FOUNDATION DESIGN REPORT
LOW TO MEDIUM EMBANKMENTS
HIGHWAY 11/17 RED ROCK TO NIPIGON
FROM 4.8 KM WEST OF HWY 628 TO 1.5 KM WEST OF HWY 585
G.W.P. 647-89-00

Geocres Number: 52A-182

VOLUME 2 / 2

Report to

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THURBER

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ENGINEERING DISCUSSION AND RECOMMENDATION

Appendices

Appendices B to I include (where applicable):

- Recommendations Summary Table
- Selected Slope Stability Analysis Figures
- Selected Settlement Analysis Figures
- Summary of Subsurface Conditions

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Appendix J

Non-Standard Provisions (NSSP)

SUPPLY AND INSTALLATION OF EMBANKMENT MONITORING EQUIPMENT – Item No.

Special Provision

1.0 SCOPE

This special provision contains the requirements for the supply and installation of the following geotechnical instruments:

- Slope Inclinometer (SI)
- Survey Benchmarks (BM)
- Settlement Rods (SR)
- Digital Settlement System (DSS)
- Vibrating Wire Piezometers (VWP)
- Settlement Pins (SP)
- Vertical ShapeAccelArray (VSAA)
- Horizontal ShapeAccelArray (HSAA)

The purpose of these instruments is to monitor settlements, lateral displacement and pore water pressures in the foundation soils during construction of the Highway 11/17 embankments. The rate of fill placement, the wait period between stages of fill, the timing for the removal of surcharge and the construction of structures shall be controlled by the instrumentation readings.

2.0 REFERENCES

2.1 Drawings

Reference shall be made to the following drawings:

- Typical Monitoring Section A
- Typical Monitoring Section B
- Typical Monitoring Section C
- Typical Monitoring Section D
- Typical Monitoring Section E
- Typical Monitoring Section F
- Typical Monitoring Section G
- Monitoring Section Location Plan STA. 12+050 to 12+250
- Monitoring Section Location Plan STA. 13+280 to 13+430
- Monitoring Section Location Plan STA. 14+570 to 14+780
- Monitoring Section Location Plan STA. 15+500 to 15+720
- Monitoring Section Location Plan STA. 16+250 to 16+460
- Monitoring Section Location Plan STA. 16+800 to 16+940
- Monitoring Section Location Plan STA. 17+650 to 17+950
- Monitoring Section Location Plan STA. 18+600 to 19+000
- Monitoring Instrument Details #1
- Monitoring Instrument Details #2
- Monitoring Instrument Details #3

2.2 Subsurface Conditions

The subsurface conditions at the sites are described in the reports:

- Foundation Investigation Report, High Embankments and Deep Cuts, Highway 11/17 Red Rock to Nipigon from 4.8 kM West of Highway 628 to 1.5 kM West of Highway 585, Township of Nipigon, G.W.P. 647-89-00, Geocres No. 52A-180, Thurber Engineering Limited.
- Foundation Investigation Report, Low to Medium Embankments, Highway 11/17 Red Rock to Nipigon from 4.8 kM West of Highway 628 to 1.5 kM West of Highway 585, Township of Nipigon, G.W.P. 647-89-00, Geocres No. 52A-182, Thurber Engineering Limited.
- Foundation Investigation Report, Itzcaulde Creek Culvert, Highway 11/17 Red Rock to Nipigon from 4.8 kM West of Highway 628 to 1.5 kM West of Highway 585, Township of Nipigon, G.W.P. 647-89-00, Geocres No. 52A-179, Thurber Engineering Limited.
- Foundation Investigation Report, Culverts, Supplementary Embankments and Cut Slopes, Highway 11/17 Red Rock to Nipigon from 4.8 kM West of Highway 628 to 1.5 kM West of Highway 585, Township of Nipigon, G.W.P. 647-89-00, Geocres No. 52A-184, Thurber Engineering Limited

3.0 DESIGN AND SUBMISSION REQUIREMENTS

2.1 Personnel

The Contractor shall retain a Geotechnical Consultant who is approved for MTO RAQS category of "***Geotechnical*** (Structures and Embankments) – **High Complexity**", to undertake the supply and installation of geotechnical instruments. Monitoring of the instruments shall be carried out by others.

The *Contractor* shall be understood to refer to the Contractor and his Geotechnical Consultant.

2.2 Or equal

The term, "*or equal*", shall be understood to indicate that the equal product is the same or better than the specified product in function, performance, reliability, quality and general configuration. Only one supplier should be selected for the supply of all vibrating wire instruments (i.e. piezometers, digital settlement system and data acquisition system for vibrating wire instruments).

2.3 Notification

The Contract Administrator shall be notified a minimum of 15 days in advance of commencing the installation of instruments.

2.4 Submission Requirements

The Contractor shall submit details of proposed installation methods, including location and types of data-acquisition system, survey benchmarks, and installation schedule to the Contract Administrator, a minimum of 15 days before the start of instrument installation.

3.0 EQUIPMENT

All installation and monitoring equipment and associated materials shall be capable of withstanding the range of temperatures possible for their locations within the ground or on the surface. The instruments shall be capable of operating within the manufacturer's stated accuracy throughout the temperature range. Monitoring shall be conducted year round. The Contractor shall repair monitoring instruments as required at no cost to the Ministry.

4.0 CONSTRUCTION

4.1 Instrument Location

Prior to the installation of instruments, the Contractor shall accurately survey and stake the location of each instrument and obtain a ground elevation and northing/easting coordinates at each instrument location.

The quantities and locations of instruments are shown in Table 1.

Table 1 – Instrument Quantities and Locations

LOCATION		APPROXIMATE EMBANKMENT HEIGHT (m) (*)	MONITORING SECTION TYPE	NO. OF INSTRUMENTS							
LANE	STATION			SR	DSS	SI	VWP	SP	RVWP	HSAA	VSSA
WBL	12+075	4.0	E	2				4			
EBL	12+075	5.6	E	2				4			
WBL	12+190	3.0	B	2			2	4			
EBL	12+190	4.6	B	2			2	4	1		
WBL	12+235	4.8	C	2			2	2			
EBL	12+235	5.6	C	2			2	2			
WBL	13+324	4.9	B	2			2	4			
EBL	13+340	6.0	F	1	1	2	3	3	1		
WBL	13+341	4.8	A	2	1	2	4	4			
EBL	13+358	7.2	G	1	1		2	3			
WBL	13+380	4.2	B	2			2	4			
EBL	13+380	5.6	G	1	1		2	3			
WBL	14+635	5.3	B	2			2	4			
EBL	14+625	6.7	A	2	1	2	4	4	1		
EBL	14+365	-	-							1	1
WBL	14+675	4.8	A	2	1	2	4	4			
EBL	14+675	6.1	B	2			2	4			
WBL	14+740	4.2	E	2				2			
EBL	14+740	3.7	E	2				2			
WBL	15+580	2.9	D	2				4			
EBL	15+600	3.2	B	2			2	4	1		
WBL	15+670	4.1	B	2			2	4			
EBL	16+300	1.6	D	2				4			
EBL	16+400	3.7	E	2				2			
WBL	16+450	4.0	E	2				2			
EBL	16+845	4.1	C	2			2	2			
EBL	16+870	3.2	D	2				4			
WBL	16+875	2.8	C	2			2	2	1		
WBL	17+735	8.4	C	2			2	2	1		
WBL	18+660	6.1	B	2			2	4			
EBL	18+660	6.4	B	2			2	4			
WBL	18+700	5.6	A	2	1	2	4	4	1		
WBL	18+710	-	-							1	1

LOCATION		APPROXIMATE EMBANKMENT HEIGHT (m) (*)	MONITORING SECTION TYPE	NO. OF INSTRUMENTS							
LANE	STATION			SR	DSS	SI	VWP	SP	RVWP	HSAA	VSSA
EBL	18+710	5.9	A	2	1	2	4	4			
WBL	18+755	5.0	C	2			2	2			
EBL	18+775	5.4	C	2			2	2			
EBL	18+850	5.4	B	2			2	4			
			Total	87	8	12	63	151	7	2	2

Note: (*) Approximate embankment height at centreline of specified lane measured from existing ground surface to top of pavement (not including surcharge).

4.2 Survey Benchmarks (BM)

The Contractor shall provide a minimum of two non-yielding temporary survey benchmarks (BM) at each site or as specified in the contract drawings.

The number and locations of benchmarks shall be such that direct sighting is possible within each site, from all slope inclinometer (SI), settlement rods (SR), digital settlement system (DSS), settlement pins (SP), Horizontal ShapeAccelArray (HSAA) and Vertical ShapeAccelArray (VSAA) to at least one benchmark.

The locations of the temporary benchmarks are to be approved by the Contract Administrator prior to installation of monitoring instruments.

4.3 Accuracy of Surveying for Elevations

Elevations shall be surveyed to an accuracy of ± 2 mm or better.

4.4 Materials and Equipment

The Contractor shall supply all materials and equipment required for the installation of instrumentation unless noted otherwise.

4.5 Underground Utilities

The Contractor shall be responsible for locating and protecting all underground utilities prior to drilling boreholes for installing instruments. Any damage to underground utilities caused by the Contractor's work shall be repaired by the Contractor, at no cost to the Ministry.

4.6 Marking and Labelling

The location of any above ground monitoring fixture shall be made clearly visible to nearby traffic before, during and after embankment and surcharge construction. Marking shall be of sufficient size to be visible from a reversing vehicle and after heavy snow falls.

Instruments or their data cables shall be clearly labelled in the field, each instrument having a unique identifier. The labelling shall remain legible for at least 5 years.

4.7 Protection of Instruments

All instruments shall be adequately protected by the Contractor such that they are not damaged during construction. Any instrument damaged by the Contractor's work shall be immediately replaced at the Contractor's cost.

Instruments should also be adequately protected by the Contractor from natural effects such as lightning strikes. This can be achieved by using appropriate grounding and transient protection systems; such as Geokon Lab 3 Surge Module, lightning diversion systems and/or equipotential grounding systems, or equal.

4.8 Boreholes

The Contractor shall make a basic stratigraphic log of boreholes as they are being drilled. Occasional Standard Penetration Test (SPT) sampling are required to confirm soil type. Other in-situ testing and laboratory testing are not required.

Boreholes shall be advanced using appropriate drilling methods and shall be as straight and vertical as practical.

4.9 Installation Program

Instrument installation shall commence immediately after installation of wick drains and granular blanket and before any embankment fill placement. No material stockpiling shall be allowed within the embankment construction area during instrument installation. Table 2 gives a summary of the installation schedule requirements.

Table 2 – Installation Program

TYPE	START INSTALLATION	FINISH INSTALLATION
BM	After wick drain installation	Before embankment construction
SI	After wick drain installation	Before embankment construction
SR	After wick drain installation and granular blanket immediately after culvert installation, where relevant	At completion of embankment surcharge and construction
DSS	After wick drain installation	Before embankment construction
VWP/RVWP	After wick drain installation	Before embankment construction
SP	Immediately after culvert installation and after completion of embankment surcharge construction	Before embankment construction
HSAA	After wick drain installation	Before embankment construction
VSAA	After wick drain installation	Before embankment construction

5.0 INCLINOMETERS (SI) – SUPPLY & INSTALLATION

5.1 Scope

This section contains the requirements for the supply and installation of inclinometer casing and accessories.

The purpose of the inclinometers is to monitor lateral displacement and the rate of lateral displacement in the foundation soils as a result of the embankment construction.

The location and approximate installation depths of the inclinometers are given in Table 3:

Table 3 – Inclinometer Locations and Approximate Installation Depths

LOCATION			SECTION TYPE	No. of SI	Estimated Elevation of Bottom of Inclinometer (m)*	Estimated Inclinometer Length (m) To the top of Berm/ Embankment
LANE	APPROXIMATE STATION MEDIAN CENTRELINE C/L	APPROXIMATE OFFSET FROM MEDIAN C/L (**)				
EBL (West of Culvert 10)	13+340	20 m R of C/L	F	1	198	20+6**=26
	13+343	29 m R of C/L		1	198	16+6**=22
WBL (East of Culvert 10)	13+336	36 m L of C/L	A	1	199	17+6**=23
	13+343	27 m L of C/L		1	199	21+6**=27
EBL	14+620	31 m R of C/L	A	1	195	25+6**=31
	14+620	46 m R of C/L		1	195	21+6**=27
WBL	14+678	36 m L of C/L	A	1	193	23+6**=29
	14+678	28 m L of C/L		1	193	27+6**=33
WBL	18+703	35 m L of C/L	A	1	242	14+6**=20
	18+703	24 m L of C/L		1	242	18+6**=24
EBL	18+710	35 m R of C/L	A	1	242	14+6**=20
	18+710	24 m R of C/L		1	242	18+6**=24

Note: (*) Inclinometers shall be socketed into bedrock as per the attached drawings. The actual elevation of the bottom of the inclinometer shall be determined by the Contractor during drilling of the borehole.

(**) Actual locations of SI shall be selected on site based on the location of the culverts and the embankment toe.

The inclinometers shall be installed to the ground surface elevations after wick drain installation but prior to embankment construction. Monitoring, by others, shall be carried out prior to embankment construction to obtain baseline data.

Where the inclinometer will be installed through the embankment, the inclinometer casing shall be extended upward through the embankment fill. Where there is a berm (if any) the inclinometer casing shall be extended upward through the berm fill. Immediately after the addition of extensions to the inclinometer and surrounding backfill is placed, a new inclinometer reading shall be taken.

The installation phase shall be complete when the surrounding embankment is at final design height and extension of the inclinometer casing is no longer required.

5.2 MATERIALS

5.2.1 General

The Contractor shall supply inclinometer QC casing, manufactured by Slope Indicator Company - or equal. Fittings for the casing shall be consistent in manufacturer and system, (e.g. QC

casing system and fittings by Slope Indicator).

5.2.2 Casing

Casing shall be 70 mm OD, (Slope Indicator - model 51150210 or 51150211 - or equal).

5.2.3 Splices

If required, splice-kits shall be Slope Indicator model 51150250 (male) or 51150251 (female) - or equal.

5.2.4 Bottom Caps

Bottom caps shall be Slope Indicator model 51150230 - or equal.

5.2.5 Top Caps

Top caps shall be Slope Indicator model 51101500 - or equal.

5.2.6 Telescopic Section

Telescopic section shall be Slope Indicator model 51150220 – or equal.

5.2.7 Anchor

If required, casing anchor shall be Slope Indicator model 51104370 – or equal.

5.2.8 Protective Surround – during embankment/berm construction

The Contractor shall supply a protective surround for the portion of the inclinometer casing in the berm or embankment. The surround shall consist of 300 mm diameter corrugated steel pipe (CSP - OPSS 1801) and a friction reducing sleeve 80mm minimum I.D. Schedule 40 PVC pipe. The space between both the CSP and the PVC pipes shall be filled with medium to coarse sand. The 300 mm corrugated pie shall be cut perpendicular to the axis of the pipe and shall be free of burrs and sharp edges.

5.2.9 Protective Housing – post embankment construction

On completion of the construction of the embankment, the contractor shall supply a locking protective cover over the inclinometer installation. A lockable cover attached to the 300 mm CSP would be suitable.

5.2.10 Grout

The annular space between the inclinometer casing and the borehole shall be filled with cement-bentonite grout prepared as follows: 17.7 kg of bentonite (OPSS 1205), 284 litres of water and 42.6 kg of cement (Type 10 - OPSS 1301).

5.3 CONSTRUCTION

5.3.1 General

Installation of the inclinometer casing shall be as per the manufacturer's recommendations in addition to what is stated or emphasised below.

Standard inclinometer casing lengths shall be used.

Boreholes for inclinometers shall be ± 2 % of vertical. The boreholes shall be of sufficient diameter to enable installation of the inclinometer casing and grouting of the annular space between the inclinometer casing and borehole.

The A inclinometer casing grooves shall be aligned perpendicular to the road centreline, with the A+ direction towards the outer side slope.

The B inclinometer casing grooves shall be aligned parallel to the road centreline, with the B+ direction 90 degree positive (anti-clockwise) from the A+ direction.

A+ and B+ direction grooves shall be permanently marked and identified on each casing.

Care shall be taken not to apply torsion to the inclinometer casing during installation.

Inclinometer casing shall not be exposed to prolonged direct sunlight as it will cause deformation

The inclinometer socket length, (in bedrock) shall be as per the attached drawings and shall be confirmed by the Contractor during drilling of the borehole.

5.3.2 Telescopic Sections

Three telescopic sections shall be included per inclinometer. The telescopic sections shall each accommodate up to 0.15 m of contraction.

Table 4 gives the approximate depths of telescopic sections for the inclinometers (depths are from existing ground level).

Table 4 – Elevation of Telescopic Section for Inclinometers

LOCATION			Estimated Elevation(s) of Top Of Telescopic Sections (m) (***)
LANE	STATION ALONG MEDIAN CENTRELINE C/L	APPROXIMATE OFFSET FROM MEDIAN CENTRELINE C/L	
EBL	13+342	20 m R of C/L	212 / 208
	13+346	29 m R of C/L	212 / 208
WBL	13+346	36 m L of C/L	212 / 208
	13+352	27 m L of C/L	212 / 208
EBL	14+620	31 m R of C/L	214 / 208 / 204
	14+620	46 m R of C/L	214 / 208 / 204
WBL	14+678	36 m L of C/L	214 / 208 / 204
	14+678	28 m L of C/L	214 / 208 / 204
WBL	18+703	35 m L of C/L	252
	18+703	24 m L of C/L	252

EBL	18+710	35 m R of C/L	252
	18+710	24 m R of C/L	252

Note: (*) The actual elevation of the bottom of the inclinometer shall be determined by the Contractor during drilling of the borehole. (Inclinometers shall be socketed into bedrock as per the attached drawings)

(**) The estimated inclinometer length includes an additional 6 m of inclinometer casing per inclinometer to allow for a deeper installation than anticipated.

(***) Telescopic sections are not required within the embankment or socket length.

5.3.3 Grouting

Prior to grouting, the Contractor shall lower a dummy probe to confirm that all grooves are properly aligned and that the probe can reach the bottom of the casing.

The annulus between the borehole and inclinometer casing shall be grouted up to the ground level. All drilling slurry shall be flushed out of the borehole. Grout shall displace any water from the borehole.

When grouting around the inclinometer casing, the buoyancy force acting on the casing must be opposed. Clean water can be added inside the inclinometer casing but additional force may be required. If so, the force shall be ideally applied at the base of the inclinometer casing. The casing shall not be pushed down from the top as this will likely distort the casing profile.

Once grouting is completed and the grout has set, the Contractor shall lower the dummy probe to the bottom of the inclinometer casing to confirm that it has been correctly installed.

Once the grout has set, the water level inside the casing shall be lowered to approximately 6 m below ground to prevent freezing.

5.3.4 Protective Surround

A protective surround, consisting of a CSP and a friction reducing sleeve (PVC pipe) and sand backfill as specified in Item 2.2, shall be placed around the portion of inclinometer casing that is above the ground level. The length of the protective surround shall be such that the top of the inclinometer is approximately 300 mm above the top of the friction sleeve and the CSP.

The above ground portion of inclinometer casing shall be greater than 0.3 m in length.

5.3.5 Extension of Inclinometer

As embankment/berm construction proceeds (where applicable), the inclinometer casing, PVC pipe sleeve and the protective surround shall be extended so that they are always above the current ground level. Extensions shall be accomplished using 1.5 m (or 5 ft) lengths of casing (51150211 – or equal). Extension of the casing shall be coordinated with the placement of fill such that after the extension is added, the top of casing is not more than 2 m above the surrounding fill before placement and shall not be less than 0.3 m after fill placement.

5.3.6 Protective Housing

When final height of the embankment/berm has been reached, a protective housing shall be

installed securely over the protective surround.

The protective housing shall allow easy access to the top of the inclinometer casing by hand and shall allow for the installation of the cable pulley/cable grip collar assembly used in monitoring by others.

5.3.7 Cutting of Inclinometer Casing

The standard lengths of inclinometer casing shall not be cut during the construction of the embankment/berm. Extensions shall be made using shorter standard lengths, 5 ft or 1.5 m, to maintain the top of the casing at a readily accessible level.

The inclinometer casing shall not be cut after completion of the construction of the embankment except with the approval of the Contract Administrator. All cuts shall be made square, perpendicular to the axis of the casing and shall be free of burrs. The elevation of the cut shall be carefully coordinated with others responsible for conducting the monitoring.

5.4 COORDINATION WITH MONITORING

5.4.1 Notification

The Contractor shall notify the Contract Administrator no later than 3 days after grouting of an inclinometer. At this time, the Contractor shall also supply the following information to the Contract Administrator.

- Magnetic and grid bearings of A+ and B+ groove directions;
- Difference between A-axis bearing and line perpendicular to road centreline;
- Stratigraphic log of subsurface conditions at the inclinometer, including drilling method notes;
- Telescopic section and socket details;
- Elevations of top and bottom of casing and ground;
- Installation notes and grouting notes.

5.4.2 Baseline Readings

Baseline readings of the inclinometers shall be done by a Foundation Engineering Consultant retained by the Contract Administrator. The Contractor should be prepared to wait for a period of 15 days after completion of installation of instruments for the baseline readings to stabilize. Stabilization of readings shall be deemed to have reached for three consecutive readings, in both A and B directions, when:

a. Changes in the incremental deflection at the same depth are within ± 0.5 mm; and
b. Changes in the cumulative deflection at the same depth are within ± 1 mm;
c. Failing either of the two above criteria, as determined by the Contract Administrator.

5.4.3 Monitoring

Monitoring of the inclinometers shall be done by others. The Contractor shall provide installation information as specified above and provide access to the inclinometer for monitoring, including but not limited to providing a scaffolding platform and ladder as required and snow clearing in the winter. The contractor shall provide electric power and general area lighting as needed for reading the instruments.

5.5 REPORTING

The Contractor shall record and report relevant inclinometer installation details to the Contract Administrator no later than 5 days after installation. These include, but are not limited to:

- Inclinometer location, easting, northing;
- Elevation of ground levels and top of casing;
- Magnetic and grid bearing of A+ and B+ groove directions;
- Difference between A-axis bearing and line perpendicular to road centreline;
- Date of installation;
- Depths of casing and stick up;
- Installation notes, grouting notes and results of the dummy probe runs.

6.0 BENCHMARKS (BM) – SUPPLY & INSTALLATION

6.1 SCOPE

This Section contains the requirements for the supply and installation of benchmarks (BM).

The purpose of the benchmarks is to provide non-settling references for the surveying of slope inclinometers (SI), settlement rods (SR), digital settlement system (DSS), settlement pins (SP) and vertical/horizontal ShapeAccelArray (VSAA and HSAA).

6.1.1 General Procedure

The benchmarks shall be installed prior to the embankment construction. The benchmark (BM) consists of a steel rod anchored to the bottom of a borehole.

6.1.2 Number and Location

The minimum number of benchmarks is specified on the contract drawings at each site. The number and locations of benchmarks shall be adjusted in the field such that the benchmarks are sufficient distance from the embankments to remain non-yielding, not affected by the embankment construction and direct sighting is possible from all slope inclinometers (SI), settlement rods (SR), settlement pins (SP), vertical/horizontal ShapeAccelArray (VSAA and HSAA) to at least one benchmark within each site.

6.2 MATERIALS

6.2.1 General

The Contractor shall supply all materials and equipment required for the installation of the benchmarks (BM).

6.2.2 Rod

The Contractor shall supply a steel pipe Schedule 40 with an outside diameter not less than 25.4mm (1"), supplied in lengths as required to complete the installation as described in Section 3.1.

The top end of each length of rod shall be threaded to receive a cap. A rounded cap shall be installed at the top of the rod in such a way that a single survey point can be clearly identified

and returned to.

6.2.3 Sand

The Contractor shall supply clean washed sand with the following gradation:

MTO Sieve Designation	Percentage Passing
4.5 mm - #4	100%
2 mm - #10	80% - 100%
850 µm - #20	20% - 100%
425 µm - #40	5% - 40%
150 µm - #100	0% - 5%

6.2.4 Grout

The Contractor shall supply cement-bentonite grout. A suitable grout mix design consists of 17.7 kg of bentonite (OPSS 1205), 284 litres of water and 42.6 kg of cement (Type 10 - OPSS 1301).

6.2.5 Rod Anchor Grout

The Contractor shall supply cement-bentonite grout. A suitable grout mix design consists of 14 kg of bentonite (OPSS 1205), 49 litres of water and 40 kg of cement (Type 10 - OPSS 1301).

6.3 CONSTRUCTION

6.3.1 General

The Contractor shall install benchmarks (BM) as per the drawings provided in addition to the information below.

6.3.2 Borehole Installation

The borehole shall be advanced to a depth of 1.5 m into a non-yielding stratum (e.g. bedrock) below the existing ground surface using suitable drilling techniques. The diameter of the borehole shall be sufficient to fit the rod, and rod anchor. The sides of the borehole shall be stable and the borehole shall be free of drilling mud and debris.

6.3.3 Rod Couplings

The coupling of the rods shall be such that all sections have the same axis and no separation or contraction will occur at the couplings.

6.3.4 Rod Anchor

The rod shall be installed vertically in the borehole with its bottom end resting at the bottom of the borehole. The rod shall be grouted in place.

6.3.5 Installation Details

The elevation, easting and northing of the top of the benchmark rod shall be surveyed.

6.4 COORDINATION WITH MONITORING

6.4.1 Notification

The Contractor shall notify the Contract Administrator no later than 3 days after installing a benchmark. At this time the Contractor shall also supply the following information to the Contract Administrator:

- Elevations of the rod anchor and the top of rod;
- Dates of installation;
- Stratigraphic log of subsurface conditions at the benchmark, including drilling method notes;
- Installation notes, sketches and photographs;
- Description of benchmarks.

6.4.2 Monitoring

Monitoring of settlements with reference to the benchmarks shall be done by others. Monitoring shall be conducted before, during and after the embankment construction. The Contractor shall provide installation information as specified above and provide access to the benchmarks for monitoring including, but not limited to snow clearing in the winter. The contractor shall provide electric power and general area lighting as needed.

6.5 REPORTING

The Contractor shall record and report relevant installation details to the Contract Administrator. These include, but are not limited to:

- Benchmark northing and easting;
- Elevation to the top of rod;
- Dates of installation;
- Installation notes, sketches and photographs.

7.0 SETTLEMENT RODS (SR) – SUPPLY & INSTALLATION

7.1 SCOPE

This Section contains the requirements for the supply and installation of settlement rods.

The purpose of the settlement rods is to monitor settlements of the embankment base. The settlement readings shall help establish the timing for fill placement of subsequent stages and the removal of surcharge. Settlement is measured by survey of the top of the rod with reference to stable, non-settling benchmarks.

7.1.1 General Procedure

The settlement rods shall be attached to a plate at the existing ground surface. As embankment construction proceeds the rods shall be extended above the new top of embankment.

Sleeves around the rods shall be installed to reduce friction and allow uninhibited movement of the rod with the plate.

A protective surround shall be extended with the rods as embankment construction proceeds.

7.1.2 Location

The locations of the settlement rods are shown on the attached drawings and are given in Table 5.

Table 5 – Approximate Settlement Rod Locations

LOCATION			ESTIMATED EMBANKMENT HEIGHT (m) (***)	SECTION TYPE	No. of SR
LANE	STATION ALONG MEDIAN CENTRELINE C/L(*)	APPROXIMATE OFFSET FROM ECL(**)			
WBL	~12+075 (Offset 3m from Culvert 6A)	5 m L of ECL and 5 m R of ECL	4.0	E	2
EBL	~12+075 (Offset 3 m from Culvert 6B)	5 m L of ECL and 5 m R of ECL	5.6	E	2
WBL	12+190	5 m L of ECL and 5 m R of ECL	3.0	B	2
EBL	12+190	5 m L of ECL and 5 m R of ECL	4.6	B	2
WBL	12+235 (Offset 3 m from Culvert 7A)	5 m L of ECL and 5 m R of ECL	4.8	C	2
EBL	12+235 (Offset 3 m from Culvert 7B)	5 m L of ECL and 5 m R of ECL	5.6	C	2
WBL	~13+322 (11 m West of Itzcauld Creek)	5 m L of ECL and 5 m R of ECL	4.9	B	2
EBL	~13+340 (14 m West of Itzcauld Creek)	5 m L of ECL	-	F	1
WBL	~13+340 (11 m East of Itzcauld Creek)	5 m L of ECL and 5 m R of ECL	4.8	A	2
EBL	~13+358 (14 m East of Itzcauld Creek)	5 m L of ECL	-	G	1
WBL	13+380	5 m L of ECL and 5 m R of ECL	4.2	B	2
EBL	13+380	5 m L of ECL	-	G	1
WBL	14+635	5 m L of ECL and 5 m R of ECL	5.3	B	2
EBL	14+623	5 m L of ECL and 8 m R of ECL	6.7	A	2
WBL	14+675	5 m L of ECL and 5 m R of ECL	4.8	A	2
EBL	14+675	6 m L of ECL and 9 m R of ECL	6.1	B	2

LOCATION			ESTIMATED EMBANKMENT HEIGHT (m) (***)	SECTION TYPE	No. of SR
LANE	STATION ALONG MEDIAN CENTRELINE C/L(*)	APPROXIMATE OFFSET FROM ECL(**)			
WBL	~14+740 (Offset 3 m from Culvert 14)	5 m L of ECL and 5 m R of ECL	4.2	E	2
EBL	~14+740 (Offset 3 m from Culvert 14)	5 m L of ECL and 5 m R of ECL	3.7	E	2
WBL	15+580	5 m L of ECL and 5 m R of ECL	2.9	D	2
EBL	15+600	5 m L of ECL and 5 m R of ECL	3.2	B	2
WBL	15+670	5 m L of ECL and 5 m R of ECL	4.1	B	2
EBL	16+300	5 m L of ECL and 5 m R of ECL	1.6	D	2
EBL	~16+400 (Offset 3 m from Culvert 24A)	5 m L of ECL and 5 m R of ECL	3.7	E	2
WBL	~16+450 (Offset 3 m from Culvert 24B)	5 m L of ECL and 5 m R of ECL	4.0	E	2
EBL	~16+845 (Offset 3 m from Culvert 25)	5 m L of ECL and 5 m R of ECL	4.1	C	2
EBL	16+870	5 m L of ECL and 5 m R of ECL	3.2	D	2
WBL	~16+875 (Offset 3 m from Culvert 25)	5 m L of ECL and 5 m R of ECL	2.8	C	2
WBL	~17+735 (Offset 3 m from Culvert 28)	5 m L of ECL and 5 m R of ECL	8.4	C	2
WBL	18+660	5 m L of ECL and 7 m R of ECL	6.1	B	2
EBL	18+660	5 m L of ECL and 5 m R of ECL	6.4	B	2
WBL	18+700	5 m L of ECL and 5 m R of ECL	5.6	A	2
EBL	18+710	5 m L of ECL and 7 m R of ECL	5.9	A	2
WBL	~18+755 (Offset 3 m from Culvert 32)	5 m L of ECL and 5 m R of ECL	5.0	C	2
EBL	~18+775 (Offset 3 m from Culvert 32)	5 m L of ECL and 5 m R of ECL	5.4	C	2
EBL	18+850	5 m L of ECL and 5 m R of ECL	5.4	B	2

Note: (*) Instrument locations shall be as per plan drawings
(**) Embankment Centreline (ECL) refers to the centreline of the embankment of a

given lane (EBL or WBL)

(***) Embankment thickness does not include surcharge.

7.2 MATERIALS

7.2.1 General

The Contractor shall supply all materials and equipment required for the installation of the settlement rods.

7.2.2 Plate

The Contractor shall supply a steel plate with thickness of at least 6.35 mm. The plate shall be at least 0.5 m by 0.5 m.

7.2.3 Rod

The Contractor shall supply a steel pipe Schedule 40 with an outside diameter not less than 25.4mm (1"), supplied in lengths as required to complete the installation.

The top end of each length of rod shall be threaded to receive a cap. A rounded cap shall be installed at the top of the rod in such a way that a single survey point can be clearly identified and returned to.

7.2.4 Friction Reducing Sleeve

The Contractor shall supply a friction reducing sleeve consisting of Schedule 40 - 50.8mm (2") O.D. PVC pipe cut perpendicular to the axis of the pipe.

7.2.5 Protective Surround

The Contractor shall supply a protective surround for the portion of the rod within the embankment.

The surround shall consist of 300 mm diameter corrugated steel pipe (CSP - OPSS 1801) with the ends cut perpendicular to the axis of the pipe and free of burrs and sharp edges. The space between the CSP and the Friction Reducing Sleeve (PVC pipe) shall be filled with medium to coarse sand.

7.3 CONSTRUCTION

7.3.1 General

The Contractor shall install settlement rods as per the contract drawings provided in addition to what is stated or emphasized below.

7.3.2 Settlement Plate

The settlement plate shall be installed horizontally on undisturbed native soil just below the existing ground surface or the granular drainage blanket.
The elevation of the base of the plate shall be surveyed before backfilling.

7.3.3 Rod

The rod shall be fixed to the centre of the plate and perpendicular to the plate.

The coupling of the rods shall be such that all sections have the same axis and no separation or contraction will occur at the couplings.

7.3.4 Friction Reducing Sleeve

The friction reducing sleeve shall be over the entire length of the rod that is below ground and within the embankment fill except that the cap on top of the settlement rod shall extend 25 mm above the top of the friction sleeve at all times.

7.3.5 Extension of Rod

The settlement rods shall be extended upwards as the embankment is constructed so that the top of the rod is always at least 0.3 m but no more than 2 m above the surrounding fill. The top of the rod shall be surveyed before and after each rod extension is added.

7.3.6 Protective Surround

The CSP, Friction Reducing Sleeve and sand protective surround shall be extended with the rods.

The settlement rod shall be in the centre of the CSP and friction reducing sleeve.

The annulus between the CSP and the friction-reducing sleeve shall be filled with sand to a level not higher than the top of the sleeve.

7.3.7 Installation Details

The elevation, easting and northing of the centre of the base of the plate shall be surveyed.

The elevation, easting and northing of the top of the rod shall be surveyed before and after each rod extension is added.

The total distance from the base of the plate to the top of the rod shall be measured to an accuracy of ± 2 mm or better.

7.4 COORDINATION WITH MONITORING

7.4.1 Notification

The Contractor shall notify the Contract Administrator no later than 3 days after installing a settlement rod. At this time the Contractor shall also supply the following information to the Contract Administrator:

- Elevations of plate and top of rod;
- Dates of installation;
- Description of settlement rods, sleeve and plate;

- Installation photos.

During the embankment and surcharge construction, the Contractor shall extend all settlement rods, friction protective sleeves and CSP protective surrounds simultaneously prior to the placement of the next lift of fill. The Contractor shall notify the Contract Administrator no less than 3 days prior to extending any settlement rod. Adjustments in the length of any settlement rod shall be coordinated with the Contract Administrator to allow surveying by others of the elevation of the top of rod immediately before and immediately after adjustment. This surveying is necessary to accurately track the settlement data.

