1.0 GENERAL

1.1 REFERENCES

.1 Provide geotechnical instruments in accordance with the following standards (latest revision) except where specified otherwise.

.2 Canadian Standards Association (CSA)

.1	CAN/CSA-G164-M	Hot-Dip Galvanizing of Irregularly Shaped Articles.

.3 Canadian General Standards Board (CGSB)

.1	CAN/CGSB-1.40	Anticorrosive Structural Steel Alkyd Primer.

.4 American Society for Testing and Materials (ASTM)

.1	ASTM A36	Specifications for Structural Steel.
.2	ASTM A53	Specification for Structural Steel Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless.
.3	ASTM D698	Standard Test Methods for Moisture-Density Relations of Soils and Soil Aggregate Mixtures Using 5.5 lb (2.49 kg) Rammer and 12” (305 mm) Drop.

1.2 SUBMITTALS

.1 Provide the following submittals.

.2 The name, qualifications, and relevant experience of the company and personnel that will install the geotechnical instruments at least 30 days prior to their installation.

.3 Product Data:

.1 Detailed descriptions for all the instruments, readout devices, and associated equipment 7 days prior to their purchase.

.2 The manufacturer’s installation and operation instructions and the calibration information for each instrument prior to delivery to the Site.

.3 The Contractor’s calibration data for each instrument prior to their installation.

.4 Operation and maintenance manuals for all instruments installed prior to the request for the Minister’s inspection for Substantial Performance of the Work.

.4 Shop Drawings:

.1 A detailed description of the drilling and sampling equipment at least 30 days prior to mobilizing the equipment to the Site.

.2 Details of the installation and backfill procedures to be used for the instruments at least 7 days prior to their installation.

.3 A copy of the daily log of the drilling and installation operations within 48 hours.

.4 A record plan for each instrument within [ ] days of completing the installation. Show the stratigraphic profile of the instrument boreholes, backfill details, and the surveyed location and elevation of the instruments, cables, leads, and tubing.

1.3 QUALITY CONTROL

.1 Provide a Professional Engineer registered with the Association of Professional Engineers, Geologists, and Geophysicists of Alberta, with a minimum of 5 years direct experience in the logging of boreholes and in the calibration, testing, and installation of all types of geotechnical instruments to be used in the Work, to direct and supervise the work required by this section.

.2 Provide drilling rigs equipped for geotechnical drilling, and operated by personnel experienced in soil and rock sampling and installation of geotechnical instruments. The Minister may authorize that some of the drilling and sampling tasks can be completed by the Contractor's personnel provided that they have the necessary experience, and have demonstrated competence in the completion of such tasks.

.3 Maintain a daily log of the drilling and instrumentation installation operations.

.4 Test the operation and calibrate each instrument in accordance with the manufacturer's written instructions and in the presence of the Minister, prior to its installation. Carry out additional tests, in the presence of the Minster, after its installation to confirm its operation.

1.4 QUALITY ASSURANCE

.1 The Minister will observe the calibration and testing of each instrument.

.2 The Minister will provide the final locations and depths for each instrument.

.3 The Minister will monitor the instruments after their installation.

1.5 DELIVERY, STORAGE, AND HANDLING

.1 Inspect each shipment of material and timely replace any damaged materials.

.2 Handle and store products in accordance with the manufacturer's recommendations and protect them from damage, contamination, or deterioration. Store all packaged or bundled products in their original packaging with the manufacturer's seals and labels intact. Do not remove products from the packaging or bundling until required.

2.0 PRODUCTS

2.1 MATERIALS

.1 Provide materials in accordance with the following.

.2 Pneumatic piezometers:

.1 [Slope Indicator Catalogue No. 51417800. Substitutions are not permitted.]

.2 Tubing: [Slope Indicator Catalogue No. 51416900 with Catalogue No. 51407302 quick connect plugs], pre-attached to the piezometer tip without joints or connections in the tubing. Additional compression fittings for each pneumatic piezometer to allow the quick connect plug to be re-attached to the lead after the lead is shortened for terminal panel connection. Hardware to allow the quick connect plugs to be installed in the instrument terminal panels.

