Oyu Tolgoi LLC

Health, Safety, Environment and Communities Management System Procedures

Water Monitoring Plan

TABLE OF CONTENTS

TABLES

FIGURES (compiled at end of report)

APPENDICES

1. INTRODUCTION

1.1 Background

The Oyu Tolgoi (OT) copper-gold project is located in the southeast Gobi region of Mongolia, approximately 50 km north of the China/Mongolia border. Oyu Tolgoi deposit stretches over 12 km, from the Hugo North deposit in the North through the adjacent Hugo South, down to the Southern Oyu deposit and extending to the Heruga deposit in the South. The Southern Oyu deposits will be mined by open pits while the deeper Hugo and Heruga deposits are to be mined using underground block caving.

Oyu Tolgoi is a remote project and extensive infrastructure has been constructed including; water supply borefield (Gunii Hooloi), tailing storage facility (TSF), river diversion, processing facilities, highway link to the Mongolia-China border, regional airport, water treatment facility, housing and support facilities (these areas and the associated water basins and infrastructure are termed the Project Area).

1.2 Document Hierarchy

The Water Resource Management Plan (WRMP) is part of the overall suite of Operations Management Plans developed for OT. The WRMP has overlaps and cross-linkage to several other Management Plans (example Mineral Waste and Biodiversity Management Plans). The water resource management measures will be implemented by means of Procedures that includes this Water Monitoring Plan (WMP). The WMP will provide details on groundwater/surface water monitoring requirements that will be implemented through a series of Standard Work Procedures (SWPs) and Job Hazard Assessments (JHAs).

The initial WMP was produced in 2013 for immediate implementation; with an annual review planned to accommodate any necessary changes and updates. This 2015 update is the result of the first review.

1.3 Water Monitoring Plan objectives

The objectives of the WMP are to meet the water commitments and lender obligations as detailed in the Environmental and Social Action Assessment (ESIA) (OT, 2012), Detailed Environmental Impact Assessment (DEIA) (JEMR Consulting, 2011), and Water Resource Management Plan (Oyu Tolgoi, 2013).

The ESIA commitments have been developed based on the relevant requirements for the International Finance Corporation (IFC) and European Bank for Reconstruction and Development (EBRD), the Equator Principles, plus Mongolian legislation.

Items that are outside the scope of this document include the monitoring of on-site water quality at the bottling plant and effects of groundwater abstraction on fauna and flora. The construction and operational monitoring for the planned power station will be included in later updates of the WMP when this project is defined.

1.4 Structure of the Water Monitoring Plan

The OT monitoring network, including requirement for additional monitoring locations, are discussed for the Project Area separated into discrete target areas. Responses (actions) where a change in data trend is identified (alert) are discussed and outlined.

Standard Working Procedures (SWP) required to complete all groundwater/surface water monitoring task have been updated to ensure all safety and technical aspects have been included and are referenced to in this document. Details for groundwater data management, Quality assurance and quality control (QA/QC) and a strategy for the implementation, schedule, priorities, and training for the monitoring programme are discussed.

1.5 Previous Studies

The hydrogeological and hydrological environment of the Project Area has been subject to a number of complementary and evolving studies by Oyu Tolgoi since 2000. These studies have involved both the physical measurement, assessment of characteristics, and development of a conceptual understanding. Key reference documents for the OT operations are presented in Appendix - A.

2. MONITORING Overview

2.1 Monitoring Network

The WMP is designed to ensure the groundwater and surface water monitoring requirements are met throughout the OT Project Area.

The primary focus of the WMP is monitoring of groundwater and surface water. In addition, a number of associated elements are also included, including pore pressure monitoring around the open pit, photography (i.e. for visual record of springs), stream gauging and culvert inspections.

2.2 Participatory Water Monitoring

A key component of the Participatory Environmental Monitoring (PEM) programme is the Participatory Water Monitoring (PWM) programme, which started formally in mid-2011 with an initial nine herders that has now increased to 26. The PWM aims to involve the local community in environmental monitoring, and to present the environmental activities of the OT Project more clearly to the local community, with the objective of increasing the environmental knowledge of the local community. The herders measure water levels of their own wells with equipment supplied by Oyu Tolgoi, and this data is integrated into the OT monitoring data. The herders involved in the PWM are located in the vicinity of OT, GH and along the OT-GSK infrastructure corridor.

2.3 Water level monitoring frequency

Water level monitoring frequency has been determined based on the sensitivity of monitoring locations, period of baseline data collection, and where relatively rapid changes of water level are anticipated (i.e. alluvial monitoring bores during rainfall/flood events). For example, groundwater level data from Gunii Hooloi water supply production bores is required on a continuous basis (i.e. every 30 seconds) for operational management. In comparison groundwater level data from less sensitive locations or those with long baseline monitoring records (e.g. baseline groundwater level monitoring locations in Galbyn Gobi and along OT-Gashuun Sukhait border transport corridor) is subject to a lower monitoring frequency. Monitoring frequencies recommended in the 2013 WMP have been reduced through review of the data sets at the end of the 2014 period. A continuing annual review will be conducted to ensure that the measurement frequency is appropriate for each monitoring site and adjustment made where required.

Subject to the specified frequency and monitoring site sensitivity, monitoring is conducted using either automated water level measuring devices (i.e. pressure transducers for continuous measurement requirements) or manually (i.e. hand held water level dipper for less frequent monitoring requirements). Where automated devices are used regularly manual measurements will be required, when downloading the data, for calibration purposes. Additional automated recording devices will be purchased during operations.

2.4 Water quality monitoring frequency and analysis suites

Water quality sample analysis requirements vary subject to the monitoring objectives of each location.

The 2013 WMP recommended regular analysis (monthly) for field parameters (pH, Total Dissolved Solid - TDS, Electric Conductivity - EC) to be conducted, with less frequent analysis (quarterly) sampling for standard water quality parameters (i.e. major/minor ions) and tailored analytical requirements targeting potential sources of contamination. The monitoring frequency has been reduced where appropriate through the 2014 review of the data.

The water quality analysis requirements for the project have been divided in four suites and are summarised below:

- Suite 1: General Chemistry and Heavy Metals Analysis
- Suite 2: Hydrocarbons Analysis and the analytes from Suite 1
- Suite 3: Drinking Water Standard Analysis

- Suite 4: Effluent Water Analysis

A comprehensive list of all analytes per suite type is presented in Appendix - B. Mongolian regulatory and international standards have been applied to define the standards. The analysis of all parameters as determined in the 2013 WMP was not achievable due to the limitations of the Mongolian laboratories. This is to be addressed in 2015 with the consideration of international laboratories where feasible.
The specific analysis suite for groundwater and surface water monitoring areas and/or monitoring locations is presented in **Error! Reference source not found.**.

Table 2-1. Water Quality Analysis Requirements

Location	**Water Analysis Requirement**
Groundwater	
Oyu Tolgoi Mine Area	
Mine Camp and Offices Area	Suite 1 (Suite 2 for refueling area)
Waste Management Facility	Suite 1
Heating plant	Suite 1
Airport (international)	Suite 1
Interim landfill	Suite 1
Water Storage Lagoon	Suite 1
Workshop Area	Suite 1 (Suite 2 for refueling area)
Waste Water Treatment Plant	Suite 4
TSF	Suite 1
Active mining Operations	Suite 1
Undai Diversion	Suite 1
OT Regional	Suite 1
Gunii Hooloi Area	Suite 1
Khanbogd Soum	Suite 1 (Suite 3 for water supply bores)
Surface Water	
Settlement pond, sumps, seepage/runoff capture ditches	Suite 1 (and 2 & 4 as required)

2.5 Standardized monitoring location code

A standardized monitoring location code will be adopted to reduce potential confusion relation to monitoring location identification. The standardized code offers the following advantages:

- Reduces likelihood of error where herder wells have two local names;
- Reduces likelihood of error where existing locations have similar names;
- Sample location anonymity prevents bias with data analysis and interpretation.

