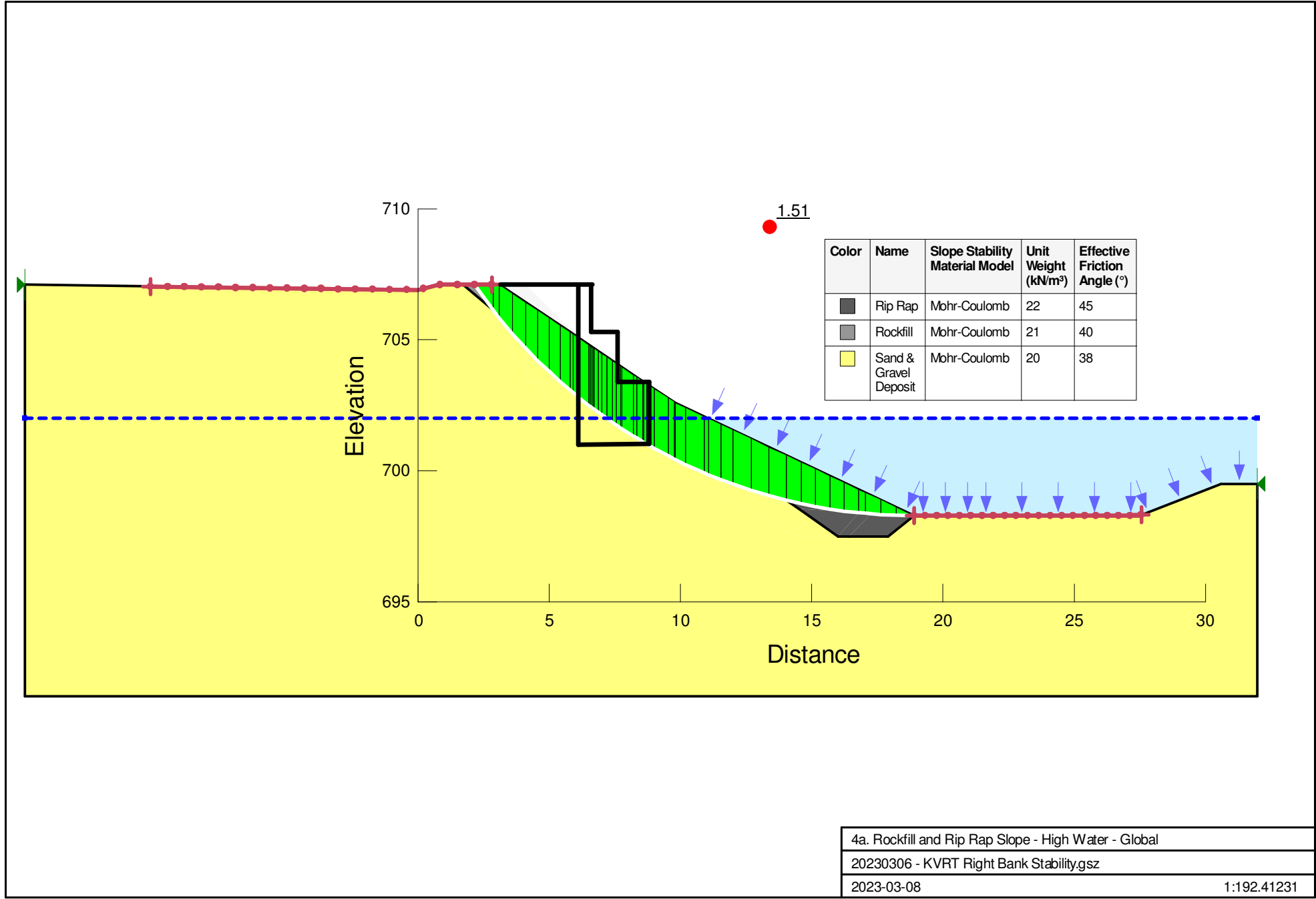


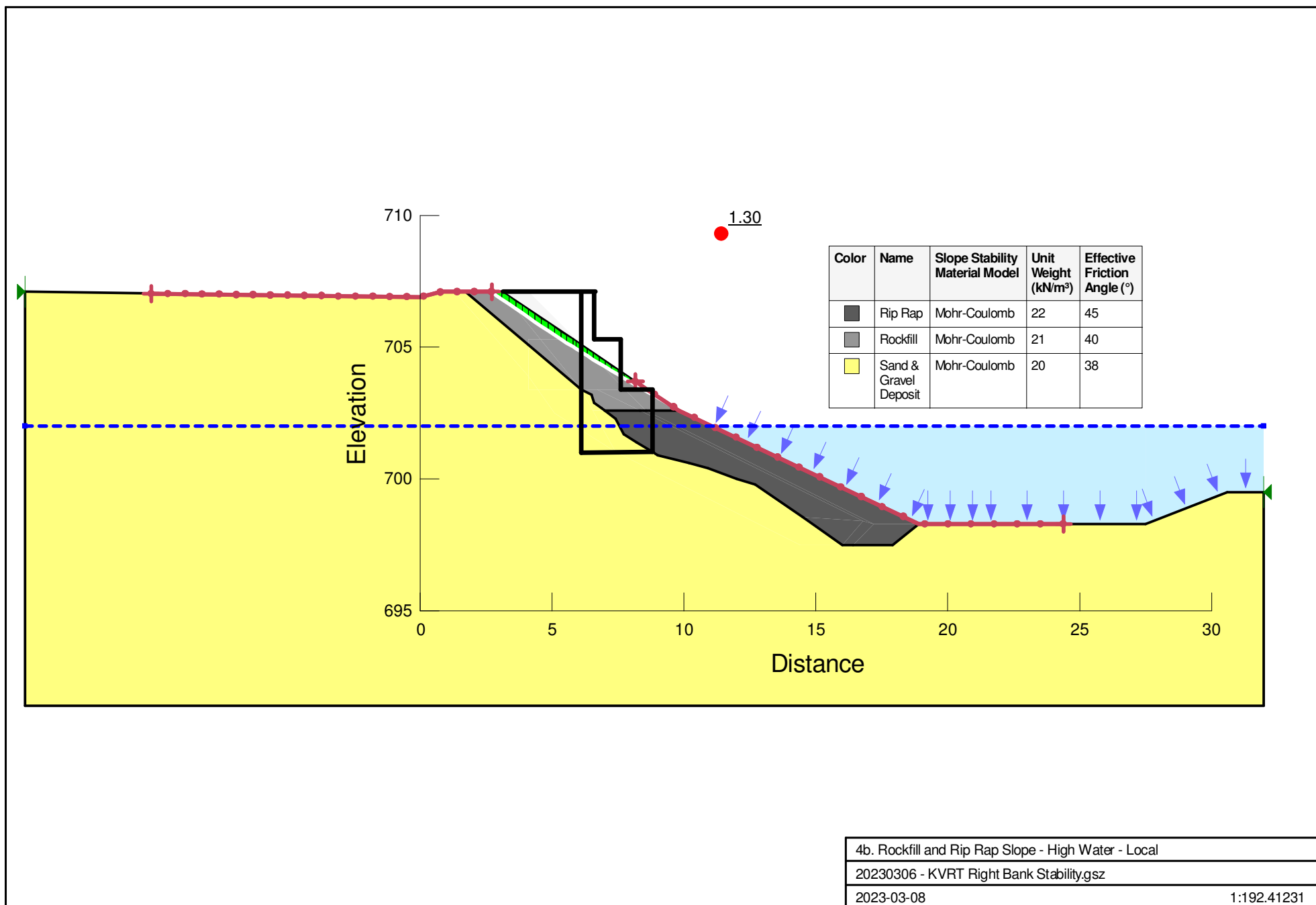


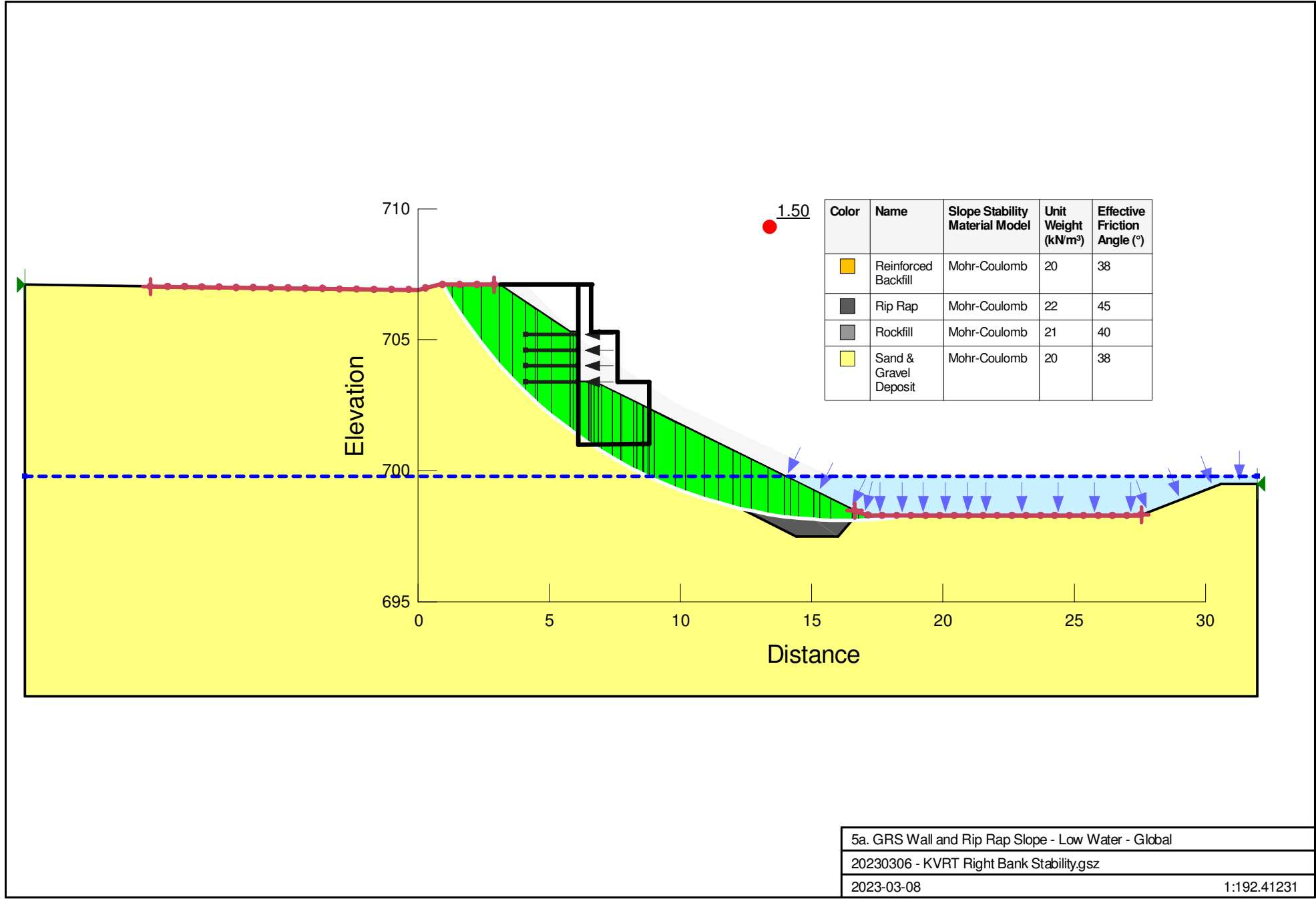


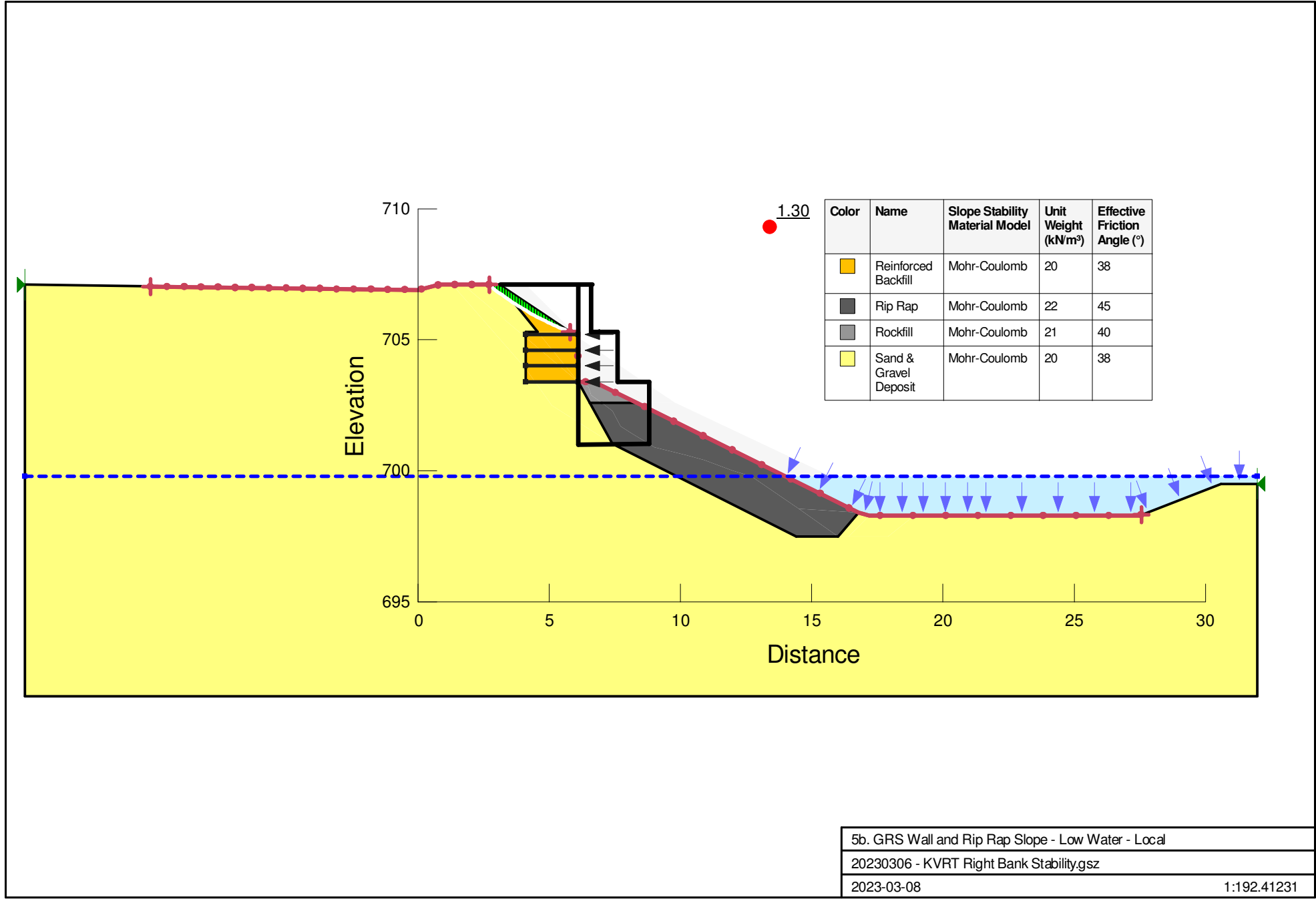


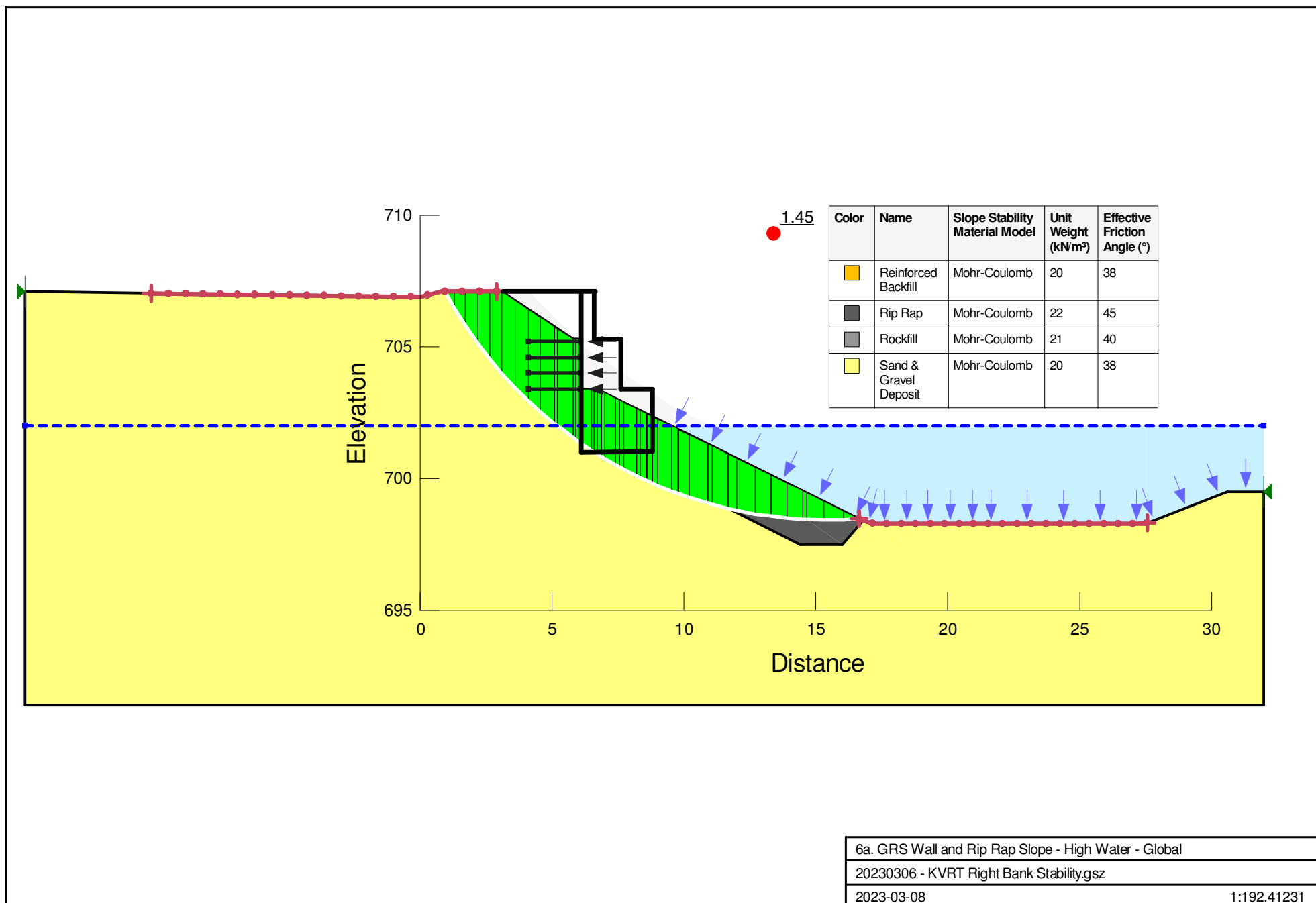


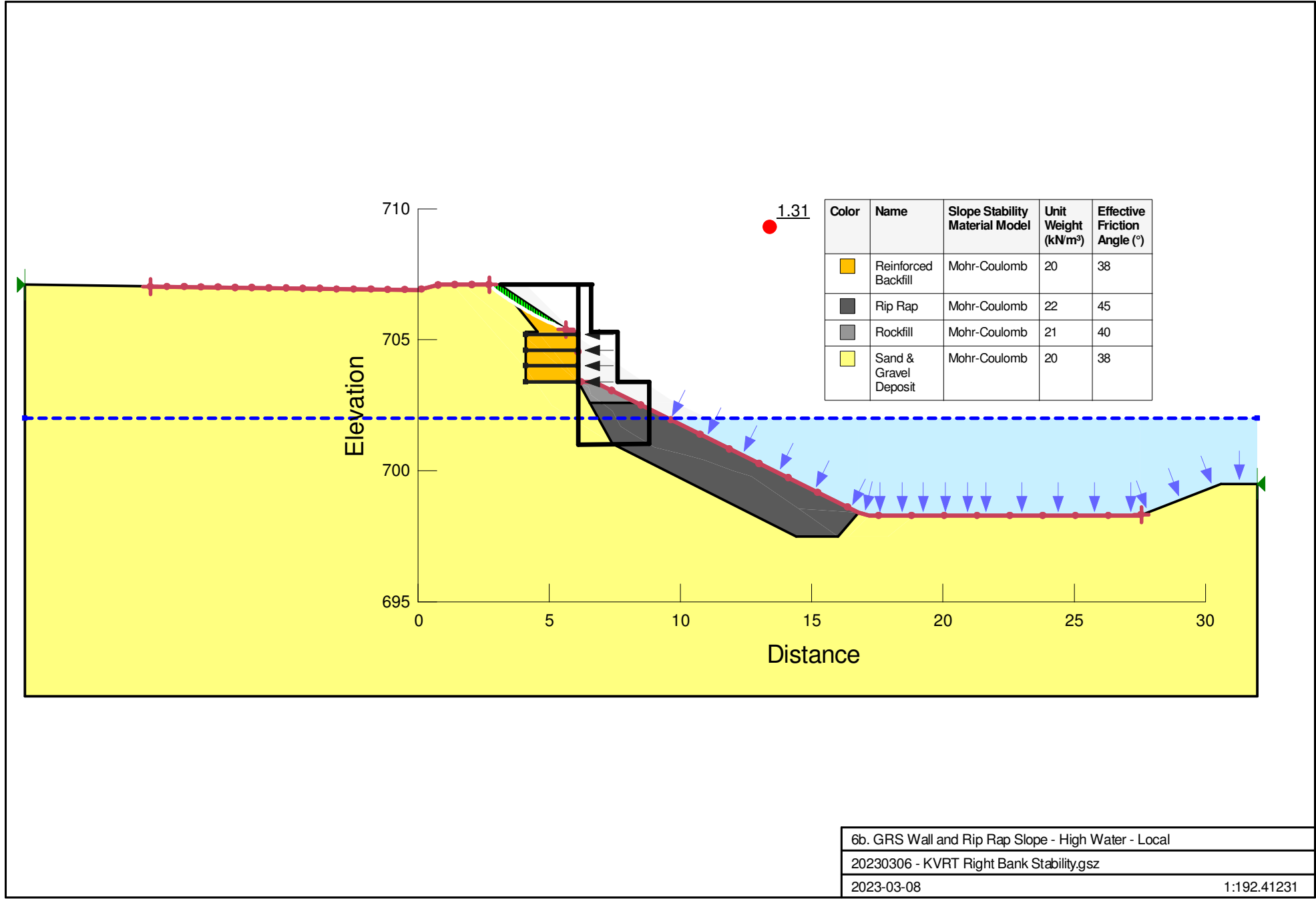


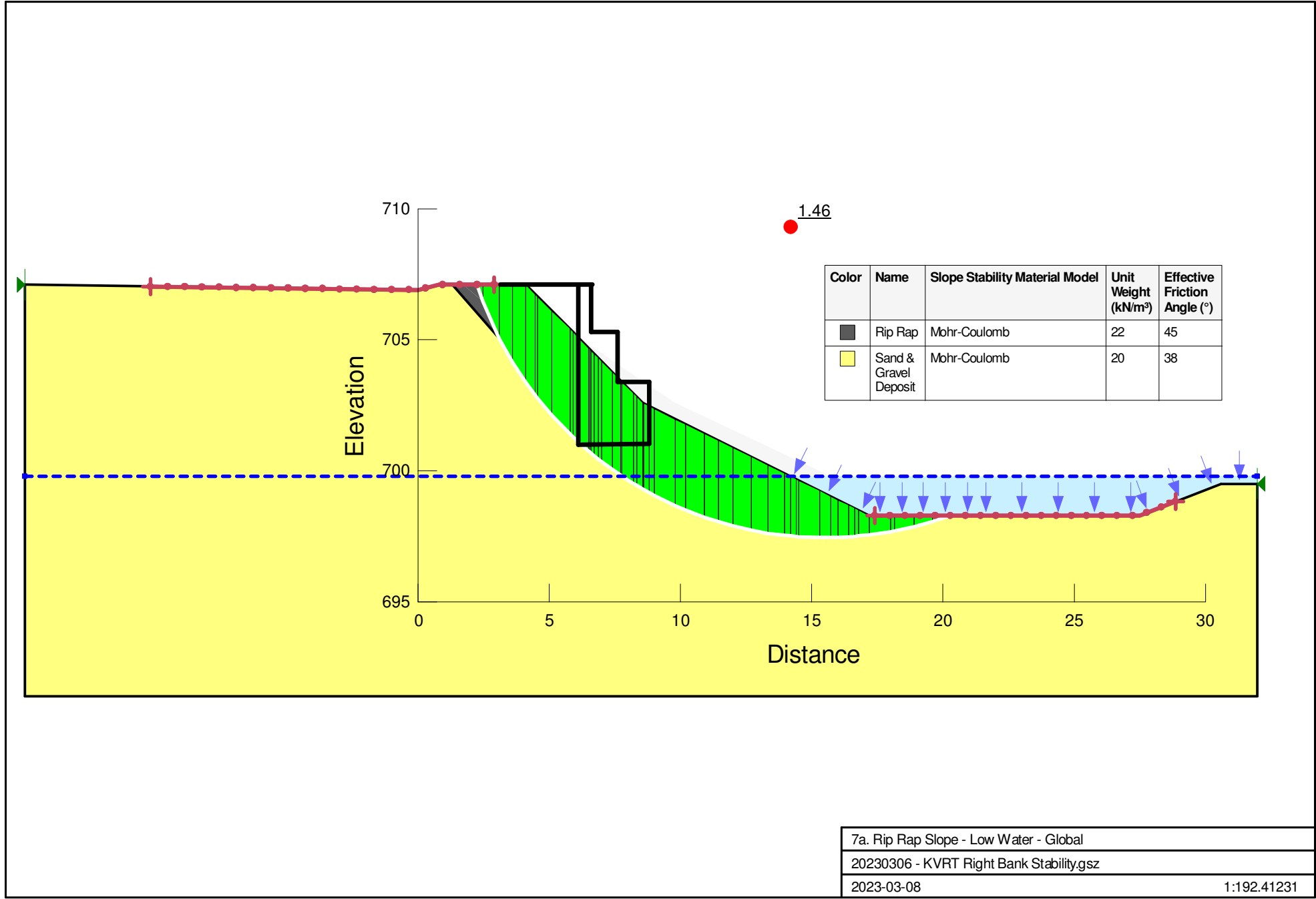


