NEW GOLD RAINY RIVER MINE
APPENDIX C
PAG COVER TRIAL FACTUAL DATA REPORT

Rainy River Mine – Potentially Acid Generating Mine Rock Cover Trial 2023 Annual Monitoring Report

January 26, 2024

newgold™ okane

Integrated Mine Closure and Relinquishment Solutions

Rainy River Mine – Potentially Acid Generating Mine Rock Cover Trial 2023 Annual Monitoring Report

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DISCLAIMER

EXECUTIVE SUMMARY

New Gold Inc. (New Gold) has developed cover system designs for the closure of potentially acid generating (PAG) mine rock stockpiles (MRSs) at Rainy River Mine. New Gold has implemented cover system field trials to evaluate the cover system design's effectiveness to limit acid rock drainage (ARD). Okane Consultants (Okane) was retained to design, instrument, and interpret monitoring data collected from performance monitoring systems installed at the cover system field trials. The objective of this report is to summarize and interpret findings from data collected during the monitoring period of November 1, 2022 to October 31, 2023.

The primary objectives of the cover system field trials are to evaluate the ability of overburden clay to manage oxygen ingress and net percolation (NP) through altering the surface water and gas balances. Two cover system field trials were constructed in fall of 2017. Trial #1 consists of 0.50 m compacted Brenna clay (CBC), 0.75 m non-compacted clay overburden, and 0.25 m topsoil. Propagules present in the topsoil layer aided re-vegetation on Trial #1. Trial #2 consists of 0.50 m CBC and 1.0 m non-compacted clay overburden. Re-vegetation was completed by both hand-seeding an appropriate seed-mix on Trial #2 in July 2019 as well as hydroseeding in late 2019.

The ability of the cover system to manage oxygen ingress is evaluated by monitoring the degree of saturation of the CBC layer. A cover system containing a layer maintained at a degree of saturation of approximately 85% is generally expected to efficiently limit oxygen ingress (McMullen et al., 1997, MEND, 2004). During the 2022-23 monitoring period, the annual average saturation levels measured for both Trial #1 and Trial #2 was greater than 90% in the CBC layer. Maintaining a 90% degree of saturation in the cover system demonstrated that the compacted clay layer is retaining sufficient pore-water to prevent advective oxygen transport, and limit oxygen ingress through diffusion. The 2022-23 monitoring period observed a minimum degree of saturation within the CBC of 93% and 83% at Trial #1 and Trial #2, respectively. Decreases in degree of saturation were minimal, and a result of as-expected water cycling coupled with peak temperatures during a drier than average summer. Precipitation following this period, as well as cooler temperatures, allowed saturation levels in the CBC to rebound to historically maintained levels.

Oxygen diffusion into the mine rock was estimated using the collected field performance data within a numerical gas flow model. Using cover system material properties and the degree of saturation measured over the monitoring period, oxygen diffusion was estimated to be approximately 1.8 mol/m^2/year for Trial #1 and 5.6 mol/m^2/year for Trial #2. This is considered a very low and low oxygen flux, respectively, as outlined by the International Network for Acid Prevention (INAP) Guidance Document (INAP, 2017). Oxygen diffusion rates increased in July 2023 at Trial #2 as the water content and associated degree of saturation of the cover system's compacted was reduced to below 85% for a short period during the summer months as a result of less rainfall and increased drying.

Water balances were developed for each cover system configuration to estimate NP of meteoric waters into the underlying mine rock. The total estimated NP over the monitoring year was 5% and 10% for Trial #1 and Trial #2, respectively. Runoff was observed to be higher than predicted by the conceptual model (10 - 20%) at 23% and 25% for Trial #1 and Trial #2, respectively. The primary events driving runoff were freshet snowmelt in April, as well as a series of large rainfall events between May 31 and June 4.

Performance monitoring of cover systems provides insight into cover system response to climatic variation in terms of temperature and water storage dynamics. The monitoring systems installed at Rainy River are providing data required to assess the performance trajectories for the site. Continued monitoring and reporting offers insight to field-derived material properties and the opportunity to optimize future closure activities at site.

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1 INTRODUCTION

New Gold Inc. (New Gold) has developed cover system designs for the closure of potentially acid generating (PAG) mine rock stockpiles (MRSs) at Rainy River Mine. New Gold has implemented cover system field trials to evaluate the cover system design's effectiveness to limit acid rock drainage. Okane Consultants (Okane) was retained to design, instrument, and interpret monitoring data collected from performance monitoring systems installed at the PAG mine rock cover system field trials. This report summarizes and provides interpretation of both the monitoring data obtained between November 1, 2022, and October 31, 2023 (referred to herein as 'the monitoring period'). The previous annual report contained information from the 2021-2022 monitoring period, as well as a three-year summary of monitoring (Okane, 2023).

1.1 Project Objectives and Scope

The objectives of the PAG mine rock cover system field trials are to:

1) Evaluate overburden clay as a potential cover material for mitigation of oxygen ingress during stockpile construction (operations) due to advective airflow;

2) Evaluate the effectiveness of compacted overburden clay as a low hydraulic conductivity barrier layer and overlying protective growth medium cover borrow material for mitigation of NP and oxygen ingress (closure); and

3) Update and refine conceptual models of performance for the cover system field trial area through examining water balance components (e.g., precipitation, runoff, evapotranspiration, water storage, etc.).

1.2 Report Organization

For convenient reference, this report has been subdivided into the following section:

- Section 2 – provides pertinent background information of the cover system field trials and a summary of activities completed during the monitoring period;
- Section 3 – presents and discusses field data collected during the monitoring period, as well as discusses the performance of the cover system compared to previous monitoring periods
- Section 4 – provides recommendations for the following monitoring period.

2 BACKGROUND

2.1 Description of Cover System Field Trials

Construction of the cover system field trials commenced October 2017 and was completed early November 2017. The constructed field trials span an approximate area of 65 m × 100 m with a 1 to 2% sloping plateau of ~3,000 m^2. A 3H:1V slope was constructed on the north, east and west slopes. Two enhanced store-and-release, low permeability layer cover systems were constructed to meet the objectives stated in Section 1.1. Trial #1 consists of 0.50 m compacted Brenna clay (CBC), 0.75 m non-compacted clay overburden, and 0.25 m topsoil. Propagules present in the topsoil layer provided re-vegetation on Trial #1. Trial #2 consists of 0.50 m CBC and 1.0 m non-compacted clay overburden. Re-vegetation was initiated by hand-seeding an appropriate seed-mix on Trial #2 in July 2019, and later hydroseeded in autumn 2019. Complete as-built details can be found in Okane Report No. 1003/08-001 (2018).

Okane installed and commissioned meteorological and in-situ instrumentation throughout the trial area to monitor cover system performance over time under site specific conditions. Two instrumentation nests (Primary and Secondary) were installed in both Trial #1 and Trial #2 areas. Primary nests consist of a full arrangement of sensors throughout the cover system profile. Secondary nests consist of a reduced number of sensors and was implemented to ensure data redundancy in the profile. The following in-situ instrumentation was installed in each trial area:

- Eleven matric suction sensors (Campbell Science International [CSI] 229) to measure suction (i.e., negative pore-water pressure) and soil temperature;
- Fourteen water content sensors (CSI 616) to measure in situ volumetric water content; and,
- Six oxygen sensors (Apogee SO-110) to measure differential oxygen concentrations above and below the CBC.

Two meteorological instruments were installed on Trial #2. A Texas Electronics model 525M tipping bucket rain gauge (TBRG) to capture trial area specific rainfall events and a Kipp & Zonen NR-LITE2 net radiometer to monitor hourly averages and daily totals of net radiation (i.e., the sum of incoming and outgoing all-wave radiation). The tipping bucket and net radiometer are used to determine theoretical maximum potential rates of evaporation from the cover system surface. Additional site-specific meteorological data will be collected from New Gold's on-site weather station.

2.2 Conceptual Model of Cover System Performance

A conceptual model of cover system performance was developed by Okane (2017a). The conceptual model was used to identify key processes and mechanisms, and then evaluate the cover system design's control on those mechanisms under a range of potential scenarios. It was identified that weathering (oxidation) and leaching (net percolation) in the MRSs will cause acid rock drainage and have negative effects on the receiving environment. The cover system designs aim to provide controls on oxygen ingress and NP to limit acid rock drainage.

Diffusion and advection represent the primary mechanisms for oxygen transport through a cover system. Oxygen diffusion can be restricted by decreasing the bulk diffusion coefficient of the cover system, generally by increasing the degree of saturation. A cover system containing a layer maintained at a degree of saturation at approximately 85% is expected to efficiently limit oxygen ingress (McMullen et al., 1997, MEND, 2004). The compacted clay layer incorporated in both cover system configurations is designed to provide higher water retention characteristics of the cover system profile. It is expected that the compacted layer will maintain a degree of saturation greater than, or close to 85% for the majority of the climate cycle. Limiting advective transport of oxygen requires the cover to restrict air flow by reducing pressure and thermal gradients or the permeability of the material. The compacted clay layer aims to reduce permeability of the material to limit advective air movement.

NP is limited by taking advantage of the store-and-release properties of the 1 m non-compacted layer. Infiltrating water is stored within the cover system so it can be subsequently released via transpiration and evaporation. A store-and-release system uses the variability in timing, volume, and intensity of precipitation events to take advantage of available evaporative energy during summer. Additionally, the compacted layers form a barrier-type cover system which limits NP by reducing the hydraulic conductivity within the layer.

The conceptual model was based on Rainy River Mine's site-specific climate, hydrogeological setting, and materials. Given the site-specific climate of the Rainy River Mine, the conceptual ranges of performance are classified as low NP (5 to 15% of average annual precipitation) and low oxygen flux (1 to 10 mol/m^2/year) according to the INAP Guidance Document (INAP, 2017).

2.3 2022 – 2023 Monitoring Activities

The cover system field trials were monitored by Okane personnel throughout the monitoring period. Major activities that were completed on the field trials include automated data collection and data QA/QC, field inspections and instrumentation maintenance, snow survey, and cover system performance updates. On-site New Gold personnel supported Okane with data collection when Okane was not on site (Table 2.1).

Table 2.1: 2022-2023 monitoring period activities.

Activity	Date
Automated data download and QA/QC	March 7, April 4, May 2, June 6, August 7, September 6, and November 11, 2023
Snow Survey	March 7, 2023
Site visit and instrumentation maintenance	March 7, September 26, 2023
Semi-annual performance update	July 2023

3 COVER SYSTEM PERFORMANCE MONITORING RESULTS

3.1 Meteorology

Meteorological parameters were measured at Rainy River Mine to monitor site-specific climate conditions. Rainfall, snowfall, and net radiation were measured directly on the field trial plateau while air temperature, relative humidity, and wind speed and direction were monitored at Rainy River Mine's Barron weather station. Minor data gaps exist in the Barron station meteorological monitoring.

3.1.1 Air Temperature

Annual average air temperature recorded at the Barron weather station during the monitoring period was 4.0 °C, 0.7 °C warmer than the 30-year historical average of 3.3°C (Figure 3.1). The average winter temperature is of interest with respect to performance monitoring for the purpose of evaluating frost penetration into the cover system. Between December 2022 and March 2023, ambient air temperature ranged from -39.8 °C to 7.5 °C with an average temperature of -10.6 °C. Historic winter air temperatures since 2019-2020 range from a low of -43.0 °C and a high of 17.2 °C both occurring during 2020-2021 monitoring period (Table 3.1).

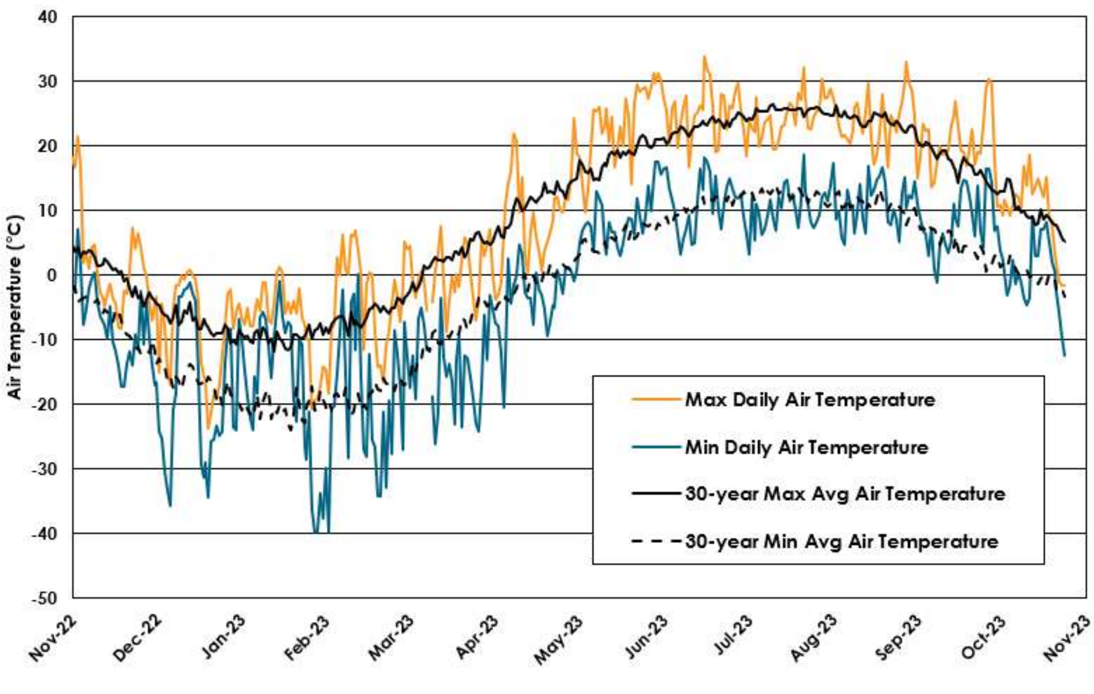

Figure 3.1: Maximum and minimum daily air temperatures recorded at Barron weather station compared to 30-year averages.

Table 3.1: Historical ambient winter air temperature (December to March period).

Monitoring Period	2019-2020	2020-2021	2021-2022	2022-2023
Lowest Winter Temperature (°C)	-39.9	-43.0	-39.9	-39.8
Highest Winter Temperature (°C)	12.4	17.2	14.6	7.5
Average Winter Temperature (°C)	-10.5	-8.9	-13.8	-10.6
Average Annual Temperature (°C)	2.6	4.8	2.3	4.0

3.1.2 Rainfall

Rainfall is collected directly on the cover system field trials with a Texas Electronics 525M Tipping Bucket Rain Gauge (TBRG). The TBRG installed on Trial #2 and has been collecting rainfall data since June 2018. The TBRG was calibrated to within 2% of specification during the September 6, 2023 site visit. A total of 440 mm of rainfall was recorded during the monitoring period (112 mm less than the 30-year historic average of 552 mm). Monthly rainfall from April to October 2023 was compared to the 30-year historic average (Figure 3.2, Table 3.2).

It was observed that July was drier than average, experiencing about 55% less total rainfall compared to the 30-year historical average. The largest rainfall event (39.6 mm) occurred June 1, 2023. Rainfall activity was also considered since 2019 (Figure 3.3). Rainfall in 2023 was less than 2022 rainfall, but similar to both 2020 and 2021 rainfall. 2022 was observed to be a much wetter than average year.