7.4.2 Monitoring

Monitoring of the settlement rods shall be done by others. Monitoring shall be conducted prior to, during the embankment and surcharge construction. The Contractor shall provide installation information as specified above and provide access to the settlement rods for monitoring including, but not limited to a scaffolding platform and ladder if required and snow clearing in the winter. The Contractor shall provide electric power and general area lighting as needed for reading the instruments.

7.5 REPORTING

The Contractor shall record and report relevant installation details to the Contract Administrator. These include, but are not limited to:

- Settlement rod easting, northing;
- Elevations of the plate and the top of the rod;
- Distance between the base of plate and top of rod;
- Dates of installation;
- Installation notes, sketches and photographs.

8.0 DIGITAL SETTLEMENT SYSTEM (DSS) – SUPPLY & INSTALLATION

8.1 SCOPE

This Section contains the requirements for the supply and installation of a digital settlement system (DSS).

The purpose of the settlement system is to monitor settlements of the embankment base at critical locations or at locations where installation of SR is not possible. The settlement readings shall help establish the timing for each stage of fill placement and surcharge removal. Settlement data shall be logged by a data logger.

8.1.1 General Procedure

The settlement system shall be installed in boreholes after wick drain installation but prior to any embankment construction.

The DSS signal cables shall be extended out of the embankment footprint area through a metal or plastic conduit buried in trenches, as shown in the attached drawings.

8.1.2 Locations

The Contractor shall install the settlement system sensors at the centre of the triangular wick drain grid of the locations and depths given in Table 6.

Table 6 – Digital Settlement System Locations

LOCATION			SECTION TYPE	No. of DSS	Approximate Elevation of the Existing Ground Surface (m)	Approximate Elevation of Bedrock or Non-Yielding Stratum(m)
LANE	STATION ALONG MEDIAN CENTRELINE C/L	OFFSET (*)				
EBL	~13+332 (5 m West of Culvert 10)	20 m R of Median C/L	F	1	215	200
WBL	~13+338 (11 m East of Culvert 10)	ECL	A	1	215	200
EBL	~13+365 (11 m East of Culvert 10)	20 m R of Median C/L	G	1	214	190
EBL	13+383	20 m R of Median C/L	G	1	214	190
EBL	14+620	ECL	A	1	216	196
WBL	14+680	ECL	A	1	217	198
WBL	18+703	ECL	A	1	257	250
EBL	18+707	ECL	A	1	256	246

Note: (*) Embankment Centreline (ECL) refers to the centreline of the embankment of a given lane (EBL or WBL)

8.2 MATERIALS

8.2.1 Digital Settlement Sensor and Data logger

The Contractor shall supply Settlement Sensors (eg. Geokon model 4600 or equal); and a compatible data logger (eg. Geokon model 8002-1, 8002-4, 8002-16 data logger or equal). All settlement sensors and data loggers shall be of the same make.

All settlement sensors shall be calibrated prior to installation and the calibration data for each settlement sensor shall be provided to the Contract Administrator.

8.2.2 VW Data Recorder

The Contractor shall supply one VW Data Recorder (eg. Geokon model GK-404 – or equal); compatible with the above settlement sensors.

8.2.3 Signal Cable and Liquid Line

The Contractor shall supply signal cable and liquid line compatible with the settlement sensor. The DSS shall be designed to withstand all temperature variations. The length of cable for each settlement sensor shall be carefully estimated from the construction drawings to ensure that

there is enough signal cable for each settlement sensor to provide enough slack in the borehole and along the trenches until each cable is out of the embankment footprint area where they shall be protected from earthmoving equipment.

The liquid line connecting the settlement plate and settlement sensor shall be long enough to reach bedrock from the base of the embankment.

8.2.4 Bentonite Grout

The annular space between the DSS and the borehole sidewall shall be filled with cement-bentonite grout prepared as follows: 17.7 kg of bentonite (OPSS 1205), 284 litres of water and 42.6 kg of cement (Type 10 - OPSS 1301).

8.2.5 Settlement System Anchor

The Contractor shall supply cement-bentonite grout to ensure the settlement system is founded in bedrock. A 1" diameter steel pipe 3 feet long, or equal, can be used to anchor the settlement system in place. A suitable cement grout mix design consists of 14 kg of bentonite (OPSS 1205), 49 litres of water and 40 kg of cement (Type 10 - OPSS 1301).

8.2.6 Trench Burial and Conduit

The signal cable for each settlement sensor shall be buried in a shallow trench as shown in the contract drawings, and taken out of the embankment footprint area. The Contractor shall supply suitable conduits (e.g. Schedule 40 - 75mm - 3" rigid PVC pipe) to protect the signal cables in the trenches and above ground surface. If appropriate, several signal cables may be housed in a single conduit and laid in a common trench. Before trenches are backfilled, the settlement sensors shall be tested.

8.3 CONSTRUCTION

8.3.1 General

Installation of the settlement sensors shall be as per the manufacturer's recommendations in addition to what is stated or emphasised below.

8.3.2 Borehole Installation

The borehole shall be advanced to 0.5 m into bedrock or competent ground. The sides of the borehole shall be stable and the borehole shall be free of drilling mud and debris.

The exact borehole location shall be at the centre of the triangular wick drain grid and shall be determined in the field, after the wick drain installation.

8.3.3 Data Logger Boxes and Monitoring Shed

The data logger boxes shall be lockable and weatherproofed and securely attached to the monitoring shed. The terminal boxes and data logger accessories shall be properly grounded.

The Contractor shall provide appropriate protection against natural hazards including but not limited to lightning strike.

The Contractor shall ensure safe access to the Terminal Boxes at all times including, but not limited to, snow clearing in the winter.

8.4 COORDINATION WITH MONITORING

8.4.1 Notification

The Contractor shall notify the Contract Administrator no later than 3 days after installing the DSS. At this time, the Contractor shall also supply the following information to the Contract Administrator.

- Digital Settlement System location, easting, northing;
- Elevation of the Settlement Plate;
- Stratigraphic log of subsurface conditions, including drilling method notes;
- Dates of installation;
- Installation notes, grounding method, sketches and photographs;
- Model, make and serial numbers of digital settlement sensors, readout unit and signal cable;
- Calibration details of digital settlement sensors.

8.4.2 Monitoring

Monitoring of the DSS, including establishment of baseline data, shall be done by others. Monitoring shall be conducted during the embankment and surcharge construction. The Contractor shall provide installation information as specified above and provide access to the monitoring shed for data retrieval.

The Contractor shall transfer the Portable Laptop Computer as specified in Section 9.1.1 and VW Data Recorder to the Contract Administrator, including all of the data logging software and hardware, operation instructions and calibration constants. The contractor shall also transfer the keys for the locks of the Monitoring Shed(s). The contractor shall be available for one site meeting with the Contract Administrator to transfer the items and answer any questions the Contract Administrator may have regarding the data-logging system.

9.0 VIBRATING WIRE PIEZOMETER (VWP) & REFERENCE VWP (RVWP) – SUPPLY & INSTALLATION

9.1 SCOPE

This Section contains the requirements for the supply and installation of vibrating wire piezometers (VWP) and reference vibrating wire piezometers (RVWP)

The purpose of the piezometers is to monitor the piezometric head at depth within the foundation soil. The piezometer readings shall help establish the timing for fill placement for various stages and surcharge removal.

9.1.1 General Procedure

The piezometers shall be installed in boreholes after wick drain installation but prior to any embankment construction.

The VW signal cables shall be extended out of the embankment footprint area through a metal or plastic conduit buried in trenches, as shown in the attached drawings.

9.1.2 Locations

The Contractor shall install VW sensors at the centre of the triangular wick drain grid of the locations and depths given in Table 7.

Table 7 – VWP Locations

LOCATION			SECTION TYPE	Approximate Existing Ground Elevation (m)	No. of VWP	Elevation of VWP (m)
LANE	APPROXIMATE STATION MEDIAN C/L	APPROXIMATE OFFSET (**)				
WBL	12+187	ECL	B	227.6	1	225.7
	12+190	ECL			1	223.8
EBL	12+190	ECL	B	226.2	1	224.4
	12+193	ECL			1	222.5
WBL	12+235	ECL	C	225.5	1	223.8
	12+241	ECL			1	222.1
EBL	12+230	ECL	C	224.9	1	223.3
	12+236	ECL			1	221.7
WBL (West of Itzcauld Creek)	13+321	ECL	B	215.2	1	210.0
	13+324	ECL			1	207.0
EBL (West of Itzcauld Creek)	13+337	20 m R of Median C/L	F	214.4	1	211.9
	13+340				1	209.8
	13+343				1	205.3
WBL (East of Itzcauld Creek)	13+334	ECL	A	215.1	1	209.1
	13+342	ECL			1	211.0
	13+345				1	209.1
	13+348				1	204.4
EBL (East of Itcauld Creek)	13+359	20 m R of Median C/L	G	213.3	1	210.0
	13+361				1	209.0
WBL	13+377	ECL	B	215.5	1	211.4
	13+380				1	209.4
EBL	13+377	20 m R of Median C/L	G	214.0	1	207.0
	13+380				1	205.0
WBL	14+632	ECL	B	217.0	1	214.2
	14+635				1	211.4
EBL	14+622	ECL	A	214.9	1	212.2
	14+625				1	209.5
	14+628				1	203.0
	14+622	51 m R of Median C/L			1	209.5
WBL	14+675	39 m L of Median C/L	A	217.3	1	211.4
	14+675	ECL			1	214.2
	14+672				1	211.4
	14+669				1	204.3
EBL	14+675	ECL	B	216.0	1	213.2
	14+678				1	210.4
EBL	15+600	ECL	B	221.5	1	218.5
	15+603				1	215.5
WBL	15+667	ECL	B	221.0	1	219.0
	15+670				1	217.0
EBL	16+845	ECL	C	242.0	1	240.0
	16+851				1	237.0
WBL	16+870	ECL	C	242.8	1	240.5
	16+876				1	238.0
WBL	17+730	ECL	C	258.0	1	256.5*
	17+736				1	256.5*
WBL	18+660	ECL	B	257.2	1	254.2

LOCATION			SECTION TYPE	Approximate Existing Ground Elevation (m)	No. of VWP	Elevation of VWP (m)
LANE	APPROXIMATE STATION MEDIAN C/L	APPROXIMATE OFFSET (**)				
	18+663				1	251.2
EBL	18+657	ECL	B	257.0	1	254.5
	18+660				1	252.0
WBL	18+700	45 m L of Median C/L	A	257.0	1	252.2
	18+694	ECL			1	254.2
	18+697				1	252.2
	18+700				1	250.2
EBL	18+710	55 m R of Median C/L	A	256.8	1	254.2
	18+713	ECL			1	252.2
	18+716				1	250.2
	18+710				1	252.2
WBL	18+752	ECL	C	256.6	1	254.6
	18+758				1	251.6
EBL	18+770	ECL	C	256.2	1	254.2
	18+776				1	251.2
EBL	18+847	ECL	B	257.0	1	254.9
	18+850				1	252.8

Note: (*) Direct push VWP shall be installed at these locations
(**) Embankment Centreline (ECL) refers to the centreline of the embankment of a given lane (EBL or WBL)

Table 8 – RVWP Locations

LOCATION			SECTION TYPE	Approximate Existing Ground Elevation (m)	No. of RVWP	Elevation of RVWP (m)
LANE	STATION ALONG MEDIAN C/L	APPROX. OFFSET FROM MEDIAN CENTRELINE C/L				
EBL	12+190	50 m R of C/L	B	226.2	1	222.5
EBL	13+348	50 m R of C/L	F	214.4	1	209.8
EBL	14+625	70 m R of C/L	A	214.9	1	209.5
EBL	15+600	50 m R of C/L	B	221.5	1	218.5
WBL	16+895	50 m L of C/L	C	242.8	1	238
WBL	17+735	60 m L of C/L	C	258.0	1	256.5*
WBL	18+700	50 m L of C/L	A	257.0	1	254.2

Note: (*) One direct push VWP shall be installed at this location.

9.2 MATERIALS

9.2.1 VW Piezometers

The Contractor shall supply VW borehole piezometers (eg. Geokon model 4500S rated at -5 to 50 psi, or equal); compatible with a data logger (eg. Geokon model 8002-1, 8002-4, 8002-16 data logger, or equal). At sites with known artesian condition, a push-in type piezometer (eg. Geokon model 4500DP, or equal) shall be used instead of a standard VWP. All VW piezometers and data loggers shall be of the same make.

All VWP shall be calibrated prior to installation and the calibration data for each VWP shall be provided to the Contract Administrator.

9.2.2 VW Data Recorder

The Contractor shall supply a VW Data Recorder (eg. Geokon model GK-404, or equal); compatible with the above VW piezometers. All VW equipment shall be of the same make.

9.2.3 Signal Cable

The Contractor shall supply signal cable compatible with the VW equipment. The VWPs shall withstand all of the temperature variations. The length of cable for each piezometer shall be carefully estimated from the construction drawings to ensure that there is enough signal cable for each piezometer to provide enough slack in the borehole and along the trenches until each cable is out of the embankment footprint area where they shall be protected from construction equipment.

9.2.4 Bentonite

The Contractor shall supply bentonite (OPSS 1205) in pellet form in sufficient quantity to form borehole plugs as required.

9.2.5 Filter Sand

The Contractor shall supply clean sand for filter around VW sensors. The sand shall be Sakcrete washed general purpose sand or equal.

9.2.6 Grout

The annular space between the vibrating wire, cables and the borehole shall be filled with cement-bentonite grout prepared as follows: 17.7 kg of bentonite (OPSS 1205), 284 litres of water and 42.6 kg of cement (Type 10 - OPSS 1301).

9.2.7 Trench Burial and Conduit

The signal cable for each piezometer shall be buried in a shallow trench as shown in the attached drawings, and taken out of the embankment footprint area. The Contractor shall supply suitable conduits (e.g. Schedule 40 - 75mm - 3" rigid PVC pipe) to protect the signal cables in the trenches and above ground surface. If appropriate, several signal cables may be housed in a single conduit and laid in a common trench. Before trenches are backfilled, the VW piezometers shall be tested.

9.3 CONSTRUCTION

9.3.1 General

Installation of the VW piezometers shall be as per the manufacturer’s recommendations in addition to what is stated or emphasised below.

9.3.2 Borehole Installation

The borehole shall be advanced to 500 mm below the lowest tip elevation using suitable drilling techniques. The sides of the borehole shall be stable and the borehole shall be free of drilling mud and debris.

The exact borehole location shall be at the centre of the triangular wick drain grid and shall be determined in the field, after the wick drain installation.

9.3.3 Data Logger Boxes and Monitoring Shed

The data logger boxes shall be lockable and weatherproofed and securely attached inside the monitoring shed. The terminal boxes and data logger accessories shall be properly grounded.

The Contractor shall provide appropriate protection against natural hazards including but not limited to lightning strike.

The Contractor shall ensure safe access to the Monitoring Shed at all times including, but not limited to, snow clearing in the winter.

9.3.4 Completion of Installation

It is known that the process of installing VW piezometers can temporarily alter the pore water pressure acting on the piezometer tip. The installation of a VW piezometer shall not be considered to be complete until the pore pressure acting on the piezometer has returned to and stabilized at the value prevailing in the surrounding, unaffected soil mass. The Contractor shall take daily reading of the pore pressures until the value has stabilized. Stabilization shall be deemed to have occurred:

a) When no change in the measured value has occurred over a period of 5 days and the measured value is within 10% of the anticipated hydrostatic value;
b) When the daily rate of change is less than (3) kPa per day for three consecutive days and the measured value is within 5% of the anticipated hydrostatic value;
c) Failing either of the two above conditions, as determined by the Contract Administrator

The Contractor should be prepared to wait for a period of 15 days after completion of installation of instruments for the baseline readings to stabilize.

9.4 COORDINATION WITH MONITORING

9.4.1 Notification

The Contractor shall notify the Contract Administrator no later than 3 days after installing a VW piezometer. At this time, the Contractor shall also supply the following information to the Contract Administrator.

- VW piezometer location, easting, northing;
- Elevations of VWP sensors;
- Stratigraphic log of subsurface conditions, including drilling method notes;
- Dates of installation;
- Installation notes, grounding method, sketches and photographs;
- Model, make and serial number of VW sensors, data logger and signal cable;
- Calibration details of VW sensors.

9.4.2 Monitoring

Monitoring of the VW piezometers, including establishment of baseline data, shall be done by

others. Monitoring shall be conducted during the embankment and surcharge construction. The Contractor shall provide installation information as specified above and provide access to the monitoring shed for data retrieval.

The Contractor shall transfer the Portable Laptop Computer, as specified in Section 9.1.1, and VW Data Recorder to the Contract Administrator, including all of the data logging software and hardware, operating instructions and calibration constants. The contractor shall also transfer the keys for the locks of the Monitoring Shed(s). The contractor shall be available for one site meeting with the Contract Administrator to transfer the items and answer any questions the Contract Administrator may have regarding the data-logging system.

10.0 SETTLEMENT PIN (SP) – SUPPLY & INSTALLATION

10.1 SCOPE

This non-standard special provision contains the requirements for the supply and installation of settlement pins.

The purpose of the settlement pin is to monitor settlement of the culverts and at the top of the embankment. Settlement is measured by surveying the top of the pin with reference to stable non-settling benchmarks.

10.1.1 General Procedure

For the Monitoring Section C and E specified in the Contract, two settlement pins shall be installed on the top of each culvert, one at each end of the culvert. The exact location shall be 0.5m from each end and along the centreline of the culvert.

For other Monitoring Sections, settlement pins shall be installed on the top of embankment or surcharge (if applicable) upon completion of embankment/surcharge construction.

10.1.2 Location

The locations of the culvert settlement pin monitoring sections are given in Table 9.

Table 9 – Approximate Culvert Settlement Pin Locations

LOCATION			SECTION TYPE	
LANE	STATION (*)	CULVERT		SP
WBL	12+075	6A	E	2
EBL	12+075	6B	E	2
WBL	12+235	7A	C	2
EBL	12+235	7B	C	2
WBL	14+740	14	E	2
EBL	14+740	14	E	2
EBL	16+400	24A	E	2
WBL	16+450	24B	E	2
EBL	16+845	25	C	2
WBL	16+875	25	C	2
WBL	17+735	28	C	2
WBL	18+755	32	C	2

EBL	18+775	32	C	2

Note: (*) The stations for the settlement pins are approximate and are located along the median centreline (C/L). All settlement pins shall be installed on top of the culverts and along the culverts centreline based on the locations above. Settlement pins are to be installed 0.5 m from the North and South ends of each culvert.

The locations of the embankment settlement pin monitoring sections are given in Table 10.

Table 10 – Approximate Embankment Settlement Pin Locations

LOCATION		MONITORING SECTION TYPE	No. of SP (*)	NORTH AND SOUTH OFFSET FROM STATION REFERENCE LINE (m)
LANE	STATION			
WBL	12+075	E	2	3
EBL	12+075	E	2	3
WBL	12+190	B	4	6
EBL	12+190	B	4	6
WBL	12+235	C	2	3
EBL	12+235	C	2	3
WBL	13+324	B	4	6
EBL	13+336	F	3	3
WBL	13+343	A	4	6
EBL	13+362	G	3	0
WBL	13+380	B	4	6
EBL	13+380	G	3	0
WBL	14+635	B	4	6
EBL	14+625	A	4	6
WBL	14+675	A	4	6
EBL	14+675	B	4	6
WBL	14+740	E	2	3
EBL	14+740	E	2	3
WBL	15+580	D	4	3
EBL	15+600	B	4	6
WBL	15+670	B	4	6
EBL	16+300	D	4	3
EBL	16+400	E	2	3
WBL	16+450	E	2	3
EBL	16+845	C	2	3
EBL	16+870	D	4	3
WBL	16+875	C	2	3
WBL	17+735	C	2	3
WBL	18+660	B	4	6
EBL	18+660	B	4	6
WBL	18+700	A	4	6
EBL	18+710	A	4	6
WBL	18+755	C	2	3
EBL	18+775	C	2	3
EBL	18+850	B	4	6

Note: (*) All embankment settlement pins will be positioned as per the contract drawings.

10.2 MATERIALS

10.2.1 General

The Contractor shall supply all materials and equipment required for the installation of the culvert and embankment settlement pins.

10.2.2 Pin

The Contractor shall supply a 25.4 mm minimum diameter reinforcing steel bar (OPSS 905) cut 0.15 m long or equal for culvert settlement pins. The Contractor shall supply a 25.4 mm minimum diameter reinforcing steel bar (OPSS 905) cut 0.4 m long or equal for embankment settlement pins.

The top of the reinforcing steel bar shall be angled or rounded in such a way that a single survey point can be clearly identified and repeated.

10.2.3 Concrete

The Contractor shall supply concrete (OPSS 1350) with strength and set time sufficient to secure the pin within two days of pouring.

10.3 CONSTRUCTION

10.3.1 General

The Contractor shall install settlement pins as per the drawings provided.

10.4 COORDINATION WITH MONITORING

10.4.1 Notification

The Contractor shall notify the Contract Administrator no later than 3 days after installing a settlement pin. At this time, the Contractor shall also supply the following information to the Contract Administrator.

- Settlement pin location, easting and northing;
- Elevation of top of pin;
- Dates of installation and datum readings;
- Installation notes, sketches and photographs;

10.4.2 Monitoring

Monitoring of the settlement pins shall be done by others. Monitoring shall be conducted during the embankment construction. The Contractor shall provide installation information as specified above and provide access to the settlement pins for settlement monitoring.

11.0 HORIZONTAL/VERTICAL SHAPEACCELARRAY (HSAA/VSAA)

11.1 SCOPE

This section contains the requirements for the supply and installation of horizontal and vertical ShapeAccelArrays (HSAA and VSAA) systems, data loggers and portable readout device. These instruments shall be installed under the direct supervision of a representative of Measurand (supplier of the instrument) to be arranged by the contractor.

The purpose of the Horizontal SAA (HSAA) is to monitor foundation settlement across the embankment base. The purpose of the Vertical SAA (VSAA) is to monitor lateral displacement

in the foundation soils due to embankment construction.

11.1.1 General Procedure

The installation procedure for the SAA summarized in the Measurand Product Manual (2013) for the ShapeAccelArray shall be followed.

The Contractor shall verify with the selected manufacturer that the designated model, or the updated version, or allowed equal, meets the design performance outlined by the contract drawings and specifications.

11.1.2 Location

The locations of the HSAA and VSAA systems are given in Table 11.

Table 11 – Approximate SAA Locations

LOCATION			TYPE	APPROXIMATE LENGTH/DEPTH (m) (*)
LANE	STATION ALONG MEDIAN C/L	APPROXIMATE OFFSET FOR VSSA		
EBL	14+635	46 m R of Median C/L	VSAA	20
EBL	14+635	Below Embankment	HSAA	60
WBL	18+710	35 m L of Median C/L	VSAA	20
WBL	18+710	Below Embankment	HSAA	55

Note: (*) Final length/depth shall be determined based on careful measurement of the embankment base width for HSAA and drilling the borehole and installing PVC conduit for VSAA.

11.2 MATERIALS

11.2.1 General

The Contractor shall supply all materials and equipment required for the installation of the SAA System.

11.2.2 SAA Systems

The Contractor shall supply the SAA system, model SAAF, manufactured by Measurand Inc, Fredericton, New Brunswick. The SAA system shall be constructed to the lengths shown in Table 11. The lengths shall be confirmed on site and based on careful measurement of the embankment base width for HSAA and after drilling the borehole (ie. with known bedrock elevation) and installing PVC conduit for VSAA. The depth of VSAA embedment in bedrock and the horizontal extent of HSAA beyond embankment/berm footprint are shown in the Contract Drawings. The SAA system shall have segment lengths of 500 mm.

Sufficient cable to extend the SAA to the data logger shall be purchased from Measurand.

Only SAA splice kits, manufactured by Measurand, or "ScotchCast Signal and Control Cable Inline Splicing Kit 72-N1" manufactured by 3M will be used for splicing SAA cables if required. Other splicing kits can only be used with SAA Manufacturer approval.

SAA install kits shall be purchased from Measurand Inc.

11.2.3 PVC Conduit

PVC conduit used for housing the SAA shall have an inside diameter of 27 mm +1 mm / -0.5 mm. Outside diameter shall be 32 mm +/- 1 mm.

11.2.4 Data Logger

The Data Logger components shall be housed in a NEMA 4 rated enclosure. The Data Logger shall contain a CR800, CR1000, or a CR3000 logger, manufactured by Campbell Scientific for collecting data from the SAA system.

Either SAA232 or SAA232-5 logger interface modules shall be used to connect the SAA systems to the logger communications ports. Only one interface shall be connected per logger communications port.

A 12 V 100 Ah deep cycle absorbed glass mat (AGM) battery shall be supplied to provide power for the logger and SAA system. The battery shall be replaced by the Contractor as necessary.

The battery shall be housed in a separate NEMA 3R rated enclosure or the monitoring shed.

A solar panel not exceeding 50 W of rated power shall be used to charge the battery for the SAA data logger. A single solar panel may be used to charge both the SAA logger(s) and VW logger(s) provided there is sufficient power for both. A 12 V regulator to control battery charging via the solar panel shall be used. The solar panel shall be maintained operational for the duration of the monitoring period.

11.2.5 Portable Read-Out System

The portable read-out system shall be composed of the portable laptop computer as specified in Section 9.1.1, SAARecorder Software from Measurand, and one of the following:

- SAAUSB, manufactured by Measurand Inc., or
- SAA Field Unit, manufactured by Measurand Inc.

11.2.6 Grout – VSAA Only

The annular space between the PVC Conduit and the borehole shall be filled with cement-bentonite grout prepared as follows: 17.7 kg of bentonite (OPSS 1205), 284 gallons of water and 94 lb of cement (Type 10 - OPSS 1301).

11.2.7 Trench Burial and Conduit

The conduit and signal cable shall be buried in a shallow trench as shown in the Contract

drawings, and taken out of the embankment footprint area. Before trenches are backfilled, the SAA systems shall be tested.

11.2.8 Trench Bedding Sand

The Contractor shall supply clean washed sand with the following gradation:

MTO Sieve Designation	Percentage Passing
4.5 mm - #4	100%
2 mm - #10	80% - 100%
850 µm - #20	20% - 100%
425 µm - #40	5% - 40%
150 µm - #100	0% - 5%

11.2.9 Geotextile Fabric

The Contractor shall supply a geotextile fabric to be used between the trench bedding sand and surrounding ground.

11.3 CONSTRUCTION

11.3.1 General

The Contractor shall install SAA systems as per the Contract drawings and the Measurand Product Manual. The Contractor shall be responsible for providing adequate security and protection of the instrumentation during construction, including proper earth grounding and lightning protection.

Installation of the SAA systems shall be carried out in accordance with the manufacturer's handling and installation specifications.

11.3.2 Instrument and Conduit Assembly (HSAA)

The instrument and conduit assembly shall be carried out in accordance with the following procedure:

a. The PVC conduit shall be assembled in a generally flat area using PVC cement suitable for the temperature and weather conditions.
b. The SAA reel shall be placed on a reel stand with a minimum height of 630 mm. The reel shall be placed on the reel stand such that the SAA will be pulled from the bottom of the reel.
c. The SAA shall be pulled into the conduit using a rope or a cable with swivel attachment.
d. The X-marks shown on the SAA shall be marked onto both ends of the PVC conduit. The X-marks on the PVC will be verified to make sure that the PVC is not twisted.
e. The end cap shall be glued onto the bottom end of the conduit, at the eyelet end of the SAA.
f. The PEX at the cable end of the SAA shall be secured to the conduit using the set-screw assembly provided in the SAA installation kit.

11.3.3 Horizontal Installation (HSAA)

Horizontal installation of the SAA system shall be done in accordance with the following procedure:

a. The SAA and PVC conduit assembly shall be installed into a trench no less than 400 mm deep by 400 mm wide.
b. The trench shall be lined with a geotextile used to provide separation between the surrounding soil and embankment fill and the bedding sand fill. The geotextile shall be dimensioned so that it can be wrapped over top of the bedding sand fill.
c. A layer of bedding sand shall be placed in the trench above the geotextile. This layer shall be 200 mm thick.
d. The SAA and PVC conduit assembly shall be placed into the trench on top of the bottom layer of bedding sand (200 mm thick).
e. A survey target shall be attached at the reference end of the instrument.
f. A layer of bedding sand shall be placed above the SAA and PVC conduit assembly. This layer shall be 200 mm thick.
g. The geotextile shall be wrapped over the top of the bedding sand, such that there is at least 150 mm of overlap in the geotextile.
h. The trench shall then be covered with a 100 mm thick layer of sand.
i. The location and elevation of the survey target shall be installed as per the Contract Drawings.

11.3.4 Vertical Installation (VSAA)

Vertical installation of the SAA system shall be done in accordance with the following procedure:

a. The PVC will be installed and grouted in using the appropriate grout mix as per Section 8.2.6
b. In order to avoid curving of the PVC due to buoyancy effects, the PVC conduit shall be filled with steel chain with ¾" wide links. The chain shall remain in the PVC during the grout curing process, and will be removed only once the grout has set (7 day cure minimum)
c. Once the grout has set, the SAA reel shall be placed on a reel stand with a minimum height of 630 mm. The reel stand shall be placed 1.0 to 1.6 m from the borehole. The reel shall be placed on the reel stand such that the SAA will be pulled from the top of the reel.
d. When installing the SAA into the PVC:
    i. The joint angles measured between two consecutive segments shall not exceed 135 degrees.
    ii. The SAA shall be placed into the PVC such that it does not come into contact with any sharp edges which will abrade the coverings.
    iii. The SAA will be allowed to turn freely during installation down hole in order to prevent twist in the instrument
    iv. The communications cable for the SAA shall not be used to pull on the SAA. The PEX tubing at the top of the SAA shall be used for this purpose. If the PEX tubing is not long enough for SAA handling, a PEX extension kit, manufactured by Measurand Inc., shall be used to extend the PEX tubing to the appropriate length.
e. Once the SAA is inserted into the PVC, the SAA shall be lifted up from the bottom of the conduit a minimum of 0.3 m. At this time, the X-mark shown on the SAA shall be oriented in the direction of expected movement. **If the SAA does not move freely, lower the SAA and determine the azimuth of the X-mark alignment for software**

correction.

f. The SAA shall be lowered into the conduit and up to 50 lbs of axial compression shall be applied to the PEX. Once the axial compression is applied, the set-screw assembly from the SAA Install Kit shall be tightened to hold the SAA in compression.
g. The azimuth of the X-mark shall be noted and marked on the final drawings.

11.3.5 Data Logger and Monitoring Shed

The data logger shall be lockable and weatherproofed and securely attached inside the monitoring shed. The electronics and data logger accessories shall be properly grounded.

The Contractor shall provide appropriate protection against natural hazards including but not limited to lightning strike.

The Contractor shall ensure safe access to the Monitoring Shed at all times including, but not limited to, snow clearing in the winter.

11.4 COORDINATION WITH MONITORING

11.4.1 Notification

The Contractor shall notify the Contract Administrator no later than 3 days after installing a VSAA or HSAA. At this time, the Contractor shall also supply the following information to the Contract Administrator.

- Stratigraphic log of subsurface conditions including drilling methodologies for VSAA.
- Submit a list of all HSAAs and VSAAs with the instrument, signal cable, and the PVC Conduit/SAA lengths;
- Submit manufacturer calibration sheets for all installed HSAAs and VSAAs;
- Instrument identification and serials numbers;
- Northing, Easting and top and bottom Elevations of the VSAAs;
- Northing, Easting and Elevations of the survey target, reference sensor and every 10 m along the length of the HSAAs.
- Installation depth and azimuth direction of X-marks;
- Dates of installation and datum readings;
- Installation notes, sketches and photographs;

11.4.2 Monitoring

The entire system set-up shall be tested and verified prior to leaving the site. Once this is done, the logger memory shall be cleared prior to uploading and starting the site monitoring logger program.

Monitoring of the SAA systems, including establishment of baseline data, shall be done by others. Monitoring shall be conducted during the embankment and surcharge construction. The Contractor shall provide installation information as specified above and provide access to the monitoring shed for data retrieval.

The Contractor shall transfer the Portable Laptop Computer and SAA portable readout system to the Contract Administrator, including all of the data logging software and hardware, operation instructions and calibration constants. The contractor shall also transfer the keys for

the locks of the Monitoring Shed(s). The contractor shall be available for one site meeting with the Contract Administrator to transfer the items and answer any questions the Contract Administrator may have regarding the data-logging system.

12.0 DATA LOGGER AND DATA RETRIEVAL

The signal cables from the VWP, RVWP and DSS shall be connected to the nearest data logger. Data loggers such as Geokon LC-2 Series Model 8002-1 (single channel), 8002-4 (four channel) and/or 8002-16 (16 channel) or equal shall be used. The data logger shall include, but not be limited to, interface modules, interface cables, data logger retrieval computer software, power supplies, solar panels, charge regulators and batteries that will allow for 7 years of regular monitoring. All data loggers shall be of the same make and shall be compatible with the DSS, VWP and RVWP instruments.

Data logger for vertical/horizontal SAA systems shall be as summarized in Section 8.2.4.

The contractor shall submit a detailed proposal on the setup of the data-logger (ie. Numbers and locations of the data-logger units) to the Contract Administrator for review and approval, prior to ordering the data-loggers. An effort should be made to minimize the amount of data loggers at each site location to ease data retrieval. The contractor shall program the data loggers according to the following:

- DSS, VWP, RVWP, HSAA and VSAA data shall be recorded eight times a day (one reading every 3 hours)

The data shall be retrieved on site by direct wire (eg. RS232 or USB Cable) with a portable laptop computer.

12.1.1 Portable Laptop Computer

The Contractor shall supply a laptop computer, Lenovo X140e or equal, equipped with a 128 gigabyte (gb) solid state drive, 4 gb of RAM, two batteries, Microsoft Windows 7 Professional, Microsoft Office Home and Business 2013, Adobe Acrobat XI Standard and data logger software compatible with the selected data logger system.

The portable laptop computer shall be handed to the Contract Administrator after the installation of instruments for the Monitoring Program.

The calibration factors for all vibrating wire and SAA instruments shall be entered in the portable laptop computer by the Contractor for initialization of the instruments.

12.1.2 Protection for Long-Term Monitoring (Monitoring Shed)

At each site, the data-logger and all associated accessories shall be installed in a walk-in (minimum 2 m x 2 m) monitoring shed to prevent vandalism and wear-out of the data-loggers against extreme weather. The monitoring shed shall have a shelf to support the laptop computer during data download. The solar panel shall be securely mounted to the top of the monitoring shed in a way to maximize the hours of daylight. The monitoring shed shall be a lockable and weather proof enclosure surrounded by a 6 ft high chain-link fence and lockable gate. The monitoring shed shall also be seated on a stable gravel pad and secured to the ground. All data loggers and associated accessories shall be properly grounded and protected from lightning

strike. The contractor shall submit a detailed proposal of the monitoring sheds (ie. materials, location(s), etc) to the Contract Administrator for review and approval, prior to construction.