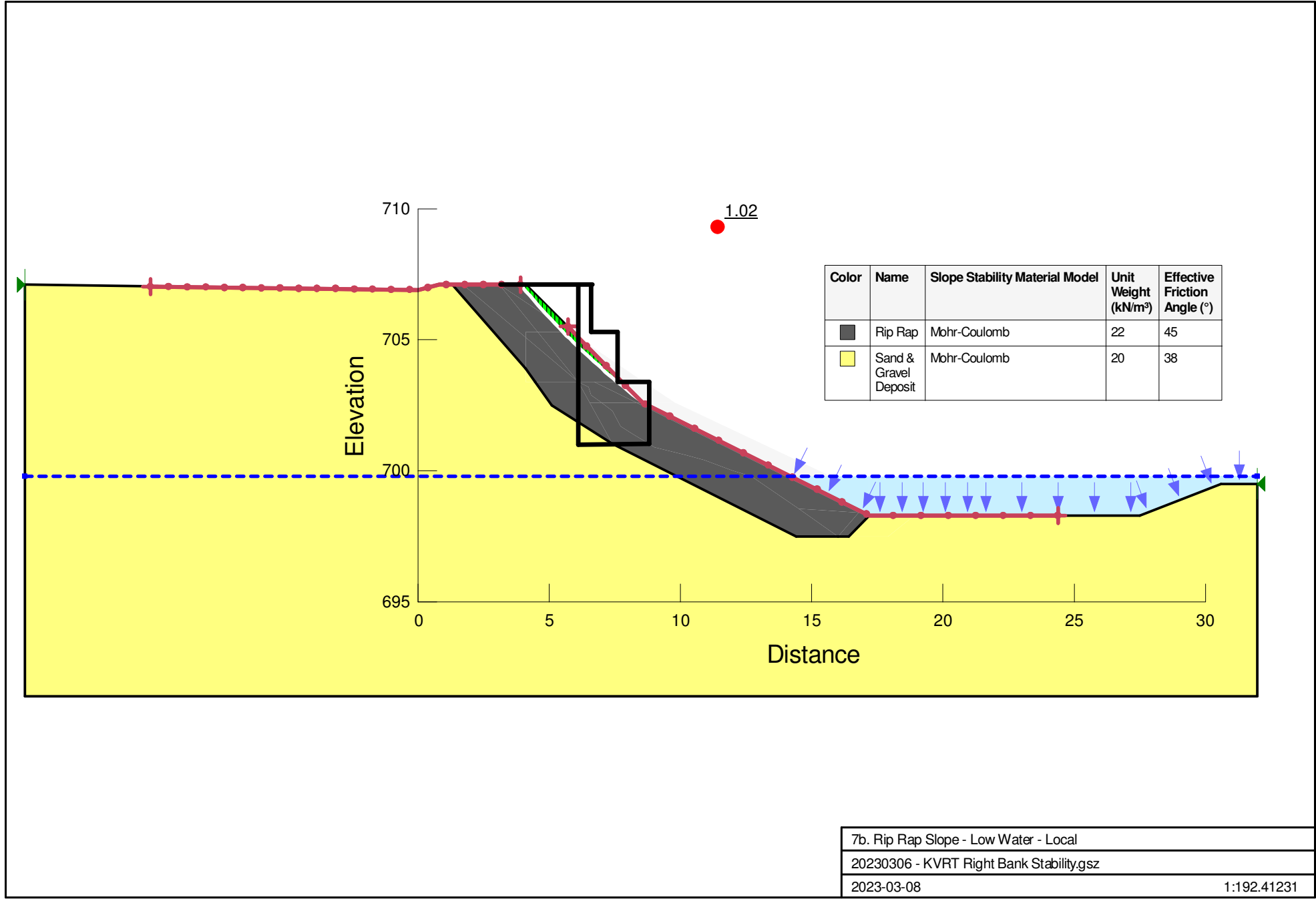


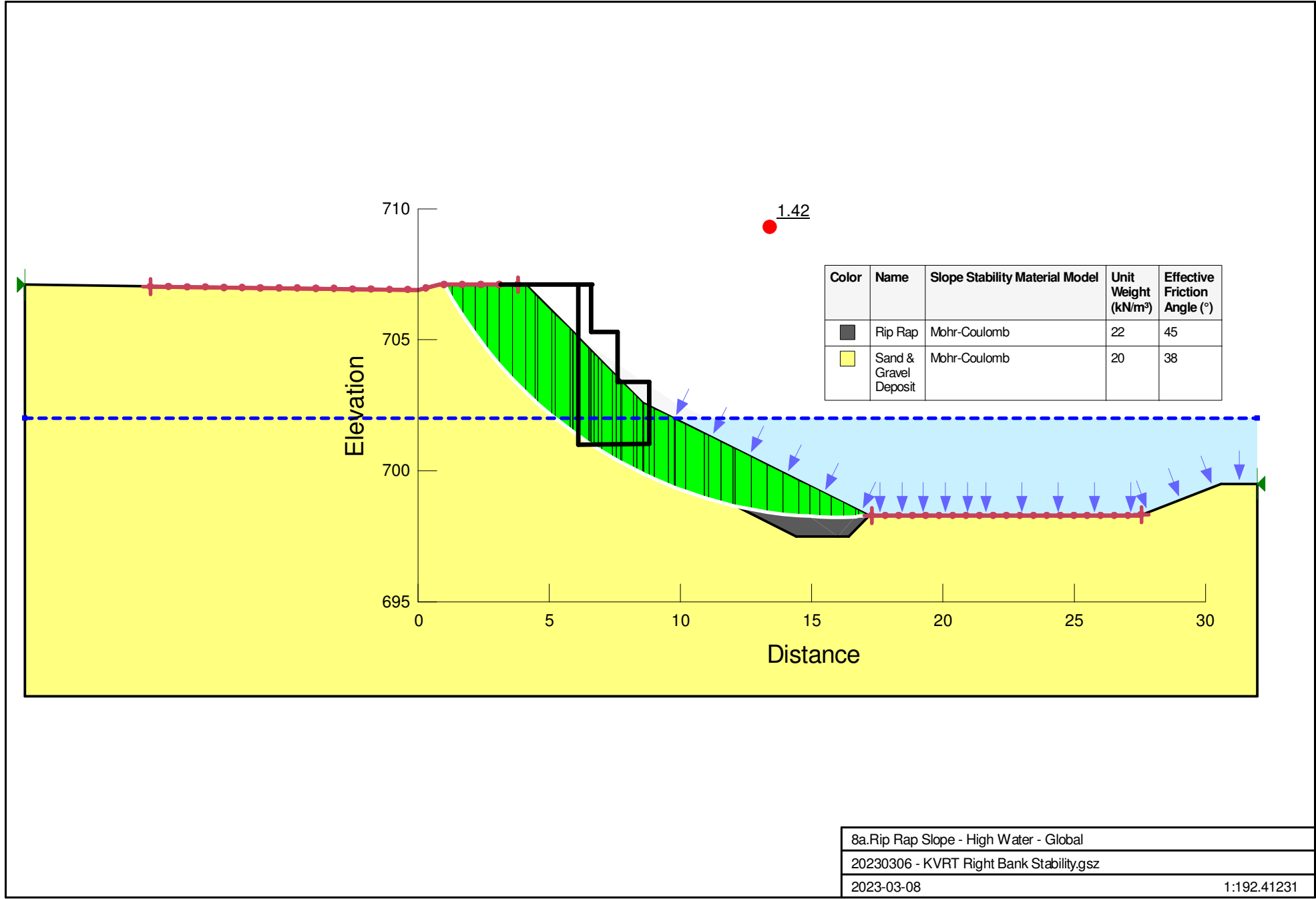


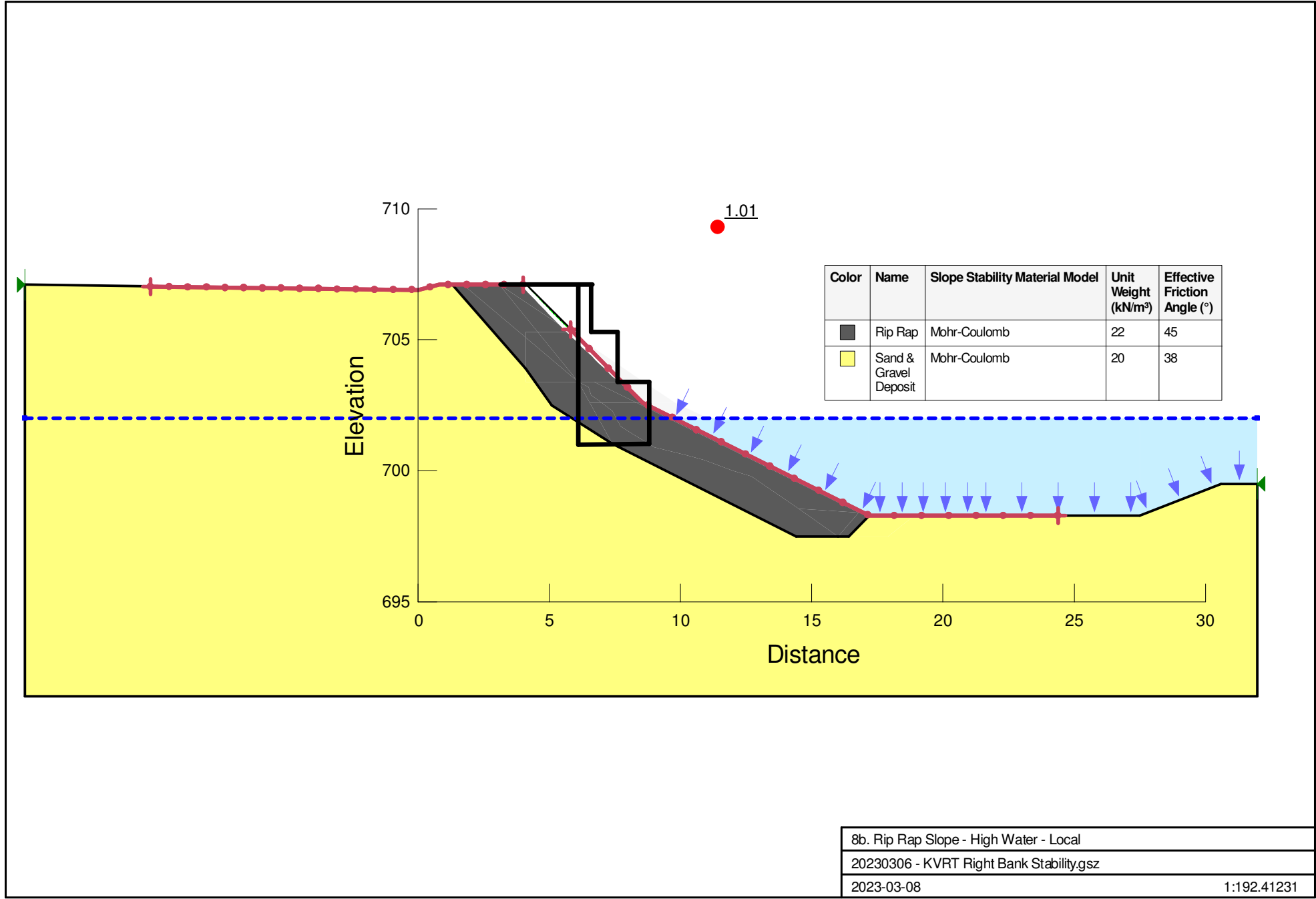












## **APPENDIX IV**

### **Conceptual Design Drawings**

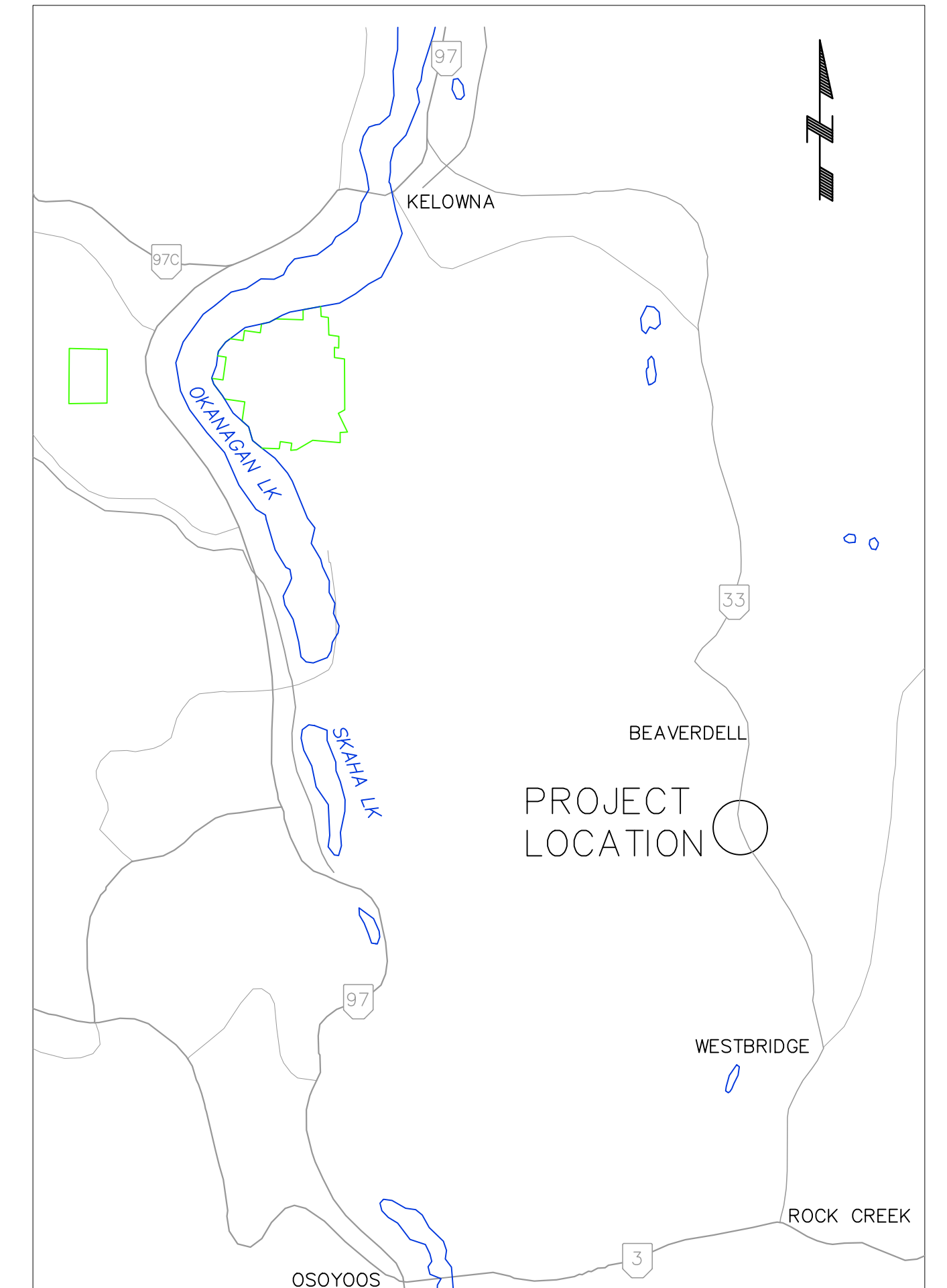
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# RECREATION SITES AND TRAILS BC