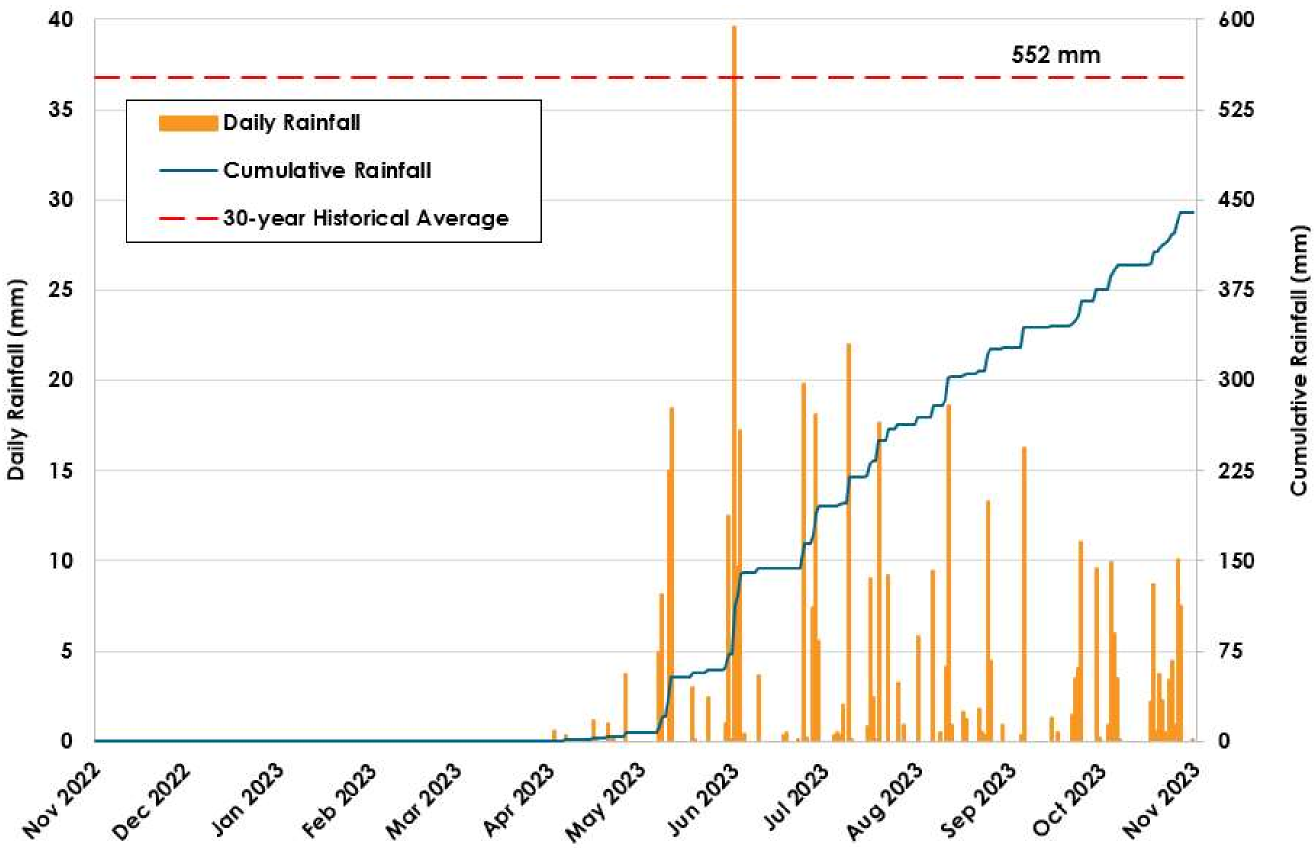

Figure 3.2: Daily and cumulative rainfall recorded at cover system field trials.

Table 3.2: April to October 2023 monthly rainfall.

Month	2023		30-year Average	
	Rain Days	Rainfall (mm)	Rain Days	Rainfall (mm)
April	2	7.2	8	48.4
May	7	65.5	13	87.2
June	8	122.5	13	107.9
July	7	68.4	11	123.6
August	9	63.3	10	78.6
September	7	48.2	11	77.5
October	11	64.8	11	63.6

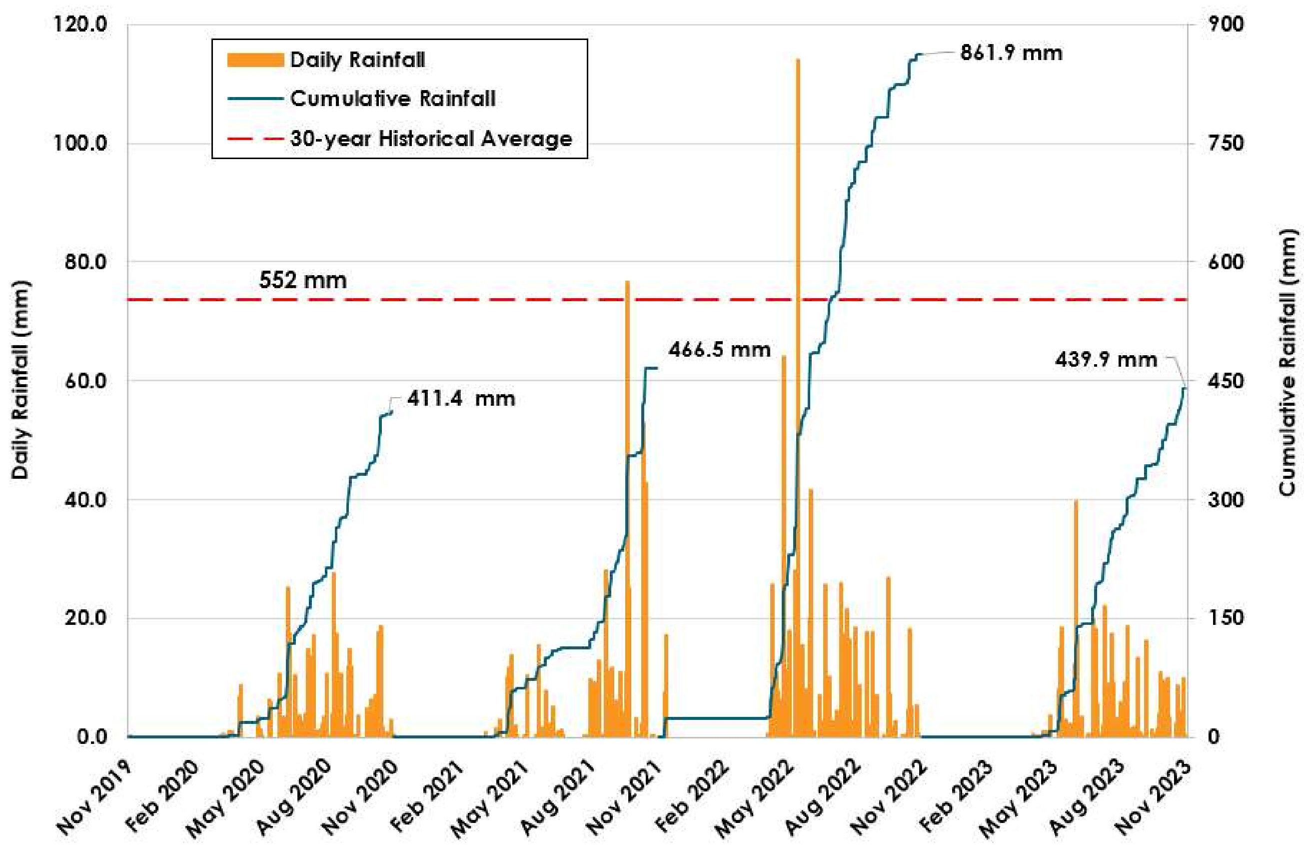

Figure 3.3: Daily and cumulative rainfall recorded at the cover trials since the onset of monitoring.

3.1.3 Snowfall

The TBRG on the trial plateau does not measure snow accumulation. A snow survey was conducted on March 7, 2023 by Okane to measure the depth of the snowpack on each cover system field trial. Photos of the cover trials were collected during the snow survey (Figure 3.4 through Figure 3.6)

Figure 3.4: Plateau of Trial #1 and Trial #2 (looking west).

Figure 3.5: Snow on PAG Cover Trial Plateau.

Figure 3.6: Snowpack on PAG Cover Trial plateau.

Using the measured snow depth and weight, both density, and average snow water equivalent (SWE) for Trial #1 and Trial #2 were calculated. Snow density was calculated to be 282 kg/m^3 and 291 kg/m^3, and SWE was calculated to be 65 mm and 75 mm, respectively, for Trial #1 and Trial #2. Average snow depth on Trial #1 and Trial #2 were measured to be 223 mm, and 260 mm, respectively. Density was higher during the 2023 snow survey as compared to previous years. This is likely due to the warmer temperature preceding the 2023 snow survey, causing melt water saturation within the snowpack, and snowpack densification. There may have been the potential for SWE loss prior to the 2023 snow survey, and it is recommended that snow surveys in the future take place prior to the occurrence of above zero temperatures.

Previous snow surveys were conducted on March 3, 2020, March 7, 2021, and February 22, 2022 (Table 3.3). The 2021 snow survey had no snow present.

Table 3.3: Four-year monitoring period snow survey results.

Measured Parameter	2020		2021		2022		2023	
	Trial #1	Trial #1	Trial #1	Trial #2	Trial #1	Trial #2	Trial #1	Trial #2
Snow Density (kg/m^3)	150	150	N/A	N/A	189	175	282	291
Snow-water Equivalent (SWE)	60 mm	60 mm	N/A	N/A	88 mm	78 mm	65 mm	75 mm

3.1.4 Reference Evapotranspiration

Reference evapotranspiration (ET_0) was calculated using the Penman-Monteith method. The Penman-Monteith method is the sum of transpiration of water within vegetation and evaporation of free water from the surface. A hypothetical grass crop having a height of 0.12 m, 70 s m^{-1} surface resistance, and albedo of 0.23 was used (Allen *et al.* 1998). Reference evapotranspiration was calculated based on air temperature, relative humidity, and wind speed data collected at the Barron weather station. Net radiation was measured on the Trial #2 cover system surface. Between March and October 2023, a total of 558 mm of ET_0 calculated at Trial #2.

Monthly ET_0 was compared to monthly rainfall for April to October (Figure 3.7). A decrease in the water stored within the upper layers of the cover system is observed in months where ET_0 is greater than rainfall (e.g., April, May, July, August, and September). During these months there is higher potential for drying of the compacted layer resulting in a reduction in maintained degree of saturation. Similarly, periods where ET_0 is less than rainfall observe an increase in water storage and increased potential for NP into the underlying mine rock (e.g., June and October).

When compared to the monitoring period rainfall, as well as the 30-year average, higher wetting rates were only observed in June and October, indicating water was added from the system during these months (Table 3.4). These processes occur due to a drier summer (July through September) than average. Less ET_0 was observed in 2023 compared to both 2020 and 2021, but slightly more than 2022. This is due to weather conditions less favourable for drying in 2022 or 2023 as compared to 2020 or 2021, such as cooler temperatures, less wind, less humidity, less solar radiation, or a combination of some or all these meteorological conditions.

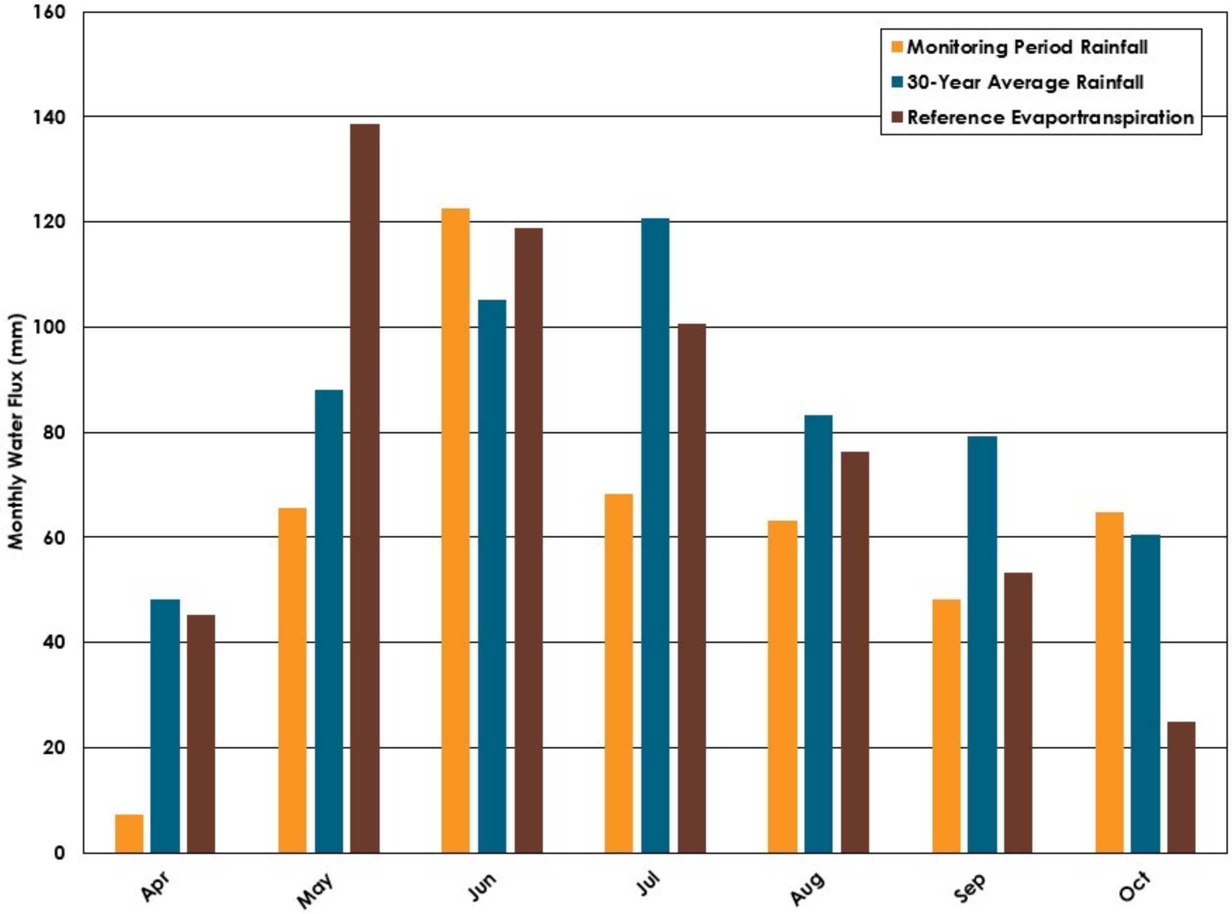

Figure 3.7: Reference evapotranspiration and total rainfall measured at Trial #2 from April to October 2023.

Table 3.4: Summary of monthly rainfall and reference evapotranspiration since 2020.

Month	2020		2021		2022*		2023	
	Rainfall (mm)	ET_0 (mm)	Rainfall (mm)	ET_0 (mm)	Rainfall (mm)	ET_0 (mm)	Rainfall (mm)	ET_0 (mm)
March	18.8	12.1	5.8	40.2	-	18.5	-	0.0
April	4.9	42.9	56.1	53.3	196.6	26.8	7.2	45.1
May	89.1	97.8	37.9	100.8	262.9	107.7	65.5	138.7
June	64.6	115.6	12.9	136.7	71.9	118.4	122.5	118.8
July	68.9	117.7	10.3	124.6	161.4	110.5	68.4	100.7
August	82.3	107.2	85.2	108.9	65.0	80.5	63.3	76.3
September	26.5	64.7	147.9	69.8	41.8	55.4	48.2	53.4
October	56.4	24.2	110.3	33.3	37.4	32.8	64.8	24.9
Total	**411.5**	**582.2**	**466.4**	**667.7**	**837.0**	**550.7**	**439.9**	**558.0**

**November rainfall not included in total*

3.2 Cover System Temperature Profiles

Soil temperature was monitored throughout the cover system profile of Trial #1 and Trial #2 to observe freeze-thaw cycling and the depth of frost penetration. The largest implication of freeze-thaw cycles on cover system performance is potential changes to physical properties of the compacted clay material, such as altering the hydraulic conductivity. Freezing temperatures were briefly observed in both cover system configurations during the monitoring period. A singular freezing temperature was recorded at Trial #1 was first observed April 7, 2023 at the 10 cm sensor (Figure 3.8). Trial #2 observed five instances of freezing temperatures between April 7 and April 11, 2023, at the 10 cm sensor (Figure 3.9). The 2022-2023 monitoring period measured the least severe freezing since the onset of monitoring; likely due to:

- sustaining vegetation on the surface of the cover trials which provides an insulating effect;
- a more temperate winter; and/or
- a combination of residual energy (temperature) and antecedent water content from the summer and fall of 2022.

Trial #2 observed cooler temperatures during the winter, and warmer temperatures in the summer, compared to Trial #1. Average temperatures in the compacted Brenna clay layer varied by approximately 1 °C throughout the monitoring period between Trial #1 and Trial #2, indicating minimal discrepancies between temperature at depth. Vegetation is reasonably established on both Trial #1 and Trial #2 and therefore had minimal differentiating influencing factors on temperature. Historically, Trial #2 has been more sensitive to atmospheric temperature changes, likely a result of increased early vegetation success as compared to Trial #1. A summary of freezing depths and dates is also provided for data since 2019 (Table 3.5).