.3 Pneumatic piezometer terminal pipes:

.1 [Slope Indicator Catalogue No. 51417100]

.2 [Slope Indicator Catalogue No. 51409900]

.4 Pneumatic piezometer terminal box: [Slope Indicator Catalogue No. 51401510].

.5 Pneumatic readout instrument: [Slope Indicator Model 256 with 414 kPa analogue readout, Catalogue No. 51425601. Substitutions are not permitted.]

.3 Casagrande piezometers:

.1 [RST Instruments Inc. – Casagrande Type Standpipe Piezometer or Slope Indicator Catalogue No. 51417402.]

.2 Schedule 40 PVC pipe, [25] mm diameter, for use as Casagrande Piezometer Standpipe and compatible with the Casagrade Piezometer tips supplied.

.3 Water level meter complete with winding reel, brake, light, buzzer, variable sensitivity and test switch. Tape to be a minimum of 60 m in length and inscribed in 1 mm gradations.

.4 Inclinometer casing:

.1 Telescoping casing: [ABS “Telescoping” inclinometer casing approximately 85 mm outside diameter, with biaxial guide grooves and accessories manufactured by Slope Indicator Co. Substitutions are not permitted.] Provide 1.5 m lengths and 3 m lengths for installation above and below the bedrock surface, respectively.

.2 Non-telescoping casing: [ABS “Quick Lock” (CPI) inclinometer casing, approximately 85 mm outside diameter, with biaxial guide grooves and accessories manufactured by Slope Indicator Co. Substitutions are not permitted.]

.3 Casing not to have more than 0.1° (angular measure) per metre length of twist at any temperature between +25°C and –25°C, and under axial loading (tension or compression) equal to the weight of 50 m (minimum) of the casing.

.4 Couplings and all recommended accessories including screws, rivets, lubricant, and waterproof tape to provide a waterproof, non-rotating joint.

.5 [Slope Indicator Co. Digitilt Inclinometer Probe: Catalogue No. 50302510 complete with probe, control cable Catalogue No. 50601010 minimum length 40 m, pulley assembly Catalogue No. 51104606, cable reel Catalogue No. 50500105, jumper cable, connectors, Digitilt Datamate recorder Catalogue No. 50310900, and a copy of the latest version of G-Tilt software package from Mitre Software Corporation. Substitutions are not permitted for any of the inclinometer probe system components.]

.6 [Slope Indicator Co. hook type settlement probe Catalogue No. 50800100.]

.7 [Yamayo HMT-YYN50] nylon coated steel measuring tape and reel, 50 m long with 1-mm metric gradations.

.5 Liquid level settlement gauge system:

.1 [Nine cell liquid level settlement gauge system, Model SSH01000, manufactured by RST Instruments Inc. Substitutions are not permitted.]

.2 [All accessories including 2-m-long manometers, de-airing unit, connectors, and fluid manufactured or provided by RST Instruments Ltd.]

.6 Instrument leads:

.1 If authorized by the Minister, couple or field splice the leads to achieve the required length, in accordance with the manufacturer's requirements.

.2 Firmly affix a minimum of 3 aluminum tags to each lead. Locate 1 tag at the free end of the lead and locate 1 tag at the top of the drill hole or excavation required for installation. Locate 1 tag at the point where the lead enters the fill and carefully move or replace it as the lead becomes buried in the fill. Permanently, clearly, and legibly engrave each tag with the identification designation of the instrument to which it is attached. Have 2 of the tags remain affixed to the accessible portion of the lead near its terminal connection.

.7 [Surface monuments: As specified in the Contract Documents.]

.8 Protective steel casings and lockable caps:

.1 Steel casings and lockable caps, in accordance with ASTM A53 and ASTM A36 respectively, as specified in the Contract Documents.

.2 Galvanize all casings and caps mounted on structures in accordance with CAN/CSA-G164-M.

.3 Paint the exterior of all casings as well as the interior and exterior of all caps, except those that are galvanized, against corrosion with 2 coats of red coloured oil alkyd paint in accordance with CAN/GGSB-1.40.