PROJECT No. P10443A01

## KETTLE VALLEY RAIL TRAIL BRIDGE ASSESSMENT AND REPAIRS



KEY PLAN  
N.T.S.

| LIST OF DRAWINGS |     |                                                                      |
|------------------|-----|----------------------------------------------------------------------|
| DWG. No          | REV | TITLE                                                                |
| 00               | -   | COVER AND KEY PLAN                                                   |
| 01               | A   | GENERAL NOTES                                                        |
| 02               | A   | GENERAL ARRANGEMENT AND SECTIONS                                     |
| 03               | A   | UNDERMINING REPAIR SECTION AND DETAILS                               |
| 04               | A   | EROSION CONTROL AND SLOPE STABILIZATION OPTIONS GENERAL ARRANGEMENTS |
| 05               | A   | EROSION CONTROL AND SLOPE STABILIZATION OPTIONS SECTIONS             |
| 06               | A   | RETAINING WALL DETAILS                                               |
| 07               | A   | PHOTOS                                                               |

GENERAL NOTES:

- ELEVATIONS AND DIMENSION OF EXISTING BRIDGE ARE BASED ON SURVEY BY VAST RESOURCE SOLUTIONS TAKEN OCTOBER 2021 AND FIELD MEASUREMENTS TAKEN DECEMBER 2022 AND ARE APPROXIMATE ONLY.
- ALL DIMENSIONS ARE IN MILLIMETRES (mm) AND ELEVATIONS ARE IN METERS (m).
- CRITICAL REFERENCE DIMENSIONS ARE TO BE CONFIRMED IN THE FIELD.
- WEST KETTLE RIVER CONTAINS SENSITIVE FISH HABITAT. THE CONTRACTOR IS RESPONSIBLE FOR TAKING APPROPRIATE MEASURES TO PROTECT THE QUALITY AND LIMIT THE DISTURBANCE TO FISH HABITAT DURING CONSTRUCTION IN ACCORDANCE WITH THE CONSTRUCTION ENVIRONMENTAL MANAGEMENT PLAN (CEMP).
- EXISTING BRIDGE DESIGN IS BY OTHERS.
- LOCATIONS OF UNDERGROUND UTILITIES THAT MAY BE AFFECTED SHALL BE VERIFIED BY THE CONTRACTOR PRIOR TO COMMENCING WORK.
- THE CONTRACTOR SHALL BE RESPONSIBLE FOR PROTECTING THE EXISTING BRIDGE DURING EXECUTION OF THE WORK. ANY DAMAGE CAUSED TO THE EXISTING BRIDGE DURING CONSTRUCTION SHALL BE REPAIRED AT THE CONTRACTOR'S EXPENSE.
- UPON COMPLETION OF THE WORK, THE CONTRACTOR SHALL SUBMIT "AS-BUILT" DRAWINGS WITH CLEARLY MARKED CHANGES FROM THE DESIGN DRAWINGS.

CONCRETE:

- CONCRETE MIXES SHALL MEET THE FOLLOWING MINIMUM REQUIREMENTS:

| CLASSIFICATION                          | MINIMUM COMPRESSIVE STRENGTH @ 28 DAYS (MPa) | NOMINAL MAXIMUM SIZE OF COARSE AGGREGATE | AIR CONTENT (%) | SLUMP (mm) | MAXIMUM W/Cm RATIO BY MASS |
|-----------------------------------------|----------------------------------------------|------------------------------------------|-----------------|------------|----------------------------|
| ABUTMENT AND PIER SCOUR REPAIR CONCRETE | 30                                           | 20                                       | 5 ± 1           | 150 ± 20   | 0.45                       |

- ALL EXPOSED CONCRETE EDGES SHALL HAVE A 20 mm CHAMFER UNLESS NOTED OTHERWISE.
- WHERE CONCRETE IS BONDED TO EXISTING CONCRETE, THE SURFACE SHALL BE THOROUGHLY CLEANED AND ROUGHENED.
- REINFORCING STEEL SHALL BE STAINLESS STEEL AND SHALL CONFORM TO ASTM A276 AND ASTM A955M, MINIMUM GRADE 420.
- SPECIFIED CONCRETE COVER AND TOLERANCES TO REINFORCING STEEL SHALL BE 60 ± 10.
- CONTRACTOR SHALL STRICTLY ADHERE TO MANUFACTURER'S RECOMMENDATIONS AND PROCEDURES FOR ALL CONCRETE AND EPOXY ADHESIVE PRODUCTS.
- ALL ORGANIC MATERIALS AND DEBRIS SHALL BE REMOVED FROM WITHIN THE UNDERMINED AREA DOWN TO COMPETENT GROUND. THE GROUND SURFACE SHALL BE EXAMINED AND ACCEPTED BY A QUALIFIED GEOTECHNICAL ENGINEER PRIOR TO INFILLING THE AREA WITH CONCRETE.

CREEK DIVERSION:

- REPAIR OF PIER UNDERMINING AND EXCAVATION/PLACEMENT OF RIPRAP BELOW THE HIGH WATER LEVEL, AS DETERMINED BY THE ENVIRONMENTAL MONITOR, SHALL BE CARRIED OUT IN ISOLATION OF STREAM FLOWS. THE CONTRACTOR IS RESPONSIBLE FOR INSTALLING APPROPRIATE FLOW DIVERSION WORKS FOR THE DURATION OF INSTREAM WORK.
- TEMPORARY DIVERSION WORKS SHALL BE DESIGNED, SIGNED, AND SEALED BY A REGISTERED PROFESSIONAL ENGINEER TO SAFELY PASS THE 10-YEAR RETURN PERIOD FLOOD DURING THE CONSTRUCTION PERIOD. THE CONTRACTOR SHALL SUBMIT THE PROPOSED CREEK DIVERSION DESIGN FOR REVIEW AT LEAST 14 DAYS BEFORE EXECUTING THE WORK.
- A FISH SALVAGE SHALL BE CONDUCTED IN ACCORDANCE WITH THE CEMP PRIOR TO COMMENCEMENT OF WORK. DEWATERING PUMPS SHALL BE FITTED WITH FISH SCREENS TO PREVENT ENTRAPMENT OF FISH.

EXCAVATION:

- ALL EXCAVATIONS SHALL COMPLY WITH THE REQUIREMENTS OF THE WORKERS' COMPENSATION BOARD OF BRITISH COLUMBIA, "INDUSTRIAL HEATH AND SAFETY REGULATIONS", OF THE CANADIAN CONSTRUCTION SAFETY CODE.
- THE CONTRACTOR SHALL NOTIFY THE ENGINEER AT LEAST 72 HOURS BEFORE COMMENCING EXCAVATION.
- THE CONTRACTOR SHALL BE RESPONSIBLE FOR PERFORMING THE CONSTRUCTION IN A SEQUENCE THAT MINIMIZES GROUND MOVEMENT OF THE SLOPES ABOVE THE EXCAVATIONS.
- VERTICAL SOIL CUTS SHALL NOT BE ALLOWED.
- DURING PERIODS OF HEAVY OR CONSISTENT RAINS OR SNOW THE CONTRACTOR SHALL COVER THE TEMPORARY SLOPE WITH A POLY TARP TO MINIMIZE THE AMOUNT OF WATER ON THE TEMPORARY SLOPE OVERNIGHT. THE CONTRACTOR SHALL MAKE AN EFFORT TO RE-USE THE TARP TO MINIMIZE MATERIAL WASTE.
- ALL EXCAVATION SUPPORT SYSTEMS, IF ANY, SHALL BE REMOVED FROM SITE UPON COMPLETION OF THE WORK BY THE CONTRACTOR.

- ALL EXCAVATION VOLUMES WILL BE MEASURED IN-BANK AT THE SOURCE.
- ALL MATERIAL UNSUITABLE OR SURPLUS TO THE PROJECT SHALL BE REMOVED OFFSITE TO A DISPOSAL SITE PROVIDED BY THE CONTRACTOR. THE CONTRACTOR SHALL ENSURE THAT THE DISPOSAL SITE COMPLIES WITH ALL FEDERAL, PROVINCIAL AND REGIONAL BYLAWS AND REGULATIONS.

TEMPORARY ACCESS:

- THE CONTRACTOR SHALL RESPONSIBLE FOR PROVIDING SAFE TEMPORARY ACCESS ON THE STEEP SLOPES TO THEIR PERSONNEL IN ACCORDANCE WITH THE WORKERS' COMPENSATION BOARD OF BRITISH COLUMBIA, "INDUSTRIAL HEATH AND SAFETY REGULATIONS" AND OF THE CANADIAN CONSTRUCTION SAFETY CODE.
- PROVIDE AND MAINTAIN TEMPORARY ACCESS ONLY AT APPROVED LOCATIONS.
- THE CONTRACTOR SHALL SUBMIT TEMPORARY ACCESS DRAWINGS A MINIMUM OF 14 DAYS PRIOR TO THE WORK. THE DRAWINGS SHALL CLEARLY SHOW THE DETAILS AND LOCATIONS OF ALL REQUIRED TEMPORARY ACCESS WORKS.
- UNLESS OTHERWISE APPROVED, ALL TEMPORARY ACCESS ROADS AND ASSOCIATED STRUCTURES SHALL BE REMOVED UPON COMPLETION OF THE WORK AND SITE RESTORED TO THE SATISFACTION OF THE ENGINEER.
- THE CONTRACTOR IS RESPONSIBLE FOR ALL COSTS ASSOCIATED WITH TEMPORARY ACCESS REQUIRED TO COMPLETE THE WORK.

GRS WALL:

- GENERAL

- 1.1 DESIGN

- THE RETAINING WALL IS DESIGNED IN GENERAL ACCORDANCE WITH THE U.S. DEPARTMENT OF TRANSPORTATION, FEDERAL HIGHWAY ADMINISTRATION (FHWA)'S PUBLICATION FHWA-NHI-10-024, DESIGN AND CONSTRUCTION OF MECHANICALLY STABILIZED EARTH WALLS AND REINFORCED SOIL SLOPES VOLUME 1 AND 2 AND CANADIAN FOUNDATION ENGINEERING MANUAL (4TH EDITION).

- 1.2 RESPONSIBILITIES

- THE CONTRACTOR SHALL EMPLOY A SUPERVISOR AND PERSONNEL EXPERIENCED IN THE TYPE OF WORK DESCRIBED IN THIS SECTION.
- WORK SHOULD BE CONDUCTED IN A WAY THAT PREVENTS ANY LOSS OF GROUND OR MOVEMENT OF ADJACENT TRAIL AND BRIDGE STRUCTURE. THE ENGINEER SHALL BE NOTIFIED IMMEDIATELY IN THE EVENT OF ANY NON-ELASTIC GROUND MOVEMENT SUCH AS, BUT NOT LIMITED TO, SLOUGHING BEYOND THE SPECIFIED EXCAVATION FACE, OR SLOPE FAILURE. IF DEEMED NECESSARY BY THE ENGINEER, THE SLOPE SHALL BE BACKFILLED WITH A BERM OF SOIL AND WORK STOPPED IN THE AREA.

- 1.3 SUBMITTALS

- THE CONTRACTOR SHALL SUBMIT A DETAILED WORK PLAN INLCUDING SCHEDULING AND WORK SEQUENCING A MINIMUM OF 14 DAYS PRIOR TO COMMENCEMENT OF WORK TO BE REVIEWED BY THE ENGINEER.
- THE CONTRACTOR SHALL SUBMIT A DETAILED QUALITY CONTROL PLAN A MINIMUM OF 14 DAYS PRIOR TO COMMENCING THE WORK, TO BE REVIEWED BY THE ENGINEER. THE QUALITY CONTROL PLAN SHALL DESCRIBE THE LENGTH OF GEOGRID, OVERLAP THICKNESS OF GEOGRID AND BASKETS, AND FREQUENCY AND METHODOLOGY OF COMPACTION TESTING FOR THE STRUCTURAL BACKFILL OF THE WALL.
- THE CONTRACTOR SHALL SUBMIT THE NAME AND QUALIFICATIONS OF THE COMPACTION TESTERS AND FREQUENCY OF COMPACTION TESTING AS PART OF THE QUALITY CONTROL PLAN.
- THE CONTRACTOR SHALL PROVIDE THE ENGINEER WITH ALL PRODUCT SHEETS AND TECHNICAL SPECIFICATIONS OF THE CHOSEN PRODUCTS FOR REVIEW AND APPROVAL BY THE ENGINEER A MINIMUM OF 14 DAYS PRIOR TO START OF CONSTRUCTION.
- THE CONTRACTOR SHALL SUBMIT TO THE ENGINEER SIEVE TESTS AND PROCTOR TEST DATA FOR THE STRUCTURAL BACKFILL FOR REVIEW AND APPROVAL A MINIMUM OF 14 DAYS PRIOR TO THE START OF CONSTRUCTION.

2. MATERIALS

- 2.1 STRUCTURAL BACKFILL

- REINFORCED SOIL SHALL CONSIST OF SELECT GRANULAR SUB-BASE (SGSB) WITH PROPERTIES IN ACCORDANCE WITH THE BC MINISTRY OF TRANSPORTATION AND INFRASTRUCTURE (MOTI) 2020 STANDARD SPECIFICATIONS FOR HIGHWAY CONSTRUCTION (SS) SECTIONS 202.04 AND 202.05 "SGSB".

- 2.2 FACING (UNLESS OTHERWISE NOTED ON THE DRAWINGS)

- WELDED WIRE MESH FACING SHALL BE 100 mm X 100 mm (4"X 4"), 4 GAUGE POST-FABRICATION HOT DIP GALVANIZED.
- STEEL STRUTS SHALL BE 4 GAUGE, HOT DIPPED GALVANIZED AND SIZED TO FIT BY THE SUPPLIER.
- HOT DIPPED GALVANIZING SHALL CONFORM TO CSA G164 AND HAVE A MINIMUM COATING THICKNESS OF 600 g/m².

- FACING UNITS SHALL OVERLAP A MINIMUM OF 100 mm.

- 2.3 GEOGRID (UNLESS OTHERWISE NOTED ON THE DRAWINGS)

- GEOGRID SHALL BE AS NOTED ON THE DRAWINGS OR AN APPROVED EQUIVALENT.
- IF THE CONTRACTOR ELECTS TO USE AN EQUIVALENT PRODUCT, THE CONTRACTOR SHALL PROVIDE ALL SPECIFICATIONS AND PRODUCT SHEETS OF THE PROPOSED EQUIVALENT PRODUCT A MINIMUM OF 14 DAYS PRIOR TO PROCUREMENT OF THE MATERIALS, FOR REVIEW AND APPROVAL BY THE ENGINEER.

- GEOGRID SHALL BE PLACED END-TO-END OR AS PER MANUFACTURE'S RECOMMENDATIONS.

- 2.4 GEOTEXTILE

- GEOTEXTILE AT THE GRS WALL FACING SHALL BE MIRAMESH GR OR APPROVED EQUIVALENT.
- IF THE CONTRACTOR ELECTS TO USE AN EQUIVALENT PRODUCT, THE CONTRACTOR SHALL PROVIDE ALL SPECIFICATIONS AND PRODUCT SHEETS OF THE PROPOSED EQUIVALENT PRODUCT A MINIMUM OF 14 DAYS PRIOR TO PROCUREMENT OF THE MATERIALS, FOR REVIEW AND APPROVAL BY THE ENGINEER.

- GEOTEXTILE SHALL OVERLAP A MINIMUM 600 mm.

- 2.5 LEVELING PAD

- LEVELING PAD MATERIAL SHALL CONSIST OF 25 mm MINUS CRUSHED GRAVEL, 75 mm MINUS CRUSHED GRAVEL OR AN APPROVED EQUIVALENT.

3. CONSTRUCTION

- 3.1 BACKFILL AND COMPACTION

- COMPACTION OF STRUCTURAL BACKFILL SHALL BE 95% STANDARD PROCTOR AND COMPACTED WITHIN 2% OF OPTIMAL MOISTURE CONTENT. STRUCTURAL BACKFILL SHALL BE PLACED AND COMPACTED IN LIFTS OF NO GREATER THAN 150 mm.

- ONLY HAND-HELD POWER TAMPERS AND VIBRATORS MAY BE USED FOR BACKFILL COMPACTION WITHIN 750 mm OF BASKETS.

- 3.2 QUALITY CONTROL

- THE CONTRACTOR SHALL CONDUCT COMPACTION TESTING ON EVERY LIFT AT SPACING OF 10 m OVER THE LENGTH OF GRS WALLS.

- THE CONTRACTOR SHALL PROVIDE THE ENGINEER WITH COMPACTION TESTING REPORTS FOR REVIEW AND APPROVAL PRIOR TO PLACEMENT OF THE NEXT LIFT.

- MATERIAL TESTING AND REPORTING SHALL BE AT NO COST TO ENGINEER.

- THE CONTRACTOR SHALL PLACE AND INSTALL MATERIAL AS PER MANUFACTURE'S SPECIFICATION AND GUIDELINES.

- 3.3 GEOGRID

- TRACKED EQUIPMENT SHALL NOT BE OPERATED DIRECTLY ON ANY GEOGRID. A MINIMUM LIFT THICKNESS OF 150 mm OF STRUCTURAL BACKFILL IS REQUIRED FOR OPERATION OF TRACKED EQUIPMENT OVER THE GEOGRID. THE CONTRACTOR SHALL MINIMIZE TURNING OF TRACKED EQUIPMENT TO PREVENT THE TRACKS FROM DISPLACING THE FILL AND GEOGRID. THE CONTRACTOR SHALL FOLLOW MANUFACTURE'S RECOMMENDATIONS FOR OPERATING TRACKED EQUIPMENT OVER THE GEOGRID AND GEOTEXTILE.

- GEOGRID SHALL BE INSTALLED ACCORDING TO THE DRAWINGS.