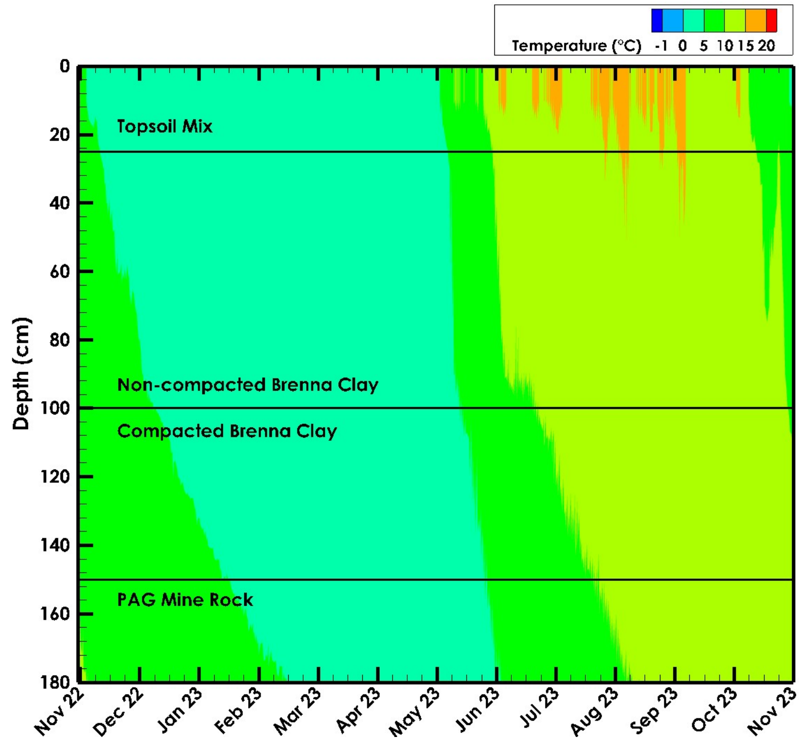

Figure 3.8: Soil temperature profile measured at the Trial #1 Primary nest during the monitoring period.

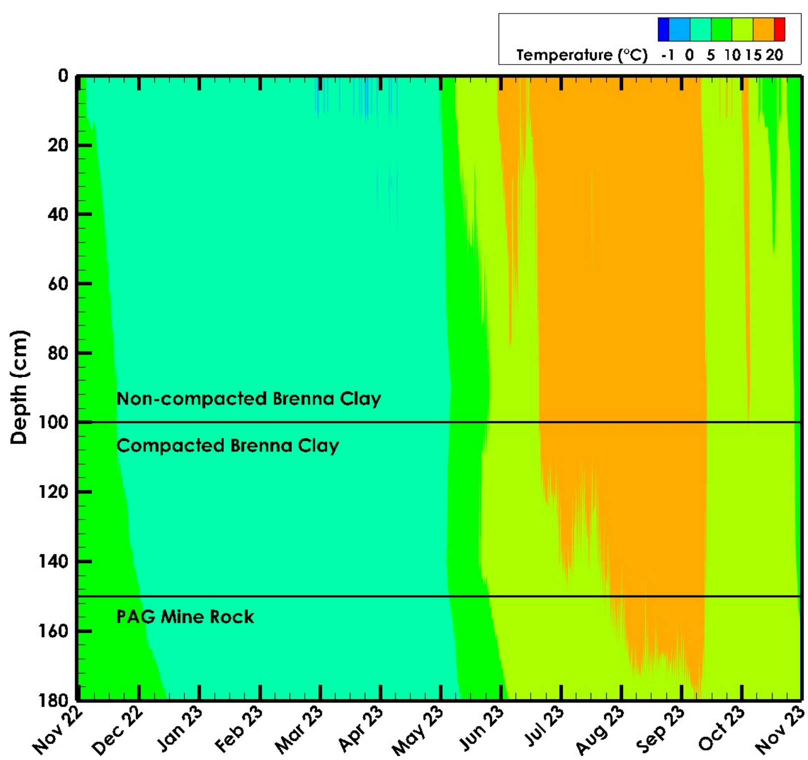

Figure 3.9: Soil temperature profile measured at the Trial #2 Primary nest during the monitoring period.

Table 3.5: Summary of freezing depths and dates.

Measured Parameter	2019-2020		2020-2021		2021-2022		2022-2023	
	Trial #1	Trial #2	Trial #1	Trial #2	Trial #1	Trial #2	Trial #1	Trial #2
Date of freezing	Dec 9, 2019	Dec 17, 2019	Dec 15, 2020	Feb 6, 2021	Feb 18, 2022	Dec 26, 2021	Apr 7, 2023	Apr 7, 2023
Depth of freezing (cm)	30	10	30	20	30	110	10	10

Since the onset of monitoring, temperatures within the mine rock vary between 2 °C and 12 °C for Trial #1 (Figure 3.10) and 1 °C and 16 °C for Trial #2 (Figure 3.11). Mine rock temperatures follow similar atmospheric heating and cooling patterns as the cover system. There is no clear additional source of heating within the mine rock mass.

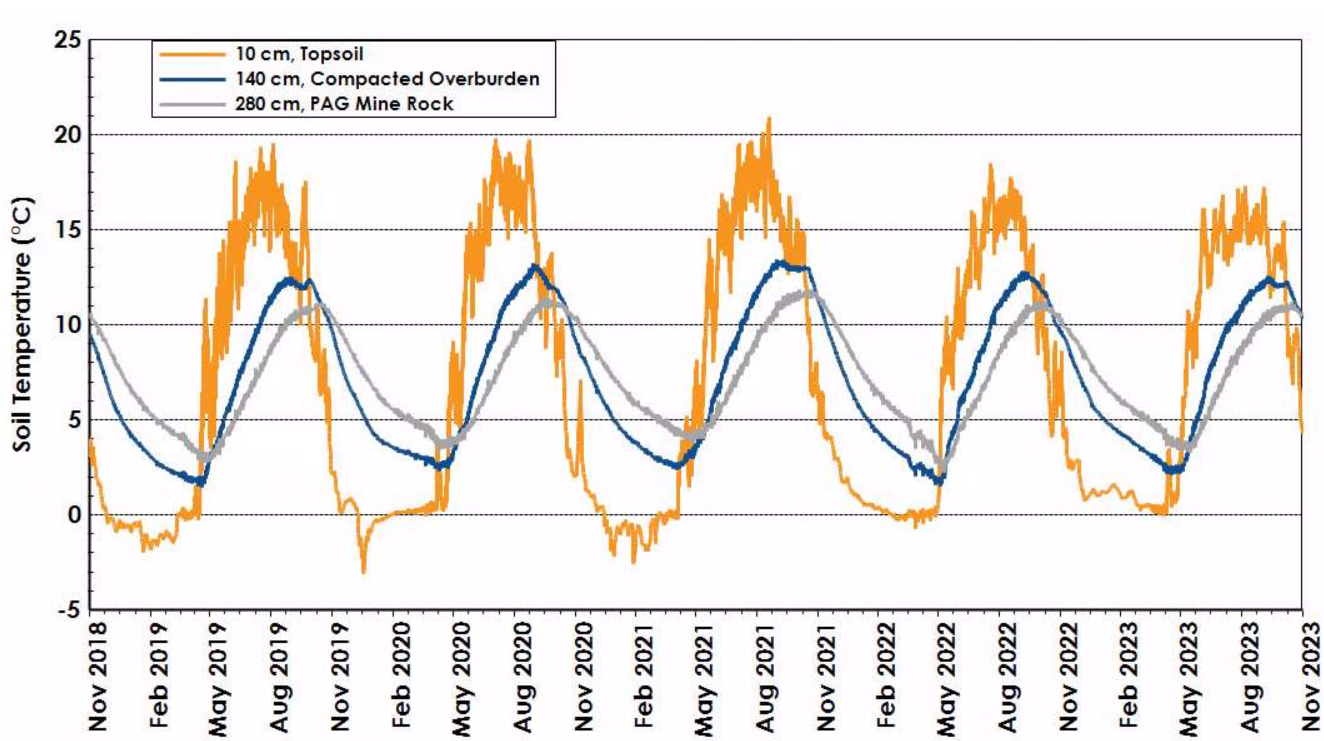

Figure 3.10: Trial #1 PAG mine rock temperatures since the onset of monitoring.

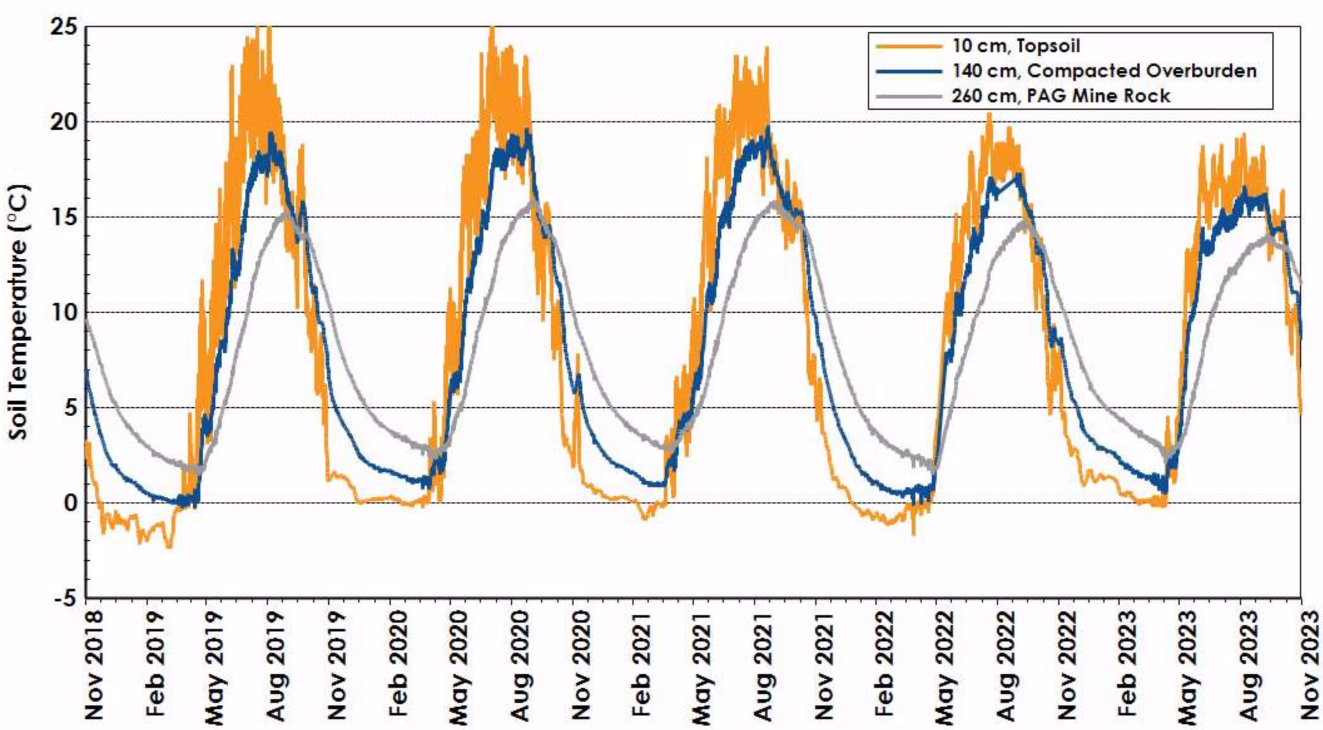

Figure 3.11: Trial #2 PAG mine rock temperatures since the onset of monitoring.

3.3 Cover System Water Dynamics

Volumetric water content and matric suction were measured throughout each cover system profile. Volumetric water content and matric suction measurements can be further analyzed to investigate performance and water dynamics of the cover system. This section presents the results of the data analysis, while direct *in situ* measurements are presented in Appendix B. The top of each cover system was selected as origin datum for all instrumentation depths.

3.3.1 Degree of Saturation

Volumetric water content was measured throughout each cover system profile to observe changes in the degree of saturation of the cover system material. To limit the ingress of oxygen into the underlying mine rock, a material must remain at or near saturated levels. As the degree of saturation exceeds 80%, the diffusion coefficient typically decreases by several orders of magnitude. A general guideline suggests that maintaining a consistent degree of saturation of 85% or greater within a layer will effectively limit the amount of oxygen movement by diffusion (Aachib *et al.* 2004).

Water content data shows that the compacted clay layer in both cover system profiles maintained a high degree of saturation throughout the monitoring period, having an annual average degree of saturation of 94%, and 92%, for Trial #1 and Trial #2, respectively (Table 3.6). The degree of saturation maintained in the cover systems demonstrates that the compacted clay layer is retaining sufficient pore-water to attenuate oxygen transport. Data from the 2022-2023 monitoring period reflected previous monitoring periods, in which the observed the degree of saturation of the compacted layer drop below 90% throughout the dry, warm summer. Water content of the compacted layer recovered during the wetter 2023 spring/summer months and remained primarily above 90% for the duration of the monitoring period. It can be determined from monitoring results that the objective of mitigating oxygen ingress is effectively achieved through the maintenance of an adequate degree of saturation in both the compacted and noncompacted layers throughout the monitoring period. Degree of saturation fell to a minimum of 83% in the compacted layer at Trial #1 in August, resulting in increased estimated oxygen ingress into the underlying waste rock. Estimated oxygen diffusion modelling is further quantified and discussed in Section 3.5.

Table 3.6: Average degree of saturation of cover system layers.

	Non-compacted Clay		Compacted Clay		
	0 – 50 cm	50 – 100 cm	Maximum	Minimum	Average
Trial #1 Primary Nest	75%	92%	95%	93%	94%
Trial #2 Primary Nest	85%	86%	98%	83%	92%

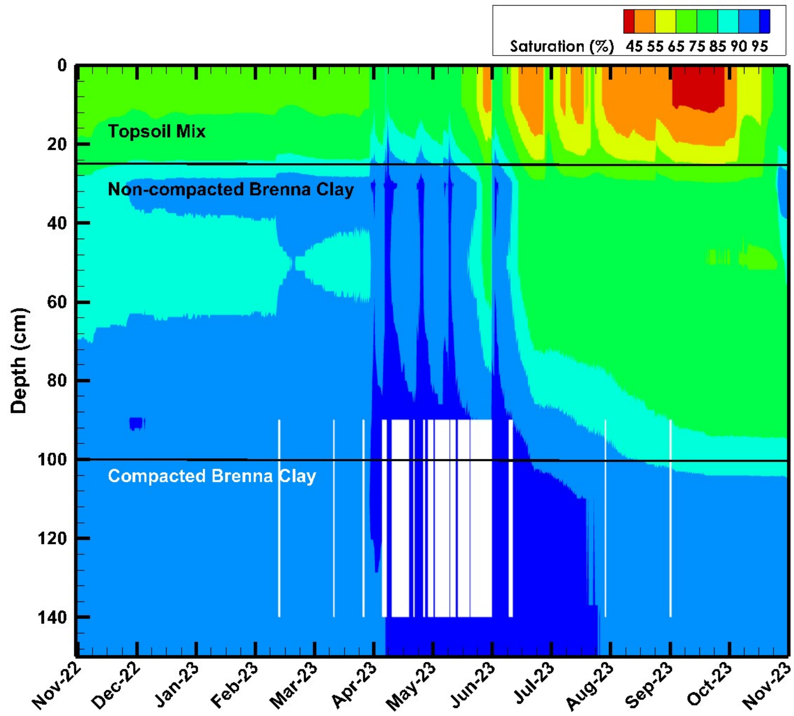

Figure 3.12: Change in degree of saturation at the Trial #1 Primary nest (white areas indicate periods of erroneous data).

