1.0 GENERAL

.1 The required geotechnical instrumentation for monitoring the performance of the dams is presented in this section.

.2 Ground temperature cables, casings, and data logger housings will be supplied and installed by the Engineer with the Contractor's assistance when needed. The following specifications for these instruments are provided for information only.

.3 The Contractor shall be responsible for providing protection for all instruments installed before construction of the dams is complete. The method of protection must be approved by the Engineer. The Contractor may be held responsible (at the Engineer's discretion) for replacement or repair of instruments damaged during construction.

2.0 INSTRUMENTATION REQUIREMENTS

.1 Ground temperature cables must be installed as shown on the Construction Drawings to measure ground temperature during construction and operation of the dams. Ground temperature cables will be provided by the Engineer.

.2 Data logger housings for the ground temperature cables will be provided by the Engineer. The housings will be rigidly attached to steel pipe as shown on the Construction Drawings.

.3 Single bead ground temperature cables will be used to monitor the freeze back of individual lifts of key trench backfill. These instruments will be provided by the Engineer.

.4 Settlement monuments must be installed as shown on the Construction Drawings to allow any settlements of the dams to be measured. The settlement monuments will be supplied and installed by the Contractor.

3.0 GROUND TEMPERATURE CABLE INSTALLATION

.1 Horizontal ground temperature cables must be installed during construction. Vertical ground temperature cables must be installed during construction. The locations and orientation of the ground temperature cables are shown in the Construction Drawings.

.2 Drillholes for ground temperature cable installation must be 100 mm ID or greater. Drillholes must be drilled in the presence of the Engineer to the depths shown on the Construction Drawings. Schedule 40 PVC 50 mm ID pipe, or approved equivalent, with a water tight end cap, must be placed in the hole prior to casing removal.

.3 The portion of the cable extending beyond the dam fill must be protected with a steel pipe extending 1 m above the final elevation of the dam. The steel pipe must be painted with fluorescent paint.

.4 The inside and outside of the PVC pipe must be backfilled with sand such that there are no air voids around the pipe or ground temperature cable.

.5 The installed instrument must be surveyed to 100 mm horizontal and 20 mm vertical accuracy.

.6 Horizontal ground temperature cables passing through the –200 mm rockfill material and the run-of-mine material must be placed in a steel pipe of sufficient strength to resist crushing upon placement of fill material.

4.0 SETTLEMENT MONUMENTS

.1 Settlement monuments must be supplied and installed by the Contractor as directed by the Engineer.

1.0 GENERAL

.1 The quality assurance testing required by the Engineer is described in this section.

.2 The quality testing will be conducted by the Engineer.

2.0 FILL TESTING REQUIREMENTS

.1 Bedding Material

a. Quality control testing must be performed during the crushing operation when the Bedding material is being processed. The tests and testing frequency required during processing of the Bedding material are presented in Table 1010.1. Additional testing may be required at the discretion of the Engineer.

TABLE 1010.1: REQUIRED TESTING AND FREQUENCY DURING PROCESSING OF BEDDING MATERIAL

Test	Test Frequency
Grain Size Analysis	One per 500 m3 produced
Standard Proctor Density	One per 1000 m3 produced

l. Additional sieve analysis testing may be conducted by Engineer on samples collected from the dam fill to verify that the placed gradation meets the gradation requirements stated herein.

c. The compacted density of the Bedding material used as key trench backfill must be evaluated by coring samples for lab testing and in-situ compaction testing. Samples of the placed key trench backfill will be obtained using a concrete coring rig. The sample will be used to determine if the lift of key trench backfill is completely frozen and to determine the soil properties. The testing frequency may be adjusted as determined by the Engineer. The required tests and testing frequency for the key trench backfill is presented in Table 1010.2. Additional testing may be required at the discretion of the Engineer.

TABLE 1010.2: REQUIRED KEY TRENCH BACKFILL TESTING AND FREQUENCY		
Test	**Test Frequency of Mixed Material**	**Test Frequency for Placed Material**
Mixture Density	One per 500 m3	-
Moisture Content	One per 250 m3	4 per lift or 2 per day
Placed Bulk Density	-	4 per lift or 2 per day
Degree of Saturation	-	4 per lift or 2 per day
Grain Size Analysis	One per two days	
Specific Gravity	One per two days	

d. The compacted density of the Bedding material used as liner bedding material in the superstructure of the dams must be evaluated by using in-situ measurements of density. In-situ density measurements of the compacted Bedding material will be conducted with a nuclear densometer. Samples of the bedding material may be taken from the lift surface for additional testing at the discretion of the Engineer. The required tests and testing frequency for the Bedding material placed in the superstructure of the dams is presented in Table 1010.3.

TABLE 1010.3: REQUIRED BEDDING SUPERSTRUCTURE FILL TESTING AND FREQUENCY	
Test	**Test Frequency for Placed Material**
Moisture Content	2 per lift or 2 per day
Placed Dry Density	2 per lift or 2 per day
Grain Size Analysis	One every two days
Specific Gravity	One every two days

.2 Transition -200 mm Rockfill Material

Samples of the Transition -200 mm material will be evaluated from time to time during processing and placement to ensure that the produced and placed gradation meets the specification stated herein. Additional testing may be conducted at the discretion of the Engineer.