.9 Sand adjacent to piezometer tips: Clean, of uniform grain size between 2.0 mm and 850µm sieve sizes. Provide the sand in bags or other suitable packaging and protect from contamination.

.10 Sand for placement below seals: Fine, uniform grain size finer than 600µm with less than 1% by weight finer than 75µm.

.11 Bentonite pellets: High density type, approximately 10 mm in diameter, in watertight containers, weighing approximately 20 kg, for sealing the response zone of the piezometers.

.12 Powdered bentonite and Portland Cement Type 50: In bags, dry and protected from contamination, for grouting and backfilling of holes.

.13 Grout:

.1 Cement/bentonite grout: A liquid slurry consisting of 1.8 parts Portland Cement, 1 part water, and 0.1 part powdered bentonite proportioned by weight. Mix the cement and water first and add the bentonite dry to the cement-water slurry.

.2 Bentonite/cement grout: A liquid slurry consisting of 0.15 parts bentonite, 1 part water, and 0.25 parts Portland Cement proportioned by weight. Mix the dry bentonite and water first, and allow to hydrate prior to adding the cement.

.3 Thoroughly mix the grout from precisely recorded weights and volumes of materials using a paddle type mechanical mixer or re-circulate through a pump until all lumps are disintegrated.

.4 Revise the grout mix proportions as the Minister may require based on observations and testing during the Work.

.14 Soil backfill materials:

.1 General backfill: Same type of material as specified for the adjacent embankment fill except that maximum particle or lump size is to be 80 mm when the fill is placed within 300 mm and 1000 mm, respectively, or any instrument or instrument component.

.2 Select backfill: Same type of material specified for the adjacent embankment fill except that the maximum particle or lump size is to be 10 mm.

.15 Instrument Building: As specified in the Contract Documents.

3.0 EXECUTION

3.1 GENERAL

.1 Unless otherwise directed by the Minister, install all products in accordance with the manufacturer's written recommendations.

.2 Obtain the Minister's authorization prior to installation of each instrument component and prior to covering any instrument or component thereof.

.3 Install geotechnical instruments and their components, holes for instrument installation, instrumentation trenches, lead rise ducts, and the like at the locations, depths, elevations, and alignments specified in the Contract Documents. Confirm information with the Minister prior to installation.

3.2 EXISTING INSTRUMENTATION

.1 Maintain and protect existing instrumentation that have been previously installed on the Site by Other Contractors, unless specified otherwise in the Contract Documents.

.2 Provide measures and conduct work so that the existing instrumentation specified to remain is intact, undamaged, and operational. Promptly repair or replace, as directed by the Minister, any existing instrumentation damaged by the Contractor's operations.

.3 Extend the leads for the existing [ ] and connect to the new instrument panels at the appropriate terminal locations as specified in the Contract Documents.

3.3 ROTARY DRILLING EQUIPMENT

.1 Provide truck-mounted or self-propelled rotary type rigs equipped for drilling 150 mm diameter holes to a rated depth of at least [50 m], and equipped with hydraulic pulldown and duplex mud pumps with a minimum rated capacity of 1000 L/min.

.2 Drill 150 mm holes for geotechnical instruments. Obtain the Minister's prior authorization to drill holes larger than 150 mm in diameter.

.3 Provide drilling rigs equipped with front and rear levelling devices to drill vertical holes.

.4 Provide sampling equipment including split-spoon (Standard Penetration Test) samplers. Provide 75 mm diameter by 300 mm long normal Shelby tubes.

.5 Provide quick connect loading poles for sounding and tamping of backfill materials in the boreholes.

.6 Provide a 1200 L minimum capacity mixer and 10 L/s pump capable of handling thick bentonite/cement and cement/bentonite grout. Provide a tremie pipe to allow pumping of grout from the bottom of the drill holes upwards.

.7 Provide adequate lighting at each drill rig location to enable drilling and instrument assembly after dark to proceed safely and efficiently.

.8 Provide all supplementary equipment required to complete the work including a storage trailer, electric generators, water pumps, water truck, storage tanks, welding equipment, crew trucks, and communications equipment.