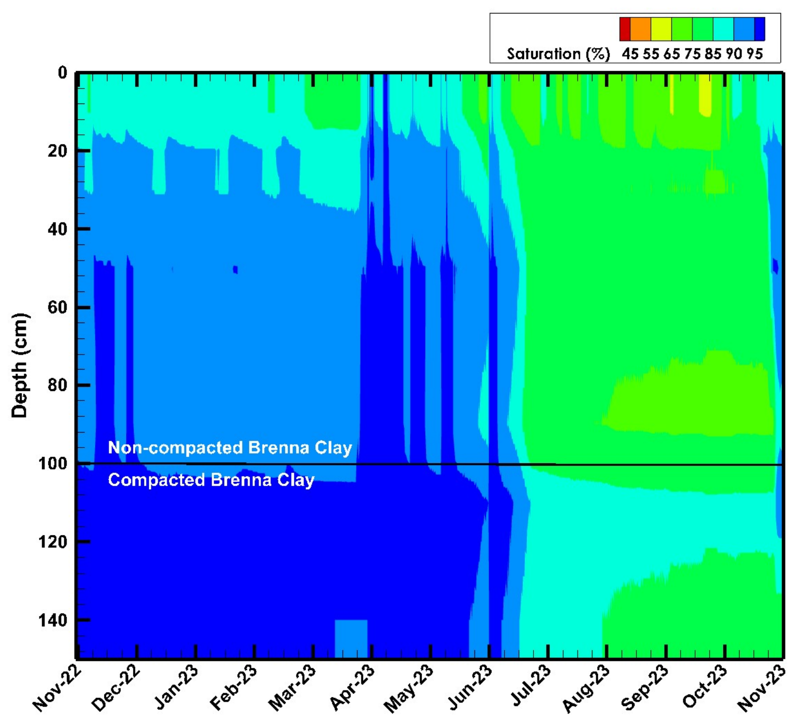

Figure 3.13: Change in degree of saturation at the Trial #2 Primary nest.

Historically, degree of saturation has remained above 85% in the compacted layer for majority of the monitoring period. Short periods near the middle to end of summer where the degree of saturation drops below 85% have historically been restored as a result of late season rainfall and cooler temperatures prior to the winter months.

3.3.2 Summary of Matric Suction Data

Matric suction sensors were installed in each cover system profile to measure negative pore-water pressure (suction). In unsaturated soils, suction provides an indication of the affinity of a soil for water, expressed as an energy potential. Measurements of less than 10 kPa are outside the installed sensor measurement range as the resolution of measurements in this range cannot be specifically measured and can be considered as any value between 0 to 10 kPa. Suction values greater than about 400 kPa are calculated from laboratory calibrations completed with salt brines generating osmotic suction. Calibration of individual sensors in this suction range can be challenging and therefore values greater than 400 kPa can be considered as high suctions but the trend in estimated suction value is likely more valuable than the absolute value.

Overall, Trial #2 (Figure 3.15) observed higher suction values deeper within the cover system than Trial #1 (Figure 3.14) (suction values measured >500 kPa within the compacted layer). Trends in suction was comparable throughout the monitoring period between Trial #1 and Trial #2, with Trial #1 experiencing higher suctions in the compacted layer during the winter months, prior to freshet. Higher suction values in the non compacted layer can indicate the established vegetations ability to translocate water out of the soil matrix during warmer and drier months. Both Trial #1 and Trial #2 showed wetting trends at the end of the monitoring period, which is common for this time of year due to late season rainfall and temperate weather.

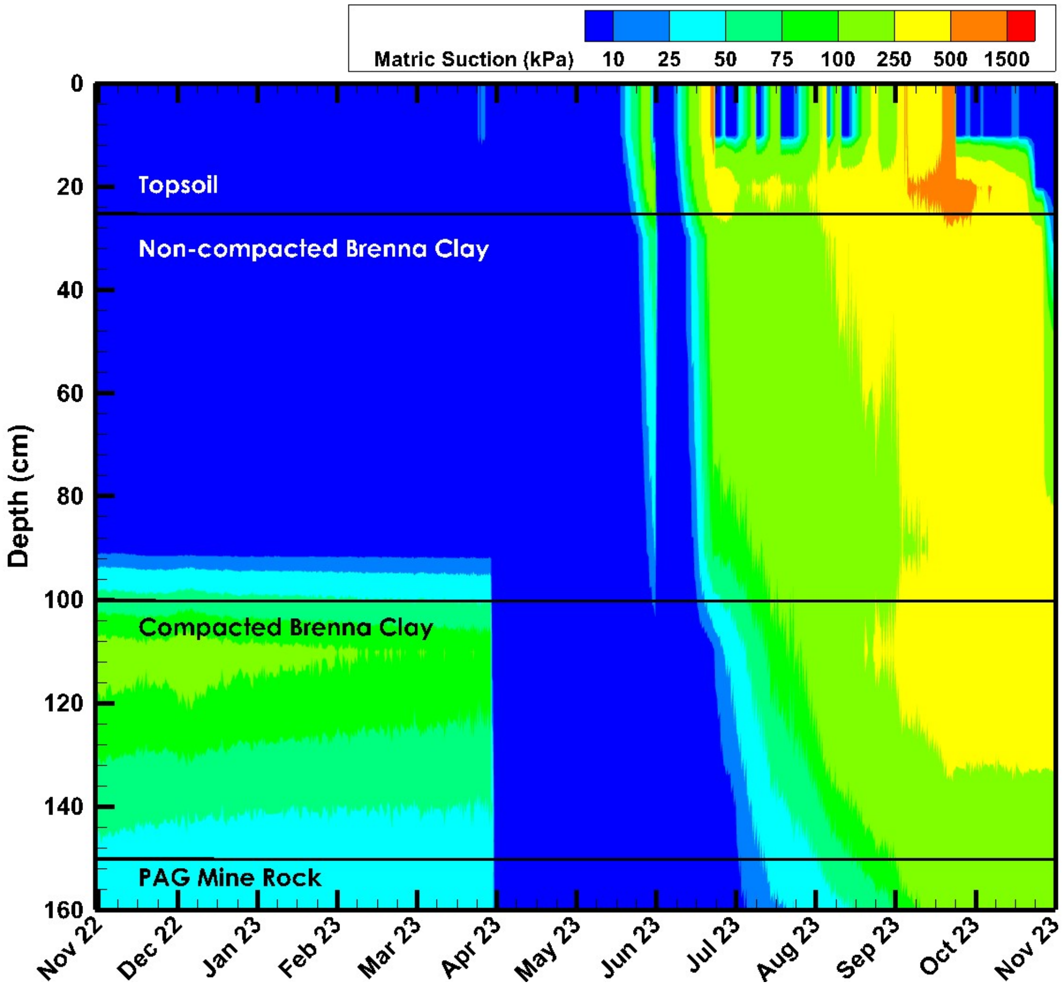

Figure 3.14: Matric suction measured at the Trial #1 Primary nest.

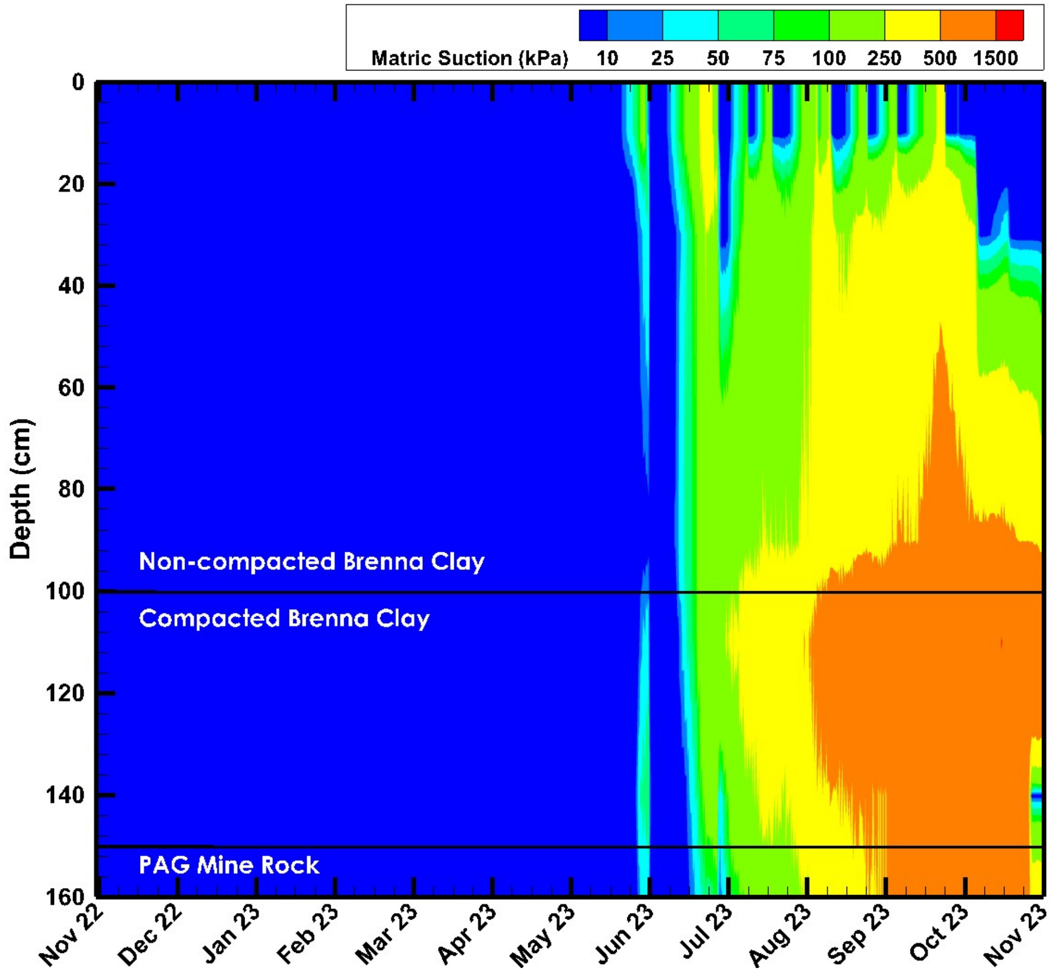

Figure 3.15: Matric suction measured at the Trial #2 Primary nest.

Trends in matric suction have remained generally consistent since the onset of monitoring. Higher suctions penetrating deeper in the cover system profile are typically observed in June through October. Typically, water levels recover in October/November and are at a seasonal high following freshet in April, resulting in reduced suctions throughout the cover profile between these months. Although the compacted layer observed higher suctions during the 2022-2023 monitoring period, the compacted layer was able to maintain a high degree of saturation, as discussed in Section 3.3.1.

3.3.3 Total Water Storage

The total water storage within the cover system profiles was determined by using field data to produce water retention curves (WRCs) from combined volumetric water content and suction data during the monitoring period. From the WRCs, the water content at which field capacity (FC) is reached can be determined. The FC is the volume of water stored in a soil matrix after the soil is allowed to drain from saturation freely under gravity (with no evaporative loss) and typically corresponds to the water content at suction values of 33 kPa for fine grained soils. Inputs of water above FC fill the largest pores, which then quickly drain under gravity due to an inability of large macropores to exert sufficient tension to retain the water. The total storage of water below field capacity within the cover system was calculated to determine the capacity to store new precipitation within the soil matrix. The total available storage in the cover system was approximately 550 mm.

Volumetric water content data was used to calculate the total measured water storage within each primary nest profile. A total water storage profile was created from sectioning the cover system into representative layers, with each layer having a sensor at its centre. For sensors placed at 10 cm, 20 cm, and 30 cm the representative layers are 0 to 15 cm and 15 to 25 cm. During periods where the measured storage is less than the total available storage, the soil has room to hold more water within the profile. Conversely, periods where the measured storage volume is greater than the total available storage the profile is not able to store new precipitation and infiltrated water will produce larger NP events.

Examination of measured water storage within the cover system profiles demonstrate the effect vegetation has on the capacity of the cover system to store and release water within the upper meter. Trial #1 and Trial #2 stored water capacity showed similar trends for the duration of the monitoring period (Figure 3.16). The decrease in storage during warmer and drier months (June through September), allows for new precipitation in October to be stored within the soil profile and not infiltrate to the underlying mine rock. If vegetation diminishes on the clay overburden, the cover system will not be as effective as a store-and-release system. Historically, as well as during the 2023 monitoring period, both Trial #1 and Trial #2 are following trends consistent with the field capacity (above field capacity in the spring, below in the summer), demonstrating effective store and release capabilities, while maintaining a high degree of saturation.

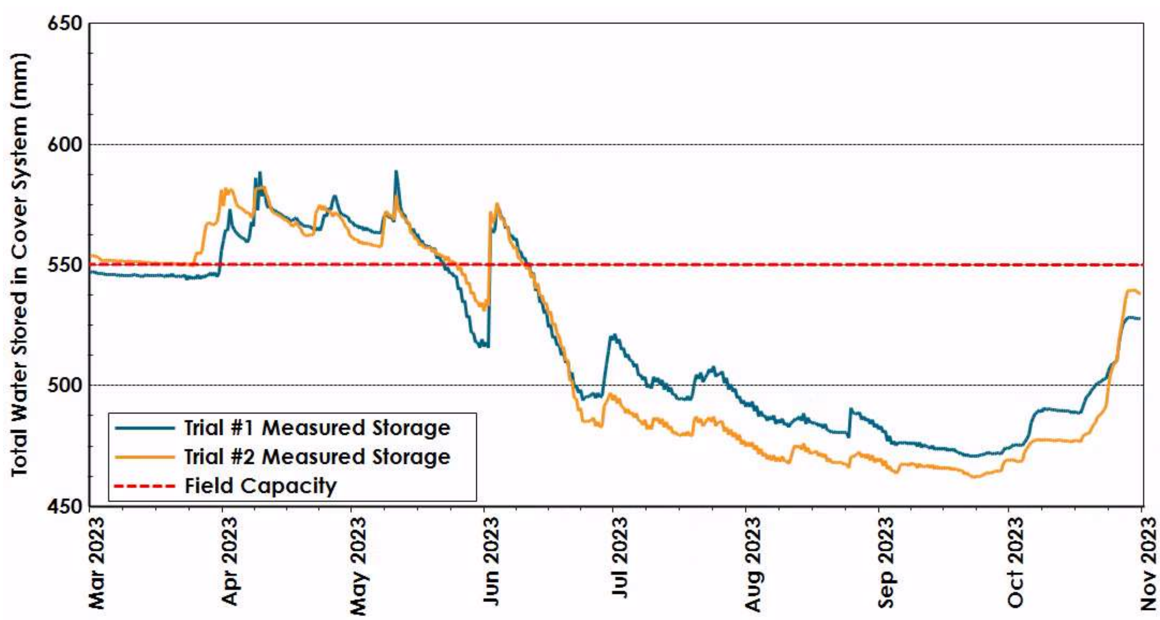

Figure 3.16: Measured storage versus cover system field capacity.

3.4 Water Balance

3.4.1 Discussion of Water Balance Inputs

A numerical model was utilized for water balance estimation that uses inputs of both meteorological data and soil monitoring data (suction gradients, VWC, measured storage) and estimates the remaining water balance components to balance the equation daily (Equation 1). The use of this software increases accuracy and consistency of water balances. Water balances were developed for each primary station to estimate the NP to the underlying mine rock.

$$PPT = SB + RO + ET_0 + NP + \Delta S + ITF \quad [1]$$

where:

PPT = precipitation (rainfall plus snow water equivalent)

SB = sublimation (assumed to be zero)

RO = runoff;

ET_0 = evapotranspiration;

NP = net percolation;

ΔS = change in water storage within the cover system profile; and

ITF = interflow (assumed to be zero)

Precipitation was measured at site with a TBRG to measure rainfall. Daily spring melt was estimated using a combination of data collected from the March 7, 2023 snow survey, and the degree-day method with a degree day coefficient of 2.74 mm/degree-day °C and an estimated snow ripening period of seven days (USDA, 2004).

Runoff is not measured at the PAG field cover trials but was estimated during spring freshet and large rainfall events based on Okane's experience at sites where runoff is monitored. At similar sites, to produce a runoff event of approximately 1 mm, rainfall events of at least 10 mm are required in periods of ~24 hours or less. Based on these findings, runoff events were estimated for the monitoring period as approximately 10% of daily rainfall totals exceeding 10 mm during spring and summer months. This may vary depending on the frequency and intensity of daily rainfall events. Snowmelt is generally considered to be runoff when ground conditions are still frozen. As ground conditions did not freeze, snowmelt was not considered to be solely runoff during the monitoring period.

The primary purpose of the water balance is to estimate NP rates based on changes in water storage in the compacted clay layer, suction gradients, and conservative flow limitations of a barrier layer (hydraulic conductivity equal to or lesser than 10^{-7} cm/s).

The water balance is an indirect method of calculating NP. Therefore, the uncertainty associated with the individual components of the water balance are compounded when estimating NP. Water balance uncertainties are constrained to the extent possible using engineering judgement. The estimated NP rates and patterns determined using the water balance method generally support the conceptual model, and as such support the suitability of the water balance method for this site. Numerical modelling methods were used in development of the water balance.