13.0 DECOMMISSIONING OF INSTRUMENTS

The Contractor shall decommission all the Settlement Rods (SR) and Settlement Pins (SP) at the end of the monitoring program following construction unless advised otherwise by the Contract Administrator. The Benchmarks (BM), Slope Inclinometers (SI), Digital Settlement System (DSS), VW Piezometers (VWP) and Vertical and Horizontal ShapeAccelArray (VSAA and HSAA) shall not be decommissioned unless advised otherwise by the Contract Administrator. Decommissioning of instrumentation shall be carried out according to the Ontario Water Resources Act, R.R.O. 1990, Regulation 903.

14.0 MEASUREMENT FOR PAYMENT

Measurement for Payment for the Supply and Installation of Embankment Monitoring Equipment shall be Lump Sum.

15 BASIS OF PAYMENT

Payment at contract price for this tender item shall be full compensation for all labour, monitoring equipment and materials to do the work.

MONITORING PROGRAM – Item No.

Special Provision

1.0 GENERAL

Requirements specified for Specialist Qualifications; Services, Deliverables and Records; and the Foundation Monitoring Plan apply to all the Instrumentation Monitoring. Instrumentation monitoring is required for the following items:

- Slope Inclinometer (SI)
- Vertical ShapeAccelArray (VSAA)
- Survey Benchmarks (BM)
- Settlement Rods (SR)
- Digital Settlement System (DSS)
- Horizontal ShapeAccelArray (HSAA)
- Settlement Pins (SP)
- Vibrating Wire Piezometers (VWP)

The instrumentation monitoring services include:

1. Data collection, data reduction and reporting;
2. Adherence to criteria used to assess the embankment performance based on the monitoring data collected from the instrumentation installed by others.
3. Interpretation of instrumentation readings for the purpose of providing geotechnical input for ongoing embankment construction

1.0.1 Or equal

The term, "*or equal*", shall be understood to indicate that the equal product is the same or better than the specified product in function, performance, reliability, quality and general configuration.

1.0.2 Specialist Qualifications

The Foundation Engineering Consultant services required for this assignment have been categorized ***Geotechnical*** specialty – **High Complexity**.

The Foundation Engineering Consultants that are registered in MTO's consultant acquisition system (RAQS) at complexity ratings in the required specialty that meet or exceed the identified complexity requirement for this assignment are eligible to provide Foundation Engineering services for this project. The Foundation Monitoring Consultant shall not be the same Geotechnical Consultant retained by the Contractor for the supply and installation of embankment monitoring equipment.

The Foundation Monitoring services shall be provided by the Foundation Engineering Designer (Service Provider) for this project to allow for timely management of the ground improvement works and minimize any delays in the construction schedule.

1.0.3 Services, Deliverables and Records

The Foundation Monitoring Consultant shall:

- Review the Monitoring Program and, if deemed necessary, submit in writing to the Contract Administrator recommendations for modifications to the Monitoring Program;
- Review the proposal of installation of DSS, VSAA, HSAA and data logger setup by the Contractor;
- Review the reading frequency (ie. number of readings taken per day per instrument) to be programed and saved in the data loggers based on the available data logger storage capacity;
- Meet with the Contractor in order to receive the VW Data Recorder, SAA Portable Readout Unit, Portable Laptop Computer and associated software used for monitoring vibrating wire and SAA instruments and to receive reports with details about installation of instruments installed by the Contractor, as specified in special provision entitled "Supply and Installation of Embankment Monitoring Equipment", included in the contract documents. Contractors reports shall include all calibration certificates;
- The Foundation Monitoring Consultant is required on site to establish the baseline readings. The Contract Administrator staff may take all other required readings provided they are immediately forwarded to the Foundation Monitoring Consultant.
- With the exception of the Portable Laptop Computer, VW Data Recorder and SAA Portable Readout Unit, referred to above, and all instruments installed by the Contractor, supply all materials and equipment (e.g. slope inclinometer probe, cable and readout unit) that are required for the Monitoring Program;
- Calibrate and maintain monitoring equipment;
- Take selected instrument readings, reduce data, prepare reports;
- Provide transmittal of instrumentation readings and reports to the Contract Administrator;
- Interpret instrumentation readings as needed for the purposes of ongoing construction;
- Notify the Contract Administrator of required modifications to the construction procedures accordingly, if necessary. Interpretation shall include making correlations between instrumentation data and specific construction activities;
- Notify the Contract Administrator within 24 hours if review measurement readings, as specified herein, for any instrumentation are reached;
- Discuss within 48 hours with the Contract Administrator response action(s), and submit a plan of actions, to prevent the critical instrument readings (ie. review/alert levels) from being exceeded.

A monthly progress report shall be submitted to the Contract Administrator, MTO Contract Control Officer and MTO Foundation Engineer. Monthly reports shall be issued from the

beginning of construction monitoring to the end of one month period after the top of preload is reached. The progress report shall discuss the Contractor's operations with respect to the installation of instrumentation and/or a summary of the monitoring that was completed for the month.

The Contract Administrator shall maintain a Foundations Monitoring diary and shall provide this diary to the Foundation Monitoring Consultant. The diary shall document original conditions, work in progress, including extent and height of fill placement, any unusual or problem situations that arise, record of actions taken by the Contractor to rectify the situation, and restored conditions. The diary shall be supported by photographs of these conditions.

1.0.4 Submission of Foundation Monitoring Plan

The Foundation Monitoring Consultant shall, in a brief narrative, discuss the applicable experience and qualifications of specialist staff, the role that each will play in administration of the contract, the authority to be assumed, and the reporting relationships with the construction administration staff.

The Consultant shall also complete the Foundation Monitoring Plan table in the format provided below.

Foundation Monitoring Plan		
Major Monitoring Tasks	**Level of Monitoring**	**Deliverable Record(s)**
List major monitoring tasks associated with foundation monitoring.	State frequency/level of monitoring.	List associated Deliverable Records for each task.

1.1 PURPOSE

The purpose of these instruments is to monitor lateral displacements, settlements and pore water pressures in the foundation soils at selected locations during construction of the embankments along Highway 11/17 from Red Rock to Nipigon, Ontario.

The rate of fill placement, waiting period between successive stages of fill, the timing for the removal of surcharge and the construction of culverts shall be controlled by the instrumentation readings.

The instrumentation shall not be decommissioned unless instructed by the Contract Administrator after discussion with and concurrence from MTO.

1.2 DRAWINGS

Reference shall be made to the drawings titled Embankment Monitoring Equipment – Plan, Sections and Details included in the Contract Package and as listed below:

- Typical Monitoring Section A
- Typical Monitoring Section B
- Typical Monitoring Section C
- Typical Monitoring Section D
- Typical Monitoring Section E
- Typical Monitoring Section F
- Typical Monitoring Section G
- Monitoring Section Location Plan STA. 12+050 to 12+250
- Monitoring Section Location Plan STA. 13+280 to 13+430
- Monitoring Section Location Plan STA. 14+570 to 14+780
- Monitoring Section Location Plan STA. 15+500 to 15+720
- Monitoring Section Location Plan STA. 16+250 to 16+450
- Monitoring Section Location Plan STA. 16+800 to 16+940
- Monitoring Section Location Plan STA. 17+650 to 17+950
- Monitoring Section Location Plan STA. 18+600 to 19+000
- Monitoring Instrument Details #1
- Monitoring Instrument Details #2
- Monitoring Instrument Details #3

1.3 SUBSURFACE CONDITIONS

The subsurface conditions at the sites are described in the following reports:

- Foundation Investigation Report, High Embankments and Deep Cuts, Highway 11/17 Red Rock to Nipigon from 4.8 kM West of Highway 628 to 1.5 kM West of Highway 585, Township of Nipigon, G.W.P. 647-89-00, Geocres No. 52A-180, Date October 1, 2014 – Thurber Engineering Limited.
- Foundation Investigation Report, Low to Medium Embankments, Highway 11/17 Red Rock to Nipigon from 4.8 kM West of Highway 628 to 1.5 kM West of Highway 585, Township of Nipigon, G.W.P. 647-89-00, Geocres No. 52A-182, Date October 1, 2014 – Thurber Engineering Limited.
- Foundation Investigation Report, Itzcaulde Creek Culvert, Highway 11/17 Red Rock to Nipigon from 4.8 kM West of Highway 628 to 1.5 kM West of Highway 585, Township of Nipigon, G.W.P. 647-89-00, Geocres No. 52A-179, Date June 18, 2014 – Thurber Engineering Limited.
- Foundation Investigation Report, Culverts, Supplementary Embankments and Cut Slopes, Highway 11/17 Red Rock to Nipigon from 4.8 kM West of Highway 628 to 1.5 kM West of Highway 585, Township of Nipigon, G.W.P. 647-89-00, Geocres No. 52A-184, Date October 3, 2014 – Thurber Engineering Limited.

1.4 EQUIPMENT OPERATION

Monitoring shall be conducted year round. Monitoring equipment supplied by the Foundation Monitoring Consultant shall be maintained and rendered operational throughout the monitoring period.

1.5 READING SCHEDULE AND FREQUENCY

The Foundation Monitoring Consultant shall save and archive raw data in electronic and hard copy format.

Monitoring shall commence immediately after the installation of an instrument. Monitoring is to continue during a period from the date of instrument installation to three years following surcharge removal.

The minimum monitoring frequencies along with the anticipated number of readings for the Highway 11/17 embankments are given in the following sections. The monitoring frequency is the same for each individual instrument except SR and SP which are not required for long term monitoring. Instruments shall be read more or less frequently if determined to be required by the Contract Administrator.

It should be noted that the number of readings given in the following sections are approximate and may vary due to uncertainties associated with the embankment performance.

1.5.1 Minimum Monitoring Frequency

The minimum monitoring frequency for the instruments is summarized in the following section.

Table 1 Minimum Monitoring Frequency of Highway 11/17 Embankments
for Sta. 12+050 to 12+100 (EBL/WBL)

STAGE	**FREQUENCY**	**ANTICIPATED NUMBER OF READINGS PER MONITORING SECTION AND PER LANE(*)**
Baseline Reading(**)	3 readings on 3 consecutive days, no sooner than 15 days following installation	3
Immediately prior to start of embankment construction	Once	1
During embankment construction	Once every 1.5 m lift and following placement of last lift	Minimum once per day but not less than 5 readings over the period of embankment construction
During preload period (anticipated duration: 5 months)	Weekly - For Month 1 Once every 2 Weeks - For Month 2 Monthly - For Months 3 to 5	 4 2 4
For a period of 3 years following preload (Long Term Monitoring)	Once on Months - 1, 3, 6, 12, 18, 24, 30, 36	8

Note: (*) Due to the uncertainty of the construction schedule, or the possibility that the embankments at various locations may be constructed independently at various times, the number of readings may be greater than shown above.

(**) Baseline Readings: Value of instrumentation readings taken prior to construction to provide a baseline against which all subsequent readings are compared to assess movements of ground and changes in piezometric head.

Table 2 Minimum Monitoring Frequency of Highway 11/17 Embankments
for Sta. 12+170 to 12+270 (EBL/WBL)

STAGE	**FREQUENCY**	**ANTICIPATED NUMBER OF READINGS PER MONITORING SECTION AND PER LANE(*)**
Baseline Reading(**)	3 readings on 3 consecutive days, no sooner than 7 days following installation	3
Immediately prior to start of embankment construction	Once	1
During embankment construction	Once every 1.5 m lift and following last lift	Minimum once per day but not less than 7 readings over the period of embankment construction
During preload period (anticipated duration: 10 months)	Weekly - For Month 1 Once every 2 Weeks - For Month 2 Monthly - For Months 3 to 10	 4 2 9
For a period of 3 years following preload (Long Term Monitoring)	Once on Months - 1, 3, 6, 12, 18, 24, 30, 36	8

Note: (*) Due to the uncertainty of the construction schedule, or the possibility that the embankments at various locations may be constructed independently at various times, the number of readings may be greater than shown above.

(**) Baseline Readings: Value of instrumentation readings taken prior to construction to provide a baseline against which all subsequent readings are compared to assess movements of ground and changes in piezometric head.

Table 3 Minimum Monitoring Frequency of Highway 11/17 Embankments

for Sta. 13+300 to 13+450 (EBL/WBL)

STAGE	**FREQUENCY**	**ANTICIPATED NUMBER OF READINGS PER MONITORING SECTION AND PER LANE(*)**
Baseline Reading(**)	3 readings on 3 consecutive days, no sooner than 7 days following installation	3
Immediately prior to start of embankment construction	Once	1
During Stage 1 embankment construction	Once every 1.5 m lift and following last lift	Minimum once per day but not less than 5 readings over the period of embankment construction
During Stage 1 waiting period (anticipated duration: 6 months)	Weekly - For Month 1 Once every 2 Weeks - For Month 2 Monthly - For Months 3 to 6	 4 2 5
During Stage 2 embankment construction	Before and after fill placement	Minimum once per day but not less than 2 readings over the period of embankment construction
During Stage 2 waiting period (anticipated duration: 6 months)	Weekly - For Month 1 Once every 2 Weeks - For Month 2 Monthly - For Months 3 to 6	 4 2 5
For a period of 3 years following surcharge removal (Long Term Monitoring)	Once on Months - 1, 3, 6, 12, 18, 24, 30, 36	8

Note: (*) Due to the uncertainty of the construction schedule, or the possibility that the embankments at various locations may be constructed independently at various times, the number of readings may be greater than shown above.

(**) Baseline Readings: Value of instrumentation readings taken prior to construction to provide a baseline against which all subsequent readings are compared to assess movements of ground and changes in piezometric head.

Table 4 Minimum Monitoring Frequency of Highway 11/17 Embankments

for Sta. 14+425 to 14+800 (EBL/WBL)

STAGE	**FREQUENCY**	**ANTICIPATED NUMBER OF READINGS PER MONITORING SECTION AND PER LANE(*)**
Baseline Reading(**)	3 readings on 3 consecutive days, no sooner than 7 days following installation	3
Immediately prior to start of embankment construction	Once	1
During Stage 1 embankment construction	Once every 1.5 m lift and following last lift	Minimum once per day but not less than 4 readings over the period of embankment construction
During Stage 1 waiting period (anticipated duration: 6 months)	Weekly - For Month 1 Once every 2 Weeks - For Month 2 Monthly - For Months 3 to 6	 4 2 5
During Stage 2 embankment construction	Once every 1.5 m lift and following last lift	Minimum once per day but not less than 2 readings over the period of embankment construction
During Stage 2 waiting period (anticipated duration: 6 months)	Weekly - For Month 1 Once every 2 Weeks - For Month 2 Monthly - For Months 3 to 6	 4 2 5
During Stage 3 embankment construction	Before and after fill placement	Minimum once per day but not less than 2 readings over the period of embankment construction
During Stage 3 waiting period (anticipated duration: 6 months)	Weekly - For Month 1 Once every 2 Weeks - For Month 2 Monthly - For Months 3 to 6	 4 2 5
For a period of 3 years following surcharge removal (Long Term Monitoring)	Once on Months - 1, 3, 6, 12, 18, 24, 30, 36	 8

Note: (*) Due to the uncertainty of the construction schedule, or the possibility that the embankments at various locations may be constructed independently at various times, the number of readings may be greater than shown above.

(**) Baseline Readings: Value of instrumentation readings taken prior to construction to provide a baseline against which all subsequent readings are compared to assess movements of ground and changes in piezometric head.

Table 5 Minimum Monitoring Frequency of Highway 11/17 Embankments
for Sta. 15+500 to 15+725 (EBL/WBL)

STAGE	**FREQUENCY**	**ANTICIPATED NUMBER OF READINGS PER MONITORING SECTION AND PER LANE(*)**
Baseline Reading(**)	3 readings on 3 consecutive days, no sooner than 7 days following installation	3
Immediately prior to start of embankment construction	Once	1
During embankment construction	Once every 1.5 m lift and following last lift	Minimum once per day but not less than 3 readings over the period of embankment construction
During preload period (anticipated duration: 12 months)	Weekly - For Month 1 Once every 2 Weeks - For Month 2 Monthly - For Months 3 to 12	 4 2 11
For a period of 3 years following preload (Long Term Monitoring)	Once on Months - 1, 3, 6, 12, 18, 24, 30, 36	8

Note: (*) Due to the uncertainty of the construction schedule, or the possibility that the embankments at various locations may be constructed independently at various times, the number of readings may be greater than shown above.

(**) Baseline Readings: Value of instrumentation readings taken prior to construction to provide a baseline against which all subsequent readings are compared to assess movements of ground and changes in piezometric head.

Table 6 Minimum Monitoring Frequency of Highway 11/17 Embankments for Sta. 16+425 to 16+450 (EBL)

STAGE	**FREQUENCY**	**ANTICIPATED NUMBER OF READINGS PER MONITORING SECTION AND PER LANE(*)**
Baseline Reading(**)	3 readings on 3 consecutive days, no sooner than 7 days following installation	3
Immediately prior to start of embankment construction	Once	1
During embankment construction	Once every 1.5 m lift and following last lift	Minimum once per day but not less than 3 readings over the period of embankment construction
During preload period (anticipated duration: 4 months)	Weekly - For Month 1 Once every 2 Weeks - For Month 2 Monthly - For Months 3 to 4	4 2 3
For a period of 3 years following preload (Long Term Monitoring)	Once on Months - 1, 3, 6, 12, 18, 24, 30, 36	8

Note: (*) Due to the uncertainty of the construction schedule, or the possibility that the embankments at various locations may be constructed independently at various times, the number of readings may be greater than shown above.

(**) Baseline Readings: Value of instrumentation readings taken prior to construction to provide a baseline against which all subsequent readings are compared to assess movements of ground and changes in piezometric head.

Table 7 Minimum Monitoring Frequency of Highway 11/17 Embankments for Sta. 16+830 to 16+940 (EBL/WBL)

STAGE	**FREQUENCY**	**ANTICIPATED NUMBER OF READINGS PER MONITORING SECTION AND PER LANE(*)**
Baseline Reading(**)	3 readings on 3 consecutive days, no sooner than 7 days following installation	3
Immediately prior to start of embankment construction	Once	1
During embankment construction	Once every 1.5 m lift and following last lift	Minimum once per day but not less than 3 readings over the period of embankment construction
During preload period (anticipated duration: 12 months)	Weekly - For Month 1 Once every 2 Weeks - For Month 2 Monthly - For Months 3 to 12	 4 2 11
For a period of 3 years following preload (Long Term Monitoring)	Once on Months - 1, 3, 6, 12, 18, 24, 30, 36	8

Note: (*) Due to the uncertainty of the construction schedule, or the possibility that the embankments at various locations may be constructed independently at various times, the number of readings may be greater than shown above.

(**) Baseline Readings: Value of instrumentation readings taken prior to construction to provide a baseline against which all subsequent readings are compared to assess movements of ground and changes in piezometric head.

Table 8 Minimum Monitoring Frequency of Highway 11/17 Embankments
for Sta. 17+675 to 17+925 (EBL/WBL)

STAGE	**FREQUENCY**	**ANTICIPATED NUMBER OF READINGS PER MONITORING SECTION AND PER LANE(*)**
Baseline Reading(**)	3 readings on 3 consecutive days, no sooner than 7 days following installation	3
Immediately prior to start of embankment construction	Once	1
During Stage 1 embankment construction	Once every 1.5 m lift and following last lift	Minimum once per day but not less than 5 readings over the period of embankment construction
During Stage 1 waiting period (anticipated duration: 5 months)	Weekly - For Month 1 Once every 2 Weeks - For Month 2 Monthly - For Months 3 to 5	 4 2 6
During Stage 2 embankment construction	Once every 1.5 m lift and following last lift	Minimum once per day but not less than 3 readings over the period of embankment construction
During Stage 2 waiting period (anticipated duration: 5 months)	Weekly - For Month 1 Once every 2 Weeks - For Month 2 Monthly - For Months 3 to 5	 4 2 6
For a period of 3 years following preload (Long Term Monitoring)	Once on Months - 1, 3, 6, 12, 18, 24, 30, 36	8

Note: (*) Due to the uncertainty of the construction schedule, or the possibility that the embankments at various locations may be constructed independently at various times, the number of readings may be greater than shown above.

(**) Baseline Readings: Value of instrumentation readings taken prior to construction to provide a baseline against which all subsequent readings are compared to assess movements of ground and changes in piezometric head.

Table 9 Minimum Monitoring Frequency of Highway 11/17 Embankments
for Sta. 18+600 to 18+950 (EBL/WBL)

STAGE	**FREQUENCY**	**ANTICIPATED NUMBER OF READINGS PER MONITORING SECTION AND PER LANE(*)**
Baseline Reading(**)	3 readings on 3 consecutive days, no sooner than 7 days following installation	3
Immediately prior to start of embankment construction	Once	1
During Stage 1 embankment construction	Once every 1.5 m lift and following last lift	Minimum once per day but not less than 3 readings over the period of embankment construction
During Stage 1 waiting period (anticipated duration: 6 months)	Weekly - For Month 1 Once every 2 Weeks - For Month 2 Monthly - For Months 3 to 6	 4 2 5
During Stage 2 embankment construction	Once every 1.5 m lift and following last lift	Minimum once per day but not less than 2 readings over the period of embankment construction
During Stage 2 waiting period (anticipated duration: 6 months)	Weekly - For Month 1 Once every 2 Weeks - For Month 2 Monthly - For Months 3 to 6	 4 2 5
During Stage 3 embankment construction	Before and after fill placement	Minimum once per day but not less than 2 readings over the period of embankment construction
During Stage 3 waiting period (anticipated duration: 6 months)	Weekly - For Month 1 Once every 2 Weeks - For Month 2 Monthly - For Months 3 to 6	 4 2 5
For a period of 3 years following surcharge removal (Long Term Monitoring)	Once on Months - 1, 3, 6, 12, 18, 24, 30, 36	 8

Note: (*) Due to the uncertainty of the construction schedule, or the possibility that the embankments at various locations may be constructed independently at various times, the number of readings may be greater than shown above.

(**) Baseline Readings: Value of instrumentation readings taken prior to construction to provide a baseline against which all subsequent readings are compared to assess movements of ground and changes in piezometric head.

2.0 INSTRUMENTATION SPECIFIC REQUIREMENTS

2.0 MONITORING OF LATERAL FOUNDATION DISPLACEMENTS; SLOPE INCLINOMETERS (SI), VERTICAL SHAPEACCELARRAYS (VSAA)

2.0.1 Equipment

The Foundation Monitoring Consultant retained by the Contract Administrator shall supply an inclinometer probe, a control cable of adequate length to read all the slope inclinometers, a readout unit and the required accessories for the slope inclinometer monitoring. The slope inclinometer system shall consist of a DigiTilt AT Inclinometer System, or equal.

The slope inclinometer shall be read by an experienced geotechnical technologist or geotechnical engineer. It is critical to use one slope inclinometer probe, one control cable and one readout unit exclusively throughout the monitoring program. If any of this equipment is exchanged for another, two sets of readings shall be taken one immediately after the other, the first with the original equipment and the second with the replacement equipment. Comparison and corrections shall be made if required. The readings obtained with the replacement equipment shall become the initial (baseline) readings for subsequent readings.

The probe, cable and readout unit shall be calibrated prior to taking baseline readings and following the manufacturers recommended maintenance schedule. Calibration records shall be available upon request by the Contract Administrator.

Slope inclinometer reading shall be taken consistently in either metric or imperial units, never a mixture.

2.0.2 Data Collection

Slope Inclinometer (SI)

Data collection shall be done in accordance with the slope inclinometer probe's manufacturer's recommendations and instructions. Care shall be taken not to take readings with the probe wheels in a casing joint. The readings shall be taken from the bottom of the casing upward.

The convention for the direction and sign of lateral movements shall be:

"A" direction shall be in the direction perpendicular to the embankment centerline
"B" direction shall be in the direction parallel to the embankment centerline
A+ shall be towards the toe of the embankment (away from embankment centerline)
A- shall be towards the centerline of the embankment

One complete data set shall consist of two runs:

Run 1 – with the uppermost wheel in the A+ grove (expected direction of movement)
Run 2 – rotate probe 180^0, with uppermost wheel in the A- grove (opposite expected direction of movement

During fill placement near the inclinometer, additional casing will be installed and the elevation of the top of the inclinometer casing will increase. The slope inclinometer casing shall be extended to accommodate the change in reference point (top of casing) such that the readings are taken at the same elevations for each data set.

Vertical ShapeAccelArray (VSAA)

VSAA shall be read using the SAA portable readout unit during installation and thereafter by SAA Data Loggers via a direct connection with RS232 serial port and a laptop computer supplied by the Contractor.

The readout and data logger units shall be tested prior to taking any baseline readings to ensure functionality. The initial readings shall be obtained in the presence of a Measurand representative.

2.0.3 Reporting

As a minimum, the Contract Administrator shall be notified within 24 hours if critical measurement readings are reached and the following shall be submitted to the Contract Administrator within five (5) working days after each set of readings is obtained:

- Top elevation of the slope inclinometer casing (+/- 2 mm)
- Cumulative and incremental lateral displacement versus depth/elevation plots for both A and B directions
- Cumulative and incremental lateral displacement versus time plots at the elevation(s) of maximum lateral displacement, for both A and B directions
- Fill height vs time
- Plan view, cross section and profile sketches showing the top of fill location while the inclinometer readings were being taken

A brief interpretation of recorded displacements shall be provided. Plots shall clearly show and identify each data set. A sign convention of "+" lateral displacement equal to movement towards the embankment toe (away from the embankment centerline) shall be employed.

2.0.4 Review and Alert Levels

Typically embankment failures result from a displacement after placement of a lift of fill. If any of these conditions is observed or the maximum displacement measured exceeds the Review Levels in Table 10, the Foundation Monitoring Consultant shall immediately inform the Contract Administrator and discuss response action(s). Contract Administrator will advise the Contractor to submit a plan of action(s) to prevent alert levels being reached. The Foundation Monitoring Consultant will review the Contractors plan with the Contract Administrator and provide appropriate recommendations to the Contract Administrator. All construction work shall be continued such that instrument alert levels are not reached.

If the maximum displacement measured exceeds the Alert Levels in Table 10, the Foundation Monitoring Consultant shall immediately inform the Contract Administrator and the Contract Administrator shall instruct the Contractor to stop all construction activities on and within the embankment. No construction shall take place on the affected embankment until all the following conditions are satisfied:

- The cause of the lateral displacement has been identified and analyzed by the Foundation Monitoring Consultant;
- Contract Administrator to ask Contractor to submit a plan of corrective action(s)
- Foundation Monitoring Consultant to review Contractors plan of corrective action and provide recommendations for corrective actions to the Contract Administrator
- Any corrective action deemed necessary by Contract Administrator and the Foundation Monitoring Consultant has been implemented;
- The Contract Administrator deems it is safe to proceed with the construction of the remainder of the embankment.

Table 10 – Review and Alert Levels for Horizontal Displacement Monitoring

Location			**Instrument Type**	**Horizontal Displacement Response Levels (mm)**	
Lane	**STATION ALONG MEDIAN CENTRELINE C/L**	**APPROXIMATE OFFSET FROM MEDIAN C/L**		**Review**	**Alert**
EBL	13+340	20 m R of C/L	SI	25	35
	13+344	29 m R of C/L	SI		
WBL	13+336	36 m L of C/L	SI		
	13+344	27 m L of C/L	SI		
EBL	14+620	31 m R of C/L	SI	75	100
	14+620	46 m R of C/L	SI		
	14+635	46 m R of C/L	VSAA		
WBL	14+678	36 m L of C/L	SI		
	14+678	28 m L of C/L	SI		
WBL	18+703	35 m L of C/L	SI	45	60
	18+703	24 m L of C/L	SI		
	18+710	35 m L of C/L	VSAA		
EBL	18+710	35 m R of C/L	SI		
	18+710	24 m R of C/L	SI		

2.1 MONITORING OF FOUNDATION SETTLEMENT: DIGITAL SETTLEMENT SYSTEM (DSS), HORIZONTAL SHAPEACCELARRAY (HSAA), SETTLEMENT RODS (SR) AND SETTLEMENT PINS (SP)

2.1.1 Surveying

The elevations of the survey target of the horizontal ShapeAccelArray (HSAA), settlement rods (SR) and settlement pins (SP) shall be surveyed to an accuracy of plus/minus three (+/- 2) mm or better and shall be reported to the nearest millimeter.

During each reading of the SRs and SPs, the elevations of top of embankment and top of berm (if applicable) shall be surveyed to an accuracy of plus/minus ten (+/- 10) mm or better and shall be reported to the nearest 10 millimeters.

During the embankment construction, the Contractor will extend all settlement rods, friction protection sleeves and CSP protective surrounds simultaneously prior to the placement of the next lift of fill. The Contractor will notify the Contract Administrator no less than 3 days prior to extending any settlement rod. Surveying of the elevations of the top of rod immediately before and immediately after the extension of SRs to an accuracy of +/- 2 mm is necessary to accurately track the settlement data. The survey of SR length adjustments shall be coordinated with the Contract Administrator and the Contractor.

Surveying for settlement monitoring shall be conducted by a registered surveyor with appropriate equipment and experience. The surveyor shall be retained by the Contract Administrator.

2.1.2 Data Logger and Readout Unit

The DSS shall be read using the Data Recorder and VW Data Loggers via a direct connection with RS232 serial port and a laptop computer supplied by the Contractor.

HSAA shall be read using the SAA portable readout unit during installation and thereafter by SAA Data Loggers via a direct connection with RS232 serial port and a laptop computer supplied by the Contractor.

These readout and data logger units shall be tested prior to taking any baseline readings to ensure functionality.

2.1.3 Reporting

The Contract Administrator shall be notified within 24 hours if critical measurement readings are reached and a brief interpretation of the updated monitoring data shall be reported to the Contact Administrator within five (5) working days after each set of readings is obtained. A full set of up-to-date and processed monitoring data shall be presented in tabular and graphical form in the monthly progress report.

As a minimum the following shall be submitted to the Contract Administrator in the monthly progress report based on the readings collected from HSAA, DSS, SR and SP instruments:

- A plot of settlement of the base of the embankment (HSAAs, DSSs, SRs) versus time and comparison with predicted settlement;
- A plot of settlement of the culvert (SRs and SPs) versus time and comparison with predicted settlement;
- Fill height/top of fill elevation within 20 m of the instruments versus time;
- Plan view, cross section and profile sketches showing the top of fill location of the embankment and berm (if applicable) while the instrument data is collected.

2.1.4 Review and Alert Levels

Typically embankment failures result from an acceleration of settlements after placement of a lift of fill. If any of these conditions is observed or the maximum settlement measured exceeds the Review Levels in Table 11, the Foundation Monitoring Consultant shall immediately inform the Contract Administrator and the Contract Administrator will request the Contractor for plan of action(s). The Foundation Monitoring Consultant will review the plan of action(s) submitted by the Contractor to prevent alert level being reached and provide recommendations to the Contract Administrator. All construction work shall be continued such that instrument alert levels are not reached.

If the maximum settlement measured exceeds the Alert Levels in Table 11, the Foundation Monitoring Consultant shall immediately inform the Contract Administrator and the Contract Administrator shall instruct the Contractor to stop all construction activities on and within the embankment. No construction shall take place on the affected embankment until all the following conditions are satisfied:

- The cause of the accelerated settlement has been identified and analyzed by the Foundation Monitoring Consultant;
- Contract Administrator to ask Contractor to submit a plan of corrective action(s)
- Foundation Monitoring Consultant to review Contractors plan of corrective action and provide recommendations for corrective actions to the Contract Administrator
- Any corrective action deemed necessary by Contract Administrator and the Foundation Monitoring Consultant has been implemented;
- The Contract Administrator deems it is safe to proceed with the construction of the remainder of the embankment.

Table 11 – Review and Alert Levels for Settlement Monitoring

Location			Instrument Type	Settlement Response Levels (mm)	
Lane	**STATION ALONG MEDIAN CENTRELINE C/L**	**APPROX. OFFSET FROM ECL(*)**		**Review**	**Alert**
WBL	~12+075 (Offset 3 m from Culvert 6A)	5 m L of ECL and 5 m R of ECL	SR	100	135
WBL	12+075	(**)	SP	(***)	(***)
EBL	~12+075 (Offset 3 m from Culvert 6B)	5 m L of ECL and 5 m R of ECL	SR	170	225
EBL	12+075	(**)	SP	(***)	(***)
WBL	12+190	5 m L of ECL and 5 m R of ECL	SR	75	95
EBL	12+190	5 m L of ECL and 5 m R of ECL	SR	115	150
WBL	12+235 (Offset 3 m from Culvert 7A)	5 m L of ECL and 5 m R of ECL	SR	115	150
WBL	12+235	(**)	SP	(***)	(***)
EBL	12+235 (Offset 3 m from Culvert 7B)	5 m L of ECL and 5 m R of ECL	SR	135	180
EBL	12+235	(**)	SP	(***)	(***)
WBL	~13+324 (11 m West of Culvert 10)	5 m L of ECL and 5 m R of ECL	SR	275	370
EBL	~13+345 (5 m East of Culvert 10)	20 m R of Median C/L	DSS	340	450
WBL	~13+342 (11 m East of Culvert 10)	5 m L of ECL and 5 m R of ECL	SR	275	370
WBL	~13+340 (11 m West of Culvert 10)	ECL	DSS	275	370
EBL	~13+365 (11 m West of Culvert 10)	20 m R of Median C/L	DSS	340	450
WBL	13+380	ECL	SR	195	260
EBL	13+383	20 m R of Median C/L	DSS	195	260
EBL	14+620	ECL	DSS	1340	1785
EBL	14+623	5 m L of ECL and 8 m R of	SR	1340	1785

Location			Instrument Type	Settlement Response Levels (mm)	
Lane	**STATION ALONG MEDIAN CENTRELINE C/L**	**APPROX. OFFSET FROM ECL(*)**		**Review**	**Alert**
		ECL			
EBL	14+635	ECL	HSAA	1230	1640
WBL	14+635	5 m L of ECL and 5 m R of ECL	SR	720	960
WBL	14+680	ECL	DSS	900	1200
WBL	14+675	5 m L of ECL and 5 m R of ECL	SR	900	1200
EBL	14+675	6 m L of ECL and 9 m R of ECL	SR	1095	1460
WBL	~14+740 (Along Culvert 14)	5 m L of ECL and 5 m R of ECL	SR	420	560
WBL	14+740	(**)	SP	(***)	(***)
EBL	~14+740 (Along Culvert 14)	5 m L of ECL and 5 m R of ECL	SR	340	455
EBL	14+740	(**)	SP	(***)	(***)
WBL	15+580	5 m L of ECL and 5 m R of ECL	SR	105	145
EBL	15+600	5 m L of ECL and 5 m R of ECL	SR	120	160
WBL	15+670	5 m L of ECL and 5 m R of ECL	SR	150	200
WBL	~16+450 (Along Culvert 24B)	14m N of C/L and 19 m N of C/L	SR	55	75
WBL	16+450	(**)	SP	(***)	(***)
EBL	~16+845 (Along Culvert 25)	5 m L of ECL and 5 m R of ECL	SR	175	230
EBL	16+845	(**)	SP	(***)	(***)
EBL	16+870	5 m L of ECL and 5 m R of ECL	SR	95	125
WBL	~16+875 (Along Culvert 25)	5 m L of ECL and 5 m R of ECL	SR	175	230
WBL	16+875	(**)	SP	(***)	(***)

Location			Instrument Type	Settlement Response Levels (mm)	
Lane	**STATION ALONG MEDIAN CENTRELINE C/L**	**APPROX. OFFSET FROM ECL(*)**		**Review**	**Alert**
WBL	~17+735 (Along Culvert 28)	5 m L of ECL and 5 m R of ECL	SR	205	270
WBL	17+735	(**)	SP	(***)	(***)
WBL	18+660	5 m L of ECL and 7 m R of ECL	SR	525	700
EBL	18+660	5 m L of ECL and 5 m R of ECL	SR	525	700
WBL	18+700	5 m L of ECL and 5 m R of ECL	SR	540	720
WBL	18+703	ECL	DSS	540	720
EBL	18+707	ECL	DSS	545	730
EBL	18+710	5 m L of ECL and 7 m R of ECL	SR	540	720
WBL	18+710	ECL	HSSA	540	720
WBL	18+735	(**)	SP	(***)	(***)
WBL	~18+755 (Along Culvert 32)	5 m L of ECL and 5 m R of ECL	SR	415	550
WBL	18+755	(**)	SP	(***)	(***)
EBL	~18+775 (Along Culvert 32)	5 m L of ECL and 5 m R of ECL	SR	410	550
EBL	18+775	(**)	SP	(***)	(***)
EBL	18+850	5 m L of ECL and 5 m R of ECL	SR	460	615

Note: (*) Embankment Centreline (ECL) refers to the centreline of the embankment of a given lane (EBL or WBL)

(**) The stations for the settlement pins are approximate and are referenced from the median centreline. All culvert settlement pins shall be installed on top of the culverts and along the culverts centreline based on the locations above. Culvert settlement pins are to be installed 0.5 m from each end of the culvert

(***) The settlement data from SP's will be used to confirm stabilization of settlements and not for monitoring total settlements.