2.6 Confidence in analytical results

During 2014, the consistency of analytical results between three Mongolian laboratories was tested to confirm the accuracy of the analytical methods and determine the reliability of long term data sets where the chosen laboratory had changed mid-monitoring period. The results have been used to inform the reporting of data sets and record errors in the apparent long term changes.

Duplicate and blank samples are routinely included in each sample batch to confirm reliability of the analyses. Inconsistent samples are re-tested on request. An ion balance analyses and data checks for outlier results are used to confirm the reliability of the data and re-testing is requested where necessary according to the Quality Assurance and Quality Control Project Plan.

2.7 Subsidence monitoring

Subsidence monitoring of the underground mine subsidence zone, buried water supply pipeline (GH to lagoon), break tanks and pump station collection tanks is required to assess changes in ground level induced due to block cave mining and borefield operation.

Datum points are installed and elevation surveyed annually to ascertain if any subsidence has occurred. The subsidence survey data is collected by the mining operations team and supplied to the OT Environmental team.

3. MONITORING REQUIREMENTS

3.1 Introduction

The objectives, rationale, and monitoring requirements for the specific project areas are introduced and discussed in this Section. Details on monitoring location, monitoring frequency, and, where appropriate, laboratory testing requirements are also provided. Where possible, the use of monitoring sites for multiple purposes has been promoted to ensure efficiency. Required actions, where necessary, to ensure an appropriate monitoring network is detailed and example monitoring bore designs provided (Appendix C). Optimal locations of additional monitoring bores will be detailed under separate cover. Monitoring bores that will be removed during the development of the open pit, WRD and TSF have not been included in the monitoring network.

The monitoring areas are:

- Oyu Tolgoi Mine Licence Area: auxiliary infrastructure constructed around the mine licence area not directly related to mining, including the airport and water storage lagoons outside the Mine Licence Area;
- Active Mining Operations, encompassing:
  - Open Pit
  - Underground Operations
  - Waste Rock Dump (WRD);
  - Tailing Storage Facility (TSF);
- Undai Diversion (immediate to mining operations);
- Oyu Tolgoi Regional (including Undai regional, Galbyn Gobi and Main Transport Corridor);
- Gunii Hooloi (GH) Borefield; and
- Khanbogd Soum.

The monitoring to be undertaken in each of these areas is described in detail in the following sections.
The areas identified where monitoring is required are shown on Figure 1 and details of all monitoring locations provided in Appendix D.

3.2 Oyu Tolgoi Mine Licence Area

3.2.1 Objective

To provide detailed monitoring to sufficiently characterise groundwater, surface water, and potential surface water erosion. Data will be used to assess potential environmental impacts and to modify operations as required. Auxiliary operations in the mine area identified as having the potential to impact groundwater and/or surface water include:

- Mine Camp and Office Area (including LV refueling area);
- Workshop Area (including LV/HV refueling area);
- Waste Water treatment plant;
- Airport (international);
- Interim landfill;
- Waste Management Facility;
- Land farm Area;
- Water storage lagoons; and
- Batch plant.

3.2.2 Rationale

Potential for groundwater and surface water impacts associated with the above detailed facilities are minimised through:

- All grey water from the mine facilities is treated at the waste water treatment plant prior to re-entering the water process circuit;

- Storm-water runoff is collected in lined and non-lined settling ponds and recycled for use in mine operations;
- WMF construction to USEPA standards.

Monitoring sites are required to enable early detection of any issues should they occur (i.e. contaminant release from a potentially contaminating facility; change in groundwater level/quality, impact of localised abstraction) and allow actions to be taken as required.
Potential sources of contamination include re-fuel area, workers camp, water storage lagoons, airport, waste management facility (both permanent and temporary), waste water treatment plant, heating plant, batch plants and wash down areas.
The potential for production and movement of gases has also been identified at the WMF with a requirement for monitoring as detailed in the Air Quality Monitoring Report.

3.2.3 Environmental – Groundwater Monitoring

Environmental monitoring will comprise regular groundwater level and quality sampling to assess potential derogation and / or contamination effects on local water users. The location of these facilities and current monitoring bores are shown in Figure - 2. **Error! Reference source not found.** presents planned environmental monitoring requirements with monitor bore details provided in Appendix - D. Provisional locations of additional monitoring bores are also discussed in Section **Error! Reference source not found.**.

Table 3-1. OT Mine Area Groundwater Environmental Monitoring Requirements

Location Id	Location Type	Measurement Type	Measurement Frequency
Mine Camp and Office Area (including LV refueling area)	Monitoring bore	Groundwater Level	Manual Dip: semi-annual Datalogger download: semi-annual
Workshop Area (including LV/HV refueling area)		Groundwater Quality	Field: Annual
Waste Water treatment plant			Laboratory: Annual
Interim landfill			
Airport (international)			
Waste Management Facility (new)			
Land farm area			
Water Storage Lagoon (outside)	Outflow Collection Sump	Water Quality	Field: Semi-annual if water present
		Leakage volume	Semi-annual if water present
Central Heating plant	Production bore	Groundwater Level	Manual Dip: Monthly
		Groundwater Quality	Field: Semi-annual
			Laboratory: Semi-annual
		Abstraction volume	Monthly if operational

3.2.4 Environmental – Surface Water Monitoring

Water collected in the various ponds at site will be sampled and checked to ensure it meets water use criteria for operations. Figure-3 shows the locations of the various surface water ponds around the mine area and they are summarized in the Table 3-2.

Table 3-2. OT Mine Area Surface Water Environmental Monitoring Requirement

Location Id	Location Type	Measurement Type	Measurement Frequency
Batch plant#1 West Pond	Outflow from settlement pond	Water quality	Field parameters: quarterly when water is present and unfrozen

Khaliv South Plonk			Laboratory: annual where water is present or after rainfall event and unfrozen
Grey Water Pond North			
Grey Water Pond Middle			
Grey Water Pond South			
Lagoon West 3			
Lagoon West 4			
Power Camp Pond			
NWMC Evaporation Pond 1			
NWMC Evaporation Pond 2			
NWMC West Plonk			

Note: The Primary Crusher West Side Pond and the Airport Settlement Pond no longer exist and have been removed from the monitoring schedule.

3.2.5 Water Erosion Monitoring

Visual erosion monitoring and photography of culverts is included to provide qualitative identification of potential long-term erosion patterns caused by the modified surface water regime within the mine area. Since completion of installation, major culverts within the mine area are identified for monitoring, and assigned a unique identification number.
The visual inspection and photography of the culverts occurs after every wet season; or more frequently if there is a series of significant flood events in one wet season.

3.2.6 Operational Water Quality Monitoring

According to the OT Water Resource Management Plan, bacteriological and chemical lab analysis should be carried out to ensure safe drinking water quality, water facilities effective operation such as Water Treatment & Bottling Plant, WWTP etc. and raw water circuit water quality and hygiene control. Location and frequencies are showed in the Table 3-3 and 3-4. Sampling location and frequencies are defined by national consultant Eruul zui and Quality control and assurance should be ensured by QA/QC project plan.

Table 3-3. Water quality monitoring – chemical analysis

Location Id	Measurement type	Analysis suite	Measurement/sampling frequency
Bottled water	Water quality – chemical sampling for lab analysis	Suite 3	Monthly
Domestic water			
Raw water			
Water to kitchen			
Manlai 1 WWTP effluent		Suite 4	
Manlai 2 WWTP effluent			
Main WWTP effluent			
Main WWTP influent			

Table 3-4. Water quality/hygiene monitoring – Bacteriological analysis

Location Id	Number of samples	Measurement type	Measurement/sampling frequency
Main mess hall potable water points	7	Total coliform, E-coli (of the suite 3) and Pathogens	Monthly
WTBP water treatment points	4		
OT site water supply points	3		
Manlai camp kitchen potable water points	4		
Bottled water dispensers	2		
Pipeline tap clean water	13		
WWTP effluent water	3		
Road watering truck water	1		
Main WWTP deposit tank	1		
Concentrator process water	1		
Total	**39**		

3.2.7 Required Actions

During the review of the monitoring locations within the OT mine area the following actions have been identified for 2015:

- Establish additional targeted groundwater monitoring sites at waste water treatment plant, refueling areas, interim landfill, airport (international), and landfarm facility (**Error! Reference source not found.**5). Nominal monitoring site locations are presented in Figure 2; and
- Ensure access routes to all surface water monitoring sites are established.