The numerical model uses soil parameters such as hydraulic conductivity and porosity to improve accuracy in estimating runoff and NP. Manual adjustments are also completed based on site specific conditions that the simulation may not account for, such as hard panning of the topsoil or site topography, which help further improve the accuracy of the water balance results. The numerical simulation software utilizes the Soil Conservation Science (SCS) curve number (CN) to increase the accuracy of runoff estimation. The CN is determined through defining the Hydrologic Soil Group (HSG), cover description, and hydrologic condition. HSG Group C was chosen based on the results of the permeability testing completed on the compacted clay at the East Mine Rock Stockpile. An HSG Group C classification means that the soil has a slow infiltration rate. The other parameter used in the simulation is the vegetation cover type, which was chosen to be brush in good condition (>75% of the surface is covered), based on site observations during the various 2022 site visits. The vegetation cover at both Trial #1 and Trial #2 resulted in a curve number for the hydrologic soil group of 70 (USACE et.al.,2022).

3.4.2 Water Balance Results

Calculated change in storage matched measured change in storage for Trial #1 (Figure 3.17) and Trial #2 (Figure 3.18) water balances. Calculated NP in Trial #1 was 26 mm (5% of annual precipitation); following the performance outlined in the conceptual model and produced low NP rates given the climate region (INAP, 2017). Calculated NP in Trial #2 was 50 mm (10% of the annual precipitation) (Table 3.7), also resulting in low NP rates. Runoff for Trial #1 and Trial #2 was 23% and 25%, respectively; slightly higher than the conceptual model predictions of 10-20%. The primary events driving runoff were freshet snowmelt in April, as well as a series of rainfall events between May 31 and June 4 (79 mm of rainfall generating approximately 25 mm runoff).

Table 3.7: Water balance components.

	Precipitation (mm)	ET_0 mm (% PPT)	Runoff mm (% PPT)	Net Percolation mm (% PPT)	Change in Storage mm (% PPT)
Conceptual Model	-	50 – 70%	10 – 20%	5 – 15%	N/A
Trial #1	505	372 (74%)	115 (23%)	26 (5%)	-8 (-2%)
Trial #2	515	377 (73%)	127 (25%)	50 (10%)	-39 (-9%)

PPT = Annual Precipitation

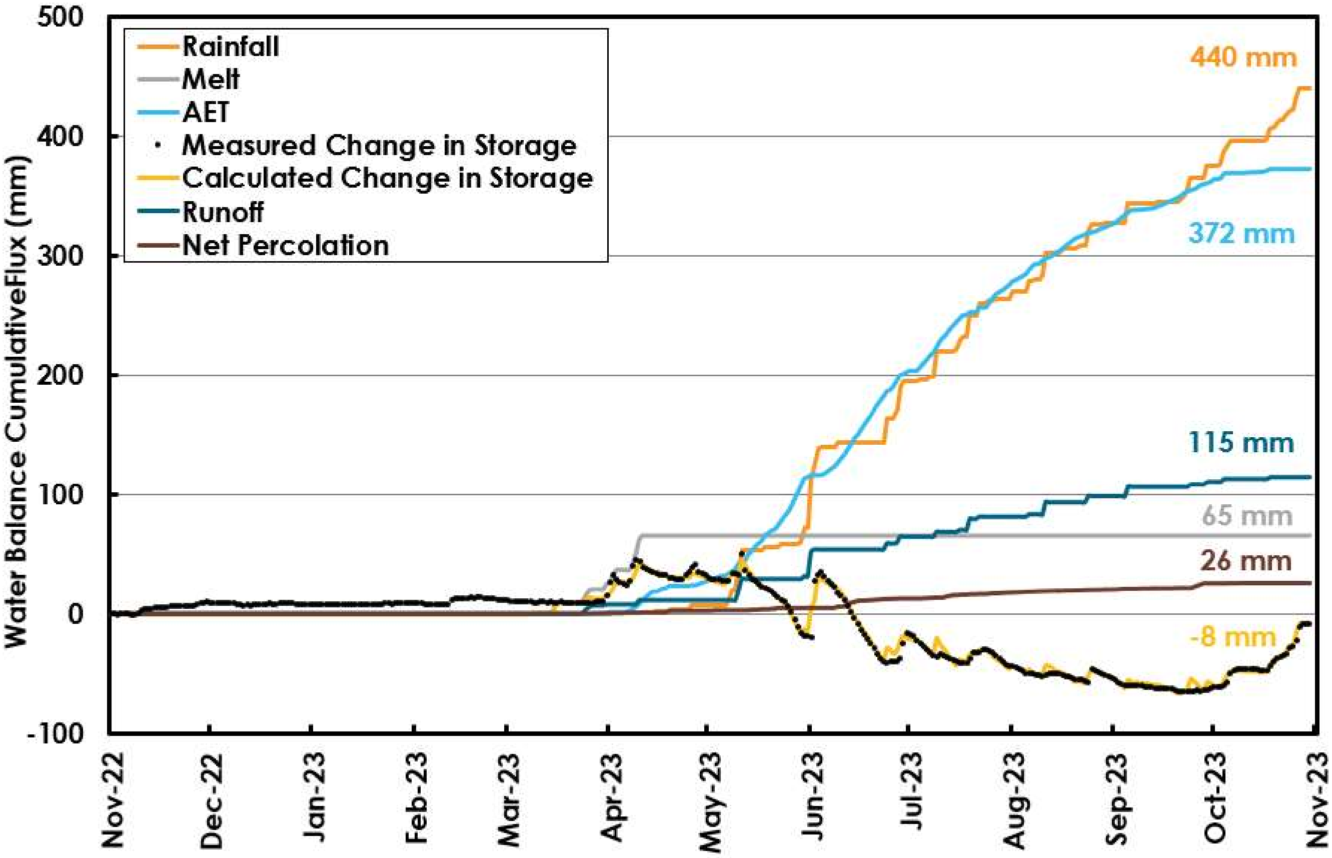

Figure 3.17 : Cumulative water balance flux at Trial #1 for the monitoring period.

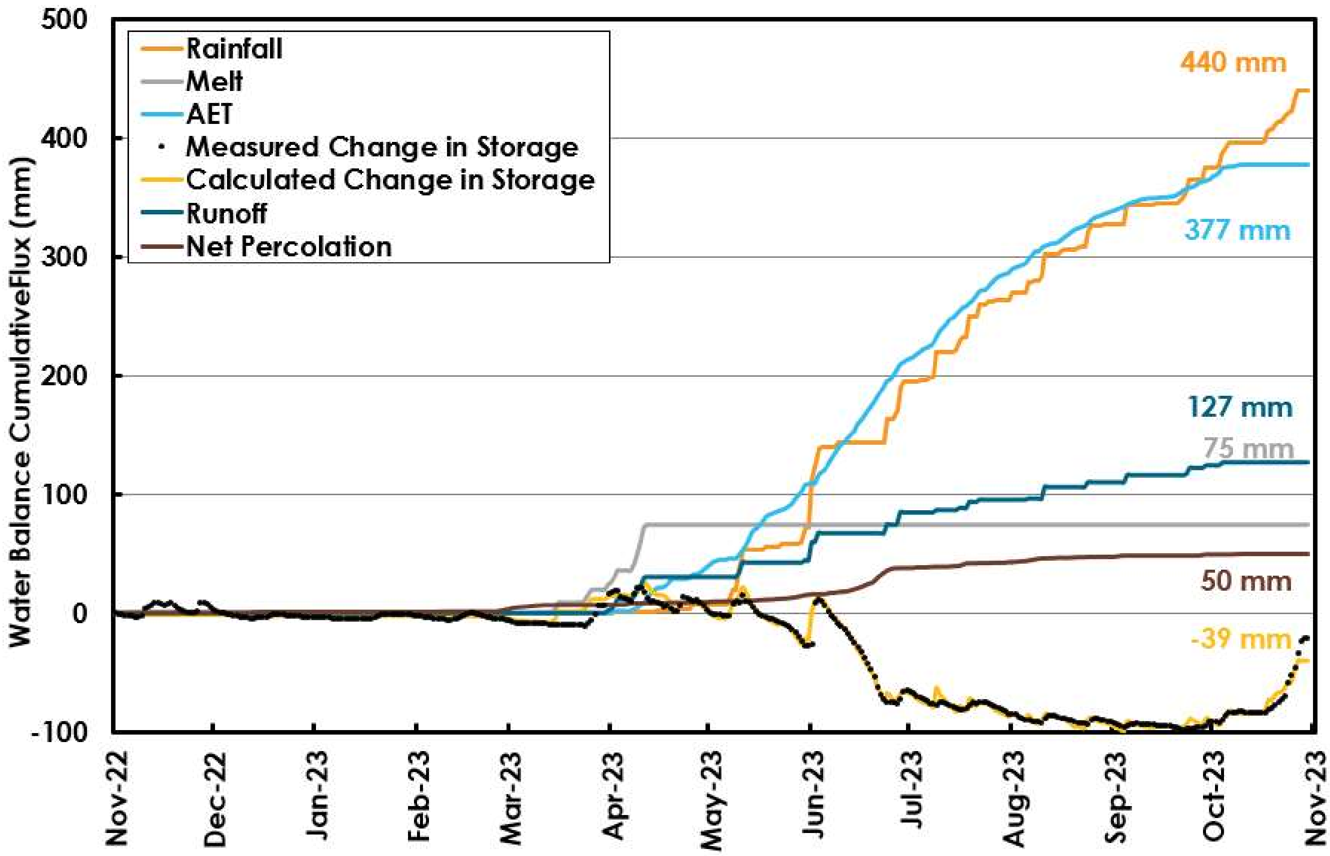

Figure 3.18: Cumulative water balances flux at Trial #2 for the monitoring period.

The results of the previous water balances are provided for comparison (Table 3.8). Water balance modelling was refined for the 2021-2022 water year with the use of a numerical modelling software. Notable values include the increase in runoff as a percentage of precipitation during the 2021-2022 monitoring period. The runoff value was inflated due to the excess rainfall measured during the monitoring period. The 2022-2023 water balance more similarly reflects the 2019-2020 water balance, with the exception that evapotranspiration values are more similar between Trial #1 and Trial #2 during the current monitoring period. As vegetation has developed over the previous five years, evapotranspiration rates have generally increased, and vegetation growth and retention between both cover trials has become more alike. Storage losses were observed at both Trials during the 2022-2023 monitoring period, reaching maximum storage deficits in mid-September of -65 mm and -98 mm for Trial #1 and Trial #2, respectively. Storage rates were increasing towards pre-freshet values at the end of the monitoring period for both Trials, as evapotranspiration decreases as vegetation degrades and temperatures cool. NP continues to be within the 5 – 15% range as defined by the conceptual model for both cover system configurations

Table 3.8: Water balance components over the four-year monitoring period.

Monitoring period		ET_0 mm (% PPT)	Runoff mm (% PPT)	Net Percolation mm (% PPT)	Change in Storage mm (% PPT)
	Conceptual Model	50 – 70%	10 – 20%	5 – 15%	N/A
2019-2020	Trial #1	378 (80%)	114 (24%)	43 (9%)	-
	Trial #2	287 (60%)	113 (23%)	75 (16%)	-
2020-2021	Trial #1	239 (49%)	122 (25%)	75 (15%)	60 (13%)
	Trial #2	240 (48%)	139 (28%)	120 (24%)	-2 (-0.4%)
2021-2022	Trial #1	468 (49%)	388 (41%)	119 (12.5%)	-25 (-2.5%)
	Trial #2	441 (47%)	372 (39.5%)	130 (14%)	-4 (-0.5%)
2022-2023	Trial #1	372 (74%)	115 (23%)	26 (5%)	-8 (-2%)
	Trial #2	377 (73%)	127 (25%)	50 (10%)	-39 (-9%)

3.5 Estimated Oxygen Ingress

Automated oxygen sensors located in the underlying mine rock were monitored to observe the ingress and consumption of oxygen. Fluctuation in oxygen concentrations have been observed since the construction of the cover trials. These fluctuations have been attributed to insufficient thickness of the clay key surrounding the field trials allowing oxygen to bypass the cover system through advection. Due to this ingress pathway, monitoring oxygen concentrations is not a definitive approach to measure the ability of the cover system to mitigate oxygen ingress.

To quantitatively estimate oxygen diffusion into the mine rock through the cover materials, a Monte Carlo simulation has been completed separately for both trials. The simulation used the degree of saturation as provided in Section 3.3.1, and varied the following material properties as a sensitivity analysis to estimate both best- and worst-case scenarios:

- Dry density of CBC between 1,600 kg/m^3 and 1,700 kg/m^3;
- Dry density of non-compacted clay overburden between 1,450 kg/m^3 and 1,550 kg/m^3;
- Dry density of topsoil between 1,400 kg/m^3 and 1,500 kg/m^3 (Trial #1 only); and

- Initial oxidization rate (IOR) of the mine rock between $1x10^{-11}$ kg/tonne/s and $1x10^{-7}$ kg/tonne/s.

The simulation was repeated 1,000 times, with the above parameters varied for each simulation. The results of the simulation for Trial #1 show that the median results predict approximately 1.8 mol of oxygen had diffused into the mine rock over the monitoring period (Figure 3.19). The 99th percentile oxygen ingress estimation was approximately 3.6 mol over the monitoring period. The median results for Trial #2 indicate approximately 5.6 mol of oxygen had diffused into the mine rock over the monitoring period, with approximately 8.5 mol of oxygen diffusion occurring in the 99th percentile estimate (Figure 3.20). Trial #2 both shows an increase in oxygen diffusion rates after July 2023 caused by the decrease in the degree of saturation to less than 85%.

The results of the previous three years of modelling indicate a very low to low oxygen flux through the cover system (Table 3.9) according to the INAP Guidance Document (INAP, 2017). The oxygen flux through the cover system was able to stay within conceptual performance expectations, even during drier periods.

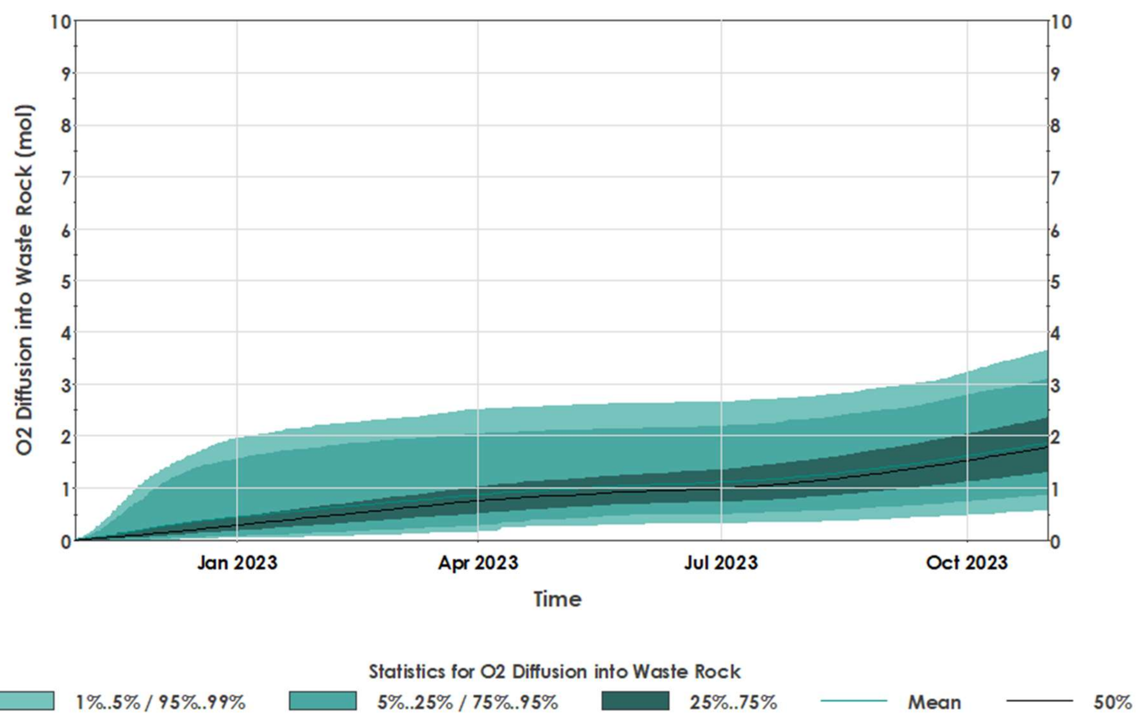

Figure 3.19: Oxygen diffusion simulation through cover materials on Trial #1 over the monitoring period.