- 3.4 FIELD REVIEW

- FIELD INSPECTIONS DURING GRS WALL CONSTRUCTION SHALL WILL BE PROVIDED BY THE ENGINEER TO REVIEW THE SUBSURFACE CONDITIONS EXPOSED IN THE CUTS AND TO CONFIRM THAT ACTUAL SOIL CONDITIONS ARE SIMILAR TO THOSE ASSUMED IN THE DESIGN OF THE GRS SYSTEM. THE CONTRACTOR SHALL NOT COMMENCE PLACEMENT OF LEVELING COURSE AND FIRST BASKET LAYER PRIOR TO APPROVAL OF BEARING SURFACE BY THE ENGINEER.

RIPRAP:

- ROCK IS TO BE HARD, DURABLE, ABRASIVE RESISTANT AND NON-ACID GENERATING, FREE FROM SEAMS, CRACKS, LAMINATIONS, ORGANICS AND DEBRIS.
- ROCK SOURCE TO BE APPROVED BY ENGINEER PRIOR TO PLACEMENT.
- RIPRAP SHALL BE THE SIZE NOTED ON THE DRAWINGS WITH PROPERTIES IN ACCORDANCE WITH BC MOTI SS SECTION 205.04.
- AREAS TO RECEIVE RIPRAP SHALL BE PREPARED AS PER MOTI SS SECTION 205.05. EXISTING RIPRAP LOCATED WITHIN THE CONSTRUCTION LIMITS SHALL BE SALVAGED AND STORED TO BE MIXED IN WITH THE SUPPLIED RIPRAP. FINAL ACCEPTANCE OF RE-USE OF MATERIAL IS AT THE SOLE DISCRETION OF THE ENGINEER.
- ALL MATERIAL UNSUITABLE OR SURPLUS TO THE PROJECT SHALL BE REMOVED OFFSITE TO A DISPOSAL SITE PROVIDED BY THE CONTRACTOR. THE CONTRACTOR SHALL ENSURE THAT THE DISPOSAL SITE COMPLIES WITH ALL FEDERAL, PROVINCIAL AND REGIONAL BYLAWS AND REGULATIONS.
- PLACEMENT OF RIPRAP SHALL BE IN ACCORDANCE WITH MOTI SS SECTIONS 205.06, 205.07 AND 205.08.

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- RIPRAP TO BE DISTRIBUTED EVENLY AND PLACED MATERIAL SHALL BE TAMPED OR OTHERWISE TREATED TO PROVIDE AN EVEN, DENSE SURFACE WITH A MINIMUM OF VOIDS.
- RIPRAP PLACED ON SLOPING BANKS SHALL BE UNDERLAIN WITH CLASS 1 NON-WOVEN GEOTEXTILE.
- NON-WOVEN GEOTEXTILE SHALL BE A PRODUCT LISTED ON THE MOTI'S CURRENT RECOGNIZED PRODUCTS LIST.
- GEOTEXTILE SHALL BE KEYED INTO THE TOP OF THE SLOPE AND LAID ALONG THE SLOPE LENGTH WITH APPROPRIATE SLACK TO PREVENT TEARING DURING PLACEMENT OF RIPRAP.

ROCKFILL:

- ROCKFILL SHALL CONSIST OF HIGH QUALITY, WELL-GRADED SOUND ROCK CONTAINING NO MORE THAN 15% BY VOLUME ROCK LARGER THAN 150 mm.
- ROCKFILL SHALL BE CONSTRUCTED IN HOTIZONTAL LIFTS NOT GREATER THAN 700 mm IN HEIGHT.
- MATERIAL SHALL BE SPREAD EVENLY IN EACH LAYER SO THAT THE LARGER PARTICLES ARE WELL DISTRIBUTED, AND INTERVENING SPACES ARE FILLED WITH SMALLER SIZES.
- EACH ROCKFILL LAYER SHALL BE UNIFORMLY COMPACTED BY A VIBRATORY DRUM ROLLER OR PLATE TAMPER. THE NUMBER OF PASSES REQUIRED TO ACHIEVE ADEQUATE COMPACTION TO BE APPROVED BY THE ENGINEER.
- PLACEMENT OF ROCKFILL SHALL BE IN ACCORDANCE WITH MOTI SS SECTION 201.36.

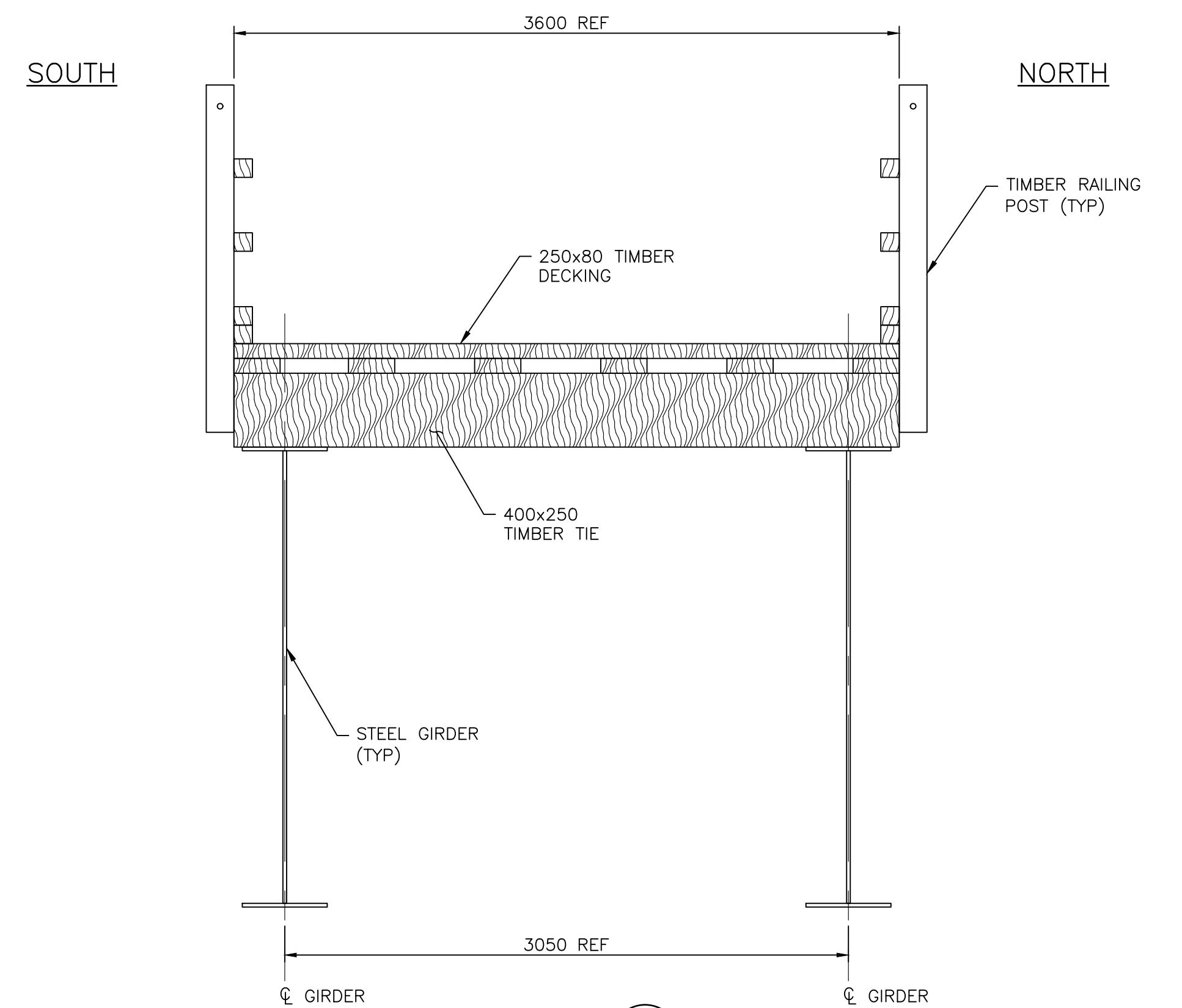
ROCK STACKED WALL:

- INDIVIDUAL ROCK BLOCKS SHALL EXCEED 90 kg IN WEIGHT AND SHALL BE GREATER THAN 450 mm DIAMETER IN ALL DIRECTIONS.
- ROCK BLOCKS SELECTED SHALL BE RECTANGULAR, TABULAR OR CUBIC IN SHAPE. ROUNDED ROCKS SHALL NOT BE USED IN CONSTRUCTION OF THE ROCK STACKED RETAINING WALL.
- ROCKS SHALL BE INTACT AND MASSIVE WITH NO OPEN FRACTURES, FOLIATION OR OTHER PLANES OF WEAKNESS.
- ROCK SHALL BE HARD AND RESISTANT TO WEATHERING.
- ROCKS SHALL BE STACKED IN A MANNER SO THAT THERE IS NO CONTINUOUS VERTICAL OR HORIZONTAL JOINTS.
- ROCKS SHALL BE SELECTED TO HAVE GOOD CONTACT BETWEEN ADJACENT ROCK BLOCKS.
- VOIDS LEFT BETWEEN ROCKS SHALL BE FILLED WITH SMALLER PIECES SO THAT NO VOIDS REMAIN.
- THE LARGEST ROCKS SHALL BE PLACED AT THE BASE OF THE ROCK STACKED RETAINING WALL.

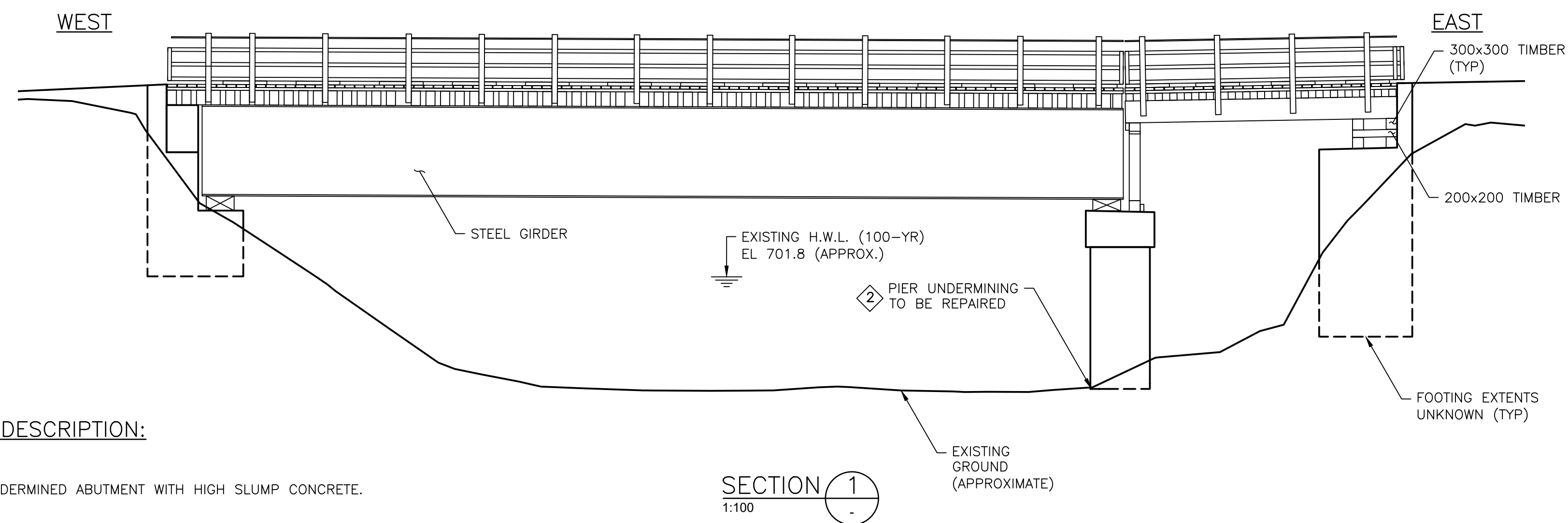
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|--|--|--|-------------------|-------------------------|--------------------|-------|----------|---------|-------------------|--------------------------|----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------|--|--|--|
|  |  |  | DRAWING REVISIONS |                         |                    |       |          |         |                   | ORIGINAL ISSUE           |                | AS A MUTUAL PROTECTION TO OUR CLIENT, THE PUBLIC AND OURSELVES, ALL REPORTS AND DRAWINGS ARE SUBMITTED FOR THE CONFIDENTIAL INFORMATION OF OUR CLIENT FOR A SPECIFIC PROJECT AND AUTHORIZATION FOR USE AND/OR PUBLICATION OF DATA, STATEMENTS, CONCLUSIONS OR ABSTRACTS FROM OR REGARDING OUR REPORTS AND DRAWINGS IS RESERVED PENDING OUR WRITTEN APPROVAL. | <div>CLIENT</div> <div></div> <div></div> | PROJECT<br>KETTLE VALLEY RAIL TRAIL<br>BRIDGE ASSESSMENT AND REPAIRS |  |  |  |
|  |  |  |                   |                         |                    |       |          |         |                   | DRAWN:                   | J. PANG        |                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                     | TITLE                                                                |  |  |  |
|  |  |  |                   |                         |                    |       |          |         |                   | DESIGNED:                | M. COVENEY     |                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                     |                                                                      |  |  |  |
|  |  |  |                   |                         |                    |       |          |         |                   | CHECKED:                 | K. GREINACHER  |                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                     |                                                                      |  |  |  |
|  |  |  |                   |                         |                    |       |          |         |                   | APPROVED:                | K. MITCHELL    |                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                     |                                                                      |  |  |  |
|  |  |  | A                 | CONCEPT DESIGN          | 2023-02-10         | J.P.  | M.C.     | K.G.    | K.M.              |                          |                |                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                     |                                                                      |  |  |  |
|  |  |  | REVISION          | DESCRIPTION OF REVISION | DATE<br>(mm-mm-dd) | DRAWN | DESIGNED | CHECKED | APPROVED          |                          |                |                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                     |                                                                      |  |  |  |
|  |  |  |                   |                         |                    |       |          |         | SCALE<br>AS SHOWN | PROJECT NO.<br>P10443A01 | DWG. NO.<br>01 | REV.<br>A                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                     |                                                                      |  |  |  |

CANCEL PRINTS BEARING PREVIOUS REVISION

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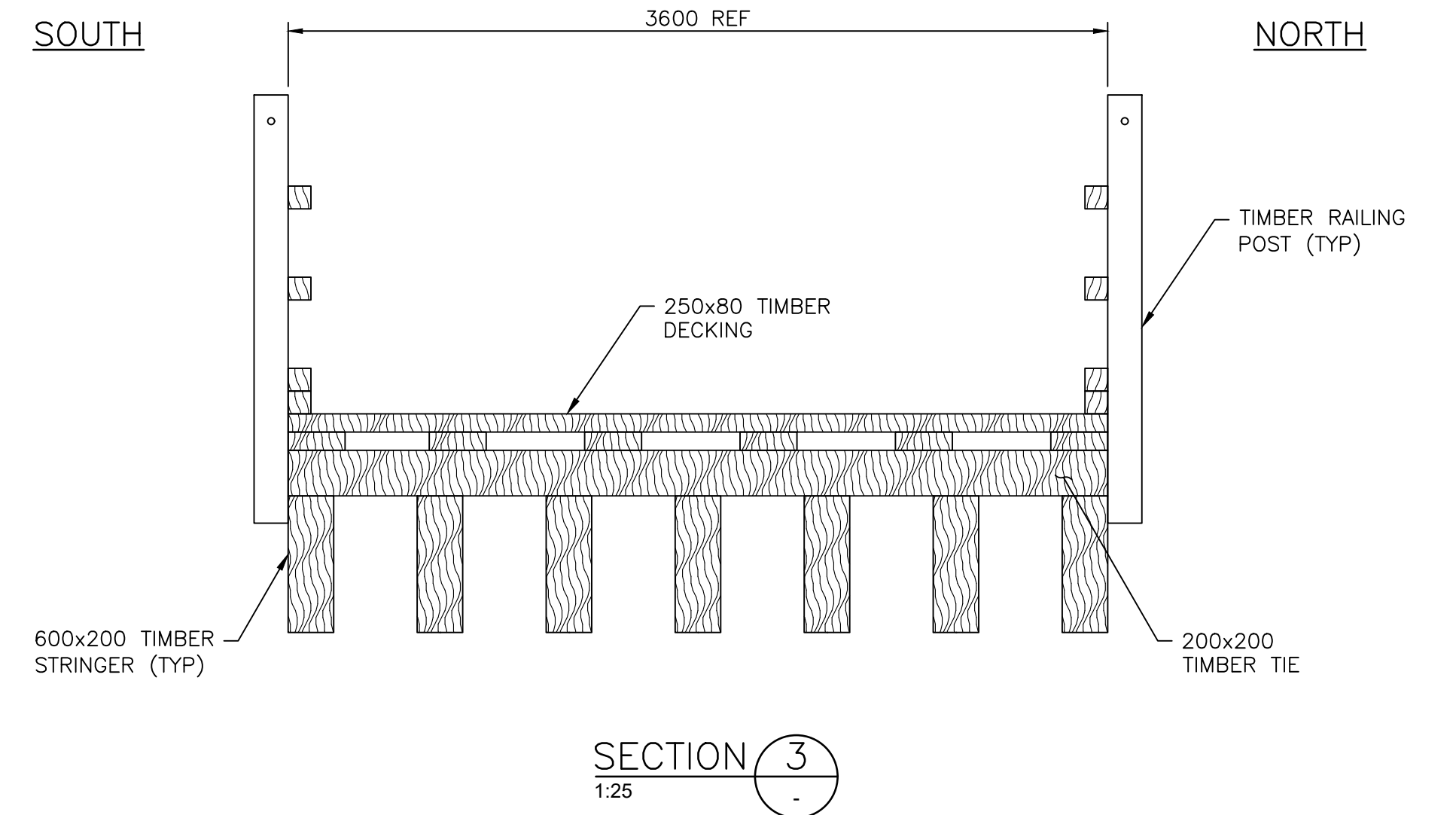


PLAN  
1:100



SECTION 1  
1:100

- 1 REPAIR UNDERMINED ABUTMENT WITH HIGH SLUMP CONCRETE.
- 2 REPAIR UNDERMINED PIER WITH HIGH SLUMP CONCRETE.
- 3 REINSTATE AND STABILIZE ERODED SLOPE.
- 4 PLACE RIPRAP ARMOURING ALONG SCAURED RIVERBANK.



