



GEOTEAM

Amulsar Gold Project **Environmental Monitoring Plan**

Version 5
February 2016

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Revision History

Revision	Date	Details	Prepared	Checked	Approved
V1	27 Aug 14	Appendix 8.13 of ESIA version 9	Golder Associates		
V2	9 Feb 15	Revision incorporating lender feedback and formatting into Geoteam template	CN		
V3	May 2015	Revision for 2015 (pre-construction) monitoring programme	AJB		
V4	September 2015	Revised for full alignment with ESIA v9f	AJB	UES	
V5	February 2016	Revised for issue with v10 ESIA	AJB	UES	DF

The Amulsar Environmental Monitoring plan (EMP) is a "live" document that will be updated throughout the life of the Project as necessary to reflect the monitoring requirements particular to the current Project phase.

This revision (V5) applies to the **Pre-Construction Phase**. It will be revised for the Construction Phase following review of the Project Execution Plan (PEP).

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Glossary

AQNVMP	Air Quality, Noise and Vibration Monitoring Plan
ARDMP	Acid Rock Drainage Management Plan
BMP	Biodiversity Management Plan
BRSF	Barren Rock Storage Facility
CHMP	Cultural Heritage Management Plan
CSO	Civil Society Organisation
E&S	Environment(al) and Social
EAC	Effective area covered (dust monitoring)
EBRD	European Bank for Reconstruction and Development
EHS	Environment(al), Health and Safety
EMP	Environmental Monitoring Plan
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
ESMS	Environmental and Social Management System
EVP	Executive Vice President
Geoteam	Geoteam CJSC
HLF	Heap Leach Facility
IESC	Independent Environmental and Social Consultant
IFIs	International Financial Institutions (EBRD+IFC)
IFC	International Finance Corporation
Lydian	Lydian International Ltd
mg/l	milligrams per litre
mg/m ² /d	milligrams per square meter per day
MP	Management Plan
NO ₂	Nitrogen dioxide
NO _x	Oxides of nitrogen
OP	Operating Procedure
PM	Particulate matter
PM _{2.5}	Very fine particles with a diameter of less than 2.5 microns
PM ₁₀	Small particles with a diameter of 10 microns or less
PR	Performance Requirement (of EBRD)
PS	Performance Standard (of IFC)
RA	Republic of Armenia
SO ₂	Sulphur dioxide
SWMP	Surface Water Management Plan
TOC	Total Organic Content
TPH	Total Petroleum Hydrocarbons

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TSP	Total Suspended Particles
µg/l	microgramme per litre
µm	micron or micrometre (one millionth of a metre)

1 INTRODUCTION

Lydian International Ltd (Lydian) and its wholly-owned Armenian subsidiary, Geoteam CJSC (Geoteam), are developing the Amulsar Gold Project (the Project), a gold mine and associated process facilities located in the central Republic of Armenia (RA). The proposed Amulsar mine will exploit a gold deposit via open-pit mining followed by heap-leach processing using dilute cyanide solution. In October 2014, Geoteam received a positive Expert Opinion on the Environmental Impact Assessment (EIA) submitted in July 2014 to the Ministry of Nature Protection (MNP). In November 2014 the Project was granted a Mining Right for the proposed open pits, Heap Leach Facility (HLF), Barren Rock Storage Facility (BRSF) and associated infrastructure. A value engineering and optimization study resulted in the publication of a new 43-101 Technical Report in November 2015, and the design changes mean that Lydian is required to submit a new EIA and apply for a new Mining Right. Construction of the Project is planned to start in Q2 2016.

The Project is subject to various environmental and social commitments arising from the EIA, together with licences, permits and other agreements necessary to meet Armenian legislation. Additional commitments arise from the Environmental and Social Impact Assessment (ESIA) which has been undertaken for the Project in compliance with, amongst others, the Performance Requirements (PR) of the European Bank for Reconstruction and Development (EBRD) and the Performance Standards (PS) of the International Finance Corporation (IFC). The ESIA is being amended in parallel with the EIA to reflect the changed Project design referred to above.

Environmental and social (E&S) commitments are being managed by Geoteam through the Project Environmental and Social Management System (ESMS). The ESMS includes a set of Management Plans (MPs), such as this one, that detail requirements placed upon Lydian/Geoteam in order to fulfil the Project's environmental and social commitments. The implementation of the ESMS for exploration and early construction works commenced in 2013, and the system is intended to develop in parallel with the Project. As such, the MPs will be revised and continuously improved as required throughout the life of the Project to meet its changing needs.

This document presents the Environmental Monitoring Plan (EMP) for the Amulsar Project. It is a "live" document that will be updated as necessary to reflect the different monitoring requirements of the pre-construction, construction (including early works), operational, and closure phases of the Project. It is based upon the exploration phase EMP which was developed by Golder Associates Ltd and used during exploration both to gather environmental baseline parameters and subsequently to monitor them.

1.1 OBJECTIVES

The objective of monitoring is to check for any variations from baseline conditions and to ensure compliance to standards and parameters as required by IFIs and RA. In the context of the Amulsar Project, it has two main elements:

- To check performance against the numerical Project compliance targets and assessment criteria as set out in Section 2.4 of the ESIA (and reproduced in this EMP in Chapter 13). These criteria are a combination of Armenian legal requirements and standards derived from good international industry practice.
- To measure and evaluate the effectiveness of the Project mitigation measures as identified in Chapter 6 of the ESIA and the associated MPs.

Implementation of the EMP will inform the environmental management of the Project and identify the need for any modifications or additional actions required to ensure that the Project commitments are met.

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1.2 SCOPE

This EMP brings together all of the environmental monitoring requirements relevant to the current Project phase as specified in the E&S MPs which have been developed as part of the ESIA, as well as the monitoring required to comply with Armenian legislation. It contains all of the monitoring that will be the responsibility of the Amulsar site-based environmental team.

The MPs developed as part of the ESIA, and whose monitoring requirements are included in this EMP, are:

- Air Quality, Noise and Vibration Management Plan (AQNVMF);
- Cultural Heritage Management Plan (CHMP);
- Acid Rock Drainage Management Plan (ARDMP);
- Biodiversity Management Plan (BMP); and
- Surface Water Management Plan (SWMP).

A number of monitoring commitments from the ESIA apply only from the operational phase onwards. These will therefore be added to the EMP at that time. They include:

- Monitoring of stack emissions from the ADR plant;
- Monitoring of basements and ground floor rooms for radon gas;
- Monitoring of ground vibration and air overpressure during blasting events in the early operational period;
- Monitoring of leachate emanating from the Project landfill (if appropriate).

Social parameters to be monitored are excluded from this EMP, as they will be captured through the Stakeholder Engagement Plan (SEP, Ref GEOTEAM-SOC-PLN0150). The EMP is part of the overall Project Environmental and Social Management Plan (ESMP) and will be managed through the Project ESMS.

2 MANAGEMENT STRUCTURE AND TECHNICAL COMPETENCE

The Lydian Executive Vice President (EVP) has overall responsibility for E&S management, compliance, and performance of the Amulsar Project. The EVP is also responsible for the relationship with IFC and EBRD (who are existing shareholders and potential lenders) with respect to E&S issues, and with the Independent Environmental and Social Consultant (IESC) appointed by the shareholders.

The day-to-day environmental management of the Project within Armenia is the responsibility of Geoteam, which is responsible for:

- Communicating the requirements of this plan to its staff or any contractors engaged to deliver the monitoring activities;
- Monitoring and auditing the implementation of this plan and ensuring activities are completed as required and in a timely fashion; and
- Taking action to correct any failures to complete the required monitoring activities in accordance with this plan.

Geoteam is responsible for ensuring that any staff completing monitoring activities have received appropriate training, have the necessary tools and equipment to complete monitoring, and are competent to complete the tasks assigned.

Specific responsibilities for Geoteam personnel relating to this plan are described in Table 1.

Table 1: Geoteam Environmental Management Structure

Title	Role
Project Director	Ensuring that the Project complies with its legal obligations with respect to the environment; ensuring that designated managers understand their responsibilities and have sufficient resources to carry out their functions effectively; and reviewing and approving all training programmes and ensuring that any recommendations are duly implemented.
Health, Environment, Safety and Security (HESS) Manager	Ensuring that the EMP is appropriate and up-to-date for the current Project phase, and ensuring that sufficient staff and material resources are available to implement the EMP.
Environmental Manager	Implementing all aspects of this EMP to support the Project during construction, operation and closure; liaison with and management of contractor environmental staff; ensuring all results are reported correctly (including transcription into the Monitor Pro database); and reporting the outcomes to the Sustainability & Permitting Senior Manager and HESS Manager.
Environmental Coordinator	Delivery of monitoring activities in accordance with this plan and as instructed by the Environmental Manager.
Contractors	Completion of activities in accordance with this plan as instructed by Geoteam. The contracting strategy for the Project has not yet been finalised, and it is therefore not yet known what the contractor set-up will be in terms of E&S management. Larger contractors may have their own E&S staff who will be expected to conform with the Project ESMP and ESMS, and to cooperate with Geoteam staff as necessary during monitoring activities. The contracting strategy and E&S arrangements will be finalised prior to start of work on site.

3 WEATHER AND ATMOSPHERIC PRESSURE

Geoteam maintains and operates two automated meteorological stations, located at the proposed Barren Rock Storage Facility (BRSF) near the site exploration camp and at the proposed Heap Leach Facility (HLF) location (Table 2 and figure in Appendix D).

Table 2: Weather Station Locations

Location ID	Easting	Northing	Notes
BRSF/Camp	560828	4401512	To be relocated during construction / operation outside facilities footprint.
HLF	554367	4399951	To be relocated during construction of the HLF.

The two meteorological stations record continuous data for temperature, wind speed, wind direction, humidity, rainfall and air pressure. Monitoring will be maintained throughout Project execution in order to inform any necessary modelling updates (e.g. water balance modelling) and to inform interpretation of other monitoring data (e.g. dust and noise). An Operating Procedure (OP) will be developed for meteorological data collection including download procedures, analysis of results and persons responsible for data collection and dissemination. In addition, an OP will be developed to cover use of meteorological data for determining soil handling periods, to be fed back to site operations.

Geoteam also has two barometric loggers, which are deployed temporarily and on an as-needed basis for the purpose of determining correction factors to be applied to continuous groundwater flow/level data measured at the site by pressure transducer data loggers (see Chapters 6 and 7).

As required by the Surface Water Management Plan (SWMP), meteorological data produced by the above stations will need to be supplemented by measurements of snowpack depth at widely distributed points on and near the Barren Rock Storage Facility (BRSF) and around the open pits. This information will be an important element in the SWMP because snowmelt is the primary source of spring runoff. Snowpack depth measurement will commence during Winter 2015/2016.

4 AIR QUALITY

4.1 NITROGEN DIOXIDE AND SULPHUR DIOXIDE

Air Quality, specifically in terms of nitrogen dioxide (NO₂) and sulphur dioxide (SO₂), has been monitored historically at five points in the communities around the Project site (Table 3). Following a review related to the Project ESIA, six new long-term monitoring points (AQ1-AQ6 in Table 4) were proposed to replace the original five points (the new locations are located between the mine site and communities, rather than within the communities themselves; see the drawing in Appendix D). These new points were established during the second quarter of 2015. NO₂ and SO₂ monitoring is to be undertaken at both the old and new monitoring points for a period of six months to confirm no significant variation in the results, after which monitoring at the old points will be discontinued.

Diffusive samplers are supplied by IVL Svenska Miljöinstitutet (IVL) of Sweden. A method statement¹ for use of the IVL samplers is included in Appendix A.

Table 3: Historical Air Quality Monitoring Points

Location	Easting	Northing
Jermuk	557736	4410479
Kechut	557475	4406082
Gndevaz	553224	4401116
Saravan	555510	4396861
Gorayk	565063	4392644

Table 4: New Air Quality Monitoring Points

Identifier	Location	Easting	Northing
AQ1	Jermuk	557751	4409515
AQ2	Kechut	558583	4406880
AQ3	Gndevaz	553466	4400161
AQ4	Saravan	555340	4397674
AQ5	Saralanj	558107	4397027
AQ6	Gorayk	564951	4393686

4.2 DUST

When work is taking place on site, visual assessment will be important for day-to-day management of dust. When potentially dust-generating activities are taking place, visual inspections will be undertaken at least once a day, and more often if wind direction or strength changes during the working day. A standard operating procedure (SOP) will be developed for routine visual monitoring to be employed to identify sources of dust emission; inspection positions will be determined to demonstrate coverage of identified sources of dust, including open pits, haul roads, crushing plant, BRSF and conveyor load out points.

A number of monitoring stations provide back-dated data to enable assessment of the success of actions taken in response to visual inspections of operations. Dust has been monitored at eight

¹ The term "Method Statement" is to be changed to "Operating Procedure" to align with the ESMS

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locations in the past (Table 5). From 2015, dust monitoring is to be undertaken at a total of 10 locations, including the six new locations at which NO₂ and SO₂ are to be monitored (Table 6 and drawing in Appendix D). The locations will be monitored using DustScan DS100 passive monitors. The DustScan DS100 operates with a multi-directional sticky pad gauge which collects airborne dust as it passes over the gauge. Pads are held in place and protected with a removable rain cap. The sampling head is aligned to magnetic north to ensure directional information is obtained. Dust deposition is measured as a percentage of the effective area covered (%EAC) over the sampling period. The pads are exposed for a period of two weeks after which they are returned to an accredited laboratory for analysis. A method statement for use of the DustScan pads is included in Appendix A.

Table 5: Historical Dust Monitoring Locations

Identifier	Location	Easting	Northing
ADN1	East of BRSF	562019	4402723
ADE2	East of Vorotan & proposed pits	565255	4398514
ADS3	South of proposed pits near M2 road	561005	4393813
ADW4	West of proposed pits	559983	4398101
ADJ5	Jermuk	557945	4407300
ADG7	Gndevaz	553381	4401233
ADHLP8	East of Gndevaz	556272	4401361
ADHLP9	At the HLF site	553118	4398905

Table 6: Dust Monitoring Locations from 2015

Identifier	Location	Easting	Northing
AQ1	Jermuk	557751	4409515
AQ2	Kechut	558583	4406880
AQ3	Gndevaz	553466	4400161
AQ4	Saravan	555340	4397674
AQ5	Saralanj	558107	4397027
AQ6	Gorayk	564951	4393686
AQ7DS*	Kechut	557934	4406277
AQ8DS*	Gndevaz	553381	4401233
AQ9	South-west of Tigranes/Artavazdes	560672	4403805
AQ10	North of BRSF	559983	4398093

* These locations are near to the fine particulate monitoring points listed in Table 7, the adjustment being due to equipment siting, power supply and security considerations.

4.3 FINE PARTICULATES

Four monitoring points for fine particulates were established in 2015 (Table 7 and drawing in Appendix D).

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Table 7: Fine Particulate Monitoring Locations from 2015

Identifier	Location	Easting	Northing
AQ7	Kechut	557475	4406082
AQ8	Gndevaz	553224	4401116
AQ9	South-west of Tigranes/Artavazdes	560672	4403805
AQ10	North of BRSF	559983	4398093

At the Kechut (AQ7) and Gndevaz (AQ8) locations, monitoring will be undertaken for 10-micron particulates (PM₁₀) and 2.5-micron particulates (PM_{2.5}) over a number of 24-hour periods using a Haz-Dust EPAM-5000 monitor. The EPAM equipment can only measure one parameter at a time and therefore requires frequent supervision. The two monitoring locations are within the respective villages (though near to the edges on the Amulsar side) and mains power is available, with short-term battery back-up.

At the AQ9 and AQ10 locations, continuous monitoring of PM_{2.5} and PM₁₀ will be undertaken using dedicated Turnkey Osiris monitors deployed in semi-permanent installations powered by solar-recharged car batteries. Logged data will be downloaded and checked for integrity on a weekly basis.

Method statements for use of the EPAM and Osiris monitors are included in Appendix A.

5 NOISE

Noise baseline conditions in the local communities have been established (Table 8 and drawing in Appendix D). Monitoring will be undertaken periodically at the same locations when work starts on site. If different monitoring locations are necessary then the new and previous locations will be monitored in parallel for a period of six months so the data may be calibrated to each other.

Table 8: Noise Monitoring Locations

Identifier	Location	Easting	Northing
N1	Gorayk	565238	4392694
N2	Ughedzor	558246	4393163
N3	Saralanj	557396	4395864
N4	Saravan	555504	4396867
N5	Gndevaz	553229	4401123
N6	Kechut	557532	4406156
N7	Jermuk	557724	4410486

Noise monitoring will be undertaken using type 1 Cirrus noise meters with environmental monitoring kits, using standard methods (see method statement in Appendix A). Surveys will record noise data including hourly noise level (L_{Aeq} and L_{A90}), date, times, weather conditions and any other relevant information (e.g. noise generating activities occurring at the time of the survey).

6 SURFACE WATER

6.1 MONITORING NETWORK

Surface water flow measurement has been conducted at numerous river, stream and spring locations during Project exploration and development. Appendix B contains a full list of the surface water points that have been monitored in the past; Appendix C includes a list of spring locations.

6.2 FLOW MONITORING

Surface water flow measurement is conducted both by continuously monitored gauges, comprising constructed weirs and pressure transducers, and by spot measurement.

For the pre-construction phase, periodic flow measurement is to be undertaken in order to provide data for ongoing Project design work. Of highest priority is measuring flows associated with Spring snow-melt run-off, particularly at the HLF and BRSF. Table 9 lists the locations at which flow measurements will be made during the pre-construction period. The locations are shown on the drawing in Appendix D. Note that points designated "FDMP" in Table 9 denote "Final Design Monitoring Points" proposed by Global Resource Engineering Ltd (GRE) and are new locations for measurement.

Table 9 includes locations at which pressure transducers were installed, giving continuous flow monitoring data. However, following an increase in thefts of the transducers, all were removed from the field between 1 and 4 June 2015.

Locations without transducers are planned to be measured for flow quarterly, except for the HLF and BRSF locations, at which measurement will be undertaken on a weekly basis during Spring snow-melt (for period determined by weekly site visits during early spring).