2.2 VIBRATING WIRE PIEZOMETERS (VWP) AND REFERENCE VIBRATING WIRE PIEZOMETERS (RVWP)

2.2.1 Data Logger and Readout Unit

The VWPs and RVWPs shall be read using the VW Data Loggers and Data Recorder supplied by the Contractor.

These readout and data logger units shall be tested prior to taking any baseline readings to ensure functionality.

2.2.2 Coordination of Readings

The VWP data reduction (calculation of excess pore pressure - EPP: pore pressure in excess of hydrostatic) requires the hydrostatic groundwater level elevation at the time the VWPs were read. Excess pore pressure should be calculated based on the hydrostatic groundwater level measured by the RVWP at the specific site.

2.2.3 Reporting

The Contract Administrator shall be notified within 24 hours if critical measurement readings are reached and a brief interpretation of the updated monitoring data shall be reported to the Contact Administrator within five (5) working days after each set of readings is obtained. A full set of up-to-date and processed monitoring data shall be presented in tabular and graphical form in the monthly progress report.

As a minimum the following shall be submitted to the Contract Administrator in the monthly progress report based on the readings collected from VWP and RVWP instruments:

- Plots of piezometric elevation versus time for VWPs located in the same monitoring section;
- Same as above for excess pore pressure (EPP);
- Plot of hydrostatic groundwater elevation (RVWPs) versus time for each monitoring section (if installed);
- Fill elevation in the vicinity of the VWP versus time;
- Plan view, cross section and profile sketches showing the top of fill location while the VWP and RVWP readings were being taken.

2.2.4 Review and Alert Levels

The increase in pore pressure in the foundation soils associated with the placement of fill lifts should be equal to or lower than the increase in the total vertical stress due to the fill placement. The failure of embankments founded on soft soils is usually associated with increases in pore

pressure in excess of the increase in total stress as described above. If any of these conditions is observed or the maximum excess pore pressure measured exceeds the review levels in Table 12, the Foundation Monitoring Consultant shall immediately inform the Contract Administrator and Contract Administrator will ask Contractor for response action(s). The Contractor shall submit a plan of action(s) to prevent alert level being reached. This will be reviewed by the Foundation Monitoring Consultant who will recommend a course of action to the Contract Administrator. All construction work shall be continued such that instrument alert levels are not reached.

If the maximum excess pore pressure measured exceeds the Alert Levels in Table 12, the Foundation Monitoring Consultant shall immediately inform the Contract Administrator and the Contract Administrator shall instruct the Contractor to stop all construction activities on and within the embankment. No construction shall take place on or nearby the affected embankment until all the following conditions are satisfied:

- The cause of the excess pore pressure has been identified and analyzed by the Foundation Monitoring Consultant;
- Contract Administrator to ask Contractor to submit a plan of corrective action(s)
- Foundation Monitoring Consultant to review Contractors plan of corrective action and provide recommendations for corrective actions to the Contract Administrator
- Any corrective action deemed necessary by Contract Administrator and the Foundation Monitoring Consultant has been implemented;
- The Contract Administrator deems it is safe to proceed with the construction of the remainder of the embankment.

Table 12 – Review and Alert Levels for Excess Pore Pressures

LOCATION			**Elevation of VWP(s) (m)**	**Embankment Construction Stage**	**Excess Pore Pressure (EPP) Response Levels (kPa)**		
LANE	**STATION ALONG MEDIAN C/L**	**APPROX. OFFSET (***)**			**Review**	**Alert**	**Max. Remaining EPP(****)**
WBL	12+187 12+190	ECL	225.7	1	35	45	10
			223.8	1	35	45	10
EBL	12+190 12+193	ECL	224.4	1	55	70	10
			222.5	1	55	70	10
WBL	12+235 12+241	ECL	223.8	1	55	75	10
			222.1	1	55	75	10
EBL	12+230 12+236	ECL	223.3	1	80	100	10
			221.7	1	80	100	10
WBL	13+320 13+323	ECL	210.0	1	50	65	10
				2	15	20	10
			207.0	1	45	60	10
				2	15	20	10
EBL	13+337	20 m R of	211.9(*)	1	60	75	10

LOCATION			Elevation of VWP(s) (m)	Embankment Construction Stage	Excess Pore Pressure (EPP) Response Levels (kPa)		
LANE	STATION ALONG MEDIAN C/L	APPROX. OFFSET (***)			Review	Alert	Max. Remaining EPP(****)
	13+340 13+343	Median C/L		2	15	20	10
			209.8(*)	1	50	65	10
				2	15	20	10
			205.3(*)	1	40	50	10
				2	15	20	10
WBL	13+339 13+342 13+345 13+348	ECL	211.0	1	50	65	10
				2	15	20	10
			209.1	1	45	60	10
				2	15	20	10
			209.1(*)	1	35	45	10
				2	15	20	10
			204.4	1	40	50	10
				2	15	20	10
EBL	13+359 13+362	20 m R of Median C/L	210.0(*)	1	55	70	10
				2	15	20	10
			209.0(*)	1	55	70	10
				2	15	20	10
WBL	13+377 13+380	ECL	211.4	1	50	65	10
				2	15	20	10
			209.4	1	40	50	10
				2	15	20	10
EBL	13+377 13+380	20 m R of Median C/L	207.0(*)	1	55	70	10
				2	15	20	10
			205.0(*)	1	55	70	10
				2	15	20	10
WBL	14+632 14+635	ECL	214.2	1	60	75	10
				2	30	40	10
			211.4	1	55	75	10
				2	30	40	10
EBL	14+622 14+625 14+628	ECL and 52 m R of Median C/L	212.2	1	60	75	10
				2	35	40	10
				3	25	30	10
			209.5	1	55	70	10
				2	30	35	10
				3	20	25	10

LOCATION			Elevation of VWP(s) (m)	Embankment Construction Stage	Excess Pore Pressure (EPP) Response Levels (kPa)		
LANE	STATION ALONG MEDIAN C/L	APPROX. OFFSET (***)			Review	Alert	Max. Remaining EPP(****)
			209.5(*)	1	40	50	10
				2	20	30	10
				3	15	20	10
			203.0	1	45	55	10
				2	30	35	10
				3	15	15	10
WBL	14+669 14+672 14+675	ECL and 42 m L of Median C/L	214.2	1	60	75	10
				2	20	25	10
			211.4	1	55	70	10
				2	20	25	10
			211.4(*)	1	25	30	5
				2	10	15	5
			204.3	1	45	55	10
				2	20	25	10
EBL	14+675 14+678	ECL	213.2	1	60	75	10
				2	35	45	10
				3	15	15	10
			210.4	1	55	70	10
				2	30	40	10
				3	10	15	5
EBL	15+600 15+603	ECL	218.5	1	50	65	10
			215.5	1	45	60	10
WBL	15+667 15+670	ECL	219.0	1	60	80	10
			217.0	1	60	75	10
EBL	16+845 16+851	ECL	240.0	1	60	80	10
			237.0	1	60	75	10
WBL	16+870 14+876	ECL	240.5	1	50	65	10
			238.0	1	50	60	10
WBL	17+730 17+736	ECL	256.5(**)	1	70	90	10
				2	35	45	10
WBL	18+660 18+663	ECL	254.2	1	55	70	10
				2	35	45	10
				3	20	30	10
			251.2	1	50	65	10
				2	35	40	10

LOCATION			Elevation of VWP(s) (m)	Embankment Construction Stage	Excess Pore Pressure (EPP) Response Levels (kPa)		
LANE	STATION ALONG MEDIAN C/L	APPROX. OFFSET (***)			Review	Alert	Max. Remaining EPP(****)
				3	20	25	10
EBL	18+657 18+660	ECL	254.5	1	55	70	10
				2	35	45	10
				3	25	35	10
			252.0	1	55	70	10
				2	35	45	10
				3	25	35	10
WBL	18+694 18+697 18+700	ECL and 45 m L of Median C/L	254.2	1	55	70	10
				2	35	45	10
				3	15	20	10
			252.2	1	55	70	10
				2	35	45	10
				3	15	20	10
			252.2(*)	1	30	40	10
				2	20	25	10
				3	15	20	10
			250.2	1	50	65	10
				2	30	40	10
				3	15	20	10
EBL	18+710 18+713 18+716	ECL and 55 m R of Median C/L	254.2	1	55	70	10
				2	35	45	10
				3	20	25	10
			252.2	1	55	70	10
				2	35	45	10
				3	20	25	10
			252.2(*)	1	30	40	10
				2	20	25	10
				3	15	20	10
			250.2	1	50	65	10
				2	30	40	10
				3	15	20	10
WBL	18+752 18+758	ECL	254.6	1	55	70	10
				2	35	45	10
			251.6	1	50	65	10
				2	35	40	10

LOCATION			Elevation of VWP(s) (m)	Embankment Construction Stage	Excess Pore Pressure (EPP) Response Levels (kPa)		
LANE	STATION ALONG MEDIAN C/L	APPROX. OFFSET (***)			Review	Alert	Max. Remaining EPP(****)
EBL	18+770 18+776	ECL	254.2	1	55	70	10
				2	35	45	10
				3	15	20	10
			251.2	1	50	65	10
				2	35	45	10
				3	15	20	10
EBL	18+847 18+850	ECL	254.9	1	55	70	10
				2	35	45	10
				3	15	20	10
			252.8	1	55	70	10
				2	35	45	10
				3	15	20	10

Note: (*) VWP(s) North or South of Centreline shall be located as per the attached drawings.
(**) One direct push VWP shall be installed at this location
(***) Embankment Centreline (ECL) refers to the centreline of the embankment of a given lane (EBL or WBL)
(****) Waiting period between construction stages and removal of surcharge shall be determined based on the specified Excess Pore Pressures (EPP). Fill placement following the waiting period (or removal of surcharge) shall not take place before the EPP drops below the specified values.

2.3 CONTROL MONITORING LEVELS

2.3.1 General

The monitoring program will provide input for the control of the appropriate time for fill and surcharge placement, removal of surcharge and installation of culverts.

2.3.2 Stabilization of Settlements due to Primary Consolidation

Settlement data monitored at SR, DSS, SP and HSAA allow an approximate assessment of the total settlement due to primary consolidation and the approximate time required for settlements due to primary consolidation to stabilize.

The anticipated total settlement amount and the required time for settlements due to primary consolidation to stabilize shall be assessed for each of the SR, DSS, SP and HSAA using an appropriate analytical method.

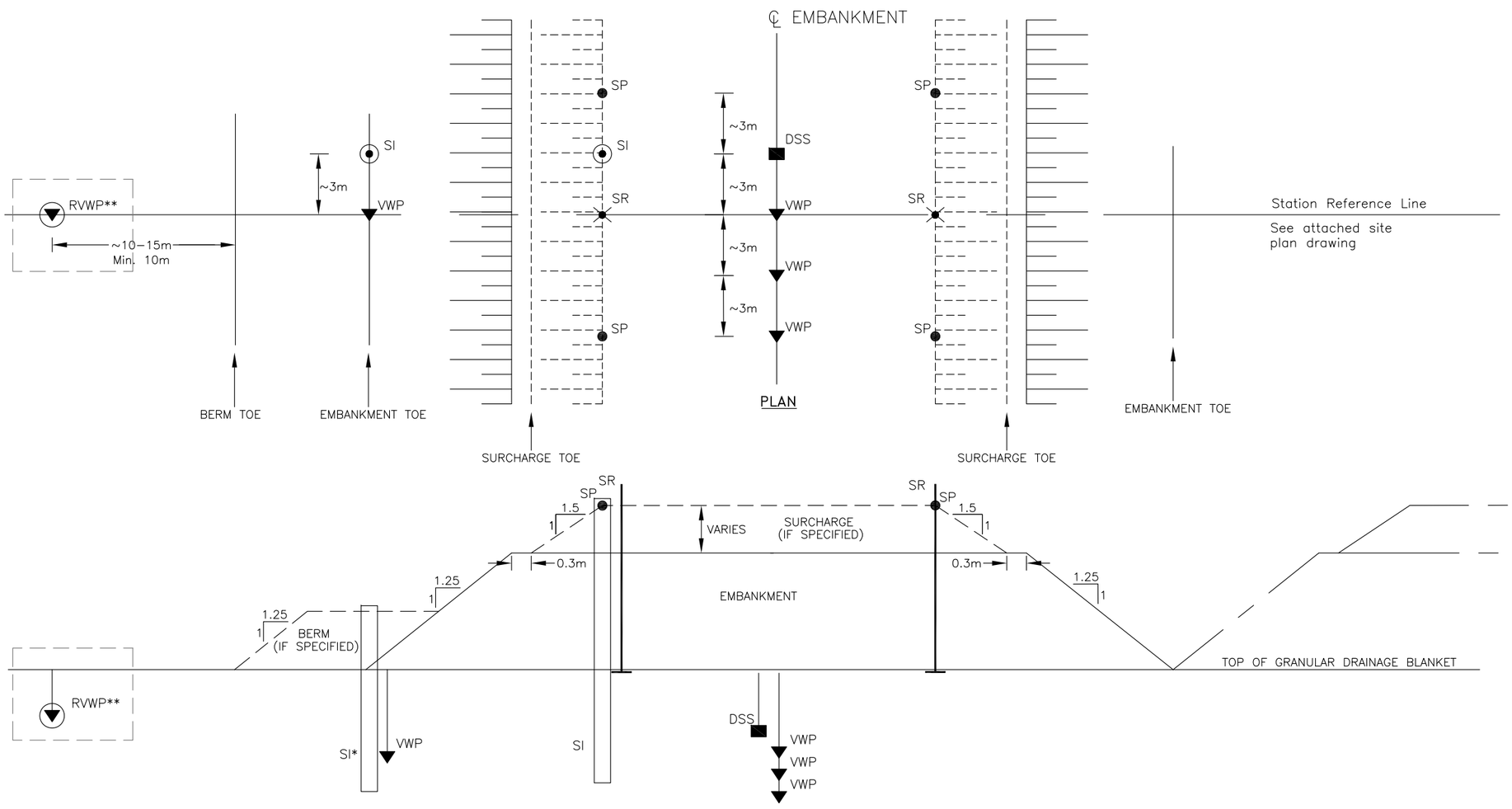
3.0 FINAL REPORT

At the completion of the monitoring program, a final monitoring report shall be issued to the Contract Administrator. The monitoring results shall be presented in tabular and graphical form as described above for each instrument type. Interpretation of the monitoring readings shall be included in the report.

MINISTRY OF TRANSPORTATION, ONTARIO

METRIC

DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN



CROSS – SECTION A

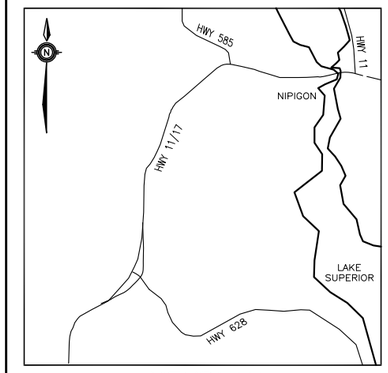
CONT No 2014–6026
GWP No 647–89–00

HIGHWAY 11/17
FOUR – LANING
REDROCK TO NIPIGON
TYPICAL MONITORING SECTION TYPE A

SHEET
1

MMM GROUP

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

- SR – Settlement Rod (*)
- DSS – Digital Settlement System (*)
- SI – Slope Inclinometer (*)
- SP – Settlement Pin (*)
- VWP – Vibrating Wire Piezometer (*)
- RVWP – Reference Vibrating Wire Piezometer (*)

-NOTES-

* This Drawing Is Schematic Only. Please Refer To NSSP "Supply And Installation of Embankment Monitoring Equipment" For Instrument Depth of Installation.

** RVWP Is Not Required For Every Monitoring Section. Please Refer To Monitoring Plan For Specified Locations.

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REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	LPG	CHK	JPL	CODE	LOAD
DRAWN	AN	CHK	SBP	SITE	STRUCT

DATE OCT 2014
DWG M–A

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MINISTRY OF TRANSPORTATION, ONTARIO

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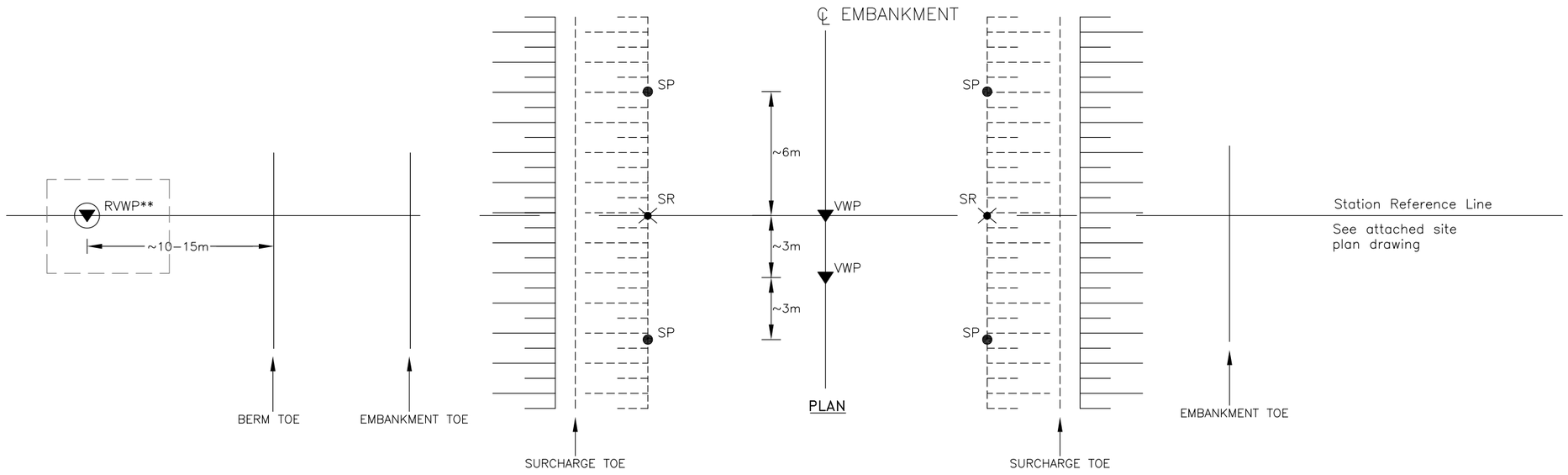
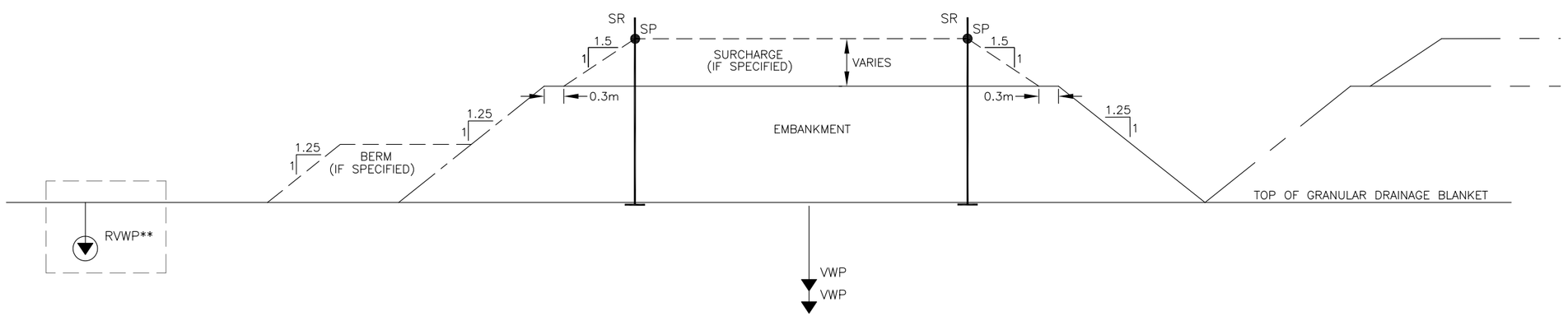


PLAN



CROSS – SECTION B

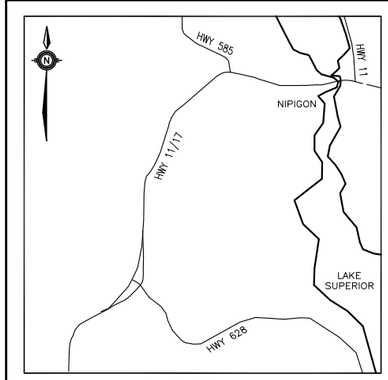
CONT No 2014–6026
GWP No 647–89–00

HIGHWAY 11/17
FOUR – LANING
REDROCK TO NIPIGON
TYPICAL MONITORING SECTION TYPE B

SHEET 2

MMM GROUP

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

- SR – Settlement Rod (*)
- DSS – Digital Settlement System (*)
- SI – Slope Inclinometer (*)
- SP – Settlement Pin (*)
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-NOTES-

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REVISIONS		
DATE	BY	DESCRIPTION

DESIGN LPG	CHK JPL	CODE	LOAD	DATE	OCT 2014
DRAWN AN	CHK SBP	SITE	STRUCT	DWG	M–B

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MINISTRY OF TRANSPORTATION, ONTARIO

METRIC

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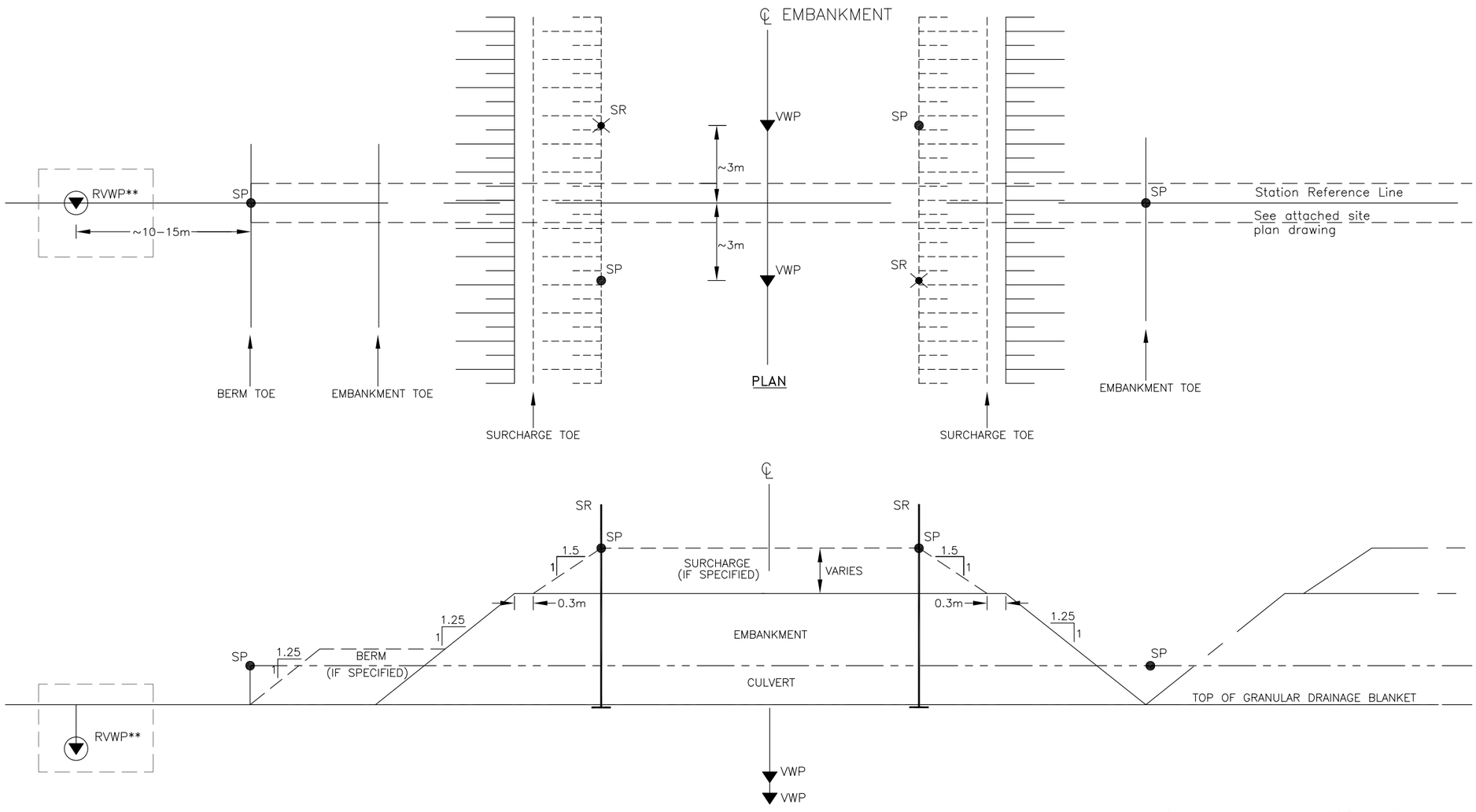


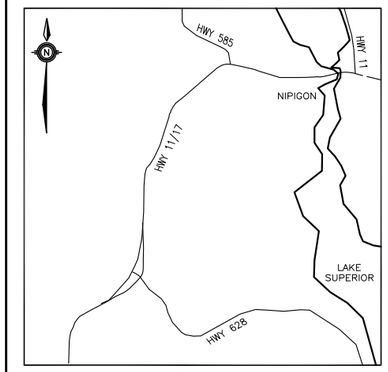
CONT No 2014–6026
GWP No 647–89–00

HIGHWAY 11/17
FOUR – LANING
REDROCK TO NIPIGON
TYPICAL MONITORING SECTION TYPE C

SHEET 3

MMM GROUP

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

- SR – Settlement Rod (*)
- DSS – Digital Settlement System (*)
- SI – Slope Inclinometer (*)
- SP – Settlement Pin (*)
- VWP – Vibrating Wire Piezometer (*)
- RVWP – Reference Vibrating Wire Piezometer (*)

-NOTES-

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REVISIONS		
DATE	BY	DESCRIPTION

DESIGN LPG	CHK JPL	CODE	LOAD	DATE OCT 2014	
DRAWN AN	CHK SBP	SITE	STRUCT	DWG M–C	

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MINISTRY OF TRANSPORTATION, ONTARIO

METRIC

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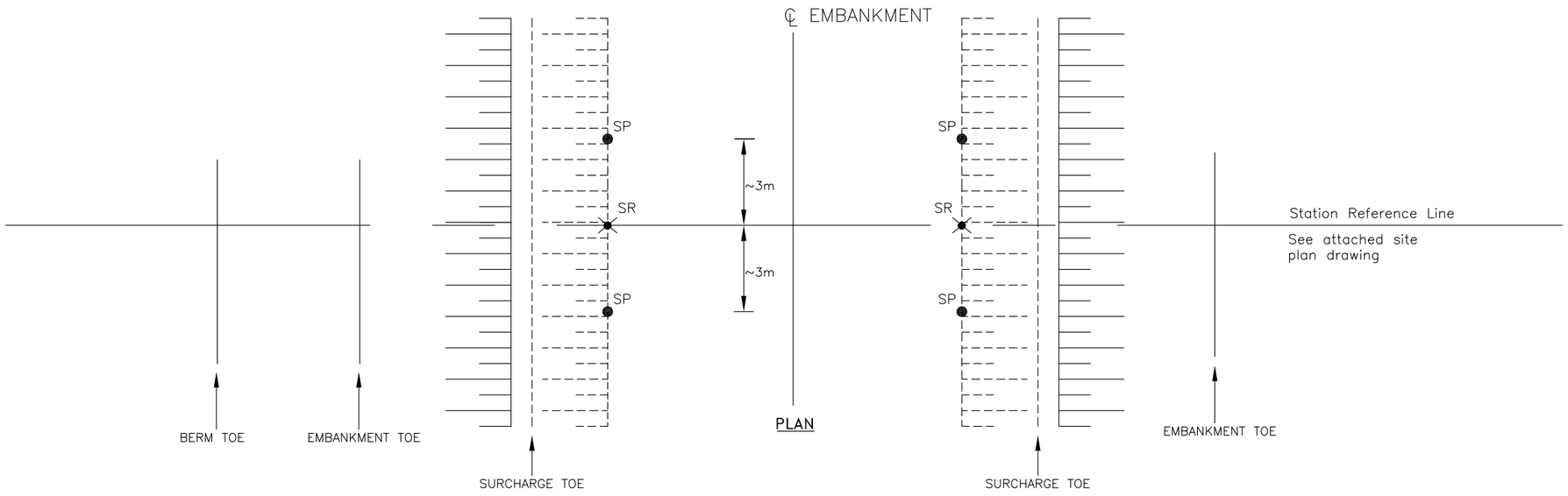
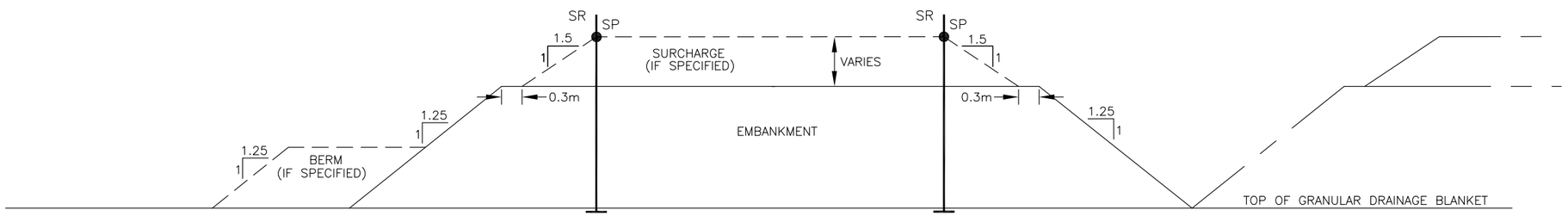




CROSS – SECTION D

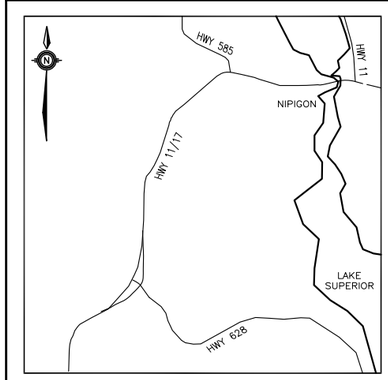
CONT No 2014-6026
GWP No 647-89-00

HIGHWAY 11/17
FOUR – LANING
REDROCK TO NIPIGON
TYPICAL MONITORING SECTION TYPE D

SHEET
4

MMM GROUP

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

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- DSS – Digital Settlement System (*)
- SI – Slope Inclinometer (*)
- SP – Settlement Pin (*)
- VWP – Vibrating Wire Piezometer (*)
- RVWP – Reference Vibrating Wire Piezometer (*)

-NOTES-

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REVISIONS		
DATE	BY	DESCRIPTION

DESIGN LPG	CHK JPL	CODE	LOAD	DATE	OCT 2014
DRAWN AN	CHK SBP	SITE	STRUCT	DWG	M-D

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MINISTRY OF TRANSPORTATION, ONTARIO

METRIC

DIMENSIONS ARE IN METRES
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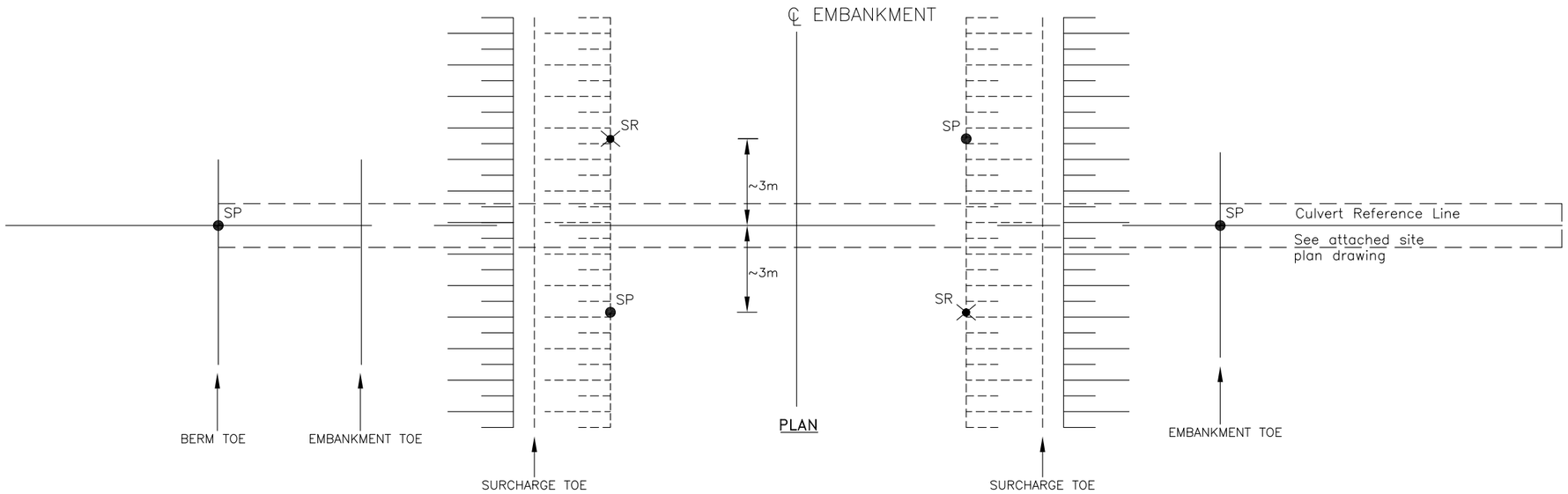
UNLESS OTHERWISE SHOWN



CROSS – SECTION E

CONT No 2014-6026
GWP No 647-89-00

HIGHWAY 11/17
FOUR – LANING
REDROCK TO NIPIGON
TYPICAL MONITORING SECTION TYPE E

SHEET 5

MMM GROUP

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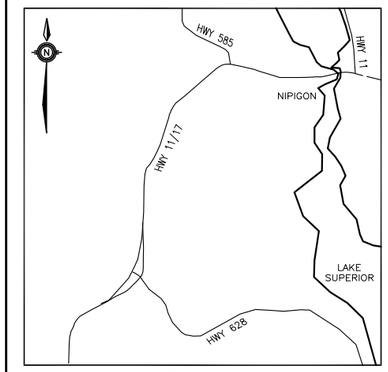

KEYPLAN

LEGEND

- SR – Settlement Rod (*)
- DSS – Digital Settlement System (*)
- SI – Slope Inclinometer (*)
- SP – Settlement Pin (*)
- VWP – Vibrating Wire Piezometer (*)
- RVWP – Reference Vibrating Wire Piezometer (*)

-NOTES-

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** RVWP Is Not Required For Every Monitoring Section. Please Refer To Monitoring Plan For Specified Locations.