Table 3-5 OT Additional Monitoring Sites Required

Area	Rationale	Action
Re-fueling area (Mine Camp and Workshop Area)	Monitoring for any hydrocarbon leakage into shallow hydrogeological unit	Four (4) monitoring points – two downgradient at each site
Interim landfill	Monitoring for any contaminant leakage into shallow hydrogeological unit	One (1) monitoring point – downgradient in uppermost hydrogeological unit
Landfarm Area	Monitoring for any contaminant leakage into shallow hydrogeological unit	One (1) monitoring point – downgradient in uppermost hydrogeological unit
Waste Water Treatment Plant	Monitoring for any contaminant leakage into shallow hydrogeological unit	Two (2) supplementary monitoring points – each side of the area
Airport (international)	Monitoring water quality discharge into the environment from storm water settling pond and effects on shallow hydrogeological unit system	Water quality at the outflow from the surface water drainage and one (1) monitoring bore installed in shallow hydrogeological unit downgradient

3.3 Active Mining Operations

3.3.1 Objective

To provide detailed monitoring to sufficiently characterise groundwater levels and quality around the active open pit, underground operations; TSF and WRD. Data will be used to assess long term drawdown impacts associated with the active mining operations on groundwater in the surrounding areas. Groundwater monitoring at the WRD and TSF was initiated in 2014 to enable the early detection of any acidic leachate / seepage.

3.3.2 Rationale

The OT open pit was fully operational at the end of 2012; the underground expected to go into production in 2015.

Operation of the open pit will result in generation of a cone of depressurization that will radially extend as the mine expands/deepens. Uncertainty exists regarding the final extent of the cone of depression at the end of mining. Initial modelling, developed for dewatering assessment, conservatively estimated 1m of drawdown up to 10km from the open pit and would pass the Undai Diversion. Planned modelling updates using new data and refined conceptualization will allow improved definition of the anticipated development and extent of drawdown. Ongoing groundwater monitoring will enable refinement of the conceptual understanding and adaptive management where required.

A comprehensive programme of groundwater level and quality monitoring around the mine area is required to further develop the conceptual understanding, update the groundwater model, and identify potential impacts on local groundwater systems resulting from mining operations.
Open pit water inflows will originate from 1) groundwater inflows that report to the pit floor and 2) incidental rainfall falling on the pit slopes and reporting to the pit floor. SWS (2011) recommend in-pit sump pumping system and opportunistic dewatering bores in higher permeability areas to manage mine inflows. The groundwater/surface water removed from the pit will be used for dust suppression. Accurate recording of the quantities of water removed from the pit are important for the establishment of the mine water balance and development of the conceptual understanding.
Outputs from initial numerical groundwater flow modelling of the OT underground indicate that inflows to the active mining zone are likely to be low and are strongly dependent on the rock mass permeability that will develop in the block caving zone and propagation zone above, hydrogeological unit storage parameters, and whether there is any ponded water at surface. The impact of the underground operations on the groundwater system is expected to be minimal due to very low permeability host rock at depth but any inflows should be monitored to ascertain water sources and influx volumes.
The underground cave propagation will result in surface subsidence over the life of mine. Various studies have been completed that delineate the subsidence corridor, which will require regular monitoring of surface elevation to measure subsidence development. Impacts associated with subsidence will be assessed and surface water diversions constructed as necessary.
The WRD will contain material from the open pit that has the potential to generate acidic leachate that may contain heavy metals. Acidic leachate, if generated and uncontrolled has the potential to impact the underlying and down gradient sediments, groundwater and surface water in the Undai River.

The WRD is designed to minimise potential for acid leachate generation through the incorporation of non-acid forming material (NAF) as a cover layer over potential acid forming material (PAF). Seepage from the WRD is anticipated to be minimal due to the arid climate and low infiltration rates. Drainage ditches are recommended around the WRD to capture surface run-off and seepage and a cut-off wall in the alluvial sediments across the Undai down-gradient of the WRD to act as a barrier to any seepage into the alluvium from the base of the WRD. Monitoring of groundwater and surface water around the WRD is required to identify any impacts. Cuttings samples are to be collected from the crusher and the TSF on a monthly frequency and sent for ARD analysis.

The operation of the TSF has the potential to impact water resources through saline and potential acidic leachate released into the underlying hydrogeological unit and run-off from the TSF into the local water courses during a flood event.
The TSF is constructed using an engineered natural clay liner and equipped with a seepage capture ditch to minimize the potential for any impacts to underlying groundwater hydrogeological units. Seepage from the base of the TSF was anticipated, and a potential seepage has been

observed on the south eastern face. Monthly monitoring around the TSF is undertaken to assess any changes in groundwater level or quality associated with potential seepage.
Any surface water flows during flood events in the Dugat River will be passed via a diversion channel, sized to the 1:100 year storm event, around the TSF to ensure both surface flows and large-scale runoff recharge events are preserved in the downstream channel. Flow will re-join the Budaa River downstream of the TSF and will require opportunistic flood water sampling and flow monitoring. Groundwater contained within drainage channel sediments is considered discontinuous having only been identified locally, likely associated with depressions in the underlying Cretaceous clay sequence (KCB, August 2011, document M09300A05). Recharge to these systems is anticipated to be relatively low given the limited catchment area. Although groundwater in the drainage channels is sporadic in nature, monitoring of groundwater level and quality will be conducted up-gradient and down-gradient of the TSF.

3.3.3 Environmental – Groundwater Monitoring

Groundwater monitoring will include monitoring bores targeting the following hydrogeological units:

- River Alluvium
- Cretaceous sediments
- Weathered bedrock
- Fresh bedrock (including faults/intrusions)

Groundwater monitoring in the different hydrogeological units will enable assessment of the influence on, and interaction between, hydrogeological units due to mine operation. A composite water level will be collected where the monitoring bore is screened over more than one hydrogeological unit (i.e. weathered bedrock and bedrock) or is an open exploration hole used to collect water level data. The evaluation of data gathered from composite wells will take this fact into account and, if issues associated with interconnection of hydrogeological units are identified, measures taken to modify the well or install a replacement monitoring site.

In 2011 a number of vibrating wire piezometers (VWP) were installed around the open pit workings targeting various lithological units and structural features (RPS Aquaterra, U25G/025b). The data from the VWP was used as part of a geotechnical assessment and will continue to be monitored during mining operations to assess changes in pore pressure.
Within the open pit, groundwater seepages or inflows are anticipated. These seeps/inflows can provide valuable information on groundwater sources and inflow rates and should be recorded (regular pit inspection to assess nature and extent of inflows obtain photographs and conduct flow estimates).

The underground operations start at over 1110 mbgl and with very little impact on groundwater at this depth expected due to the low permeability host rock. As such no dedicated monitoring network has been installed. Any inflows observed during underground development should be sampled, inflow rates should be measured (e.g. using bucket method) and the duration of inflows recorded. This data will used to refine the underground numerical model.

The underground cave propagation will result in surface subsidence over the life of mine. Various studies have been completed that delineate the subsidence corridor, which will require regular monitoring of surface elevation to measure subsidence development.

Monitoring bores have been installed along the abandoned Undai channel, downstream of the seepage collection pond, and down slope of the southeast section of the WRD to monitor the effectiveness of the cut-off wall. Monitoring bores are also positioned around the WRD targeting the alluvium, weathered bedrock, and bedrock systems for both water level and quality monitoring.

The TSF monitoring bores are targeted to enable early identification of seepage from the TSF as identified by a change in water level or quality. During the TSF assessments (KCB, 2011) a number of monitoring bores were installed within the TSF footprint. Seepage from the TSF will also be assessed using surface geophysics conducted annually along a transect down hydraulic gradient of the facility to identify any emanating saline plumes relative to baseline levels. Monitoring bores in TSF Cell 2 are included in the monitoring network. Prior to Cell 2 becoming operational all bores will be decommissioned. Bores will be replaced external to the TSF where considered necessary based on continuous review of the monitoring data.