Table 9: Surface Water Flow Measurement Locations

Identifier	Easting	Northing	General notes
Arpa River & catchment			
AW009	550603.15	4397518.02	High flow in Spring makes spot flow measurement impossible
AW010	552316.48	4400814.59	High flow in Spring makes spot flow measurement impossible
ARPA 2	551192.00	4398869.00	Transducer in place prior to June 2015
ARPA 4	550666.00	4397541.00	Transducer in place prior to June 2015
AW029	558924.00	4406963.00	
FDMP7	559201.93	4406909.27	
AWJ6	556919.50	4405190.99	
Abstraction pt.			Location to be confirmed
Darb River & catchment			
AW005	557442.58	4395363.10	
AW006	555262.90	4396738.34	
AW064	556770.00	4395947.00	
North Erato	557377.00	4400099.00	Transducer in place prior to June 2015

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Identifier	Easting	Northing	General notes
AW019A	560085	4398184	Transducer in place prior to June 2015
AW021	561095.00	4394653.00	Transducer in place prior to June 2015
AW041	556959.00	4399817.00	
Darb 1	556684.00	4395861.00	Transducer stolen, Q2 2015
Darb 2	554406.00	4396838.00	Transducer in place prior to June 2015
MP 1	562330.00	4400023.00	Transducer in place prior to June 2015
MP2	562507.00	4399174.00	Transducer in place prior to June 2015
MP4	557769.00	4399489.00	Transducer in place prior to June 2015
FDMP20	558104.76	4396822.95	
Vorotan River & catchment			
AW001	563258.40	4402024.85	High flow in Spring makes spot flow measurement impossible, but Vorotan Gauge is nearby
AW003	566529.24	4393084.58	
AW015	563200.09	4399504.18	High flow in Spring makes spot flow measurement impossible
AW030a	562900.68	4401041.17	
FDMP15	562726.21	4400758.58	Appears to be AW025 - to be checked
FDMP16	562940.81	4400062.58	Appears to be AW026 - to be checked
FDMP17	562223.17	4399383.78	Appears to be AW035 - to be checked
FDMP18	562387.86	4399052.63	Appears to be AW036 - to be checked
FM 12	561271.00	4404624.00	Transducer in place prior to June 2015
VOROTAN GAUGE	562989.60	4401173.31	Transducer stolen, Q2 2015
HLF			
FDMP10	552908.94	4399074.92	
FDMP11	553049.17	4398998.77	
FDMP12	553012.27	4398898.39	
FDMP13	552526.34	4398652.84	
FDMP14	552424.88	4398393.96	
FDMP9	553520.27	4399358.17	
Site28 G1	554236.00	4399873.00	Transducer stolen prior to 18/4/15
Site28 G2	553081.00	4399538.00	Transducer removed on 20/4/15
Site28 G3	552191.00	4398413.00	Transducer removed on 21/4/15
Site28 G4	554026.00	4399517.00	Proposed flume location
BRSF			
AW030	560908.00	4402694.00	Also Sp 13.7

Identifier	Easting	Northing	General notes
AW040	560763.00	4403199.00	AW040 is a drinking water pipeline
AW040a	560763.00	4403199.00	
Site 27 Gauge	560420.00	4401997.00	Transducer in place prior to June 2015
FM10	558626.00	4405564.00	Transducer in place prior to June 2015
FDMP1	560338.18	4401656.55	When snow melts
FDMP19	559401.07	4399420.77	When snow melts
FDMP2	560421.09	4401677.86	When snow melts
FDMP3	560468.38	4402686.42	When snow melts
FDMP4	560636.06	4403005.14	When snow melts
FDMP5	560815.22	4403460.34	When snow melts
FDMP6	560836.67	4405070.76	When snow melts
FDMP8	553189.10	4399406.51	When snow melts
Springs			
SP27.1	560538.1584	4401263.122	When snow melts
SP27.2	560439.2284	4401368.005	When snow melts
SP27.3	560415.3294	4401364.274	When snow melts
SP27.4	560444.6214	4401396.214	When snow melts
SP27.5	560469.0688	4401425.01	When snow melts
SP27.6	560459.5098	4401435.219	When snow melts
SP27.7	560362.9064	4401442.928	When snow melts
SP27.8	560350.0484	4401457.681	When snow melts
SP27.9	560340.4234	4401463.864	When snow melts
SP27.10	560301.3594	4401467.132	When snow melts
SP27.11	560270.6474	4401429.404	When snow melts
SP27.12	560286.7874	4401390.299	When snow melts
SP27.13	560228.5974	4401394.762	When snow melts
SP27.14	560222.0194	4401389.209	When snow melts
SP27.15	560228.0124	4401375.072	When snow melts
SP27.16	560118.8564	4401435.29	When snow melts
SP27.17	560175.0994	4401464.487	When snow melts
SP27.18	560357.0144	4401631.608	When snow melts
SP27.19	560404.8431	4401662.019	When snow melts
SP27.20	560494.378	4401650.408	When snow melts
SP27.21	560504.477	4401647.135	When snow melts
SP27.22	560399.0621	4401696.35	When snow melts

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Identifier	Easting	Northing	General notes
SP27.23	560535.0791	4401515.25	When snow melts
SP27.24	560530.3291	4401511.187	When snow melts
SP27.25	560516.045	4401496.306	When snow melts

When construction starts, elements of the Project surface water management infrastructure will be monitored, both visually to ensure their integrity and function is maintained, and also in terms of water quality when there is discharge to the environment. These facilities include diversion channels and culverts, and sediment ponds. In particular, there will be a network of monitoring points associated with the Acid Rock Drainage Management Plan (ARDMP).

Identification of specific facilities to be monitored will be included in this EMP following the completion of the Project detailed design.

6.2.1 Continuous Flow Measurements

Continuous measurement of water level is completed by installing a water level data logger (pressure transducer) in a stilling well (a pipe with holes to allow water entry at a fixed location in the stream, supported by a stake or other appropriate stabilisation method). The elevation of the water level is established by reference to a surveyed gauge board at the monitored location. The pressure transducer is placed within the stilling well at a depth below the minimum surface water level and automatically records the water pressure acting on its sensor due to the overlying water column at a frequency specified by the user. The elevation of the transducer sensor is calculated by reference to a manually recorded water level on the gauge board at the time of installation. The serial number of the pressure transducer installed at each location must be recorded at the time of installation. For surface water logging, transducers should record on a 15 minute interval.

A method statement describing the procedure that will be followed during installation and downloading of pressure transducers is presented in Appendix A. Transducer data will be downloaded at a maximum frequency of quarterly, such that the maximum memory capacity of the data logger is not exceeded between downloads.

Transducer data will be corrected with barometric data. The water level recorded by the pressure transducers will be verified by comparison with manual water level measurement (see following section).

The locations at which continuous monitoring was undertaken prior to June 2015 are listed in Table 9. However, as noted above all transducers were removed from the field in early June due to a marked increase in thefts.

6.2.2 Manual Level Measurements at Gauged Locations

Regular spot flow measurements under a range of flow conditions will be completed at continuously gauged locations to calibrate the recorded stage (level) measurements.

Where surveyed gauge boards have been installed for surface water level measurement, on each monitoring visit the time, date and the water level must be recorded. The water level is read directly from the gauge board. A photograph will also be taken for record.

The method statement for installation and download of continuous flow measurements in Appendix A includes description of manual level recording from gauge boards.

6.2.3 Spot Flow Measurements

The methodology for spot measurement of spring flows and surface waters is different as the volume of flow in monitored surface water courses is greater than at spring discharges.

To complete spot flow measurements of larger flows, a cross-sectional flow velocity profile is constructed for the stream flow. Water velocity is measured at a number of points at a known distance across the stream channel, and at each measurement location the water depth is recorded. The flow is calculated as an integration of the flow velocity over the segment area attributed to each measurement.

Spring flows are typically small and an approximate flow measurement can be readily made by capturing the entire discharge in a measuring vessel of known volume (a wide neck bottle, measuring jug or calibrated bucket) and recording the time to fill. Where spring discharges are high it may be more appropriate to measure flows by establishing the cross sectional area of the flow channel at a point close to the discharge and recording the flow velocity using an appropriate float.

Method statements describing both procedures to be applied for manually estimating flow are presented in Appendix A.

6.3 SURFACE WATER SAMPLING AND ANALYSIS

Water quality monitoring incorporates collection of water samples for laboratory analysis, and measurement of a number of in-field quality parameters which cannot be accurately determined from stored samples. Table 10 lists the surface water monitoring points at which sampling will be undertaken during the pre-construction period. This represents a minimal sampling programme and is justified by the fact that no work will be ongoing on site. The locations include three community water sources that occur within the Project's watershed. As the Project is likely to be perceived by local residents and civil society organisations (CSOs) as impacting drinking water sources, it may become necessary to enhance the water source monitoring programme in future.

Table 10: Surface Water Sampling Locations

Identifier	Location	Justification for monitoring
AW001	Near small hydro plant	Up-gradient Vorotan
AW003	Vorotan River - near Gorayk gauge site and Spandaryan reservoir	Down-gradient Vorotan
AW041	Darb tributary west of Erato	Flow from mountain
FDMP3	New location at north edge of BRSF	Northward-flowing discharge from BRSF area
FM10	Stream discharging from BRSF	
SP83	Madikenc spring, east of Kechut (water supply for town)	Monitor potential impacts on water supply
AW052	Residence in Gndevaz	Water from Seven Springs that crosses Project site in a pipeline
AWJ-6	Discharge from Spandaryan-Kechut tunnel	Monitor potential impacts on tunnel water
AWJ-5	Arpa outflow from Kechut Reservoir	Arpa up- and down-gradient of Project area
AW010	Arpa west of Gndevaz	
AW009	Arpa down-gradient of Gndevaz near fish farm	
AW070	Spring north of Gorayk used for drinking water (new monitoring location)	Monitor potential impacts on water supply

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The twelve locations will be sampled quarterly (if accessible). Water samples will be collected in clean, sterile, air tight, non-leaching sample bottles; suitable sample bottles are supplied by analytical laboratories and the bottles recommended by the laboratory for each analysis type will be used. Where preservatives are used to prevent deterioration of the samples in storage and transit (e.g. for metals analysis), samples must be filtered using a 45 µm filter.

In-field measurement of a number of parameters is required to record chemistry which may change in stored samples. For each field parameter, three consecutive measurements should be recorded, the aim being to achieve the tolerable uncertainty range specified in Table 11. All three measurements must be recorded. The procedure that will be followed to record field parameter measurements is described in method statements included in Appendix A.

Surface water samples will be collected using a clean, uncontaminated collection vessel (such as a stainless steel grab sampler or clean disposable bailer) which has been rinsed three times in the sampled waters before the sample is collected. Water is then transferred to the sample bottles.

Surface water samples will be analysed at an internationally accredited laboratory (currently ALS Czech Republic) to determine water quality. The analytical schedule employed previously (pre-second quarter 2015) has been adjusted slightly to ensure that the Project compliance criteria, as identified in the ESIA and reproduced in Chapter 13 of this EMP, are covered. The parameters to be analysed by the laboratory are detailed in Table 12, with their units of measurement, lab method and limit of detection (for ALS Czech Republic). Antimony, cobalt, molybdenum and beryllium have particularly low water quality standards in the Republic of Armenia, and low detection limits are required for these substances if possible.

In addition to the schedule in Table 12, on one or more quarterly monitoring rounds the three drinking water samples will be analysed for gross alpha and beta radiation, to reflect an ESIA commitment to investigate the occasional presence of this type of radioactivity.

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Table 11: In-field Measurements for Surface Water Samples

Parameter	Units	Tolerable Uncertainty*	Limit of Detection
pH	pH units	+/-0.5 units	0.01 units
Temperature	°C	+/-0.5 °C	0.01 °C
Electrical Conductivity	µS/cm	+/-10% of average reading	1 µS/cm
Dissolved Oxygen	mg/l	+/-1 mg/l	0.01 mg/l

Note: previous versions of this EMP listed turbidity as a parameter for measurement, largely because the equipment in use at the time allowed its measurement. Research confirms that it is not essential as long as the other parameters are measured (e.g. see <https://www.ysi.com/File%20Library/Documents/Application%20Notes/A532-Low-Flow-Sampling-of-Water-Quality-Determines-Groundwater-Stability.pdf>)

*This is the uncertainty of measurement allowed between 3 consecutive readings before the value is recorded.

Table 12: Determinands for Water Sample Analysis

Parameter	Project criterion*	Lab method	Method Detection Limit (MDL)	Improved MDL needed?
<i>Standard suite</i>				
pH	6.5 – 9.0	W-PH-PCT	1	
Electroconductivity	162 µS/cm	W-CON-PCT	0.1 mS/m	
Colour	<5 (natural) degree	W-COL-SPC	2 mgPt/l	
BOD5	5 mgO ₂ /l	W-BOD5-CODCR	1 mg/l	
COD-Cr	25 mgO ₂ /l	W-BOD5-CODCR	5 mg/l	
COD-Mn	10 mgO ₂ /l	W-CODMN-SPC	0.5 mg/l	
Dissolved oxygen	>6 mgO ₂ /l	W-O2D-ELE	0.2 mg/l	
Suspended particles / TSS	5.5 mg/l	W-TSS-GR	5 mg/l	
Hardness	10 mg-equ/l CaCO ₃	W-HARD-FX	0.0002 mmol/l	
Calcium hardness		W-HARD-FX	0.0002 mmol/l	
Magnesium hardness		W-HARD-FX	0.02 mg CaCO ₃ /l	
Hardness as CaCO ₃		W-HARD-FX	0.02 mg CaCO ₃ /l	
Ammonia		W-NING	0.04 mg/l	
Ammonia and ammonium ions		W-NING	0.05 mg/l	
Ammonium ion	0.4 mg N/l	W-NING	0.05 mg/l	
Nitrates		W-NING	0.27 mg/l	
Nitrites		W-NING	0.005 mg/l	
Nitrate ion	2.5 mg N/l	W-NING	0.06 mg/l	

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Parameter	Project criterion*	Lab method	Method Detection Limit (MDL)	Improved MDL needed?
Nitrite ion	0.06 mg N/l	W-NING	0.002 mg/l	
Total inorganic nitrogen	4 mg N/l	W-NING	0.5 mg/l	
Chloride ion	6.88 mg/l	W-CL-IC	1 mg/l	
Phosphate ion	0.1 mg/l	W-PO4O-SPC	0.04 mg/l	
Phosphorus, total	0.2 mg/l	W-PTOT-SPC	0.01 mg/l	
Sulphate ion	16.04 mg/l	W-SO4-IC	5 mg/l	
Sulphide		W-H2S-PHO	0.05 mg/l	
Sulphides as H2S		W-H2S-PHO	0.05 mg/l	
Total carbon dioxide		W-CO2F-CC2	-	
Free carbon dioxide		W-CO2F-CC2	-	
Aggressive CO2		W-CO2F-CC2	-	
Total mineralization	110 mg/l			
Aluminium, total		W-METMSFX2	5 µg/l	
Antimony, total	0.28 µg/l	W-METMSFX1	1 µg/l	Yes
Arsenic, total	20 µg/l	W-METMSFX1	1 µg/l	
Barium, total		W-METMSFX2	1 µg/l	
Beryllium, total		W-METMSFX1	0.2 µg/l	
Boron, total		W-METAXFX1	10 µg/l	
Cadmium, total	1.01 µg/l	W-METMSFX1	0.5 µg/l	
Calcium	100 mg/l	W-METAXFX1	5 µg/l	
Chromium, total	10.5 µg/l	W-METMSFX1	5 µg/l	
Hexavalent chromium, total		W-CR6	5 µg/l	
Cobalt, total	0.28 µg/l	W-METMSFX2	0.5 µg/l	Yes
Copper, total	21 µg/l	W-METMSFX2	1 µg/l	
Iron, total	0.072 mg/l	W-METAXFX1	2 µg/l	
Lead, total	10.14 µg/l	W-METMSFX1	1 µg/l	
Lithium, total		W-METMSFX2	1 µg/l	
Magnesium, total		W-METAXFX1	3 µg/l	
Manganese, total	8 µg/l	W-METMSFX2	0.5 µg/l	
Mercury, total	0.3 µg/l	W-HG-AFSFX	0.01 µg/l	
Molybdenum, total	0.82 µg/l	W-METMSFX1	1 µg/l	Yes
Nickel, total	10.34 µg/l	W-METMSFX1	3 µg/l	
Potassium	3.12 mg/l	W-METAXFX1	0.015 mg/l	
Selenium, total	20 µg/l	W-METMSFX1	1 µg/l	

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Parameter	Project criterion*	Lab method	Method Detection Limit (MDL)	Improved MDL needed?
Silicate ion	23.64 mg Si/l	W-SIO3-SPC	0.1 mg/l	
Silver, total		W-METMSFX2	1 µg/l	
Sodium	8.46 mg/l	W-METAXFX1	0.03 mg/l	
Tin, total	0.08 µg/l	W-METMSFX2	1 µg/l	Yes
Uranium, total		W-METMSFX3	0.1 µg/l	
Vanadium, total	10 µg/l	W-METMSFX2	5 µg/l	
Zinc, total	100 µg/l	W-METMSFX2	2 µg/l	
Aluminium, dissolved	144 µg/l	W-METAXFL1	10 µg/l	
Antimony, dissolved		W-METAXFL1	10 µg/l	
Arsenic, dissolved		W-METAXFL1	5 µg/l	
Barium, dissolved	12 µg/l	W-METAXFL1	0.5 µg/l	
Beryllium, dissolved	0.038 µg/l	W-METAXFL1	0.2 µg/l	Yes
Boron, dissolved	450 µg/l	W-METAXFL1	10 µg/l	
Cadmium, dissolved		W-METAXFL1	0.4 µg/l	
Chromium, dissolved		W-METAXFL1	1 µg/l	
Cobalt, dissolved		W-METAXFL1	2 µg/l	
Copper, dissolved		W-METAXFL1	1 µg/l	
Iron, dissolved		W-METAXFL1	2 µg/l	
Lead, dissolved		W-METAXFL1	5 µg/l	
Lithium, dissolved	2 µg/l	W-METAXFL1	1 µg/l	
Magnesium, dissolved	50 mg/l	W-METAXFL1	3 µg/l	
Manganese, dissolved		W-METAXFL1	0.5 µg/l	
Molybdenum, dissolved		W-METAXFL1	2 µg/l	
Nickel, dissolved		W-METAXFL1	2 µg/l	
Selenium, dissolved		W-METAXFL1	10 µg/l	
Vanadium, dissolved		W-METAXFL1	1 µg/l	
Zinc, dissolved		W-METAXFL1	2 µg/l	
<i>Additional analytes (to be requested specifically if required)</i>				
Gross alpha		W-GAA-SCI	0.05 Bq/l	
Gross beta		W-GBA-PRO	0.1 Bq/l	
Cyanide, total	1 mg/l	W-CNT-PHO	0.005 mg/l	
Cyanide, free	0.1 mg/l	W-CNF-PHO	0.005 mg/l	
Cyanide, WAD	0.5 mg/l	W-CNWAD-PHO	0.005 mg/l	
Oil products	0.1 µg/l	W-OIL-IR	0.1 mg/l	

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Parameter	Project criterion*	Lab method	Method Detection Limit (MDL)	Improved MDL needed?
Phenols	0.005 µg/l	W-PHI-PHO	0.005 mg/l	
Total nitrogen	10 mg/l	W-NTOT	1 mg/l	
Total coliform bacteria	400 MPN/100ml	W-COLIF	-	

* may vary according to river catchment – lowest shown

In compliance with the Biodiversity Management Plan (BMP), aquatic invertebrate indicators must be monitored at a selection of surface water locations on an annual basis when Project activities start. The details of the programme will be confirmed prior to start of construction.

