

Standard Operating Procedure No. 71

Guelph Permeameter Measurements of Hydraulic Conductivity

REVISION LOG		
Revision Number	Description	Date
71.0	Original SOP by JRM (UBC)	12/29/04
71.1	Revisions by BEB (UBC)	02/1/05
71v1	LMK edits Lynne refer to notes that came with this one about which appendices to add to this one, dated 7Feb05 from BEB; Send Brenda a note about the switch of appendix 4 in SOP 53 tot his one, and have her look over edits...	06/20/05
71v1	Finalized by LMK for posting on the Molycorp project website and to send to George Robinson for lab audit. LMK did not re-edit this SOP.	4/4/07
71v2	Editorial by SKA	10/28/08

1.0 PURPOSE AND SCOPE

This Standard Operating Procedure (SOP) serves as a supplement to the Quality Assurance Project Plan (QAPP) and provides technical guidance to measure *in situ* saturated hydraulic conductivity using a Guelph Permeameter at the Molycorp Site.

The Guelph Permeameter is an in-hole Mariotte bottle device for measuring the rate of water influx into most types of soil or other porous medium. It can be used to estimate one or more hydraulic properties of the material, including the saturated hydraulic conductivity, soil sorptivity, and matrix flux potential. The Guelph Permeameter method measures the steady-state rate, Q (m^3/s), necessary to maintain a constant depth of water, H (m), in an uncased cylindrical well of radius, a (m), above the water table. The field saturated hydraulic conductivity, K_{fs} (m/s), and matric flux, f_m (m^2/s), are calculated from Q and H using an approximate analytical solution (Reynolds et al., 1985).

A Guelph permeameter measures saturated hydraulic conductivity by applying a constant pressure within a borehole or shallow hole. Like the tension infiltrometer (tensiometer), it applies a constant head using a Mariotte bottle, infiltrates water into an unsaturated material, and requires steady state flow conditions before the measurements can be used to calculate hydraulic conductivity. It differs from the tension infiltrometer in that it applies a positive pressure, instead of a tension, and does not utilize the Wooding [1968] solution to calculate the saturated hydraulic conductivity.

2.0 RESPONSIBILITIES AND QUALIFICATIONS

The RI Project Manager or Field Manager have the overall responsibility for implementing this SOP. They will be responsible for assigning appropriate environmental staff to implement this SOP and for ensuring that all personnel follow the procedures accurately.

All personnel performing these procedures are required to have the appropriate health and safety training. In addition, all personnel are required to have a complete understanding of the procedures described within this SOP and to receive specific training regarding these procedures, if necessary.

All environmental staff and field staff are responsible for reporting deviations from this SOP to the RI Project Manager or Field Manager.

3.0 DATA QUALITY OBJECTIVES

This SOP addresses objectives 1 and 7 in the data quality objectives outlined by Virginia McLemore for the "Geological and Hydrological Characterization at the Molycorp Questa Mine, Taos County, New Mexico".

- Determine how the hydrogeochemistry and water balance dynamics influence rock pile weathering and stability.
- Determine if pyrite oxidation, moisture content, and microbe populations affect rock pile weathering and stability.

4.0 RELATED STANDARD OPERATING PROCEDURES

Related SOPs include:

- SOP 1 Data management (including verification and validation)
- SOP 3 Surveying
- SOP 4 Taking photographs
- SOP 35 Volumetric moisture content
- SOP 53 Tension infiltrometer
- SOP 40 Gravimetric moisture content

5.0 EQUIPMENT LIST

The following materials and equipment will be needed for site preparation and use of the Guelph Permeameter to measure hydraulic conductivity in the field:

- Water
- Shovel and other tools to level surface
- Guelph Permeameter
- Thermometer to measure air temperature
- GPS

- Stop watch or watch with second hand
- Bound weatherproof field logbook
- Indelible black-ink pens
- Digital camera
- Health and safety equipment as outlined in the Site-Specific Health and Safety Plan
- Field data sheets (Appendix 1)

6.0 PROCEDURES

The Guelph Permeameter consists of a Mariotte bottle (bubble tower), water reservoir column, and a tripod that together apply a constant head. The procedures below are a summary of the procedures outlined in the manual (Appendix 4 of SOP 53). The procedures in the manual are complete, succinct, and appropriate for use at Molycorp. A few deviations from the instructions in the manual are outlined in this SOP. The deviations include procedures to ensure accurate measurement of field properties in coarse mine soils.

Field Procedures

As steady-state flow is assumed for the analytical determination of the hydraulic conductivity – matric potential relationship, it is critical that the measurements continue until steady-state conditions are achieved. Depending on the initial water content and the material's hydraulic properties, the time needed to reach steady-state conditions is seldom known a priori, but drier, less conductive materials will require more time to reach steady state than wetter, more conductive materials. The manufacturer does, however, recommend judging that steady state has been achieved if one third of the water volume in the water column has flowed into the porous medium. Measurements must be taken to verify that the system has reached steady-state using a stop watch.

