

Project Memo

H353571

October 3, 2017

To: Beau Little (MTO)

From: Claudio Pasqualino

**Ministry of Transportation Ontario, Northwestern Region
Angler Creek (Hare Creek) and Mink Creek Concrete Arch Culverts****Results of Preliminary Foundation Investigations and Impacts to
Potential Replacement / Rehabilitation Options****1. Introduction**

Hatch was retained by MTO to complete the preliminary and detailed design for the rehabilitation or replacement of Angler Creek (actually on the Hare Creek watercourse) and Mink Creek Concrete Arch Culverts, Sites 48E-024/C and 48E-023/C respectively, located on Hwy 17. The Angler Creek site is located approximately 6.2 km west of the junction of Hwy 17 and Peninsula Road near Marathon, in the District of Thunder Bay, MTO Northwestern Region. The existing structure is a concrete arch culvert with an approximate span of 9.0 m, rise of 4.5 m, and length of 44.5 m. The Mink Creek site is located approximately 10.2 km west of the Angler Creek site. The existing structure is a concrete arch culvert with an approximate span of 9.1 m, rise of 4.5 m, and length of 37.9 m. The purpose of the study is to present the findings from the foundations investigation conducted by Thurber Engineering Limited (Thurber) and discuss the implications of this study on the rehabilitation or replacement of these two culverts. The information summarized herein was also discussed during a conference call on September 14, 2017 attended by Hatch, Thurber, as well as representatives from MTO Planning and Design, Structures, and Foundations sections.

The current foundations investigations focused on confirming the foundation stratum of the footings of the existing culverts, as well as revaluation of the available bearing capacities. This information would be critical in assessing rehabilitation options at these sites. It is preferred to potentially avoid complete replacement of these structures due to the complexity of staging and roadway protection requirements as well as the overall impact to traffic. Therefore, the results of the foundation investigations will determine if rehabilitation options may be a viable option. Further to these investigations, Bridge Condition Surveys were performed at each site to also assess the potential to carry out only localized repairs and provide a rehabilitation strategy that would extend the service life of the structures.

If you disagree with any information contained herein, please advise immediately.

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2. References

This memo is based on the preliminary foundations investigations (including borehole logs) from Thurber and existing / rehabilitation drawings of the structures, provided by MTO. Draft information from the foundations investigations are provided in Appendix A and B.

3. Summary and Discussion of Geotechnical Findings

Thurber completed drilling at Angler Creek and Mink Creek Culverts in the summer of 2017. Six boreholes were drilled at the Angler Creek site and three boreholes were drilled at the Mink Creek site. Borehole locations and methods were as per the agreed upon strategies developed by Thurber, Hatch and MTO. Borehole logs and photos are included as an appendix to this memo.

3.1 Angler Creek Culvert

Two boreholes (BH 17-16 and 17-19) were drilled at the centre of the culvert just off the edges of the footings. The remaining four boreholes (BH 17-15, 17-18, 17-17 and 17-20) were drilled at the ends of the culvert, inside the span near the footings. This drilling program determined that bedrock was present below the culvert at varying depths, but the footings were founded entirely on soil. The bedrock is 0.6 m below the culvert footing at the outlet and 15.4 m below the footing at the inlet. The culvert is resting on extremely erodible soils consisting of sand and silt. It is important to note that the soils are erodible at this site as there is evidence of scour and erosion below the footing. Previous preliminary foundations investigations performed as part of another assignment had demonstrated that existing bearing capacities under the footings at Angler Creek concrete arch appeared to be insufficient to support the calculated pressures from the existing structure. As noted, the intent of the current investigations was to supplement and/or confirm findings of the original investigations, such that the bedrock locations and bearing capacities could be reassessed.

Table 1 compares the existing culvert footing loads to the calculated soil bearing capacities from the current investigation. Note that the unfactored footing loads on the foundation soil were originally calculated by Thurber and have been confirmed by Hatch. The SLS and ULS live loads in this case are 8 and 13 kPa respectively.

Table 1: Angler Creek Culvert Loading and Soil Capacity

Founding Strata	Footing Width (m)	Existing Structure Footing Load due to Fill above top of Footings (kPa)			Geotechnical Resistance (kPa)		
		Factored	Unfactored		ULS	Factored ULS	SLS (up to 25mm settlement)
Compact to Dense Sand to Silty Sand	1.22 (Existing)	Maximum (Resistance Factor)	Maximum (Resistance Factor)	Average (Resistance Factor)			
		660 (1.32)	557 (1.11)	313 (0.63)	500	250	200
	1.83 (New, with liner)	493 (0.88)	408 (0.73)	243 (0.43)	560	280	170

The maximum loads are calculated under full height of fill, which is at the centre of the culvert and highway. However, the entire culvert length is not subject to the full depth of soil as the embankment slopes down to original ground. Therefore, an average load is also provided. This average load assumes that the total soil load on top of the culvert is distributed evenly over the full length of the footing. In this case, the unfactored maximum load calculated is 557 kPa at the centre of the culvert/highway with the average load being 313 kPa. In actuality, the loads on the soil are somewhere between these two values as it can be considered that loads are spread out over the length of the footing. As noted in Table 1, the unfactored ULS capacity of the soil at Angler Creek Culvert is 500 kPa which is actually less than the existing pressures at the centre of the culvert/highway. Considering that the actual loads on the foundation soil are between 557 kPa and 313 kPa, the footing is acting to spread the maximum loads over a larger area which have not exceeded the ultimate bearing capacity of the founding soil. However, it is likely that the soil is close to its capacity and the current condition does not allow for a reasonable factor of safety to be relied upon. Furthermore, both unfactored loads significantly exceed the factored ULS of 250 kPa which requires reduction of the ultimate bearing pressures by a factor of 0.5.

The values shown in Table 1 in parenthesis represent the Resistance Factor – a ratio of the calculated loads to the factored ULS resistances of the founding soils. A ratio of less than 0.5 represents an acceptable condition. As noted, these ratios exceed (significantly in some cases) the allowable values in most cases. Therefore, it will not be possible to design a rehabilitated structure within the Canadian Highway Bridge Design Code (CHBDC) under the current conditions as the ULS and SLS requirements cannot be met. It can also be noted that the current arrangement represents a potentially unsafe condition as the required factors of safety are not achieved. While this may be the case from a design perspective, existing conditions of the structure do not demonstrate any significant concerns and the structure appears to have performed well since its construction in 1950.

Originally, a re-lining operation was considered at this site with a new corrugated metal arch structure bearing on an refurbished footing that would be slightly widened when compared to existing conditions. A relining option increases the load on the soil due to the weight of the corrugated metal liner, grout, and widened footings. This increase in footing width results in an overall reduction in footing loads (represented in the values presented in Table 1). However the reduction is not significant enough to provide the required resistance factor when compared to the available geotechnical resistances. Another notable condition at this site is the size of the existing footing. It is only 1.2m wide and embedded only 1.0 m into the ground. This is a very narrow footing with a shallow depth and is not conducive for a foundation soil with relatively low bearing capacity. A much wider, and deeper footing would have provided lower bearing pressures and better scour protection. As noted previously, the soils below the footing are highly erodible. This is of critical concern at this site, as erosion of the soils reduces the area of contact between the footing and the founding soils. Loss of material under a footing would mean that a portion of its length is not available to spread the loadings from the structure above to the founding soils below. This would result in higher average bearing pressures potentially approaching the critical condition of exceeding the available bearing resistances, and therefore a structure which is less safe.

3.2 Mink Creek Culvert

Two boreholes were drilled on the road on each side of the culvert immediately adjacent to the edges of the footings. The third borehole was drilled near the rehabilitated section of the culvert at the northwest corner. This drilling program determined that bedrock was present below the culvert at depths between 8 and 14 m. The culvert is resting on erodible soils consisting of sand and silt. Similar to Angler, it is important to note that the foundation soils are erodible at this site as there is evidence of significant scour and erosion below the footing.

Table 2 compares the existing culvert footing load to the calculated soil bearing capacities. Note that the unfactored footing loads on the foundation soil were originally calculated by Thurber and have been confirmed by Hatch. The SLS and ULS live loads in this case are 28 and 53 kPa respectively.

Table 2: Mink Creek Culvert Loading and Soil Capacity

Founding Strata	Footing Width (m)	Existing Structure Footing Load due to Fill above top of Footings (kPa)			Geotechnical Resistance (kPa)		
		Factored	Unfactored		ULS	Factored ULS	SLS (up to 25mm settlement)
Compact Sand / Gravel to Sandy Silt	1.22 (Existing)	Maximum (Resistance Factor)	Maximum (Resistance Factor)	Average (Resistance Factor)			
		411 (1.21)	301 (0.89)	166 (0.49)	340	170	150
	1.83 (New, with liner)	367 (0.92)	246 (0.62)	152 (0.38)	400	200	130

The unfactored maximum load calculated is 301 kPa at the centre of the culvert/highway with the average load being 166 kPa. The unfactored ULS capacity of the existing footing at Mink Creek Culvert is 340 kPa. The unfactored loads are still within the unfactored capacities, however, the factored ULS is 170 kPa. Considering that the actual loads on the soil are between 301 and 166 kPa, it is likely that the ULS capacity is exceeded. Furthermore, these loads are unfactored; the factored maximum load in this case is 411 kPa which exceeds the unfactored ULS resistance. As noted in section 3.1, an acceptable condition is a Resistance Factor ratio of less than 0.5. With the exception of the unfactored average load (resistance factor) for the existing structure and the new, this ratio is exceeded. Therefore, it is unrealistic to design a rehabilitated structure and meet the CHBDC requirements. Under the current conditions, the ULS and SLS requirements cannot be met. However, the structure seems to be performing well since its construction in 1951 with no visible concerns.

Originally, a re-lining operation was considered at this site with a new corrugated metal arch structure bearing on an refurbished footing that would be slightly widened when compared to existing conditions. A relining option increases the load on the soil due to the weight of the corrugated metal liner, grout, and widened footings. The increase in footing width results in an overall reduction in bearing pressures (represented in the values presented in Table 2). However the reduction is not significant enough to provide adequate values when compared to the available geotechnical resistances. Another notable condition at this site is the size of the existing footing. It is only 1.2m wide and embedded only 0.5 m into the ground. This is a very

narrow footing with a shallow depth and is not conducive for a foundation with relatively low capacity. A much wider, and deeper footing would have provided lower bearing pressures and better scour protection. As noted previously, the soils below the footing are highly erodible. This is of critical concern at this site, as erosion of the soils reduces the area of contact between the footing and the founding soils. Loss of material under a footing would mean that a portion of its length is not available to spread the loadings from the structure above to the founding soils below. This would result in higher average bearing pressures potentially approaching the critical condition of exceeding the available bearing resistances, and therefore a structure which is less safe.

There is evidence of ongoing erosion at this site. A rehabilitation of the northwest corner of the structure was completed in 2007 to address a failure of the barrel footing concrete. This involved driving sheet piles around the failed concrete and casting a new concrete footing cap to support the barrel. The design drawings show a significant amount of rock protection placed around the repair. Both the concrete and sheet pile below had rock protection installed to the bottom of the channel to protect against scour. Assuming this was actually installed, it would appear that scour has been continuing at the site as there is no evidence of this local rock protection still being in place – both the edge of the concrete footing, and the supporting sheet pile appear to be exposed. Therefore, scour is a significant concern here and an ongoing issue.

4. Rehabilitation and Replacement Discussion

Based on the findings of the foundations investigations, it is recommended that the existing structures not be left in service for the long term and that some form of replacement or rehabilitation be performed at both sites. For the current structure, there is a risk that bearing resistances will be exceeded, which would be further exacerbated by ongoing scour and erosion concerns. This section will present possible rehabilitation and replacement strategies.

4.1 Angler Creek Culvert

Any rehabilitation at this site must take into account two factors: bearing capacity insufficiencies; and scour concerns.

As stated previously, a liner is not considered a feasible option due to the bearing capacity concerns. In addition, a liner adds eccentric loading onto the footing which is extremely undesirable for the current situation. It is theoretically possible to widen the footing to spread the load over a larger soil area. However, this would reduce the width of the channel and therefore reduce the hydraulic capacity as well as increasing moment loads on the footing. Significantly increasing the width of the existing footings will also pose significant constructability concerns.

Another means of addressing the bearing capacity concerns would be the installation of EPS foam over top of the arch to reduce soil load. However it is still difficult to achieve a design that satisfies the factored loads. Table 3 below summarizes the loads with 3m of EPS above the crown of the arch.

Table 3: Angler Creek Culvert Loads with 3m of EPS

Founding Strata	Footing Width (m)	Existing Structure Footing Load due to Fill above top of Footings (kPa)			Geotechnical Resistance (kPa)		
		Factored	Unfactored		ULS	Factored ULS	SLS (up to 25mm settlement)
Compact to Dense Sand to Silty Sand	1.22 (Existing)	Maximum (Resistance Factor)	Maximum (Resistance Factor)	Average (Resistance Factor)			
		364 (0.73)	288 (0.58)	193 (0.39)	500	250	200
	1.83 (New, with liner)	289 (0.52)	228 (0.41)	163 (0.29)	560	280	170

For the existing footings, while the unfactored loads are within the unfactored capacity of the soil, they are still close to the factored ULS capacity, and still exceeding the SLS capacity. Factoring the design loads as required by CHBDC will more than likely exceed the geotechnical resistances. A re-lining option will potentially meet the factored ULS requirements, but will still exceed SLS capacities. It must be stated however, that any option that utilizes EPS foam will negate the advantage of installing a liner within the existing culvert opening. The liner was originally considered a desirable option since it avoided the need for complicated staging and roadway protection. The option of EPS foam would not only add material costs, but it would require all of the same staging concerns which were intended to be avoided. Therefore, from a constructability perspective as well as a bearing capacity perspective, a solution of minimizing existing pressures by means of installing EPS foam is not considered feasible.

Bearing support for the rehabilitated structure could potentially be improved through the use of micropile installation adjacent to the existing footings. This would allow a cast-in-place footing extensions to be poured above the micropiles, thereby transmitting vertical loads from the rehabilitated structure to bedrock. Unfortunately, installation of piles within the existing barrel will be problematic and costly from an access perspective as well as from a flow control perspective. It would require a significant amount of lateral space and therefore much of the existing flow would have to be diverted to one side of the existing culvert. With the high, fast flows through the existing barrel, this will be very challenging. Another significant concern is that working adjacent to the existing footings, which have very little embedment and are already considered to be below allowable resistance requirements, may lead to destabilization. This may potentially be very unsafe and could lead to an unexpected failure of the structure. Therefore (in addition to the very high costs expected with this option), this option is not considered a feasible alternative to address the bearing capacity concerns at this site.

As stated, the scour and erosion under the footings would need to be rectified and prevented from further erosion if the existing structure were to remain in the long-term. Typical methods to achieve this include grouting the area under the footing, placing rock protection or installing sheet piles adjacent to the existing footings. Appropriate means of installation of any of these scour protection methods would be problematic.