7 GROUNDWATER

7.1 MONITORING NETWORK

7.1.1 Groundwater Monitoring Wells

Appendices C and D include, respectively, a table and figure indicating all groundwater monitoring wells that have been installed at Amulsar. There are 60 groundwater wells historically installed at Amulsar, but not all are serviceable or are deemed to require continuous monitoring. The majority of wells in the network are installed piezometers; however a number of the older wells are of uncertain construction and may be open wells, cased only in the upper few metres. All wells installed prior to 2013 are assumed to have no annular grout above the screen section and therefore are effectively open through their entire saturated length. Many monitoring wells in the network have failed as a result of unstable ground conditions or construction issues. Rehabilitation of some monitoring wells (clean out, repair or re-drilling) may be necessary to implement monitoring during future Project phases.

Certain of the wells included in the plan have historically been recorded as dry. However, in no case has this been established over the full annual cycle. It is necessary to establish that the wells remain dry throughout the year (i.e. that they are recorded dry in all four quarterly monitoring rounds) before they can be removed from the EMP.

All of the monitoring wells used for current and historical monitoring require surveying to establish a reliable reference elevation. The reference datum for monitoring is the top of headworks for all wells, or top of installation pipe where no external headworks are fitted. The reference datum surveyed should be recorded during surveying. This is a one-off exercise, although some of the wells could be surveyed annually to confirm no changes.

Groundwater has been encountered at a range of depths across the regional study area. In some areas (e.g. Site 14 and Site 28 (the proposed HLF location)) a distinct perched water table within shallow superficial deposits has been identified situated above the regional water table, which occurs in the bedrock at depth. In these areas, paired monitoring wells are present at some locations so as to monitor both units. Based on the current hydrogeological understanding, groundwater encountered in fractured silicified rocks in the mountain peak (pit) area is also perched, and predominantly discharges to springs surrounding the mountain peak. However, in this area wells are installed only in the perched groundwater and are not believed to extend to the regional water table (continuously saturated zone).

7.1.2 Springs

Springs are discharges of groundwater at surface. The water discharging from springs is chemically distinct from surface water, and representative of water quality in the aquifer which feeds the springs. Spring discharges are a key component in understanding the water balance of an area, which allows quantification of groundwater recharge rates and informs understanding of groundwater flow.

A number of permanently flowing springs has been identified surrounding the Erato, Tigranes and Artavazdes peaks of Amulsar. The locations of all known springs are tabulated in Appendix C and shown on the drawings in Appendix D. The spring elevations are not accurately known at present; therefore surveying of the locations is required.

7.2 MONITORING PROGRAMME

During the pre-construction phase, groundwater monitoring and sampling will be undertaken at 10 existing wells as indicated in Table 13. It is recognised that there is a lack of groundwater information relating to the BRSF site, and it is considered necessary to install five additional monitoring wells at this location as soon as possible. In advance of these new wells being installed, the existing wells in the BRSF vicinity will be checked and will be sampled if any of them contain water.

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Table 13: Groundwater Monitoring Wells to be Sampled

Identifier	Location	Notes from ESIA	Justification for monitoring
RCAW408*	T/A pit, west		Monitoring of pit area.
DDAW007	Erato pit, east	Lower 30m collapsed; water level assumed to be perched.	
DDAW009*	Erato pit, west	Lower 40m collapsed but water levels similar to installation.	
DDGW002	Vorotan, SE of T/A pit		Down-gradient Vorotan sample.
DDGW005	Vorotan, east of BRSF		Up-gradient Vorotan sample.
GGDW016A**	HLF		Nested pair in HLF footprint.
GGDW016**	HLF		
GGDW013A*	HLF		Nested pair in HLF footprint.
GGDW013*	HLF		
GGDW011*	HLF	Well collapsed during installation. Water levels likely perched in colluvium.	Up-gradient HLF location.
(TBC)	South of BRSF		Up-gradient of BRSF
(TBC)	South of BRSF		
(TBC)	North of BRSF		Down-gradient of BRSF
(TBC)	North of BRSF		
(TBC)	North of BRSF		

* Groundwater level monitoring transducer in place prior to June 2015, but removed due to increased incidence of theft

** Transducer stolen Q2 2015

During the construction phase it is likely that other wells will need to be installed, in addition to those required around the BRSF as noted above. This requirement will be confirmed during detailed Project design, but is likely to include two additional monitoring wells at the HLF (down-gradient of the pad and process pond), and three wells surrounding the pits, to replace wells that will be destroyed during operations (east of Tigranes-Artavazdes, at lower elevation than RCAW406; west of Tigranes-Artavazdes; and west of Erato). The procedure for supervision of monitoring well installation is described in a method statement in Appendix A.

7.2.1 Groundwater Level Measurement

7.2.1.1 Manual Measurement

Manual measurement of groundwater levels is made using a water-level meter lowered into the well from surface until the water surface is encountered. The depth to water is recorded relative to the monitoring reference datum (top of headworks or top of installation pipe) and then adjusted to make relative to ground level. The reference datum point must also be noted at the time of measurement. The water-level meter must be designed for groundwater level measurement, incorporating a calibrated, non-stretch measuring tape with graduated markings at a minimum of 1 cm intervals. Three repeated readings are to be taken, with the tolerable uncertainty for the readings being +/- 1 cm.

The depth to the bottom of each monitoring well will be checked annually, using a water-level meter or specifically adapted weighted measurement tape.

A method statement describing the procedure that will be followed to undertake manual water level measurements in groundwater monitoring wells is included in Appendix A.

7.2.1.2 Continuous Measurement

Continuous measurement of water levels may be achieved by installing a water-level data logger (pressure transducer) in a monitoring well. The pressure transducer is placed within the borehole at a depth below the minimum seasonal groundwater level but within the operational range of the transducer (normally 20m). The logger automatically records the water pressure acting on the sensor due to the overlying water column at a frequency specified by the user. The transducers are placed in each borehole with the depth of placement below the reference monitoring datum recorded; either by reference to the measured logger position above the measured borehole base (recorded prior to installation using the water-level meter) or by measurement of the suspension cable prior to installation. The serial number of the pressure transducer installed at each location must be recorded at the time of installation. For monitoring at Amulsar, loggers should be set on a minimum interval of six hours.

A method statement describing the procedure that will be followed during installation of pressure transducers is presented in Appendix A. The water level of the well must be recorded prior to logger installation, at any time the logger position is adjusted to access the borehole, and prior to removal of the logger for download.

Transducer data must be downloaded on a frequency such that the maximum memory capacity of the data logger is not exceeded between downloads. Three-month download intervals are recommended, although a period of six months is allowable, based on a six hourly recording interval.

Transducer data must be corrected with barometric data, which is to be downloaded at same time as pressure transducers are downloaded. The water level recorded by the pressure transducers will be verified by comparison with manual water level measurement.

The locations to be monitored where transducers were previously installed are identified in Table 13. However, due to a marked increase in thefts, all transducers were removed from the field in early June 2015.

7.2.2 Groundwater Quality Monitoring

Groundwater quality monitoring incorporates collection of water samples for laboratory analysis, and measurement of a number of in-field quality parameters which degrade in stored samples.

7.2.2.1 Quality Monitoring in Groundwater Monitoring Wells

A number of methods can be applied to sample water in groundwater wells. Three methods are used at Amulsar:

- Low flow sampling using a bladder pump, applied in deep wells which cannot easily be sampled using other pumping methods;
- Standard flow sampling using inertial flow pumps in shallow and intermediate depth wells; and
- Manual sampling using either Teflon (PFTE) tubing with a foot valve, or a bailer.

The column of water which is present inside the groundwater monitoring well installation may have a different chemistry to the surrounding aquifer formation, because this water has been exposed to the atmosphere. Before the water is collected for laboratory analysis, efforts should be made to ensure that the sample will be representative of water quality in the aquifer formation and not of the standing water in the borehole. This is achieved by purging water from the borehole as described below, and checking the water quality using field-measured parameters.

In the first method listed above, water is removed from the well at a low flow rate such that the column of water in the borehole is not disturbed, and water is drawn in horizontally from a small vertical interval surrounding the pump. Pumping is undertaken and field quality parameters (pH, temperature, conductivity and dissolved oxygen) are recorded. These parameters change as the captured water quality changes, and sampling may be undertaken when stable water quality is observed: at this point it is considered that the water being drawn into the well is representative of the surrounding formation.

In the other two methods listed above, the standing water is removed from the well by purging (pumping out) at least three times the volume of the well, with field parameters being recorded after each volume. Purging should continue until the measured parameters do not change significantly after each volume (i.e. within the tolerable uncertainty range listed in **Error! Reference source not found.**). The water is now considered to be representative of the surrounding formation and can be sampled. The procedure that will be followed to record field parameter measurements is described in a method statement presented in Appendix A.

Water purged from boreholes may be discharged to ground without the requirement for collection and disposal. However, the discharge point must be located a sufficient distance from the borehole that the risk of infiltration of water into the borehole through the collar is minimised.

Where multiple wells are present at a monitoring location, the shallow installation or monitoring well must be sampled first, followed by the deeper installation or monitoring well.

Water samples must be collected in clean, sterile, air tight, non-leaching sample bottles; suitable sample bottles are supplied by analytical laboratories and the bottles recommended by the laboratory for each analysis type will be used. Where preservatives are used to prevent deterioration of the samples in storage and transit (e.g. for metals analysis), samples must be filtered using a 45 µm filter. The procedures to be followed to take groundwater samples using the two methods described above are described in method statements included in Appendix A.

Groundwater samples will be analysed as described in Section 6.3 for surface water samples and as per the analytical schedule shown in Table 12.

Table 14: In-field Measurements for Groundwater Sampling

Parameter	Units	Tolerable Uncertainty*	Limit of Detection
pH	pH units	+/-0.5 units	0.01 units
Temperature	°C	+/-0.5 °C	0.01 °C
Electrical Conductivity	µS/cm	+/-10% of average reading	1 µS/cm
Dissolved Oxygen	mg/l	+/-1 mg/l	0.01 mg/l

Note: previous versions of this EMP listed turbidity as a parameter for measurement, largely because the equipment in use at the time allowed its measurement. Research confirms that it is not essential as long as the other parameters are measured (e.g. see <https://www.ysi.com/File%20Library/Documents/Application%20Notes/A532-Low-Flow-Sampling-of-Water-Quality-Determines-Groundwater-Stability.pdf>)

*This is the uncertainty of measurement allowed between 3 consecutive readings before the value is recorded.

8 SOILS

A total of 93 soil samples were obtained from the Project site in 2008 - 2010 as part of the environmental baseline sampling programme (see drawing in Appendix D). These samples were submitted for multi-element chemical analysis, giving an indication of baseline soil chemical quality.

In order to validate the ESIA and confirm that impacts to soils are not significant, soils analysis from these same locations will be conducted on a regular basis, with a minimum frequency of every 3 years.

In addition, annual soil sampling for chemical analysis will take place during the operational phase for topsoils adjacent to the open pits, crushing plant, BRSF and HLF.

Soil erosion surveys will be undertaken twice annually: on or before the onset of winter snowfall, to determine areas where additional protection (i.e. use of geotextile) is required; and after snow melt, to determine any areas affected by erosion. Method statements for these surveys will be developed so that consistent monitoring can be conducted. Soil surveys will be augmented by continual visual observation during and following precipitation events, which will consequently require training of appropriate individuals.

The above work will be commenced after construction starts and will be detailed in an updated version of this EMP.

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9 ECOLOGY

The Biodiversity Management Plan (BMP) identifies a number of monitoring requirements, including day-to-day observations and formal, periodic surveys undertaken by specialists. The BMP addresses actions to be taken in relation to the implementation of the Project on site. A separate document, the Biodiversity Action Plan (BAP), is concerned with actions that need to take place in the wider region (for example the establishment of a biodiversity offset) and which will generally be undertaken by specialist teams. The BAP actions are generally not within the scope of this EMP, except where there is overlap with the BMP, and therefore specific BAP actions are not included in this EMP.

Monitoring actions required by the BMP apply from the start of construction, and will be detailed in a later version of this EMP.

10 FLORA

Baseline data have shown that concentrations of some heavy metals are elevated in soil and groundwater samples in the Amulsar area, as a natural consequence of the presence of the ore body. Information is needed on whether the presence of naturally elevated heavy metal concentrations in the environment is reflected by the metal content of fruits, vegetables and wild herbs that are harvested in the area.

The initial work programme will comprise collecting ten samples of fruit and vegetables, and five samples of wild herbs, on each of three occasions, and subjecting them to laboratory analysis for a selected suite of heavy metals (antimony, arsenic, chromium, cobalt, copper, lead, mercury and nickel) together with cyanide.

Sampling locations will be determined as the Project design progresses. Of particular importance will be to establish a baseline for fruits or vegetables that may be grown in proximity to the HLF once mining starts.

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11 CULTURAL HERITAGE

The Cultural Heritage Management Plan (CHMP) requires the development of an Archaeological Monitoring Execution Procedure in order to guide the day-to-day implementation of the chance finds procedure (CFP). Appropriate training will be given to all staff regarding the CFP as part of the site inductions.

Monitoring actions required by the CHMP apply from the start of construction, and will be detailed in a later version of this EMP.

12 SUMMARY MONITORING SCHEDULE

A summary of the environmental monitoring schedule is presented in Table 15. Quarterly monitoring best captures the seasonal range if completed in February, May, August and November. It is essential that the full seasonal range of data is captured, including the winter monitoring round when conditions allow.

Where continuous measurement of surface water flow and groundwater level is specified, locations are also included in the requirements for quarterly manual monitoring. A manual measurement should be made during this visit to calibrate the digital measurements.

Table 15: Amulsar Environmental Monitoring Schedule

Category	Monitored Parameters	Frequency	Locations
Climate	Temperature, wind speed, wind direction, humidity, rainfall, atmospheric pressure	Continuous (download quarterly)	Camp meteorological station HLF meteorological station
Air Quality	Total suspended particulates, PM ₁₀ , PM _{2.5}	Periodic to establish baseline	Kechut, Gndevaz, BRSF, SW of pits
	NO ₂ and SO ₂	Continuous (monthly data recovery) for six months	Saravan, Gndevaz, Gorayk, Kechut and Jermuk (existing locations)
		Continuous (monthly data recovery)	Saravan, Gndevaz, Gorayk, Saralanj, Kechut, Jermuk (new locations)
	Dust	Continuous (monthly data recovery) for six months	Saravan, Gndevaz, Gorayk, Saralanj, Kechut, Jermuk, east of Gndevaz, east of Kechut, BRSF, SW of pits
Noise	Noise level, including hourly noise level (L _{Aeq} and L _{A90}),	None required pre-construction	Jermuk, Kechut, Gndevaz, Saravan, Saralanj, and Gorayk
Surface water	Continuous flow	Continuous recording	13 locations (Table 9)
	Spot flow	Quarterly; weekly during Spring melt.	58 locations (Table 9)
	Water quality sampling	Quarterly	12 locations (Table 10)
Groundwater	Groundwater level	Quarterly (or continuous where transducers installed)	Eight locations (Table 13) plus routine download from transducers; also any monitoring well at the BRSF that is found to contain water, plus new BRSF wells when installed
	Water quality	Quarterly	Ten locations (including two springs; Table 13) plus any well at BRSF found to contain water, plus new BRSF wells when installed.

13 PROJECT COMPLIANCE TARGETS

The Project is committed to complying with relevant IFIs guidelines and/or national standards for environmental releases, whichever is more stringent. This section presents the specific compliance criteria for the various environmental release categories that could result from Project implementation. Further details may be found in Section 2.4 of the ESIA v10 or as otherwise referenced.

13.1 AIR QUALITY

The air quality standards to be adopted by the Project are based on those of the IFC Environmental, Health and Safety (EHS) Guidelines (2007) and EU Directive 2008/50/EC, as identified in Table 16.

Table 16: Ambient Air Quality Standards

Pollutant	Receptor	Averaging Period	Guideline Value for human health in $\mu\text{g}/\text{m}^3$	Critical Level for vegetation in $\mu\text{g}/\text{m}^3$
Sulphur Dioxide (SO_2)	Human	24-Hour	20	N/A
	Vegetation	Calendar Year and Winter (1 October to 31 March)	N/A	20
Oxides of Nitrogen (NO_x)	Vegetation	Calendar Year	N/A	30
Nitrogen Dioxide (NO_2)	Human	Calendar Year	40	N/A
Particulate Matter PM_{10}	Human	24-hour	50	N/A
Particulate Matter $\text{PM}_{2.5}$	Human	24-hour	25	N/A
Ozone	Human	N/A	N/A	N/A
Notes: The 24-hour referencing period for human health criteria has been selected for Compliance Target that for the Project will be based on the Guideline Values and monitored biannually. Ambient Air Quality Guidelines for Human Health are from the IFC EHS Guidelines, and Critical Levels for Vegetation are from EU Directive 2008/50/EC.				

The Air Quality, Noise and Vibration Management Plan for the Project provides the following compliance trigger levels and targets:

Passive monitoring tube:

Compliance trigger level:	NO_2 - 20 $\mu\text{g}/\text{m}^3$ over a one month period
	SO_2 - 10 $\mu\text{g}/\text{m}^3$ over a one month period
Compliance target:	NO_2 - 40 $\mu\text{g}/\text{m}^3$ over a one month period
	SO_2 - 20 $\mu\text{g}/\text{m}^3$ over a one month period

Dustscan gauge:

Compliance trigger level:	%EAC 2.5 for a period of 2 consecutive weeks
Compliance target:	%EAC 2.5-5

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13.2 NOISE

The noise standards to be adopted by the project are based on Armenian Order No.138 and the IFC EHS Guidelines, as identified in Table 17.