Additional VWPs were installed around the TSF in 2014 to monitor changes in pore pressure. Data is collected by the Open Pit Team on a weekly basis and reported to the Water Team.

Error! Reference source not found. summarises environmental groundwater monitoring requirements for the active mining operations with locations presented in Figure 4 and monitoring bore details provided in Appendix-D

Table 3-6. Active Mining Operations Groundwater Environmental Monitoring Requirements

Installation type	Measurement Type	Measurement Frequency
Monitoring Bore (target and composite)	Groundwater Levels	Manual Dip: Quarterly Data Loggers: no logger needed
	Groundwater Quality	Laboratory: no sampling
Vibrating Wire Piezometers	Pore Pressure	TSF: Weekly download
		Open Pit: Semi-annual download
Backup Production Wells	Pumping water level	Monthly
	Groundwater Quality	Field: semi-annual
		Laboratory: semi-annual
	Abstraction volumes (Flow meter reading)	Daily recording of abstraction Monthly collection of data
Open Pit – seeps and inflows	Inflow rates and duration	Monthly / as required
	Water Quality	Monthly
	Observations and survey locations	If required
Underground seeps and inflows	Inflow rates and duration	Monthly / as required
	Water Quality	Quarterly
	Observations and survey locations	If required
Surface footprint of Underground working	Subsidence Survey Monitoring	Annual
Down-gradient TSF	Surface geophysics transect	Annual

3.3.4 Environmental – Surface Water Monitoring

Any storm water run-off, direct precipitation, or groundwater seeps/inflows experienced during the excavation of the pit will be directed to the sump established at the bottom of the pit. Accurate recording of the quantities of water removed from the pit are important for the establishment of the mine water balance. Water quality monitoring will also be completed from any sumps with the pit regularly to ensure its suitability for dust suppression.

Surface water run-off from the WRD is captured by drainage ditches and directed towards a collection basin on the south side. It is anticipated that flow will occur only following large rainfall events. Water is directed from the collection basin to the TSF to be used in the process water circuit.

Water samples will be collected for quality analysis from the collection basin (refer to **Error! Reference source not found.**).
Surface water runoff and seepage from the TSF will be recycled back into the process water circuit; water quality monitoring will be conducted regularly to ensure suitability. Additional monitoring of any seasonal flows in the Dugat river upstream/downstream of the TSF will be conducted.

The surface water ponding to the east of the TSF will be photographed and samples taken for water quality analysis to determine the source of the water and any long term changes. Two v-notches are installed for flow measurements; field water quality parameters will also be measured. The TSF monitoring will be conducted at monthly intervals unless the monitoring suggests the situation is stabilized or changing.

The active mining operations surface water environmental monitoring requirement are summarized in **Error! Reference source not found.** and shown in Figure 5.

Table 3-7. Active Mining Operations Surface Water Environmental Monitoring Requirement

Location Id	Location Type	Measurement Type	Measurement Frequency
Surface run-off waters	Surface run-off ponds	Water Quality	During rainfall events – Field and Laboratory analysis
Shaft Settling Ponds (x3)	Ponds	Groundwater Quality	Field: Quarterly Laboratory: Annual
Box Cut	Pit	Groundwater Quality	Field: Quarterly Laboratory: Annual
In-pit Sump	Open pit	Groundwater Quality	Field: Monthly
In-pit Sump	Open pit	Abstraction volumes	Monthly
TSF	Seepage/run-off capture ditches	Water Quality	During rainfall events – Field and Laboratory analysis
TSF	Ponding to east	Water Quality Photographs	Quarterly
	Surface water diversion	Flow measurement	During rainfall events when flow occurs
WRD	Southern Collector pond	Water Quality	During rainfall events – Field and Laboratory analysis
ARD	TSF	Tailing sample for lab analysis	Monthly
Undai Diversion	Culvert	Flow measurement	Flowmeter: monthly download
	New Bor Ovoo spring		V-notch: monthly when not frozen
Undai Diversion	New Bor Ovoo spring	Water Quality	Monthly
Dugat River within mine lease area	Flood occurrence	Observations (including duration and extent), photographs, flow measurement, water quality	During rainfall events when flow occurs

3.3.5 Required actions

Additional monitoring (two sites) is required in the weathered bedrock and bedrock between the open pit and the Undai to the north of the diversion to provide data on the radial extent of drawdown associated with the open pit mine.

A further six installations targeting alluvium or weathered bedrock will be installed at key locations along drainage channels prior to and after confluences and proximal to the mine area.

As the open pit progresses it is anticipated that a number of the VWPs will be destroyed reducing the ability to measure pore pressure. Guidance from the OT Geotechnical team will be required to determine if replacement VWP installations are required. Alternatively, when possible the reinstatement of VWPs can be investigated after blasting has occurred.

The option to install temporary in-pit monitoring points (probe holes) on the lower benches or pit floor should be investigated. The “probe holes” could provide useful near face water level data in the open pit.

When the northern TSF cell is developed several monitor bores will be destroyed. Monitoring locations around the TSF will be evaluated as and when bores are removed to determine if and where replacements are required.

Two clustered monitoring bores (targeting alluvium and Cretaceous, and; alluvium and weathered bedrock strata) on the Dugat River upstream and downstream of the TSF surface water diversion are required as detailed in Table 3-8.

Nominal locations for groundwater monitoring sites are presented in Figure 4; final locations will be determined following ground-truthing of sites.

Additional seepage monitoring controls will be implemented for the TSF and will comprise:

- Surface geophysics survey along a transect down-gradient of the TSF to determine “baseline” electrical conductance prior to TSF operation.
- Annual repeats of the surface geophysics survey along same transect to assess for changes in conductance; and

During the baseline survey installing monitoring wells to ground-truth surface geophysics results (where current installations can’t be used). Table 3-8. Shallow River Alluvial Monitoring Bore Requirements Upstream and Downstream TSF

Area	Target	Number
Northwest of open pit	Clustered monitoring points targeting weathered bedrock and bedrock strata	2
Drainage channels	Monitoring points targeting alluvial or weathered bedrock strata	6
Dugat River (Upstream and downstream of TSF)	Clustered monitoring points targeting alluvial/Cretaceous (up gradient) and alluvial/weathered bedrock (down gradient)	2

3.4 Undai Diversion

3.4.1 Objectives

To provide monitoring to sufficiently characterise groundwater and surface water flows upstream, along and downstream of the Undai Diversion and identify any impacts resultant from the diversion or mining operations on nearby springs and herder wells.

3.4.2 Rationale

The Undai River, the most significant and sensitive ephemeral watercourses within the Project Area, has been diverted as the open pit excavation extends into the Undai flood plain and the WRD covers part of the river course.

The diversion comprises diversion of surface water, when flowing, into the adjacent ‘Western Channel’ (or Nuur Tsankhi) watercourse which flows into the Khuren Tolgoi River and rejoins the original channel to the south of the WRD (Figure 6). Groundwater within the alluvial hydrogeological unit associated with the Undai River is collected at a diversion positioned to the north of the WRD and transported along a pipe before being returned to the alluvial hydrogeological unit to the south of the WRD. The returned water is used, in part, to establish a permanent surface water source to replace the original Bor Ovoo spring that is to be covered by the WRD. The replacement water source aims to replicate the size, nature, water quality and availability of the Bor Ovoo spring.

Ensuring that groundwater and surface water flows are maintained downstream of the mine licence area and do not impact the springs, herder wells, local fauna or flora are a key commitment for OT. To enable assessment of this, monitoring of groundwater level and quality, surface water flows and quality, and flux through the diversion system will be conducted.

Flood events in the Undai will result in the geometry of the Western Channel evolving to accommodate the increased flows and developing a natural sedimentation and erosion regime along the diversion. Monitoring will be conducted to ensure that the diversion performs to specifications and there are no issues with regard erosion or sedimentation.