It is recommended that a complete structure replacement be undertaken for this site. The current arrangement presents a potentially unsafe situation for the traffic on Highway 17.

Furthermore, attempting to rehabilitate the footings has the potential to destabilize the structure as stated previously. Possible replacement options at this site include a metal arch culvert founded on new cast-in-place footings or a bridge structure. While the first option is potentially feasible, consideration needs to be given to costs and the poor bearing capacities. Significantly larger footings would be necessary to provide the required bearing capacity, or a deep footing alternative which would transmit vertical loads to bedrock. Furthermore, removing the existing structure and supplying a new structure in conjunction with the high embankment at this site present significant staging challenges. There are no viable detours at this site, therefore traffic staging will be required. In addition, the new footings of an open arch structure would need to be protected from the high probability of scour due to the high volume and velocity of flow. Considering the many issues with replacing the existing structure with a metal arch culvert on open footings, it is not considered to be a feasible alternative.

Replacement of the existing culvert with a bridge structure spanning over the existing creek and most likely founded on bedrock is considered to be the most feasible solution at this site. While, it will be a costly alternative, it will eliminate concerns with bearing capacity, scour, temporary flow diversion and potential destabilization of the existing structure. Temporary traffic will most likely have to be accommodated by a modular bridge spanning over the work zone to unload the existing structure, allow it to be removed safely, and to build a new bridge past the excavation limits.

4.2 Mink Creek Culvert

Similar to Angler, any rehabilitation at this site must take into account two factors: bearing capacity insufficiencies; and scour concerns

As stated previously, a liner is not considered a feasible option due to the bearing capacity concerns. In addition, a liner adds eccentric loading onto the footing which is extremely undesirable for the current situation. It is theoretically possible to expand the width of the footing to spread the load over a wider area. However, this would reduce the width of the channel and therefore reduce the hydraulic capacity as well as increasing moment loads on the footing. Significantly increasing the width of the existing footings will also pose significant constructability concerns.

Bearing support for the rehabilitated structure could potentially be improved through the use of micropile installation adjacent to the existing footings. This would allow a cast-in-place footing extensions to be poured above the micropiles, thereby transmitting vertical loads from the rehabilitated structure to bedrock. Unfortunately, installation of piles within the existing barrel will be problematic and costly from an access perspective as well as from a flow control perspective. It would require a significant amount lateral space and therefore much of the existing flow would have to be diverted to one side of the existing culvert. With the high, fast flows through the existing barrel, this will be very challenging. Another significant concern is that working adjacent to the existing footings, which have very little embedment and are already considered to be near allowable resistance requirements, may lead to destabilization. This may potentially be very unsafe and could lead to an unexpected failure of the structure. Therefore (in addition to the very high costs expected with this option), this option is not considered a feasible alternative to address the bearing capacity concerns at this site.

As stated, the scour and erosion under the footings would need to be rectified and prevented from further erosion if the structure were to remain in the long-term. Typical methods to achieve this include grouting the area under the footing, placing rock protection or installing sheet piles adjacent to the existing footings. Appropriate means of installation of any of these scour protection methods would be problematic.

Placing EPS over top of the arch to reduce soil load is not applicable at this site. This is because there is approximately 1.2 m of soil cover on top of the arch. It is not practical to place EPS in this case.

It is recommended that a complete structure replacement be undertaken for this site. The current arrangement presents a potentially unsafe situation for the traffic on Highway 17. Furthermore, attempting to rehabilitate the footings has the potential to destabilize the structure as stated previously. Possible replacement options at this site include a metal box culvert founded on new cast-in-place footings (possibly supported on H-piles) or a bridge structure. Both options are considered feasible, however the significant skew at this site will make any replacement problematic. Similar to Angler, significantly larger footings would be necessary to provide the required bearing capacity, or a deep foundation alternative which would transmit vertical loads to bedrock. In contrast to Angler, removing the existing structure and supplying a new structure will not be as challenging since the embankment is not as high. There are no viable detours at this site, therefore traffic staging will be required. In addition, the new footings of an open arch structure would need to be protected from the high probability of scour due to the high volume and velocity of flow. While there are significant challenges with this option, it is considered feasible.

Replacement of the existing culvert with a bridge structure spanning over the existing creek and most likely founded on bedrock is also considered feasible. It is likely a more expensive option than replacement with a metal box structure, it eliminates concerns with bearing capacity, scour, temporary flow diversion and potential destabilization of the structure. Temporary traffic will most likely have to be accommodated by a modular bridge spanning over the work zone to unload the existing structure, allow it to be removed safely, and to build a new bridge past the excavation limits.

5. Conclusion

It is evident that the existing foundations are near capacity for the current loadings at both Angler Creek and Mink Creek concrete arch culverts. It is recommended that each of the structures be replaced.

Angler Creek Concrete Arch Culvert is recommended to be replaced with a bridge structure as it provides the most feasible alternative. Costs associated with a bridge structure will be higher but is the ideal solution in this case.

Mink Creek Concrete Arch Culvert can feasibly be replaced with either an metal box culvert structure founded on piles, or a bridge structure. The significant skew poses concerns at this site which will have more impact to a culvert replacement structure. In addition, the significant scour concerns at this site will have to be mitigated against. Although it may be a more costly

option, a bridge structure may represent the most feasible structure replacement for Mink Creek Culvert.

Bridge Condition Surveys for each of these structures determined that each are in fair condition with no immediate structural, foundations, or settlement concerns. However due to the uncertainties of the existing loading conditions which have been confirmed with the recent foundation investigation as well as the ongoing erosion, it is recommended that a strategy for replacement is in place within one to two years for each of these structures.

Claudio Pasqualino

CP:CLP
Attachment(s)/Enclosure

Appendix A

**Angler Creek Concrete Arch Culvert
Draft Foundations Investigation Information**

exposed bedrock along south side of creek

Angler Creek Concrete Arch BH Plan

- ⊕ = Proposed Borehole Locations
- water 1-2 feet deep
 - no exposed bedrock inside culvert
 - erosion noted under footings at south end only

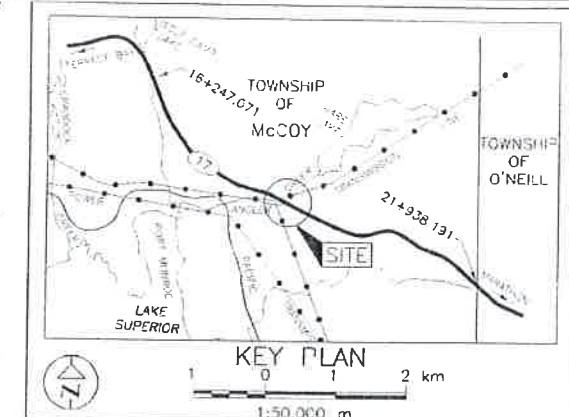
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 6331-14-00



HIGHWAY 17
ANGLER CREEK CULVERT STA 18+953
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



LEGEND

- Borehole
- Standard Penetration Test Value
- ⊕ Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 g/blow)
- ⊖ Refusal
- WL upon completion of drilling

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
AN-1	211.8	5404383.5	348398.1
AN-2	219.2	5404373.2	348374.8
AN-3	219.2	5404363.5	348383.5
AN-4	209.4	5404342.3	348374.6

NOTES

This drawing is for informational purposes only. The proposed structure design/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contract Documents.

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office. Otherwise, information contained in this report and related documents is specifically excluded in accordance with Section 02.2.01 of OHS General Conditions.

REFERENCE

Base plans provided in digital format by MTO, drawing file no. BC88-178, received FEB 20, 2015.

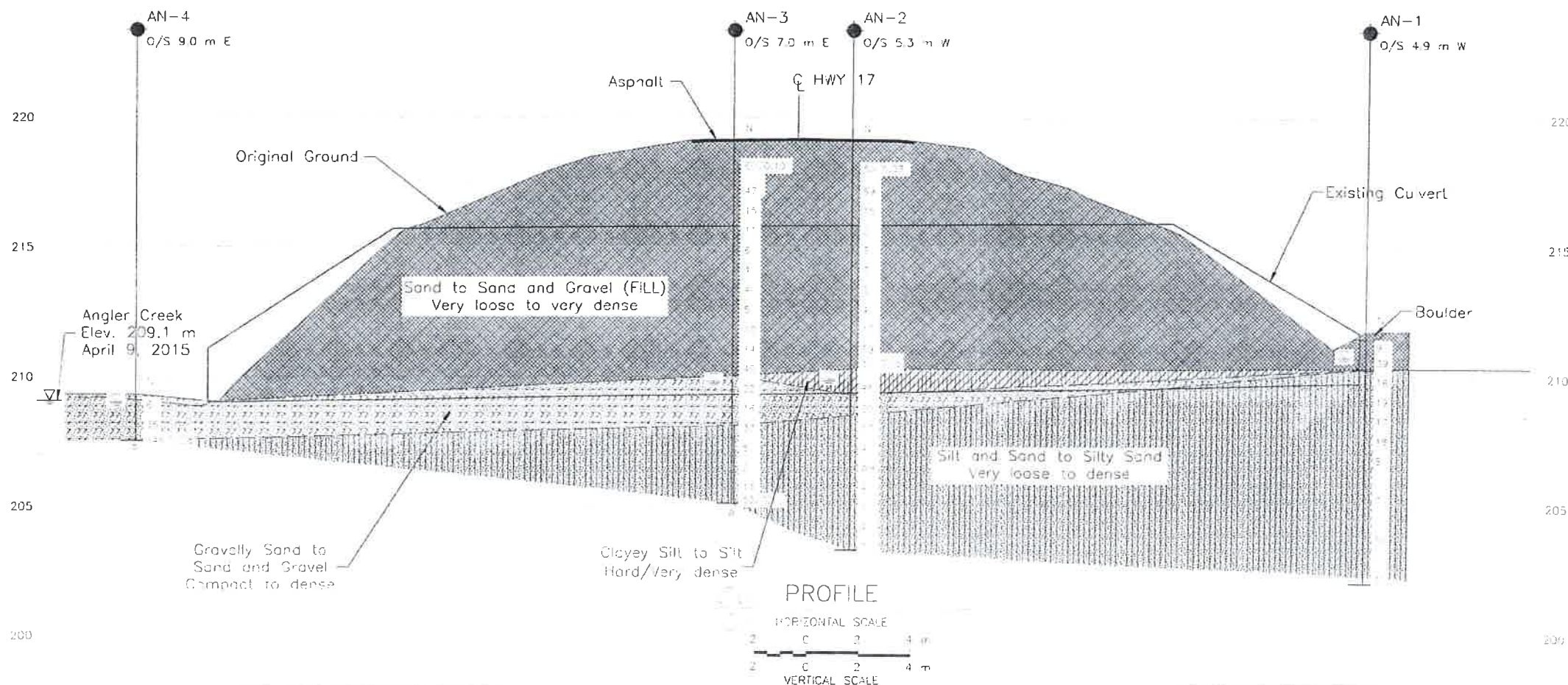
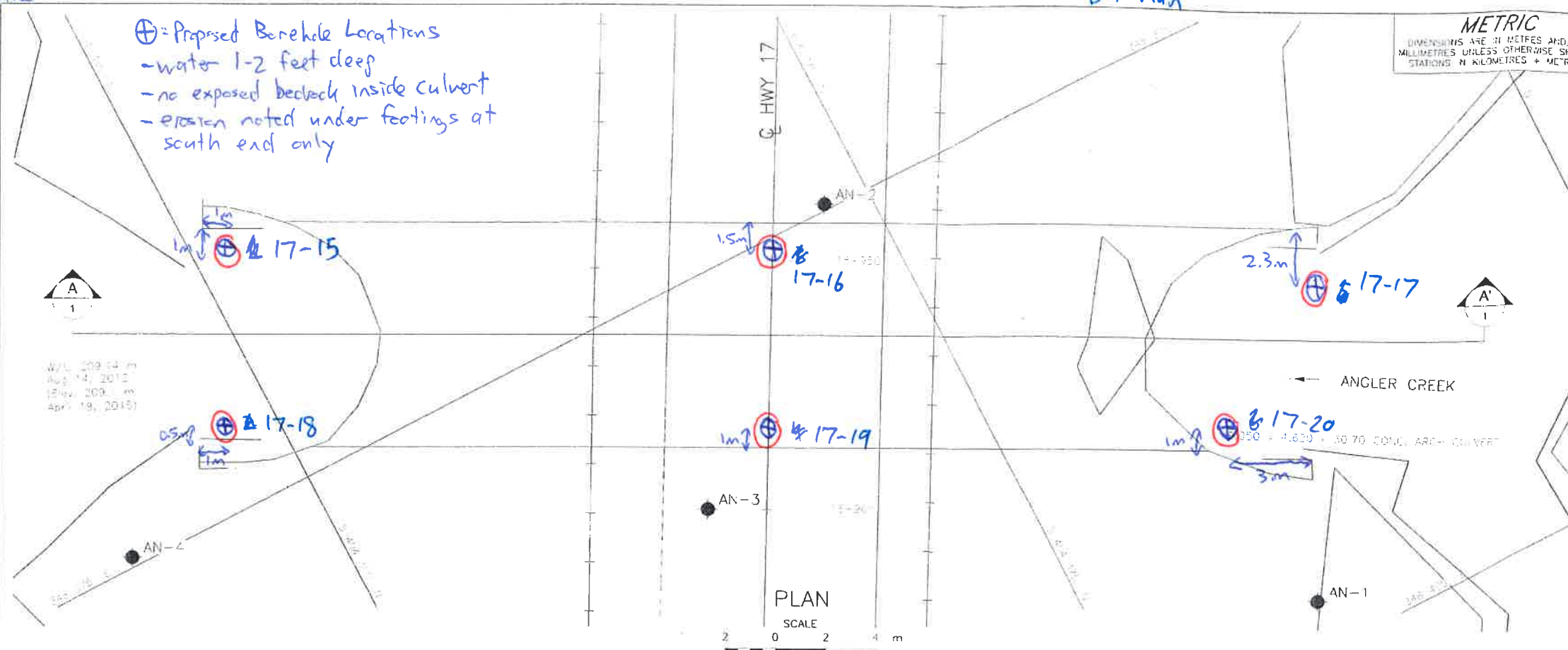
All boreholes to be drilled using portable drilling rig in water

- drill + SPT to bedrock, core 3m bedrock
- DPT beside each BH
- measure length & depth of erosion under footings

DRAFT

NO.	DATE	BY	REVISION
1	8/6/2015	JUL/TB	1

Geocria No. 1411523
PROJECT NO. 1411523
SUB'D. AC. CHKD. DATE: 8/6/2015
CRAWN: JUL/TB CHKD. SEMP JAPPD. JMAC
SITE: 48E-24/C
DWG: 1



RECORD OF BOREHOLE No 17-15

1 OF 1

METRIC

W.P. _____ LOCATION Angler Creek Culvert ORIGINATED BY BRM
 HWY 17 BOREHOLE TYPE NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2017.07.18 - 2017.07.18 CHECKED BY CZ

SOIL PROFILE			SAMPLES			GROUND WATER P N CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								20 40 60 80 100					W _P W W _L				
209.6	GROUND SURFACE																
0.0	CONCRETE / RUBBLE / COBBLES																
209.0																	
0.6	BEDROCK strong, iron oxide staining, dark blue: (GRANITE)		1	RUN			209									RUN #1 TCR=100% SCR=100% RQD=91%	
			2	RUN			208									RUN #2 TCR=100% SCR=85% RQD=75%	
			3	RUN			207									RUN #3 TCR=103% SCR=100% RQD=86%	
			4	RUN			206									RUN #4 TCR=91% SCR=72% RQD=46%	
205.6																	
4.0	END OF BOREHOLE AT 4.0m. WATER LEVEL AT 0.2m ABOVE THE BOREHOLE. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.																