Table 17: Noise Standards

Receptor Edge of community closest to mine	A-weighted broadband sound pressure level, $L_{Aeq,1hr}$ (dB)	
	Daytime (07:00-22:00)	Night time (22:00-07:00)
Absolute noise level (compliance criteria - not to be exceeded)	45 ^a	45 ^b
Predicted site noise level should not exceed the background (or ambient) by:	+3 ^b	+3 ^b
Notes: Compliance is measured at residential properties within communities Source of compliance criteria: ^a Republic of Armenia Order 138; norm 9 and 12 ^b IFC EHS Guidelines		

Standards for air overpressure related to blasting and for ground vibration are based on those of the Australian and New Zealand Environment Conservation Council (ANZECC) (1990), as indicated in Table 18.

Table 18: Airblast and Ground Vibration Standards

Criterion	Recommended Limit
Maximum level for airblast	115 dBL ^a
Maximum ground vibration	5 mm/s, Peak Vector Sum (PVS) vibration ^b
Notes: ^a The level of 115 dBL may be exceeded on up to 5% of the total number of blasts over a period of 12 months. The level should not exceed 120 dBL at any time. ^b PVS level of 5 mm/s may be exceeded on up to 5% of the total number of blasts over a period of 12 months. The level should not exceed 10 mm/s at any time.	

13.3 WATER

Project water quality standards have been developed for discharge of treated domestic wastewater (Table 19) and industrial effluent (Table 20), and for receiving water (Table 21).

Table 19: IFC Indicative Values for Treated Sanitary Sewerage Discharges

Pollutant	Units	Guideline Value ^a
pH	pH	6 – 9
BOD	mg/l	30
COD	mg/l	125
Total nitrogen	mg/l	10

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Pollutant	Units	Guideline Value ^a
Total phosphorus	mg/l	2
Oil and grease	mg/l	10
Total suspended solids	mg/l	50
Total coliform bacteria	MPN ^b /100 ml	400 ^c
Notes: a. The compliance point is 500m from the discharge outlet. b. MPN = most probable number c. Not applicable to centralized, municipal, wastewater treatment systems, which are included in EHS Guidelines for Water and Sanitation.		

Table 20: IFC Guidelines for Mining Effluent

Determinand	Guideline value (µg/l)
pH	6 - 9
Temperature °C	<3 differential
Biochemical Oxygen Demand (BOD)	50mg/l
Chemical Oxygen Demand (COD)	150mg/l
Oil and Grease	10
Total Suspended Solids (TSS)	50 mg/l
Arsenic	100
Phenols	500
Cadmium	50
Copper	300
Chromium (VI)	100
Cyanide	1000
Cyanide Free	100
Cyanide WAD	500
Iron (total)	2000
Lead	200
Mercury	2
Nickel	500
Zinc	500
Note: metals concentrations are total concentrations	

Table 21: Standards for Receiving Water Quality

Quality indicators	Arpa Catchment	Vorotan Catchment	Unit	Source
Ammonium ion	0.4	0.4	mg N/l	RA Decree N75-N Basin specific standards, Appendices 3 - 25
Chloride ion	6.88	8	mg/l	RA Decree N75-N Basin specific standards, Appendices 3 - 25
Nitrate ion	2.5	2.5	mg N/l	RA Decree N75-N Basin specific standards, Appendices 3 - 25
Nitrite ion	0.06	0.06	mg N/l	RA Decree N75-N Basin specific standards, Appendices 3 - 25
Phosphate ion	0.1	0.1	mg/l	RA Decree N75-N Basin specific standards, Appendices 3 - 25
Phosphorus, Total	0.2	0.2	mg/l	RA Decree N75-N Basin specific standards, Appendices 3 - 25
Sulphate ion	16.04	17.02	mg/l	RA Decree N75-N Basin specific standards, Appendices 3 - 25
Total inorganic nitrogen	4	4	mg N/l	RA Decree N75-N Basin specific standards, Appendices 3 - 25
Total mineralization	131.88	110	mg/l	RA Decree N75-N Basin specific standards, Appendices 3 - 25
Aluminium	144	284	µg/l	RA Decree N75-N Basin specific standards, Appendices 3 - 25
Antimony, total	0.28	0.5	µg/l	RA Decree N75-N Basin specific standards, Appendices 3 - 25
Arsenic, total	20	20	µg/l	RA Decree N75-N Basin specific standards, Appendices 3 - 25
Barium	28	12	µg/l	RA Decree N75-N Basin specific standards, Appendices 3 - 25
Beryllium	0.038	0.054	µg/l	RA Decree N75-N Basin specific standards, Appendices 3 - 25
Boron	450	450	µg/l	RA Decree N75-N Basin specific standards, Appendices 3 - 25
Cadmium, total	1.014	1.01	µg/l	RA Decree N75-N Basin specific standards, Appendices 3 - 25
Calcium	100	100	mg/l	RA Decree N75-N Basin specific standards, Appendices 3 - 25
Chromium, total	11	10.5	µg/l	RA Decree N75-N Basin specific standards, Appendices 3 - 25

Quality indicators	Arpa Catchment	Vorotan Catchment	Unit	Source
Cobalt, total	0.36	0.28	µg/l	RA Decree N75-N Basin specific standards, Appendices 3 - 25
Copper, total	21	22	µg/l	RA Decree N75-N Basin specific standards, Appendices 3 - 25
Cyanide, total	10	10	µg/l	Commercial laboratory method detection limit
Iron, total	0.072	0.16	mg/l	RA Decree N75-N Basin specific standards, Appendices 3 - 25
Lead, total	10.14	10.14	µg/l	RA Decree N75-N Basin specific standards, Appendices 3 - 25
Lithium	3	2	µg/l	RA Decree N75-N Basin specific standards, Appendices 3 - 25
Magnesium	50	50	mg/l	RA Decree N75-N Basin specific standards, Appendices 3 - 25
Manganese, total	12	8	µg/l	RA Decree N75-N Basin specific standards, Appendices 3 - 25
Mercury (total)	0.3	0.3	µg/l	RA Decree N75-N Appendix 2, National standards
Molybdenum, total	0.82	2	µg/l	RA Decree N75-N Basin specific standards, Appendices 3 - 25
Nickel, total	10.34	10.45	µg/l	RA Decree N75-N Basin specific standards, Appendices 3 - 25
Potassium	3.12	4.46	mg/l	RA Decree N75-N Basin specific standards, Appendices 3 - 25
Selenium, total	20	20	µg/l	RA Decree N75-N Basin specific standards, Appendices 3 - 25
Silicate ion	25	23.64	mg Si/l	RA Decree N75-N Basin specific standards, Appendices 3 - 25
Sodium	10	8.46	mg/l	RA Decree N75-N Basin specific standards, Appendices 3 - 25
Tin, total	0.08	0.16	µg/l	RA Decree N75-N Basin specific standards, Appendices 3 - 25
Vanadium, total	10	16	µg/l	RA Decree N75-N Basin specific standards, Appendices 3 - 25
Zinc, total	100	100	µg/l	RA Decree N75-N Basin specific standards, Appendices 3 - 25
Oil products	0.1	0.1	µg/l	RA Decree N75-N Appendix 2, National standards

Quality indicators	Arpa Catchment	Vorotan Catchment	Unit	Source
Phenols	0.005	0.005	µg/l	RA Decree N75-N Appendix 2, National standards
Biochemical Oxygen Demand (BOD5)	5	5	mgO ₂ /l	RA Decree N75-N Basin specific standards, Appendices 3 - 25
Chemical Oxygen Demand (COD-Cr)	25	25	mgO ₂ /l	RA Decree N75-N Basin specific standards, Appendices 3 - 25
Chemical Oxygen Demand (COD-Mn)	10	10	mgO ₂ /l	RA Decree N75-N Basin specific standards, Appendices 3 - 25
Colour	<5 (natural)	<5 (natural)	degree	RA Decree N75-N Basin specific standards, Appendices 3 - 25
Dissolved oxygen	>6	>6	mgO ₂ /l	RA Decree N75-N Basin specific standards, Appendices 3 - 25
Electroconductivity	215.62	162	µS/cm	RA Decree N75-N Basin specific standards, Appendices 3 - 25
Hardness	10	10	mg-equ/l CaCO ₃	RA Decree N75-N Basin specific standards, Appendices 3 - 25
Odour (20°C and 60°C)	<2 (natural)	<2 (natural)	points	RA Decree N75-N Basin specific standards, Appendices 3 - 25
pH	6.5-9.0	6.5-9.0		RA Decree N75-N Appendix 2, National standards
Suspended particles	6.8	5.5	mg/l	RA Decree N75-N Basin specific standards, Appendices 3 - 25

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13.4 SOIL

Standards for soil quality have been adopted as indicated in Table 22.

Table 22: Standards for Soil Quality

Substance	MAC ^a	CCME (1999), Agricultural Soils ^b	Baseline Conditions (mg/kg)				Compliance criterion ^e (mg/kg)	
			Maximum Concentration (All Data) ^c	Open Pit (OP) ^d	Barren Rock Storage Facility (BRSF) ^d	Heap Leach Facility (HLF) ^d		
				Max. Concentration	Max. Concentration	Max. Concentration		
Arsenic	2	12	161	161	20.5	13.4	OP BRSF HLF	190 23.6 15.4
Cobalt	5	40	38	18.3	31	30.8		40
Copper	3	63	97.4	55.6	79	42.2	OP BRSF HLF	63 93 63
Mercury	2.1	6.6	0.6	0.1	0.1	0		6.6
Manganese	1,500	--	1680	1040	1680	1400		1967
Nickel	4	50	101	59.2	58.8	84.6	OP BRSF HLF	68 67.6 100
	20	70	288	288	19.6	20.5	OP BRSF HLF	339 70 70
Zinc	N/A	200	126	96.9	100	127.1		200
Antimony	4.5	20	137	47.4	2.4	2.4	OP BRSF HLF	56 20 20

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Substance	MAC ^a	CCME (1999), Agricultural Soils ^b	Baseline Conditions (mg/kg)				Compliance criterion ^e (mg/kg)	
			Maximum Concentration (All Data) ^c	Open Pit (OP) ^d	Barren Rock Storage Facility (BRSF) ^d	Heap Leach Facility (HLF) ^d		
				Max. Concentration	Max. Concentration	Max. Concentration		
Vanadium	150	130	108	83.4	101	103		130

Notes:

^a Ecological norms for soil quality expressed as Maximum Allowable Concentrations (RA standards)

^b Canadian Council of Ministers for the Environment - Soil Quality Guidelines, see: http://www.ccme.ca/ourwork/soil.html?category_id=44

^c Data from sampling points within the Project boundary

^d Data from sampling points within area of the Project, where soil will be removed during construction

^e Compliance targets identified as:

Where the natural background concentrations, as measured within the soil, exceed the MAC and CCME, the compliance target is set at the maximum recorded area concentration + 15% tolerance. Otherwise compliance targets are identified to conform with CCME requirements for agricultural soils.

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14 DATA MANAGEMENT AND RECORD KEEPING

The ESMS Standard 11 describes how Lydian manages its documented information associated with its Health, Safety, Environment and Community (HSEC) Management System.

Electronic data from monitoring devices will be downloaded to laptop computers in the field and the data files will then be transferred to the environmental data repository on the Lydian/Geoteam server.

Data recorded manually in the field will be transcribed to suitable electronic files and stored on the Lydian/Geoteam server.

Laboratory analysis results will be checked for internal consistency and for anomalous results (results significantly outside the normal range for the location or area) either prior to or immediately following upload, so that any anomalous results can be addressed with the laboratory in a timely fashion and whilst the laboratory is still in possession of the sample. The procedures to be followed for checking of incoming data are described in Section 15.4.

Water analytical data will be transcribed into Geoteam's EHS Monitor Pro database system.

A brief quarterly monitoring report will be produced within one month of the end of each Quarter. Quarterly monitoring reports will be filed on the Lydian/Geoteam server.

Monitoring data will be maintained for a minimum of ten years following mine closure, in accordance to the site data management procedures.

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15 QUALITY ASSURANCE

15.1 WATER LEVEL DATA FROM LEVEL LOGGERS

Pressure transducers and data loggers are used to record water level data in a number of boreholes. These will be retrieved quarterly when possible (some are inaccessible for longer periods during winter). All pressure transducers have a manufacturer's specification that details the full scale of water depth that the specific model can record with an associated accuracy of measurement.

Following the download of the water-level data recorded by the pressure transducers and data loggers, the data will be analysed to determine that the full scale of water depth that the pressure transducer can measure was not exceeded.

The elevation of the data logger sensor will be calculated from the water level measurement recorded at the time of installation. The water level elevation over the monitored period will be calculated from the sensor elevation and corrected pressure record. The calculated groundwater elevations from the manual dips measured prior to the removal of the transducer from the borehole will be compared with the elevation measurement from the pressure transducer. The tolerable uncertainty for the difference in these elevations is +/-10 cm. If this tolerance is exceeded, action will be taken to investigate any cause of error in the logged data. This will include actions such as investigating incorrect placement resulting in slipping of the logger during monitoring; reviewing the potential for stretching of the suspension cable and replacing with materials less susceptible to stretching; reviewing water quality data for the monitoring location to confirm whether discrepancy may be caused by density effects; and, if no physical problems are identified, downloading of the diagnostics utility function of the data logger software to test the equipment and obtain a memory dump suitable for discussion with technical support from the supplier. If accuracy problems cannot be solved via discussion with technical support, the pressure transducer will need to be replaced.

15.2 QUALITY ASSURANCE OF WATER ANALYTICAL DATA

Field blanks, equipment blanks and duplicate samples will be collected as part of the monitoring quality assurance procedure. At least one field blank, one equipment blank, and one duplicate water sample will be collected per quarterly monitoring round.

The field blank will consist of a sample of deionised water that will be taken into the field and will be discharged into sample bottles in the same fashion, and subjected to the same storage and transport procedures, as the sample bottles being filled in the field during one day of monitoring. Analysis will be carried out on the field blank for those indicator parameters and contaminants of potential concern which are liable to be affected by the sample collection, transport and storage procedures: metals, ammoniacal nitrogen, Total Organic Carbon (TOC), conductivity and pH.

The equipment blank will consist of a sample of deionised water which has been passed through the sampling pump and sample lines after cleaning. The equipment blank will be analysed for substances that are distinguishing features of the chemical signature of the water to be sampled: iron, manganese, barium and sulphate.

The duplicate sample will be taken at a selected monitoring location and will comprise a full second sample taken immediately following collection of the scheduled sample at the sampling location. The duplicate will be given a unique identifier that does not imply which water sample it duplicates. A comparison of the duplicate samples will be undertaken using a relative percent difference analysis. This will be defined using the equation below and the benchmark is anticipated to be within +/-10%.

$$\text{Relative Percentage Difference} = \frac{\text{Lab1value} - \text{Lab2value}}{\text{Total of Lab values}} \times 100$$

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15.3 CALIBRATION OF WATER QUALITY FIELD PROBES

All instrumentation will be calibrated in accordance with manufacturer's instruction.

The YSI Multimeter used to measure in-field water parameters will be calibrated daily before use, using standard calibration solutions.

All instruments will be maintained in accordance with manufacturer's instructions, and will be function-checked prior to use to check that they are working correctly.

15.4 GROUNDWATER AND SURFACE WATER DATA HANDLING PROCEDURES

Where data is recorded on paper in the field and transferred to electronic media prior to upload to the Monitor Pro database, checks will be completed to verify the accuracy of the data transfer from paper to electronic media. This check will be undertaken on the transferred data by an internal third party (not the author), who should check every value in the transferred data set.

The following quality assurance procedures will be undertaken for laboratory samples either prior to or immediately following upload to the Monitor Pro database:

- Check that the analytes requested in the analysis schedule (chain of custody) submitted to the laboratory have been analysed at the detection limits requested;
- Where metals analysis is completed for total and dissolved metals, confirm that the dissolved result is less than or equal to the dissolved result. If not, investigate any discrepancies with the laboratory;
- Review the analysis for field and equipment blank samples. Investigate the occurrence of any above-detection results. Detections in the equipment sample of contaminants of potential concern are of significance to the monitoring programme and, if verified, will be addressed by implementing changes to the decontamination procedure. Detection of substances in the field blank may suggest that contamination of the samples is occurring during handling. Detections will be verified with the laboratory and action taken to investigate possible contamination sources and address them;
- Calculate the relative percentage difference between paired duplicate samples using the method described in Section 15.2. Where the acceptable tolerance of +/- 10% is exceeded, confirm the reported result with the laboratory. If significant variance remains between the duplicate samples, this will be carried forward for investigation at the next monitoring round and to inform the understanding of uncertainty associated with the reported results;

The findings of these quality assurance checks will be documented for every sampling round and records held at the Lydian/Geoteam site and main offices.

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16 PERFORMANCE MONITORING

The ESMS Standards 14 – Monitoring, Measurement, Analysis and Analysis of Compliance, 15 – Internal Audit, and 16 - Management Review describe how Lydian manages its performance evaluation associated with its HSEC Management System.

16.1 VERIFICATION AND MONITORING

Whenever monitoring indicates a non-conformance related to Project standards, requirements and commitments, Geoteam will carry out an investigation to determine the cause. Geoteam reserves the right to issue a Non-conformance Report (NCR), Corrective Action Request (CAR), Work Improvement Notice (WIN) or Temporary Work Suspensions (TWS), as appropriate, to the relevant entity, which will include a time frame for addressing the issue.

In addition to internal verification and monitoring and audits conducted by Geoteam, external audits may also be carried out by recognised third parties including Armenian regulatory authorities.

All non-conformances, investigations and resulting corrective actions will be documented in the appropriate Quarterly Monitoring Report.

16.2 REVIEW OF INCIDENTS WITH AUTHORITIES

Geoteam will cooperate fully with the competent authorities in any investigation and review of accidents and incidents.

16.3 ESMS MANAGEMENT REVIEW

The Environmental Manager will ensure that all activities covered by this EMP are duly discussed in the ESMS Management Review meetings. As appropriate, the Environmental Manager will provide information on the performance of the plan and recommendations for further improvement.

16.4 ANNUAL AUDIT

The Environmental Manager and the Sustainability and Permitting Senior Manager will ensure that all activities and contingency plans covered by this EMP are subject to an ESMS audit (the minimum frequency will be annual). The results of audits are to be discussed during annual management meetings, where the management team will provide information on the performance of site operations and recommendations for improvement.

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17 SUPPORTING DOCUMENTS

The following documents are used to support and implement this EMP:

- Document Control Procedure (Ref GEOTEAM-ENV-PRO0210);
- Air Quality, Noise and Vibration Management Plan (AQNVMP);
- Cultural Heritage Management Plan (CHMP);
- Acid Rock Drainage Management Plan (ARDMP);
- Biodiversity Management Plan (BMP);
- Integrated Waste Management Plan (IWMP); and
- Surface Water Management Plan (SWMP).