3.4.3 Environmental – Groundwater Monitoring

Groundwater level and quality will be measured in monitoring bores completed in the alluvial, weathered bedrock, and bedrock hydrogeological units both upstream and downstream of the diversion (Figure 6 and **Error! Reference source not found.**). A number of nested piezometers have been installed that target these individual hydrogeological units at the same location. The groundwater flux is measured in the diversion pipe using a flow meter and the discharge volume at the Bor Ovoo Replacement spring is measured using 2 v-notch weirs.

Groundwater flow in the diversion pipe is measured continuously using an automated system. Data collected for a two year (between 2013 and 2015) period was assessed to determine the appropriate frequency for long-term monitoring and to identify appropriate alert and action levels. In-pipe and spring flow data will be collected in conjunction with 1) adjacent piezometer water level measurements, 2)water levels further upstream and downstream, and 3) flood and rainfall records to determine efficiency of the cut-off and diversion in terms of diverting all sub-surface flow.

Springs along the Undai will be photographed and water depth and area measured as part of the routine condition survey; water samples will also be collected for quality analysis.

Springs as identified in Table 3-9 will be photographed within the first week of every month. The photographs will be taken from the identified reference point (to be clearly identified in the field) and directed to the centre of the spring, which will also be identified in the field. This identification consists of a concrete monument with a labelled reference point and direction for photographs. Depth and area of water available at each spring will also be recorded each month. The depth of water will be measured either using a graduated stationary reference point of by submerging a graduated pole into the deepest part of the spring. The area will be estimated combining visual observations and pace. Further, qualitative assessments will be made at each spring location relative to the amount of water available. The definitions of the terms to be used for this assessment are also presented in the Water Monitoring Plan. Other descriptive information may be obtained at each site, but the referenced photograph, depth and area estimates and the qualitative descriptor of available water will be the minimum monthly information collected.

Details of the monitoring bores are provided in Appendix D.

Table 3-9. Undai Diversion Environmental Groundwater Monitoring Requirements

Installation Type	Measurement Type	Measurement Frequency
Herder wells	Water Level	Monthly
	Groundwater Quality	Field: Quarterly
		Laboratory: Annually
Khukh khad, Buural, Maanit and Budagt (springs)	Groundwater Quality	Field: Quarterly
		Laboratory: Annually
	Photographs	Monthly

Installation Type	Measurement Type	Measurement Frequency
Bor Ovoo Replacement spring	Groundwater Quality	Laboratory: Monthly
Surface flow at Bor Ovoo Replacement spring	Groundwater Quality	Field: Monthly (from both start and end point of the surface water flow)
Monitoring Bores (target and composite): URD-11, OTMB11-45, OTMB15-76 and OTMB11-22	Groundwater Levels	Manual Dip: Monthly / semi-annual Data Loggers: semi-annual
	Groundwater Quality	Field: Quarterly
		Laboratory: Quarterly
Undai Diversion pipe (upstream and Bor Ovoo Replacement spring downstream)	Flow rate	Monthly download and field reading
Drive points in Undai riverbed	Groundwater level	Monthly

3.4.4 Environmental - Surface Water Monitoring

Adoption of water level measurements made in existing (and planned) alluvial monitoring bores, each installed with pressure transducers, as proxy flood observation points, will provide a fixed, well-positioned and automated system with capacity to register flood occurrence and extent, relative magnitude of events and, additionally, influence on local groundwater levels.

Piezometry data will be supplemented with observations and measurements to be made during the flood event at or near the flood observation points (Figure 6).

At each flood observation point, a surveying transect will be completed each spring to identify the elevation profile across the channel. Further, a permanent flood monitoring device (graduated at least to the 0.2 meter) that will allow visual observations/recordings from a distance will be installed at each location identified in Figure 6 of the Water Monitoring Plan. These locations will be monitored regularly (no less than every two hours during daylight) during periods of sustained or substantial rainfall, or any other time when surface water is observed or suspected. In addition to noting the depth of water, estimates of velocity will be obtained using a float tethered to a rope.
Such measurements will be made at least five times per location per visit in attempt to estimate the average velocity across the width of the stream in m/s. The depth of water will be used along with the pre-measured cross sectional profile and estimates of flow rates to provide a first order estimate of discharge volumes in the streams. In addition to the information mentioned above, observations and measurements related to flood duration and extent will be made. Photographs are to be taken from fixed positions to enable direct comparison of events.

Local and regional sustained rainfall events will be used as a general guide to prepare for rapid deployment to conduct flood measurements/observations in order to maximise the number of sites where flow measurements are made (although it should be recognised that floods can result from rainfall higher in the catchment). Where a flood is identified observations will be made at that site as soon as possible. Other sites in the area will also be visited to see and record if flooding has occurred.

Combined analysis of groundwater level responses associated with flood flows and rainfall will be conducted as part of the annual environmental assessment and reporting to improve understanding of the recharge processes along drainage channels. Rainfall data, flood observations (i.e. occurrence, time, depth, duration, extent, flow rates) and recharge to the alluvial hydrogeological unit (i.e. time, magnitude of change, rate of response, event period) will be compared to, and where possible, calibrated against each other.

3.4.5 Water Erosion Monitoring

Erosion and sedimentation affecting the diversion, springs, or herder wells located downstream in the Undai River will be monitored for any impacts to the local water resources. **Error! Reference source not found.** provides Undai diversion water erosion monitoring requirements.

Table 3-10. Undai Diversion Water Erosion Monitoring Requirements

Location Id	Location Type	Measurement Type	Measurement Frequency
Western Channel (upstream, middle and downsteam)	Diversion channel	Visual inspection and photography	Annual
Undai downstream of diversion	Undai River	Visual inspection and photography	Annual
Khukh Khad, Buural, Maanit and Budagt	Spring	Visual inspection and photography	Annual
Herder wells	Herder wells	Well condition inspection	Annual

3.4.6 Required Actions

Undai River surface flow will be diverted into the Western Creek. The diversion will be engineered to include a stream flow gauge to enable volumetric assessment of Undai flow during rainfall events. Flood measuring boards will be placed at identified flood monitoring locations to allow assessment of peak flows and extent of flooding. A survey of the drainage cross-section at each flood monitoring site is to be conducted and updated on an annual basis. Additional monitoring bores will be installed in the Undai channel as detailed in Section 3.3.5.

In addition, the lenders and auditors recommendations as described below are implemented in summer of 2015, including:

- installation of new water level monitoring points, covering the full width of the profile of the alluvial strip aquifer immediately down-gradient of the outfall bore and in the vicinity of monitoring bore OTMB11-45. Depth to bedrock would be established at each monitoring point across the profile to enable definition of alluvial thickness;
- installation and monitoring of two additional alluvial monitoring bores between the southern cut-off dam and Khukh Khad spring;

installation of drive point or equivalent water level monitoring bores immediately above the confluence of the Undai and Brown Hill Rivers (one each on each braid of the Undai River at this location);

3.5 OT Regional

3.5.1 Objectives

To provide improved understanding of the regional hydrogeological regime, connectivity of identified units, seasonal groundwater recharge and discharge, and enable updates to the regional numerical groundwater flow model for improved mine dewatering impact predictions.

3.5.2 Rationale

A regional monitoring network (outside the mine lease and includes the OT-GSK road alignment and Galbyn Gobi area) has been developed by OT over many phases of investigation comprising herder wells, targeted monitoring bores, water supply exploration bores, and springs.

The monitoring network has allowed development of a baseline data set for river/spring water quality, and groundwater level and quality in identified hydrogeological units.

Continued monitoring during operations is required to identify any impacts associated with mining and to improve understanding of the site and regional hydrogeological regime.

3.5.3 Environmental – Groundwater Monitoring

The regional groundwater monitoring network comprises monitoring bores, production bores, herder wells, and springs (Figure 7). This includes herder wells that are part of the PWM, which will be monitored by the local community. The data will be obtained from the community and incorporated into the monitoring data for the regional area.
The monitoring requirements for the OT regional area are provided in **Error! Reference source not found.**, with details provided in Appendix - D.