+³, ×³: Numbers refer to Sensitivity
 20
 15
 10
 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-16

1 OF 2

METRIC

W.P. _____ LOCATION Angler Creek Culvert ORIGINATED BY BRM
 HWY 17 BOREHOLE TYPE NQ Coring/Dynamic Cone Penetration Test COMPILED BY AN
 DATUM Geodetic DATE 2017.07.23 - 2017.07.25 CHECKED BY CZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				
210.4	GROUND SURFACE							20 40 60 80 100	PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	
0.0	SAND , some silt, trace clay, trace gravel Loose to Dense Grey Wet		1	SS	5		210	○ UNCONFINED + FIELD VANE	W _P	W	W _L	
			2	SS	19		209	● QUICK TRIAXIAL × LAB VANE				
			3	SS	19		208					
			4	SS	64		207					
			5	SS	5		206					
206.3			6	SS	14		205					
4.1	SILT , some sand Compact Light Grey Saturated		7	SS	10		204					
	Occasional bedrock pieces						203					
203.4			1	RUN			202					
7.0	BEDROCK strong, fresh: (GRANITE)		2	RUN								
			3	RUN								
			4	RUN								
201.0												
9.4	END OF BOREHOLE AT 9.4m. WATER LEVEL AT 0.2m ABOVE THE BOREHOLE. BOREHOLE BACKFILLED WITH											

RUN #1
TCR=100%
SCR=80%
RQD=60%

RUN #2
TCR=99%
SCR=99%
RQD=99%

RUN #3
TCR=100%
SCR=97%
RQD=76%

RUN #4
TCR=278%
SCR=270%
RQD=224%

ONTM14S MTO-15595.GPJ 2017TEMPLATE(MTO).GDT 17/8/23

Continued Next Page

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

METRIC

[illegible]

RECORD OF BOREHOLE No 17-17

1 OF 2

METRIC

W.P. _____ LOCATION Angler Creek Culvert ORIGINATED BY JZ
 HWY 17 BOREHOLE TYPE B Casing/NQ Coring/Dynamic Cone Penetration Test COMPILED BY AN
 DATUM Geodetic DATE 2017.07.27 - 2017.08.21 CHECKED BY CZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						
210.4	GROUND SURFACE													
0.0	BEDROCK slightly weathered, hard, grey: (GRANITE)		1	RUN			210						FI	RUN #1 TCR=100% SCR=100% RQD=74%
209.8							209						5	
0.6	SAND , trace gravel, trace silt, trace organics Loose Grey Wet		1	SS	6		209						3	
			2	SS	7		209							
			3	SS	9		208							
			4	SS	0		208							
207.2							207							
3.2	Silty SAND , trace gravel Loose to Very Dense Grey Wet		5	SS	6		207							
			6	SS	6		205							
			7	SS	52		203							
			8	SS	30		201							

Continued Next Page

+³, ×³: Numbers refer to Sensitivity
 20
 15
 10
 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-17

2 OF 2

METRIC

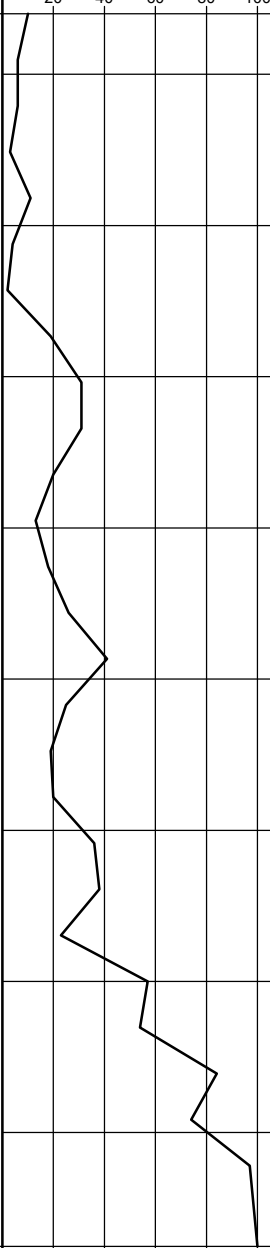
W.P. _____ LOCATION Angler Creek Culvert ORIGINATED BY JZ
 HWY 17 BOREHOLE TYPE B Casing/NQ Coring/Dynamic Cone Penetration Test COMPILED BY AN
 DATUM Geodetic DATE 2017.07.27 - 2017.08.21 CHECKED BY CZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE LIQUID CONTENT LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				
								20 40 60 80 100	○ UNCONFINED + FIELD VANE			W _P W W _L				
	Continued From Previous Page		9	SS	30											
							200									
							199									
			10	SS	80											
							198									
							197									
			11	SS	130/ 0.275		196									
195.0			12	SS	100/ 0.050		195									
15.4	BEDROCK slightly weathered, hard, grey: (GRANITE)		2	RUN			194							2 1 8 4 4 1 3	RUN #2 TCR=97% SCR=97% RQD=72% RUN #3 TCR=96% SCR=96% RQD=88%	
	Moderately weathered from 16.1m to 16.3m															
	Horizontal fracture (25mm) at 16.3m, 16.5m, 16.8m, 17.1m, 17.3m and 17.4m		3	RUN												
	Sub-vertical fracture (25mm) at 16.6m															
192.9							193									
17.5	END OF BOREHOLE AT 17.5m.															

ONTMT4S MTO-15595.GPJ 2017TEMPLATE(MTO).GDT 17/8/23

RECORD OF BOREHOLE No 17-17 DCPT 1 OF 1 METRIC

W.P. _____ LOCATION Angler Creek Culvert ORIGINATED BY BRN
 HWY 17 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY AN
 DATUM Geodetic DATE 2107.07.27 - 2017.07.27 CHECKED BY CZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				
210.4 0.0	GROUND SURFACE Start DCPT from surface											
202.2 8.2	END OF DCPT AT 8.2m UPON REFUSAL.											

ONTMT4S MTO-15595.GPJ 2017TEMPLATE(MTO).GDT 17/8/23

RECORD OF BOREHOLE No 17-18

1 OF 1

METRIC

W.P. _____ LOCATION Angler Creek Culvert ORIGINATED BY BRM
 HWY 17 BOREHOLE TYPE NQ Coring/Dynamic Cone Penetration Test COMPILED BY AN
 DATUM Geodetic DATE 2017.07.20 - 2017.07.20 CHECKED BY CZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								20 40 60 80 100						
209.6	GROUND SURFACE													
0.0	GRAVEL some sand, trace cobbles Compact Saturated	◊ ◊<												

+³, ×³: Numbers refer to Sensitivity
 20
15
10
5
0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-19

1 OF 1

METRIC

W.P. _____ LOCATION Angler Creek Culvert ORIGINATED BY BRM
 HWY 17 BOREHOLE TYPE NQ Coring/Dynamic Cone Penetration Test COMPILED BY AN
 DATUM Geodetic DATE 2017.07.21 - 2017.07.23 CHECKED BY CZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				
210.4	GROUND SURFACE							<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div> <div><div>204060</div><div>WATER CONTENT (%)</div></div>				GR SA SI CL
0.0	SAND , some gravel Loose to Compact Dark Grey to Black Saturated		1	SS	6		210					
			2	SS	29		209					
			3	SS	32							
208.6												
1.8	Silty SAND Very Dense to Very Loose Light Grey Saturated		4	SS	51		208					
			5	SS	3	207						
			6	SS	11	206						
204.5						205						
5.9	BEDROCK fresh, strong, dark blue: (GRANITE)		1	RUN		204					RUN #1 TCR=100% SCR=90% RQD=23%	
			2	RUN		203					RUN #2 TCR=97% SCR=87% RQD=87%	
			3	RUN							RUN #3 TCR=100% SCR=80% RQD=67%	
			4	RUN		202					RUN #4 TCR=100% SCR=95% RQD=89%	
			5	RUN							RUN #5 TCR=102% SCR=86% RQD=86%	
201.6												
8.8	END OF BOREHOLE AT 8.8m. WATER LEVEL AT 0.2m ABOVE BOREHOLE. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.											

ONTMT4S MTO-15595.GPJ 2017TEMPLATE(MTO).GDT 17/8/23

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-20

1 OF 1

METRIC

W.P. _____ LOCATION Angler Creek Culvert ORIGINATED BY BRM
 HWY 17 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY AN
 DATUM Geodetic DATE 2107.07.27 - 2017.07.27 CHECKED BY CZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	W _p W W _L	WATER CONTENT (%)				
210.4 0.0	GROUND SURFACE Start DCPT from surface													
							210							
							209							
							208							
							207							
							206							
205.6 4.8	END OF DCPT AT 4.8m UPON REFUSAL.													

ONTMT4S MTO-15595.GPJ 2017TEMPLATE(MTO).GDT 17/8/23

PROJECT 1411523

RECORD OF BOREHOLE No AN-1

1 OF 1 **METRIC**

G.W.P. 6331-14-00

LOCATION N 5404383.5; E 348398.1

ORIGINATED BY MR

DIST HWY 17

BOREHOLE TYPE NW Casing and Wash Boring

COMPILED BY MT

DATUM GEODETTIC

DATE April 8, 2015

CHECKED BY SEMP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
211.8	GROUND SURFACE													
0.0	Sand, some gravel, trace organics, trace wood (FILL) Loose to dense Brown to black Wet		1	SS	9		211							
	Boulder encountered from ground surface to 0.3 m depth.		2	SS	39									
210.4														
1.4	SILT and SAND, trace to some clay, trace gravel Loose to dense Grey Wet		3	SS	16		210							2 52 36 10
			4	SS	19		209							
			5	SS	17		208							
			6	SS	18		207							4 60 33 3
			7	SS	5		206							
			8	SS	7		205							
			9	SS	10		204							2 50 45 3
			10	SS	31		203							
202.0							202							
9.8	END OF BOREHOLE													
	Note: 1. Water level at a depth of 1.0 m below ground surface (Elev. 210.8 m) upon completion of drilling.													

SUD-MTO 001 1411523.GPJ GAL-MISS GDT 06/06/15 DATA INPUT:

PROJECT 1411523		RECORD OF BOREHOLE No AN-2				1 OF 2 METRIC						
G.W.P. 6331-14-00		LOCATION N 5404373.2; E 348374.8		ORIGINATED BY RI								
DIST _____ HWY 17		BOREHOLE TYPE 108 mm I. D. Continuous Flight Hollow Stem Augers		COMPILED BY MT								
DATUM GEODETIC		DATE March 16, 2015		CHECKED BY SEMP								
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE			"N" VALUES	20 40 60 80 100	20 40 60 80 100	W _p	W		
219.2	GROUND SURFACE											
0.9	ASPHALT (100 mm)											
	Sand, trace to some silt/silt seams, trace gravel (FILL) Very loose to compact Brown Frozen* to moist to wet	1	SS	50/0.03								
		2	SS	59*								
		3	SS	15								
		4	SS	2								
	Trace organics above 3.7 m depth.	5	SS	3								
		6	SS	3								
		7	SS	5								
		8	SS	4								
		9	SS	17								
211.7		10	SS	59								
7.5	Sand and gravel, trace silt (FILL) Very dense Grey Wet	11	SS	50/0.05								
210.4												
8.8	CLAYEY SILT to SILT, trace sand, trace organics (rootlets) Hard/Very dense Grey to black Wet	12 A	SS	85								
209.4		12 B										
9.8	Gravelly SAND Compact Grey Wet	13	SS	20								
208.6												
10.6	SILT and SAND to Silty SAND, trace clay Very loose to compact Grey Wet	14	SS	17								
		15	SS	4								
		16	SS	WH								
		17	SS	4								
		18	SS	6								
		19	SS	4								

SUD-MTO 001 1411523.GPJ CAL-MISS.GDT 06/08/15 DATA INPUT:

Continued Next Page

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT 1411523		RECORD OF BOREHOLE No AN-2		2 OF 2 METRIC	
G.W.P. 6331-14-00		LOCATION N 5404373.2; E 348374.8		ORIGINATED BY RI	
DIST _____ HWY 17		BOREHOLE TYPE 108 mm I. D. Continuous Flight Hollow Stem Augers		COMPILED BY MT	
DATUM GEODETIC		DATE March 16, 2015		CHECKED BY SEMP	

SOIL PROFILE				SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	SHEAR STRENGTH kPa										WATER CONTENT (%)	GR SA SI CL		
						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED													
— CONTINUED FROM PREVIOUS PAGE —							20 40 60 80 100					20 40 60							
203.4			20	SS	7		204												
15.8	END OF BOREHOLE																		
	Note: 1. Water level at a depth of 9.2 m below ground surface (Elev. 210.0 m) upon completion of drilling.																		