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REVISIONS		
DATE	BY	DESCRIPTION

DESIGN LPG	CHK JPL	CODE	LOAD	DATE OCT 2014	
DRAWN AN	CHK SBP	SITE	STRUCT	DWG M-E	

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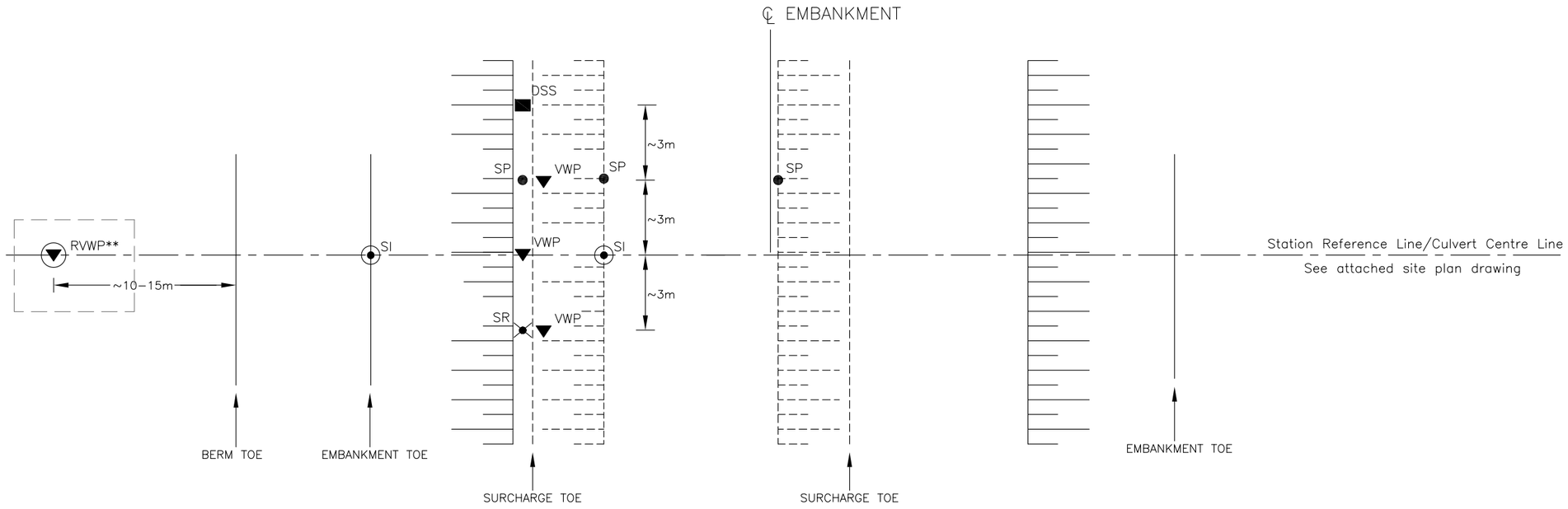
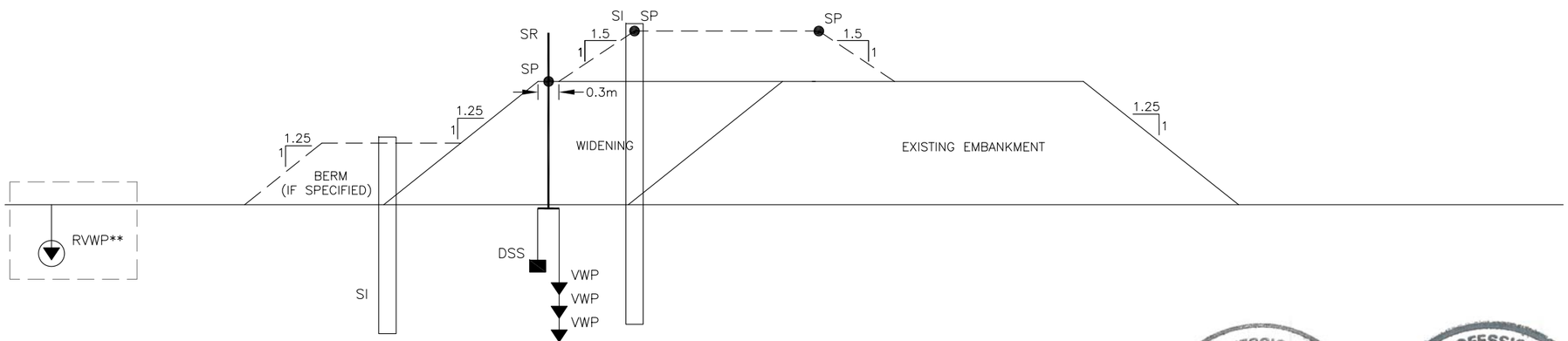
MINISTRY OF TRANSPORTATION, ONTARIO

METRIC

DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN



PLAN



CROSS – SECTION F

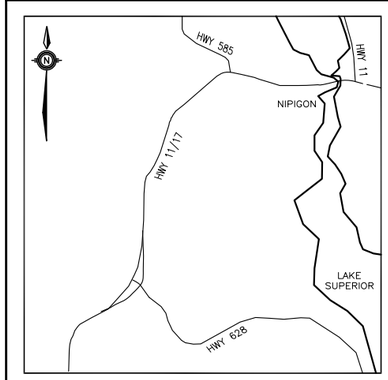
CONT No 2014–6026
GWP No 647–89–00

HIGHWAY 11/17
FOUR – LANING
REDROCK TO NIPIGON
TYPICAL MONITORING SECTION TYPE F

SHEET
6

MMM GROUP

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND	
✕	SR – Settlement Rod (*)
■	DSS – Digital Settlement System (*)
◉	SI – Slope Inclinometer (*)
●	SP – Settlement Pin (*)
▼	VWP – Vibrating Wire Piezometer (*)
▼	RVWP – Reference Vibrating Wire Piezometer (*)

-NOTES-

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REVISIONS		
DATE	BY	DESCRIPTION

DESIGN LPG	CHK JPL	CODE	LOAD	DATE	OCT 2014
DRAWN AN	CHK SBP	SITE	STRUCT	DWG	M–F

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MINISTRY OF TRANSPORTATION, ONTARIO

METRIC

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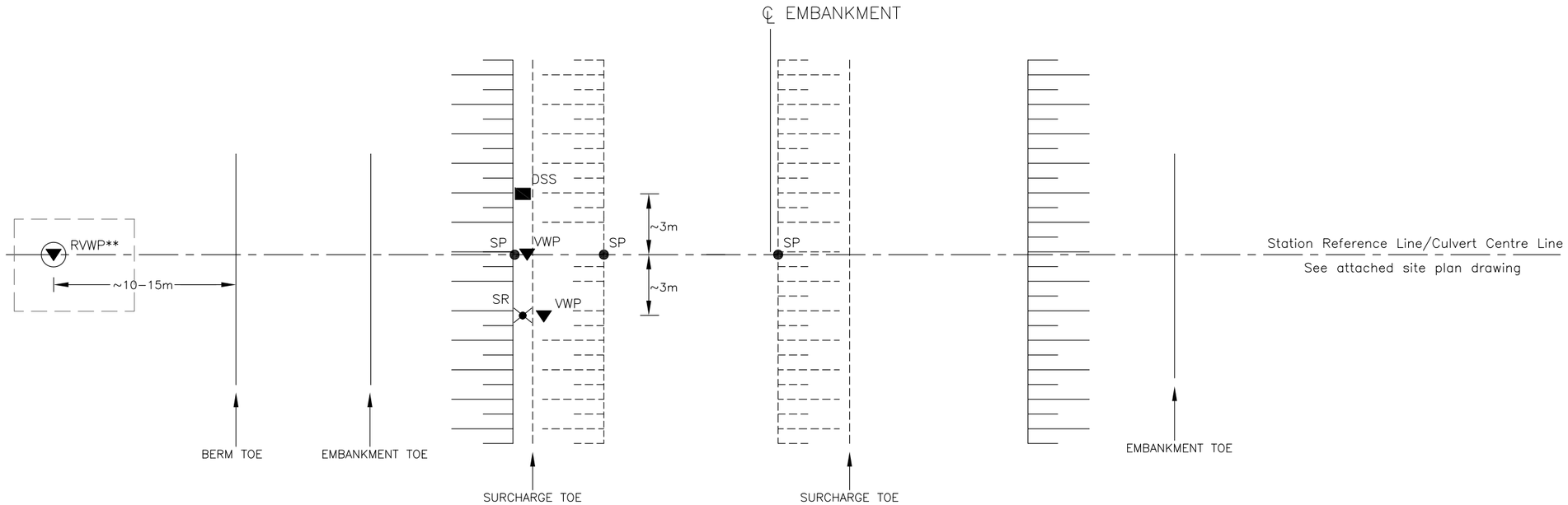
UNLESS OTHERWISE SHOWN



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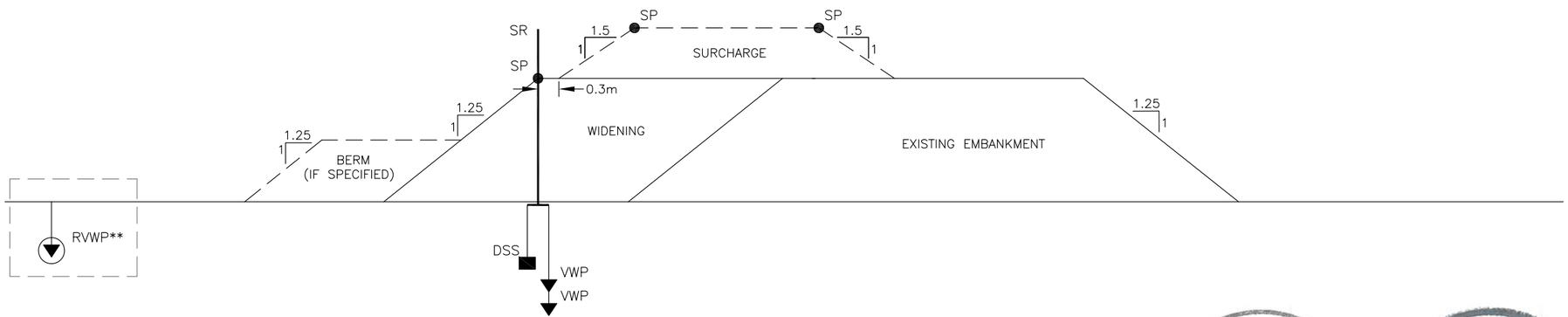


CROSS – SECTION G

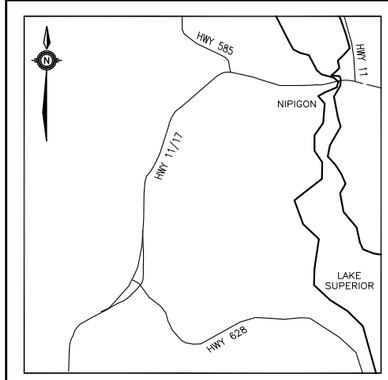
CONT No 2014–6026
GWP No 647–89–00

HIGHWAY 11/17
FOUR – LANING
REDROCK TO NIPIGON
TYPICAL MONITORING SECTION TYPE G

SHEET
7

MMM GROUP

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

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-NOTES-

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PROVINCE OF ONTARIO

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN LPG	CHK JPL	CODE	LOAD	DATE	OCT 2014
DRAWN AN	CHK SBP	SITE	STRUCT	DWG	M–G

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MINISTRY OF TRANSPORTATION, ONTARIO

METRIC

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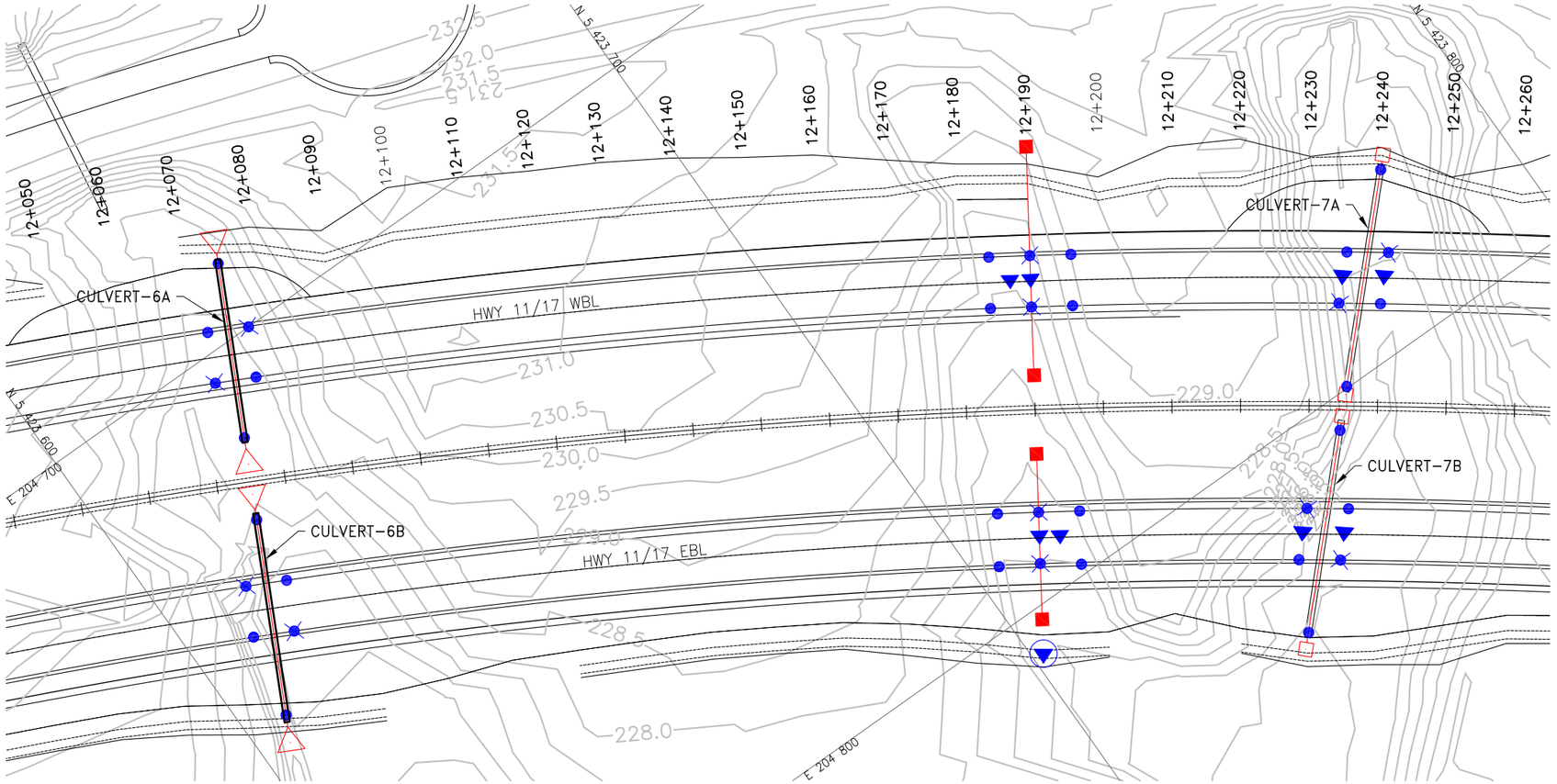

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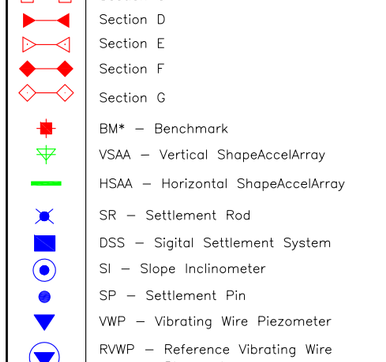


KEYPLAN

L E G E N D

- Section A
- Section B
- Section C
- Section D
- Section E
- Section F
- Section G
- BM* – Benchmark
- VSAA – Vertical ShapeAccelArray
- HSAA – Horizontal ShapeAccelArray
- SR – Settlement Rod
- DSS – Sigital Settlement System
- SI – Slope Inclinometer
- SP – Settlement Pin
- VWP – Vibrating Wire Piezometer
- RVWP – Reference Vibrating Wire Piezometer

-NOTES-

1. Base plan, highway and culvert alignments are current as of Feb. 14, 2014.
2. Skewed sections shall be parallel to culvert.
3. Instrument locations are approximate. For actual locations refer to Typical Monitoring Sections (Sheet 1 to 7). Some field adjustment to instrument locations may be required.
4. Care must be exercised not to damage the wick drains. Where SI, VWP and/or DSS are installed in wick drain areas refer to Typical Instrumentation Layout within a wick drain area (Sheet 19)

GEOCRES No. 52A-182

LICENSED PROFESSIONAL ENGINEER S. PETERS 100194478 Oct 1/14 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER P. K. CHATTERJI Oct 1/14 PROVINCE OF ONTARIO

*2 BM'S (■) shall be installed in this area. Please refer to NSSP ''Supply and Installation of Embankment Monitoring Equipment – Benchmark'' for installation details.

CONT No 2014-6026
GWP No 647-89-00

HWY 11/17 FOUR LANING
EBL & WBL
(STA. 12+050 TO 12+250)
MONITORING PLAN

SHEET 8

MMM GROUP

THURBER ENGINEERING LTD.

REVISIONS			
	DATE	BY	DESCRIPTION

DESIGN	SBP	CHK PKC	CODE	LOAD	DATE OCT 2014
DRAWN	MFA	CHK SBP	SITE	STRUCT	DWG M-P1

FILENAME: H:\Drafting\101\351\237\test1237-MonitoringPlan.dwg
PLOTDATE: 10/2/2014 4:17 PM

MINISTRY OF TRANSPORTATION, ONTARIO

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

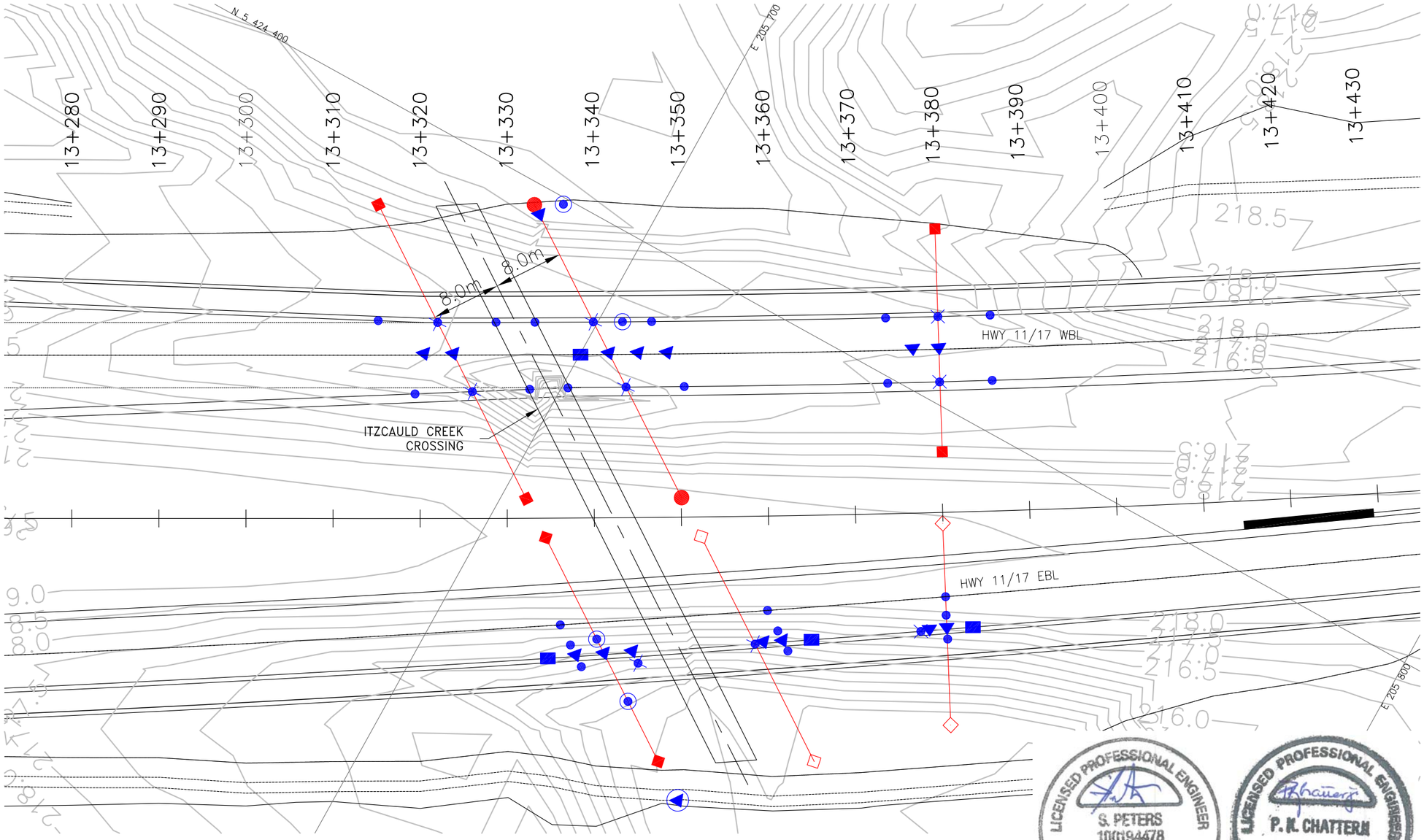
CONT No 2014-6026
GWP No 647-89-00

HWY 11/17 FOUR LANING
EBL & WBL
(STA. 13+280 TO 13+430)
MONITORING PLAN

SHEET 9

MMM GROUP

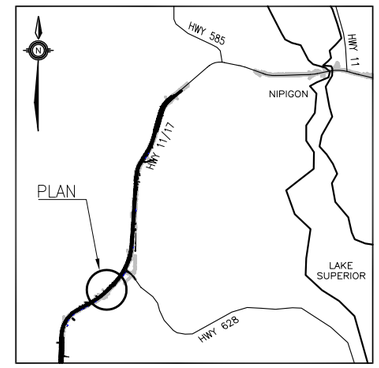
THURBER ENGINEERING LTD.



PLAN

10 0 10 20m

SCALE 1:500



KEYPLAN

LEGEND

- Section A
- Section B
- Section C
- Section D
- Section E
- Section F
- Section G
- BM* – Benchmark
- VSAA – Vertical ShapeAccelArray
- HSAA – Horizontal ShapeAccelArray
- SR – Settlement Rod
- DSS – Sigital Settlement System
- SI – Slope Inclinometer
- SP – Settlement Pin
- VWP – Vibrating Wire Piezometer
- RVWP – Reference Vibrating Wire Piezometer

-NOTES-

1. Base plan, highway and culvert alignments are current as of Feb. 14, 2014.
2. Skewed sections shall be parallel to culvert.
3. Instrument locations are approximate. For actual locations refer to Typical Monitoring Sections (Sheet 1 to 7). Some field adjustment to instrument locations may be required.
4. Care must be exercised not to damage the wick drains. Where SI, VWP and/or DSS are installed in wick drain areas refer to Typical Instrumentation Layout within a wick drain area (Sheet 19)

LICENSED PROFESSIONAL ENGINEER
S. PETERS
100194478
Oct 1/14
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Oct 1/14
PROVINCE OF ONTARIO

*2 BM'S (■) shall be installed in this area. Please refer to NSSP ''Supply and Installation of Embankment Monitoring Equipment – Benchmark'' for installation details.

GEOCRES No. 52A-182

REVISIONS			
DATE	BY	DESCRIPTION	

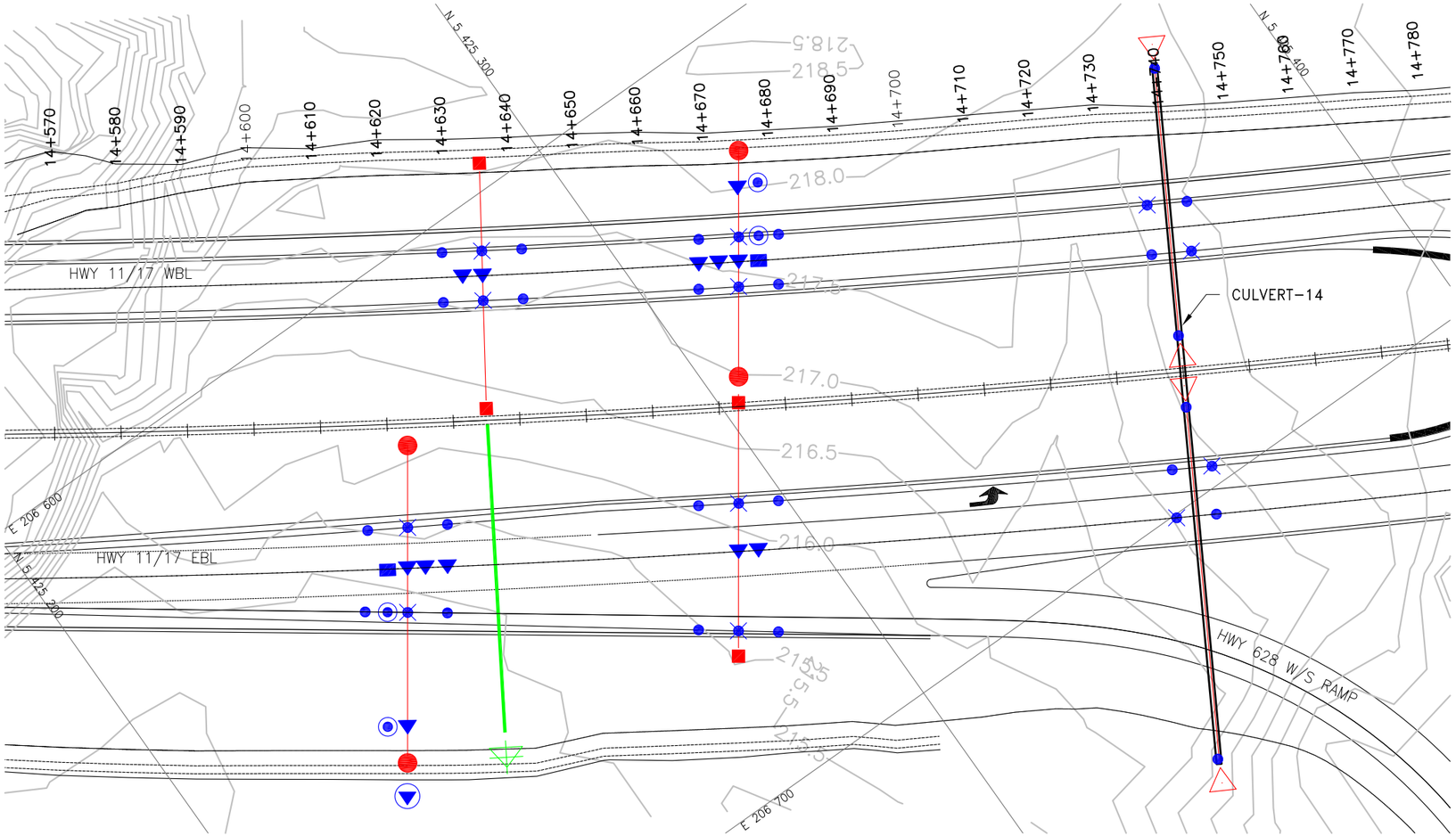
DESIGN	SBP	CHK	PKC	CODE	LOAD	DATE	OCT 2014
DRAWN	MFA	CHK	SBP	SITE	STRUCT	DWG	M-P2

FILENAME: H:\Drafting\19\1351\237\ed1237-MonitoringPlan.dwg
PLOTDATE: 10/2/2014 4:16 PM

MINISTRY OF TRANSPORTATION, ONTARIO

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN



PLAN

16 0 16 32m

SCALE 1:800

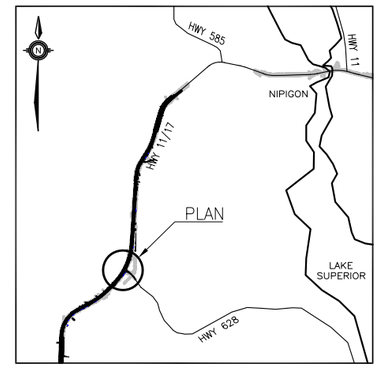
CONT No 2014-6026
GWP No 647-89-00

HWY 11/17 FOUR LANING
EBL & WBL
(STA. 14+570 TO 14+780)
MONITORING PLAN

SHEET 10

MMM GROUP

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

- Section A
- Section B
- Section C
- Section D
- Section E
- Section F
- Section G
- BM* – Benchmark
- VSAA – Vertical ShapeAccelArray
- HSAA – Horizontal ShapeAccelArray
- SR – Settlement Rod
- DSS – Sigital Settlement System
- SI – Slope Inclinometer
- SP – Settlement Pin
- VWP – Vibrating Wire Piezometer
- RVWP – Reference Vibrating Wire Piezometer

-NOTES-

1. Base plan, highway and culvert alignments are current as of Feb. 14, 2014.
2. Skewed sections shall be parallel to culvert.
3. Instrument locations are approximate. For actual locations refer to Typical Monitoring Sections (Sheet 1 to 7). Some field adjustment to instrument locations may be required.
4. Care must be exercised not to damage the wick drains. Where SI, VWP and/or DSS are installed in wick drain areas refer to Typical Instrumentation Layout within a wick drain area (Sheet 19)

GEOCRES No. 52A-182

LICENSED PROFESSIONAL ENGINEER
S. PETERS
100194478
Oct 1/14
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Oct 1/14
PROVINCE OF ONTARIO

*2 BM'S (■) shall be installed in this area. Please refer to NSSP "Supply and Installation of Embankment Monitoring Equipment – Benchmark" for installation details.

REVISIONS		
DATE	BY	DESCRIPTION

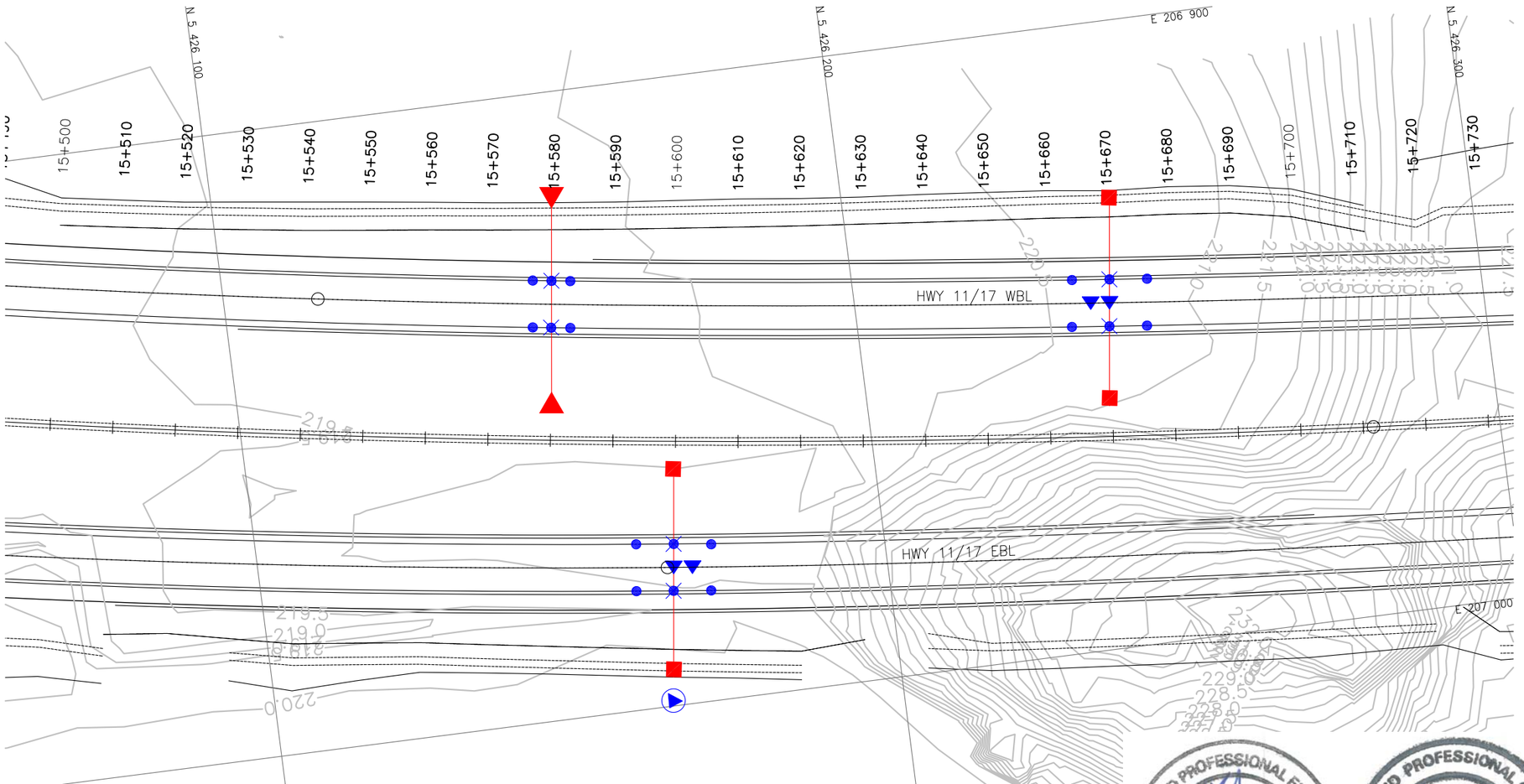
DESIGN	SBP	CHK	PKC	CODE		LOAD	DATE OCT 2014
DRAWN	MFA	CHK	SBP	SITE		STRUCT	DWG M-P3

FILENAME: H:\Drafting\19\1351\237\esd1237-MonitoringPlan.dwg
PLOTDATE: 10/2/2014 4:20 PM

MINISTRY OF TRANSPORTATION, ONTARIO

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN



PLAN

16 0 16 32m

SCALE 1:800

*2 BM'S (■) shall be installed in this area. Please refer to NSSP ''Supply and Installation of Embankment Monitoring Equipment – Benchmark'' for installation details.