3.4 PROTECTION OF INSTRUMENTATION

.1 Protect all instrumentation products from damage, contamination, or deterioration during and after installation.

.2 Provide measures to protect instruments, cables, leads, tubing, and other components from damage resulting from construction activities. Such measures may include providing high visibility markings, warning lights, barricades, precast concrete barriers, portable corrals fabricated from steel pipe, or other provisions as required by the Minister, around all instrument and instrument component locations.

.3 Place and spread fill material within 1000 mm of any geotechnical instrument, instrument lead, or other instrument component by hand and compact to the same density as the adjacent fill with pneumatic or mechanical hand tamping equipment. Compact select backfill in 100 mm thick lifts to a minimum of 95% of its Standard Proctor Maximum Dry density at a moisture content within a range of 1% under to 2% over optimum as determined in accordance with ASTM D698. Do not permit compaction equipment to come into direct contact with the instrument or instrument components.

.4 Do not allow concentrated, repetitive, vehicle or equipment traffic over instruments or instrument components until the compacted backfill reaches a minimum of 1500 mm above the instruments or instrument components.

.5 Place fill material within 1000 mm of any geotechnical instrument, lead, or other instrument components ahead of the placement of surrounding fill material such that the level of the fill material within 1000 mm of the instrument component remains a minimum of 300 mm above the surrounding fill material.

.6 Cap and protect the free ends of all instrument leads.

3.5 SEQUENCING AND SCHEDULING OF INSTALLATION

.1 Drill holes and install instruments and bury leads in the embankment foundation prior to fill placement in these areas.

.2 Install pneumatic piezometers in the embankment fill upon completion of fill placement in these areas.

.3 Extend the inclinometer casing and lead riser duct so that the top of the casing or lead riser duct remains a minimum of 500 mm above the level of the surrounding fill.

.4 Drill holes and install the inclinometer casing and Casagrande piezometers ahead of fill placement in these areas.

.5 Drill holes and install each inclinometer casing and Casagrande piezometer upon completion of excavation at each instrument location. Where no excavation is required at the inclinometer or piezometer location, schedule its drilling and installation prior to the commencement of excavation in the area.

.6 Install the surface monuments immediately upon completion of fill placement in these areas.

.7 Sequence and construct the instrument building as specified in the Contract Documents concurrently with the installation of instruments.

.8 [ ].

3.6 INSTALLATION OF PNEUMATIC PIEZOMETERS

.1 General:

.1 Complete all excavations in the vicinity of the pneumatic piezometer locations prior to installation.

.2 Keep pneumatic piezometer tips saturated during calibration and installation.

.2 Piezometers installed by drilling:

.1 Drill a vertical hole to the depth required for the piezometer installation.

.2 Install temporary casing if necessary to stabilize the drill holes during drilling and installation. Alternatively, use Revert as a drilling fluid to stabilize drill holes during drilling and installation.

.3 Obtain a sample of the foundation soil or rock at the piezometer tip elevation using the split spoon sampler.

.4 Clean the drill hole of drill cuttings upon completion of drilling operations.

.5 Install only 1 piezometer in each drill hole. In piezometer cluster locations, space each drill hole a minimum of 2 m from adjacent holes. In such instances, install the deepest piezometer and the next deepest second and so forth.

.3 [ ]

3.7 CASAGRANDE PIEZOMETERS

.1 Drill holes at the specified Casagrande Piezometers locations and to the specified depths or as designated by the Minister.

.2 Obtain a sample of the foundation soil or rock at the piezometer tip elevation using the split spoon sampler.

.3 Clean the drill hole of drill cuttings at the completion of drilling operations.

.4 Install temporary casing if necessary to stabilize the drill holes during drilling and installation. Alternatively, use Revert as a drilling fluid to stabilize drill holes during drilling and installation.

.5 Install the Casagrande Piezometer tip at the specified elevation or as directed by the Minister.

.6 Install only 1 piezometer in each drill hole. In piezometer cluster locations, space each drill hole a minimum of 2 m from adjacent holes. In such instances, install the deepest piezometer first and the next deepest second and so forth.