SECTION 3  
1:25

NOTES:

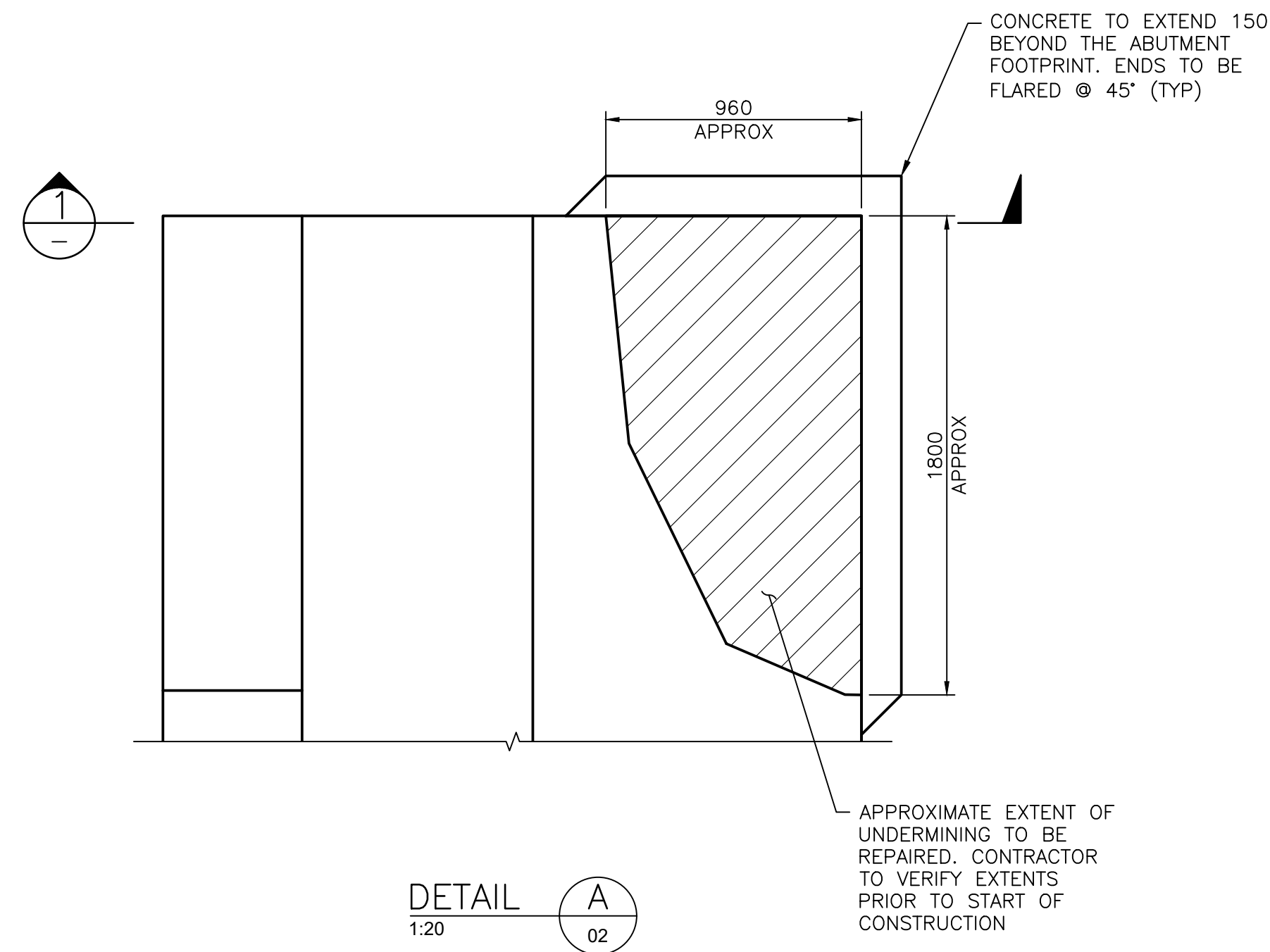
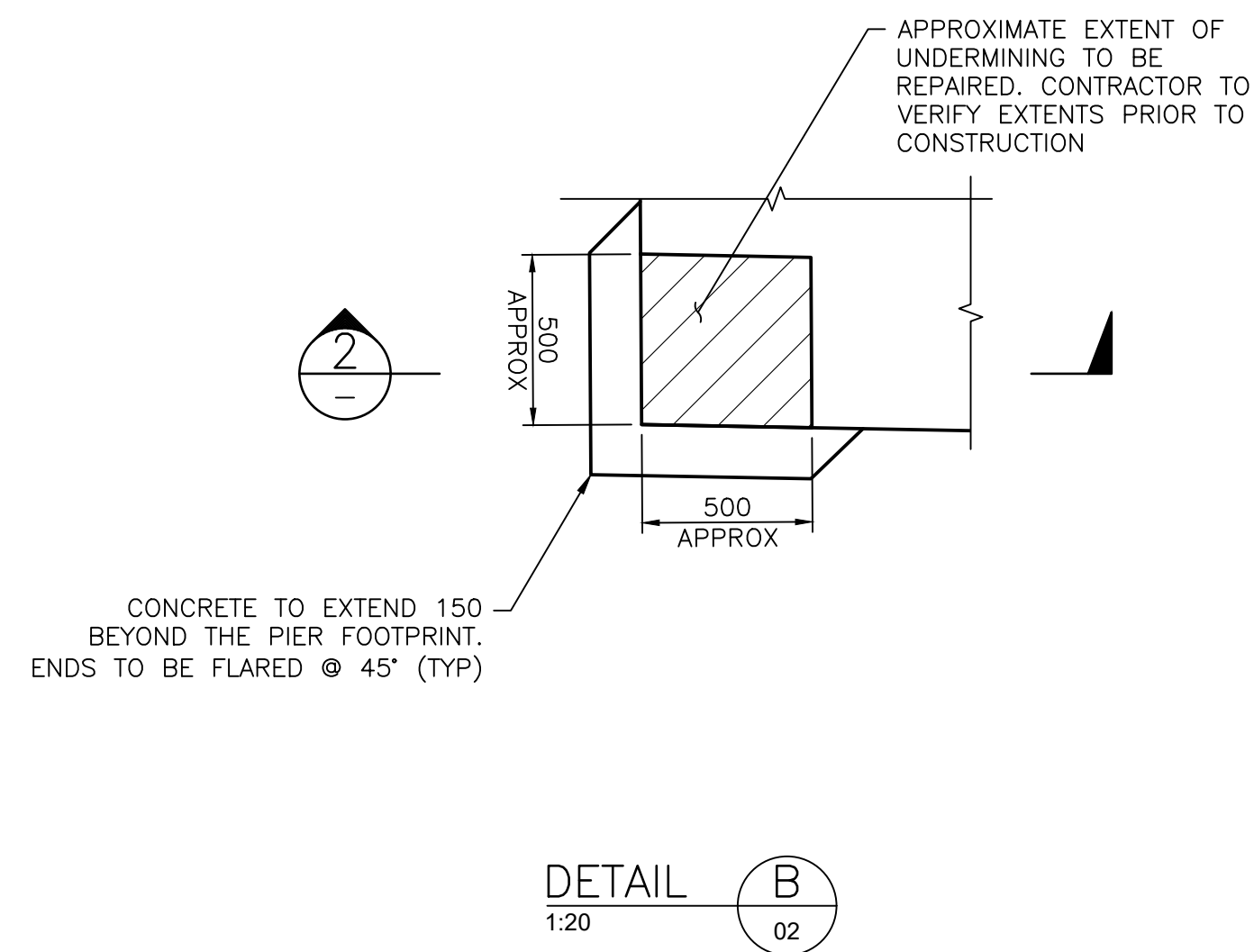
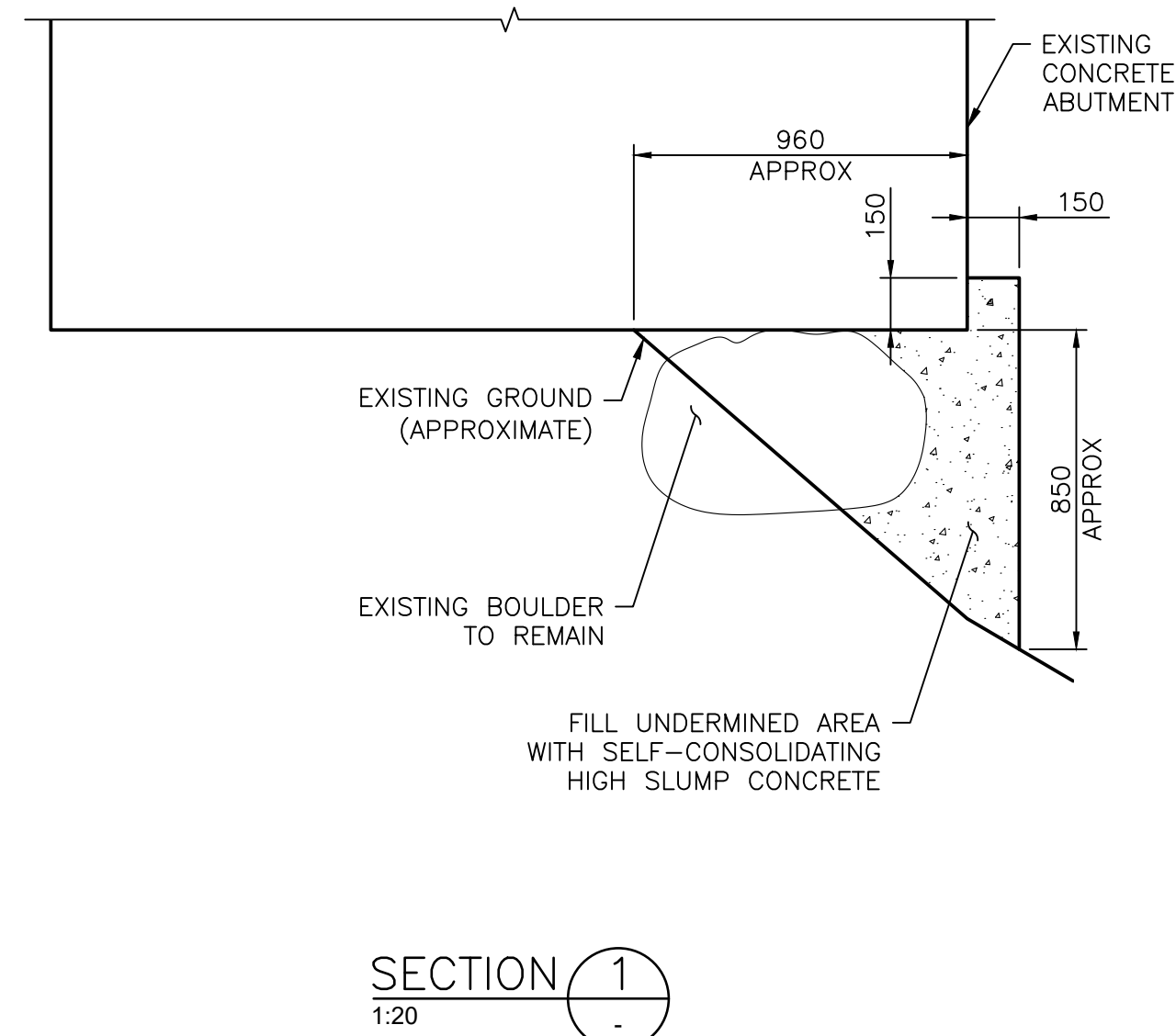
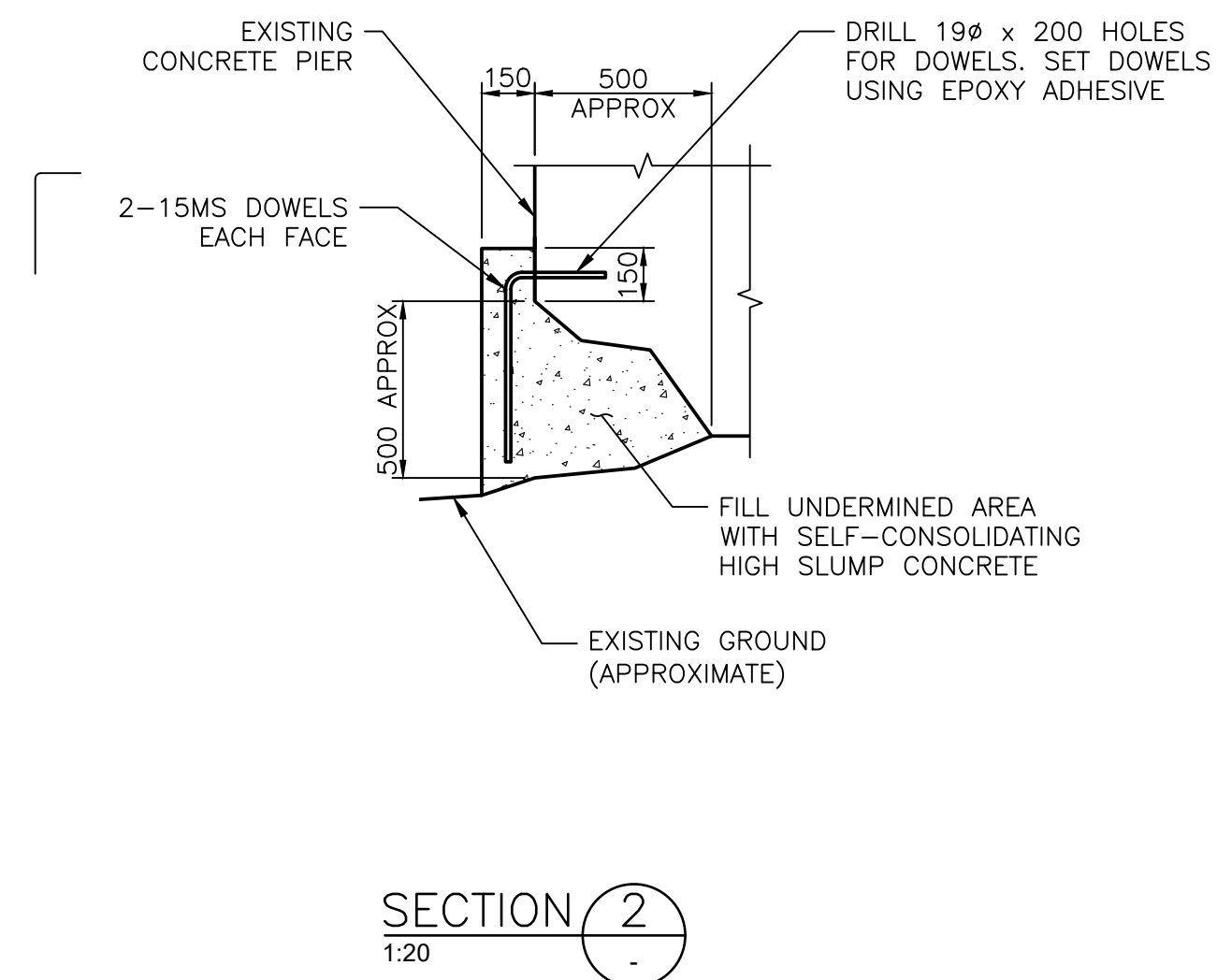
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|  |  |                   |                         |                 |       |          |         |          |                |               |                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                             |                                                                      |                   |                          |                |
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|  |  |                   |                         |                 |       |          |         |          | DRAWN:         | J. PANG       |                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                             | TITLE<br><br>KV-005 BRIDGE<br>GENERAL ARRANGEMENT AND SECTIONS       |                   |                          |                |
|  |  |                   |                         |                 |       |          |         |          | DESIGNED:      | M. COVENEY    |                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                             |                                                                      |                   |                          |                |
|  |  |                   |                         |                 |       |          |         |          | CHECKED:       | K. GREINACHER |                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                             |                                                                      |                   |                          |                |
|  |  |                   |                         |                 |       |          |         |          | APPROVED:      | K. MITCHELL   |                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                             |                                                                      |                   |                          |                |
|  |  |                   |                         |                 |       |          |         |          |                |               |                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                             |                                                                      |                   |                          |                |
|  |  | A                 | CONCEPT DESIGN          | 2023-02-10      | J.P.  | M.C.     | K.G.    | K.M.     |                |               |                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                             |                                                                      |                   |                          |                |
|  |  | REVISION          | DESCRIPTION OF REVISION | DATE (mm-dd-yy) | DRAWN | DESIGNED | CHECKED | APPROVED |                |               |                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                             |                                                                      | SCALE<br>AS SHOWN | PROJECT NO.<br>P10443A01 | DWG. NO.<br>02 |

CANCEL PRINTS BEARING PREVIOUS REVISION

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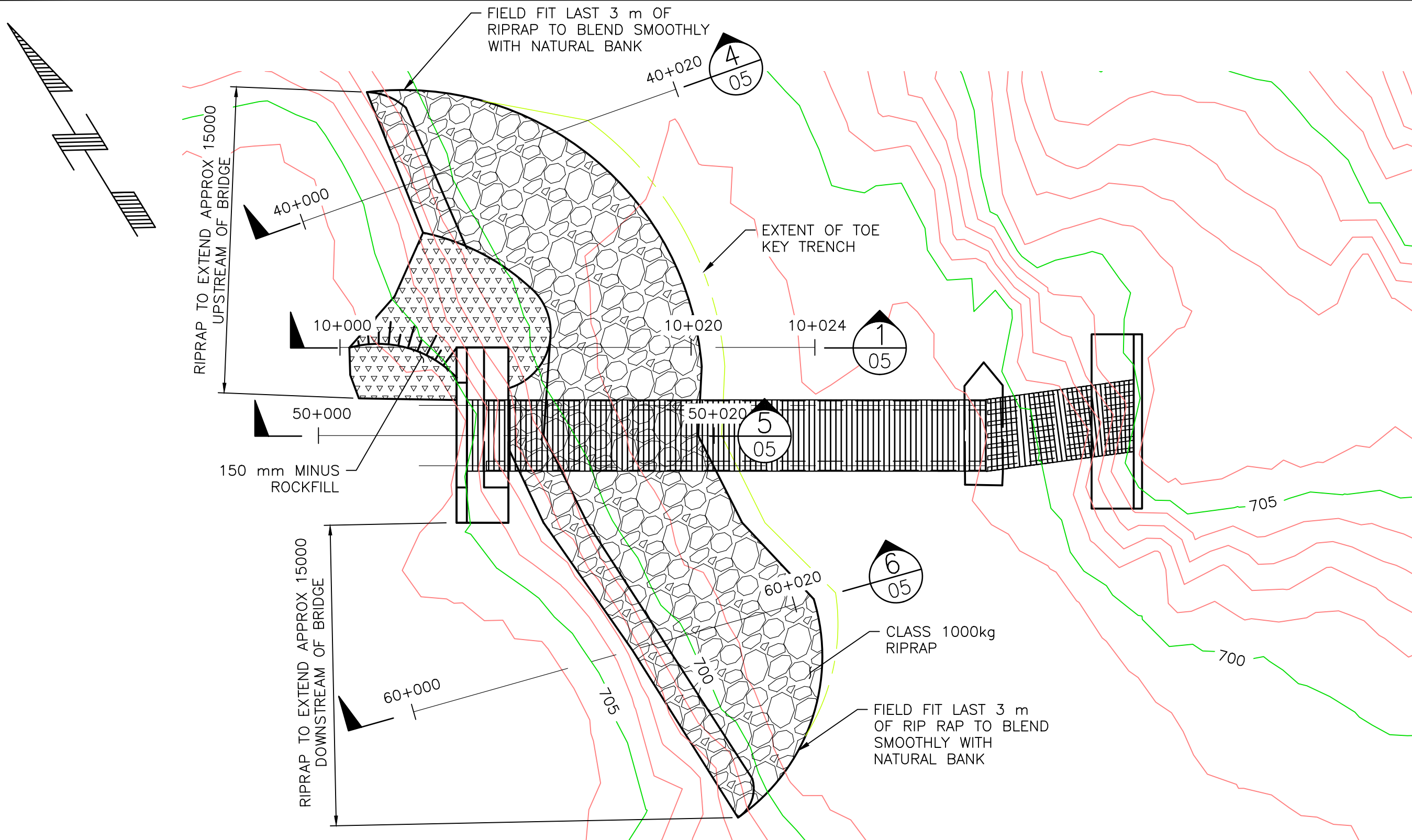
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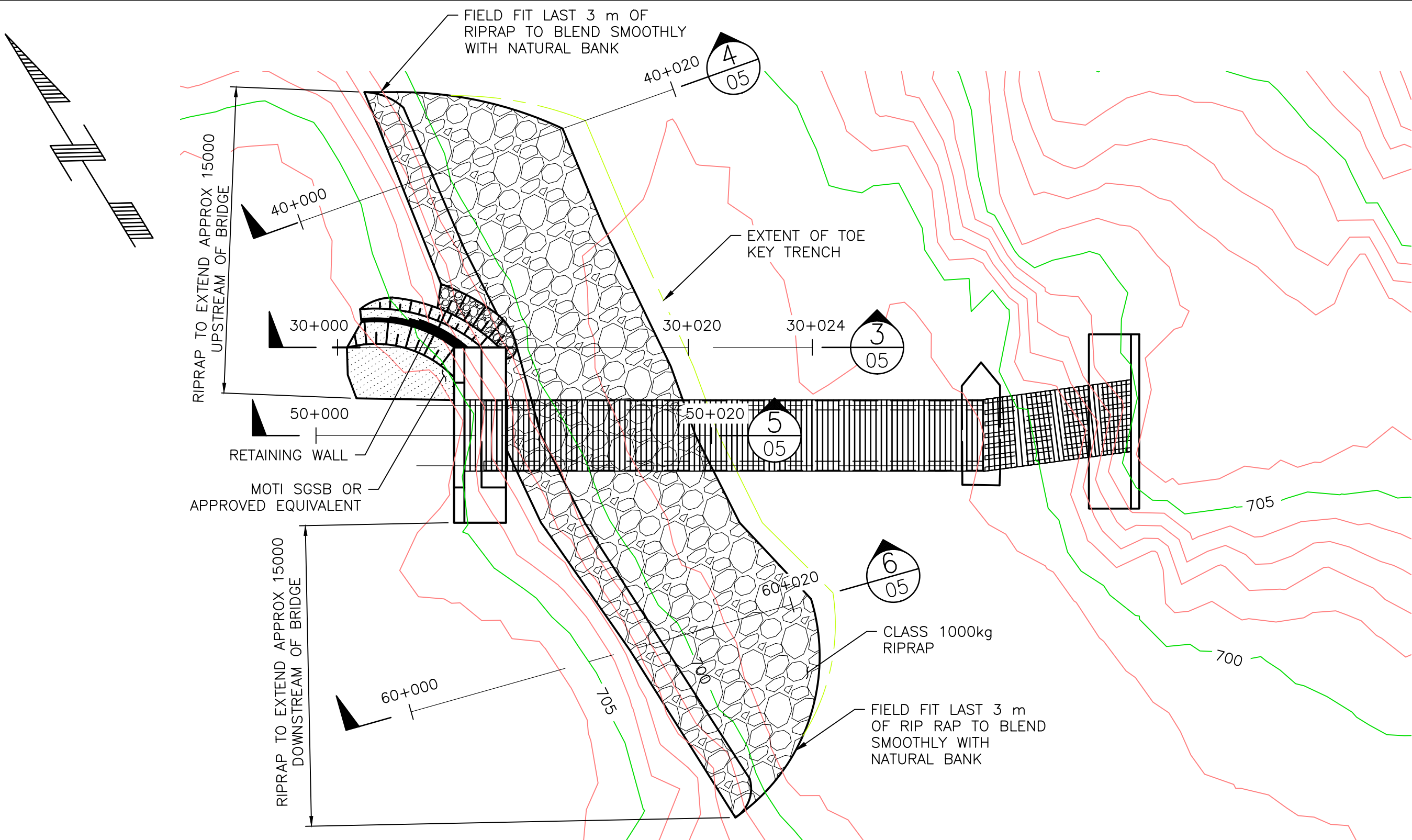
| DRAWING REVISIONS |                         |                 |       |          |         |          |  | ORIGINAL ISSUE |               | AS A MUTUAL PROTECTION TO OUR CLIENT, THE PUBLIC AND OURSELVES, ALL REPORTS AND DRAWINGS ARE SUBMITTED FOR THE CONFIDENTIAL INFORMATION OF OUR CLIENT FOR A SPECIFIC PROJECT AND AUTHORIZATION FOR USE AND/OR PUBLICATION OF DATA, STATEMENTS, CONCLUSIONS OR ABSTRACTS FROM OR REGARDING OUR REPORTS AND DRAWINGS IS RESERVED PENDING OUR WRITTEN APPROVAL. | CLIENT<br><br> | PROJECT<br>KETTLE VALLEY RAIL TRAIL<br>BRIDGE ASSESSMENT AND REPAIRS |                          |                |           |
|-------------------|-------------------------|-----------------|-------|----------|---------|----------|--|----------------|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------|--------------------------|----------------|-----------|
|                   |                         |                 |       |          |         |          |  | DRAWN:         | J. PANG       |                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                          | TITLE<br>KV-005 BRIDGE<br>UNDERMINING REPAIR<br>SECTIONS AND DETAILS |                          |                |           |
|                   |                         |                 |       |          |         |          |  | DESIGNED:      | M. COVENEY    |                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                          |                                                                      |                          |                |           |
|                   |                         |                 |       |          |         |          |  | CHECKED:       | K. GREINACHER |                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                          |                                                                      |                          |                |           |
|                   |                         |                 |       |          |         |          |  | APPROVED:      | K. MITCHELL   |                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                          |                                                                      |                          |                |           |
| A                 | CONCEPT DESIGN          | 2023-02-10      | J.P.  | M.C.     | K.G.    | K.M.     |  |                |               |                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                          |                                                                      |                          |                |           |
| REVISION          | DESCRIPTION OF REVISION | DATE (YY-MM-DD) | DRAWN | DESIGNED | CHECKED | APPROVED |  |                |               |                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                          | SCALE<br>AS SHOWN                                                    | PROJECT NO.<br>P10443A01 | DWG. NO.<br>03 | REV.<br>A |