DRAFT

PROJECT 1411523		RECORD OF BOREHOLE No AN-3		1 OF 2 METRIC	
G.W.P. 6331-14-00		LOCATION N 5404363.5; E 348383.5		ORIGINATED BY RI	
DIST HWY 17		BOREHOLE TYPE 108 mm I. D. Continuous Flight Hollow Stem Augers		COMPILED BY MT	
DATUM GEODETIC		DATE March 15, 2015		CHECKED BY SEMP	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)		
								20 40 60 80 100										
219.2	GROUND SURFACE																	
0.0	ASPHALT (100 mm)																	
0.1	Sand, trace to some silt (FILL) Loose to compact Brown Frozen* to moist		1	SS	60/ 0.10													
			2	SS	47*													
			3	SS	15													
			4	SS	11													
			5	SS	6													
			6	SS	4													
213.6	Gravelly sand to sand and gravel, trace to some silt (FILL) Loose to dense Brown Moist to wet		7	SS	4													
5.6			8	SS	5													
			9	SS	10													
			10	SS	14													
			11	SS	40													
210.1	SAND and GRAVEL, trace silt, trace clay Compact to dense Grey Wet		12	SS	22													
9.1			13	SS	16													
			14	SS	33													
208.2	SILT and SAND, trace clay Very loose to compact Grey Wet		15	SS	5													
11.0			16	SS	2													
			17	SS	14													
205.2			18	SS	50/10													
14.0																		

SUD-WTO 001 1411523.GPJ GAL-MISS.GDT 06/08/15 DATA INPUT:

Continued Next Page

+ 3, X 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT 1411523

RECORD OF BOREHOLE No AN-3

2 OF 2 **METRIC**

G.W.P. 6331-14-00

LOCATION N 5404363.5; E 348363.5

ORIGINATED BY RI

DIST HWY 17

BOREHOLE TYPE 108 mm I. D. Continuous Flight Hollow Stem Augers

COMPILED BY MT

DATUM GEODETIC

DATE March 15, 2015

CHECKED BY SEMP

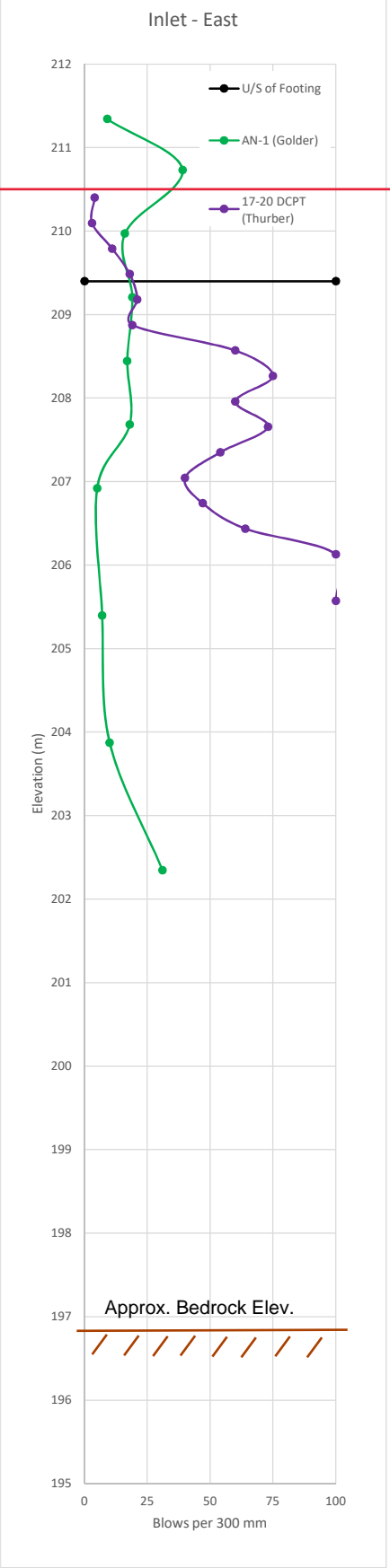
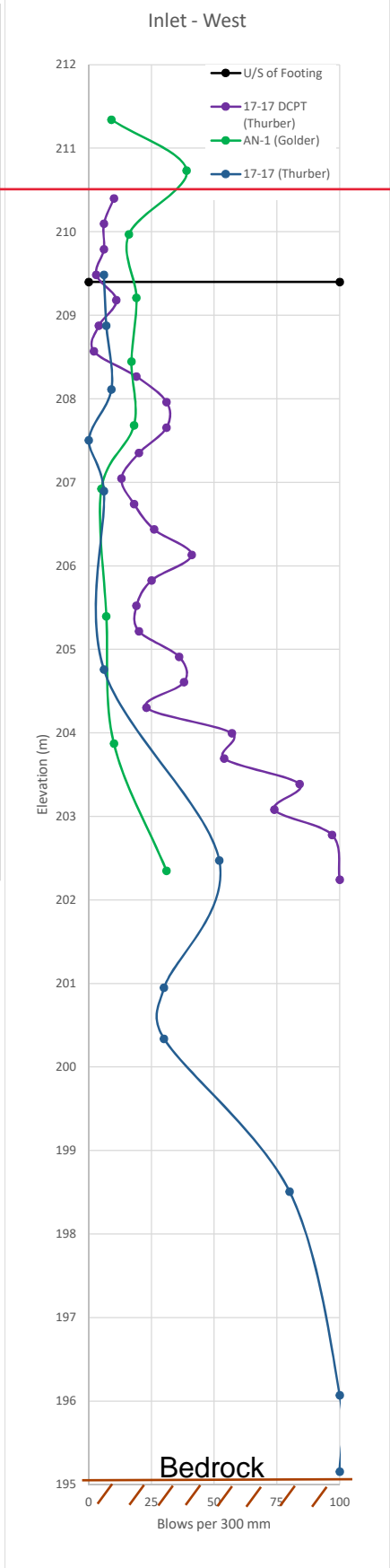
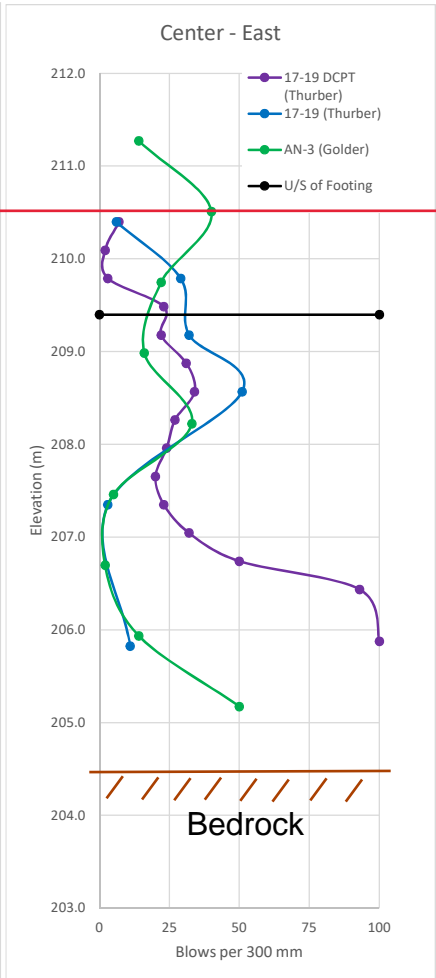
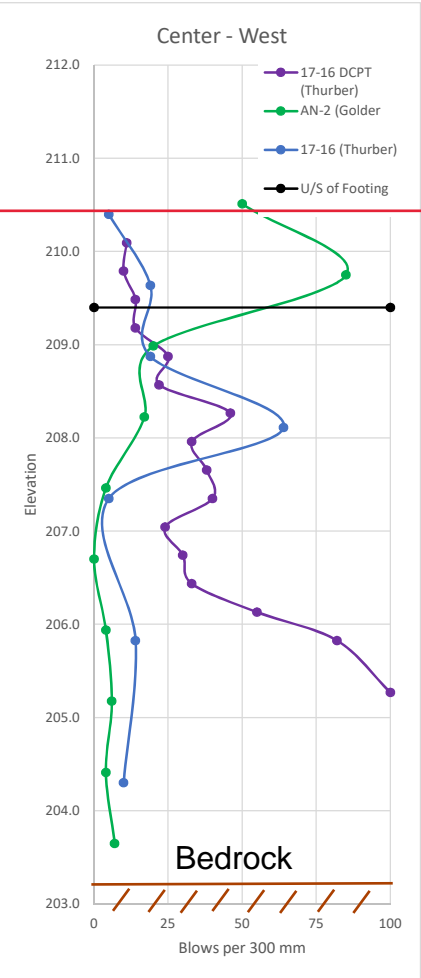
SOIL PROFILE		SAMPLES				GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40					
— CONTINUED FROM PREVIOUS PAGE —														
	END OF BOREHOLE AUGER REFUSAL Note: 1. Water level at a depth of 9.3 m below ground surface (Elev. 209.9 m) upon completion of drilling.													

DRAFT

PROJECT 1411523		RECORD OF BOREHOLE No AN-4		1 OF 1 METRIC	
G.W.P. 6331-14-00		LOCATION N 5404342.3; E 348374.6		ORIGINATED BY MR	
DIST HWY 17		BOREHOLE TYPE NW Casing and Wash Boring		COMPILED BY MT	
DATUM GEODETIC		DATE April 9, 2015		CHECKED BY SEMP	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40						60	80	100	20
209.4	GROUND SURFACE																	
0.0	Gravelly SAND, trace to some silt Dense Brown to grey Frozen* to wet Cobbles encountered at 0.8 m depth.		1	SS	6*	▽	209											
			2	SS	35		208										23	70 (7)
207.6	END OF BOREHOLE REFUSAL TO SPLIT-SPOON/FURTHER CASING PENETRATION Note: 1. Water level at a depth of 0.3 m below ground surface (Elev. 209.1 m) upon completion of drilling. 2. Moved 0.7 m east and 0.3 m south of Borehole AN-4 and advanced a borehole to casing refusal at 1.1 m depth below existing grade. 3. Moved 0.6 m east and 2.9 m south of Borehole AN-4 and advanced a borehole to casing refusal at 1.3 m depth below existing grade.		3	SS	46/0.05													
1.8																		

+ 3, × 3, Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE



Approximate Creek
Bed Elevation

North east corner



Outlet looking north



South east corner



South east corner



North west corner



South west corner



South west corner





File Name: 48E-24C-21-Barrel, east wall, looking north.JPG

Description: 48E-24C-21-Barrel, east wall, looking north



File Name: 48E-24C-22-Barrel, east wall, looking south.JPG

Description: 48E-24C-22-Barrel, east wall, looking south



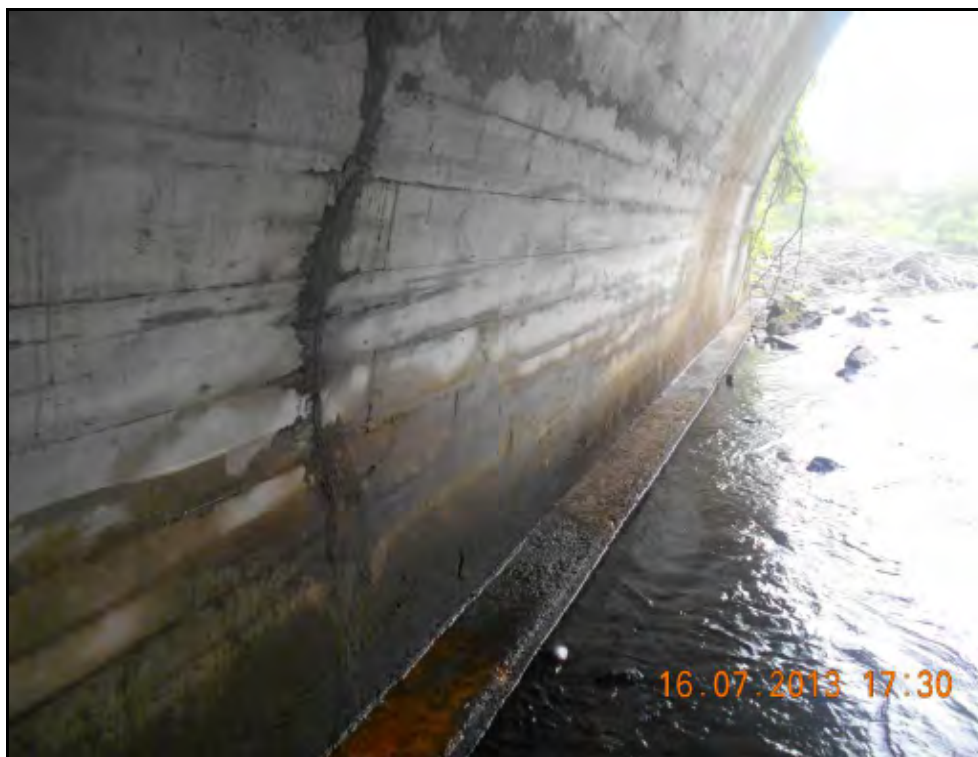
File Name: 48E-24C-23-Barrel soffit - note wide crack over full circumference.J

Description: 48E-24C-23-Barrel soffit - note wide crack over full circumference



File Name: 48E-24C-24-Barrel, north end - note delamination.JPG

Description: 48E-24C-24-Barrel, north end - note delamination



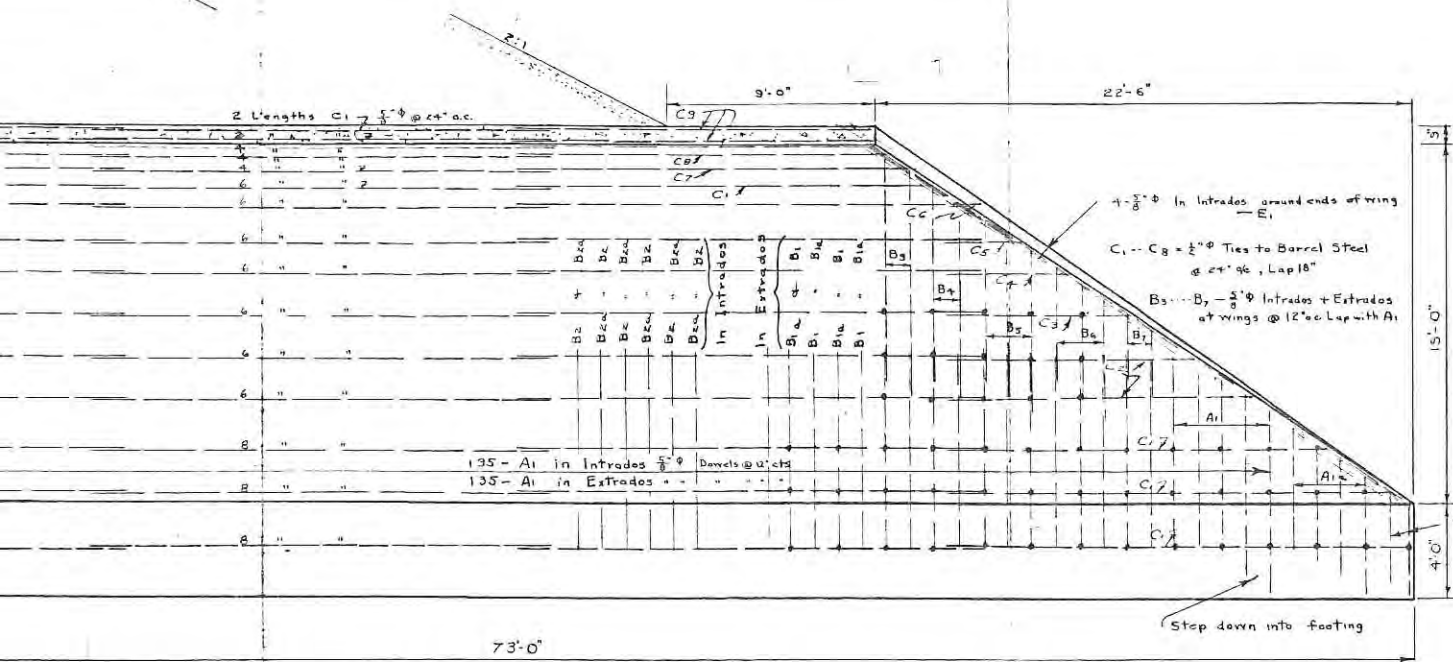
File Name: 48E-24C-29-Barrel, southeast - note erosion of concrete footing.JPG