.3 Fill Testing Methods

Mixture density of key trench backfill shall be determined by using a concrete yield bucket as specified in CSA Can 3-A23.2-M90 or approved equivalent.

b. Samples of placed key trench backfill must be taken once freezeback is completed by means of a concrete coring machine. The core must extend through the lower contact of the lift. All cored samples must be evenly distributed over the lift surface. All holes must be thoroughly washed with clean water to remove any remaining drilling fluid and backfilled with saturated Bedding material immediately after extraction of the core.

c. Each cored sample of key trench backfill shall be split in half longitudinally and transversely to be examined and photographed by the Engineer. The bonding between layers, ice-saturation and ice bonding will be evaluated.

d. Moisture content is defined as the ratio of the weight of water to the weight of dry soil. Moisture content testing must be conducted according to ASTM D2216.

e. The method of determining bulk density of the cored key trench material will depend on the quality of the sample. The sample volume can be determined from its dimensions if the core has uniform dimensions. The Engineer will rely on in-situ measurements of key trench backfill density with a nuclear densometer if core recovery is poor or if the recovered cores are non-uniform.

f. The degree of saturation for cored key trench backfill samples will be determined, when possible, from the measured moisture content, bulk density and measured specific gravity.

g. Specific gravity shall be determined using the flask method according to ASTM D854.

3.0 POLYPROPYLENE GEOMEMBRANE TESTING REQUIREMENTS

.1 General

a. The Contractor is responsible for obtaining mill certificates from the manufacturer and forwarding them to the Engineer.

b. The Contractor shall record all seam parameters (i.e. time, date, operator, welding speed and temperature) on the liner.

c. The Engineer will conduct a limited program of testing on seam welds.

d. The Contractor shall be responsible for completing the vacuum box testing and fusion seam pressure testing. The Contractor shall mark the test number and parameters on the liner.

e. The Contractor shall supply a field tensometer for testing liner seams for shear and peel strength. The tester shall be available for the Engineer's use.

f. Qualifying seams will be tested by the Engineer.

g. The Engineer is responsible for maintaining testing records.

h. All coupons and test specimens remain the property of the Owner

.2 Preliminary Qualification

a Upon delivery of the material to the site, the Contractor shall remove a sample and submit it to the Engineer for audit testing if required. Samples shall consist of a strip 0.75 m wide cut across the full width of one roll, which was not sampled at the factory. If all rolls were sampled, then one roll shall be picked at random by the Engineer.

b. Immediately after delivery of material to the site, the Contractor shall submit to the Engineer a 1 m long sample of each type of seam to be used in the installation. The test seams will be fabricated from a sheet used in the installation by a welder working on the installation. Test seams will be used to evaluate the welding procedures used by the Contractor. Evaluation of welding procedures will involve destructive testing, as described in this specification, for each type of weld. Test values obtained during this procedure will not be considered as "bench mark" values for any subsequent evaluations.

.3 Qualifying Welds

a Qualifying seams shall be conducted on fragment pieces of sheet at the following times:

- At the start of each shift of production seaming, and at 4 hour intervals during production seaming,
- When a new operator or new machine starts welding,
- When a machine is restarted after repairs,
- When welding is stopped for sixty (60) minutes or more,
- When there is a change in the ambient conditions, and
- At the discretion of the Engineer.

b Qualifying seams shall be 1 m long, and shall be subject to shear and peel testing. The test seam shall meet the minimum requirements stated herein for seam strength, when tested on a field tensiometer. If a qualifying seam fails, the seaming procedure must be reviewed and the test must be repeated.

.4 Non Destructive Testing

a. Test all welded seams over their full length using a vacuum unit or air pressure test (for split-wedge fusion process).

- Seam intersections will also be subject to vacuum box testing, regardless of seaming method employed.
- The Contractor shall supply all apparatus and personnel for this type of test.
- The tests shall be witnessed and documented by the Engineer.

b. Clean all seams to permit proper inspection.

c. Repair any seams which fail non-destructive testing in accordance with this Specification. Repairs shall be fully documented by the Contractor.

.5 Destructive Testing for Production Seams

a. Cut-out coupons shall be taken at a minimum frequency of one (1) per 150 m of seam, or once per seam. Coupons shall be cut by the contractor at the location directed by the Engineer. Coupons should generally be taken form a location that does not affect the performance of the liner. All cut-outs must have rounded corners. Care shall be taken to ensure that no slits penetrate the parent liner.

b. All holes left by cut outs must be patched immediately.

.6 Testing of Repairs

a. All repairs shall be tested using the Air Lance or Vacuum Box methods as laid out in ASTM 4437-84 or CGSB 148.1 Method 111, respectively.

.7 Seam Acceptance Criteria

a. Seam and adhesion tests will be performed according to ASTM D3083 NSF54 and ATSM D413 NSF54.

b. Seam and adhesion strength acceptance will be based on five (5) samples in each coupon, which must meet or exceed the minimum value specified. No individual sample may have a seam shear strength less than the minimum value specified in Table 1007.2.

c. If a coupon does not meet the acceptance criteria, two (2) additional coupons shall be cut from the seam within three (3) meters to each side of the failed coupon, and tested. This shall continue until the extent of the unsatisfactory seam has been defined.

.8 Seam Strength Acceptance

a. All seams shall meet or exceed the seam strength and adhesion criteria presented in Table 1007.2

.9 Vacuum Box Testing and Fusion Seam Pressure Testing

a. No leaks shall be permitted. Leak testing shall be conducted using vacuum box testing and fusion seam pressure testing.

b. If a vacuum box test cannot be carried out on a particular area a pick test and air lance test must be performed on the area.

.10 Air Pressure Testing

a Air pressure tests must be conducted for seams made with split wedge welding. The split wedge welder prepares welds with two bonded areas separated by an unbonded channel. This channel can then be sealed at each end and air pressure applied to determine the integrity of the seams. Air pressure testing shall be carried out according to GRI Test Method GM6, Pressurized Air Channel Test for Dual Seamed Geomembranes.