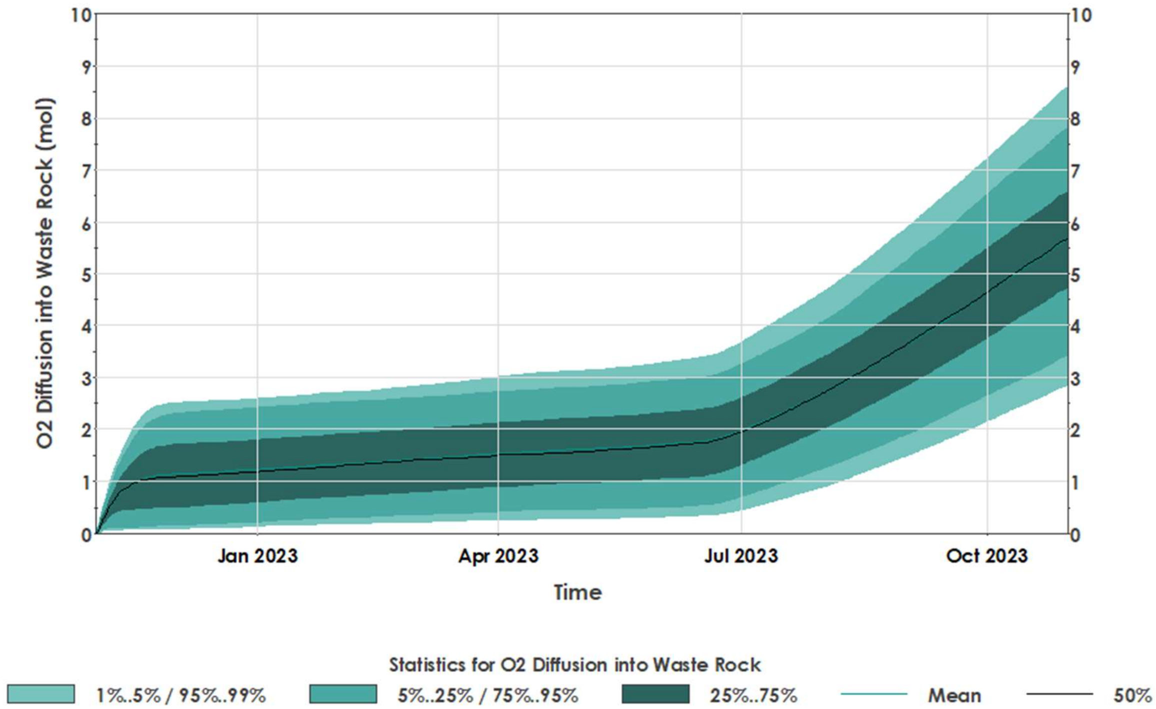

Figure 3.20: Oxygen diffusion simulation through cover materials on Trial #2 over the monitoring period.

Table 3.9: Historical estimated oxygen ingress

Monitoring Period	2020-2021		2021-2022		2022-2023	
	Trial #1	Trial #2	Trial #1	Trial #2	Trial #1	Trial #2
Median estimated oxygen ingress (mol/yr)	1	2	1	1.4	1.8	5.7
INAP oxygen flux classification	Very Low	Very Low	Very Low	Very Low	Very Low	Low

(INAP, 2017)

4 RECOMMENDATIONS

To further understand cover system performance, the following is recommended to be completed during the upcoming monitoring period:

- Continued performance monitoring as the cover trials is easily accessible, not infringing on mine operations, and require little maintenance and further investments. The learnings from the performance of the cover trials in response to varying climate conditions allow for better understanding of cover system performance at the Rainy River site.
- Continued generation of annual water balances to better understand climatic cycles and the influence of further established vegetation to modify the water fluxes.
- Completion of an annual snow survey prior to observing above 0 °C temperatures, to limit the amount of snow water equivalent that may be lost prior to the snow survey.

4.1 Opportunities

Automated performance monitoring data has been collected at the field trials for approximately 4.5 years, which represents a substantial database of material properties and soil response to wet/dry and freeze/thaw cycling. The PAG cover trial database provides New Gold with a better understanding of cover system performance under varying climatic and vegetative conditions. The database will foster additional confidence in the results from the EMRS progressive reclamation cover construction, which started in late 2020.

5 CLOSURE

We trust information provided is satisfactory for your requirements. Please do not hesitate to contact the undersigned at (306) 241-3111 for further information or questions.

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6 REFERENCES

Aachib, M., Mbonimpa, M., and M. Aubertin. (2004). Measurement and Prediction of the Oxygen Diffusion Coefficient in Unsaturated Media, with Applications to Soil Covers. Water, Air, and Soil Pollution 156: 163–193, 2004.

Allen, R. G., Pereira, L.S., Raes, D. and Smith, M. (1998). Crop evapotranspiration – Guidelines for computing crop water requirements. FAO Irrigation and Drainage Paper 56. Food and Agriculture Organization (FAO) of the United Nations, Rome, Italy.

International Network for Acid Prevention (INAP). (2017). Global Cover System Design – Technical Guidance Document.

McMullen, J., Firlotte, R., Knapp, R., Aubertin, M. (1997). Les Terrains Auriferes property site closure and rehabilitation – conceptual to construction. In Proceedings of the 29th Annual meeting of the Canadian mineral processors, Ottawa, Ont. 274-292.

Mine Environment Neutral Drainage (MEND). (2004). Design, construction, and performance monitoring of cover systems for waste rock and tailings. Canadian MEND Program, Project 2.21.4, July.

Okane Consultants (Okane). (2017a). Rainy River Project: Preliminary Evaluation of Cover System Design for Mine Rock Stockpiles. Okane report no. 1003/06-02 submitted to New Gold October 17, 2017

Okane Consultants (Okane). (2017b). Rainy River Project Failure Modes and Effects Analysis for Mine Rock Stockpiles. Okane report no. 1003/03-001 prepared for New Gold Inc. November 2017.

Okane Consultants (Okane). (2018). PAG Cover System Field Trials 2017 Field Trial Report. Okane report no. 1003/08-001 prepared for New Gold Inc. August.

Okane Consultants (2020a). Rainy River PAG Cover Trial – Annual Monitoring Report. Submitted to New Gold January 21, 2020.

Okane Consultants (Okane) (2020b). Rainy River PAG Cover Trial – Annual Monitoring Report. Submitted to New Gold December 16, 2020.

Okane Consultants (Okane). (2023). Rainy River Mine – Potentially Acid Generating Mine Rock Cover Trial 2022 Annual Monitoring Report. Revision 1. Submitted to New Gold January 9, 2023.

United States Department of Agriculture (USDA). (2004). Hydrology National Engineering Handbook. Chap. 11. pp. 11-5.

USACE Hydrologic Engineering Center. (2022). HEC-HMS Technical Reference Manual SCS TR-55 Table 2-2c "Runoff curve numbers for other agricultural lands". Accessed at: https://www.hec.usace.army.mil/confluence/hmsdocs/hmstrm/cn-tables

Appendix A

Photo Log

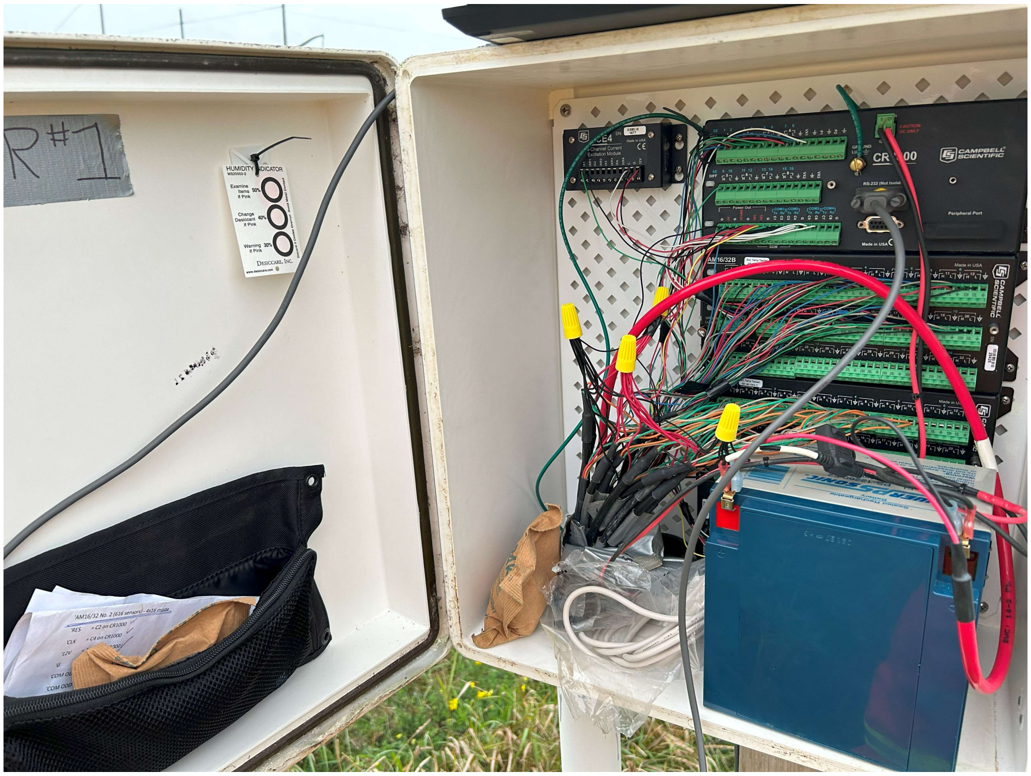

Photo A.1: PAG Trial #1 enclosure.

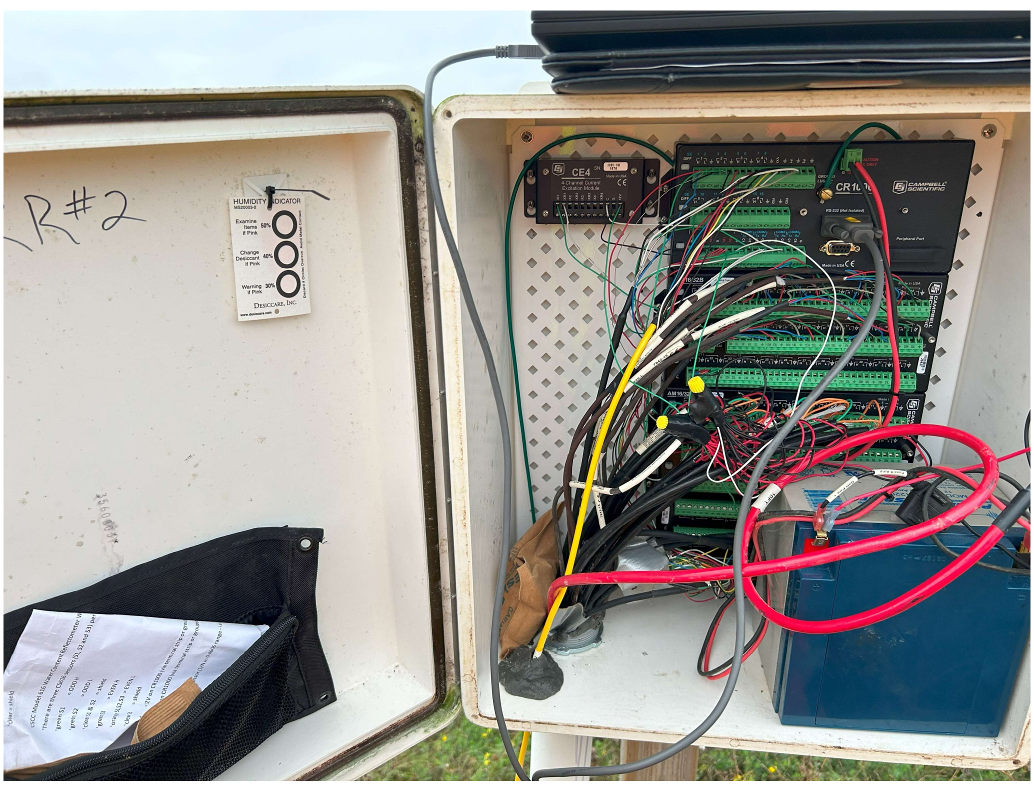

Photo A.2 PAG Trial #2 enclosure.

Photo A.3: PAG Trial plateau vegetation, looking west. September 6, 2023.

Photo A.4: PAG Trial plateau, looking east. September 6, 2023.

Photo A.5: PAG Trial south slope, looking east. September 6, 2023.

Photo A.6: PAG Trial north slope, looking west. September 6, 2023.

Appendix B

In Situ Instrumentation Measurements

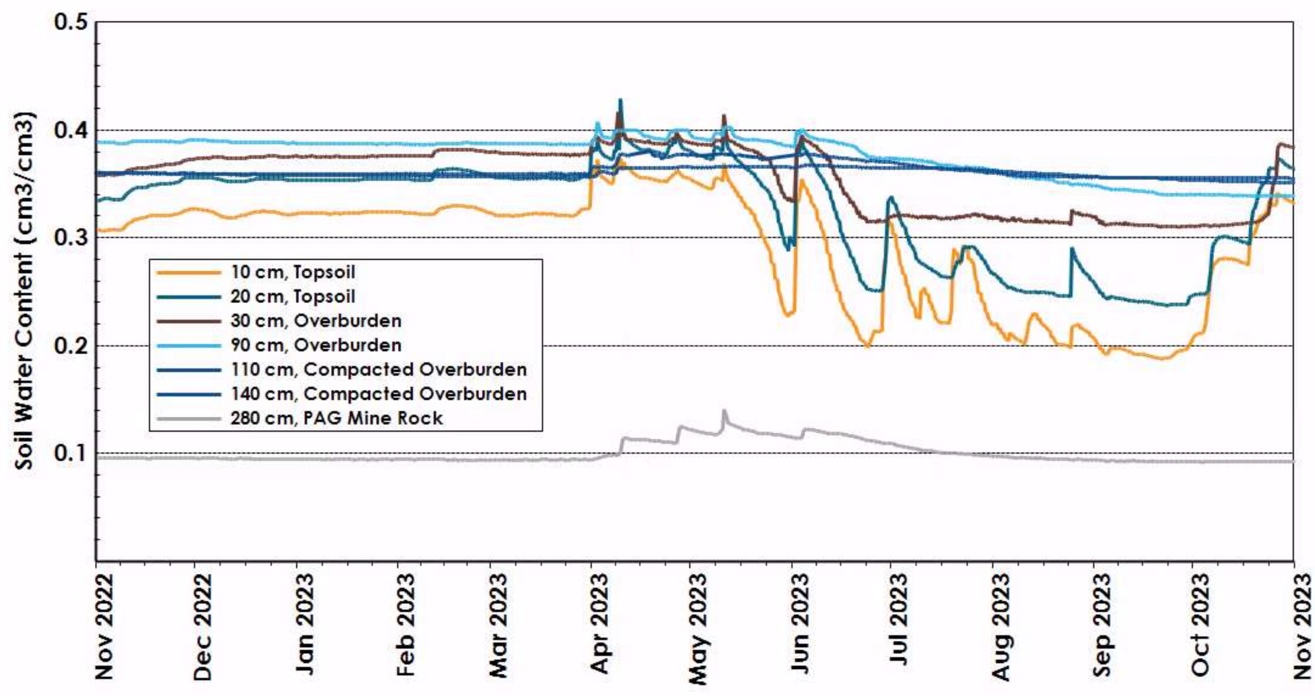

Figure B.1: VWC profile at Trial #1 primary station during the monitoring period.