Description: 48E-24C-29-Barrel, southeast - note erosion of concrete footing

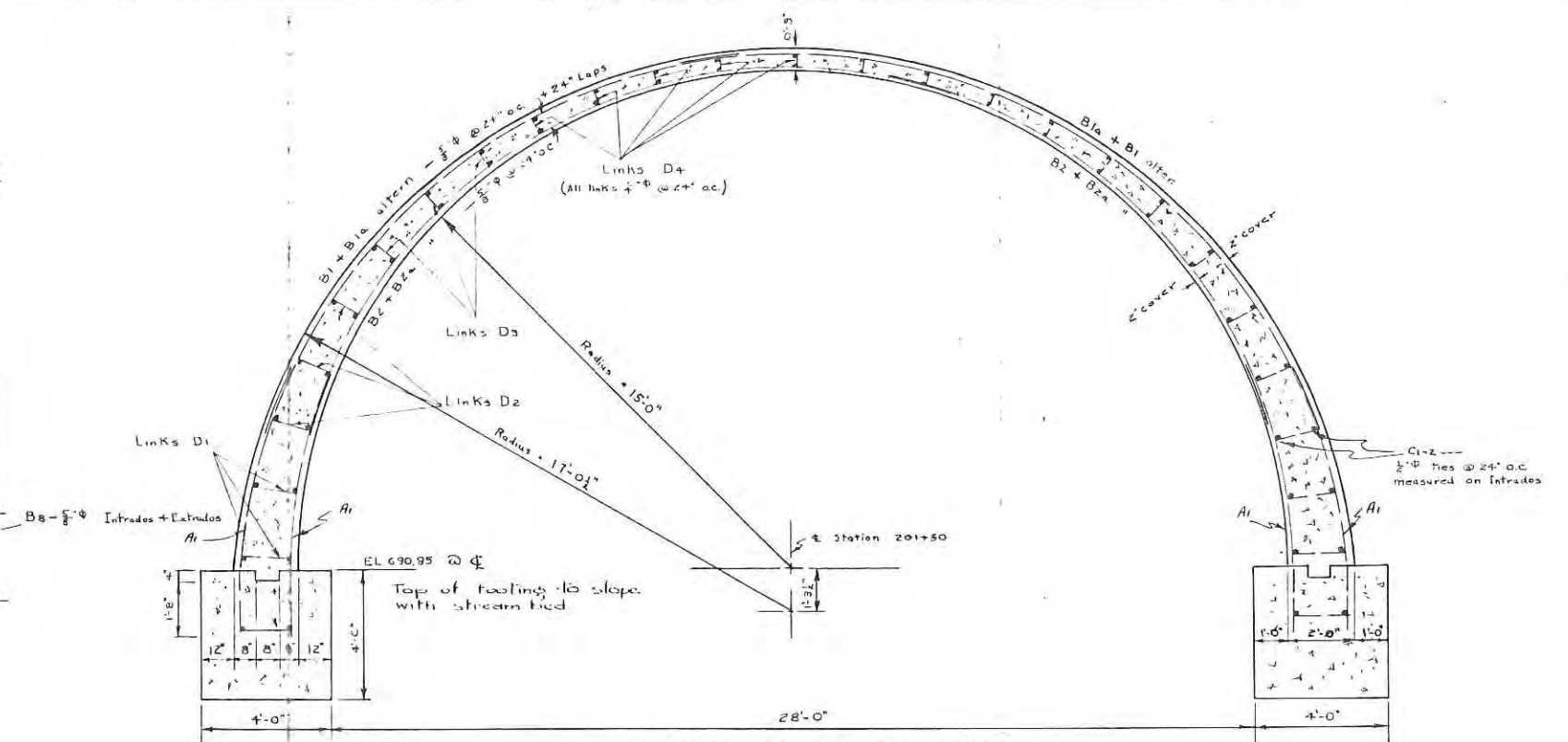


File Name: 48E-24C-30-Soffit, looking north.JPG

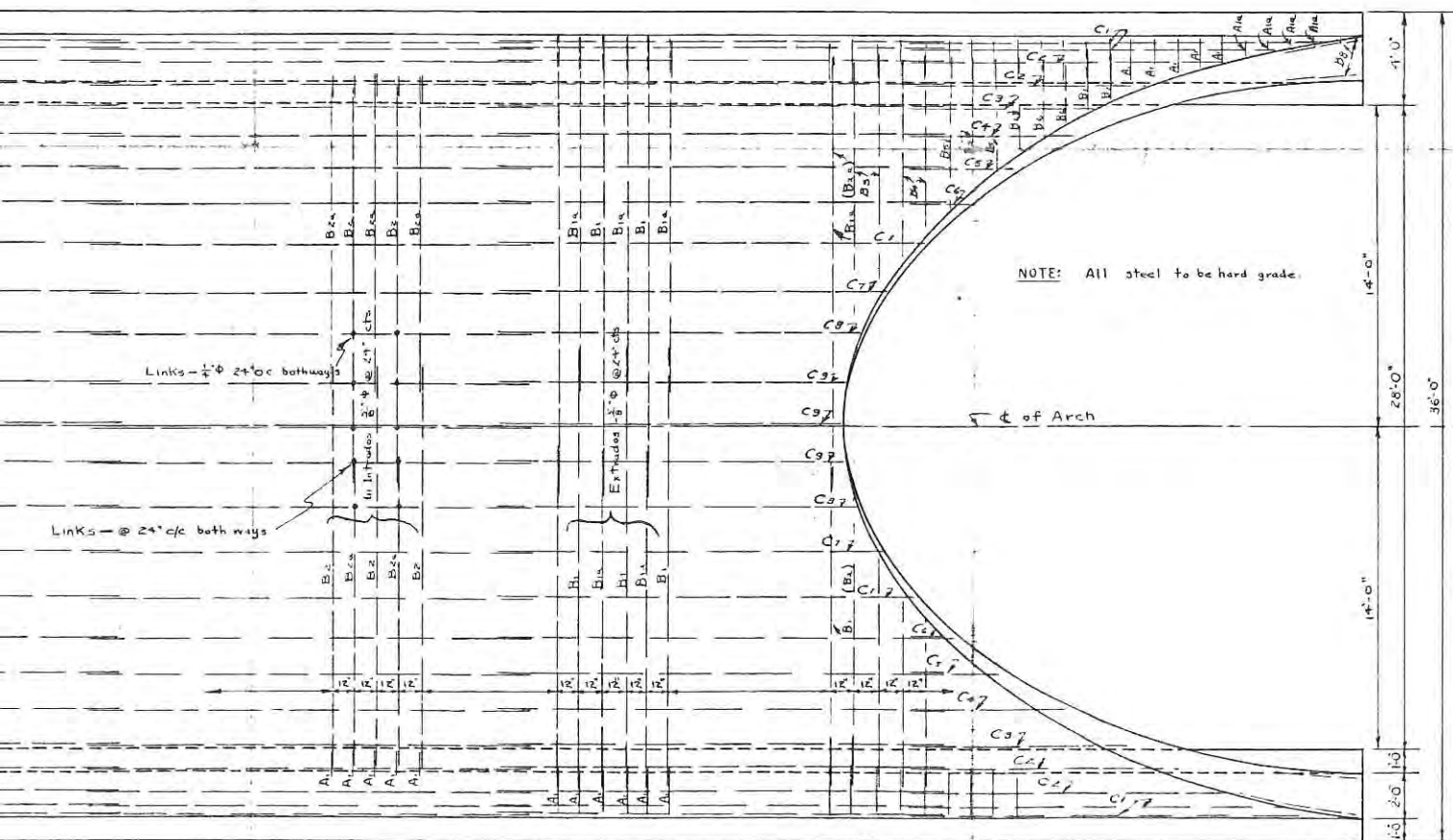
Description: 48E-24C-30-Soffit, looking north



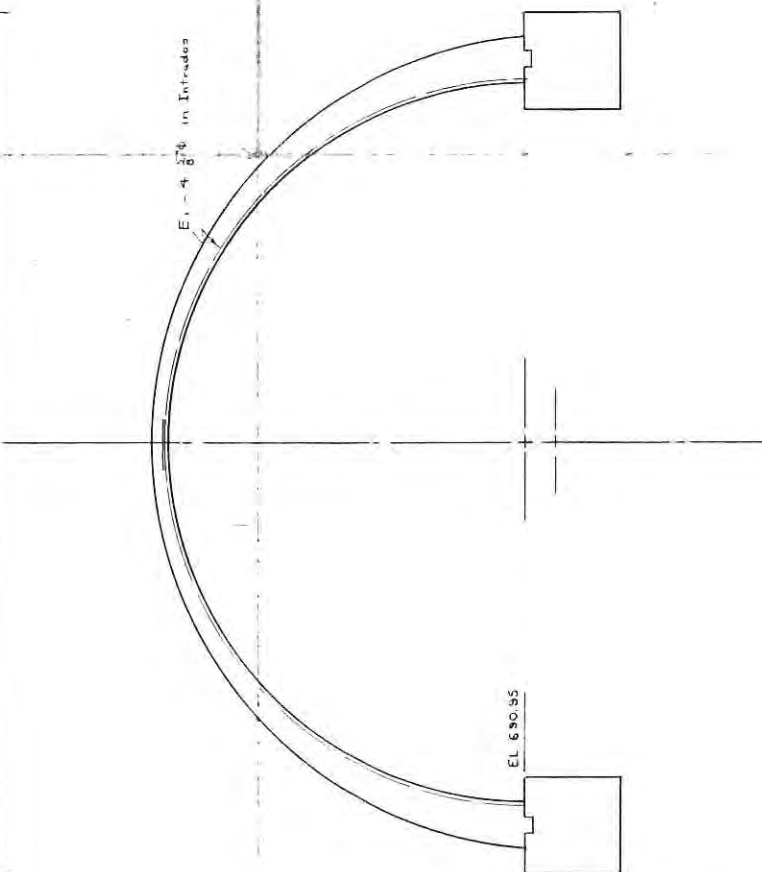
HALF LONGITUDINAL SECTION
SCALE $\frac{1}{4}'' = 1'-0''$



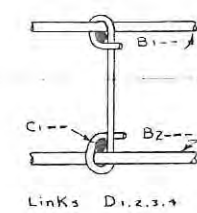
SECTION THROUGH ARCH
SCALE $\frac{3}{8}'' = 1'-0''$



HALF PLAN
SCALE $\frac{1}{4}'' = 1'-0''$



END ELEVATION
SCALE $\frac{1}{4}'' = 1'-0''$



NOTE TO DIV. ENGINEER.
Concrete work on this structure must not be commenced until monuments to fix control points have been erected and checked by the Div. Engineer.

NOTE TO CONTRACTOR.
Structure to be built according to D.H.O. General Specifications for Highway Bridges 1935 Form No. 9 and special specifications attached to the information to bidders sheet, extra copies of which may be obtained from the Div. Engineer. All construction joints must be approved by the Bridge Engineer.

CONCRETE MIX.
Footings: - Class B 1:2:4
Entire structure above footings: - Class A 1:1 1/2:3 1/2 with 1/2 lb of Pozzolith per bag of cement

Volume of Concrete
Frame - 279 Cu Yds.
Footings - 113 " "
Weight of Reinforcing Steel
Steel - 10 x Pcs

DEPARTMENT OF HIGHWAYS - ONTARIO
BRIDGE OFFICE - TORONTO

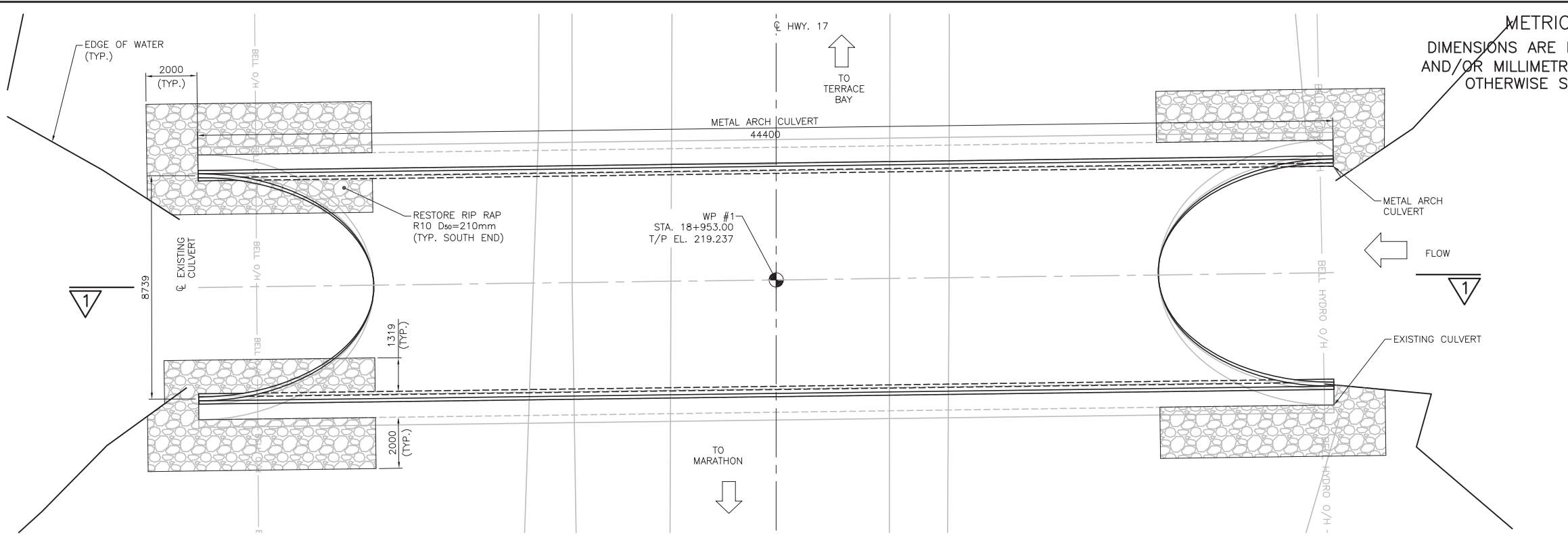
BRIDGE
OVER
ANGLER CREEK

THE KING'S HIGHWAY No. 17 DIV. No. 19
DISTRICT - THUNDER BAY Sta. 201+30
TWP. No. 77 LOT CON.