.7 [ ].

3.8 INSTALLATION OF INCLINOMETERS

.1 Drill a vertical hole to the depth required for installing the inclinometer casing. Where the drill hole is to penetrate a minimum distance into bedrock, carry out soil sampling using the split spoon sampler to confirm the top of the bedrock in each drill hole.

.2 Clean the drill hole of drill cuttings at the completion of the drilling operations.

.3 Use bentonite drilling fluid to wash out cuttings and stabilize the holes. Install temporary casing if necessary to stabilize drill holes during drilling and installation.

.4 Install the inclinometer casing to the elevation, depth, or level specified.

.5 Orientate the inclinometer casing with 1 pair of grooves parallel to the [dam] [structure] centreline.

.6 Install telescoping joints in the fully extended position.

.7 Place grout backfill in the drill hole annulus as specified. Tremie the grout, starting at the bottom of the drill hole and progressing upwards.

.8 Resist buoyant forces on the inclinometers from the bottom of the inclinometer. Do not clamp or weight inclinometer tops.

.9 Extend telescoping inclinometer casing up through the fill as placement proceeds.

.10 [ ].

3.9 INSTALLATION OF LIQUID LEVEL SETTLEMENT GAUGES

.1 Install in accordance with the manufacturer's requirements.

.2 Connect required lead lengths to liquid level settlement gauge cells and arrange the cells and leads to provide a continuous gentle gradient upward from the free ends of the leads to the cells. Fill the overflow reservoir in each cell and its lead tube with de-aired fluid pumped in from the free end of the lead in accordance with the manufacturer's recommendations. Securely plug the free ends of the filled lead tubes. Keep the system filled.

.3 Install liquid level settlement gauge cells on benches excavated in the instrumentation trench sides at the specified locations or as directed by the Minister. Place the tops of the cells at the elevations specified or as directed by the Minister.

.4 Seat each settlement gauge cell by placing it on a levelling base of sand approximately 25 mm thick and arrange the lead down the trench side to the base.

.5 Do not move or disturb the settlement gauge cells after installation is complete. Carefully place and compact 300 mm of select backfill around and above each cell.

.6 Install the liquid level settlement gauge manometer panel in the instrument building dry well such that the tops of the manometers are 100 mm above the overflow levels on the cells.

.7 Connect leads to the manometer panel taking care to minimize fluid loss. Allow a small amount of fluid to drain from each of the filled leads into the corresponding manometer to ensure that no air is trapped in the system.

.8 Fill the overflow settlement gauge system with fluid in accordance with the manufacturer's recommendations except first pump the fluid into the manometer tube until any air trapped in the filling system is ejected into the manometer.

.9 After flow is observed in the drain tube, close the fill tube and allow the drain tube to empty. Inject nitrogen gas into the vent line to force any trapped fluid out of the drain line. Regulate the nitrogen gas pressure used at a safe level as determined by the manufacturer.

.10 [ ].

3.10 INSTALLATION OF SURFACE MONUMENTS

.1 Drill a vertical hole at the specified location, or as directed by the Minister, for the surface monument installation. Clean the cuttings and slough from the base of the hole upon completion of drilling.

.2 Use temporary casing if necessary to stabilize the drill holes during drilling and installation.

.3 Install surface monument components and complete the first grout placement as specified. Set the protective casing in the borehole so that its bottom slightly penetrates the grout surface to form a seal.

.4 Once the first grout placement has set, fill the annulus around the outside of the protective casing with grout.

.5 [ ].

3.11 PLACEMENT OF INSTRUMENT LEADS

.1 Place instrument leads in instrumentation trenches along the specified alignments in all areas where the alignment gradient is 4H:1V or flatter.

.2 Excavate the lead trenches as specified leaving a smooth, regular base free of stones and other irregularities.

.3 Place and compact 100 mm of select backfill on the trench base.

.4 Place the leads on the compacted select backfill so there is no overlap, and the leads are snaked back and forth across the routes.