Table 3-11. OT Regional Environmental Groundwater Monitoring Requirements

Installation Type	Measurement Type	Measurement Frequency
Herder wells	Water Level	Daily(PWM Herder) /Monthly (OT all herder wells)
	Groundwater Quality	Field: Quarterly
		Laboratory: Annual
Spring (Dundangiin us, and Khar khad)	Groundwater Quality	Field: Quarterly
		Laboratory: Annual
	Photographs/ depth and area measurement	Monthly / Quarterly
Monitoring bores (target and composite)	Groundwater Level	Manual Dip: Quarterly*
	Groundwater Quality	Laboratory: no sampling
Production Bores	Groundwater Level	Manual Dip: Monthly
	Groundwater Quality	Field: Semi-annual
		Laboratory: Semi-annual
	Abstraction volumes (Flow meter reading)	Monthly

*Note: Quarterly groundwater monitoring of monitoring bores along OT-GSK road alignment

3.5.4 Environmental - Surface Water Monitoring

Surface water flows in the regional river systems should be recorded where practical. It is not considered possible to record every regional flood event due to the intermittent nature and extent of flood events, and some measurements will be opportunistic and associated with other field works. Assessment of associated groundwater data (water levels) will be used in support of identifying flooding occurrence and extent.

The OT regional environmental surface water monitoring requirements are summarised in **Error! Reference source not found.**.

Table 3-3. OT Regional Environmental Surface Water Monitoring Requirements

Location Id	Location Type	Measurement Type	Measurement Frequency
Regional Rivers (Khuren Tolgoi, Ulziit, Undai, Dugat, and Budaa River)	Flood occurrence	Observations, photographs, flow measurement	During rainfall events when flow occurs

3.5.5 Water Erosion Monitoring

The OT-GSK road will cross several ephemeral rivers with a culvert installed at each crossing. A total of 129 culverts will be installed along the length of the road. Visual inspection and photographs should be taken of major culverts to provide qualitative assessment of erosion caused by the road construction. Additionally, herder well condition surveys will be conducted annually to check for any deleterious impacts from erosion and sedimentation.

3.5.6 Required Actions

No actions are required at this stage.

3.6 Gunii Hooloi Borefield

3.6.1 Objective

To collect adequate water level and water quality data sufficient to enable effective operational borefield management and assessment of potential environmental effects (changes to water quality or derogation of local water supplies).

3.6.2 Rationale

The Gunii Hooloi Borefield was installed during 2011/2012 and will provide an average supply of 696 L/s to the mine site.
Production bore discharge volumes, dynamic water levels (in production bores, monitoring bores and herder wells), and water quality data will be collected and used for;

- Borefield operational assessment.
- Assessment of potential impacts on local groundwater sources and users; and
- Improvement of conceptual understanding (interconnection between hydrogeological units).

3.6.3 Environmental – Groundwater Monitoring

The groundwater monitoring comprises regular water level monitoring at designated production bores, targeted monitoring bores, and Herder wells, including those monitored as part of the Participatory Water Monitoring programme. The discharge volume and flow rate data for each production bore is collected.
GH monitoring requirements are summarised in the **Error! Reference source not found.**3, with monitoring bore details provided in Appendix - D and the monitoring network shown in Figure 8 and Figure 9.

Table 3-43. Gunii Hooloi Borefield Environmental Groundwater Monitoring Requirements

Installation Type	Measurement Type	Measurement Frequency
Herder wells	Groundwater Level	Fortnightly (PWM Herder) /Monthly (OT all herder wells)
	Groundwater Quality	Field: Quarterly
		Laboratory: Annual
Monitoring Bore	Groundwater Level	Manual Dip: Semi-annual Data Loggers: Semi-annual / annual
	Groundwater Quality	Laboratory: no sampling
Production bores	Groundwater Level	Manual Dip :Monthly Data Logger (bubble meter): 1 hour – connected to site telemetry system
	Groundwater Quality	Field: Semi-annual
		Laboratory: Semi-annual
	Discharge volumes and flow rates	Manual: Monthly DCS: Upload monthly into DataSight for site water balance

3.6.4 Environmental – Surface Water Monitoring

Installation of permanent flood gauging is not considered to be a practical or reliable option given the intermittent nature and spatial variability of surface water flow and the braided nature of the drainage channels. Adoption of water level measurements made in alluvial monitoring bores, each installed with pressure transducers, as proxy flood observation points will provide a fixed, well positioned automated system with capacity to register flood occurrence and extent, relative magnitude of events and, additionally, influence on local groundwater levels. This will provide a robust and simple flood monitoring system that will automatically collect data for all flood events.

Piezometry data will be supplemented with observations and measurements to be made during the flood event at or near the flood observation points (Figure 9). Observations and measurements to be recorded are:

- Flood duration and extent;
- Depth of the flood flow (from a fixed flood gauge board); and
- Flow measurements, where these can be conducted safely.

Photographs are to be taken from fixed positions during flood events to enable direct comparison of events. The drainage channel cross section will be surveyed annually at each fixed flood monitoring site.

Local and regional sustained rainfall events will be used as a general guide to prepare for rapid deployment to conduct flood measurements/observations in order to maximise the number of sites where flow measurements are made (although it should be recognised that floods can result from rainfall higher in the catchment). Where a flood is identified observations will be made at that site as soon as possible. Other sites in the area will also be visited to see and record if flooding has occurred. Each site will be revisited on a daily basis until flood(s) have disappeared.

Combined analysis of groundwater level responses associated with flood flows and rainfall will be conducted as part of the annual environmental assessment and reporting to improve understanding of the recharge processes along drainage channels.

Rainfall data, flood observations (i.e. occurrence, time, depth, duration, extent, flow rates) and recharge to the alluvial hydrogeological unit (i.e. time, magnitude of change, rate of response, event period) will be compared to, and where possible, calibrated against each other.

Table 3-5 Gunii Hooloi Borefield Environmental Surface Water Monitoring Requirements

Location Id	Location Type	Measurement Type	Measurement Frequency
Gunii Hooloi drainage channels	Flood Occurrence	Observations, photographs, flow measurement	During rainfall events when flow occurs

3.6.5 Water Erosion Monitoring

The road leading out to the Gunii Hooloi bore field crosses several watercourse and visual inspection and photography of the major culverts installed will occur annually after each wet season. A herder well condition survey will be completed annually to check for significant erosion and sedimentation around the wells that could be associated with change in surface water flow patterns due to the culverts.

3.6.6 Surface Subsidence

Subsidence monitoring through elevation surveys are completed annually by mine operations along the main pipeline and pump station to assess settlement and compare to predictions (**Error! Reference source not found.**5).

Table 3-65. Gunii Hooloi Subsidence Monitoring Requirements

Location Id	Measurement Type	Measurement Frequency
Main pipeline and pump stations	Subsidence Survey Monitoring	Annual

3.6.7 Required Actions

The production bores are connected to a Distributed Control System which collects data every 30 seconds and is stored in a database. Data captured is the instantaneous pumping water level and the flow meter reading. This data, or a reduced dataset, will require collation and incorporation into the monitoring programme.

In the 2012 GH Field programme a number of bores were recommended for rehabilitation to i) reduce the potential for flows between different hydrogeological units and to ii) complete the operational monitoring network.

Regulatory approval was granted for decommissioning of the bores by cement grouting not conversion to monitoring bores. Three (3) bores have been successfully decommissioned and decommissioning of the remaining bores will be conducted following Soum approval for the works. An additional seven (7) monitoring bores will be installed to provide adequate spatial coverage of monitoring in the Gunii Hooloi borefield area as shown in Figure 8 and detailed in Table 3-16.

The Biodiversity Assessment (Sustainability East Asia LLC, 2013) identified the need for additional monitoring sites (recommended two sites – pers. comm., John Miragliotta, April 2013) in elm and saxhaul areas away from drainage channels as detailed in Table 3-16 and Figure 9.
Two alluvial monitoring bores and associated flood gauge boards will be located in the main drainage channel (Figure 9) for flood monitoring.

Table 3-76. Gunii Hooloi Monitoring Bore Requirements

Target	Number
Gunii Hooloi aquifer system (nested targeting Gunii Hooloi aquifer, aquitard, and shallow aquifer)	7
Elm/ Saxhual area (shallow)	2
Alluvial unit associated with main drainage channels	2

3.7 Khanbogd Soum

3.7.1 Objective

To ensure water quality and water supply are not impacted by development of Khanbogd Soum centre and that abstraction does not impact on sensitive receptors (i.e. Soum shallow wells or springs).