CANCEL PRINTS BEARING PREVIOUS REVISION

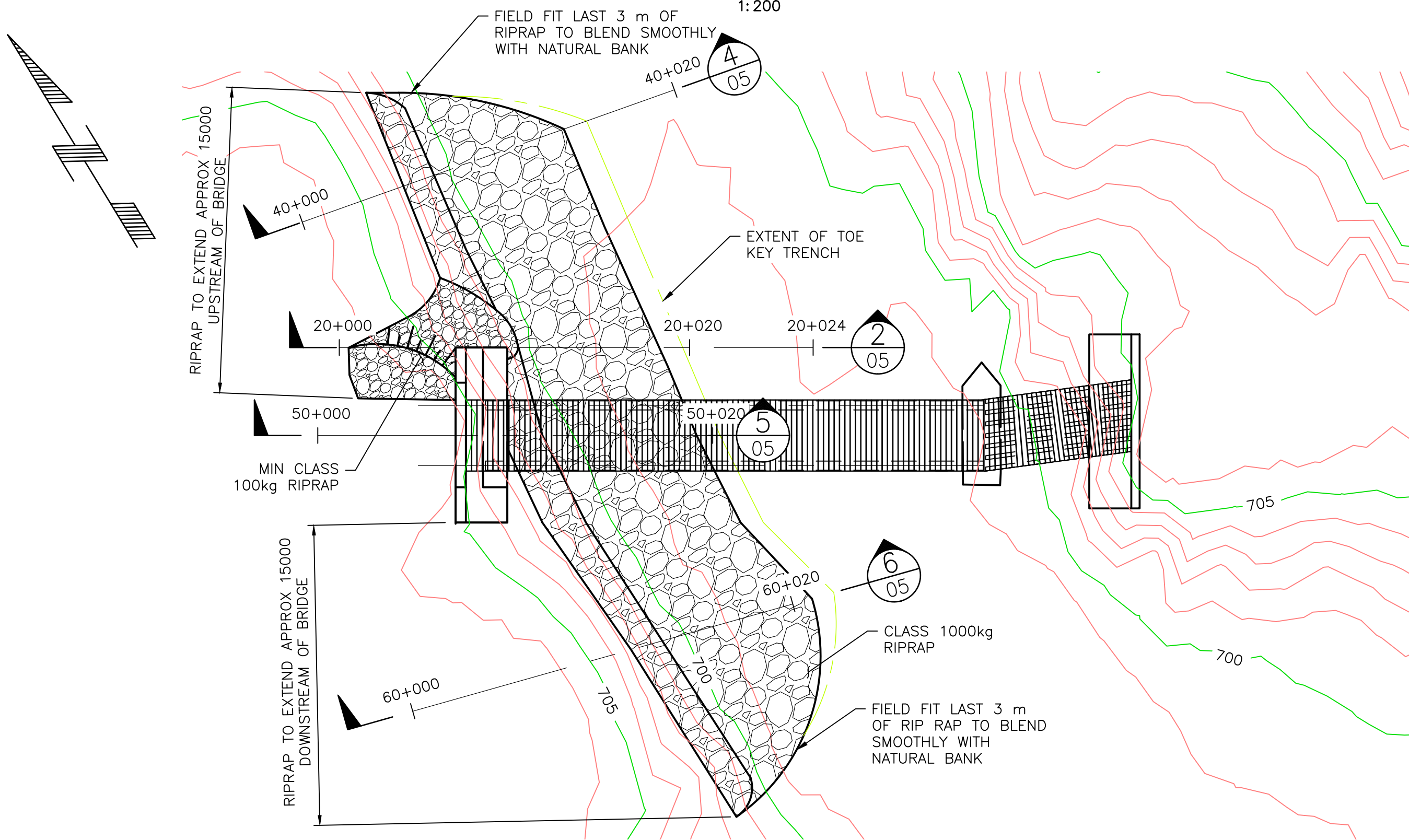
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OPTION 1: ROCKFILL SLOPE WITH RIPRAP AT BASE



OPTION 3: RETAINING WALL WITH RIPRAP AT BASE



OPTION 2: PLACED RIPRAP FILL SLOPE WITH RIPRAP AT BASE

- NOTES:
- FOR GENERAL NOTES SEE DRAWING 01.
  - THE CONTRACTOR SHALL BE RESPONSIBLE FOR PROVIDING SURVEY AND CONFIRMING LAYOUT OF THE RIPRAP EXTENTS AND RETAINING WALL/SLOPE LOCATION.

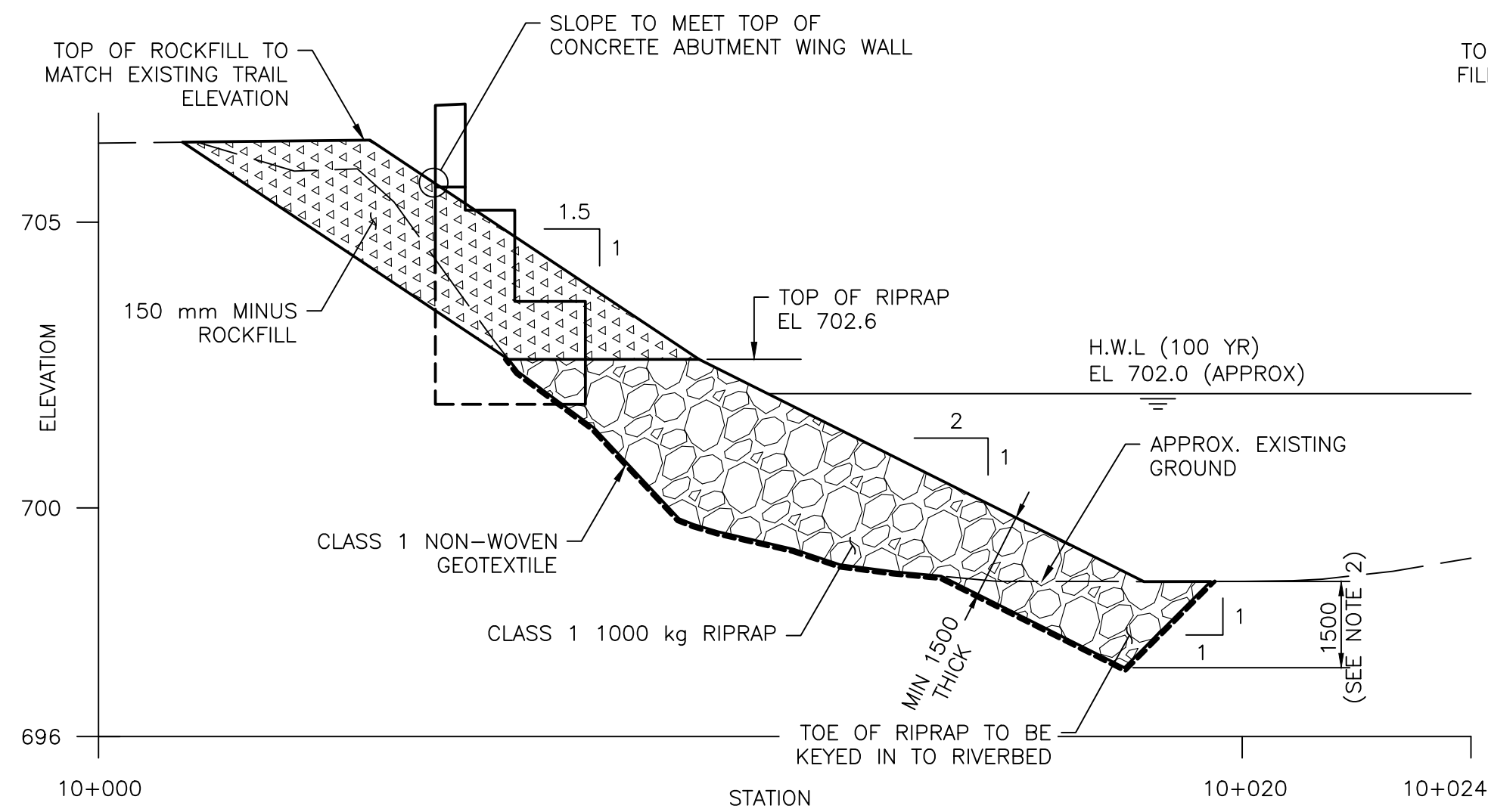
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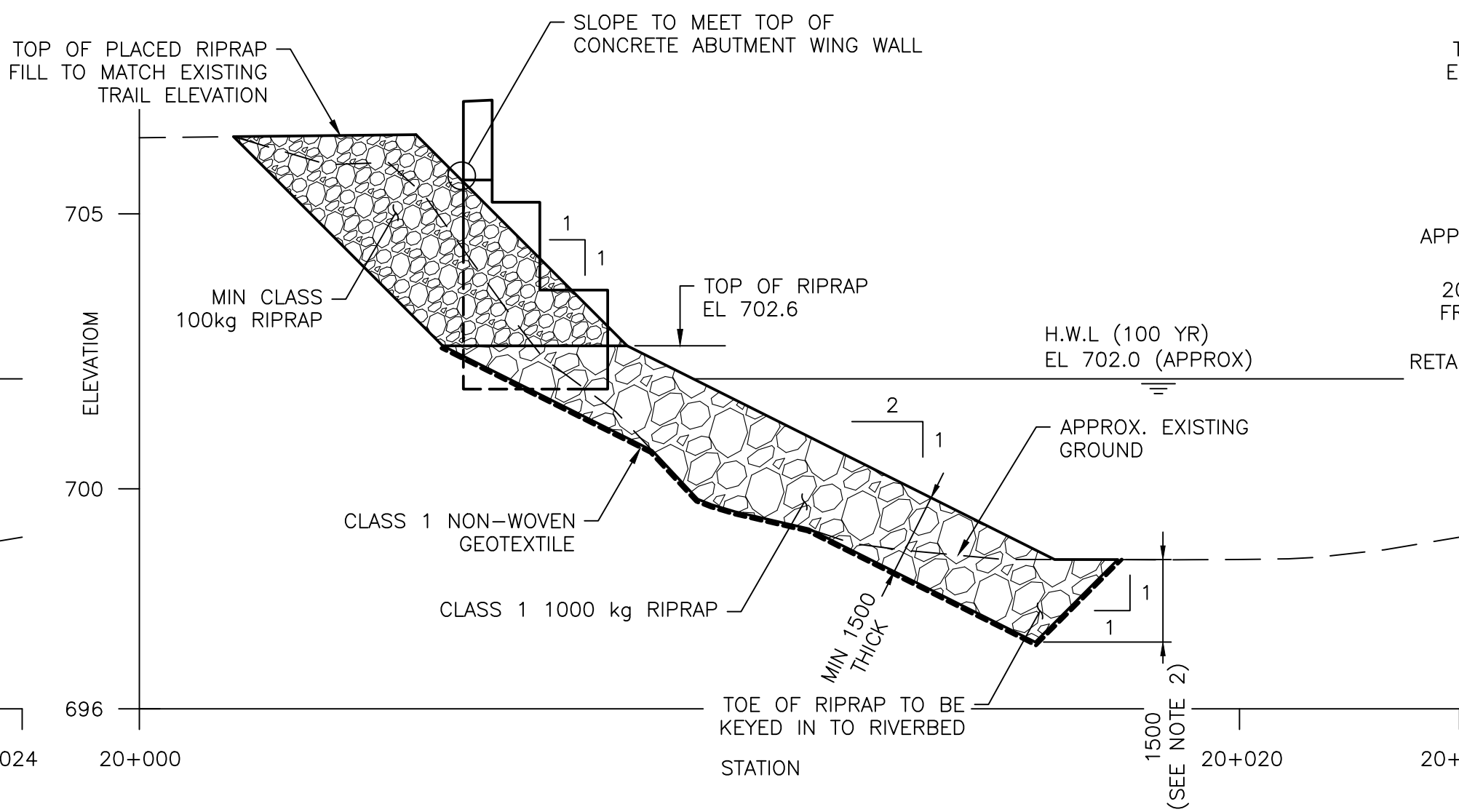
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|  |  |  |                   |                         |                      |       |          |         |          | DRAWN:         | J. PANG    |                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                             | TITLE<br><br>KV-005 BRIDGE<br>EROSION CONTROL AND SLOPE STABILIZATION<br>GENERAL ARRANGEMENT |  |  |  |                          |
|  |  |  |                   |                         |                      |       |          |         |          | DESIGNED:      | J. JOHNSON |                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                             |                                                                                              |  |  |  |                          |
|  |  |  |                   |                         |                      |       |          |         |          | CHECKED:       | C. JOHNSON |                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                             |                                                                                              |  |  |  |                          |
|  |  |  |                   |                         |                      |       |          |         |          | APPROVED:      | A. MUIR    |                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                             |                                                                                              |  |  |  |                          |
|  |  |  | A                 | CONCEPT DESIGN          | 2023-02-10           | J.P.  | J.J.     | C.J.    | A.M.     |                |            |                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                             |                                                                                              |  |  |  |                          |
|  |  |  | REVISION          | DESCRIPTION OF REVISION | DATE<br>(YYYY-MM-DD) | DRAWN | DESIGNED | CHECKED | APPROVED |                |            |                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                             |                                                                                              |  |  |  |                          |
|  |  |  |                   |                         |                      |       |          |         |          |                |            |                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                             | SCALE<br>AS SHOWN                                                                            |  |  |  | PROJECT NO.<br>P10443A01 |