GENERAL PLAN

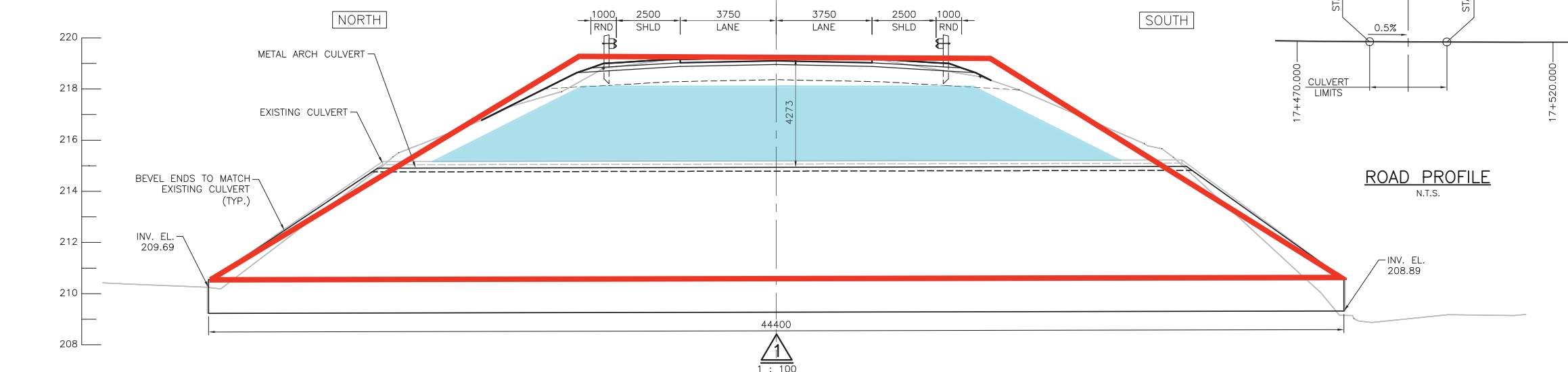
APPROVED
CHIEF BRIDGE ENGINEER CHIEF ENGINEER

PR-0-707 BB-05
MINISTRY OF TRANSPORTATION, ONTARIO
Jun 20, 2017 1:46pm
Drawing Name: C:\pwworking\hmd\project\200\1000-43001-ST-43002-ANGLER CREEK E. CULVERT-01-GENERAL ARRANGEMENT.dwg
Login Name: per61260

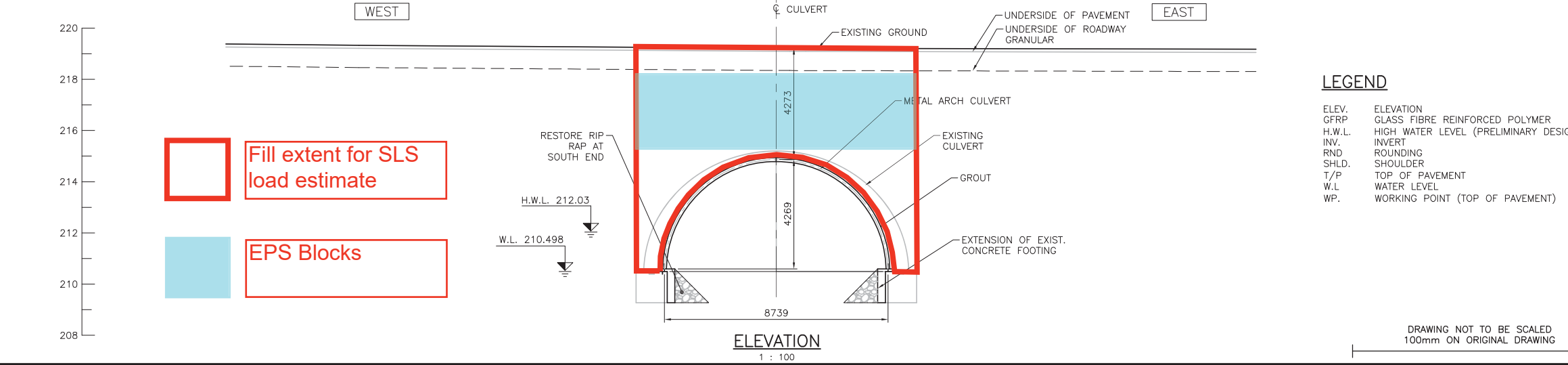


WP	NORTHING	EASTING
#1	5 404 369.517	348 378.482

PLAN
1 : 100
NOTE: FOOTINGS NOT SHOWN FOR CLARITY
C. HWY 17



ROAD PROFILE
N.T.S.



Fill extent for SLS load estimate

EPS Blocks

LEGEND

ELEV.	ELEVATION
GFRP	GLASS FIBRE REINFORCED POLYMER
H.W.L.	HIGH WATER LEVEL (PRELIMINARY DESIGN)
INV.	INVERT
RND	ROUNDING
SHLD.	SHOULDER
T/P	TOP OF PAVEMENT
W.L.	WATER LEVEL
WP.	WORKING POINT (TOP OF PAVEMENT)

CONT No.
WP No.

ANGLER CREEK EAST ARCH CULVERT
STRUCTURAL REPLACEMENT
GENERAL ARRANGEMENT

SHEET

Ministry of Transportation
Northwestern Region
Structural Section

Hatch Mott
MacDonald

- GENERAL NOTES:**
- CLASS OF CONCRETE**
ALL PRECAST CONCRETE 60MPa
- CLEAR COVER TO REINFORCEMENT**
GFRP REINFORCING 35mm±10
STEEL REINFORCING 40mm±10
- REINFORCEMENT**
- REINFORCING STEEL SHALL BE GRADE 400W.
 - UNLESS SHOWN OTHERWISE, LAP LENGTHS NOT INDICATED ON THE CONTRACT DRAWINGS SHALL BE CLASS 'B'. LAP LENGTHS FOR GFRP BARS ON THE CONTRACT DRAWINGS SHALL BE AS PER CAN/CSA-S6-06 OR MANUFACTURER'S RECOMMENDATIONS (GUIDELINES).
 - UNLESS SHOWN OTHERWISE, LAP LENGTHS SHALL BE AS PER CAN/CSA-S6-06 OR MANUFACTURER'S RECOMMENDATIONS (GUIDELINES).
 - GFRP BARS SHALL CONSIST OF CONTINUOUS GLASS FIBRE EMBEDDED IN A THERMOSETTING RESIN.
 - GLASS FIBRE REINFORCED POLYMER (GFRP) REINFORCING BARS SHALL BE IN ACCORDANCE WITH THE FOLLOWING TABLE:
- | GRADE | BAR DIA., mm | STRAIGHT BARS | | BENT BARS * | |
|-------|--------------|---|---------------------------------------|---|---------------------------------------|
| | | MIN. SPECIFIED LONG. TENSILE STRENGTH, kN | MIN. LONG. MODULUS OF ELASTICITY, GPa | MIN. SPECIFIED LONG. TENSILE STRENGTH, kN | MIN. LONG. MODULUS OF ELASTICITY, GPa |
| I | 15 | 130 | 40 | 130 | 40 |
| | 20 | 170 | | 153 | |
- * TENSILE STRENGTH AND MODULUS ARE GIVEN FOR THE STRAIGHT PORTION OF THE BENT BAR. MINIMUM STRENGTH AT THE BEND SHALL BE AT LEAST 40% OF THE MINIMUM STRENGTH OF THE STRAIGHT PORTION OF THE BENT GFRP BAR.
- BAR HOOKS SHALL HAVE STANDARD HOOK DIMENSIONS USING MINIMUM DIAMETERS, WHILE STIRRUPS AND TIES SHALL HAVE MINIMUM HOOK DIMENSIONS. ALL HOOKS SHALL BE IN ACCORDANCE WITH THE STRUCTURAL STANDARD DRAWING SS12-1 UNLESS INDICATED OTHERWISE.
- CONSTRUCTION NOTES**
- THE CONTRACTOR IS ADVISED NOT TO RELY ON THE WATER LEVEL SHOWN ON DRAWINGS. THE WATER LEVEL IS SUBJECT TO VARIATIONS.
 - THE CONTRACTOR SHALL DESIGN AN ADEQUATE ROADWAY PROTECTION SYSTEM TO MEET HIS METHOD OF OPERATION AS REQUIRED. ROADWAY PROTECTION TO BE PERFORMANCE LEVEL 2.
 - ALL EARTH SLOPES DISTURBED BY CONSTRUCTION SHALL BE TREATED WITH 100mm TOPSOIL, EROSION CONTROL BLANKET, AND SEED, IN ACCORDANCE WITH OPSS 804 UNLESS OTHER TREATMENT SHOWN.

PRELIMINARY
NOT FOR CONSTRUCTION

REVISIONS		DATE		REV.		DESCRIPTION	
DESIGN	MK/CHK	AK	CODE CAN/CSA S6-06	LOAD CL-625-ONT	DATE	NOV. 2015	
DRAWN	CR/CHK	CP	SITE	48E-24C	DWG		

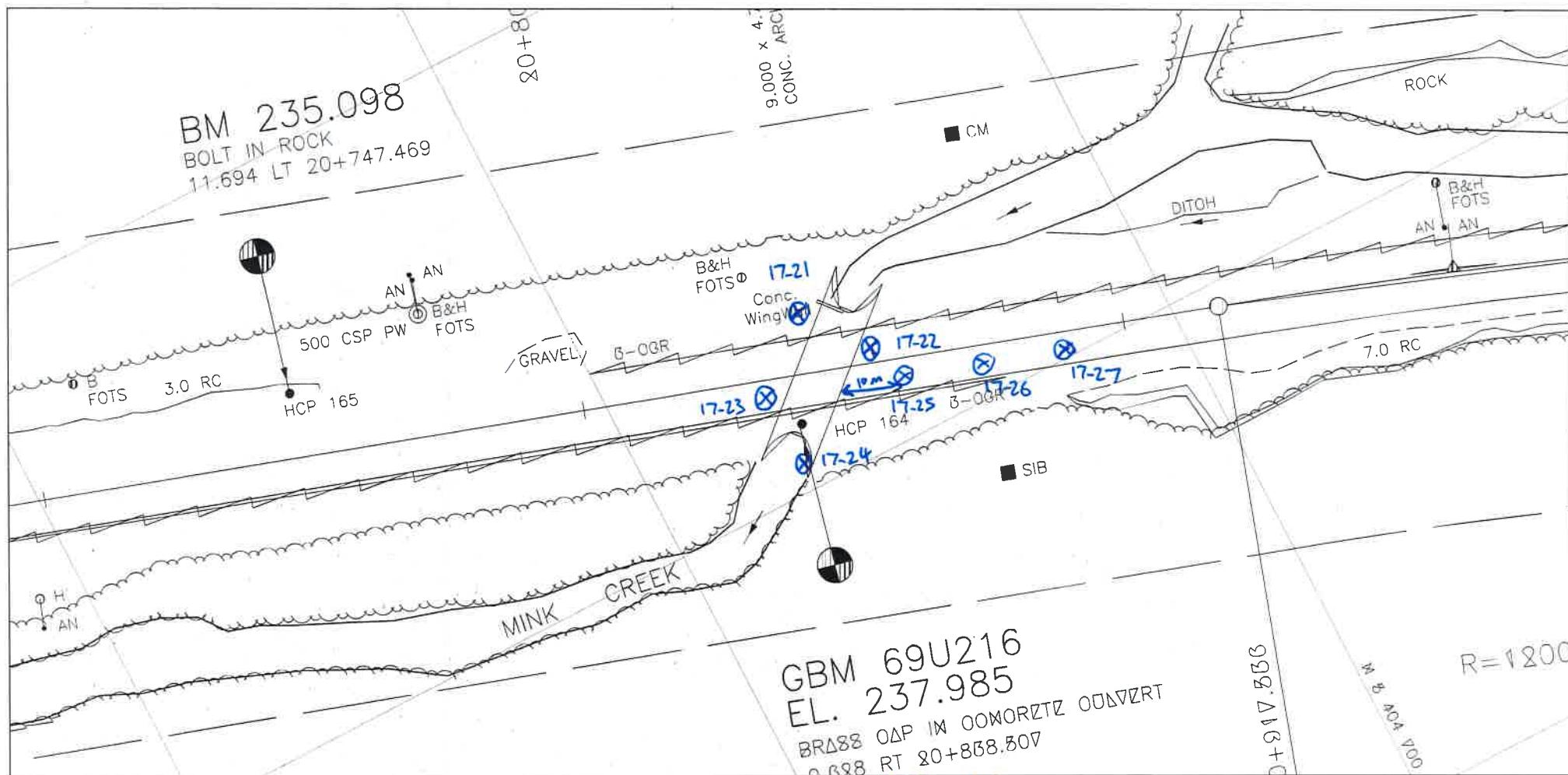
DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

Appendix B

Mink Creek Concrete Arch Culvert Draft Foundations Investigation Information



Mink Creek BH Plan



Drilling Details

- 17-21: Off-road with truckmount / bogey-tired rig, 15m deep. Core 3m bedrock. Install piezo
- 17-22, 23: Truckmount foundation BHs - middle of lane, 15m deep + core 3m
- 17-24: Portable Drill rig inside culvert (in water). Core 3m bedrock
- 17-25, 26, 27: Truckmount Frost Taper BHs, 3m deep, 10m apart + SPT at bottom

RECORD OF BOREHOLE No 17-21

1 OF 2

METRIC

W.P. _____ LOCATION Mink Creek Culvert ORIGINATED BY JZ
 HWY 17 BOREHOLE TYPE Solid Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2017.07.20 - 2017.07.20 CHECKED BY CZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
236.5	GROUND SURFACE																
0.0	Gravelly SAND , trace silt, some cobbles, trace organics Compact to Very Dense Brown to Grey Moist (FILL)		1	SS	22												
			2	SS	100/ 0.100												
			3	SS	37												
			4	SS	13												
3.0	SAND , trace silt, trace gravel, trace organics Compact Dark Brown Moist		5	SS	21												
			6	SS	100/ 0.150												
4.6	COBBLES and BOULDERS some gravel, trace silt and clay		1	RUN													
			2	RUN													
6.7	SILT , sandy, trace gravel, occasional cobbles Compact Grey Wet		7	SS	18												
			8	SS	16												
	Red/Black																

Approx. elev. of U/S of footing (232.3 m)

Continued Next Page


+³, ×³: Numbers refer to Sensitivity
 20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-21

2 OF 2

METRIC

W.P. _____ LOCATION Mink Creek Culvert ORIGINATED BY JZ
 HWY 17 BOREHOLE TYPE Solid Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2017.07.20 - 2017.07.20 CHECKED BY CZ







SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE										
	Continued From Previous Page							20	40	60	80	100						
10.2	SAND , trace silt, trace to some gravel, occasional cobbles Loose Brown Saturated		9	SS	10													
					10	SS	33											
			11	SS	7													
14.0	BEDROCK red/black: (GRANITE) 																	

RECORD OF BOREHOLE No 17-22

1 OF 1

METRIC

W.P. _____ LOCATION Mink Creek Culvert ORIGINATED BY JZ
 HWY 17 BOREHOLE TYPE Solid Stem Augers/NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2017.07.19 - 2107.07.19 CHECKED BY CZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
239.2	GROUND SURFACE							20	40	60	80	100					
0.0	ASPHALT: (150mm)							20	40	60	80	100					
0.2	SAND and GRAVEL Loose to Dense Brown Moist (FILL)		1	GS													
			2	SS	28												
			3	SS	9												
			4	SS	10												
			5	SS	40												
4.4	COBBLES and BOULDERS (FILL)		6	SS	10												
6.1	GRAVEL, trace sand, trace silt, possibel cobbles or boulders Very Dense Brown Moist (FILL)		7	SS	100/ 0.100												
																	
7.5	SAND and GRAVEL, trace organics and wood fragments Compact Dark Brown to Black Moist		8	SS	25												
8.5	Casing sheered from drill feed. Casing removed and borehole terminated END OF BOREHOLE AT 8.5m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.2m, THEN ASPHALT COLD PATCH TO SURFACE.																