.5 Place and compact 300 mm of select backfill over the leads. Subject to adequate trench depth, additional layers of leads may be added above the first as specified. Cover each layer of leads with 300 mm of compacted select backfill.

.6 Where an instrumentation trench is in an area of Impervious Zone 1A fill, provide 200 mm thick bentonite powder cutoffs across the entire cross section of the trench. Notch the cutoffs 100 mm into the adjacent Impervious Zone 1A fill along the entire perimeter of the trench. Space bentonite powder cutoffs at 4 m. Do not place bentonite powder in contact with any drainage materials.

.7 Provide bentonite powder cutoffs at any bends in the instrumentation trench alignment within Impervious Zone 1A fill.

.8 Maintain instrument leads in instrumentation trenches at least 1500 mm below the finished grade.

.9 Place instrument leads and lead groups that will extend through the fill materials at gradients steeper than 4H:1V in lead riser ducts, consisting of Schedule 40 PVC pipe of adequate size to accommodate the required number of leads and a grout hose. Install the grout hose in the duct with the leads. Do not use riser ducts larger than 150 mm in diameter unless other authorized by the Minister.

.10 Provide joints in the lead riser ducts capable of telescoping by at least 150 mm, as specified at 1500 mm intervals in the ducts.

.11 At locations where instrument leads enter the lead riser ducts, provide measures as specified to prevent cutting or crimping of the leads as a result of differential movement between the leads and the duct.

.12 Round the duct edges so the leads are not cut or crimped.

.13 Fill the lead riser ducts with bentonite/cement grout tremied from the bottom of the unfilled portion of the duct.

.14 Fill the lead riser ducts in increments so the unfilled length of a cut is less than 3 m at all times.

.15 The requirements for lead riser ducts also apply to the conduits through which the leads enter [the instrument building and] pneumatic piezometer terminal pipes.

.16 Assemble and install the required terminal boxes and panels, manometer gauges, and accessory equipment in the instrument building. Install instrument leads up to and into the instrument building and make all required connections between the leads and the instrument terminal panels, manometer gauges, and accessory equipment.

.17 Install instrument leads up to and into the pneumatic piezometer terminal pipes at the specified locations. Install the pneumatic piezometer terminal pipes as specified and make the connections between the leads and the terminal panels.

.18 [ ].

3.12 TOLERANCES

.1 Liquid-level settlement gauges: Install within 1000 mm in plan of the specified position and within 10 mm of the specified elevation.

.2 Inclinometers: Maintain a vertical plumb within +/-10 mm for each 1500 mm section as the inclinometer casing is raised through the fill zone.

.3 Surface monuments: Install surface monuments within 100 mm horizontally from the locations specified on Site by the Minister.

.4 All other components: +/-50 mm, or as otherwise authorized by the Minister.

3.13 READING OF INSTRUMENTS

.1 Do not operate any equipment within 25 m of the section being monitored during the time that instruments are being read.

.2 As part of the Inspection for Substantial Performance, the Minister will test and verify the calibration, performance, and operation of all instruments installed in the Work. Supply and install a new instrument to replace any instrument found to be defective or otherwise inoperative. The replacement instrument type and its installation method will be determined by the Minister to provide similar information to that which was to be provided by the inoperative instrument.

3.14 INSTRUMENT SUMMARY

.1 The attached Table A provides summary information regarding the geotechnical instrumentation.

END OF SECTION

TABLE A

CASAGRANDE PIEZOMETERS

Instrument Identification	Install Control	Estimated Hole Depth	Estimated Standpipe Length

ALL DIMENSIONS IN METRES

TABLE A

NON-TELESCOPING SLOPE INDICATORS

Instrument Identification	Estimated Hole Depth	Estimated Inclinometer Length

ALL DIMENSIONS IN METRES

TABLE A

TELESCOPING SLOPE INDICATORS

Instrument Identification	Estimated Hole Depth	Estimated Length in Fill	Estimated Inclinometer Length

ALL DIMENSIONS IN METRES

TABLE A

PNEUMATIC PIEZOMETERS

Instrument Identification	Install Control	Terminal Point (2)	Estimated Lead Length

ALL DIMENSIONS IN METRES