CANCEL PRINTS BEARING PREVIOUS REVISION

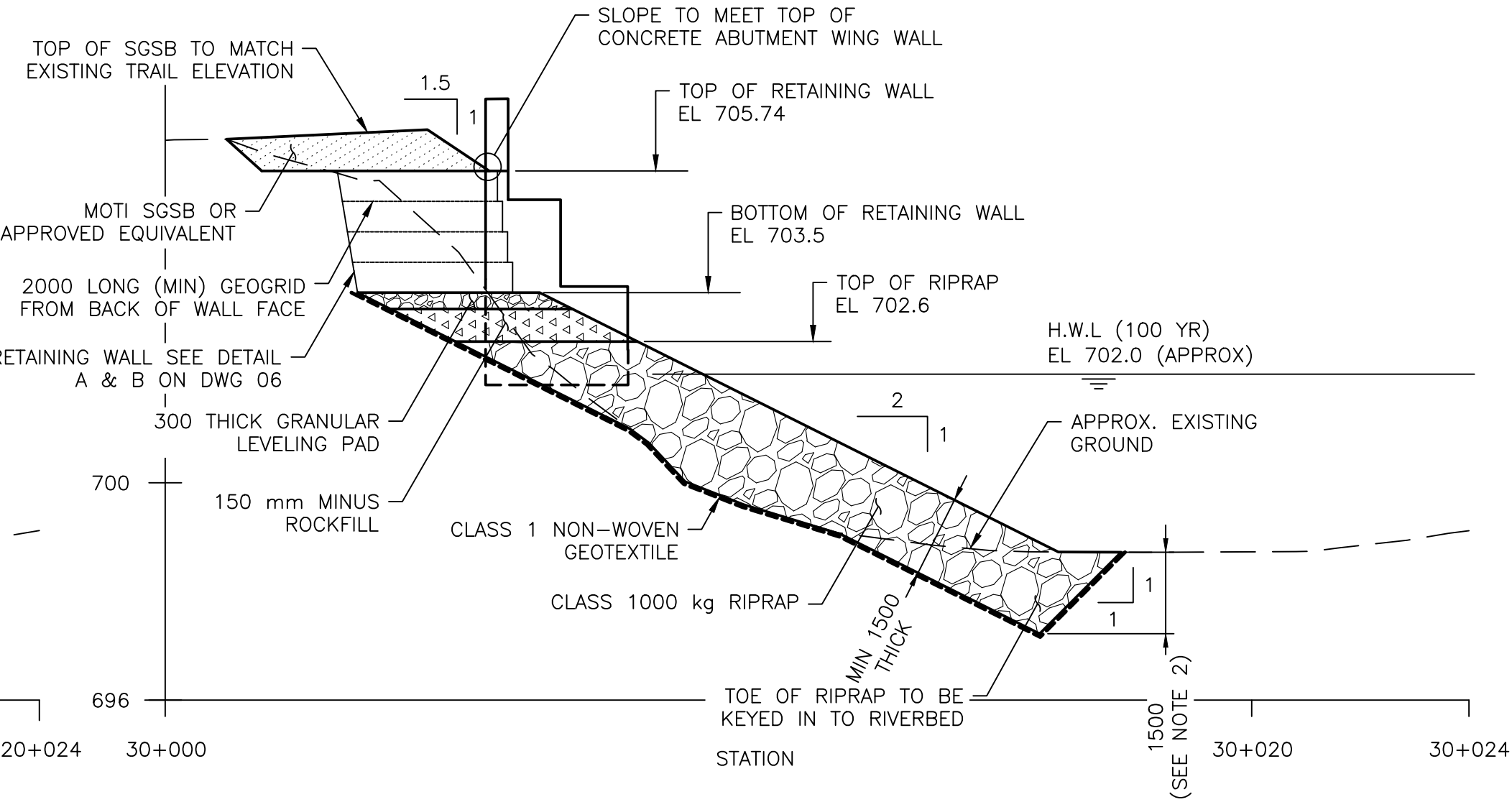
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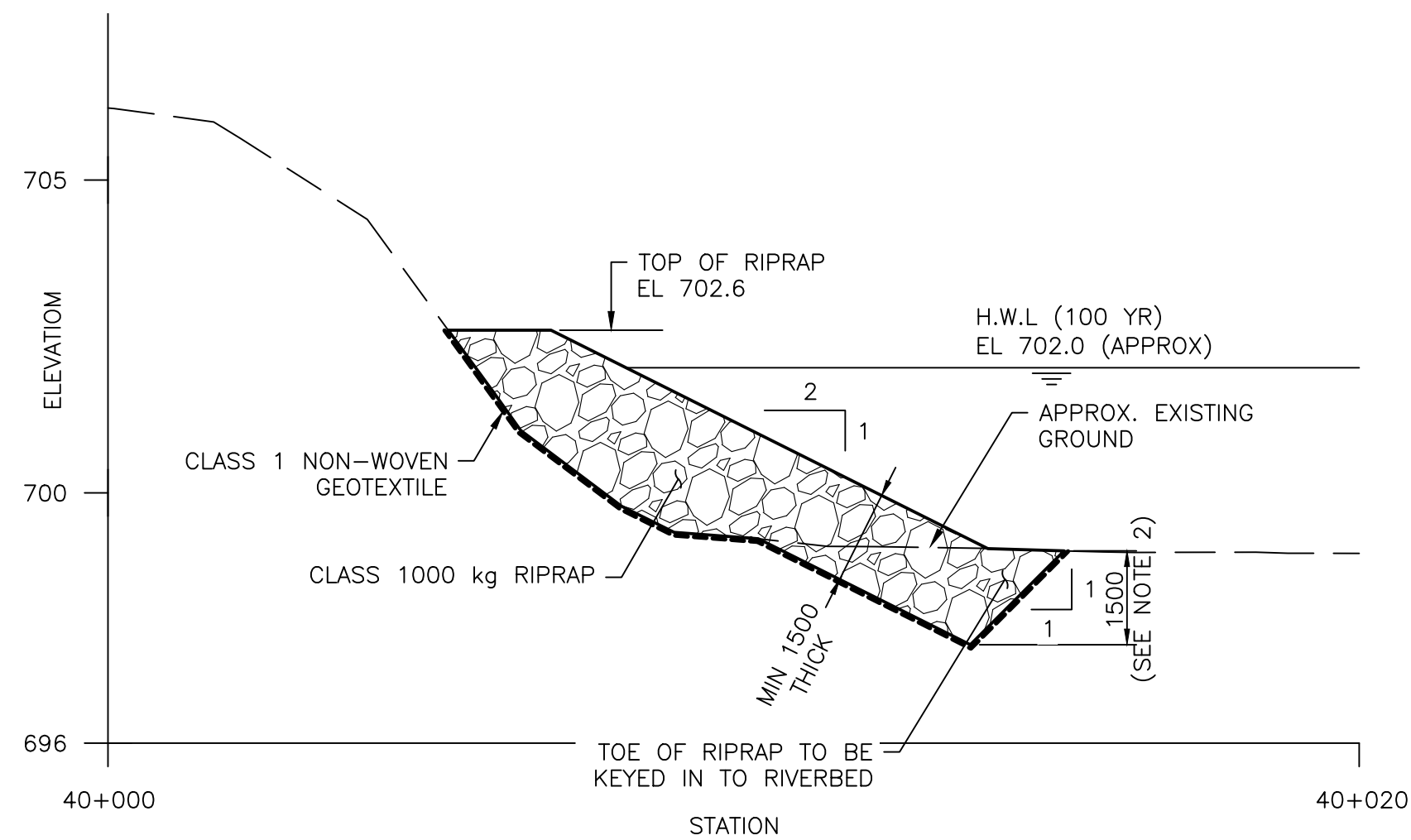
SECTION 1  
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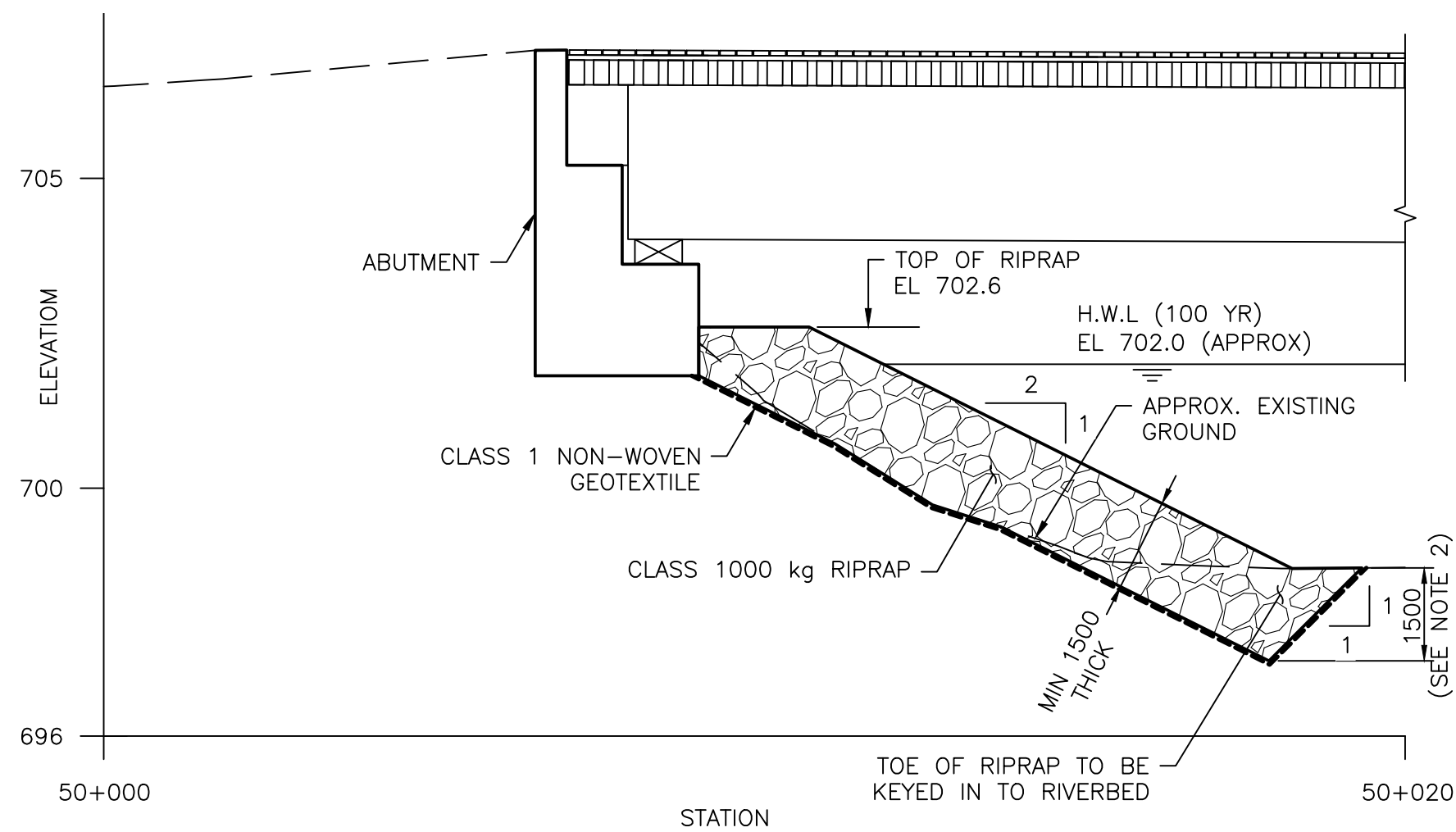
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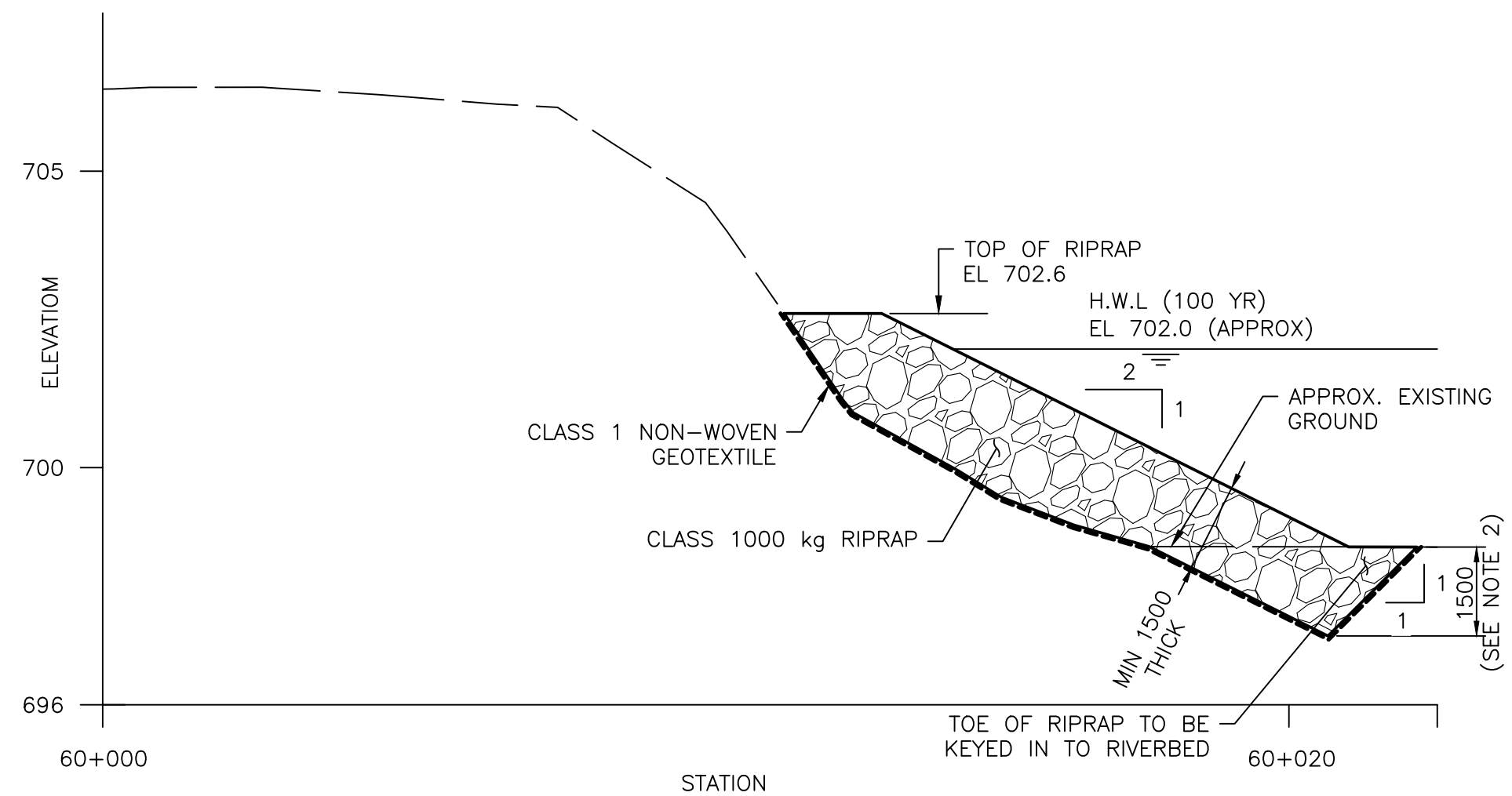
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SECTION 4  
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SECTION 5  
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SECTION 6  
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NOTES:

1. FOR GENERAL NOTES SEE DRAWING 01.
2. THE KEY TRENCH IS NOT REQUIRED IN AREAS OF RIVERBED WHERE BEDROCK ENCOUNTERED.
3. RIPRAP MAY BE SHIFTED TOWARDS THE BANK AT TIME OF CONSTRUCTION WITH APPROVAL FROM THE ENGINEER. GENERAL RIPRAP CONFIGURATION, INCLUDING TOP ELEVATION, MINIMUM THICKNESS, AND TOE KEY, SHALL MEET THE REQUIREMENTS SHOWN ON THE DRAWINGS.
4. ALL PERMANENT EXCAVATIONS AND DISTURBED SLOPES SHALL BE GRADED TO NO STEEPER THAN 1.5H:1V.