3.7.2 Rationale

At the time of writing the 2013 WMP the Khanbogd Soum water supply was provided from a mixture of private and public bores completed in shallow sediments with very little groundwater level or quality monitoring. Khanbogd is in the process of expansion and rapid population growth due to an influx of mine workers. The population of the town is expected to reach 10,000 by mid-2013. As such OT has committed to the augmentation of the current water supply by the installation of new production bores with a potential to supply water at 20 L/s targeted.

The water supply bores and complementing monitoring network is completed and monitoring is required to assess impacts to the production bores from the local developments as well as to monitor any impacts of water abstraction on the local hydrogeological system.

3.7.3 Environmental – Groundwater Monitoring and Surface Water Monitoring

Monitoring wells targeting shallow and deep aquifer horizons are installed and will comprise the primary monitoring network. Additionally, composite wells, installed as part of previous work programmes, and herder wells will be monitored to ensure spatial coverage.

Three springs on the flanks of the Khanbogd Massif will also need to be monitored to check for any impacts associated with abstraction.
The groundwater monitoring requirements are summarised in **Error! Reference source not found.**7 (detailed in Appendix - D) and presented in Figure 10.

Table 3-8. Khanbogd Soum Environmental Groundwater Monitoring Requirements

Installation Type	Measurement Type	Measurement Frequency
Herder wells	Groundwater Level	Monthly
	Groundwater Quality	Annual
Springs (Ikh Bulag, Baga Bulag and Tsagaan Tolgoi)	Groundwater Quality	Field: Quarterly
		Laboratory: Annual
	Photographs	Monthly/ Quarterly
Monitoring bore	Groundwater Level	Semi-annual/ logger install
	Groundwater Quality	Laboratory: no sampling
Production bore	Groundwater Level	Manual Dip :Monthly
	Groundwater Quality	Field: Semi-annual
		Laboratory: Semi-annual
	Discharge volumes and flow rates	Manual: Monthly

3.8 Weather Stations

3.8.1 Objective

The collection of accurate and regular meteorological data including rainfall data in regional areas.

3.8.2 Rationale

Meteorological data will be used as a basis for reference when analysing / interpreting monitoring results from the project area and regionally.

3.8.3 Monitoring Requirements

Due to the localised nature of the rainfall events across the area, rainfall measurements are necessary across the OT and GH catchments. Multi-parameter weather stations are currently established at the OT mine site, OT airstrip and Khanbogd Soum (Government system); additional rainfall data is available for Tsogttsetsii, Manlai and Bayan Ovoo soum centres. Additional rain gauges have been installed by OT at Big Ger, and Gunii Hooloi (2no.). An existing rain gauge at South Camp is to be relocated as the camp is dismantled.
Ongoing monitoring requirements are summarised in **Error! Reference source not found.**7 and shown in Figure 11.

Table 3-98. Weather Station Monitoring Requirements

Location Id	Location Type	Measurement Type	Measurement Frequency
OT mine site and OT Airstrip	Multi-parameter weather station	Rainfall, Temperature, Relative Humidity, Wind speed/Direction, Solar radiation	Daily
Khanbogd Soum	Multi-parameter weather station	Rainfall, Temperature, Relative Humidity, Wind speed/Direction, Solar radiation	Daily data purchased at the end of each year
OT minesite	Pan	Sublimation	Winter: Daily
OT and GH catchments	Rainfall gauge	Rainfall	Automatic records downloaded annual Operational only March to

Location Id	Location Type	Measurement Type	Measurement Frequency
			October

3.8.4 Required Actions

It has not been possible to implement the 2013 WMP recommendations for the installation of 10 additional weather stations due to the necessary security arrangements. Therefore some amendments to the planned locations are proposed. Additional regional rain gauges are recommended to be purchased for the OT catchments and be installed in 2015. It is suggested that a further 4 rainfall measurement devices be located in the Bag centres (Gavilud, Nomgon, Bayan and Javkhlant).

4. STANDARD WORK PROCEDURES (SWP)

Standard Work Procedures (SWP) have been developed that detail all relevant HSE aspects (hazard and risk identification, control measures), equipment requirement and detailed steps for completing the task. Any personnel completing groundwater monitoring must be familiar with the task specific SWP and use the documents as reference guides.
Regular reviews and updates of the SWP should be completed to ensure any new hazards and steps are captured. The SWP should be saved on the local server for easy access as well as Environmental Management System (EMS).

The SWPs are maintained in a digital format on the local server and will be regularly reviewed and updated to ensure any new hazards and steps are captured. The relevant SWPs should be checked prior to conducting each monitoring round to ensure that the most up to date documents are used. A list of current SWPs is provided below:

- Groundwater level monitoring;
- Processed water sample collections;
- Bacteriological water sampling;
- Waste water sampling;
- Groundwater Sampling using Waterra pump;
- Data logger install, setup, download;
- Chloride analysis on site;
- VWP Monitoring;
- VWP Data Conversion;
- Equipment maintenance and storage
- COC completion and sample dispatch
- Equipment Calibration;
- Duplicate and Blank Water samples;
- Groundwater sampling using bailers;
- Stream gauging;
- Flow meter monitoring;
- Flood monitoring
- Data Management;
- Herder well condition survey;
- Road Culvert Inspection and photography;
- Weather monitoring (weather stations and rain gauges); and
- Spring Photography.

4.1. Required Actions

To develop SWPs for the following tasks;

- Pond monitoring
- Contaminant Sampling
- Low Flow sampling

5. IMPLEMENTATION

The OT Environmental Water team will be responsible for the implementation of the Water monitoring plan. The Environmental Manager will be responsible for the ongoing coordination of all aspects of the WMP. The Environmental Manager will be supported by the water monitoring team. Support from technical specialists will be available in the early stages of WMP implementation. **Error! Reference source not found.** summarises tasks and responsibilities.

Table 5-1 WMP Implementation Roles and Responsibilities.

Role / Task	Responsible Party	Responsibilities
WMP Set Up	Environmental Manager External technical specialist	- Monitoring locations finalisation and installation - Sampling equipment procurement - Sampling consumables procurement - Specialist staff sourcing - Staff technical training - Laboratory set up - Work Plan development - Data management software procurement
Monitoring Implementation	Water Team	- Staff training - Work Plan implementation - Ongoing sampling equipment management - Ongoing sampling consumables management - Monitoring points maintenance - Field QC samples - Sample preservation - Field records management
Sample delivery to laboratories	Water Team	- Confirmation of required analytical suites - Completion of Chain of Custody forms - Sample management within sample storage time limitations - Transportation and delivery to laboratories - Completed Chain of Custody management
Data QA and Management	Water Team	- Check received laboratory data against analytical requirements - Input into database - Input QA check
Data Technical Assessment	Water Team External technical specialist	- Distribution of data to technical specialists where required (e.g. borefield and dewatering data) - Check data against water quality standards - Refer to triggers / actions where required
Reporting	Water Team External technical specialist	- Data presentation - Reporting to required regulatory bodies and organisations to meet project deadlines
Internal Auditing	Water Team	- On-site monitoring audit - Data management QA
External Auditing	External technical specialist	- On-site monitoring audit - Data management QA - Laboratory(s) QA

5.1 Work plan

The development of a detailed annual Work Plan will be required for WMP implementation across the relevant OT projects. The annual Work Plan will include:

- Monitoring roster to ensure all locations are monitored at the required frequency
- Project staffing;
- Staff roles and responsibilities;
- Equipment procurement and ongoing management;
- Laboratory set up;
- Quality control set up.

The Work Plan will be amended annually to incorporate the results of the annual review of the WMP.

5.2 Staff Training Requirements

Groundwater and surface water monitoring is a specialist activity which requires well trained staff to ensure equipment is used correctly, standard working procedures are followed and the data obtained is reliable. Training programmes will be developed to ensure appropriate standards are met and ensure development of the technical team.