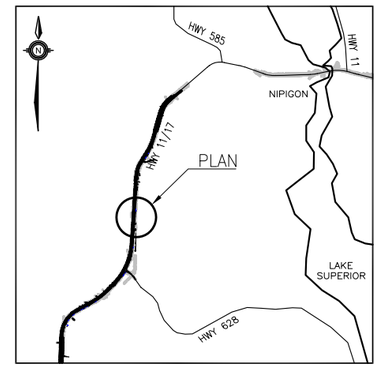
CONT No 2014-6026
GWP No 647-89-00

HWY 11/17 FOUR LANING
EBL & WBL
(STA. 15+500 TO 15+720)
MONITORING PLAN

SHEET 11

MMM GROUP

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

- Section A
- Section B
- Section C
- Section D
- Section E
- Section F
- Section G
- BM* – Benchmark
- VSAA – Vertical ShapeAccelArray
- HSAA – Horizontal ShapeAccelArray
- SR – Settlement Rod
- DSS – Sigital Settlement System
- SI – Slope Inclinometer
- SP – Settlement Pin
- VWP – Vibrating Wire Piezometer
- RVWP – Reference Vibrating Wire Piezometer

-NOTES-

1. Base plan, highway and culvert alignments are current as of Feb. 14, 2014.
2. Skewed sections shall be parallel to culvert.
3. Instrument locations are approximate. For actual locations refer to Typical Monitoring Sections (Sheet 1 to 7). Some field adjustment to instrument locations may be required.
4. Care must be exercised not to damage the wick drains. Where SI, VWP and/or DSS are installed in wick drain areas refer to Typical Instrumentation Layout within a wick drain area (Sheet 19)

LICENSED PROFESSIONAL ENGINEER
S. PETERS
100194478
Oct 1/14
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEERS
P. K. CHATTERJI
Oct 1/14
PROVINCE OF ONTARIO

GEOCRES No. 52A-182

REVISIONS		
DATE	BY	DESCRIPTION

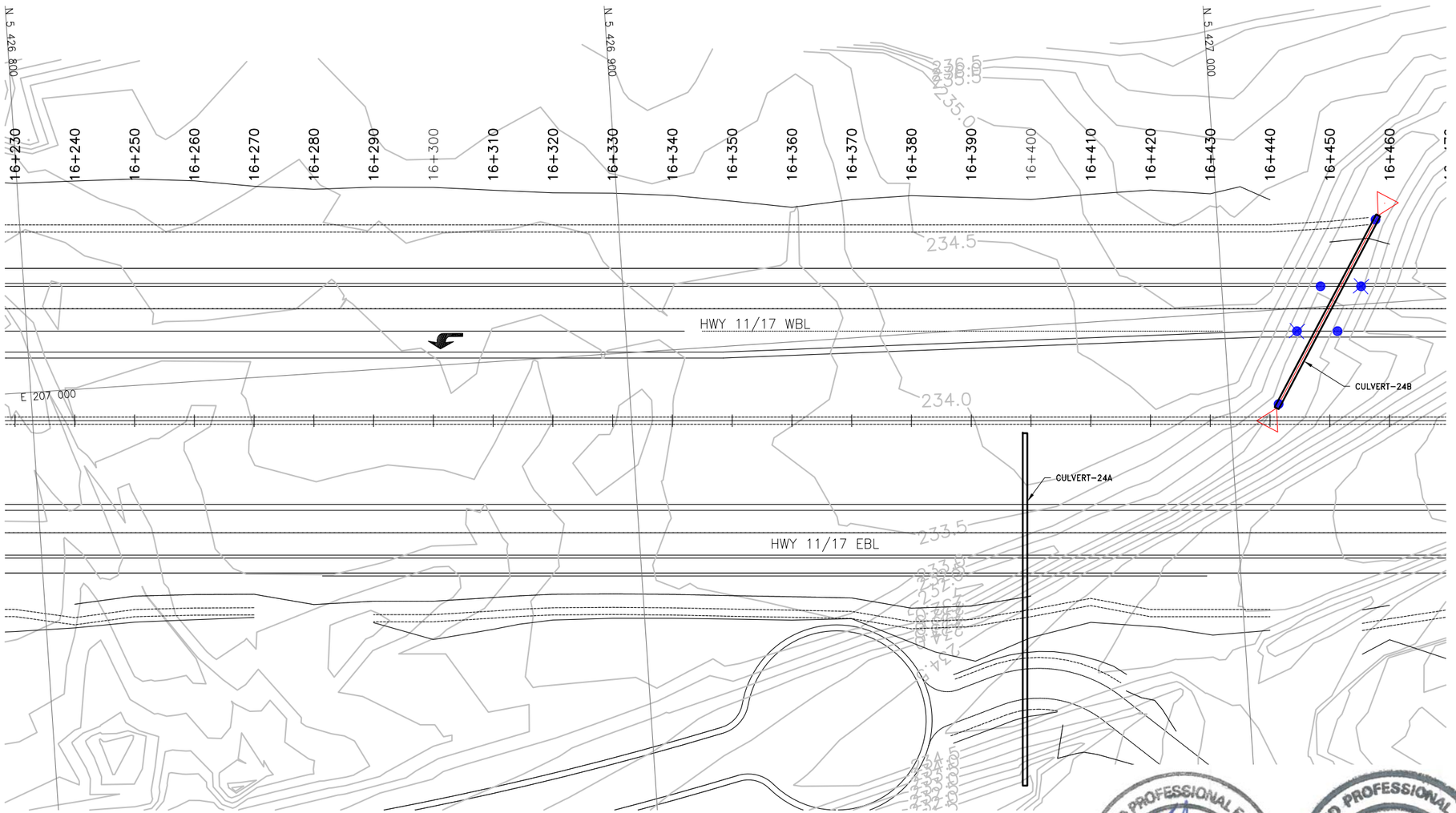
DESIGN	SBP	CHK	PKC	CODE		LOAD	DATE OCT 2014
DRAWN	MFA	CHK	SBP	SITE		STRUCT	DWG M-P4

FILENAME: H:\Drafting\19\351\237\tes1237-MonitoringPlan.dwg
PLOTDATE: 10/2/2014 4:21 PM

MINISTRY OF TRANSPORTATION, ONTARIO

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN



PLAN

16 0 16 32m

SCALE 1:800

*2 BM'S (■) shall be installed in this area. Please refer to NSSP "Supply and Installation of Embankment Monitoring Equipment – Benchmark" for installation details.

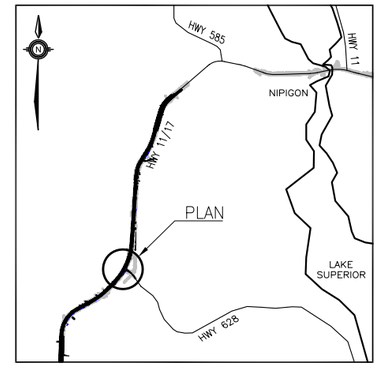
CONT No 2014-6026
GWP No 647-89-00

HWY 11/17 FOUR LANING
EBL & WBL
(STA. 16+250 TO 16+460)
MONITORING PLAN

SHEET 12

MMM GROUP

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

- Section A
- Section B
- Section C
- Section D
- Section E
- Section F
- Section G
- BM* – Benchmark
- VSAA – Vertical ShapeAccelArray
- HSAA – Horizontal ShapeAccelArray
- SR – Settlement Rod
- DSS – Sigital Settlement System
- SI – Slope Inclinometer
- SP – Settlement Pin
- VWP – Vibrating Wire Piezometer
- RVWP – Reference Vibrating Wire Piezometer

-NOTES-

1. Base plan, highway and culvert alignments are current as of Feb. 14, 2014.
2. Skewed sections shall be parallel to culvert.
3. Instrument locations are approximate. For actual locations refer to Typical Monitoring Sections (Sheet 1 to 7). Some field adjustment to instrument locations may be required.
4. Care must be exercised not to damage the wick drains. Where SI, VWP and/or DSS are installed in wick drain areas refer to Typical Instrumentation Layout within a wick drain area (Sheet 19)

GEOCRES No. 52A-182

LICENSED PROFESSIONAL ENGINEER
S. PETERS
100194478
Oct 1/14
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Oct 1/14
PROVINCE OF ONTARIO

REVISIONS			
	DATE	BY	DESCRIPTION

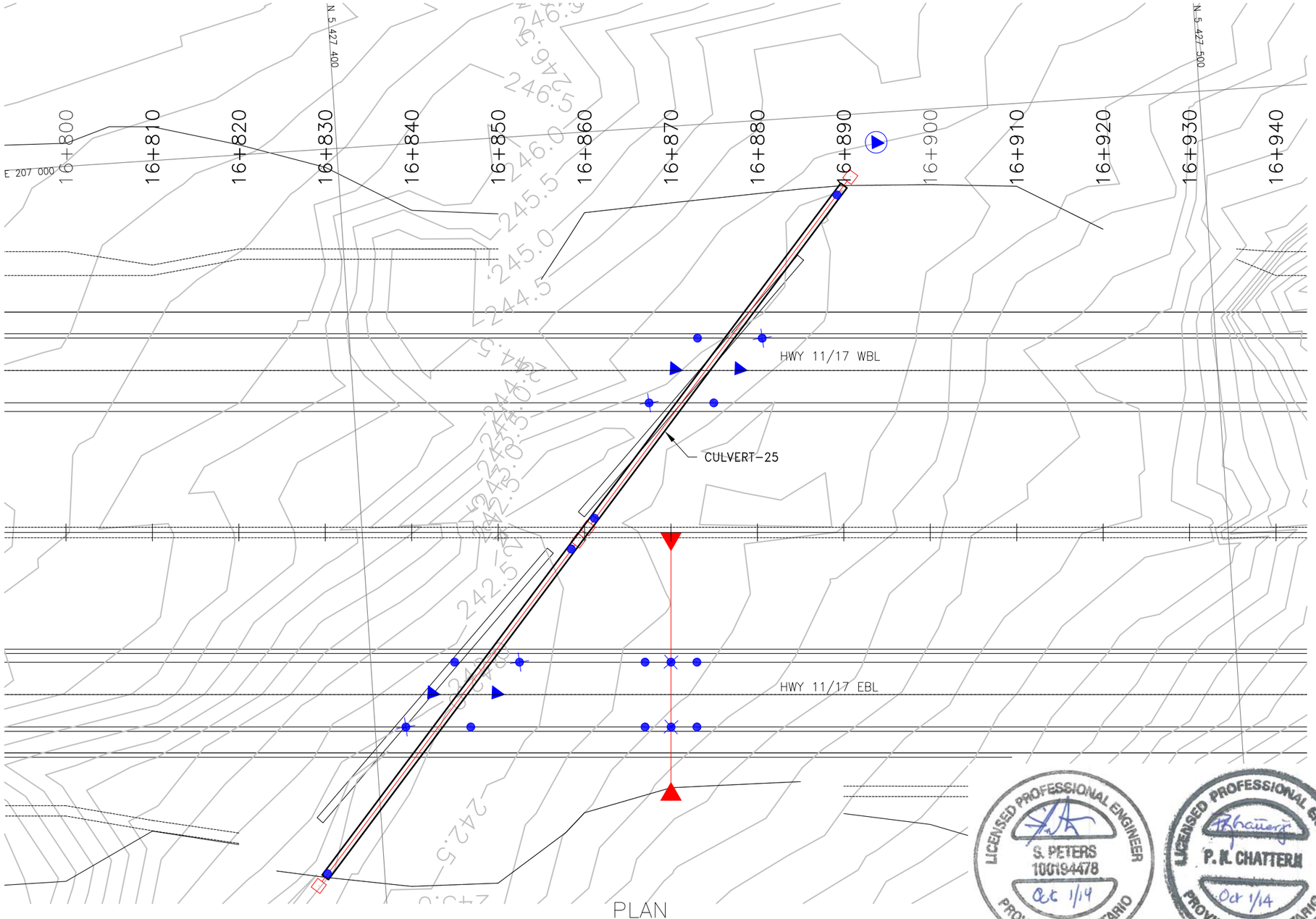
DESIGN	SBP	CHK	PKC	CODE		LOAD	DATE OCT 2014
DRAWN	MFA	CHK	SBP	SITE		STRUCT	DWG M-P5

FILENAME: H:\Drafting\19\1351\237\ed1237-MonitoringPlan.dwg
PLOTDATE: 10/2/2014 4:22 PM

MINISTRY OF TRANSPORTATION, ONTARIO

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN



PLAN

10 0 10 20m

SCALE 1:500

*2 BM'S (■) shall be installed in this area. Please refer to NSSP "Supply and Installation of Embankment Monitoring Equipment – Benchmark" for installation details.

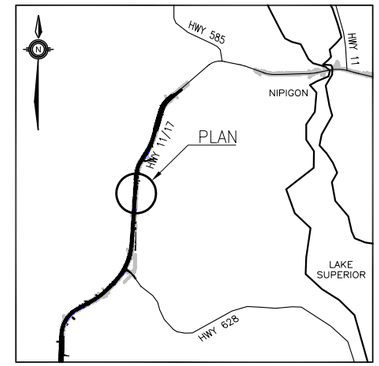
CONT No 2014-6026
GWP No 647-89-00

HWY 11/17 FOUR LANING
EBL & WBL
(STA. 16+800 TO 16+940)
MONITORING PLAN

SHEET 13

MMM GROUP

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

- Section A
- Section B
- Section C
- Section D
- Section E
- Section F
- Section G
- BM* – Benchmark
- VSAA – Vertical ShapeAccelArray
- HSAA – Horizontal ShapeAccelArray
- SR – Settlement Rod
- DSS – Sigital Settlement System
- SI – Slope Inclinometer
- SP – Settlement Pin
- VWP – Vibrating Wire Piezometer
- RVWP – Reference Vibrating Wire Piezometer

-NOTES-

1. Base plan, highway and culvert alignments are current as of Feb. 14, 2014.
2. Skewed sections shall be parallel to culvert.
3. Instrument locations are approximate. For actual locations refer to Typical Monitoring Sections (Sheet 1 to 7). Some field adjustment to instrument locations may be required.
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GEOCRES No. 52A-182

REVISIONS		
DATE	BY	DESCRIPTION

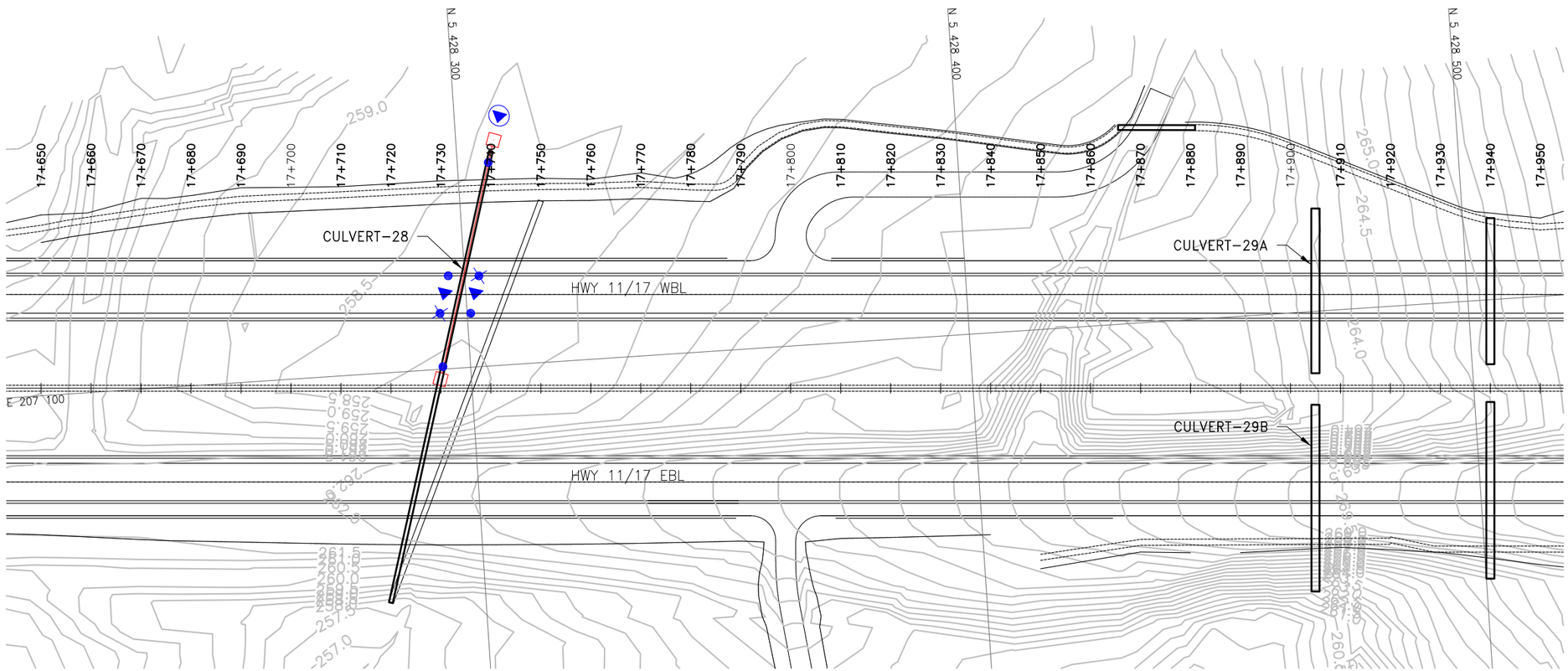
DESIGN	SBP	CHK	PKC	CODE	LOAD	DATE OCT 2014
DRAWN	MFA	CHK	SBP	SITE	STRUCT	DWG M-P6

FILENAME: H:\Drafting\19\1351\237\ted1237-MonitoringPlan.dwg
PLOTDATE: 10/2/2014 4:23 PM

MINISTRY OF TRANSPORTATION, ONTARIO

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN



PLAN

20 0 20 40m

SCALE 1:1000

*1 BM (■) shall be installed in this area. Please refer to NSSP ''Supply and Installation of Embankment Monitoring Equipment – Benchmark'' for installation details.

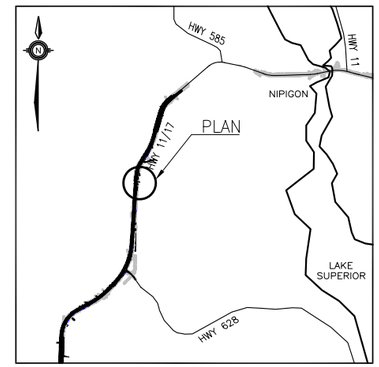
CONT No 2014–6026
GWP No 647–89–00

HWY 11/17 FOUR LANING
EBL & WBL
(STA. 17+650 TO 17+950)
MONITORING PLAN

SHEET 14

MMM GROUP

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

- Section A
- Section B
- Section C
- Section D
- Section E
- Section F
- Section G
- BM* – Benchmark
- VSAA – Vertical ShapeAccelArray
- HSAA – Horizontal ShapeAccelArray
- SR – Settlement Rod
- DSS – Sigital Settlement System
- SI – Slope Inclinometer
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- VWP – Vibrating Wire Piezometer
- RVWP – Reference Vibrating Wire Piezometer

-NOTES-

1. Base plan, highway and culvert alignments are current as of Feb. 14, 2014.
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GEOCRES No. 52A-182

LICENSED PROFESSIONAL ENGINEER S. PETERS 100194478 Oct 1/14 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER P. K. CHATTERJI Oct 1/14 PROVINCE OF ONTARIO

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	SBP	CHK	PKC	CODE	LOAD
DRAWN	MFA	CHK	SBP	SITE	STRUCT

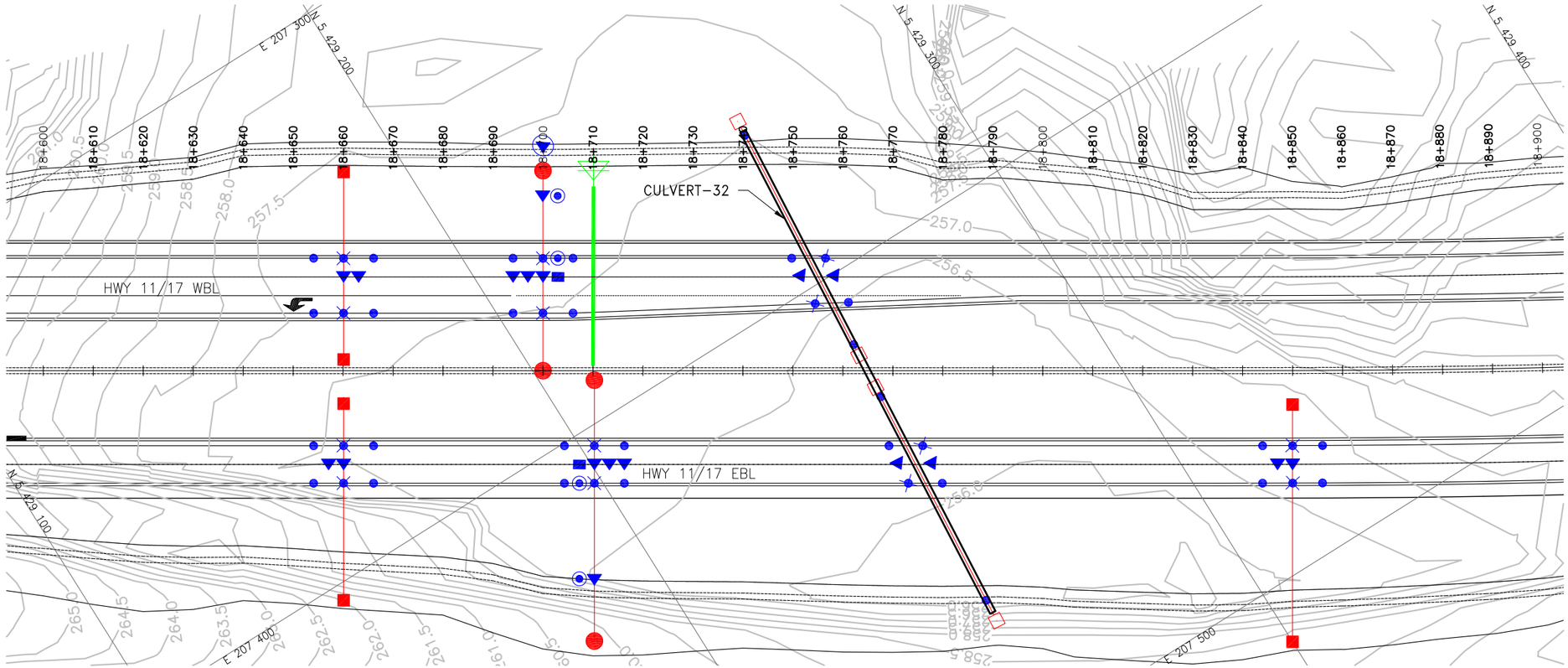
DATE OCT 2014
DWG M–P7

FILENAME: H:\Drafting\1351\237\ed1237–MonitoringPlan.dwg
PLOTDATE: 10/2/2014 4:25 PM

MINISTRY OF TRANSPORTATION, ONTARIO

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN



PLAN

20 0 20 40m

SCALE 1:1000

LICENSED PROFESSIONAL ENGINEER
S. PETERS
100194478
Oct 1/14
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Oct 1/14
PROVINCE OF ONTARIO

*2 BM'S (■) shall be installed in this area. Please refer to NSSP "Supply and Installation of Embankment Monitoring Equipment – Benchmark" for installation details.

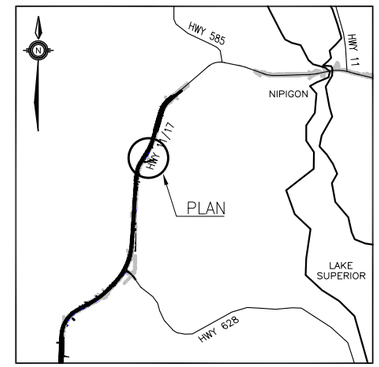
CONT No 2014-6026
GWP No 647-89-00

HWY 11/17 FOUR LANING
EBL & WBL
(STA. 18+600 TO 19+000)
MONITORING PLAN

SHEET 15

MMM GROUP

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

- Section A
- Section B
- Section C
- Section D
- Section E
- Section F
- Section G
- BM* – Benchmark
- VSAA – Vertical ShapeAccelArray
- HSAA – Horizontal ShapeAccelArray
- SR – Settlement Rod
- DSS – Sigital Settlement System
- SI – Slope Inclinometer
- SP – Settlement Pin
- VWP – Vibrating Wire Piezometer
- RVWP – Reference Vibrating Wire Piezometer

-NOTES-

1. Base plan, highway and culvert alignments are current as of Feb. 14, 2014.
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GEOCRES No. 52A-182

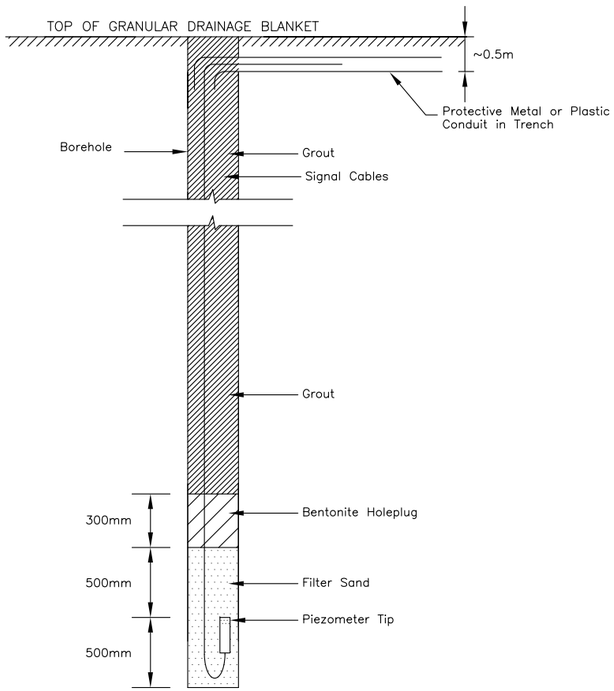
REVISIONS			
DATE	BY	DESCRIPTION	
DESIGN SBP	CHK PKC	CODE	LOAD DATE OCT 2014
DRAWN MFA	CHK SBP	SITE	STRUCT DWG M-P8

FILENAME: H:\Drafting\191351\237\esd1237-MonitoringPlan.dwg
PLOTDATE: 10/2/2014 4:26 PM

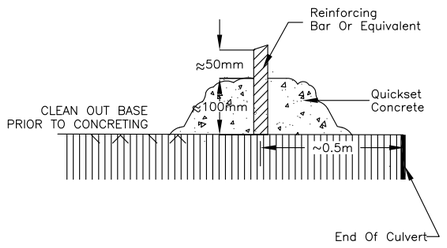
MINISTRY OF TRANSPORTATION, ONTARIO

METRIC

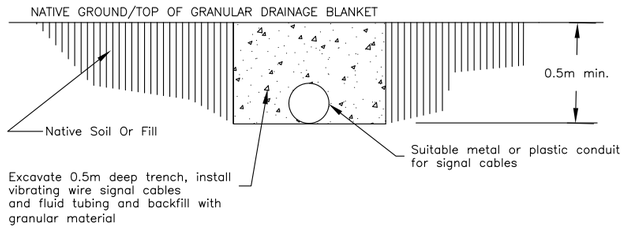
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN



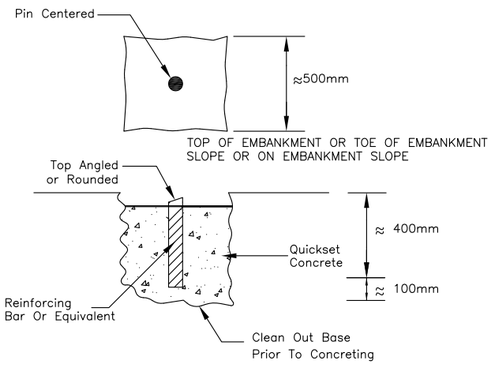
VIBRATING WIRE PIEZOMETER (VWP)
&
REFERENCE VIBRATING WIRE PIEZOMETER (RVWP)



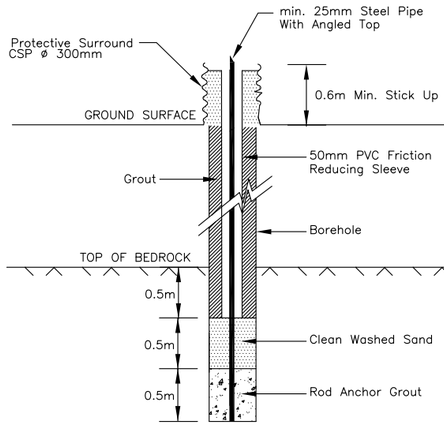
CULVERT SETTLEMEBT PIN (SP)



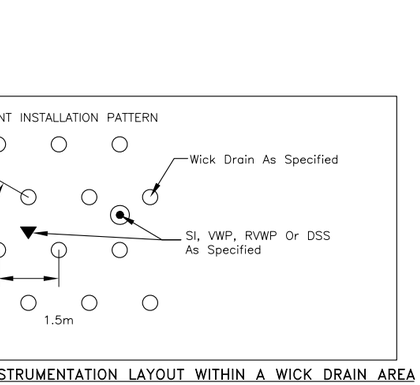
TRENCH FOR SIGNAL CABLES



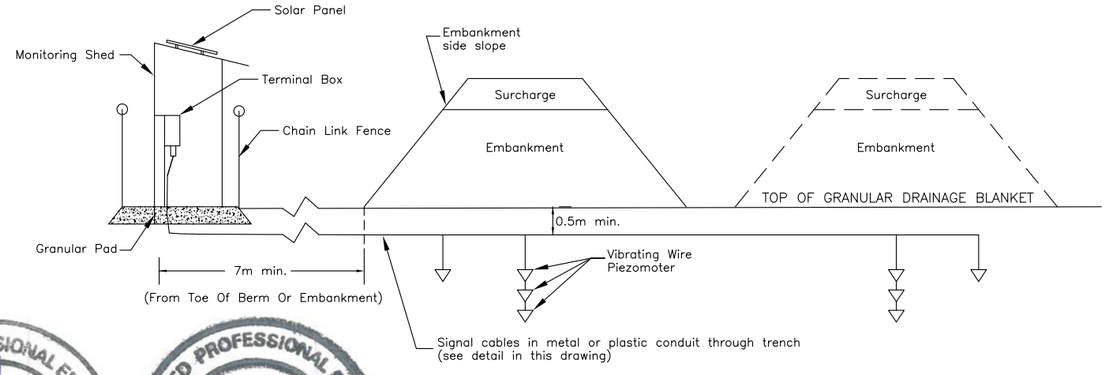
EMBANKMENT SETTLEMENT PIN (SP)



BENCHMARK (BM)



TYPICAL INSTRUMENTATION LAYOUT WITHIN A WICK DRAIN AREA



MONITORING SHED SET-UP FOR MONITORING

LICENSED PROFESSIONAL ENGINEER
S. PETERS
100194478
Oct 1/14
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Oct 1/14
PROVINCE OF ONTARIO

NOT TO SCALE

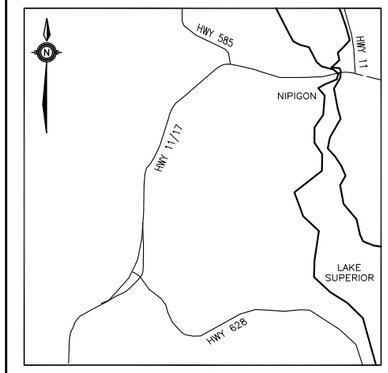
CONT No 2014-6026
GWP No 647-89-00

HIGHWAY 11/17
FOUR – LANING
REDROCK TO NIPIGON
MONITORING INSTRUMENT DETAILS # 1

SHEET 16

MMM GROUP

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

- SR – Settlement Rod (*)
- DSS – Digital Settlement System (*)
- SI – Slope Inclinometer (*)
- VWP – Vibrating Wire Piezometer (*)
- NP – Nail Pin

-NOTES-

* This Drawing Is Schematic Only. Please Refer To NSSP "Supply And Installation of Embankment Monitoring Equipment" For Instrument Depth of Installation.