1. Prior to field measurements, the Guelph Permeameter should be checked for leaks.
2. Select a location for measurements that is as close to level as possible. Collect a sample from the area to be measured for water content analysis according to SOP 35 or SOP 40.
3. Record the station ID and location information in the field log book (including UTM coordinates and elevation). Measure and record the ambient temperature.
4. Excavate a cylindrical well to the desired depth in the material to be tested. In coarse materials such as mine soils, the well used should be greater than 5cm and less than 15cm. NOTE: The results of the test are very sensitive to the bore hole surface area, and therefore also sensitive to the shape and quality of the bore hole. Care should be taken to ensure that a clean and cylindrical hole is excavated and that the dimensions are accurately measured.
5. Fill the permeameter with water and insert it in the well. Under certain circumstances, the permeameter may have to be filled after it is placed in the well. Based on professional judgment, choose the appropriate reservoir for the test. Use the large reservoir for higher permeability soils and the inner, smaller reservoir for lower permeability soils.

6. Start the permeameter by raising the air-inlet tube out of the outlet port. Set the desired 'H' level by adjusting the height of the air-inlet tube. NOTE: It is critical that the air-inlet tube be raised as slowly as possible to avoid flooding the well.
7. After the tower begins to bubble, record the water level in the water reservoir. NOTE: It is important to read the water level from the same place in the meniscus for each measurement.
8. Monitor the rate of fall, r , of the liquid surface in the reservoir until a steady rate is attained. Shorter intervals, such as 30 seconds, are needed for measurements made in high permeability materials, whereas every one or two minutes may suffice for less permeable conditions. Continue recording the water level at steady-state for at least 5 consecutive measurements (e.g., the drop should be the same every minute for 5 consecutive minutes).
9. Calculate 'Q' using 'r' and the cross-sectional area of the reservoir. All calculations should be performed in the field.
10. Calculate 'Kfs', 'S', and 'a' using the solution equations (see Appendix II).
11. Take a digital photograph showing the Guelph Permeameter and the test location (SOP 4). Record the photo number with the sample number and the GPS location (SOP 3) on the field data sheet (Appendix 1) and in the field logbook.

7.0 DOCUMENTATION

Documentation of observations and data acquired in the field will provide information on the activities concluded and also provide a permanent record of field activities. The observations and data will be recorded in a permanently bound weatherproof field logbook with consecutively numbered pages, and on field data sheets (see Appendix I for data sheet examples).

Project and subcontractor staff are responsible for documenting logging activities. Field notes will be kept during logging activities. The following information will be recorded in a bound field log book with indelible ink:

- Names of personnel
- Weather conditions
- Date, time, and location of measurement site
- Date, time, and water level in water reservoir
- Description of installation and setup
- Documentation of all problems encountered
- Other applicable information

The observations and data will be recorded on field data sheets (Appendix 1) and field logbooks and consequently entered into the database.

8.0 REFERENCES

Elrick, D.E., and W.D. Reynolds, 1992, Infiltration from constant-head well permeameters and infiltrometers, p. 1–24, *In* C.G. Topp et al. (ed), Advances in measurement of soil physical properties: Bringing theory into practice, SSSA Spec. Publ. 30, SSSA, Madison, WI.

Reynolds W.D., Elrick D.E., 1985, In situ measurement of field-saturated hydraulic conductivity, sorptivity and the α -parameter using the Guelph permeameter, Soil Sci. 1985, vol. 140, p. 292-302.

APPENDIX 1. FIELD DATA FORMS EXAMPLES

Instrument_data_gulph

Guelph Measurements

Station_id Feature_id Field_id Hole_pit_id

UTM_easting UTM_northing UTM_zone Waypoint

Location_assurance Point_of_location

Elevation Method_of_obtaining_elevation

Location_comments Coordinate_system:

weather_conditions Reason_for_measure

Date Measured_by Team

SOP_number Deviation_SOP

Task Type_of_instrument

Water_reservoir: well_radius: well_height:

Ave_rate: Ksat: Reference:

Description:

Comments

guelph_subform

Reading_no	time	time_interval	water_level	water_level_change	rate
10		9	47.2	1.5	
15		14	56	1	

Record: of 18

Record: of 58

guelph_subform

Reading_no	time	time_interval	water_level	water_level_ change	rate
5		5	56	2	
2		2	49.7	5.3	
1		0	44.4		
10		11	69.4	1.8	
7		7	59.9	2.3	
9		10	67.6	4	
3		3	51.8	2.1	
12		13	73.2	1.9	
4		4	54	2.2	
11		12	71.3	1.9	
6		6	57.6	1.6	
8		9	63.6	3.7	

Record: 1 of 610

APPENDIX II. GUELPH PERMEAMETER OPERATING INSTRUCTIONS
PLEASE SEE APPENDIX 4 OF SOP 53 FOR PERMEAMETER MANUAL