6. ALERTS AND ACTIONS

6.1 Introduction

Details of the alerts and actions to be taken where impacts are identified are provided. Impacts are defined based on notional triggers such as a sustained drop in water levels greater than the seasonal norm and/ or sufficient to present the user with issues for supply; or a statistically significant variation in water quality when compared to long term trends.

6.2 Groundwater level

A sustained groundwater level change (either rising or falling) observed in monitoring bores will alert further assessment. The trend should occur over at least three measurement periods. Assessment will also be triggered where a complaint is received with regard to groundwater levels.
The groundwater level assessment will comprise the following key steps:

- Review data for the monitoring well and ensure correct and accurate;
- Compile rainfall and relevant operational (i.e. abstraction, herder usage, open pit development, sump pumping) data and compare to monitoring bore water levels;
- Assess statistical significance of variation where possible through comparison to baseline and long term trends;
- Review groundwater levels in nearby monitoring bores or VWPs that target the same hydrogeological unit;
- Assess findings against conceptual understanding (including if subsidence had impacts on groundwater levels) and, where appropriate, groundwater flow model (i.e. was a reduction in water level expected);
- Conclude reasons for water level change – where uncertain develop work plan to collect more data to resolve uncertainty
- Where water level changes due to leakage from a storage facility then conduct an engineering assessment of the facility to identify if remedial action can be taken or is required.
- Identify sensitive receptors (water users, groundwater dependent vegetation etc) and assess magnitude of any impact
- Review of assessment and confirm if mitigation/remedial action is required and, where required, select mitigation/remedial action method (i.e. replacement water supply) and implement.

6.3 Groundwater quality

A sustained change in water quality observed in monitoring bores will action further assessment. The trend should occur over at least three measurement periods except where the measurement exceeds an appropriate quality standard relevant to the local water quality, where re-testing is required to confirm the reading. Assessment will also be triggered where a complaint is received with regard to groundwater quality.
The groundwater quality assessment will comprise the following key steps:

- Review field and laboratory data and quality standards to ensure data is correct;
- Compile rainfall and operational (i.e. abstraction, open pit development, sump pumping) data and compare to water quality;
- Assess statistical significance of variation where possible through comparison to baseline and long term trends;
- Review water quality in nearby monitoring bores that target the same hydrogeological unit and additionally features that could be the source of such anomalies (i.e. TSF outflow/seepage, waste water treatment plant, waste rock dump etc);
- Assess findings against conceptual understanding (i.e. was a change in water quality anticipated);
- Conclude reasons for water quality variance – where uncertain develop a work plan to collect more data to resolve uncertainty;

- Identify sensitive receptors (water users, groundwater dependent vegetation etc) and assess magnitude of any impact;
- Review of assessment and confirm if mitigation is required and, where required, select mitigation method and implement.

6.4 Surface water quality

Surface water quality samples are collected from a number of sources as part of the monitoring programme. These can be classified as either those collected from a feature installed or modified as part of the mining operation (i.e. surface water collected in open pit sumps, WRD capture ditches and collection basin, TSF surface water run-off capture ditches, underground seepage collection, outflow from settlement ponds and seepage collector at water storage lagoon) or those that are not (i.e. flood flows in ephemeral drainage channels).

Water quality data for samples collected from a feature installed as part of the mining operation will be assessed regularly to ensure appropriateness for use (i.e. recycling in the process water circuit or dust suppression). Where water quality criteria for use are exceeded then water will be directed to the grey water pond. A sustained deterioration in water quality will necessitate further study.

Given the intermittent and variable flood flows it is difficult to assess any mining related impacts on quality. However, a sustained deterioration in water quality for samples collected from the same location in an ephemeral drainage channel during a flood should be reviewed to ascertain likely reasons for such change and whether it could be due to mining operations. The assessment will include review of flood flows estimates and flooding extent.

6.5 Spring condition and quality

Where there is an uncharacteristic change in spring condition (i.e. a change from wet to damp or damp to dry outside that expected for normal seasonal variability), community complaints and/or uncharacteristic water quality variation (i.e. outside that expected for normal seasonal variability) then further assessment will be initiated to identify the cause of such changes. This assessment will also review the frequency of the ongoing monitoring to assess whether the existing monitoring regime is sufficient, or whether additional points or frequency should be provided. Further, the assessment will include a review of the need for any remedial actions in the case that site operations have adversely impacted the springs. Such an assessment will be based on a risk approach and will be handled under the MOC process.

The assessment will include a review of spring photographs and water quality data and comparison with trends in proximal monitoring bores and other springs. Rainfall, flooding, and relevant operational data will be reviewed and conclusions made regarding the reason for change. Where conclusions are uncertain, additional work will be initiated to remove uncertainty (to the extent possible). Where the impact on spring condition or quality is associated with the site operations then a mitigation method will be selected and implemented.

6.6 Bor Ovoo replacement spring

An investigation of Undai diversion system performance will be triggered in response to a formal community complaint or whenever surface flow at the replacement spring ceases or when measured flow in the subsurface diversion pipe declines to less than 0.5 L/s. The primary purpose of the investigation is to ensure that the diversion system is still working as designed and to ensure any mechanical failures are identified and corrected in a timely manner. Investigations and corrective actions will be implemented in the following order if required:

- If surface flow ceases an investigation will be triggered to determine if the reduction in flow likely results from regional drought conditions or from a potential mechanical failure of the diversion system. The investigation will require a review and analysis of in-pipe flow data, precipitation and runoff history, depth to water in the saturated Undai alluvial system adjacent, up gradient and down gradient of the diversion system and a review of other local spring behaviour. If this review indicates regional drought conditions with low water levels in the alluvium then no further action other than ongoing monitoring and analysis will be required.

- Conversely if the initial investigation indicates that flows in the subsurface diversion system have declined inconsistent with regional climatic and hydrogeologic behaviour then a detailed review of the physical integrity and performance of the diversion system will be required. This will include investigation of the diversion dam, groundwater intake systems, buried pipe integrity and the discharge system.
- Where the decline is identified as being associated with mining activities then short-term mitigation to return discharge to required levels will be enacted followed by development of a longer term mitigation strategy. Any physical problems with the subsurface diversion system which are found to be inhibiting its performance must be corrected in a timely manner.

6.7 Erosion and sedimentation

Where the herder (physical inspection) or OT identifies erosion or increased sedimentation from photographs due to changes in surface water flows associated with mine development and operation (i.e. culverts, diversions, etc) then a review will be initiated to assess if the erosion or operation (i.e. culverts, diversions, etc) then a review will be initiated to assess if the erosion or sedimentation is having, or could have, detrimental impact on sensitive receptors. Consultation with engineers will be conducted to identify and implement a mitigation strategy where required.

7. REFERENCES

1. OT Water Resource Management Plan, updated version 2.0;
2. Ecotrade (2006), Detailed Environmental Impact Assessment Report for the Oyu Tolgoi Project, Mining and Processing, May 2006.
3. JEMR Consulting LLC (2011), Amendment Detailed Environmental Impact Assessment Report on use of Gunii Hooloi underground water resource for Oyu Tolgoi project.
4. Klohn Crippen Berger (2011), OT Tailing Storage Facility 2010 Feasibility Study Update, August 2011.
5. Oyu Tolgoi (2012), Environmental and Social Impact Assessment (ESIA), July 2012.
6. Oyu Tolgoi (2012), Water Resource Management Plan, Draft Nov 2012.
7. Schlumberger Water Services (2011), Oyu Tolgoi Open Pit Hydrogeology and Pit Slope Depressurization Feasibility Study, June 2011.
8. RPS Aquaterra (2013), Oyu Tolgoi Water Monitoring Plan (WMP).
9. "Water Report – November 2014", Report of the Independent Environmental and Social Consultant;
10. Trip Report for Rich Borden and Craig Stevens visit to OT site in August 2014;
11. Quality Control and Quality Assurance Project Plan of Oyu Tolgoi Water Monitoring.

8. DOCUMENT CONTROL

File name	OT-10-E11-PLN-0002-E-Water monitoring plan_v2.1
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2.0	2015.12.15	Erdenebayar Naran	Dennis Hosack	Updated and approved.
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