** RVWP Is Not Required For Every Monitoring Section. Please Refer To Monitoring Plan For Specified Locations.

GEOCRES No. 52A-182

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	LPG	CHK	JPL	CODE	LOAD
DRAWN	AN	CHK	SBP	SITE	STRUCT

DATE OCT 2014
DWG MI-1

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MINISTRY OF TRANSPORTATION, ONTARIO

METRIC

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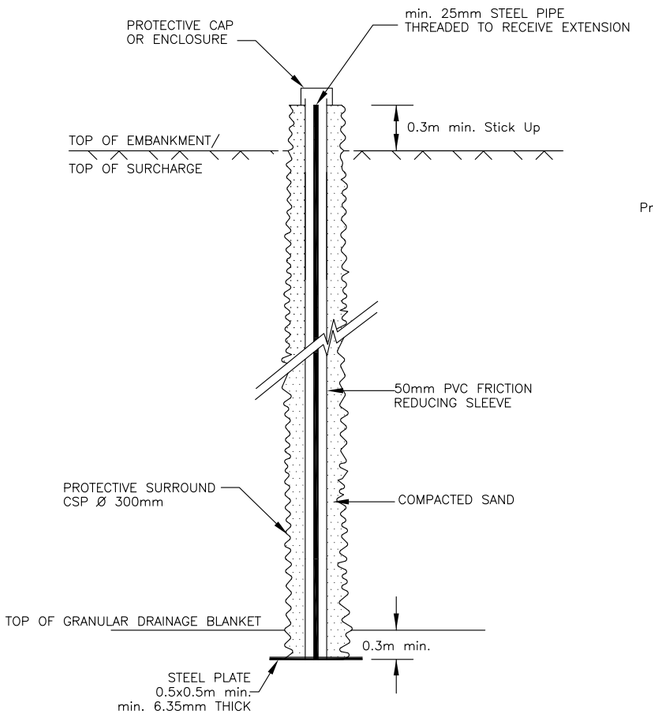
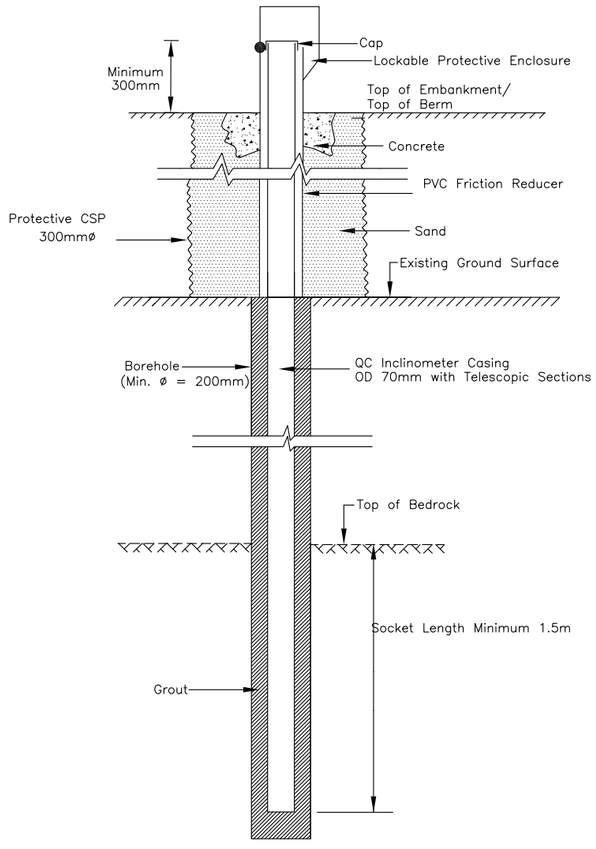
UNLESS OTHERWISE SHOWN



SETTLEMENT ROD (SR)



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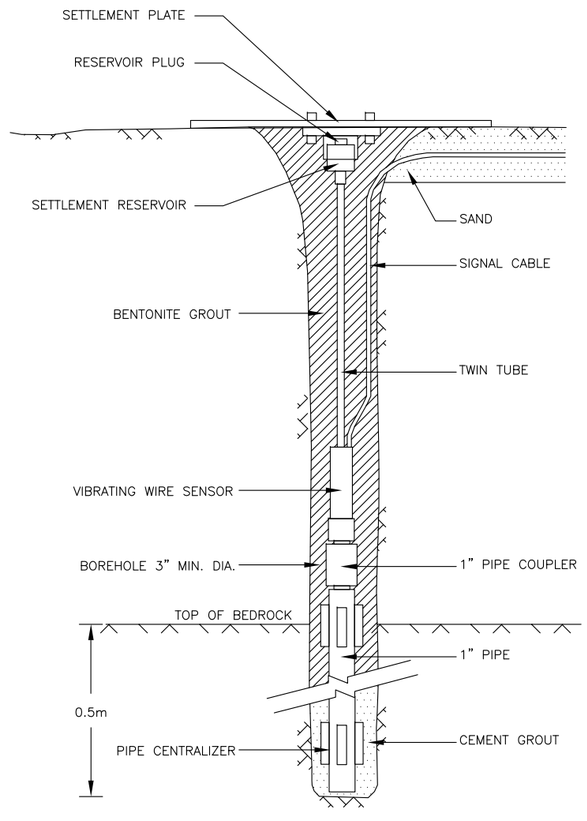


DIGITAL SETTLEMENT SYSTEM (DSS)

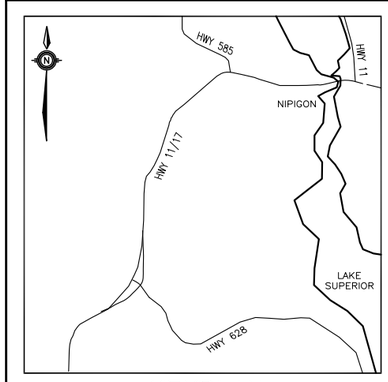
CONT No 2014-6026
GWP No 647-89-00

HIGHWAY 11/17
FOUR - LANING
REDROCK TO NIPIGON
MONITORING INSTRUMENT DETAILS # 2

SHEET
17

MMM GROUP

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

- SR - Settlement Rod (*)
- DSS - Digital Settlement System (*)
- SI - Slope Inclinometer (*)
- VWP - Vibrating Wire Piezometer (*)
- P NP - Nail Pin

-NOTES-

* This Drawing Is Schematic Only. Please Refer To NSSP "Supply And Installation of Embankment Monitoring Equipment" For Instrument Depth of Installation.

** RVWP Is Not Required For Every Monitoring Section. Please Refer To Monitoring Plan For Specified Locations.

GEOCRES No. 52A-182

LICENSED PROFESSIONAL ENGINEER
S. PETERS
100194478
Oct 1/14
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. N. CHATTERJI
Oct 1/14
PROVINCE OF ONTARIO

NOT TO SCALE

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN LPG	CHK JPL	CODE	LOAD	DATE	OCT 2014
DRAWN AN	CHK SBP	SITE	STRUCT	DWG	MI-2

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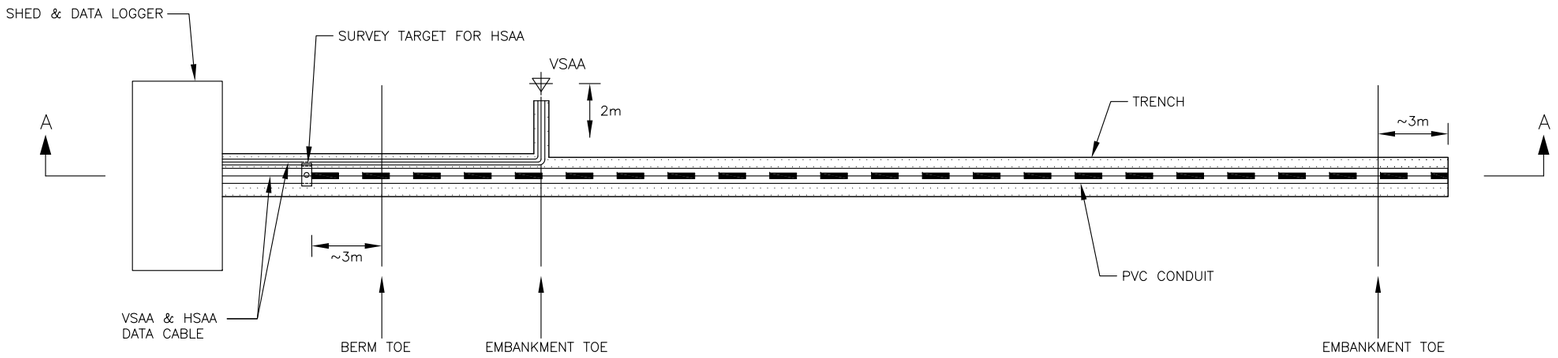
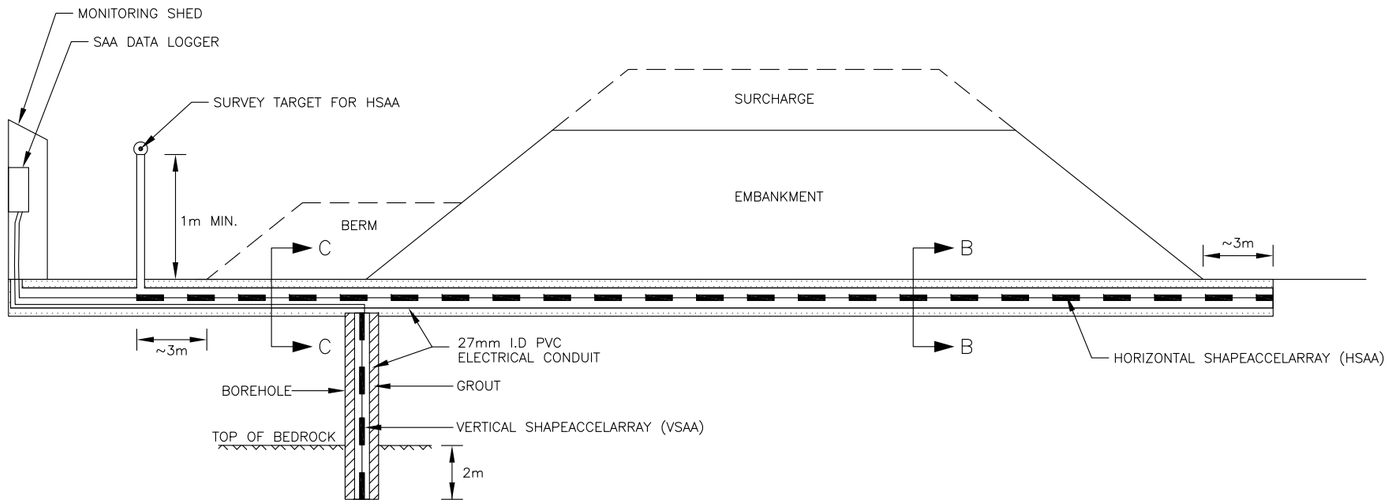
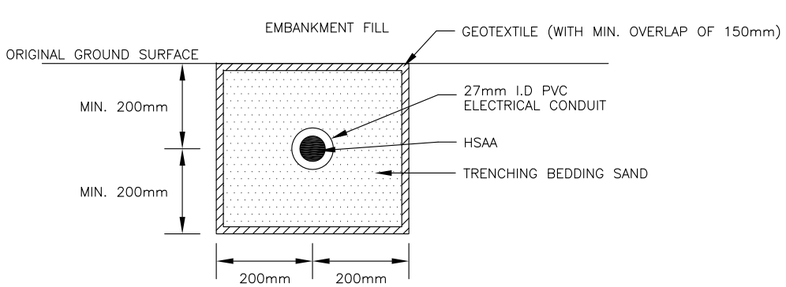
MINISTRY OF TRANSPORTATION, ONTARIO



PLAN



SECTION A–A



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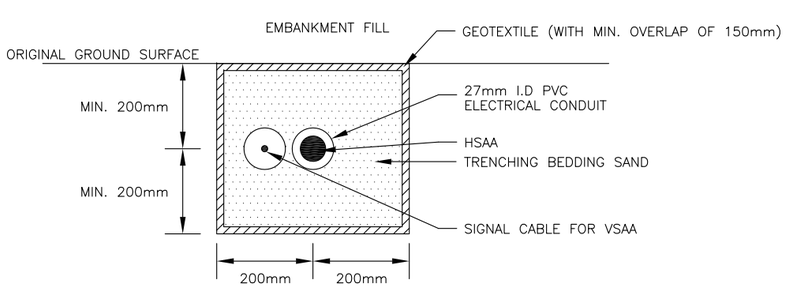


SECTION C–C

NOT TO SCALE

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

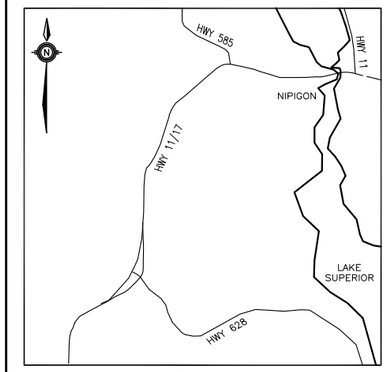
CONT No 2014–6026
GWP No 647–89–00

HIGHWAY 11/17
FOUR – LANING
REDROCK TO NIPIGON
MONITORING INSTRUMENT DETAILS # 3

SHEET 18

MMM GROUP

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

HSAA – Horizontal ShapeAccelArray

VSAA – Vertical ShapeAccelArray

-NOTES-

* This Drawing Is Schematic Only. Please Refer To NSSP "Supply And Installation of Embankment Monitoring Equipment" For Instrument Depth of Installation.

** RVWP Is Not Required For Every Monitoring Section. Please Refer To Monitoring Plan For Specified Locations.

GEOCRES No. 52A-182

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN LPG	CHK JPL	CODE	LOAD	DATE	OCT 2014
DRAWN AN	CHK SBP	SITE	STRUCT	DWG	MI–3

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OPERATIONAL CONSTRAINT (FOUNDATIONS) – Surcharge and Waiting Periods

Special Provision

1.0 SCOPE

The construction of the following embankment areas shall be subject to surcharge and waiting periods as prescribed below.

10+900 to 11+170 (Hwy 11/17 EB and WB)
11+170 to 11+800 (Hwy 11/17 EB and WB)
11+900 to 11+950 (Hwy 11/17 EB and WB)
12+050 to 12+100 (Hwy 11/17 EB and WB)
12+100 to 12+170 (Hwy 11/17 EB)
12+170 to 12+270 (Hwy 11/17 EB and WB)
12+270 to 12+590 (Hwy 11/17 EB)
12+650 to 13+300 (Hwy 11/17 EB and WB)
13+300 to 13+450 (Hwy 11/17 EB and WB)
13+590 to 13+660 (Hwy 11/17 EB and WB)
13+875 to 14+275 (Hwy 11/17 EB and WB)
14+525 to 14+800 (Hwy 11/17 EB and WB)
15+190 to 15+220 (Hwy 11/17 EB and WB)
15+500 to 15+700 (Hwy 11/17 EB and WB)
15+730 to 16+430 (Hwy 11/17 EB)
16+430 to 16+470 (Hwy 11/17 WB)
16+820 to 16+940 (Hwy 11/17 EB and WB)
17+250 to 17+400 (Hwy 11/17 EB and WB)
17+550 to 17+675 (Hwy 11/17 EB and WB)
17+675 to 17+925 (Hwy 11/17 EB and WB)
18+450 to 18+520 (Hwy 11/17 EB and WB)
18+600 to 18+950 (Hwy 11/17 EB and WB)
10+000 to 10+050 (Red Rock Road 9)
9+960 to 10+000 (Landfill Road)
9+940 to 10+000 (Red Rock Road 8)
10+120 to 10+280 (Hwy 628)

2.0 DEFINITIONS

Surcharge shall be defined as Granular B, Type II in accordance with OPSS 1010 and compacted in accordance with SP314S01. Surcharge material may be left in place as road subbase.

Within the context of this Special Provision, the term "Stage" does not refer to overall construction staging, rather to the staged construction of embankments to levels identified elsewhere in the contract.

3.0 MATERIALS – N/A

4.0 CONSTRUCTION

4.1 Embankment Construction Restrictions

The Contractor is advised that the timing for placement of embankment fill and surcharge material (where applicable) in the above areas is critical to the overall schedule. The Contractor shall schedule his operations to ensure the wait periods for surcharges described herein are met such that subsequent stages of construction are not delayed as a result of the contractor extending wait period beyond those prescribed herein without prior approval from the Contract Administrator.

In the preload/surcharge and wick drain areas no fill shall be placed on frozen ground.

No sidecasting of surplus materials shall be allowed within the limits or adjacent to the above embankment areas.

The Contractor is advised that the waiting periods in Tables 1 and 2 are governed by the embankment monitoring results and embankment performance.

4.2 Construction Equipment

Construction equipment or traffic shall not be permitted to travel in areas of exposed wicks and/or exposed geogrid.

4.3 Prior to Embankment Construction

The construction of the embankments shall be in accordance with the contract documents and drawings. The embankment construction shall start only after the following construction sequence:

- Complete removal of topsoil, organics and peat within the embankment and stabilizing berm footprint in accordance with the design templates, placement of granular drainage blanket and installation of wick drains (where applicable) in accordance with Contract Documents and Drawings;
- Completion of installation of monitoring instruments (where applicable) and subject to the determination by the Contract Administrator that the Vibrating Wire Piezometers (VWP), Digital Settlement System (DSS), ShapeAccelArray (SAA) and Slope Inclinometer (SI) "baseline readings" have stabilized. The stabilization time is estimated to be in the order of fifteen (15) days after the completion of installation of the VWPs, DSSs, SAAs, SIs;
- Completion of placement of geogrid and granular blanket (where applicable) as per Contract Documents and Drawings.

4.4 Monitoring Program

The Contractor is advised that a Monitoring Program will be carried out to monitor pore water pressures, settlements, and lateral displacements in the foundation soils at selected locations identified in the Special Provision for *Supply and Installation of Embankment Monitoring Equipment* in order to assess on-going foundation performance as a result of embankment construction. The rate of fill placement, waiting period between successive stages of fill, the timing for the removal of surcharge and subsequent construction activities shall be determined by the Contract Administrator based on the results of the instrumentation monitoring program.

Contractor shall obtain written approval from the Contract Administrator prior to proceeding to the next stage of fill placement, removal of surcharge and road paving.

4.5 Single-stage Embankment Construction

The embankment sections in Table 1 are anticipated to be constructed in a single stage of construction. The anticipated waiting periods for settlement and dissipation of excess pore pressures are shown in Table 1.

Table 1

Stations	Waiting Period After Completion of Fill Placement – prior to paving (months)		Stations	Waiting Period After Completion of Fill Placement – prior to paving (months)	
	WBL	EBL		WBL	EBL
10+900 to 11+170	1	1	15+500 to 15+725	12	12
11+170 to 11+800	1	1	15+730 to 16+430	N/A	4
11+900 to 11+950	1	1	16+430 to 16+470	6	N/A
12+050 to 12+100	3	5	16+820 to 16+940	12	12
12+100 to 12+170	1	1	17+250 to 17+400	1	1
12+170 to 12+270	3	10	17+550 to 17+675	1	1
12+270 to 12+590	2	2	18+450 to 18+520	3	3
12+650 to 13+300	5	5	10+000 to 10+050 (Red Rock Road 9)	1	
13+590 to 13+660	2	2	9+960 to 10+000 (Landfill Road)	1	
13+875 to 14+275	2	3	9+940 to 10+120 (Red Rock Road 8)	1	
15+190 to 15+220	2	2	10+120 to 10+280 (Hwy 628)	6	

The construction sequence shall be as follows:

- The Contractor shall construct the embankment in a single stage to the subgrade elevations per the design templates
- The contractor shall place 430mm of Granular B Type II over the entire width of the rockfill embankment.
- The completion of settlements and the waiting period for dissipation of excess pore pressures shall be determined by the Contract Administrator
- The Contractor shall remove the Granular B Type II to the top of the subbase course elevation and construct the pavement structure (including final placement of granular road base and any hot mix paving) as per design templates only after receiving written instruction to proceed from the Contract Administrator.

4.5.2 Multi-Stage Embankment Construction

The embankment sections shown in Table 2 are required to be built in more than one construction stage with a waiting period between stages. A waiting period is also required prior to surcharge removal (if applicable) and/or final placement of granular road base and subbase and any hot mix paving. These waiting periods are as shown in Table 2 and are necessary to allow completion of settlement and dissipation of excess pore water pressure.

Table 2

Stations	Waiting Period After Completion of Fill Placement, including Surcharge (months)						Height of Surcharge Above Final Profile (m)	
	Stage 1		Stage 2		Stage 3			
	WBL	EBL	WBL	EBL	WBL	EBL	EBL	WBL
13+300 to 13+450	6	6	6	6	N/A	N/A	1	1
14+525 to 14+800	6	6	6	6	6	6	2	2
17+675 to 17+925	5	3	5	N/A	N/A	N/A	N/A	N/A
18+600 to 18+950	6	6	6	6	6	6	2	2

The embankment construction sequence shall be as follows:

- The Contractor shall concurrently construct stabilization berms and embankment to Stage 1 level as shown elsewhere in the Contract. Once the embankment has been completed to Stage 1, the Contractor shall survey the elevation of the top of this stage.
- The completion of settlements and the waiting period for dissipation of excess pore pressures following Stage 1 fill placement shall be determined by the Contract Administrator. The anticipated waiting periods are shown in Table 2.
- Once written approval to proceed is provided by the Contract Administrator, the Contractor shall construct the embankment to the Stage 2 level (if applicable) as shown elsewhere in the Contract. There will be a requirement to top-up the embankment to achieve the Stage1 design elevation prior to placing the Stage 2 fill.
- The completion of settlements and the waiting period for dissipation of excess pore pressures following Stage 2 fill placement shall be determined by the Contract Administrator. The anticipated waiting periods are shown in Table 2. Once the embankment has been completed to Stage 2, the Contractor shall survey the elevation of the top of this stage.
- Once written approval to proceed is provided by the Contract Administrator, the Contractor shall construct embankment to the Stage 3 level (if applicable) as shown elsewhere in the Contract. There will be a requirement to top up the embankment to achieve the Stage 2 design elevation prior to placing the Stage 3 fill.
- The completion of settlements and the waiting period for dissipation of excess pore pressures following Stage 3 fill placement (if applicable) shall be determined by the Contract Administrator. The anticipated waiting periods are shown in Table 2.
- Upon receiving written instruction from the Contract Administrator, the Contractor shall remove surcharge material (if applicable) to design top of subbase course and construct the remaining pavement structure as per design templates.

WICK DRAINS – Item No.

Special Provision

1.0 SCOPE

This special provision specifies the requirements for the supply and installation of wick drains in accordance with the details shown on the contract drawings and with the requirements of these specifications.

2.0 REFERENCES

2.1 Qualifications

The work shall be undertaken by a recognized specialist subcontractor that has proven satisfactory experience in work of this type and magnitude and has completed a minimum of five wick drain installation projects in the last five years, each project with the following characteristics:

a. Maximum installation depth: not less than 15 m
b. Total length of wick drains: not less than 40,000 m

The specialist subcontractor's qualifications shall be submitted to the Contract Administrator not later than 15 working days in advance of commencing the installation of wick drains.

2.2 Wick Drain Tip Elevation Contour Drawings

Reference shall be made to the following Contract Drawings:

- Wick Drain Plan STA. 13+300 to 13+430
- Wick Drain Plan STA. 14+560 to 14+810
- Wick Drain Plan STA. 18+570 to 18+970

The anticipated wick drain tip elevations in the above contract drawings are interpreted from the available borehole data assuming that the wick drains will either terminate at top of bedrock/refusal material or penetrate 0.5 m in the cohesionless deposit underlying the compressible cohesive deposits. The wick drain tip elevations between and beyond the borehole locations were estimated by interpolation and extrapolation of the data, respectively. Therefore the actual tip elevations may vary on site during wick drain installation. The lateral extent of wick drain installation shall be at the proposed toes of embankment or stabilization berm (if applicable).

2.3 Site and Subsurface Conditions

The Contractor shall refer to the following Foundation Investigation Reports in the Contract Documents for a description of subsurface conditions at these sites:

- Foundation Investigation Report, High Embankments and Deep Cuts, Highway 11/17 Red Rock to Nipigon from 4.8 kM West of Highway 628 to 1.5 kM West of Highway 585, Township of Nipigon, G.W.P. 647-89-00, Geocres No. 52A-180, Thurber Engineering Limited.
- Foundation Investigation Report, Low to Medium Embankments, Highway 11/17 Red

Rock to Nipigon from 4.8 kM West of Highway 628 to 1.5 kM West of Highway 585, Township of Nipigon, G.W.P. 647-98-00, Geocres No. 52A-182, Thurber Engineering Limited.

- Foundation Investigation Report, Itzcaulde Creek Culvert, Highway 11/17 Red Rock to Nipigon from 4.8 kM West of Highway 628 to 1.5 kM West of Highway 585, Township of Nipigon, G.W.P. 647-89-00, Geocres No. 52A-179, Thurber Engineering Limited.
- Foundation Investigation Report, Culverts, Supplementary Embankments and Cut Slopes, Highway 11/17 Red Rock to Nipigon from 4.8 kM West of Highway 628 to 1.5 kM West of Highway 585, Township of Nipigon, G.W.P. 647-89-00, Geocres No. 52A-184, Thurber Engineering Limited

The Record of Borehole sheets are not represented as a complete description of the subsurface conditions, but only present what was found in borings at the indicated locations on the date boreholes were drilled. The subsurface conditions may be variable between and beyond the borehole locations. The Contractor should verify existing subsurface and surface conditions.

The contract drawings include elevation contour plots for wick drain tip at 0.5 m below the anticipated base of clay. Contours provided between and beyond the borehole locations are interpolated and extrapolated, respectively, and should be used for estimation purposes only.

3.0 DEFINITIONS

Quality Verification Engineer (QVE): means an Engineer who has a minimum of five (5) years experience related to the design and installation of wick drains or alternatively has demonstrated expertise by providing satisfactory quality verification services for the work at a minimum of three (3) projects of similar scope to the Contract. The Quality Verification Engineer shall be retained by the Contractor to certify that the work is in general conformance with the contract documents and to issue Certificate(s) of Conformance.

4.0 SUBMISSION AND DESIGN REQUIREMENTS

4.1 Certificate of Conformance – Material

The Contractor shall submit a sample of the wick drain to the Quality Verification Engineer for review prior to the installation of the wick drains on the Contract. The Contractor shall submit to the Contract Administrator a Certificate of Conformance sealed and signed by the Quality Verification Engineer a minimum of 15 days prior to commencement of work under this item. The Certificate shall state that the wick drain material is in conformance with the requirements and specifications of the contract documents.

4.2 Certificate of Conformance – Installation Method

The Contractor shall submit to the Contract Administrator a Certificate of Conformance sealed and signed by the Quality Verification Engineer a minimum of 15 days prior to commencement of work under this item. The Certificate shall state that the installation procedures are in conformance with the requirements and specifications of the contract documents.

4.3 Certificate of Conformance – Final

Upon completion of the wick drain installation, the Contractor shall submit to the Contract

Administrator a final Certificate of Conformance sealed and signed by the Quality Verification Engineer. The certificate shall state that the work has been carried out in general conformance with the installation procedure and specifications of the contract documents. A record of wick drain installation, including reasons for deviations from design tip elevations, shall be submitted with this Certificate of Conformance.

5.0 MATERIALS

5.1 Wick Drain

The prefabricated drain shall consist of a continuous plastic drainage core wrapped in a non-woven geotextile material. The core configuration should be 'Studded' or 'Grooved' ('Filament'or 'Cuspated' are not acceptable).

The prefabricated wick drain material shall meet the minimum requirements specified in

Table 1.

Table 1 – Wick Drain Material Specifications

Property	Test Method	Units	Specification
Physical			
Drain Body Material			Polypropylene – Studded or Grooved
Filter Material			Polypropylene – Non Woven
Width		mm	≥ 100
Core Thickness	ASTM D-5199	mm	≥ 2
Composite Thickness	ASTM D-5199	mm	≥ 3
Mass of Core	ASTM D-3776	g/m	≥ 40
Mass of Filter	ASTM D-5261	g/m^2	≥ 110
Mechanical			
Tensile Strength Core	ASTM D-638	N	≥ 800
Grab Tensile Strength Filter	ASTM D-4632	N	≥ 600
Puncture Strength	ASTM D-4533	N	≥ 200
Filter Trapezoidal Tear	ASTM D-4833	N	≥ 200
Filtration Opening Size(FOS)	CAN/CGSB-148.1, Method No. 10	μm	≥ 40
Discharge Capacity @ 10 kPa	ASTM D-4716	m^3/s	$\geq 1.2 \times 10^{-4}$
Discharge Capacity @ 240 kPa	ASTM D-4716	m^3/s	$\geq 1.0 \times 10^{-4}$
Permittivity, minimum	ASTM D-4491	sec^{-1}	0.05

All drains supplied shall be free of defects, rips, holes or flaws. During shipment the drain shall be protected from damage. During on-site storage the storage area shall be such that the drain is protected from sunlight, dirt, dust, mud, debris and any other detrimental substances.

5.2 Sample Wick Drain

The Contractor shall submit a 1 meter sample of the wick drain material to the Contract Administrator for information at least one month prior to commencement of work under this item. The sample shall be stamped or labeled by the manufacturer as being representative of the drain material having the specified trade name. Documentation indicating the source of the drain and the physical and mechanical properties of the drain shall be provided.

5.3 Manufacturer Certification

Manufacturer certification shall be provided for all drain material delivered to the project. Quality test certificates for each production lot supplied, showing compliance with all requirements of this special provision shall be obtained by the Contractor and submitted to the Contract Administrator prior to installation.

6.0 EQUIPMENT

Wick drains shall be installed with equipment, which will minimize disturbance to the granular blanket or the native subsoil during the installation operation. Static or vibratory methods are considered acceptable. Falling weight impact hammers will not be allowed.

The Contractor is advised that the wick drain areas are considered environmentally sensitive areas and therefore the control of any water effluent needs to be carefully planned and organized. Jetting techniques, therefore, shall not be used unless approved by the Contract Administrator.

The Contractor shall be permitted to use augering equipment to pre-drill or loosen the native soils and the granular blanket, if required, to facilitate the installation of the wick drains. The augers shall have a maximum outside diameter equal to the largest horizontal dimension of the mandrel, shoe or anchor.

Each prefabricated wick drain shall be installed using a mandrel or sleeve that shall be advanced through the underlying soil and the granular blanket. The mandrel shall protect the prefabricated drain material from tears, cuts and abrasions during installation and shall be withdrawn after the installation of the drain. The mandrel shall be provided with an “anchor" rod or plate at the bottom to prevent the soil from entering the bottom of the mandrel during installation of the drain and to anchor the bottom of the drain at the required depth at the time of mandrel removal. The projected cross-sectional area of the mandrel and anchor combination shall not exceed 8000 mm^2.

Upon completion of wick drain installation, construction equipment or traffic shall not be permitted to travel in areas of exposed wicks.

7.0 INSTALLATION

7.1 Installation Method Proposal Submission

At least two weeks prior to the installation of the drainage strips, the Contractor shall submit to the Quality Verification Engineer, details of the sequence and method of installation. The submission shall satisfy the specifications and at a minimum contain the following specific information:

- Size, type, weight, maximum pushing force, and configuration of the installation rig;
- Dimensions and length of mandrel;

- Details of drain anchorage;
- Detailed description of proposed installation procedures;
- Proposed methods for overcoming obstructions;
- Proposed methods for splicing drains.

7.2 Construction Sequence

Wick drains shall be installed subsequent to the construction of the granular blanket and prior to installation of monitoring instruments and placement of the embankment material. The wick drains shall not be installed in frozen ground and shall be protected by a minimum of 4m of rock fill before ground freezing.

7.3 Trial Drains

Prior to the installation of prefabricated drains within the areas designated on the plans, the Contractor shall demonstrate that the proposed materials, equipment and installation method produce a satisfactory drain installation in accordance with these specifications. The Contractor will be required to install ten trial drains at each of the three sites within the work area as designated by the Contractor Administrator.

Should the trial drains be installed to the satisfaction of the Quality Verification Engineer, the trial drains can be incorporated as part of the permanent installation. The Contractor will be compensated for each trial drain if the installation satisfies the requirements of this specification, at the same unit price as the production drains. The Contractor shall not be compensated for unsatisfactory trial drains.

Full time monitoring of the Contractor's method of installation will be required by the Contractor's Quality Verification Engineer. If, at any time, the Quality Verification Engineer considers that the method of installation does not produce a drain that satisfies the project requirements, the Contractor shall alter the method and/or equipment as necessary to comply with these specifications.

7.4 Layout

Prefabricated drains shall be located and staked out by the Contractor. The location of the drains shall not vary by more than 150 mm from the locations indicated on the drawings.

7.5 Plumbness

Drains shall be installed vertically, within a tolerance of not more than 10 mm per 500 mm except in the area between Sta. 13+300 and Sta. 13+400 where angled wick drains are specified in designated areas on the Contract Drawings. The equipment shall be carefully checked for plumbness, and the Contractor shall provide the Contract Administrator with a suitable means of verifying the plumbness of the mandrel and of determining the depth of the drain at any time.

7.6 Splices

Splices or connections in the wick drain material shall be done in a professional manner so as to ensure continuity and to avoid any reduction of the flow characteristics of the wick material. Splices shall be a minimum of 150 mm in length.

7.7 Cut-off

The prefabricated drain shall be cut at the surface such that at least a 150 mm length protrudes above the top of the granular blanket at each drain location.

7.8 Obstructions

Where obstructions are encountered below the working surface and at less than 90% of the anticipated depth that cannot be penetrated by the wick drain installation equipment, the Contractor shall complete the drain from the elevation of the obstruction to the working surface and notify the Contract Administrator. At the direction of the Contract Administrator, the Contractor shall attempt to install a new drain within a 500 mm radius of the obstructed drain. A maximum of two attempts shall be made as directed by the Contract Administrator. The Contractor will be compensated for each obstructed drain unless the drain is improperly completed, in which case no compensation will be allowed.

Obstructions encountered within 10% of the anticipated wick drain tip depth shall complete the drain from the elevation of the obstruction to the working surface and notify the Contract Administrator. No additional attempts shall be made to re-install the wick drain unless otherwise directed by the Contract Administrator. The Contractor will be compensated for each obstructed drain unless the drain is improperly completed, in which case no compensation will be allowed.

7.9 Pre-augering and Vibratory Equipment

Pre-augering and/or suitable vibratory equipment for installation through the native soils and the granular blanket to facilitate the installation of pre-fabricated wick drains may be required. The depth of augering shall be the minimum depth required to facilitate the wick drain installation. Any additional cost for pre-augering or vibratory equipment shall be incorporated into the unit price.

7.10 Rejected Drains

Prefabricated drains that are installed beyond the plan location by more than 150mm, or that are damaged or are not installed in accordance with the specifications described above shall be rejected. Rejected drains may be removed at the Contractor's own expense and time. The Contractor shall not be compensated for the materials and work associated with rejected drains.

Replacement drains shall be installed within a 500 mm radius from the location of the rejected drain as directed by the Contract Administrator.

7.11 Geotechnical Instrumentation

Installation of wick drains shall be coordinated with the placement/installation of geotechnical instrumentation as shown on the contract drawings. Special care shall be taken to install drains in such a manner so as not to disturb instrumentation already in place. The replacement of instrumentation damaged as a result of the Contractor’s activities will be the responsibility of the Contractor.

8.0 MEASUREMENT FOR PAYMENT

Measurement for payment for Wick Drains is by Plan Quantity, as may be revised by Adjusted Plan Quantity and shall be by the linear metre for all accepted drains installed including the protruding portion.

Properly completed obstructed wick drains and properly installed replacement wick drains and trial drains will be measured for payment.

9.0 BASIS OF PAYMENT

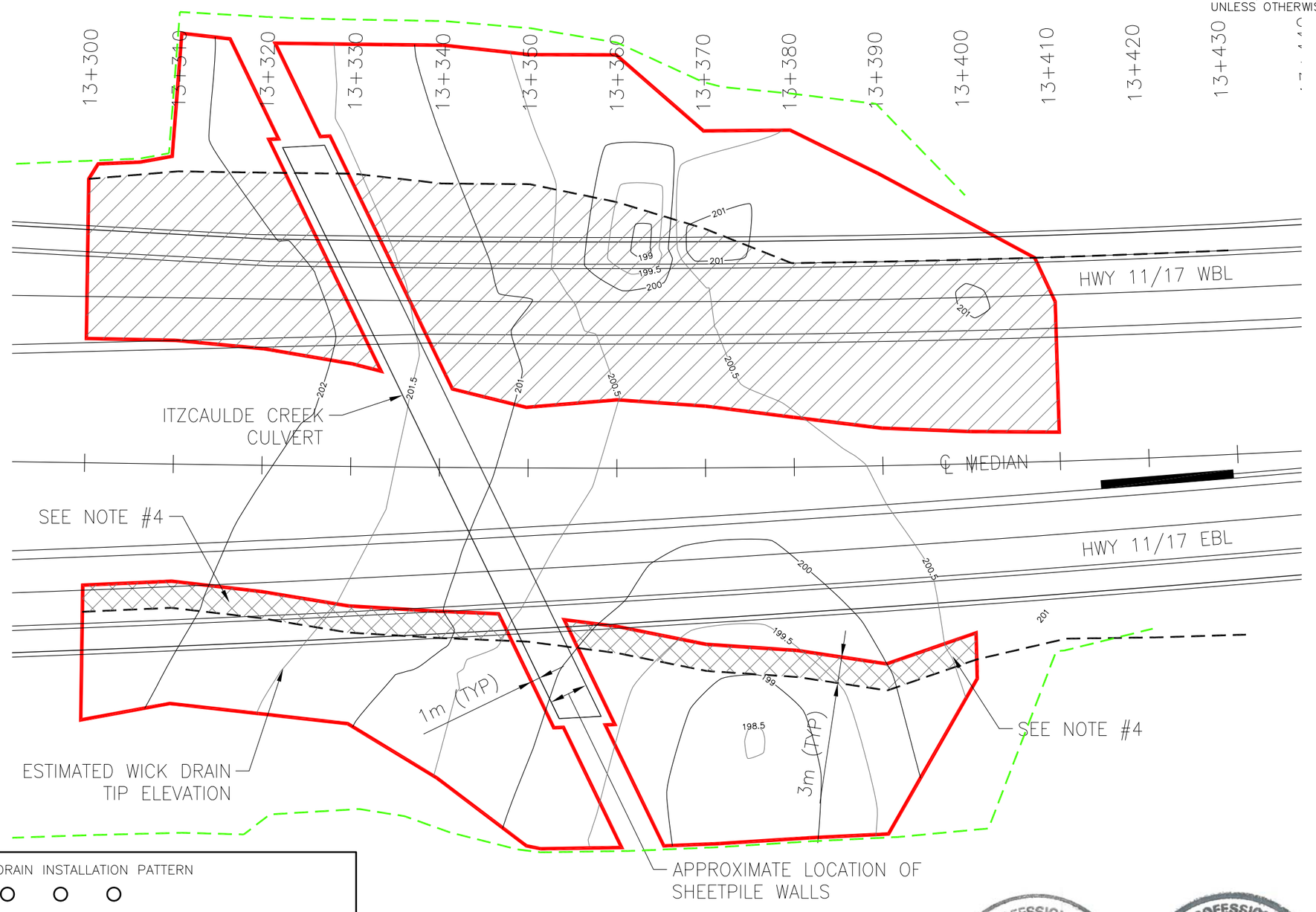
Payment at the contract unit price shall be full compensation for all labour, materials and equipment to complete the work.