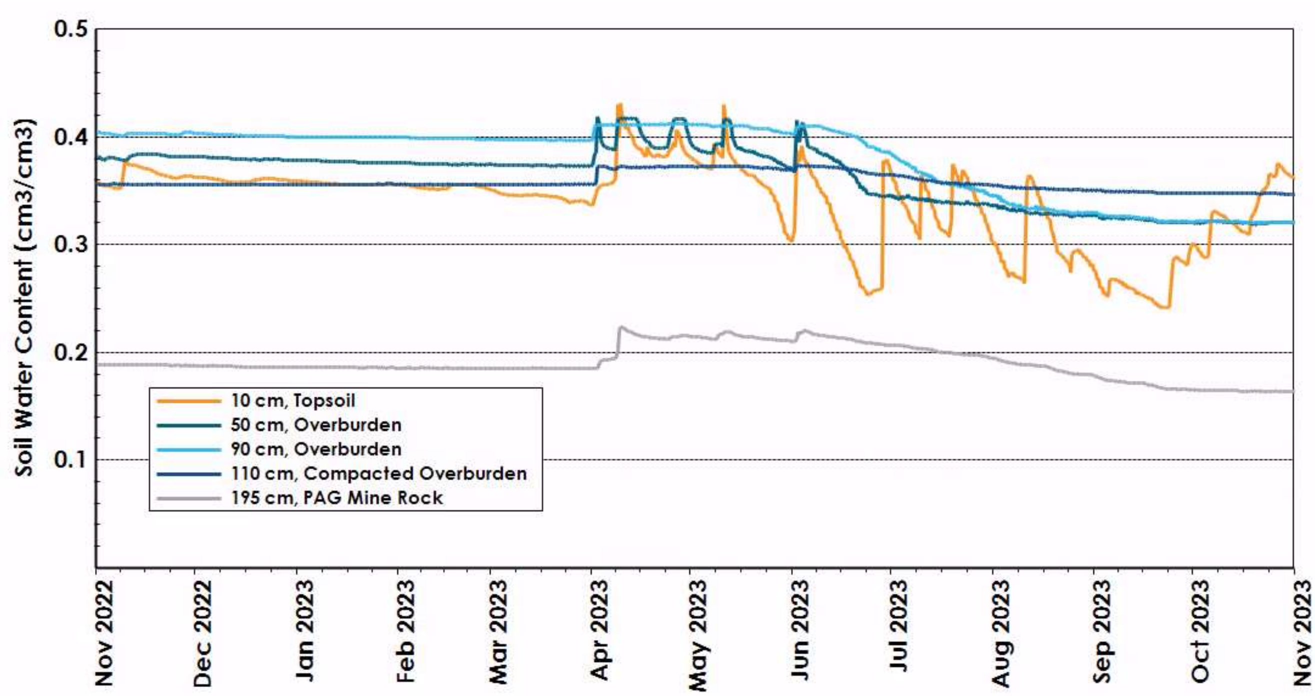

Figure B.2: VWC profile at Trial #1 secondary station during the monitoring period.

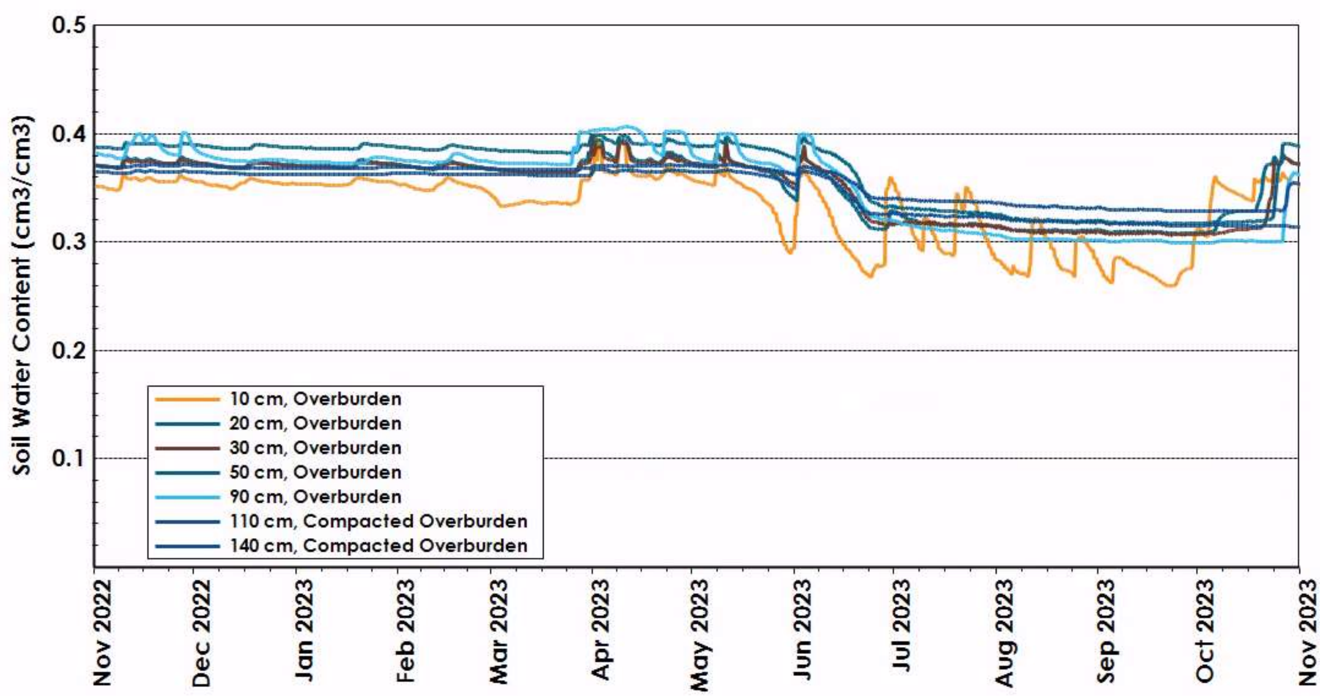

Figure B.3: VWC profile at Trial #2 primary station during the monitoring period.

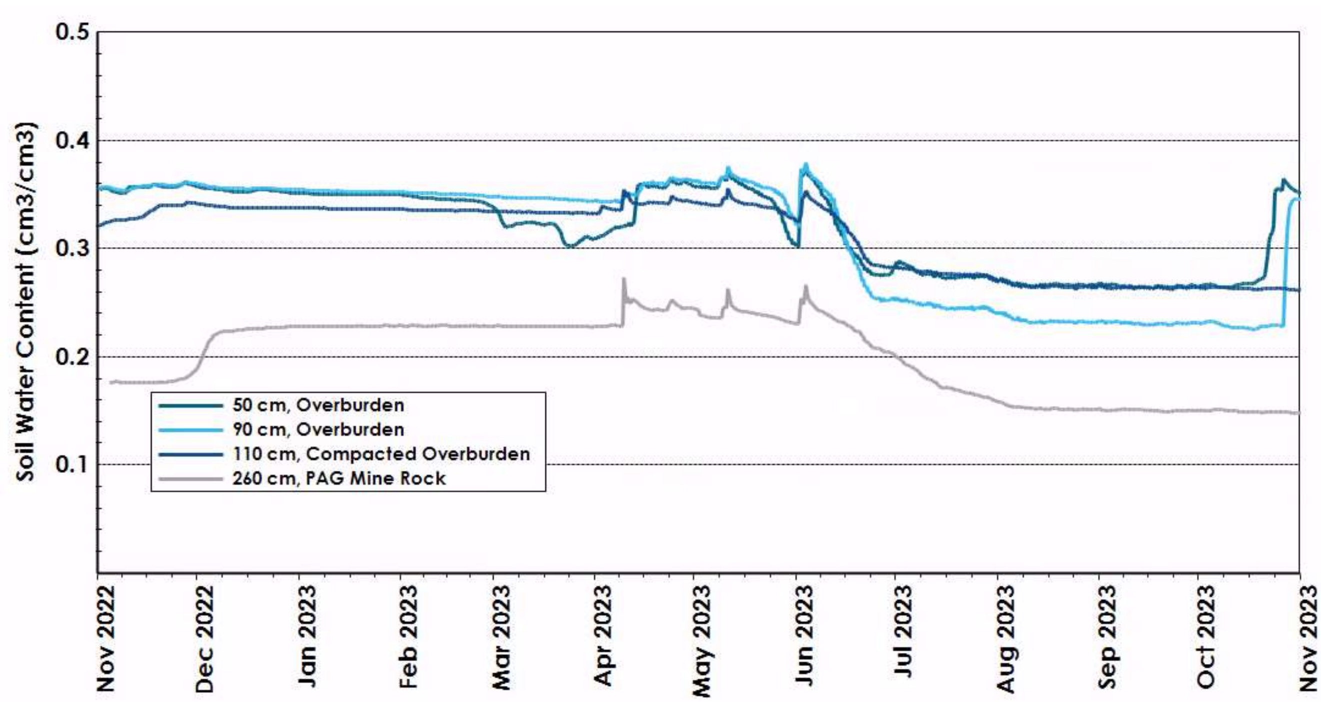

Figure B.4: VWC profile at Trial #2 secondary station during the monitoring period.

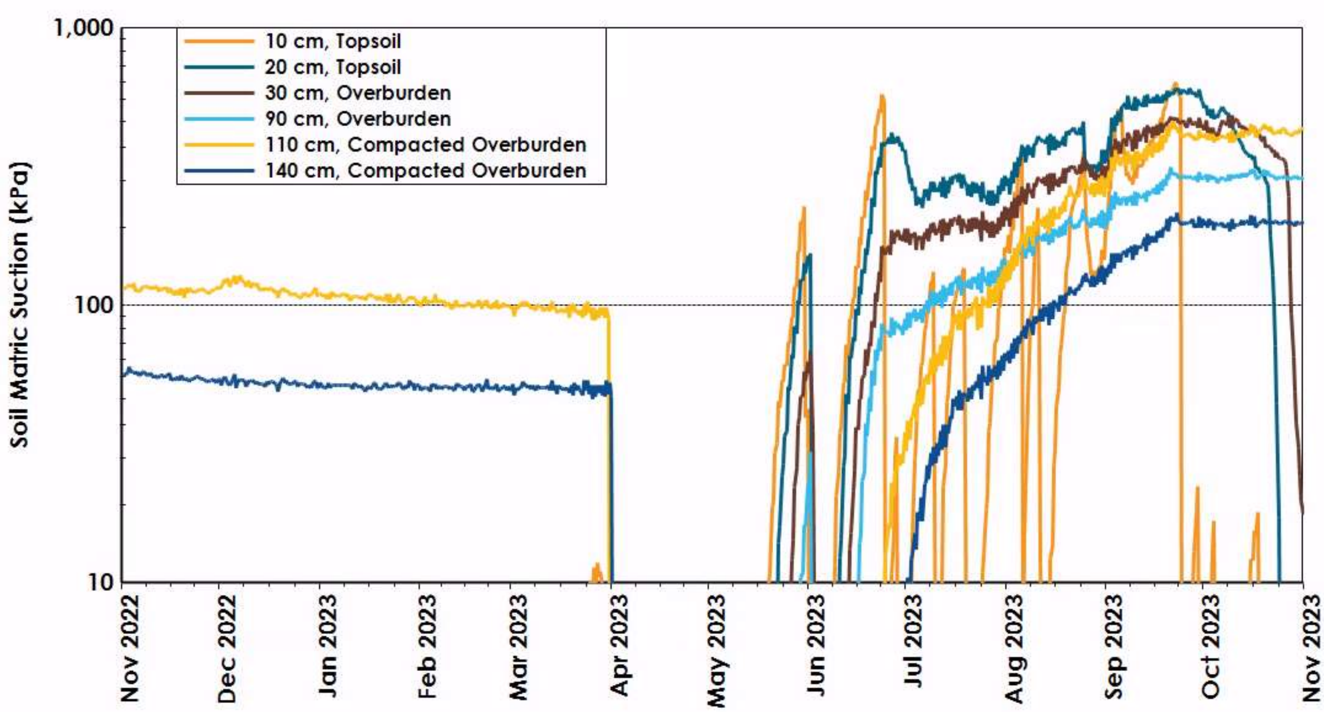

Figure B.5: Suction profile at the Trial #1 primary station during the monitoring period.

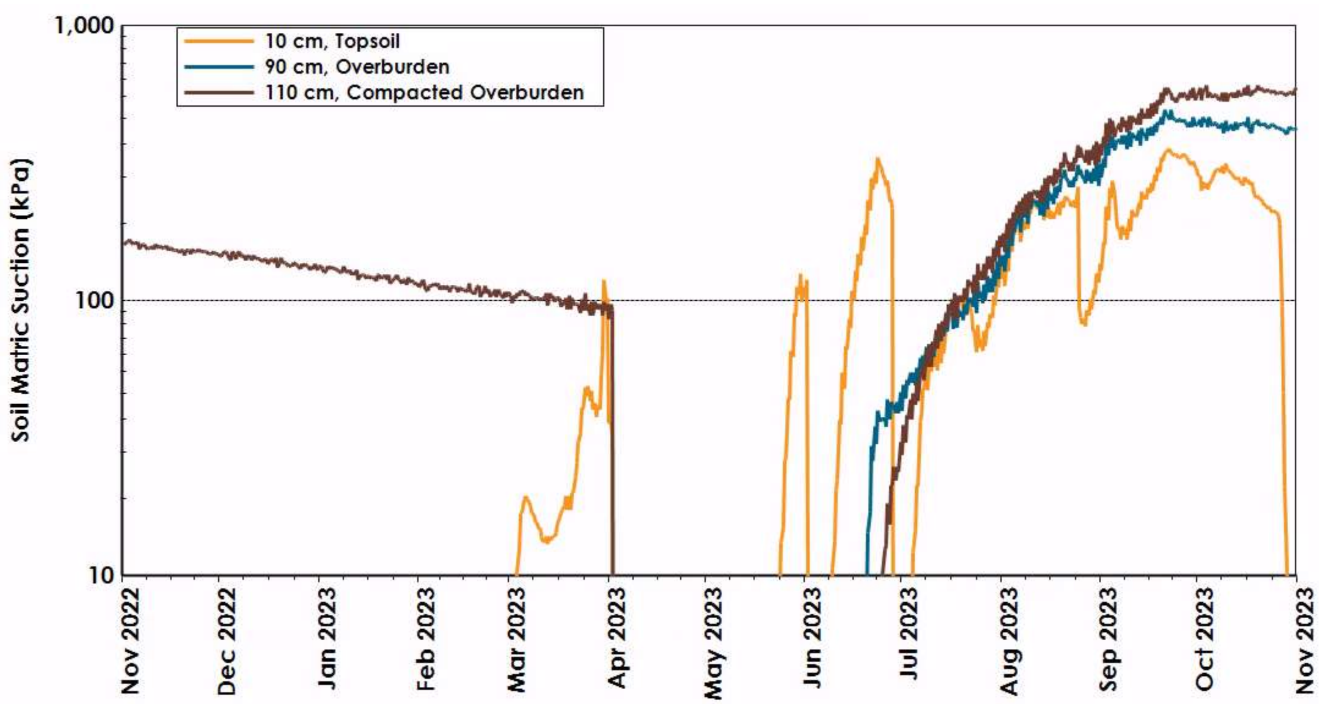

Figure B.6: Suction profile at the Trial #1 secondary station during the monitoring period.

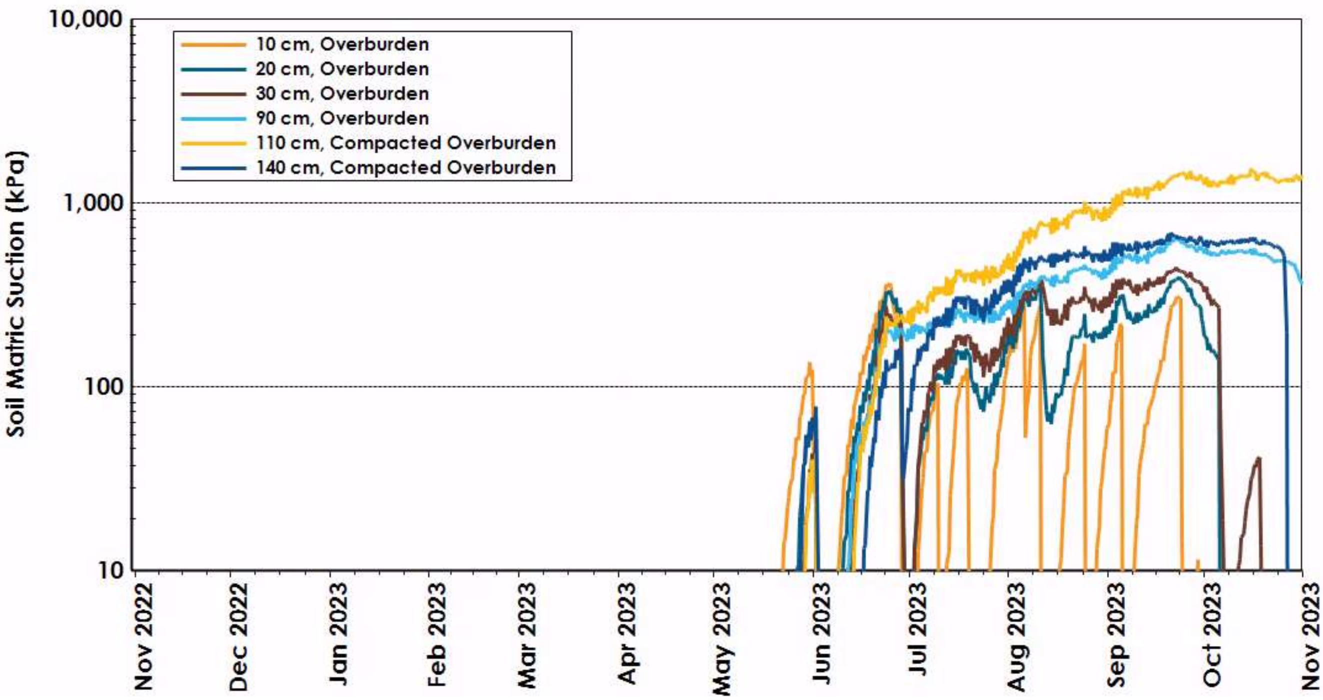

Figure B.7: Suction profile at the Trial #2 primary station during the monitoring period.