Approx. elev. of U/S of footing (232.3 m)

ONTMT4S MTO-15595.GPJ 2017TEMPLATE(MTO).GDT 8/28/17

RECORD OF BOREHOLE No 17-22A

1 OF 1

METRIC

W.P. _____ LOCATION Mink Creek Culvert ORIGINATED BY JZ
 HWY 17 BOREHOLE TYPE Solid Stem Augers/NW Casing/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2017.07.21 - 2017.07.21 CHECKED BY CZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%)						
						20	40	60	80	100	20	40	60				
0.0	GROUND SURFACE Borehole 17-22A drilled 4.0m north of borehole 17-22																
7.6	SAND and GRAVEL , trace organics, occasional cobbles Very Dense Dark Brown Moist/Wet (FILL)		9	SS	50												
9.1	END OF BOREHOLE AT 9.1m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 1.5m, SAND AND GRAVEL TO 0.2m, THEN ASPHALT COLD PATCH TO SURFACE.																

+³, ×³: Numbers refer to
Sensitivity

20
15
10
5
0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-22B

1 OF 2

METRIC

W.P. _____ LOCATION Mink Creek Culvert ORIGINATED BY JZ
 HWY 17 BOREHOLE TYPE Solid Stem Augers/NW Casing/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2017.07.23 - 2017.07.23 CHECKED BY CZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%)						
						20	40	60	80	100	20	40	60				
0.0	GROUND SURFACE Borehole 17-22B drilled 2.0m north of borehole 17-22A																
7.6	SAND and GRAVEL , trace organics Dark Brown Moist		1	SS													
8.2	BEDROCK hard, red/black: (GRANITE) Weathered zone (25mm) at 9.2m, 9.4m, 9.7m and 9.9m		1	RUN													
			2	RUN													

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
5
0
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-22B

2 OF 2

METRIC

W.P. _____ LOCATION Mink Creek Culvert ORIGINATED BY JZ
 HWY 17 BOREHOLE TYPE Solid Stem Augers/NW Casing/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2017.07.23 - 2017.07.23 CHECKED BY CZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	Continued From Previous Page																
	Weathered zone (25mm) at 10.7m, 10.8m, 11.3m, 11.5m, 11.9m and 12.1m		3	RUN												>10 >10 5 6 >10 1 >10	RUN #3 TCR=100% SCR=100% RQD=90%
12.2	END OF BOREHOLE AT 12.2m. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2017.07.24 6.8																

RECORD OF BOREHOLE No 17-23

1 OF 2

METRIC

W.P. _____ LOCATION Mink Creek Culvert ORIGINATED BY ES/JZ
 HWY 17 BOREHOLE TYPE Solid Stem Augers/NW Casing/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2017.07.18 - 2017.07.19 CHECKED BY CZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
							20 40 60 80 100			20 40 60				
238.9	GROUND SURFACE													
0.0	ASPHALT: (150mm)													
0.2	SAND, trace silt, trace gravel, occasional cobbles Dense to Very Loose Brown Moist (FILL)		1	GS										
			1	SS	35									
			2	SS	18									
			3	SS	8									
			4	SS	1									
			5	SS	5									
6.0	SAND, trace gravel, with organics Loose Dark Brown Wet (FILL)													
			6	SS	29									
7.6	SILT, trace sand Compact to Dense Grey Saturated													
			7	SS	22									

Approx. elev. of U/\$ of footing (232.3 m)

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
5
0
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-23

2 OF 2

METRIC

W.P. _____ LOCATION Mink Creek Culvert ORIGINATED BY ES/JZ
 HWY 17 BOREHOLE TYPE Solid Stem Augers/NW Casing/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2017.07.18 - 2017.07.19 CHECKED BY CZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	Continued From Previous Page		8	SS	46												
11.7	BEDROCK slightly weathered, occasional quartz veins, hard, grey/black: (GRANITE)		9	SS	29												
			1	RUN													
			2	RUN													
14.8	END OF BOREHOLE AT 14.8m. WATER LEVEL AT 3.0m FROM SURFACE. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.2m, THEN ASPHALT COLD PATCH TO SURFACE.																

Culvert Inlet



Looking south through
culvert from North East
corner



Looking North through culvert



South East corner of culvert





Looking South through culvert



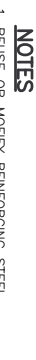
DIST HWY 17

DIST	HWY 17
CONT No	X
WP No	6300-01-C



SHEET

SHEET



REUSE OR MODIFY REINFORCING STEEL
PROVIDED IN PREVIOUS CONTRACT IF POSSIBLE.

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

[illegible]

GENERAL NOTES

1. CONTRACTOR IS RESPONSIBLE FOR ALL TRAFFIC CONTROL AND SIGNAGE AS PER OTM BOOK 7.

SCOPE OF WORK

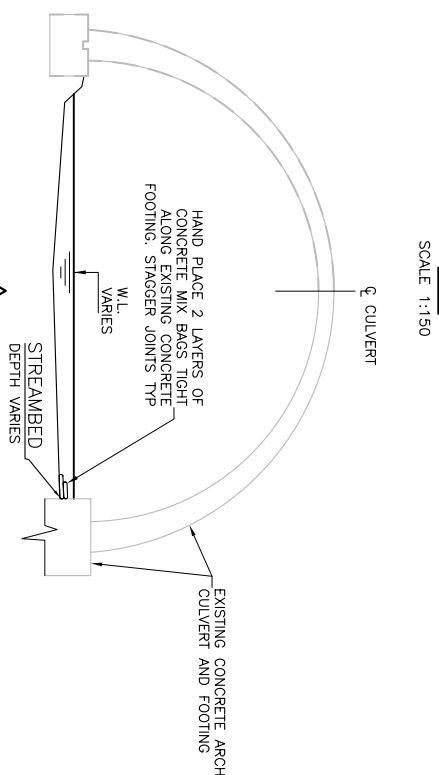
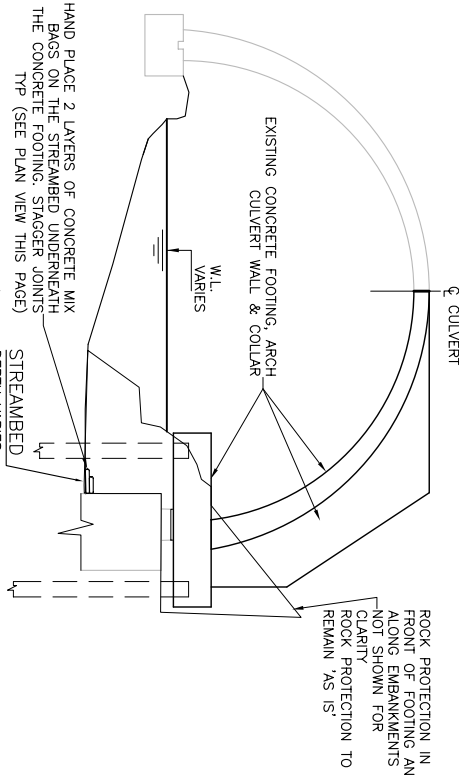
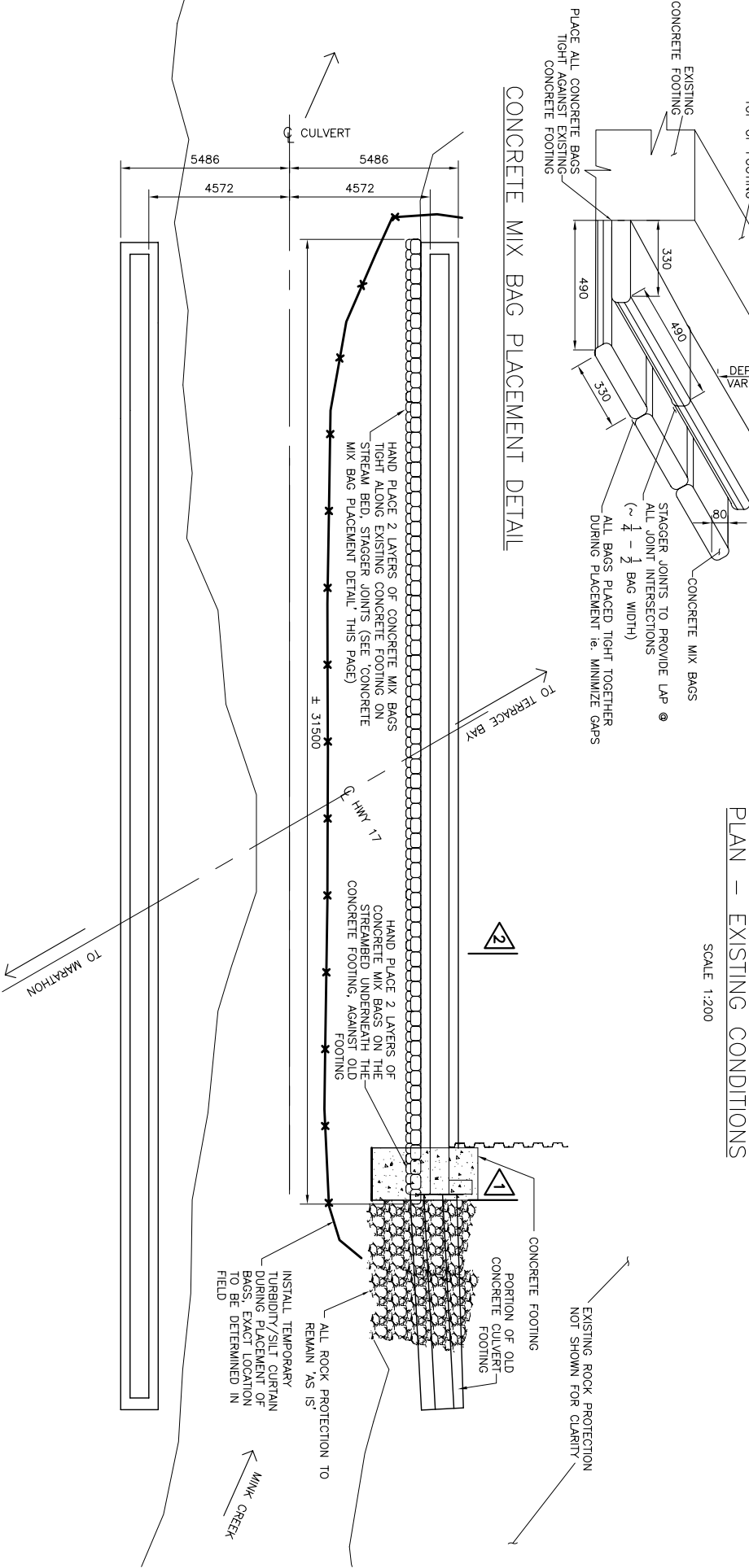
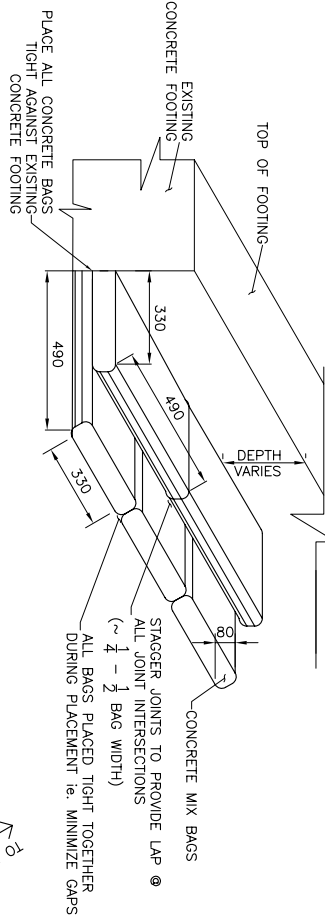
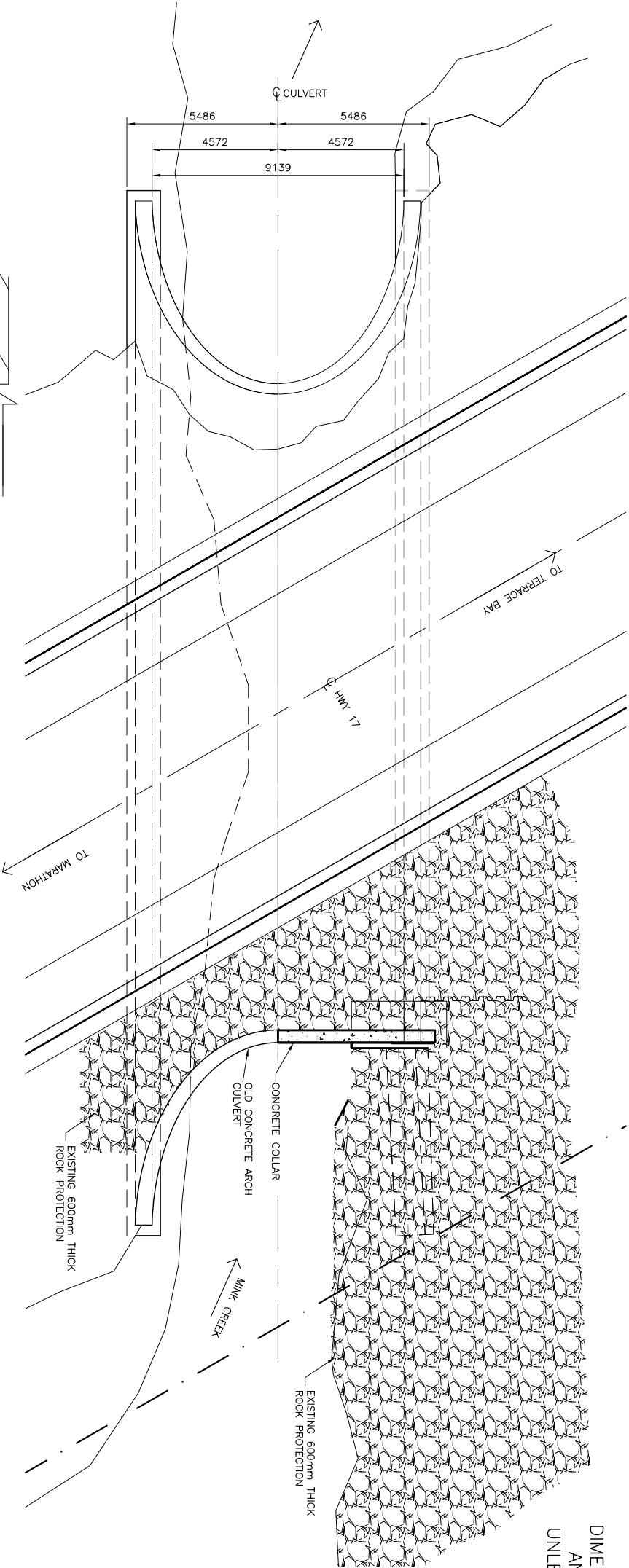
1. INSTALL TEMPORARY TURBIDITY/SILT CURTAIN DURING PLACEMENT OF BAGS.
2. PLACE CONCRETE MIX BAGS TIGHT ALONG THE FACE OF THE FOOTING. SEE DRAWINGS FOR EXACT LOCATIONS. ALL BAGS TO BE HAND PLACED. CONTRACTOR TO MAKE SURE OF A TIGHT FIT BETWEEN EACH BAG WHEN PLACING EACH BAG. CONTRACTOR TO STAGGER JOINTS OF BAGS BETWEEN TOP AND BOTTOM LAYERS.
3. ALL ROCK PROTECTION TO REMAIN 'AS IS'.