No payment shall be made for unacceptable drains or delays or expenses incurred by the Contractor as a result of improper or unacceptable material or installation.

MINISTRY OF TRANSPORTATION, ONTARIO

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

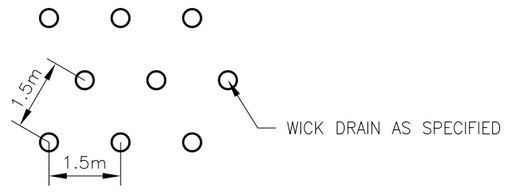


PLAN

10 0 10 20m

SCALE 1:500

WICK DRAIN INSTALLATION PATTERN



WICK DRAIN LAYOUT PLAN

N.T.S.

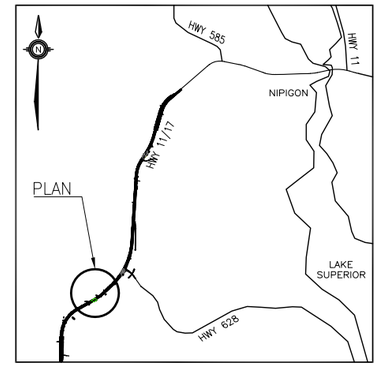
CONT No 2014-6026
GWP No 647-89-00

WICK DRAIN PLAN
STA. 13+300 TO 13+430

SHEET 1

MMM GROUP

THURBER ENGINEERING LTD.



KEYPLAN

-NOTES-

1. The anticipated termination (tip) elevation contours are interpreted from the available borehole data assuming that the wick drains will either terminate at the top of bedrock/ refusal material or penetrate 0.5m into the cohesionless deposit underlying the compressible cohesive deposits.
2. The wick drain tip elevation contours between and beyond the borehole locations were estimated by interpolation and extrapolation respectively. Therefore the actual tip elevations may vary on site during wick drain installation.
3. Wick drains shall be installed in a triangular pattern with 1.5m centre-to-centre spacing.
4. At the south toe of the existing embankment, wick drains shall be installed through the existing embankment at a 15° batter from vertical towards the existing embankment centreline.

Approximate extent of wick drain installation.

Vertical wick drains to be installed through existing embankment fills.

Battered wick drains to be installed through existing embankment fills (see note #4).

Proposed toe of embankment/stabilizing berm.

Approximate extent of existing embankment toe.

GEOCRES No. 52A-182

LICENSED PROFESSIONAL ENGINEER S. PETERS 100194478 Province of Ontario Oct 1/14

LICENSED PROFESSIONAL ENGINEER P. K. CHATTERJI Province of Ontario Oct 1/14

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN LPG	CHK JPL	CODE		LOAD	DATE OCT 2014
DRAWN AN/MFA	CHK SBP	SITE		STRUCT	DWG EWDT-01

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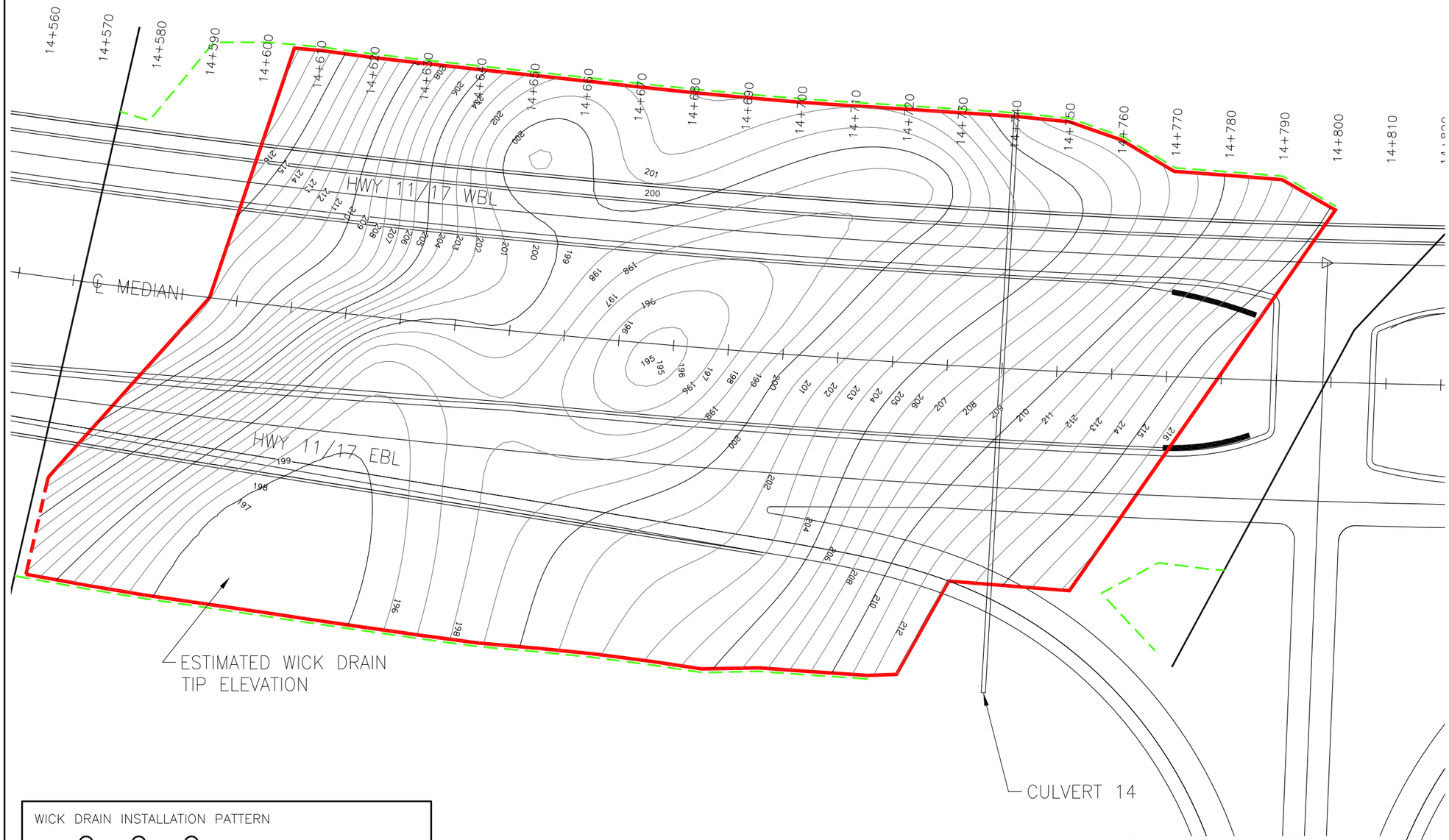
MINISTRY OF TRANSPORTATION, ONTARIO

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

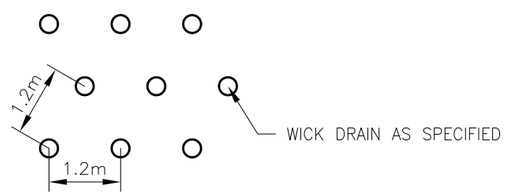


PLAN

16 0 16 32m

SCALE 1:800

WICK DRAIN INSTALLATION PATTERN



WICK DRAIN LAYOUT PLAN

N.T.S.

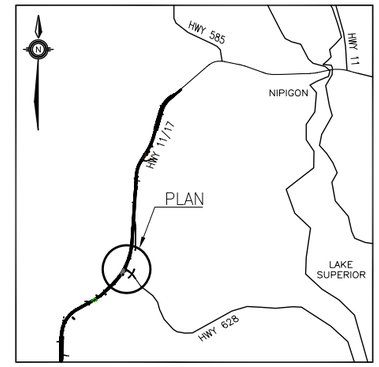
CONT No 2014-6026
GWP No 647-89-00

WICK DRAIN PLAN
STA. 14+560 TO 14+810

SHEET 2

MMM GROUP

THURBER ENGINEERING LTD.



KEYPLAN

-NOTES-

1. The anticipated termination (tip) elevation contours are interpreted from the available borehole data assuming that the wick drains will either terminate at the top of bedrock/ refusal material or penetrate 0.5m into the cohesionless deposit underlying the compressible cohesive deposits.
2. The wick drain tip elevation contours between and beyond the borehole locations were estimated by interpolation and extrapolation respectively. Therefore the actual tip elevations may vary on site during wick drain installation.
3. Wick drains shall be installed in a triangular pattern with 1.2m centre-to-centre spacing.

Approximate extents of wick drain installation.

Proposed toe of embankment/stabilizing berm.

Approximate edge of bedrock outcrop. (Location and tip elevation of wick drains near the exposed bedrock may vary)

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REVISIONS		
DATE	BY	DESCRIPTION

DESIGN LPG	CHK JPL	CODE	LOAD	DATE OCT 2014	
DRAWN AN/MFA	CHK SBP	SITE	STRUCT	DWG EWDT-02	

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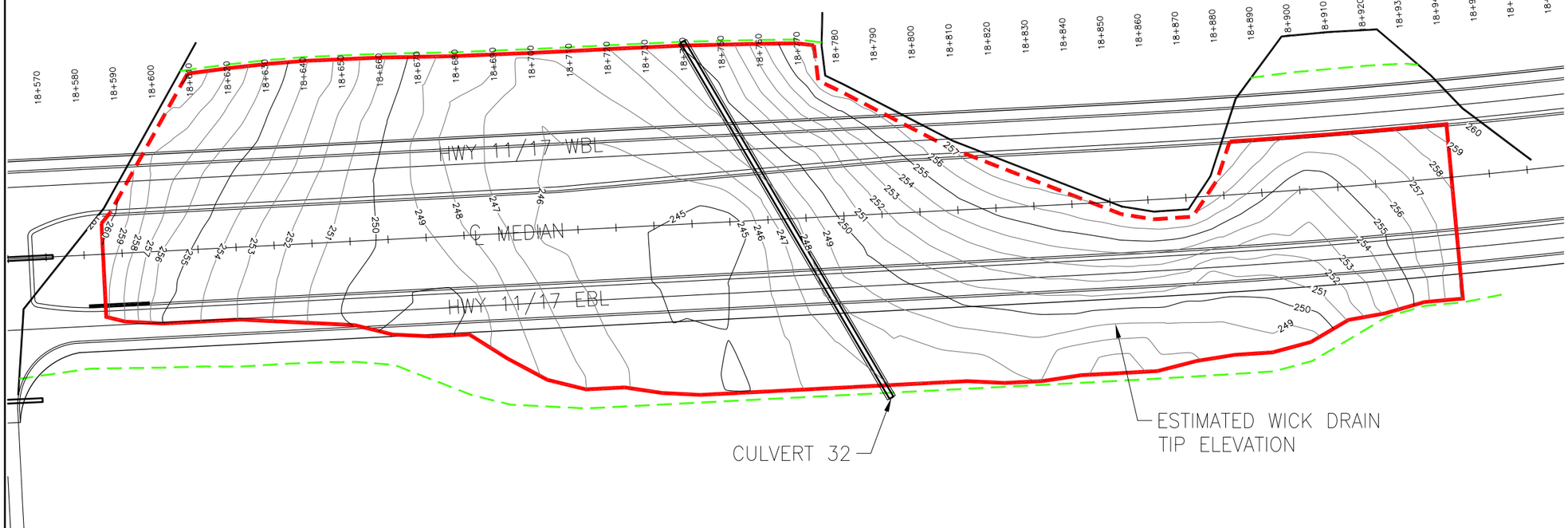
MINISTRY OF TRANSPORTATION, ONTARIO

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

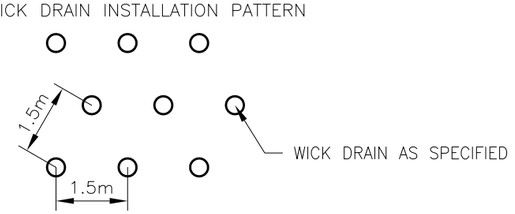


PLAN

25 0 25 50m

SCALE 1:1250

WICK DRAIN INSTALLATION PATTERN



WICK DRAIN LAYOUT PLAN

N.T.S.

CONT No 2014-6026
GWP No 647-89-00

SHEET 3

WICK DRAIN PLAN
STA. 18+570 TO 18+970

MMM GROUP

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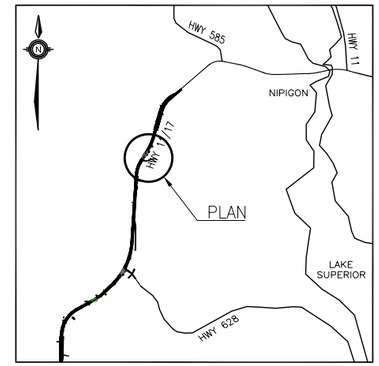

KEYPLAN

-NOTES-

1. The anticipated termination (tip) elevation contours are interpreted from the available borehole data assuming that the wick drains will either terminate at the top of bedrock/ refusal material or penetrate 0.5m into the cohesionless deposit underlying the compressible cohesive deposits.
2. The wick drain tip elevation contours between and beyond the borehole locations were estimated by interpolation and extrapolation respectively. Therefore the actual tip elevations may vary on site during wick drain installation.
3. Wick drains shall be installed in a triangular pattern with 1.5m centre-to-centre spacing.
4. The wicks shall not be installed through the existing embankment slope and shall be installed at a 15° batter from vertical towards the existing embankment centreline along the extents of the existing embankment.

Approximate extents of wick drain installation.

Proposed toe of embankment/stabilizing berm.

Approximate edge of bedrock outcrop. (Location and tip elevation of wick drains near the exposed bedrock may vary)

GEOCRES No. 52A-182

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P. K. CHATTERJI
Oct 1/14
PROVINCE OF ONTARIO

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	LPG	CHK	JPL	CODE	LOAD
DRAWN	AN/MFA	CHK	SBP	SITE	STRUCT

DATE OCT 2014
DWG EWDT-03

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AMENDMENT TO OPSS 220, NOVEMBER 2012

Special Provision No. 102S01M January 2013

Granular Blanket

220.05 MATERIALS

Subsection 220.05.02 is deleted in its entirety and replaced by the following:

The granular blanket shall be Granular B, Type II or Type III, according to OPSS 1010 except that 100% shall pass the 37.5 mm sieve and no more than 5% shall pass the 0.075 mm sieve.

220.07 CONSTRUCTION

220.07.01 Operational Constraints

Subsection 220.07.01 of OPSS 220 is amended by deleting the last sentence in the last paragraph and replacing it with the following:

Geotechnical instrumentation damaged as a result of Contractor's activities shall be replaced by the Contractor at no cost to the Owner.

220.07.03 Granular Blanket

Subsection 220.07.03 of OPSS 220 is amended by the addition of the following:

The granular drainage blanket shall be placed to a minimum of 1m above the original ground elevation or to 1m above the surface water level whichever is higher.

220.09 MEASUREMENT FOR PAYMENT

220.09.01 Actual Measurement

220.09.01.01 Granular Blanket

Clause 220.09.01.01 of OPSS 220 is deleted in its entirety.

220.10 BASIS OF PAYMENT

Subsection 220.10.01 of OPSS 220 is amended by deletion of "**Granular Blanket – Item**" and the addition of the following:

All labour, Equipment and Material required for the granular blanket shall be paid for with the appropriate road base or subbase item, Granular B Type I, Granular B Type II, Granular B Type III as specified.

GEOGRID – Item No.

Special Provision

1.0 SCOPE

This special provision specifies the requirements for the supply and installation of geogrid reinforcement in accordance with the details shown on the contract drawings and with the requirements of these specifications. The geogrid reinforcement shall be located and oriented as shown on the Contract Documents and as directed by the Contract Administrator. The geogrid reinforcement shall be installed after the installation of wick drain and monitoring instrumentation but prior to the embankment construction.

2.0 DEFINITIONS

Quality Verification Engineer (QVE): means an Engineer who has a minimum of five (5) years experience related to the design and installation of geogrid or alternatively has demonstrated expertise by providing satisfactory quality verification services for the work at a minimum of three (3) projects of similar scope to the Contract. The Quality Verification Engineer shall be retained by the Contractor to certify that the work is in general conformance with the contract documents and to issue Certificate(s) of Conformance.

3.0 SUBMISSION AND DESIGN REQUIREMENTS

3.1 Certificate of Conformance – Material

The Contractor shall submit a sample of the geogrid (per 10,000 m^2 of installed product) to the Quality Verification Engineer for review prior to the installation of the geogrid on the Contract. The Contractor shall submit to the Contract Administrator a Certificate of Conformance sealed and signed by the Quality Verification Engineer a minimum of 15 days prior to commencement of work under this item. The Certificate shall state that the geogrid material is in conformance with the requirements and specifications of the contract documents.

3.2 Certificate of Conformance – Installation Method

The Contractor shall submit to the Contract Administrator a Certificate of Conformance sealed and signed by the Quality Verification Engineer a minimum of 15 days prior to commencement of work under this item. The Certificate shall state that the installation procedures are in conformance with the manufacturer's requirements and specifications of the contract documents.

3.3 Certificate of Conformance – Final

Upon completion of the geogrid installation, the Contractor shall submit to the Contract Administrator a final Certificate of Conformance sealed and signed by the Quality Verification Engineer. The certificate shall state that the work has been carried out in general conformance with the installation procedure and specifications of the contract documents. A record of geogrid installation and as-built layout shall be submitted with this Certificate of Conformance.

4.0 MATERIALS

4.1 Geogrid

The geogrid shall be Tencate Miragrid 22XT, or equivalent, with a minimum long term design strength of 150 kN/m. The geogrid shall be free of defects or flaws which significantly affects its physical and/or mechanical properties. No joints will be allowed in the machine direction.

4.2 Storage and handling

- Storage and handling of the geogrid reinforcement shall be in accordance with the manufacturers and/or suppliers recommendations.
- During all periods of shipment and storage, the geogrid shall be wrapped in a heavy-duty protective covering to protect the geogrid from direct sunlight, dust, dirt and debris. The protective covering shall remain on the geogrid roll until installation.
- The geogrid reinforcement shall be protected from exposure to ultraviolet light during storage and temperatures greater than 60^0C.
- After the protective covering has been removed, the geogrid shall not be left uncovered under any circumstances for longer than one week.

4.3 Sample Geogrid

The Contractor shall submit a sample of the geogrid material to the Contract Administrator for information at least one month prior to commencement of work under this item. The sample shall be stamped or labeled by the manufacturer as being representative of the geogrid material having the specified trade name. Documentation indicating the source of the geogrid and the physical and mechanical properties of the geogrid shall be provided.

4.4 Manufacturer Certification

Manufacturer certification shall be provided for all geogrid material delivered to the project. Quality test certificates for each production lot supplied, showing compliance with all requirements of this special provision shall be obtained by the Contractor and submitted to the Contract Administrator prior to installation.

5.0 CONSTRUCTION

- Place a minimum of 300 mm of Granular B Type II material, as specified in OPSS 1010, above the top of the granular blanket elevation (as shown elsewhere) to 1m beyond the lateral geogrid extent as shown on the Contract Drawings.
- The geogrid shall be unrolled on level prepared granular sub-grade, with the machine direction perpendicular to the embankment centerline, to the lateral extent of the embankment footprint as shown on the Contract Drawings. The geogrid shall be tensioned until taut, free from stress, folds, wrinkles and creases. Installation of the geogrid shall conform to the lines and grades as shown on the Contract Drawings
- The geogrid shall be free of joints along the machine direction.
- Joints shall be overlapped a minimum of 900 mm between adjacent rolls of geogrid
- Construction equipment and vehicles shall not be permitted directly on the geogrid. Only low ground pressure equipment shall travel adjacent to, but not directly on the geogrid.

- The Contractor shall place a minimum of 300 mm of Granular B Type II material above each layer of geogrid. The granular layer(s) shall be compacted to a minimum 95% of its maximum dry density measured according to OPSS 501.
- The overlapping joints from the second layer of geogrid shall be offset from the bottom layer to provide a staggered arrangement.
- Remove and replace geogrid improperly installed or damaged as directed by the Contract Administrator
- After end dumping on the existing fill material, small dozers or front end-loaders may be used to spread and compact fill material. Subsequent lifts of fill material should be placed and spread using equipment and techniques that will not compromise foundation stability.

6.0 MEASUREMENT FOR PAYMENT

Measurement for payment for geogrid shall be by area. The unit of measurement shall be square meter (m^2).

No measurement or payment will be made for the 900 mm overlap described in this Specification.

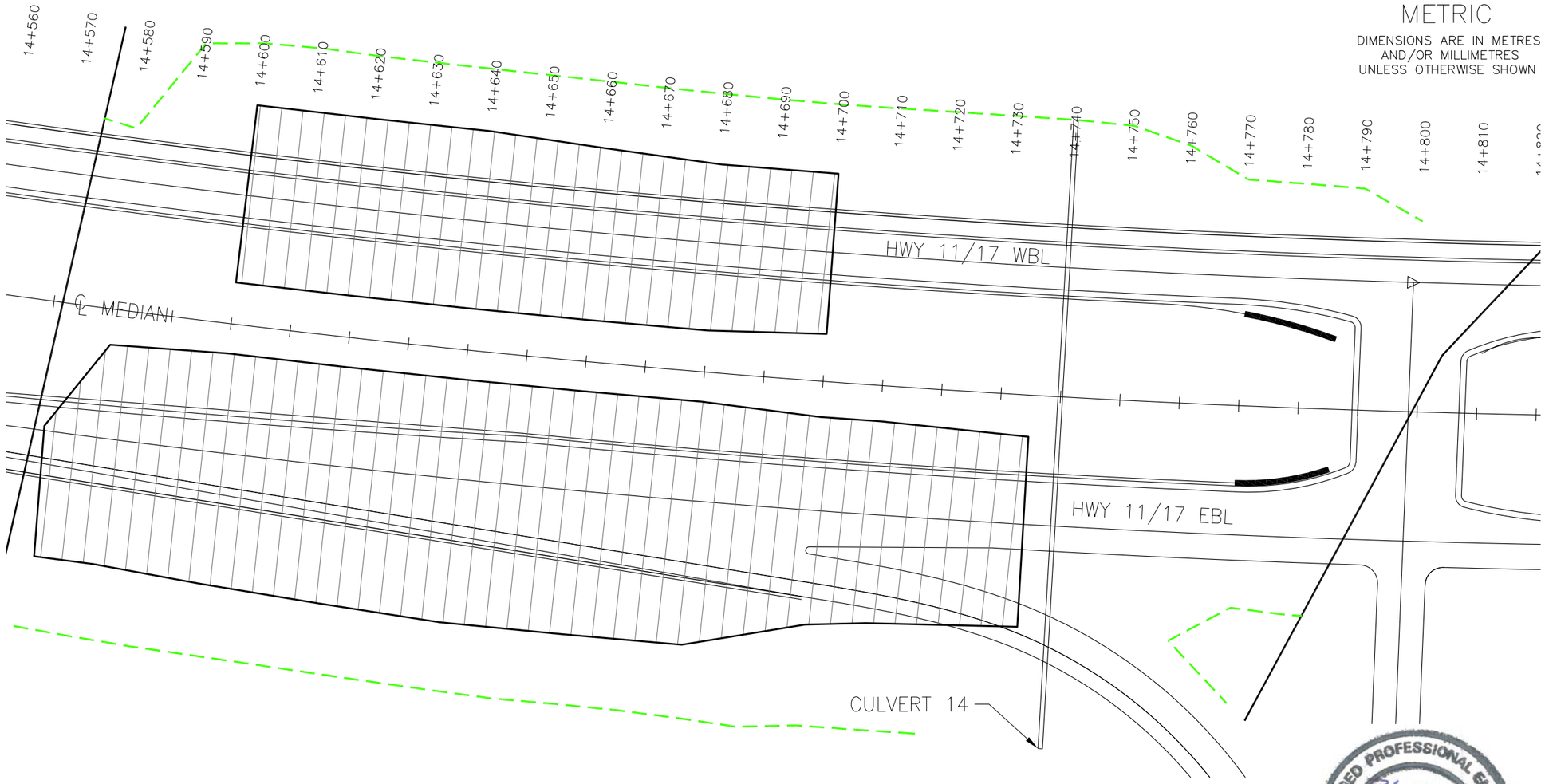
7.0 BASIS OF PAYMENT

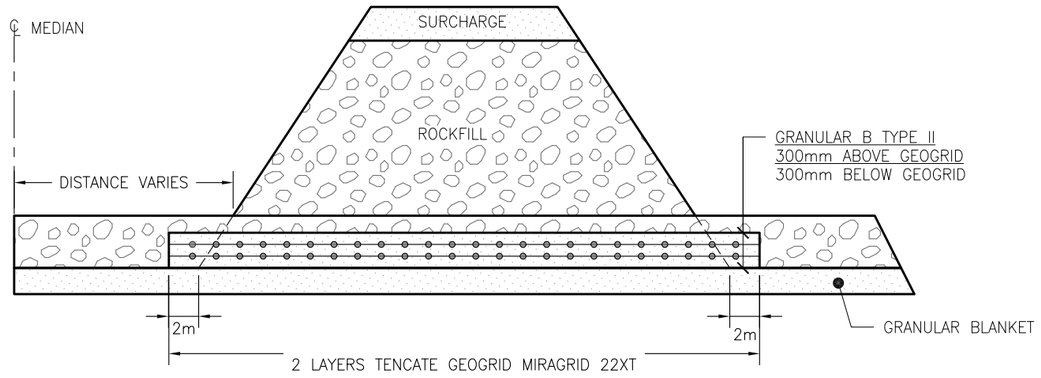
Payment at the contract price for the above item shall be full compensation for all labour, equipment and material required to do the work.

MINISTRY OF TRANSPORTATION, ONTARIO

METRIC

DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN





TYPICAL GEOGRID LAYOUT
N.T.S

LATERAL EXTENT OF GEOGRID FROM MEDIAN CENTERLINE				
STATION	WEST BOUND LANE		EAST BOUND LANE	
	WEST TOE	EAST TOE	WEST TOE	EAST TOE
14+570	N/A	N/A	21	43
14+580	N/A	N/A	6	43
14+600	−37	−7	5	44
14+620	−37	−7	5	45
14+640	−37	−7	5	46
14+660	−36	−7	5	46
14+680	−35	−7	5	46
14+700	−35	−8	6	41
14+710	N/A	N/A	6	40
14+735	N/A	N/A	7	39

PLAN
16 0 16 32m
SCALE 1:800

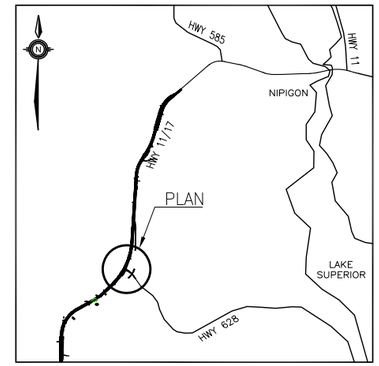
CONT No 2014-6026
GWP No 647-89-00

SHEET 2

GEOGRID PLAN
STA. 14+560 TO 14+810

MMM GROUP

THURBER ENGINEERING LTD.



KEYPLAN

-NOTES-

- Proposed toe of embankment/stabilizing berm.
- Approximate edge of bedrock outcrop.
- Approximate extent of geogrid

LICENSED PROFESSIONAL ENGINEER
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GEOCRES No. 52A-182

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	LPG	CHK JPL	CODE	LOAD	DATE OCT 2014
DRAWN	AN/MFA	CHK SBP	SITE	STRUCT	DWG EWDT-02

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METRIC

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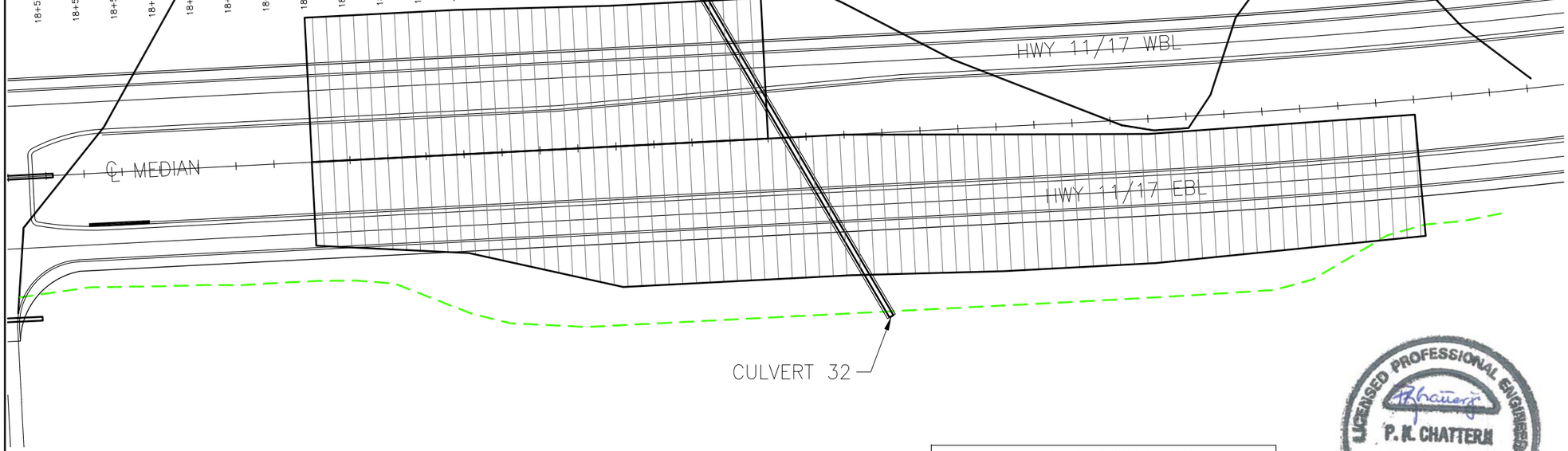
CONT No 2014-6026
GWP No 647-89-00

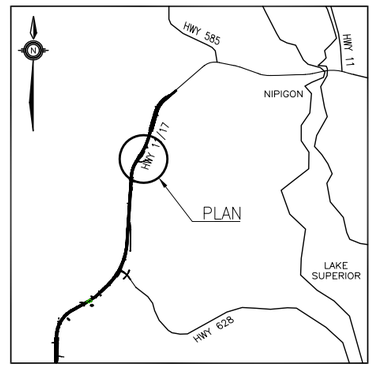
SHEET 3

GEOGRID PLAN
STA. 18+570 TO 18+970

MMM GROUP

THURBER ENGINEERING LTD.

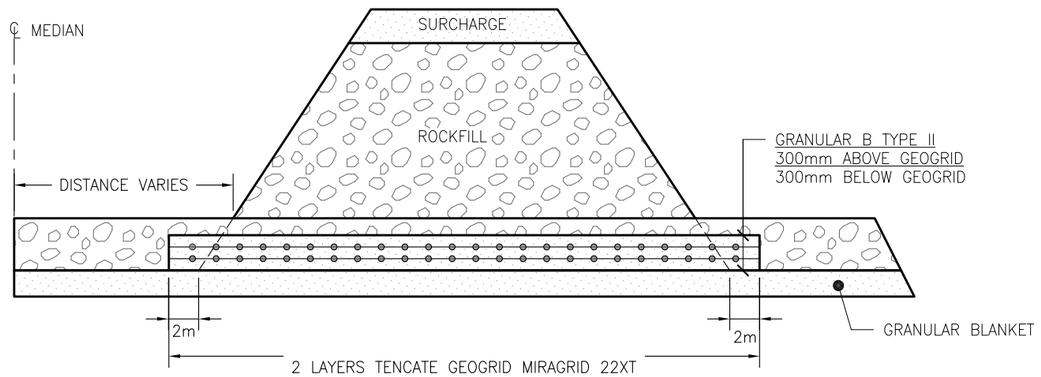




KEYPLAN

-NOTES-

- Proposed toe of embankment/stabilizing berm.
- Approximate edge of bedrock outcrop.
- Approximate extent of geogrid



TYPICAL GEOGRID LAYOUT
N.T.S

LATERAL EXTENT OF GEOGRID FROM MEDIAN CENTERLINE				
STATION	WEST BOUND LANE		EAST BOUND LANE	
	WEST TOE	EAST TOE	WEST TOE	EAST TOE
18+640	-38	0	0	22
18+680	-38	0	0	26
18+720	-37	0	0	37
18+760	-37	0	0	37
18+780	N/A	N/A	0	37
18+820	N/A	N/A	2	38
18+860	N/A	N/A	4	38
18+930	N/A	N/A	4	36

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Oct 1/14
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PLAN
16 0 16 32m
SCALE 1:800

GEOCRES No. 52A-182

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	SBP	CHK	JPL	CODE	LOAD
DRAWN	AN	CHK	SBP	SITE	STRUCT

DATE OCT 2014
DWG EWDT-03

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Appendix K

List of Standard Provisions and OPSS Documents Referenced in this Report

The following Standard Specifications and Special Provisions are referenced in this report:

OPSS.PROV 206
OPSS 209
OPSS 120
OPSS 401
OPSS 501
OPSS 539
OPSS 804
OPSS 902
OPSS.PROV 1010
OPSS 1205

OPSD 200.020
OPSD 201.020
OPSD 203.010
OPSD 205.020
OPSD 205.030
OPSD 205.040
OPSD 205.050
OPSD 208.010
OPSD 209.020
OPSD 801.010
OPSD 803.010