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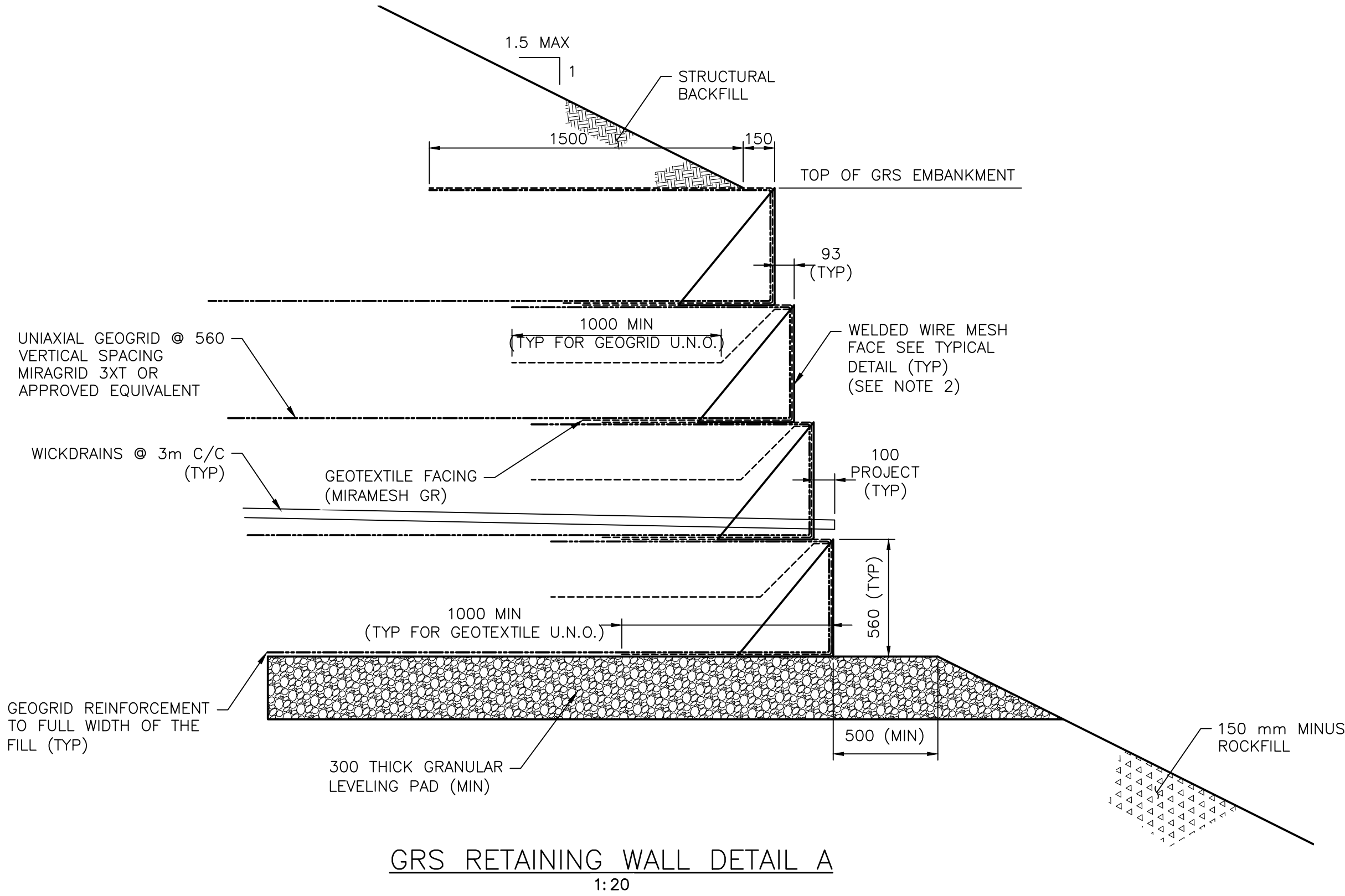
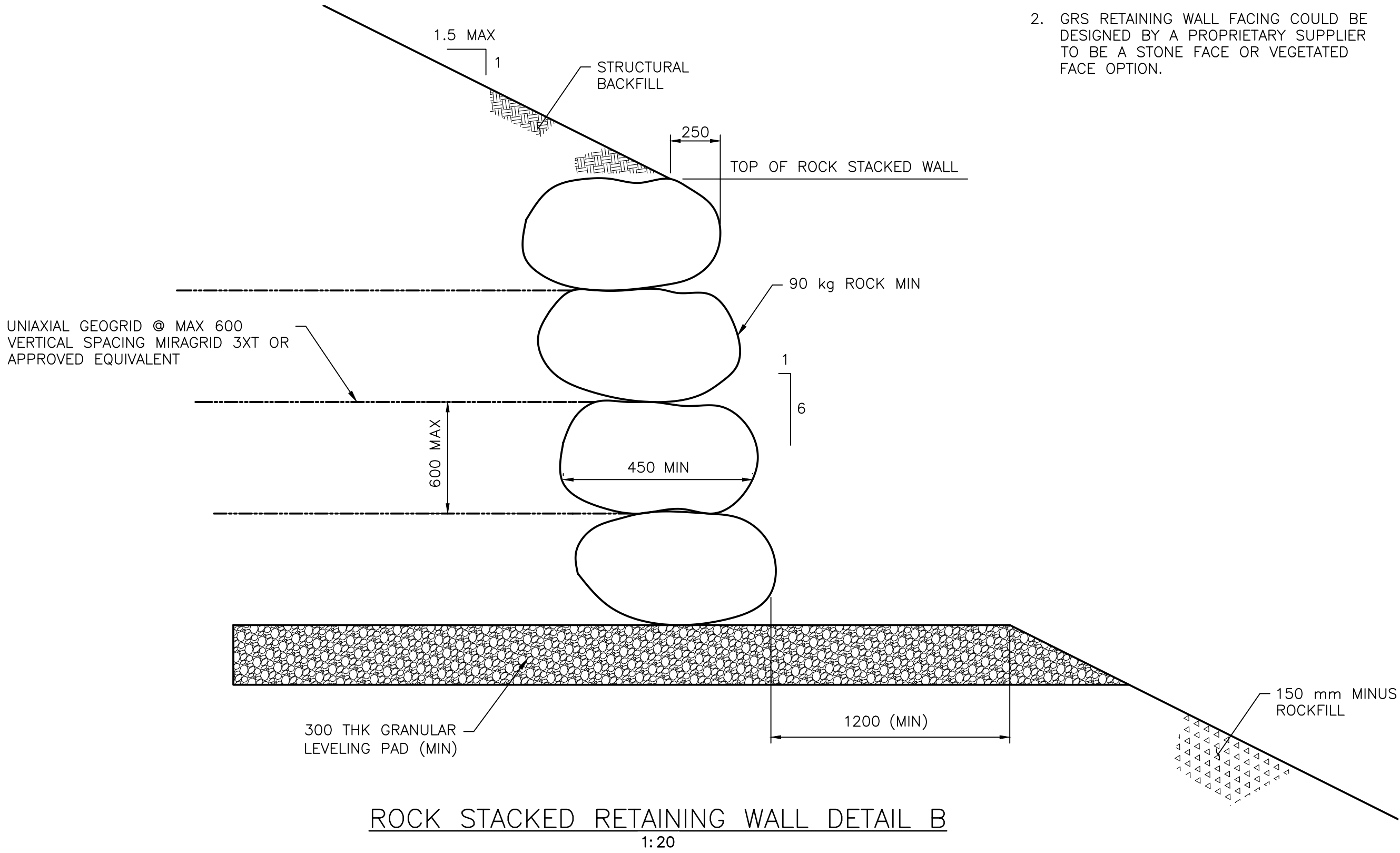
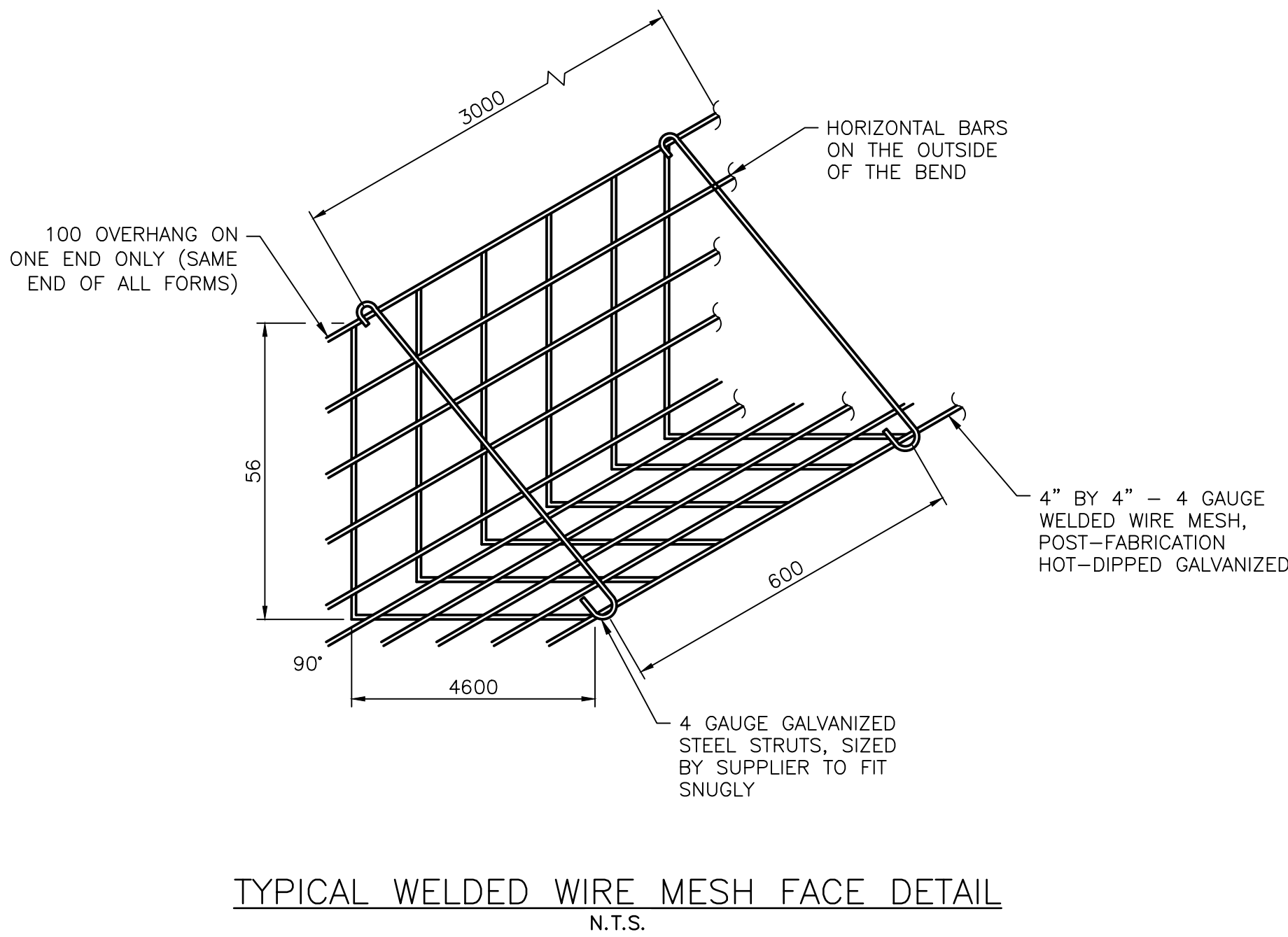
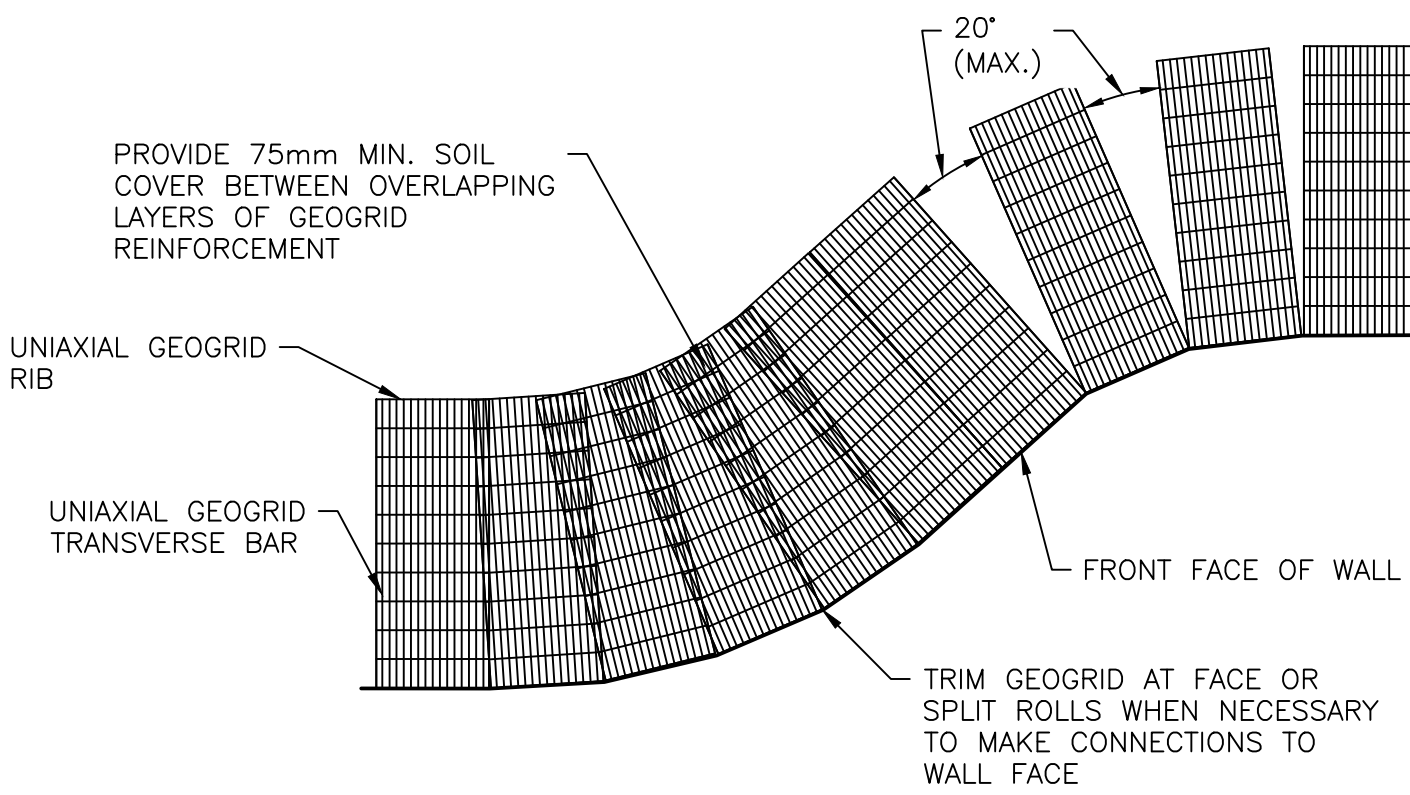
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|  |  |                   |                         |                    |       |          |         |          |                |           |                                                                                                                                                                                                                                                                                                                                                              |        |            |                                                                                                                              |                          |                |           |
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|  |  | DRAWING REVISIONS |                         |                    |       |          |         |          | ORIGINAL ISSUE |           | AS A MUTUAL PROTECTION TO OUR CLIENT, THE PUBLIC AND OURSELVES, ALL REPORTS AND DRAWINGS ARE SUBMITTED FOR THE CONFIDENTIAL INFORMATION OF OUR CLIENT FOR A SPECIFIC PROJECT AND AUTHORIZATION FOR USE AND/OR PUBLICATION OF DATA, STATEMENTS, CONCLUSIONS OR ABSTRACTS FROM OR REGARDING OUR REPORTS AND DRAWINGS IS RESERVED PENDING OUR WRITTEN APPROVAL. | CLIENT | PROJECT    |                                                                                                                              |                          |                |           |
|  |  |                   |                         |                    |       |          |         |          |                | DRAWN:    |                                                                                                                                                                                                                                                                                                                                                              |        | J. PANG    | KETTLE VALLEY RAIL TRAIL<br>BRIDGE ASSESSMENT AND REPAIRS                                                                    |                          |                |           |
|  |  |                   |                         |                    |       |          |         |          |                | DESIGNED: |                                                                                                                                                                                                                                                                                                                                                              |        | J. JOHNSON | TITLE                                                                                                                        |                          |                |           |
|  |  |                   |                         |                    |       |          |         |          |                | CHECKED:  |                                                                                                                                                                                                                                                                                                                                                              |        | C. JOHNSON | <div> <b>Klohn Crippen Berger</b></div> |                          |                |           |
|  |  |                   |                         |                    |       |          |         |          |                | APPROVED: |                                                                                                                                                                                                                                                                                                                                                              |        | A. MUIR    |                                                                                                                              |                          |                |           |
|  |  | A                 | CONCEPT DESIGN          | 2023-02-10         | J.P.  | J.J.     | C.J.    | A.M.     |                |           |                                                                                                                                                                                                                                                                                                                                                              |        |            |                                                                                                                              |                          |                |           |
|  |  | REVISION          | DESCRIPTION OF REVISION | DATE<br>(mm-mm-dd) | DRAWN | DESIGNED | CHECKED | APPROVED |                |           |                                                                                                                                                                                                                                                                                                                                                              |        |            | SCALE<br>AS SHOWN                                                                                                            | PROJECT NO.<br>P10443A01 | DWG. NO.<br>05 | REV.<br>A |

CANCEL PRINTS BEARING PREVIOUS REVISION

KCB-DWG-D-L

- NOTES:
1. FOR GENERAL NOTES SEE DRAWING 01.
  2. GRS RETAINING WALL FACING COULD BE DESIGNED BY A PROPRIETARY SUPPLIER TO BE A STONE FACE OR VEGETATED FACE OPTION.



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|          |                         |                      |       |                   |         |          |  |  |  |           |                |                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |        |  |                          |  |                                                                      |  |           |  |
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|          |                         |                      |       | DRAWING REVISIONS |         |          |  |  |  |           | ORIGINAL ISSUE |                                                      | <div>AS A MUTUAL PROTECTION TO OUR CLIENT, THE PUBLIC AND OURSELVES, ALL REPORTS AND DRAWINGS ARE SUBMITTED FOR THE CONFIDENTIAL INFORMATION OF OUR CLIENT FOR A SPECIFIC PROJECT AND AUTHORIZATION FOR USE AND/OR PUBLICATION OF DATA, STATEMENTS, CONCLUSIONS OR ABSTRACTS FROM OR REGARDING OUR REPORTS AND DRAWINGS IS RESERVED PENDING OUR WRITTEN APPROVAL.</div> <div><div></div><div></div></div> | CLIENT |  |                          |  | PROJECT<br>KETTLE VALLEY RAIL TRAIL<br>BRIDGE ASSESSMENT AND REPAIRS |  |           |  |
|          |                         |                      |       |                   |         |          |  |  |  | DRAWN:    | J. PANG        | TITLE<br><br>KV-005 BRIDGE<br>RETAINING WALL DETAILS |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |        |  |                          |  |                                                                      |  |           |  |
|          |                         |                      |       |                   |         |          |  |  |  | DESIGNED: | M. CORMER      |                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |        |  |                          |  |                                                                      |  |           |  |
|          |                         |                      |       |                   |         |          |  |  |  | CHECKED:  | C. JOHNSON     |                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |        |  |                          |  |                                                                      |  |           |  |
|          |                         |                      |       |                   |         |          |  |  |  | APPROVED: | A. PORT        |                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |        |  |                          |  |                                                                      |  |           |  |
| A        | CONCEPT DESIGN          | 2023-02-10           | J.P.  | M.C.              | C.J.    | A.P.     |  |  |  |           |                |                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |        |  |                          |  |                                                                      |  |           |  |
| REVISION | DESCRIPTION OF REVISION | DATE<br>(YYYY-MM-DD) | DRAWN | DESIGNED          | CHECKED | APPROVED |  |  |  |           |                | SCALE AS SHOWN                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |        |  | PROJECT NO.<br>P10443A01 |  | DWG. NO.<br>06                                                       |  | REV.<br>A |  |

KCB-DWG-D-L



PHOTO 1: OVERVIEW OF BRIDGE LOOKING DOWNSTREAM. REFERENCES TO "RIGHT" AND "LEFT" SIDES OF THE BRIDGE ARE AS SEEN LOOKING DOWNSTREAM



PHOTO 2: OVERVIEW OF BRIDGE LOOKING UPSTREAM



PHOTO 3: EROSION AT THE "RIGHT" BANK AND UNDERMINING AT THE ABUTMENT ON THE UPSTREAM SIDE OF BRIDGE



PHOTO 4: UNDERMINING AT THE "RIGHT" ABUTMENT

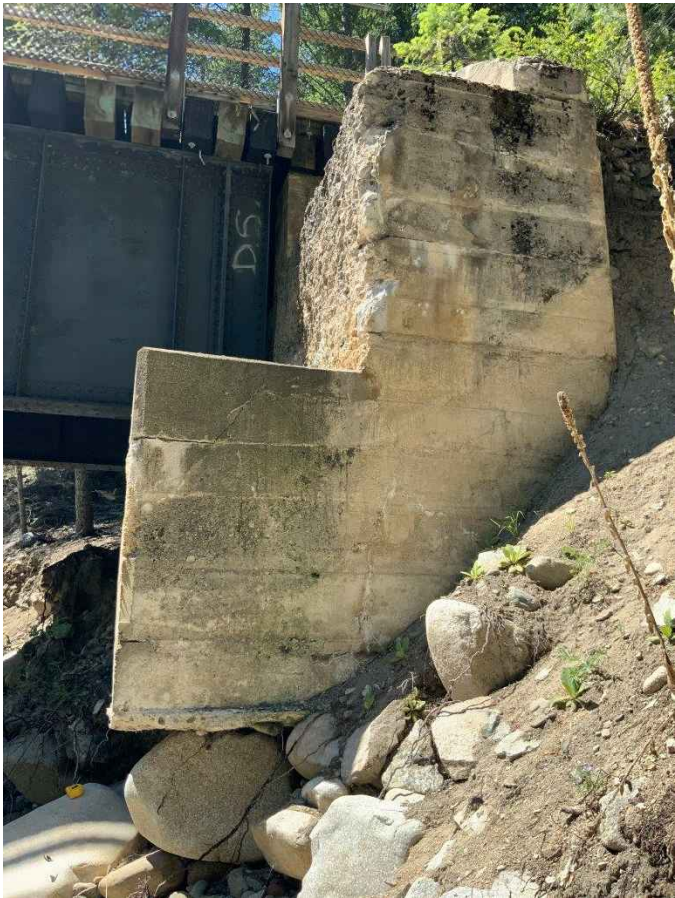


PHOTO 5: UNDERMINING AT THE "RIGHT" ABUTMENT



PHOTO 6: EROSION AT THE "RIGHT" BANK UPSTREAM OF BRIDGE



PHOTO 7: EROSION AT THE "RIGHT" BANK DOWNSTREAM OF BRIDGE



PHOTO 8: UNDERMINING AT THE DOWNSTREAM CORNER OF PIER

NOT FOR CONSTRUCTION

DRAFT

| DRAWING REVISIONS |                         |                   |       |          |         |          |  | ORIGINAL ISSUE |               | AS A MUTUAL PROTECTION TO OUR CLIENT, THE PUBLIC AND OURSELVES, ALL REPORTS AND DRAWINGS ARE SUBMITTED FOR THE CONFIDENTIAL INFORMATION OF OUR CLIENT FOR A SPECIFIC PROJECT AND AUTHORIZATION FOR USE AND/OR PUBLICATION OF DATA, STATEMENTS, CONCLUSIONS OR ABSTRACTS FROM OR REGARDING OUR REPORTS AND DRAWINGS IS RESERVED PENDING OUR WRITTEN APPROVAL. | CLIENT<br><div><br/></div> | PROJECT<br>KETTLE VALLEY RAIL TRAIL<br>BRIDGE ASSESSMENT AND REPAIRS |                          |                |           |
|-------------------|-------------------------|-------------------|-------|----------|---------|----------|--|----------------|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------|--------------------------|----------------|-----------|
|                   |                         |                   |       |          |         |          |  | DRAWN:         | J. PANG       |                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                      | TITLE<br>KV-005 BRIDGE<br>PHOTOS                                     |                          |                |           |
|                   |                         |                   |       |          |         |          |  | DESIGNED:      | M. COENEY     |                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                      |                                                                      |                          |                |           |
|                   |                         |                   |       |          |         |          |  | CHECKED:       | K. GREINACHER |                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                      |                                                                      |                          |                |           |
|                   |                         |                   |       |          |         |          |  | APPROVED:      | K. MITCHELL   |                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                      |                                                                      |                          |                |           |
| A                 | CONCEPT DESIGN          | 2023-02-10        | J.P.  | M.C.     | K.G.    | K.M.     |  |                |               |                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                      |                                                                      |                          |                |           |
| REVISION          | DESCRIPTION OF REVISION | DATE (YYYY-MM-DD) | DRAWN | DESIGNED | CHECKED | APPROVED |  |                |               |                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                      | SCALE<br>AS SHOWN                                                    | PROJECT NO.<br>P10443A01 | DWG. NO.<br>07 | REV.<br>A |