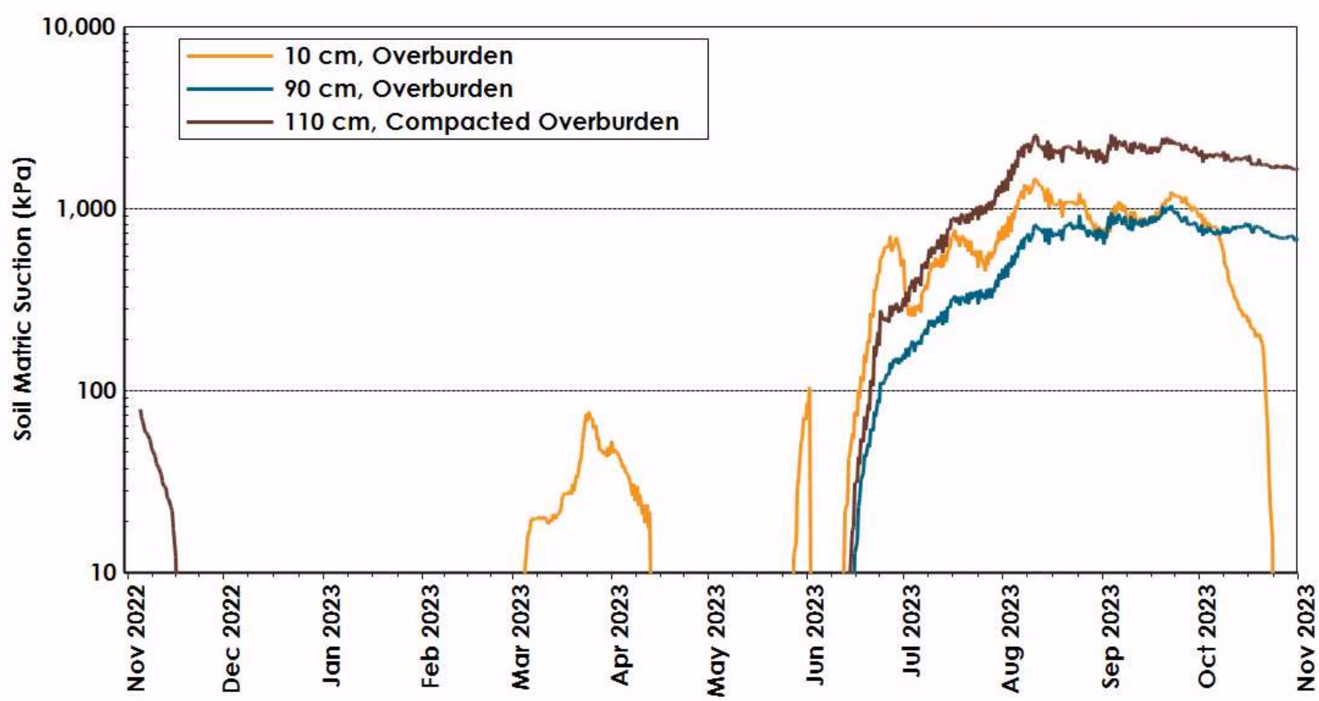

Figure B.8: Suction profile at the Trial #2 secondary station during the monitoring period.

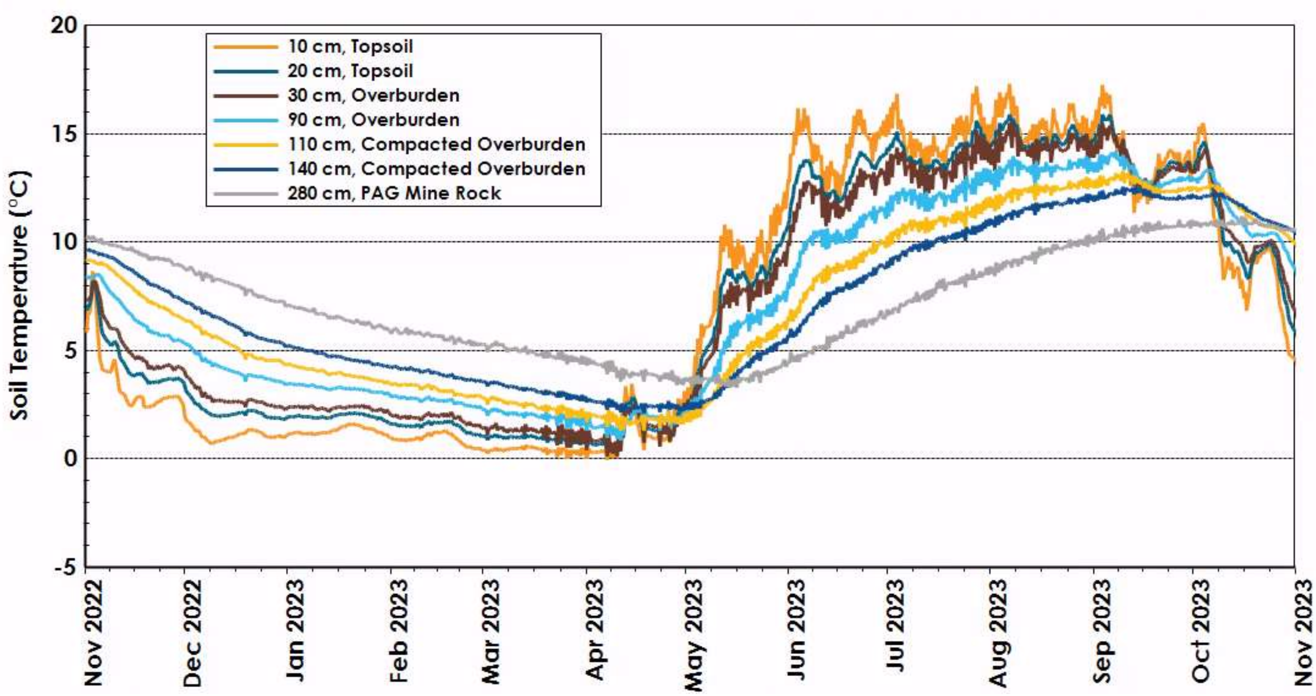

Figure B.9: Temperature profile at the Trial #1 primary station during the monitoring period.

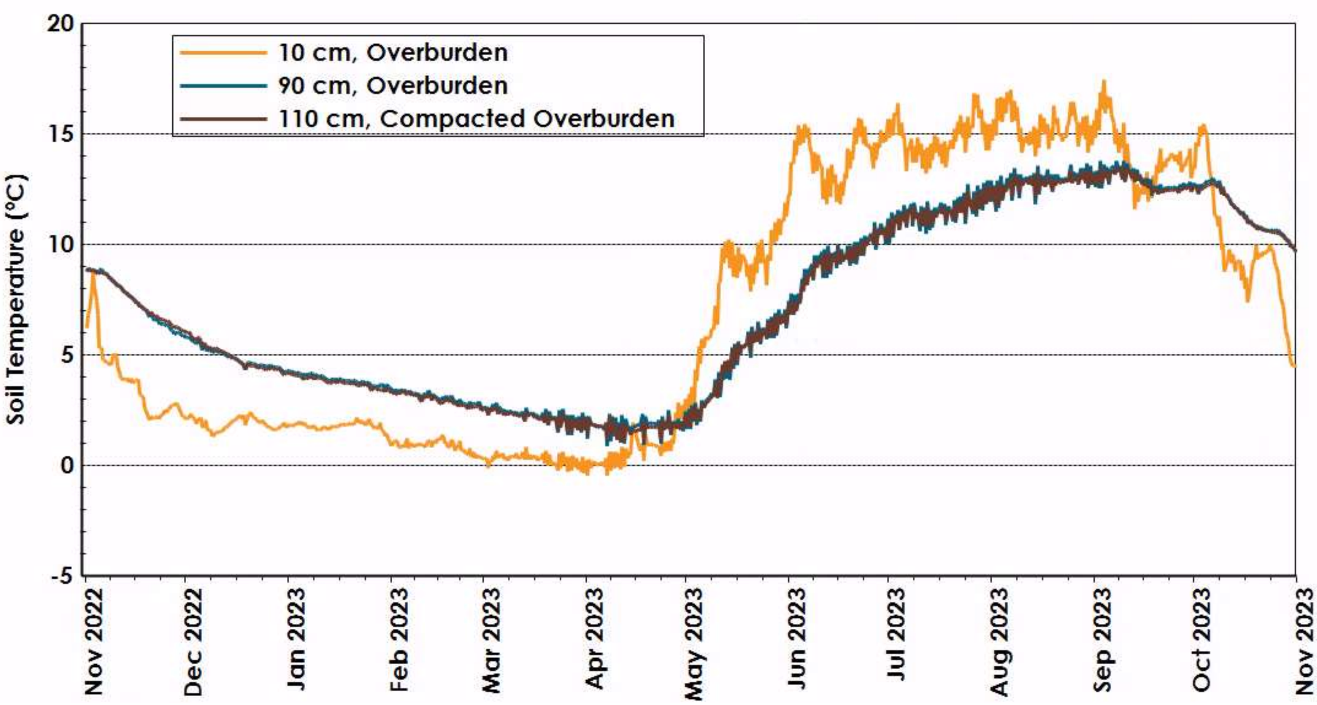

Figure B.10: Temperature profile at the Trial #1 secondary station during the monitoring period.

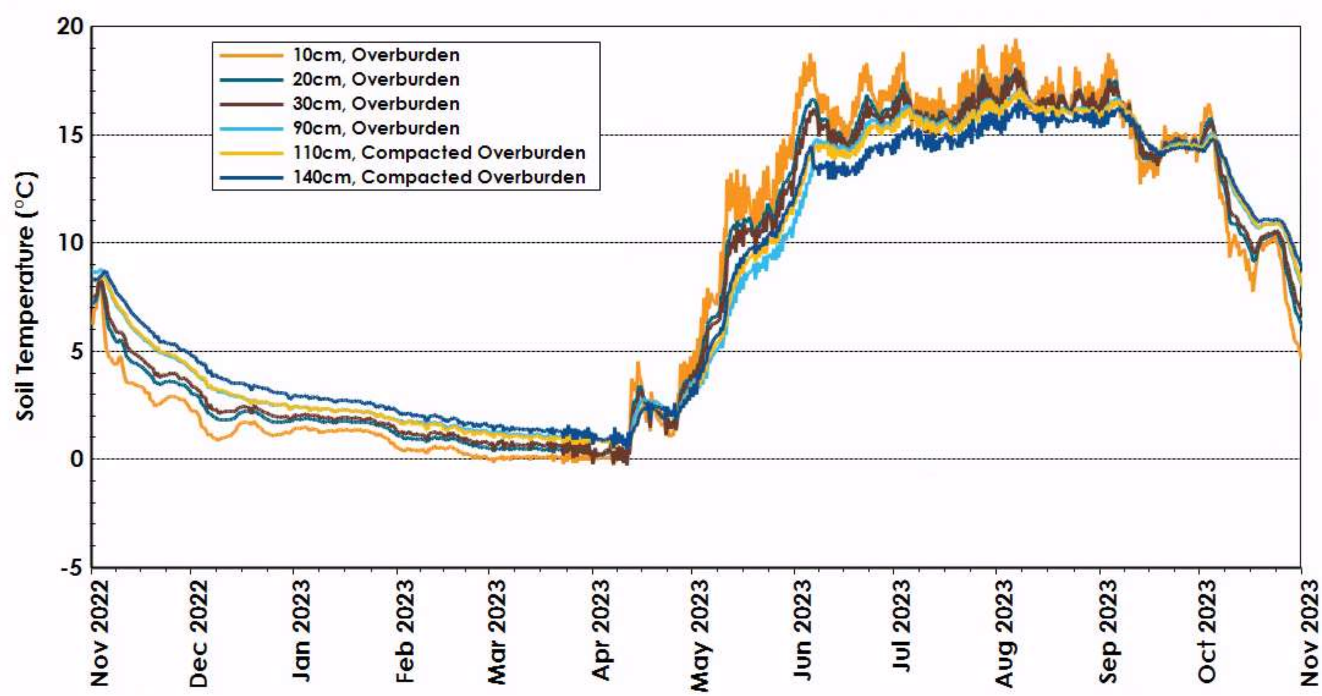

Figure B.11: Temperature profile at the Trial #2 primary station during the monitoring period.

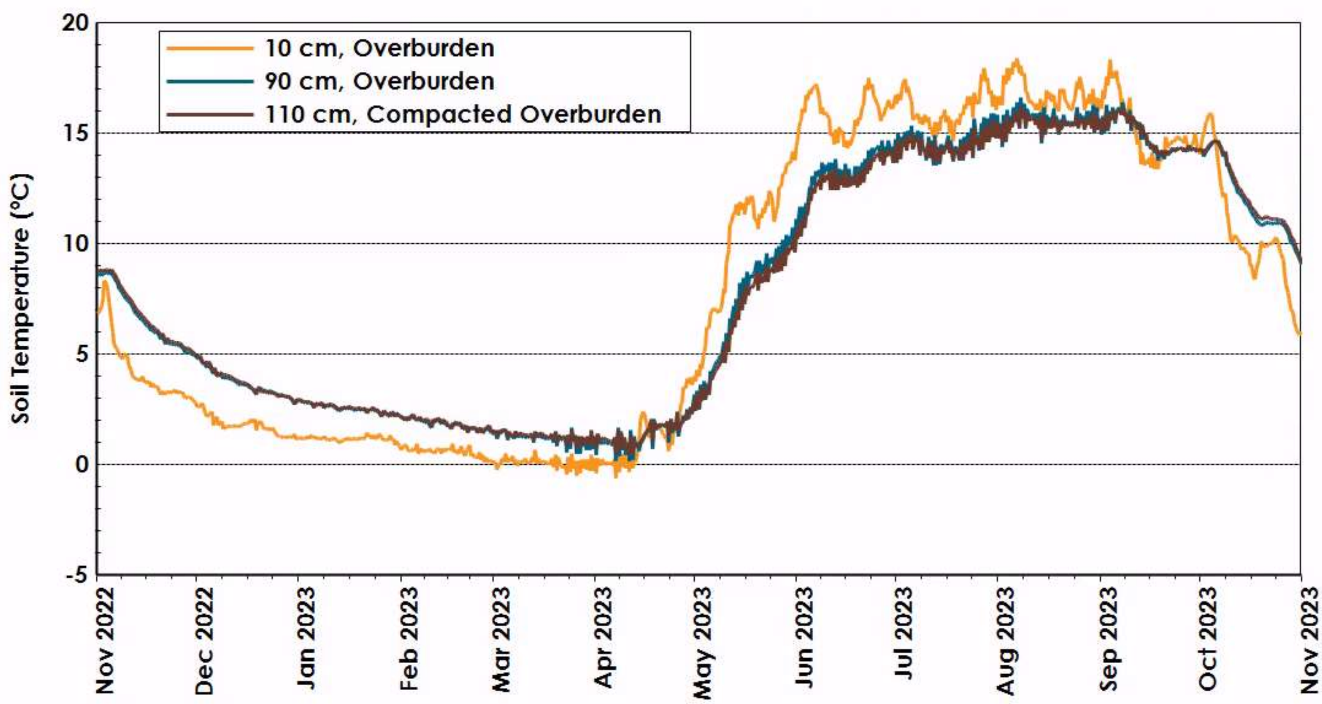

Figure B.12: Temperature profile at the Trial #2 secondary station during the monitoring period.

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