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18 DEFINITIONS

See also *Lydian HSEC STA 02 Glossary of HSEC Terms and Acronyms*.

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19 REFERENCES

- British Standards Institute OHSAS 18001:2007 Occupational Health and Safety Management Systems – Requirements
- International Organization for Standardization ISO 14001:2015 Environmental Management Systems – Requirements with Guidance for Use
- International Finance Corporation (IFC) Performance Standards on Environmental and Social Sustainability, 2012.

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20 REVISION CONTROL

REVISION CONTROL TABLE				
Version No.	Date	Pages(s)	Section(s)	Purpose of the Modification
Initial Release	February 3, 2016	All	All	Initial version developed by Alan Blakemore
1				
2				

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21 AUTHORIZATION

Approved By: _____ Date _____
Executive Vice President Sustainability

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Appendix A

Method Statements

 GEOTEAM EMP MS-01	Amulsar Gold Project Method Statement for Download of Surface Water Data Loggers and Manual Stage Measurement Revision 1, June 2015
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SCOPE

This Method Statement (MS) details the procedures for download of data from surface water pressure transducer data loggers at continuous flow gauging locations, and manual recording of gauge board levels.

GENERAL INSTRUCTIONS

- In the event that a step in the MS procedure cannot be completed, or in case of any uncertainty, all work is to stop, the equipment made safe, and the Environmental Manager consulted.
- All staff involved in the work must have completed a site induction training course and have received training in the use of equipment covered by this MS.
- All work will be undertaken utilising the correct Personal Protective Equipment (PPE) as specified in this method statement.
- Work adjacent to rivers is hazardous and should be managed through an appropriate safe system of work.

RELATED DOCUMENTATION

- Level Troll 100 and Level Troll 200 Operator's Guide.
- Environmental Monitoring Plan (EMP; GEOTEAM-ENV-PLN0225).
- Occupational Health & Safety Plan (GEOTEAM-HSE-PLN-0016).

SPECIAL TOOLS, MATERIALS AND EQUIPMENT

- Appropriate PPE. Minimum requirement: high visibility vests; hand protection (gloves); protective footwear; and a lifejacket when sampling water courses exceeding 1.0 m in width;
- Gauge board clean/repair kit: cloth and/or brush, black marker or black paint;
- Field laptop;
- Copies of related documentation identified above, if required;
- Docking station for Troll 100s;
- Com unit for Troll 200s;
- Wire Snips;
- Wire;
- Plastic ties;
- Paper towels;
- Maps/site plans;
- GPS;
- Camera; and
- Mobile phone.

CONTINGENCY PLAN

In the event of any abnormal incident, cease work, make the area safe and contact the Environmental Manager or Health & Safety Manager.

PROCEDURE

1. Before leaving for site, check all equipment is packed and check battery levels on laptop and camera. Ensure that docking station and com unit software is installed on the laptop.
2. On arrival at the monitoring location, take upstream and downstream photos of site.
3. Take stage reading from gauge board at the time of data download. Note the time and level, and take a photograph of the gauge board.
4. Check condition of gauge board and cable and note any maintenance issues. Clean gauge board with a cloth or brush if necessary (i.e. if levels are becoming difficult to read), taking care to avoid

damage to the level markings. Retouch level markings with paint if necessary.

Rugged Troll 200

5. Remove dust caps from data port and data cable. Stow safely.
6. Connect the communication unit to the direct read transducer cable and the communication unit USB to the laptop.
7. Download the data (refer to software manual if required).
8. Check the download data (beginning and end dates and logging interval).
9. If the download has been successful, wipe the data on the data logger to clear memory capacity for the coming monitoring period and restart logging at the required interval.
10. Disconnect the com unit from the transducer cable and replace dust cap. Replace dust cap on the data cable.

Rugged Troll 100

11. Following water level measurement, carefully remove the datalogger for download; note the time when this is carried out.
12. Remove the wire/cable and logger from the still well (housing). Connect the logger to the laptop using the docking station and download the data. Check the location ID programmed against its real location and record the logger serial number for checking against installation records. In addition, review the level data to assess whether the datalogger has been submerged beyond the recommended depth or is in danger of becoming above the groundwater level at the depth it is installed.
13. Stop and restart the datalogger to allow reprogramming. Select future start to restart logging shortly after re-emplacement.
14. Delete any data points recorded by the datalogger since the commencement of step 13.
15. Carefully replace the reprogrammed logger in the stilling well.

All Data

16. Calculation of the water elevation from the barometrically compensated pressure record and sensor elevation calculated from the water level at installation must be completed as soon as possible after download to allow corrective action to be taken. This value will be verified against the water level recorded manually prior to the download according to the procedure described in the Environmental Monitoring Plan and corrective actions implemented if required.

COMPLETION OR CESSATION OF WORK

- A daily log of events will be recorded and submitted to the Environmental Manager.
- Any incidents will be reported to the Environmental Manager.

END OF INSTRUCTION

 GEOTEAM EMP MS-02	Amulsar Gold Project Method Statement for Sampling Surface Water, including Springs Revision 1, June 2015
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SCOPE

This Method Statement (MS) details the procedures for sampling surface water via grab samples from river crossings or bank sides, and for sampling springs at the points of discharge.

GENERAL INSTRUCTIONS

- In the event that a step in the MS procedure cannot be completed, or in case of any uncertainty, all work is to stop, the equipment made safe, and the Environmental Manager consulted.
- All staff involved in the work must have completed a site induction training course and have received training in the use of equipment covered by this MS.
- All work will be undertaken utilising the correct Personal Protective Equipment (PPE) as specified in this method statement.
- Work adjacent to rivers is hazardous and should be managed through an appropriate safe system of work.

RELATED DOCUMENTATION

For all water quality sampling

- Environmental Monitoring Plan (EMP; GEOTEAM-ENV-PLN0225);
- Occupational Health & Safety Plan (GEOTEAM-HSE-PLN-0016);
- Sample Chain of Custody forms;
- MS-04 Measurement of Field Parameters;
- Hazardous substance assessment, where required (e.g. sample preservatives).

Relevant guidance

- BS 6068-6.14:2009, Water Quality – Part 6: Sampling;
- BS EN ISO 5667-3:2009, Water Quality-Sampling – Part 3: Guidance on the Preservation and Handling of Samples;
- BS EN ISO 5667-6:2009, Water Quality-Sampling – Part 6: Guidance on Sampling of Rivers and Streams.

SPECIAL TOOLS, MATERIALS AND EQUIPMENT

- Appropriate PPE. Minimum requirement: high visibility vests; safety glasses; hand protection (gloves); protective footwear; and a lifejacket when sampling water courses exceeding 1.0 m in width;
- Portable water monitoring kit (field parameters including turbidity meter) and flow cell;
- Sampling equipment: stainless steel grab sampler and disposable bailers if required;
- Appropriate sample containers from laboratory, labels, and pens;
- Filters and syringes;
- Cool boxes;
- Ice packs (need to be put in freezer night before sampling);
- Paper towels;
- Bubble wrap;
- Plastic bags, ziplock bags;
- Duct tape;
- Copies of related documentation identified above, if required;
- Maps/site plans;
- GPS;
- Camera; and
- Mobile phone.

CONTINGENCY PLAN

In the event of any abnormal incident, cease work, make the area safe and contact the Environmental Manager or Health & Safety Manager.

PROCEDURE

Measurement of field parameters

1. Record the monitoring point being sampled, the date, time and weather conditions and the flow conditions and visible quality of the surface water.
2. Field parameters will be measured in accordance with MS-04, Measurement of Field Parameters. A calibrated, portable multi-parameter field test kit will be used.
3. Measurements will be taken for pH, temperature, dissolved oxygen (DO), and electrical conductivity as a minimum. Sample colour will also be recorded. The results will be saved to the equipment and duplicated in the Engineer's notebook for future quality assurance purposes.
4. All field equipment must be within its respective calibration period.
5. Take photographs of the sampling location and looking upstream and downstream and record the photograph numbers on the field form/notebook.

Sample collection

6. All water sampling equipment and bottles will be stored and handled carefully to avoid contamination from soils at the sampling location.
7. For surface waters, clean sampling equipment will be used to obtain a grab sample from the watercourse, ideally mid-stream in an area of flow. The sampling device should not be allowed to contact the stream bed.
8. Long-handled grab samplers are suitable where the sample location can be reached from the river bank. If sampling is completed from a bridge, disposable bailers may be used to safely collect a water sample from the mid-stream flow.
9. If using a grab sampler, rinse the grab sampler three times in the watercourse and then collect the sample. If using a bailer that is reused, rinse the bailer three times in the water course before collecting the sample.
10. Wading to collect direct grab samples should be avoided for safety reasons. However, if a sample is collected directly, the sampler should stand downstream of the sample collection point. Preserved samples must not be collected by direct submersion of sample bottles in the watercourse.
11. For spring sampling, sample bottles for parameters not requiring preservative will be filled directly from the spring discharge at the point of exit from the ground, where possible.
12. Where spring samples cannot be collected directly from the spring discharge, and for filtered and preserved samples, samples will be collected in a clean, sterile container or cup which has been rinsed three times with water from the sample location.
13. Appropriate sample containers will be filled to the required level with surface/spring water and sealed.
14. Sample containers will be stored in a cool box (and later transferred to a refrigerator if necessary) at a temperature between 1 °C and 5 °C in order to preserve the sample during transport to the laboratory.
15. For the purposes of dissolved metal analysis, all samples shall be filtered to 0.45 µm on site as per the instructions below:
 - Rinse a clean, sterile container or cup 3 times with water from the sample location, then fill up;
 - Place a bottle containing HNO₃ preservative on a stable surface;
 - Draw water from the container into the syringe and place a filter on the end of the syringe;
 - Filter the water into the bottle containing HNO₃ preservative; and
 - Repeat until the bottle is full and secure the lid, replacing the filter if it gets clogged up with sediment.

Sample dispatch and Chain of Custody

16. Complete the Chain of Custody and/or Sample Submission Sheet as required by the contracted laboratory. This will include information on client, sample type, sample location, date of sampling, analytical requirements, sampler's name and contact details. Retain a copy with the sampling records.
17. Sample packaging for transport to laboratory shall follow the principles below:

- Clean any dirt or other contamination from the outside of the sample bottles;
 - Line each cool box with a large plastic bag;
 - Place at least 6 ice packs on the outside of the bag and sample bottles on the inside;
 - Wrap all glass bottles in bubble wrap or put in a bubble wrap bag. If enough bubble wrap is available, double wrap the glass bottles to ensure that they do not break during transport;
 - The engineer must sign the Sample Submission Sheet/Chain of Custody form to record the person(s) responsible for the samples; and
 - Use bubble wrap to fill any empty space and to keep the samples from shifting during transport.
18. Tape the cool boxes shut at both hinges and ensure the laboratory is aware to the number of boxes to be received.

COMPLETION OR CESSATION OF WORK

- All equipment is to be cleaned and calibrated (see MS-04).
- A daily log of events will be recorded and submitted to the Environmental Manager.
- Any incidents will be reported to the Environmental Manager.

END OF INSTRUCTION

 GEOTEAM EMP MS-03	Amulsar Gold Project Method Statement for Surface Water and Spring Flow Measurement Revision 1, June 2015
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SCOPE

This Method Statement (MS) details the procedures for spot flow measurement in water courses using the cross-sectional area/velocity method, and spot flow measurement at springs using the timed discharge/volume method.

GENERAL INSTRUCTIONS

- In the event that a step in the MS procedure cannot be completed, or in case of any uncertainty, all work is to stop, the equipment made safe, and the Environmental Manager consulted.
- All staff involved in the work must have completed a site induction training course and have received training in the use of equipment covered by this MS.
- All work will be undertaken utilising the correct Personal Protective Equipment (PPE) as specified in this method statement.
- Work adjacent to rivers is hazardous and should be managed through an appropriate safe system of work.

RELATED DOCUMENTATION

- Environmental Monitoring Plan (EMP; GEOTEAM-ENV-PLN0225);
- Occupational Health & Safety Plan (GEOTEAM-HSE-PLN-0016);
- AquaCalc Pro Stream Flow Computer Instruction Manual.

SPECIAL TOOLS, MATERIALS AND EQUIPMENT

- Appropriate PPE. Minimum requirement: high visibility vests; safety glasses; hand protection (gloves); protective footwear; and a lifejacket when sampling water courses exceeding 1.0 m in width;
- Portable flow meter;
- Measuring tape long enough to extend across the measurement locations with stakes/pins to secure the tape on either bank;
- Rubber boots, hip waders, or chest waders (depending on depth of water);
- Spare batteries for the flow meter and any tools required for battery replacement;
- Stop watch;
- Containers of known (measured or marked) volume around 1 L, 5 L and 10 L in capacity (beaker, bucket or wide neck bottle);
- Ruler (for measuring small flow channels);
- Copies of related documentation identified above, if required;
- Maps/site plans;
- GPS;
- Camera; and
- Mobile phone.

CONTINGENCY PLAN

In the event of any abnormal incident, cease work, make the area safe and contact the Environmental Manager or Health & Safety Manager.

PROCEDURE

Spot measurement of surface water flow in a defined channel

1. Before going to site, check that the battery has been charged and all required equipment is in good working order. Run any pre-deployment diagnostics described in the flow meter manual.
2. Assemble the flow meter.
3. Note the exact location for flow measurement, take a GPS reading and note it on the stream gauging field form. Mark the banks with a stake or mark a tree to indicate where flow

measurement is taken.

4. Clear any loose debris (branches, weeds) impeding flow along the measurement cross-section.
5. Fix the tape measure to either the left or right bank so that the zero mark is at the shoreline. If it is not possible to set the zero point on the tape measure at the water's edge, record the point on the tape which corresponds with the water's edge.
6. Secure the tape to the opposite bank so that the tape is perpendicular to the direction of flow.
7. Record the starting point side (left/right) and direction (looking upstream/downstream) and the total width on the stream gauging field form.
8. Define the frequency of measurements across the channel. Measurements should be taken at approximately every 0.5 m or less, ensuring that at least four measurements can be made (i.e. if channel is just 1.2 m wide, take measurements every 0.3m). Add in the measurement locations in such a way as to characterize any significant gradients in velocity or depth along the cross-section.
9. Measure and record the distance from the water's edge, mean column velocity and water depth at each measurement location across the channel. The following steps should be taken to operate the AquaCalc Pro flow meter (further information is provided in the instruction manual):
 - Turn on the power using the On/Off switch;
 - Set readings to m/s if it isn't already set as such;
 - Set averaging interval to a minimum of 20 seconds using key pad in Section Setup Menu;
 - Use Measure key to go to the Measure screen;
 - Attach sensor to mount on wading rod; and
 - Lower sensor to desired depth and begin measurement by pressing Measure key.
10. If the water is less than 0.75 m deep, use the velocity meter to measure the velocity at 60% of the total depth. This is $0.6 \times \text{depth}$, as measured from the water surface.
11. If the water depth is greater than or equal to 0.75 m, then measure and record the velocity at both 20% and 80% of the total depth. This is $0.2 \times \text{depth}$, and $0.8 \times \text{depth}$ as measured from the water surface (PLEASE NOTE THAT IF WATER IS DEEPER THAN 0.75 m IT SHOULD NOT BE ENTERED UNLESS THE WATERCOURSE IS SLOW FLOWING AND THE FOOTING IS FIRM)
12. Hold the wading rod so that the sensor is parallel to the direction of flow. THE OPERATOR SHOULD BE BEHIND AND TO THE SIDE OF THE FLOW METER SO AS TO NOT TO CREATE ANY BACKWATER THAT MIGHT AFFECT THE VELOCITY.
13. At each location after the velocity has been sampled for 20 seconds and no errors are indicated by the unit, record the flow velocity.
14. The water depth at each measurement point and the recorded velocity should be manually recorded by another member of the field team on the stream bank, even if digital calculation of stream flow is undertaken to allow an independent quality assurance check and in case of loss of digital data.
15. When the stream transect is complete, record the flow and flow velocity calculated by the AquaCalc Pro (if completed automatically). If flow is not automatically calculated, calculation should be completed manually (e.g. using an appropriate Microsoft Excel calculation spreadsheet) on return to the office using the recorded depth and velocity measurements.
16. The following points should be noted regarding maintenance of the AquaCalc Pro:
 - Make sure not to submerge the AquaCalc Pro meter in water or expose it to large amounts of rainfall. The unit should always be kept in the protective case and inside the vehicle during transport to and from the sites;
 - The sensor of the AquaCalc Pro meter should be cleaned with mild soap and water to keep the carbon electrodes free of non-conductive grease or oils. Hydrocarbon solvents should not be used on the sensor as they damage the sensor;
 - Ensure that spare batteries are always carried. See the instruction manual for replacement procedures;
 - Calibration - once a month or whenever a problem is noted with the AquaCalc Pro meter, a zero calibration check should be performed to determine if the internal circuitry is functioning properly.

Spot measurement of spring flows

17. On arrival at the spring, identify an appropriate point to measure the discharge in close proximity to the exit point from the ground. Ideal locations will be where the spring discharge forms a spout or cascade, or where the flow is directed into a single defined channel.

18. If necessary, a temporary dam can be constructed across the spring flow using soil or available materials and a v-notch weir or spout created for measurement purposes. Care should be taken to capture the entire flow.

19. Based on the geometry of the discharge, select an appropriate measurement method: either capturing the total flow into a collection container, or estimating the flow in the stream channel slightly downstream of the discharge point.

Time and known volume method

20. Take a container of known volume or with graduated volume markings.

21. Set the container under the spring discharge, capturing the entire flow.

22. At the same time, start the stop watch to time filling.

23. Record time to fill to the volume marker, or entire container if specified total volume, record time and volume and calculate the flow rate.

24. Repeat the measurement twice more. If the repeat measurements are not within 10% of the original measurement, amend the measurement method until a consistent flow measurement is obtained.

Velocity and Cross Sectional Area Method

25. This method is intended for use only for small discharges where the water depth is too shallow to use the AquaCalc Pro (e.g. typically for flows less than 10 cm deep and channels less than 50 cm wide; for wider channels, it is preferable to identify a location where the channel narrows and the flow deepens to a suitable depth).

26. Select a section of the discharge channel for the measurement which has a clear flow channel with minimal debris or vegetation obstructing the flow.

27. Note the exact location for flow measurement; record the GPS co-ordinates of the location. Mark the banks with a stake or mark a tree to indicate where flow measurement is taken.