SEQUENCE OF WORK

1. INSTALL TEMPORARY TURBIDITY/SILT CURTAIN DURING PLACEMENT OF BAGS.
2. WIRE DUST OFF EXTERIOR OF CONCRETE MIX BAGS PRIOR TO PLACING INTO POLYWOVEN MATERIAL BAGS.
3. PLACE CONCRETE MIX BAGS ALONG WEST FOOTING ONLY.
4. CONTRACTOR TO HAVE A DRY/WET SHOP VACUUM PRESENT TO CLEAN OFF ANY SURFACE DEBRIS INSIDE THE TURBIDITY CURTAIN AREA.

MATERIALS

1. DRY CONCRETE MIX BAGS SHALL BE PLACED IN A POLYWOVEN MATERIAL BAG.
2. CONCRETE IN MIX BAGS SHALL CONTAIN AN ANTI-WASH ADDITIVE.
3. CONCRETE IN MIX BAGS SHALL HAVE A MIN. COMPRESSIVE STRENGTH OF 20MPA WITH A MAX AGGREGATE SIZE OF 10mm..
4. CONCRETE MIX BAGS SHALL BE KWIK MIX (PRODUCT NAME).



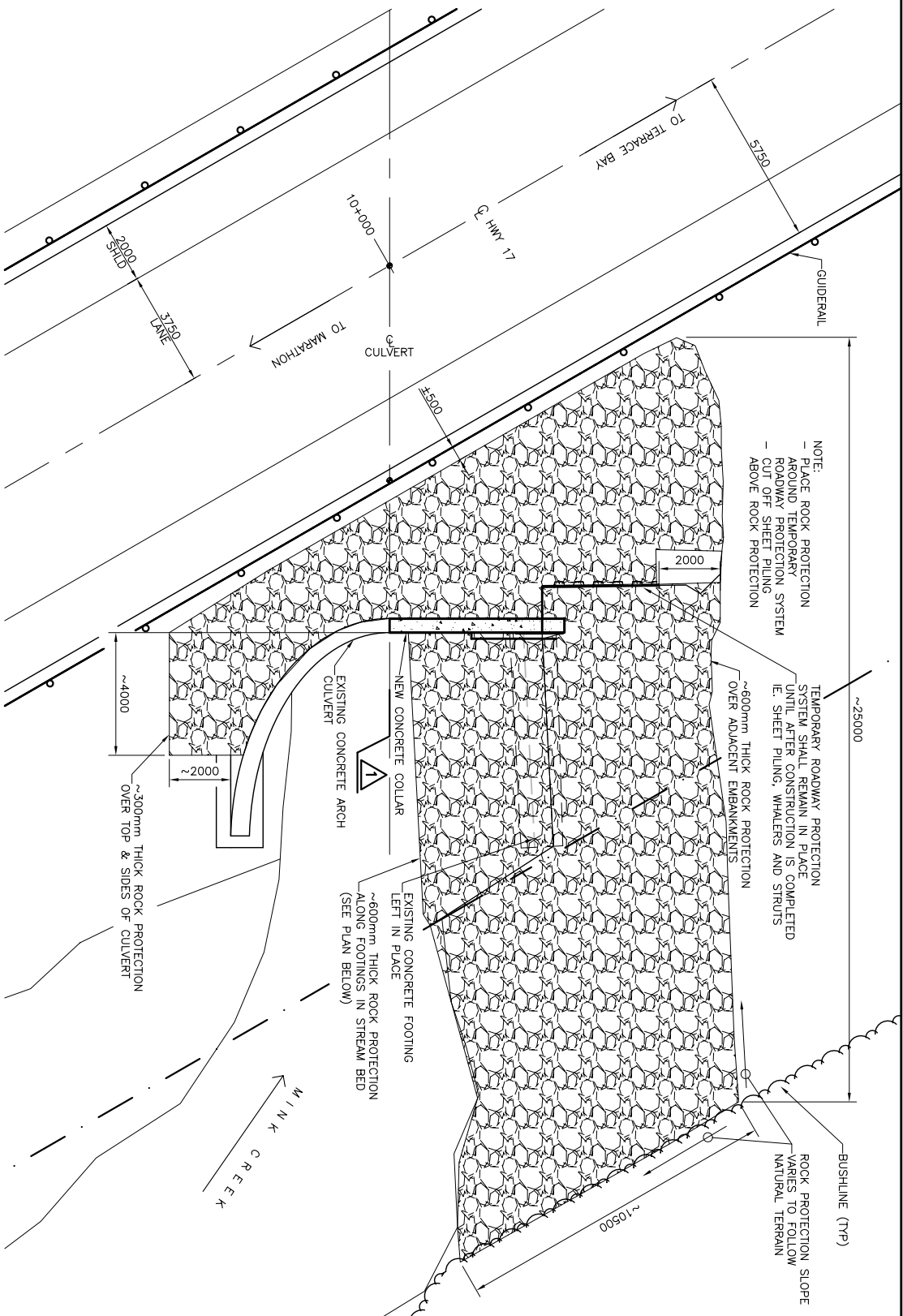
PLAN – LOCATION OF CONCRETE MIX BAG PLACEMENT
(TOP OF CULVERT, ROCK PROTECTION AND ROADWAY NOT SHOWN FOR CLARITY)

SCALE 1:200

REVISIONS				DESCRIPTION			
DESIGN	CHK	X	CODE	LOAD	DATE	08/07	
DRAWN	CHK	X	SITE 48E-23	STRUCT	SCHEME	DWG	X

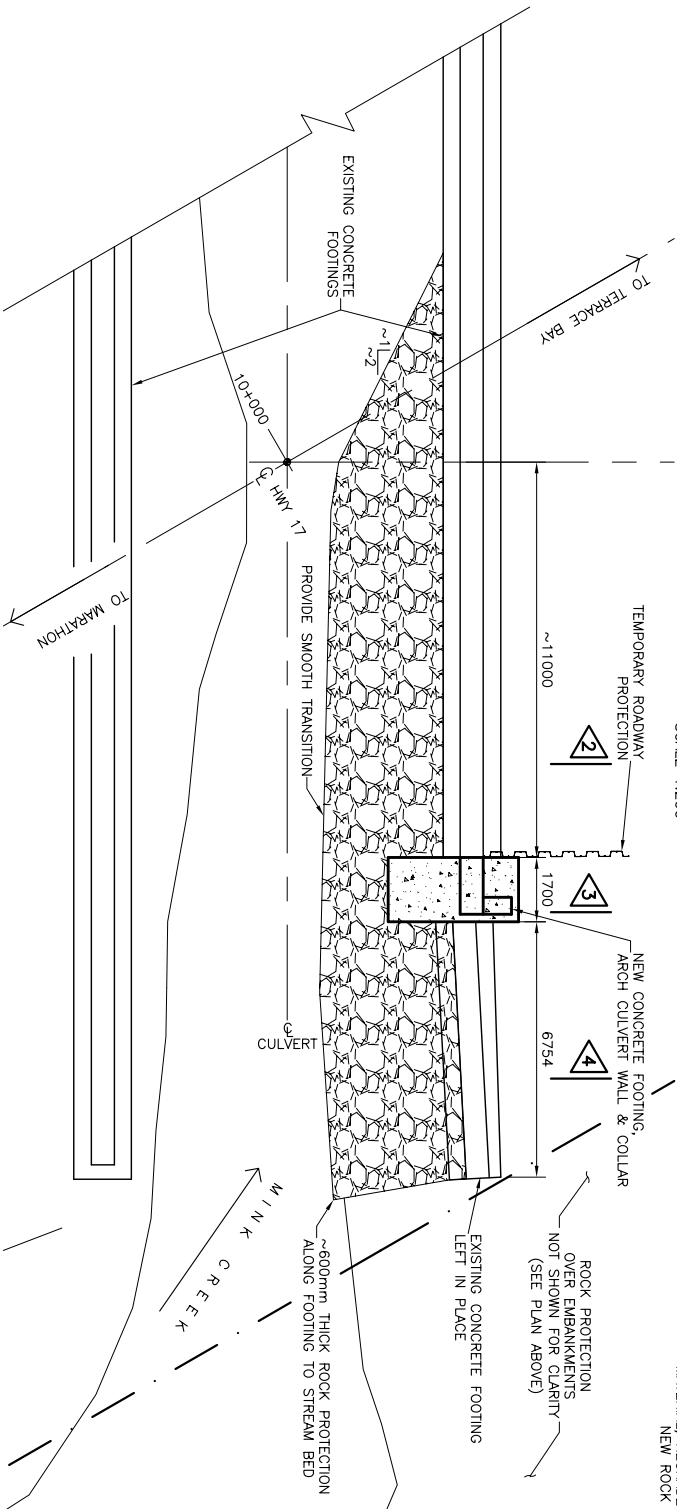
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

DIST 61	HWY. 17	
CONT No		
WP No 6300-01-01		
MINK CREEK CULVERT		SHEET
ROCK PROTECTION DETAILS		



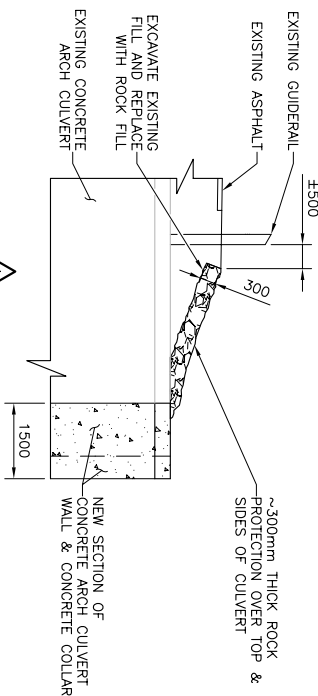
PLAN – ROCK PROTECTION OVER TOP
AND ALONG SIDES OF CULVERT

SCALE 1:200

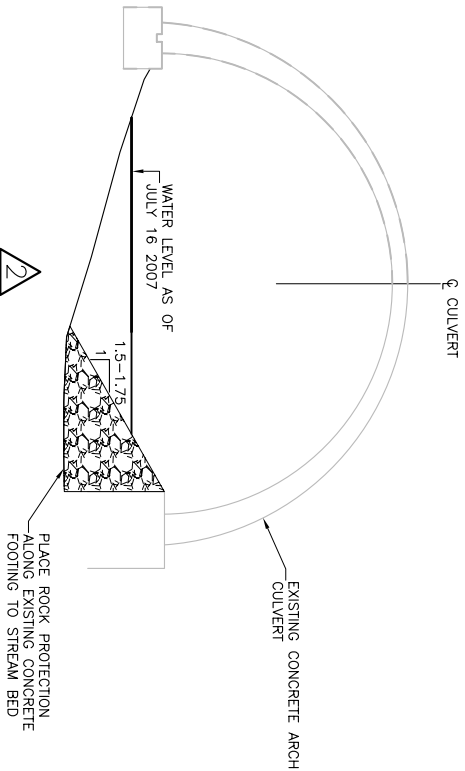


PLAN – ROCK PROTECTION INSIDE CULVERT
ALONG FOOTING TO STREAM BED

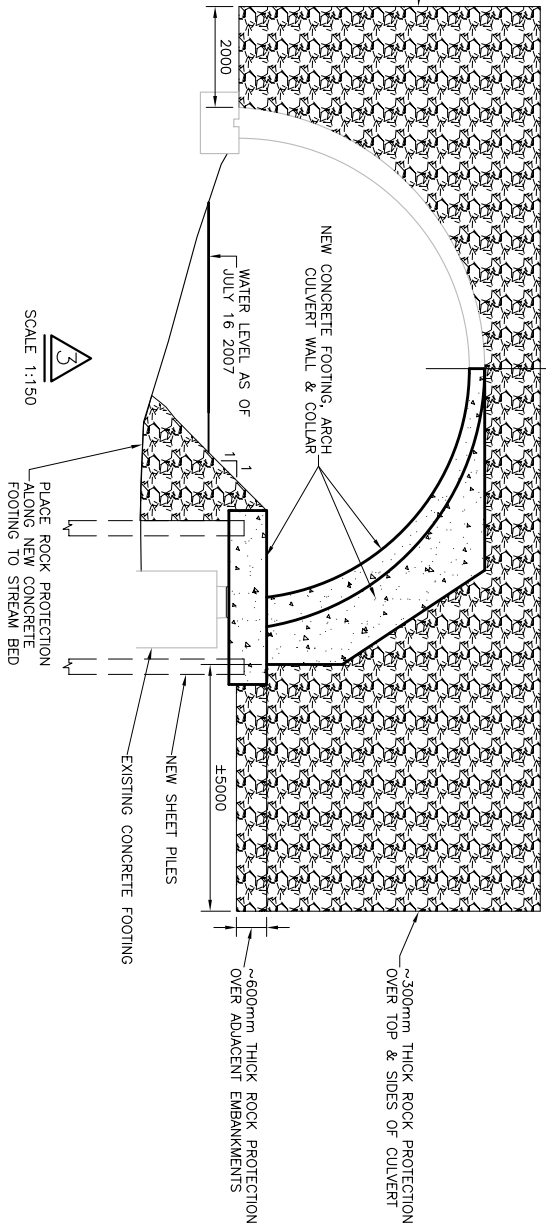
SCALE 1:200



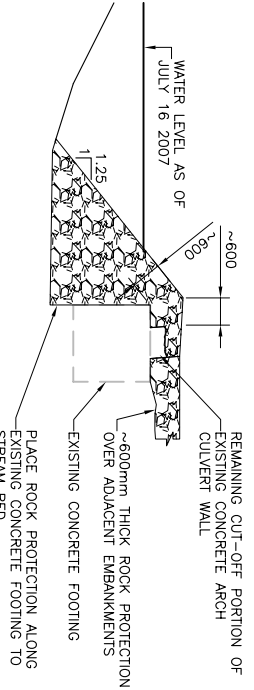
SCALE 1:150



SCALE 1:150



SCALE 1:150



SCALE 1:150

REVISIONS			
DESIGN	CHK	X	CODE
DRAWN	CHK	X	LOAD
	CHK	X	DATE
	CHK	X	SCHEME
	CHK	X	DWG