28. Mark out the start and end of a length of the channel for the measurement; the segment should be such that it takes at least 5 seconds for the flow to travel the length of the segment.

29. At a minimum of 0.5 m intervals along the segment, record the channel width and water depth at 25%, 50% and 75% of the channel width from the bank.

30. Identify a suitable object to use a float for the measurement. This will depend on the water depth; ideally the float should be neutrally buoyant and should not protrude too far from the water surface to reduce wind influence. However, it should not touch the bottom of the channel to prevent drag.

31. Drop the float into the centre of the flow stream, time the float between the start and end of the marked stream channel segment.

32. Repeat the velocity measurement twice more, and take the average of the three readings.

33. If the channel is wide enough, repeat steps 31 and 32, dropping the float in half way between the channel centre and each bank.

34. Calculate the flow velocity as distance/time, and the total flow as cross sectional area x flow velocity.

COMPLETION OR CESSATION OF WORK

- All equipment is to be cleaned and calibrated.
- A daily log of events will be recorded and submitted to the Environmental Manager.
- Any incidents will be reported to the Environmental Manager.

END OF INSTRUCTION

 GEOTEAM EMP MS-04	Amulsar Gold Project Method Statement for Measurement of Field Water Quality Parameters Revision 1, June 2015
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SCOPE

This Method Statement (MS) details the procedures for the measurement of field parameters which should be recorded whenever a groundwater or surface water sample is collected, and during purging of groundwater monitoring boreholes.

Field parameters may include temperature, pH, electrical conductivity, dissolved oxygen, oxidation/reduction potential (ORP) and turbidity.

GENERAL INSTRUCTIONS

- In the event that a step in the MS procedure cannot be completed, or in case of any uncertainty, all work is to stop, the equipment made safe, and the Environmental Manager consulted.
- All staff involved in the work must have completed a site induction training course and have received training in the use of equipment covered by this MS.
- All work will be undertaken utilising the correct Personal Protective Equipment (PPE) as specified in this method statement.
- Work adjacent to rivers is hazardous and should be managed through an appropriate safe system of work.

RELATED DOCUMENTATION

- Environmental Monitoring Plan (EMP; GEOTEAM-ENV-PLN0225);
- Occupational Health & Safety Plan (GEOTEAM-HSE-PLN-0016);
- Equipment instruction manuals).

Relevant guidance

- BS EN ISO 5667-11:2009, Water Quality-Sampling. Part 11: Guidance on Sampling of Groundwaters;
- BS EN ISO 5667-6:2009, Water Quality-Sampling – Part 6: Guidance on Sampling of Rivers and Streams.

SPECIAL TOOLS, MATERIALS AND EQUIPMENT

- Appropriate PPE. Minimum requirement: high visibility vests; safety glasses; hand protection (gloves); protective footwear; and a lifejacket when sampling water courses exceeding 1.0 m in width;
- Additional specific requirements for surface water and groundwater monitoring are set out in MS-02 and MS-06 respectively, and must be adhered to;
- Maps and drawings, notebook/forms and writing materials;
- Portable water monitoring kit (field parameters) and flow cell;
- Turbidity meter (if needed);
- Calibration solutions and distilled water;
- Spare probes, spare C cell batteries and maintenance kit;
- Appropriate surface and/or groundwater sampling equipment;
- Hand tools (e.g. screwdrivers);
- GPS;
- Camera; and
- Mobile phone.

CONTINGENCY PLAN

In the event of any abnormal incident, cease work, make the area safe and contact the Environmental Manager or Health & Safety Manager.

PROCEDURE

Checks and Calibration

1. All equipment should be checked and calibrated at the start of each day using the manufacturer's instructions before the fieldwork is to be undertaken. Dissolved oxygen should be recalibrated at each location.
2. Between each calibration, first rinse the probe with tap water and then gently shake off excess water from the probe before new calibration.
3. During short term storage and transport to and from site the travel cup should have approximately 1 cm of tap water inside to keep the probe moist (do not use de-ionized or distilled water to store the probe).
4. Check that there is sufficient battery life, and spare batteries and tools appropriate for the equipment.

Undertaking Field Measurements

5. At each sampling location, remove the probe(s) from their case(s) and turn them on. Allow the dissolved oxygen probe time to warm up, and recalibrate if the value reported in open air is below 95% saturation.
6. When sampling in surface water, avoid rapidly flowing or turbulent water as this increases the amount of time required for a reading to stabilise. When using the flow-through cell, ensure that flow is slow enough that entrainment of air or turbulence in the flow cell does not occur.
7. Completely immerse the probes in the watercourse or insert the probes into the flow-through cell in the case of groundwater. When monitoring surface water it is recommended that the hard protective cover is used on the probes to prevent damage.
8. Keep the probes in the same position until the reading stabilises within the prescribed error tolerance (note: this could take up to 10 minutes in high velocities and/or low conductivities).
9. Once the readings have stabilised, record them.
10. Repeat to obtain at least three measurements for each parameter (to demonstrate that an acceptable error tolerance has been achieved).
11. If measuring turbidity, once the readings have stabilised collect a sample from the rising pipe or water course to put into the turbidity cuvette (sample bottle). Ensure no bubbles are present in the sample, and place it into the turbidity meter cell. Detailed instructions are provided below if using a Hanna Turbidity Meter.

Undertaking Field Measurements – Hanna Turbidity Meter

12. Remove the turbidity meter from the protective case and place on a level surface.
13. Put on nitrile gloves.
14. Turn on the turbidity meter. It should initially read - - - - FTU
15. Take one sample bottle (cuvette), remove the lid and rinse the inside of the bottle three times with the sample water.
16. Fill the sample bottle to within 0.5 cm of the rim, allow any bubbles to escape and close the lid.
17. Wipe thoroughly around the bottle with the blue lint-free cloth included inside the box so no finger prints are visible on the bottom 2 cm of the bottle.
18. Place the bottle in the turbidity meter with the tip of triangle on the bottle aligned with the arrow on the outside of the hole.
19. Press the "read" button and wait about 25 seconds for the value to appear.
20. Write the turbidity value on the field form.
21. Discard the sample water. Clean the inside and outside of the bottle using a small amount of the antistatic solution, rinse the inside of the bottle with a small amount of 0 FTU solution and place the bottle back in the case.

COMPLETION OR CESSATION OF WORK

- All equipment should be cleaned and calibrated if appropriate.
- A daily log of events will be recorded and submitted to the Environmental Manager.
- Any incidents will be reported to the Environmental Manager.

END OF INSTRUCTION

 GEOTEAM EMP MS-05	Amulsar Gold Project Method Statement for Installation of Pressure Transducers in Groundwater Monitoring Wells and Download of Data Revision 1, June 2015
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SCOPE

This Method Statement (MS) details the procedures for installing and retrieving data from pressure transducers in groundwater monitoring wells to measure water levels.

GENERAL INSTRUCTIONS

- In the event that a step in the MS procedure cannot be completed, or in case of any uncertainty, all work is to stop, the equipment made safe, and the Environmental Manager consulted.
- All staff involved in the work must have completed a site induction training course and have received training in the use of equipment covered by this MS.
- All work will be undertaken utilising the correct Personal Protective Equipment (PPE) as specified in this method statement.

RELATED DOCUMENTATION

- Environmental Monitoring Plan (EMP; GEOTEAM-ENV-PLN0225);
- Occupational Health & Safety Plan (GEOTEAM-HSE-PLN-0016).

SPECIAL TOOLS, MATERIALS AND EQUIPMENT

- Appropriate PPE. Minimum requirement: high visibility vests; hand protection (gloves); protective footwear;
- Maps and drawings, notebook/forms and writing materials;
- Water level tape;
- For installation: pressure transducers of known range, pre-programmed to appropriate start time and at sampling interval as specified in the EMP;
- For download, field laptop;
- Non-stretch Kevlar cord or steel wire, cut to pre-measured lengths where a specific installation depth is specified;
- If steel wire, rope grips;
- Duct tape (to secure loggers at surface);
- Hand tools (e.g. screwdrivers);
- GPS;
- Camera; and
- Mobile phone.

CONTINGENCY PLAN

In the event of any abnormal incident, cease work, make the area safe and contact the Environmental Manager or Health & Safety Manager.

PROCEDURE

1. Before departure, ensure that the field laptop has sufficient batteries and that docking station driver/data logger management software has been installed.

Recording Standing Water Level

2. The monitoring well cover will be opened and the plastic cap that seals the top of the borehole installation (if present) removed.
3. If a logger is already installed, it will not be removed until a water level measurement has been taken.
4. The water level tape will be lowered into the well until a tone is heard. The water level will be recorded in relation to a pre-defined mark on the top of the borehole casing or to ground level, and the reading repeated two further times for accuracy. The water depth will be recorded to the nearest centimetre and the reference point used in measurement will be recorded.
5. The water level tape will then be lowered to the base of the borehole. A record of the base level in

relation to the reference mark or ground level will be made. The water level tape will be rewound. Dry the water level tape as it is being raised using paper towelling.

Pressure Transducer Installation

6. The height of the standing water column measured in steps 3 and 4 will be calculated.
7. The height of the standing water column in the borehole will be compared to the design specification for pressure transducer installation provided in the EMP.
8. If the height of the standing water column is comparable to the estimated value in the EMP and a logger with a range equal to the range detailed in the EMP is available, the logger will be suspended at the depth indicated in the EMP.
9. If the height of the standing water column is not comparable to the value estimated in the EMP and/or a logger of the designed range is not available, the installation design must be adjusted by the Engineer. The pressure transducer must be installed at a depth which does not exceed its design range + 3 m (to provide an allowance for rise in water level). The depth of installation must be recorded.
10. The serial number and range of the logger will be recorded at the time of installation, along with the date and time of installation. The timing interval to which the logger is programmed will be recorded.
11. Where the pressure transducer is to be installed 0.5 m from the borehole well base, the suspension cord/cable will be attached to the pressure transducer. The transducer will be lowered to the base of the borehole and pulled back by 0.5 m (measured from the reference point used in step 1.3). The suspension cable will be secured to the borehole headworks.
12. Where the pressure transducer is to be installed at a specific depth, the data logger will be attached to a suspension cable of known length, and lowered into the borehole. The suspension cable will be secured in place to the borehole headworks at surface. The length of the suspension cable will be recalculated to adjust for the length used to tie the logger and secure at surface.
13. In conjunction with the placement of the water level data loggers, there will also be the emplacement of a barometric data logger in the headworks of one nominated borehole or surface water stilling well as specified in the EMP to measure and record changes in atmospheric pressure. The data-logging of the barometric data logger will be programmed to automatically record at a date and time identical to highest frequency logger (this is likely to be surface water data loggers).

Pressure Transducer Download

14. Following water level measurement the datalogger will be removed for download, and the time when this is carried out noted.
15. The wire/cable and logger will be removed from the borehole. The logger will be connected to the docking station and via USB to laptop. The data will be downloaded. The location ID programmed will be checked against its real location, the logger serial number will be recorded for checking against installation records. In addition the level data will be reviewed to assess whether the datalogger has been submerged beyond the recommended depth or is in danger of becoming above the groundwater level at the depth it is installed.
16. The datalogger will be stopped and restarted to allow reprogramming. Future starting will be selected to restart logging shortly after re-emplacement.
17. Any data points recorded by the datalogger since the commencement of step 13 shall be deleted.
18. Calculation of the water elevation from the barometrically compensated pressure record and sensor elevation calculated from the water level at installation shall be completed as soon as possible after download to allow corrective action to be taken. This value will be verified against the water level recorded manually prior to the download according to the procedure described in the EMP and corrective actions implemented if required.

COMPLETION OR CESSATION OF WORK

- A daily log of events will be recorded and submitted to the Environmental Manager.
- Any incidents will be reported to the Environmental Manager.

END OF INSTRUCTION

 GEOTEAM EMP MS-06	Amulsar Gold Project Method Statement for Sampling Groundwater Monitoring Wells Revision 1, June 2015
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SCOPE

This Method Statement (MS) details the procedures for sampling groundwater monitoring wells using submersible pumps.

GENERAL INSTRUCTIONS

- In the event that a step in the MS procedure cannot be completed, or in case of any uncertainty, all work is to stop, the equipment made safe, and the Environmental Manager consulted.
- All staff involved in the work must have completed a site induction training course and have received training in the use of equipment covered by this MS.
- All work will be undertaken utilising the correct Personal Protective Equipment (PPE) as specified in this method statement.

RELATED DOCUMENTATION

For all water quality sampling

- Environmental Monitoring Plan (EMP; GEOTEAM-ENV-PLN0225);
- Occupational Health & Safety Plan (GEOTEAM-HSE-PLN-0016);
- Sample Chain of Custody forms;
- MS-04 Measurement of Field Parameters;
- Geotech Portable Bladder Pumps Installation and Operation Manual;
- Hazardous substance assessment, where required (e.g. sample preservatives).

Relevant guidance

- BS 6068-6.14:2009, Water Quality – Part 6: Sampling;
- BS EN ISO 5667-3:2009, Water Quality-Sampling – Part 3: Guidance on the Preservation and Handling of Samples;
- BS EN ISO 5667-11:2009, Water Quality-Sampling. Part 11: Guidance on Sampling of Groundwaters.

SPECIAL TOOLS, MATERIALS AND EQUIPMENT

- Appropriate PPE. Minimum requirement: high visibility vests; safety glasses; hand protection (gloves); hearing protection (where use of compressor requires this); protective footwear;
- Equipment for measurement of field parameters: flow cell, oxygen, pH, electrical conductivity and temperature probes;
- Submersible bladder pump, control unit and portable petrol air compressor and/or inertial pump foot valve and tubing;
- Appropriate sample containers from laboratory, labels, and pens;
- Filters and syringes;
- Cool boxes;
- Ice packs (need to be put in freezer night before sampling);
- Paper towels;
- Bubble wrap;
- Plastic bags, ziplock bags;
- Duct tape;
- Hand tools;
- 25 litre container of tap water for equipment decontamination;
- Copies of related documentation identified above, if required;
- Maps/site plans;
- GPS;
- Camera; and
- Mobile phone.

CONTINGENCY PLAN

In the event of any abnormal incident, cease work, make the area safe and contact the Environmental Manager or Health & Safety Manager.

PROCEDURE

1. Before commencing sampling works, ensure generator (if required) has sufficient fuel. Refuelling of the generator, if required, should be carried out with the compressor switched off, after cooling and within a drip tray. Petrol fuel will be transported in jerry cans. Nitrile gloves and eye protection must be worn during refuelling.
2. Carry out function test of equipment (generator/compressor and field testing kit) and calibrate field testing kit daily using appropriate solutions (e.g. conductivity solution, dissolved oxygen solution, pH 4 and pH 7 buffer solutions) prior to leaving for site.

Recording standing water level

3. The borehole cover will be opened and the plastic cap that seals the top of the borehole installation (if present) removed.
4. No data loggers or installed pipework will be removed from the borehole until a water level has been recorded.
5. The water level tape will be lowered into the well until a tone is heard. The water level will be recorded in relation to a pre-defined mark on the top of the borehole casing or ground level, and the reading repeated two further times for accuracy. The water depth will be recorded to the nearest centimetre and the reference point used in measurement will be recorded.
6. The water level tape will then be lowered to the base of the borehole. A record of the base level in relation to the ground level will be made. The water level tape will be rewound. Dry the water level tape as it is being raised using paper towelling.

Purging Using Low Flow Sampling Using a Bladder Pump

7. Prior to sampling, any data-loggers encountered in the borehole will be carefully removed. Any metal wires or cord carrying data loggers will be coiled up in a tidy manner to avoid trip hazards and damage to the wires/cord.
8. In all boreholes, sampling will be completed 3 m above the borehole base. Where a dedicated pump is not in place already, a bladder pump is lowered into the borehole until it is at required depth, and secured at this level.
9. Connect the air line from the compressor to the control unit; connect the pump air line to the control unit. Apply whip checks to all lines carrying compressed air to ensure that they are secure.
10. The rising pipe from the pump is connected to the flow cell at surface. Field parameters will be measured in accordance with MS-04, Measurement of Field Parameters. A calibrated, portable multi-parameter field test kit will be used to measure field parameters.
11. Measurements will be taken for pH, temperature, dissolved oxygen (DO), and electrical conductivity as a minimum. The results will be saved to the equipment memory and duplicated in the Engineer's notebook, together with the time/date/weather of measurements and other relevant observations.
12. To start the compressor:
 - Turn petrol supply on;
 - Adjust choke as required; and
 - Pull starting handle.
13. Purging rate and pump controller set up:
 - Turn the pump controller pressure regulator to zero;
 - Adjust the pump controller vent and drive dials;
 - Start the pump; and
 - During the drive cycle only, increase the pressure (60 – 125 psi).
14. If necessary adjust the discharge and refill times until water flows from the well into the flow cell. Flow rate should be low enough such that drawdown is not caused within the borehole.
15. As a guideline, flow rates should be reduced to 0.1 L/min and should not exceed 0.5 L/min in fine grained formation.
16. Purge a minimum of three litres to clear the water line. Purged water can be allowed to discharge

to ground at the site; however, the discharge point must be located such that water flows away from the borehole and does not pool around the borehole headworks.

17. Continue purging until the conductivity, temperature and pH field parameters stabilize with three consecutive stable readings on a frequency proportional to the flow rate (at a minimum 30 seconds apart), or a maximum purge of 15L is reached. Record all measurements or at least the three final measurements.
18. Care will be taken to ensure that all field equipment is within its calibration period as appropriate (see MS-04).
19. Parameter stabilisation should be determined as set out in the EMP and should apply to three successive readings.

Purging Using an Inertial Pump

20. Prior to sampling, any data-loggers encountered in the borehole will be carefully removed. Any metal wires or cord carrying data loggers will be coiled up in a tidy manner to avoid trip hazards and damage to the wires/cord.
21. The dimensions of the installation and depth to groundwater will be measured. Based on the requirement for purging of the boreholes prior to sampling, at least three well volumes of groundwater will be removed. To calculate the total purge volume representing three well volumes the following equation will be used:

$$V = 3 \times [\pi \times (\theta/2000)^2] \times [B - A] \times 1000$$

Where:

V = Volume of purged water (litres)

θ = Diameter of standpipe installation (mm)

B = Depth to base of installation, below ground level or datum (m)

A = Depth to groundwater level, below ground level or datum (m)

It should be noted that for ease of calculation, a single well volume in litres for approximately 50 mm ID installations can be calculated by applying a factor of 2 to the total water column length (m).

22. If no sampling tubing is installed at the well location, clean and unused Teflon or HDPE tubing will be installed. A foot valve will be attached to the end of the tubing. The tubing will be lowered to the base of the borehole, and when it reaches a stable base, it will be cut at least 1 metre above the borehole top. If cut shorter than the full borehole length, the tubing must be attached to and suspended from the borehole headworks if left in-situ.
23. To avoid taking the sample from too close to the base of the well, raise the tubing a minimum of 2 m to lift the intake from the borehole base, or if the water column is shorter than 2 m, to the middle of the water column.
24. Groundwater will be pumped (purged) from the well by raising and lowering the inertial pump until a minimum of 3 well volumes has been removed.
25. Where recharge is poor, purging will continue until either three well volumes have been removed or until the well has been purged dry and recharged three times. After the third recharge, field parameters can be measured as described below.
26. Where groundwater recharge is good, after three well volumes have been purged, the discharge pipe should be connected to the flow cell. Purging should continue until the field parameters have reached a stable value, within the error tolerance referenced in the EMP. Dissolved oxygen usually requires the longest time for stabilisation.
27. Field parameters will be measured in accordance with MS-04, Measurement of Field Parameters. A calibrated, portable multi-parameter field test kit will be used to measure field parameters.
28. Measurements will be taken for pH, temperature, dissolved oxygen (DO), and electrical conductivity, as a minimum. The results will be saved to the equipment memory and duplicated in the Engineer's notebook, together with the notes recording the time/date/weather conditions at the time of measurements and other relevant observations (including sample colour).
29. Care will be taken to ensure that all field equipment is within its calibration period as appropriate (see MS-04).
30. Parameter stabilisation should be determined as detailed in the EMP and should apply to three successive readings.

Sample Collection

31. When purging is complete, groundwater samples will be collected by disconnecting the flow cell and pumping water from the water line or discharge tubing directly into the appropriate sample containers.
32. Filtered samples shall be taken first, followed by other samples.
33. Appropriate pre-labelled sample containers will be filled to the required level with groundwater and sealed.
34. Sample containers will be stored in a cool box (and later transferred to a refrigerator if required) at a temperature between 1 °C and 5 °C in order to preserve the sample during transport to the laboratory.
35. For the purposes of dissolved metal analysis, all samples shall be filtered to 0.45 µm on site using one of the methods below:

Syringe and filter paper:

- Rinse a clean, sterile container 3 times with water from the discharge pipe, then fill up with groundwater;
- Place a 125 mL sample bottle containing HNO₃ preservative on a stable surface;
- Draw water from the container into the syringe and place a filter on the end of the syringe;
- Filter the water into the 125 mL bottle containing HNO₃ preservative;
- Repeat until the bottle is full and secure the lid, replacing the filter if it gets clogged up with sediment. Do not allow the bottle to overflow.

In-line Filter:

- Attach the in-line filter to the inertial pump tubing;
- Place a 125 mL sample bottle containing HNO₃ preservative on a stable surface;
- Pumping slowly to produce a low flow rate, discharge water through the filter and into the sample bottle. Do not allow the bottle to overflow.

Equipment Removal and Decontamination

36. On completion of sampling, if a dedicated inertial pump is used, the tubing and foot valve is lowered to the base of the borehole until it is resting in a stable position.
37. If a bladder pump is used, the pump will be removed from the borehole, with care taken to reel the air and water lines back onto cable reels to avoid damage or tangling.
38. Carefully replace any removed data loggers in the borehole, do not disturb the logger attachment at surface and ensure that the suspension point is unchanged.
39. Following equipment removal, or replacement, the borehole will be secured at the top. The plastic cap (if present) will be replaced and the surface cover or headworks closed.
40. Before moving to the next location, the equipment will be decontaminated to avoid cross-contamination between boreholes.
41. The polyethylene bladder in the bladder pump will be replaced with a new, unused bladder. The procedure for bladder replacement is described in the manufacturer's instruction manual.
42. The bladder pump water line will be rinsed with clean tap water (using a clean funnel to apply a pressure head and drive flow); a minimum of 5 litres of tap water will be rinsed through the tubing.
43. The flow cell will be wiped dry with paper towel.
44. The effectiveness of the decontamination procedure will be evaluated through collection of equipment blanks. To collect an equipment blank, deionised water will be passed through the bladder pump and water line. Once at least one litre has passed through, sample bottles will be filled from the discharge line. One equipment blank should be taken during each monitoring quarterly monitoring round. Other quality assurance samples are described in the EMP.

Sample Dispatch and Chain of Custody

45. Complete the Chain of Custody and/or Sample Submission Sheet as required by the contracted laboratory. This will include information on client, sample type, sample location, date of sampling, analytical requirements, sampler's name and contact details. Retain a copy with the sampling records.
46. Sample packaging for transport to laboratory shall follow the principles below:
 - Clean any dirt or other contamination from the outside of the sample bottles;
 - Line each cool box with a large plastic bag;

- Place at least 6 ice packs on the outside of the bag and sample bottles on the inside;
 - Wrap all glass bottles in bubble wrap or put in a bubble wrap bag. If enough bubble wrap is available, double wrap the glass bottles to ensure that they do not break during transport;
 - The engineer must sign the Sample Submission Sheet/Chain of Custody form to record the person(s) responsible for the samples; and
 - Use bubble wrap to fill any empty space and to keep the samples from shifting during transport.
47. Tape the cool boxes shut at both hinges and ensure the laboratory is aware to the number of boxes to be received.

COMPLETION OR CESSATION OF WORK

- All equipment is to be cleaned and calibrated (see MS-04).
- A daily log of events will be recorded and submitted to the Environmental Manager.
- Any incidents will be reported to the Environmental Manager.

END OF INSTRUCTION



EMP MS-07

Amulsar Gold Project

Method Statement for Supervision of Installation of Groundwater Monitoring Wells

Revision 1, June 2015

SCOPE

This Method Statement (MS) details the procedure for supervision of installation of monitoring wells for measuring groundwater level and quality.

GENERAL INSTRUCTIONS

- In the event that a step in the MS procedure cannot be completed, or in case of any uncertainty, all work is to stop, the equipment made safe, and the Environmental Manager consulted.
- All staff involved in the work must have completed a site induction training course and have received training in the use of equipment covered by this MS.
- All work will be undertaken utilising the correct Personal Protective Equipment (PPE) as specified in this method statement.

RELATED DOCUMENTATION

- Occupational Health & Safety Plan (GEOTEAM-HSE-PLN-0016);
- Design documents relating to proposed new wells.

SPECIAL TOOLS, MATERIALS AND EQUIPMENT

- Appropriate PPE. Minimum requirement: high visibility vests; safety glasses, hand protection (gloves); protective footwear; hard hat (when working around drilling rig);
- Copies of related documentation identified above, if required;
- Record of Monitoring Well Installation form;
- Calculator;
- GPS;
- Camera; and
- Mobile phone.

CONTINGENCY PLAN

In the event of any abnormal incident, cease work, make the area safe and contact the Environmental Manager or Health & Safety Manager.

PROCEDURE

1. Drilling will proceed until the borehole has progressed to at least 10 m below the water table, unless alternative criteria are defined by the specific well design. Water strikes should be monitored during drilling. Installation should not be undertaken until it is confirmed that the observed water level is stable or rising.
2. Once the base depth of the borehole has been defined, the supervising engineer will review the well design based on the template provided in Attachment 1.
3. The supervising engineer will calculate and record on the Record of Installation Form in Attachment 1:
 - The volume of bentonite grout required, based on the borehole diameter (d_1), installation diameter (d_2) and number of metres of grouting (L):
$$V = \pi \left(\left(\frac{d_1}{2} \right)^2 - \left(\frac{d_2}{2} \right)^2 \right) L$$
 - The volume of bentonite pellets required (as above, where L is 1 m);
 - The volume of fine sand filter required (as above, where L is 1 m);
 - The volume of coarse sand filter required (as above, where L is 8 m if a 6 m screen is used, or the screen length plus 2 m if a shorter screen is required by site setting).
4. The driller will mobilise the appropriate installation materials to the drill site. Unless otherwise specified by the well design, this will comprise a 6 m length of 50 mm internal diameter (ID) slotted well screen, the required length of plain HDPE 50 mm ID installation pipe, bentonite pellets, fine

sand filter material, coarse sand filter material, materials for liquid grouting, cement for surface sealing and lockable casing headworks.

5. The supervising engineer will monitor the installation, recording:

- The length of pipework installed;
 - The volume of installation materials installed;
 - The recorded depth of the top of the gravel filter pack before placement of the sand filter;
 - The recorded depth of the top of the sand filter pack before placement of the bentonite seal;
 - The recorded depth of the top of the bentonite seal before grouting of the borehole;
 - Volume of grout pumped into the annular void and final grouted level.
6. After a suitable interval has been left for the grout to cure, the supervising engineer will ensure that the driller seals the headworks with a cement seal and places the lockable headworks.
7. The supervising engineer will clearly mark the identity of the borehole on the headworks using appropriate materials (paint or a paint pen).

COMPLETION OR CESSATION OF WORK

- A daily log of events will be recorded and submitted to the Environmental Manager.
- Any incidents will be reported to the Environmental Manager.

Attachment: Record of Monitoring Well Installation Form

END OF INSTRUCTION

Amulsar Monitoring Well Installation Record Form

Borehole Name:

Date:

Template Borehole Design	Planned Installation and Volume Calculation	Actual Installation and Notes



EMP MS-08

Amulsar Gold Project

Method Statement for Use of EPAM 5000 Environmental Particulate Air Monitor

May 2015

SCOPE

This Method Statement (MS) details the procedure for use of the EPAM 5000 Environmental Particulate Air Monitor.

GENERAL INSTRUCTIONS

- In the event that a step in the MS procedure cannot be completed, or in case of any uncertainty, all work is to stop, the equipment made safe, and the Environmental Manager consulted.
- All staff involved in the work must have completed a site induction training course and have received training in the use of equipment covered by this MS.
- All work will be undertaken utilising the correct Personal Protective Equipment (PPE) as specified in this method statement.

RELATED DOCUMENTATION

- Environmental Monitoring Plan (EMP; GEOTEAM-ENV-PLN0225);
- Occupational Health & Safety Plan (GEOTEAM-HSE-PLN-0016);
- User's Guide: Haz-Dust Environmental Particulate Air Monitor: Model EPAM 5000 (Environmental Devices Corporation document HD50111).

SPECIAL TOOLS, MATERIALS AND EQUIPMENT

- Appropriate PPE. Minimum requirement when working in the designated Amulsar site boundary: high visibility vest; protective footwear; hand protection (gloves);
- Field laptop and connecting cable;
- Spare battery for EPAM 5000 (if required);
- Cleaning solvent and grease for maintenance of the impactors;
- Low-pressure air spray and alcohol wipes for cleaning the optics;
- Maps/Site plan;
- GPS;
- Mobile phone; and
- Camera.

CONTINGENCY PLANS

In the event of any abnormal incident, cease work, make the area safe and contact the Environmental Manager or the HSE Manager.

PROCEDURE

General considerations

- This MS applies to use of the EPAM 5000 for monitoring to establish baseline data or routine monitoring during Project operations. The instrument measures and displays data in real-time and could therefore be used for occupational health monitoring or incident response purposes; if so, the manual should be consulted to determine the correct operating procedures.
- The EPAM 5000 is capable of monitoring Total Suspended Particulates (TSP) and concentrations of Particulate Matter (PM) of sizes less than or equal to 10, 2.5 and 1 micron (i.e. PM10, PM2.5 and PM1). However, only one of these parameters can be measured at a time, and the unit must be manually re-set to change the monitored parameter. At Amulsar, compliance criteria for PM10 and PM2.5 have been set and it is therefore unlikely that there will be a need for TSP and PM1 measurement.
- The Project compliance criteria for PM10 and PM2.5 apply to a 24-hour averaging period, which is therefore the most appropriate minimum sampling time for straightforward interpretation.
- The EPAM 5000 can be set to various sampling rates between 1 second and 30 minutes. However, a 1-second sampling rate will only allow a sampling time of 6 hours until the memory is full, and therefore is unlikely to be appropriate. A sampling rate of 1 minute is considered to be

adequate and will give a total sampling time of 15 days, although download of the data is generally preferable immediately after each 24-hour sampling period.

- The machine's battery will last for approximately 24 hours from a full charge. Mains operation is preferred where practicable.

Establishment of baseline data / routine compliance monitoring

1. For routine compliance monitoring it is envisaged that the EPAM 5000 will be deployed at fixed monitoring positions for defined sampling periods as identified in the Project Air Quality, Noise and Vibration Management Plan (GEOTEAM-HSE-PLN0148) and the Environmental Monitoring Plan (GEOTEAM-ENV-PLN0225).
2. Prior to each sampling period, the following will be checked:
 - a. If being used, the battery is fully charged (6.1 VDC or higher);
 - b. The memory has been cleared (**unless** data from the previous sampling period have not yet been downloaded; see step 5 below)
 - c. The correct impactor is installed (i.e. PM₁₀ or PM_{2.5})
 - d. The machine has been set to the correct sampling parameter (i.e. PM₁₀ or PM_{2.5})
3. A manual-zero set will be performed (even if the machine is set to auto-zero).
4. The sample rate will be set to 1 minute. **This is very important because the machine defaults to a 1 second rate when switched off.** A 1-second rate gives only a 6-hour sampling period, whereas a 1-minute rate gives up to 15 days.
5. "Run" is selected to begin sampling. If the memory is not empty, there is an option to either "Continue" or "Over-write data". If data from the previous sampling event have not yet been downloaded, "Continue" should be selected. If the memory has been cleared (see step 2d above) then it does not matter which option is selected.
6. When sampling starts, the Run Screen will be checked to confirm date & time and the sampling parameter. The parameter concentration should also be watched for a few minutes; consistent negative numbers may indicate a zero error (in which case cease sampling and re-perform the zero-set).
7. It is desirable to download the data as soon as practicable. This may be after one 24-hour sampling period or, more probably, after two periods where PM₁₀ and PM_{2.5} are sampled consecutively at one location. Data must be downloaded to a laptop computer equipped with DustComm Pro software via a RS232-to-USB cable set (this will have been set up in advance). Data will be analysed, stored, backed up and reported as required by the Air Quality, Noise and Vibration Management Plan (GEOTEAM-HSE-PLN0148) and the Environmental Monitoring Plan (GEOTEAM-ENV-PLN0225).
8. A brief note of weather conditions during each sampling event should be made.

Maintenance

As per the EPAM 5000 User Manual, the following maintenance will be carried out at the specified frequencies and will be documented in the equipment log and in Quarterly Monitoring Reports:

- Monthly cleaning of the impactors;
- Monthly calibration span check (or if the machine is dropped or damaged);
- Monthly flow-rate check;
- Bi-monthly cleaning of the sensor optics;

COMPLETION OR CESSATION OF WORK

- A daily report will be filed with the Environmental Manager;
- Any incidents will be reported to the Environmental Manager.

END OF INSTRUCTION



EMP MS-09

Amulsar Gold Project

Method Statement for Use of Osiris Environmental Monitor

September 2015

SCOPE

This Method Statement (MS) details the procedure for use of the Osiris Environmental Monitor for particulate monitoring.

GENERAL INSTRUCTIONS

- In the event that a step in the MS procedure cannot be completed, or in case of any uncertainty, all work is to stop, the equipment made safe, and the Environmental Manager consulted.
- All staff involved in the work must have completed a site induction training course and have received training in the use of equipment covered by this MS.
- All work will be undertaken utilising the correct Personal Protective Equipment (PPE) as specified in this method statement.

RELATED DOCUMENTATION

- Environmental Monitoring Plan (EMP; GEOTEAM-ENV-PLN0225);
- Occupational Health & Safety Plan (GEOTEAM-HSE-PLN-0016);
- Turnkey Instruments Ltd Osiris Operating Instructions.

SPECIAL TOOLS, MATERIALS AND EQUIPMENT (for field work)

- Appropriate PPE. Minimum requirement when working in the designated Amulsar site boundary: high visibility vest; protective footwear; hand protection (gloves);
- Maps/Site plan;
- GPS;
- Mobile phone; and
- Camera.

CONTINGENCY PLANS

In the event of any abnormal incident, cease work, make the area safe and contact the Environmental Manager or the HSE Manager.

PROCEDURE

1. Geoteam owns two Osiris monitors, serial numbers TNO3041 and TNO3042. Except during winter, the monitors are installed in secure, purpose-constructed boxes with solar-panel-charged battery power, at two locations AQ9 and AQ10.
2. The monitors are remotely controllable, and data may be reviewed and downloaded, via secure website as follows:
www.airqweb.co.uk
Username: geoteam
Password: Password01
3. The monitors record Total Particulates, PM₁₀, PM_{2.5} and PM₁ simultaneously and continuously.
4. The website should be checked at least every two days to ensure that the monitors are functioning.
5. Data should be downloaded from the website at least every two weeks. Automatic delivery of data can be scheduled.
6. In order to avoid over-writing and loss of data, the memory must be manually erased (via the website) at least every two weeks.
7. An air flow check and filter change must be carried out quarterly using the Osiris service kit.

COMPLETION OR CESSATION OF WORK

- A daily report will be filed with the Environmental Manager;
- Any incidents will be reported to the Environmental Manager.

END OF INSTRUCTION

 GEOTEAM EMP MS-10	Amulsar Gold Project Method Statement for Passive Gas Monitoring September 2015
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SCOPE

This Method Statement (MS) details the procedure for use of passive nitrogen dioxide (NO₂) and sulphur dioxide (SO₂) monitoring using diffusive samplers supplied by IVL Svenska Miljöinstitutet (IVL).

GENERAL INSTRUCTIONS

- In the event that a step in the MS procedure cannot be completed, or in case of any uncertainty, all work is to stop, the equipment made safe, and the Environmental Manager consulted.
- All staff involved in the work must have completed a site induction training course and have received training in the use of equipment covered by this MS.
- All work will be undertaken utilising the correct Personal Protective Equipment (PPE) as specified in this method statement.

RELATED DOCUMENTATION

- Environmental Monitoring Plan (EMP; GEOTEAM-ENV-PLN0225);
- Occupational Health & Safety Plan (GEOTEAM-HSE-PLN-0016);
- IVL Instructions for Outdoor Sampling with Diffusive Samplers.

SPECIAL TOOLS, MATERIALS AND EQUIPMENT

- Appropriate PPE. Minimum requirement when working in the designated Amulsar site boundary: high visibility vest; protective footwear; hand protection (gloves);
- Maps/Site plan;
- GPS;
- Mobile phone; and
- Camera.

CONTINGENCY PLANS

In the event of any abnormal incident, cease work, make the area safe and contact the Environmental Manager or the HSE Manager.

PROCEDURE

1. The IVL diffusive samplers must be installed in tool holders mounted on poles with rain covers. These have been established at monitoring locations AQ1 to AQ6 at Amulsar.
2. The samplers must be kept in their plastic containers until the time of installation. Exposure starts when the containers are opened.
3. Upon arrival at the sampling site, the samplers in place should first be removed and returned to their dedicated containers. The end-time of exposure should be recorded.
4. Each new sampler should be removed from its container and placed in the tool holder with the grey mesh downwards. One NO₂ sampler and one SO₂ sampler should be installed at each location. The start time of exposure should be recorded.
5. The empty containers should be closed and retained for collection of the samplers.
6. The exposure time for each sampler is one month.
7. Exposed samplers must be dispatched to IVL in Sweden with a record of the sample identification/location number and start and stop times.

COMPLETION OR CESSATION OF WORK

- A daily report will be filed with the Environmental Manager;
- Any incidents will be reported to the Environmental Manager.

END OF INSTRUCTION

 GEOTEAM EMP MS-11	Amulsar Gold Project Method Statement for Passive Dust Monitoring September 2015
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SCOPE

This Method Statement (MS) details the procedure for use of passive dust monitoring pads supplied by DustScan Ltd.

GENERAL INSTRUCTIONS

- In the event that a step in the MS procedure cannot be completed, or in case of any uncertainty, all work is to stop, the equipment made safe, and the Environmental Manager consulted.
- All staff involved in the work must have completed a site induction training course and have received training in the use of equipment covered by this MS.
- All work will be undertaken utilising the correct Personal Protective Equipment (PPE) as specified in this method statement.

RELATED DOCUMENTATION

- Environmental Monitoring Plan (EMP; GEOTEAM-ENV-PLN0225);
- Occupational Health & Safety Plan (GEOTEAM-HSE-PLN-0016).

SPECIAL TOOLS, MATERIALS AND EQUIPMENT

- Appropriate PPE. Minimum requirement when working in the designated Amulsar site boundary: high visibility vest; protective footwear; hand protection (gloves);
- Maps/Site plan;
- GPS;
- Mobile phone; and
- Camera.

CONTINGENCY PLANS

In the event of any abnormal incident, cease work, make the area safe and contact the Environmental Manager or the HSE Manager.

PROCEDURE

1. The DustScan pads are to be installed on purpose-constructed poles with rain covers. These have been established at monitoring locations AQ1 to AQ6, AQ7DS, AQ8DS, AQ9 and AQ10 at Amulsar.
2. The pads must be kept in their plastic sleeves until the time of installation.
3. Upon arrival at the sampling site, the pad in place should first be removed and returned to its protective sleeve. The exposure end time should be recorded.
4. The new pad should then be fixed to the frame, ensuring that it is aligned correctly to North. The exposure start time should be recorded.
5. The exposure time for each pad is two weeks.
6. Exposed samplers must be dispatched to DustScan in the UK with a record of the sample identification/location number and start and stop times.

COMPLETION OR CESSATION OF WORK

- A daily report will be filed with the Environmental Manager;
- Any incidents will be reported to the Environmental Manager.

END OF INSTRUCTION

 GEOTEAM EMP MS-12	Amulsar Gold Project Method Statement for Noise Monitoring September 2015
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SCOPE

This Method Statement (MS) details the procedure for noise monitoring using Cirrus Research plc's C811 Sound Level Meter.

GENERAL INSTRUCTIONS

- In the event that a step in the MS procedure cannot be completed, or in case of any uncertainty, all work is to stop, the equipment made safe, and the Environmental Manager consulted.
- All staff involved in the work must have completed a site induction training course and have received training in the use of equipment covered by this MS.
- All work will be undertaken utilising the correct Personal Protective Equipment (PPE) as specified in this method statement.

RELATED DOCUMENTATION

- Environmental Monitoring Plan (EMP; GEOTEAM-ENV-PLN0225);
- Occupational Health & Safety Plan (GEOTEAM-HSE-PLN-0016);
- Cirrus Research plc User Manual for the CR:800C Series of Sound Level Meters.

SPECIAL TOOLS, MATERIALS AND EQUIPMENT

- Appropriate PPE. Minimum requirement when working in the designated Amulsar site boundary: high visibility vest; protective footwear; hand protection (gloves);
- Maps/Site plan;
- GPS;
- Mobile phone; and
- Camera.

CONTINGENCY PLANS

In the event of any abnormal incident, cease work, make the area safe and contact the Environmental Manager or the HSE Manager.

PROCEDURE

1. The following applies to manual measurement.
2. Upon arrival at the monitoring location the monitor must be calibrated. Switch on the monitor and attach the microphone extension cable, if to be used. Connect the Acoustic Calibrator to the Sound Level Meter and select the 94dB setting. Press the 'Menu' key to select the calibrate option, then press 'OK'. When calibration is complete, press the 'Exit' key.
3. The monitor is then set up as follows:
 - a. Set Measurement Mode to Broadband;
 - b. Set measurement duration to 15 minutes;
 - c. Switch off Auto Repeat & Auto Synchronise;
 - d. Set Measurement Range to 30dB to 100 dB (for in-community monitoring).
4. Start measurement.
5. Allow the monitor to run for the planned time period.
6. Stop measurement.
7. Review the collected data.

COMPLETION OR CESSATION OF WORK

- A daily report will be filed with the Environmental Manager;
- Any incidents will be reported to the Environmental Manager.

END OF INSTRUCTION

 GEOTEAM	Amulsar Gold Project Environmental Monitoring Plan	February 2016
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Appendix B

List of all known surface water monitoring points

Appendix B - Surface Water Monitoring Locations

Catchment	Gauge point*	Type ⁺	Easting	Northing	Notes
Arpa (downstream of Kechut Reservoir)	AWJ5	Spot	555468	4404865	
	Arpa1	Continuous			
	Arpa2	Continuous	551192	4398869	
	Arpa3	Continuous / spot			
	Arpa4	Continuous	550666	4397541	
	AW009	Spot	550603	4397518	
	AW010	Spot	552316	4400815	
Arpa (upstream of Kechut Reservoir)	AWJ1	Spot			Not considered essential for monitoring (EMP)
	AWJ2	Spot	557829	4410072	
	AWJ3				Not considered essential for monitoring (EMP)
	AWJ4	Spot	556364	4406943	
	AW040	Spot	560763	4403199	
Tunnel inflow to Kechut Reservoir	AWJ6	Spot	556919	4405191	
Arpa tributary (downstream of Kechut Reservoir)	Site 28 G1	Spot	554243	4399884	Different coords in different tables in EMP Transducer stolen prior to 20/4/15
	Site 28 G2	Spot	553078	4399467	Different coords in different tables in EMP Transducer removed 20/4/15

Appendix B - Surface Water Monitoring Locations

Catchment	Gauge point*	Type ⁺	Easting	Northing	Notes
	Site 28 G3	Spot	552338	4398438	Different coords in different tables in EMP Transducer removed 21/4/15
	Site 14 Gauge	Continuous			
Arpa tributary (upstream of Kechut Reservoir)	AW028	Spot	559437	4407259	
	AW029	Spot	558924	4406963	
	AW063	Spot	561244	4405352	
	FM10	Continuous	558626	4405564	
	FDMP3	Spot	560468	4402686	
	FM11	(not on map)	557815	4405075	
	FM12	Continuous	561271	4404624	
	Site 27	Continuous	560420	4401997	
Darb	AW003a	Spot	566529	4393085	
	AW005	Spot	557443	4395363	
	AW006	Spot	555263	4396738	
	Darb1	Spot	556684	4395861	Transducer stolen Q2 2015
	Darb2	Continuous	554406	4396838	
Darb tributary	AW004	Spot pre-2012			
	AW021	Spot	560690	4394467	

Appendix B - Surface Water Monitoring Locations

Catchment	Gauge point*	Type ⁺	Easting	Northing	Notes
	AW021a	Continuous	561095	4394653	
	MP3	Continuous	557156	4398429	
	MP4	Continuous	557769	4399489	
	AW041	Spot	556959	4399817	
	North Erato	Continuous	557377	4400099	
	AW019				Benick's Pond
	AW019a	Spot	560085	4398184	Stream from Benick's Pond
	AW064	Spot	556770	4395947	
	Por-1	Spot	564943	4392263	
	AW070	Sample only	564435	4392477	Spring used for drinking water
Vorotan	AW001	Spot	563258	4402025	
	AW002				Sampled once; no longer monitored
	AW003	Spot	566529	4393085	
	AW015	Spot	563200	4399504	
	AW017a	Spot	565584	4406649	
	AW065	Spot	565876	4394950	
	Vorotan Gauge	Spot	562990	4401173	Transducer stolen Q2 2015
	AW007	(not on map)			Location unknown (EMP)

Appendix B - Surface Water Monitoring Locations

Catchment	Gauge point*	Type ⁺	Easting	Northing	Notes
	AW008	(not on map)			Location unknown (EMP)
Vorotan tributary	AW002	Spot			
	AW017	Spot	564786	4406991	
	AW025	Spot	562876	4400742	
	AW026	Spot	562989	4400057	
	AW027	Spot	563215	4399294	
	AW030	Spot	560908	4402694	Adit discharge; classified as both surface water and spring (EMP)
	AW030a	Spot	562901	4401041	
	AW052	Sample only	566544	4408533	Coordinates reflect spring location; actual sampling point is a residence in Gndevaz to where the water is piped (553180, 4401226)
	AW066	Spot	565929	4394212	
	AW067	Spot	564921	4392336	
	FM1	Spot 2012-14			
	FM2	Spot 2012-14			
	FM3	Spot 2012-14			
	FM4	Spot 2012-14			
	FM5	Spot	562068	4402763	
	FM6 Hi	Spot	562850	4401230	
	FM6 WEIR	Spot	562834	4401248	

Appendix B - Surface Water Monitoring Locations

Catchment	Gauge point*	Type ⁺	Easting	Northing	Notes
	MP1	Continuous	562330	4400023	
	MP2	Continuous	562507	4399174	
	AW036				Not considered essential for monitoring (EMP)
	AW037				Not considered essential for monitoring (EMP)
Unknown locations	AW006a				Location unknown (EMP)
	AW006b				Location unknown (EMP)
	AW016				Location unknown (EMP)

* Locations compiled from Table 4.9.4 and Figure 4.9.5 of ESIA; EMP (V2, 9 February 2015)

⁺ From Figure 4.9.5 of ESIA and EMP (V2, 9 February 2015); EMP takes precedence (to reflect current situation)

 GEOTEAM	Amulsar Gold Project Environmental Monitoring Plan	February 2016
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Appendix C

List of all known groundwater monitoring wells and spring monitoring points



Amulsar Gold Project
Environmental Monitoring Plan

February 2016

Area	Monitoring Well ID	Date	Easting	Northing	Head-works Elevation	Incl*	Total depth (m)	Top of screen (mbgl)	Bottom of screen (mbgl)	Trans ⁺	Notes
Site 13	RCAW399		560702	4402856		90			53		
Site 13	RCAW400		561263	4402314		90			45	Yes	
Site 13	RCAW401		562336	4403139		90			66		
Site 13	RCAW403		562432	4402226		90			24	Yes	
Site 13	DDAW-002		562169	4402759		90			32	Yes	
Site 13	DDAW-003		561490	4402807		90			28	Yes	
Site 13	DDAW-004									Yes	
Pit	RCAW405a		561640	4397780		90			128		
Pit	RCAW406		562083	4398009		60			173		
Pit	RCAW408		560871	4397975		68			77	Yes	
Pit	RCAW286		561533	4398618		90			80		
Pit	RCAW288		560562	4398393		58			41		
Pit	DDAW007	May 2013	561249	4399375		90	82.7	75.3	81.3		
Erato	DDAG-369		560714	4399630		70			297.8		
Erato	DDAG-371		560647	4399251		60			120		
BRSF	DDAW005	May 2013	560158	4401268		90	61.1	42	60		
Pit	DDAW008	Jun 2013	560799	4400239		90	72.8	52	64	Yes	



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Area	Monitoring Well ID	Date	Easting	Northing	Head-works Elevation	Incl*	Total depth (m)	Top of screen (mbgl)	Bottom of screen (mbgl)	Trans ⁺	Notes
Pit	DDAW009	Jun 2013	559342	4399870		90	120	112	118	Yes	
	DDAW390		562728	4396738	2871				66		
	DDAW393		561697	4396213	2715				32.8		
Site 6	DDGW001		565751	4397752		90			60		
	DDGW002		565688	4396434							
Site 6	DDGW003		566545	4395357		90			50		
Site 6	DDGG001		566044	4395779		90			8.2		
Site 11	DDGW005		563068	4403536		90			52		
Site 11	DDGW007		564001	4404566		90			58		
HLF	GGDW002		555310	4401315		90			100.5		
HLF	GGDW003A	May 2013	556151	4401409		90	100	89	98		
	GGDW004						118	104	110		
	GGDW004B						60	52.6	58.6		
HLF	GGDW005	May 2013	556028	4402133		90	83.8	76.4	82.4		
HLF	GGDW006	May 2013	557348	4402276		90	112	104.7	110.7		
Site 28	GGSC-035		552753.9	4398474	1636.4	90	12.1	5	11		
Site 28	GGDW-016A		552170.1	4398445	1587.0					Yes	Trans. stolen Q2 2015
Site 28	GGDW-016	Nov 2013	552174	4398443	1587.0		60	53	59	Yes	Trans. stolen Q2 2015



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Area	Monitoring Well ID	Date	Easting	Northing	Head-works Elevation	Incl*	Total depth (m)	Top of screen (mbgl)	Bottom of screen (mbgl)	Trans ⁺	Notes
Site 28	GGDW-014	Oct 2013	552384.7	4398975	1677.5	90	93	70.5	79.5		
Site 28	GGDW-013A	Oct 2013	553230.7	4399013	1664.5	90	21	14	20	Yes	
Site 28	GGDW-013	Oct 2013	553219.9	4399010	1663.4	90	63.6	54	60	Yes	
Site 28	GGDW-010A	Oct 2013	553901.6	4399558	1794.2	90	24.4	18	24	Yes	
Site 28	GGDW-010B	Oct 2013	553897.9	4399557	1793.9	90	70	60	69	Yes	
Site 28	GGDW-015	Nov 2013	554003.1	4399203	1794.1		60	53	59		
Site 28	GGDW-007	Oct 2013	552536	4398302	1620.9	90	129	121.5	127.5	Yes	
Site 28	GGDW-008	Oct 2013	552932.2	4398566	1653.2	90	60	52.5	58.5		
Site 28	GGDW-011	Oct 2013	554714.3	4399713	1918.3	90	60	50	59	Yes	
Site 28	GGDW-012	Oct 2013	553947.5	4398843	1818.7	90	70.4	60.4	69.4	Yes	
Site 28	GGDW-009A		552980.3	4399665	1695.9	90			26		
Site 28	GGDW-009	Oct 2013	552978.5	4399660	1695.8	90	118	108	117	Yes	
Site 27	GGSC-049	Oct 2013					24	13	19		
Site 27	GGSC-050	Oct 2013	560542.5	4401892	2518.0	90	25	9.5	15.5		
	DDAW010	Jun 2013					120	112	118		
	DDAW011	Oct 2013	559901	4401853	2648		89	71	77		
Site 27	DDAW-011A	Nov 2013	559883.7	4401861	2628.1	90	46	23	29		
Site 27	DDAW-013	Oct 2013	560225	4402622	2525.3	90	100	93	99	Yes	



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Area	Monitoring Well ID	Date	Easting	Northing	Head-works Elevation	Incl*	Total depth (m)	Top of screen (mbgl)	Bottom of screen (mbgl)	Trans ⁺	Notes
Site 27	DDAW-012	Oct 2013	560817.2	4401622	2585.0	90	34	27	33	Yes	
Site 13	GGSC-037	Oct 2013	560789.8	4403154	1636.4	90	17.6	10.6	16.6	Yes	
Arshak	DDAW-390	Jun 2014	563391	4396312	1587.0	90	66.0	51	60		
Arshak	DDAW-393	Jul 2014	561965	4396314	1587.0	90	32.8	25.8	31.8		

* inclination of borehole from horizontal, in degrees

⁺ transducer installed

Appendix C (2) - Springs

Catchment	Spring ID	Type	Easting	Northing	Elevation (m)	Notes
Arpa	SP44	Perennial	551486	4397535	1568	
Arpa	SP54		560366	4398449		
Arpa	SP60		562148	4399951		
Arpa	SP73	Perennial	552757	4401419	1730	
Arpa	SP80	Perennial	556861	4405248	1962	
Arpa	SP81		559055	4405496		
Arpa	SP82		560761	4405505		
Arpa	SP83	Perennial	558382	4405951	2021	Madikenc springs
Arpa	SP89	Perennial	557907	4405643	2008	
Arpa	SP90		557805	4405764		
Arpa	SP27.1		560538	4401263		

Appendix C (2) - Springs

Catchment	Spring ID	Type	Easting	Northing	Elevation (m)	Notes
Arpa	SP27.2		560439	4401368		
Arpa	SP27.3		560415	4401364		
Arpa	SP27.4		560444	4401396		
Arpa	SP27.5		560469	4401425		
Arpa	SP27.6		560459	4401435		
Arpa	SP27.7		560362	4401442		
Arpa	SP27.8		560350	4401457		
Arpa	SP27.9		560340	4401463		
Arpa	SP27.10		560301	4401467		
Arpa	SP27.11		560270	4401429		
Arpa	SP27.12		560286	4401390		
Arpa	SP27.13		560228	4401394		
Arpa	SP27.14		560222	4401389		
Arpa	SP27.15		560175	4401464		
Arpa	SP27.16		560357	4401631		
Arpa	SP27.17		560404	4401662		
Arpa	SP27.18		560494	4401650		
Arpa	SP27.19		560504	4401647		
Arpa	SP27.20	Perennial	560494	4401650	2538	

Appendix C (2) - Springs

Catchment	Spring ID	Type	Easting	Northing	Elevation (m)	Notes
Arpa	SP27.21	Perennial	560504	4401647	2539	
Arpa	SP27.22		560399	4401696		
Arpa	SP27.23		560535	4401515		
Arpa	SP27.24		560530	4401511		
Arpa	SP27.25		560516	4401496		
Arpa	SP28.1		551957	4398346		
Arpa	SP28.2		552633	4398806		
Arpa	Spring8, Flow		560365	4401446		
Arpa	Spring8, Quality		560356	4401703		
Darb	SP11		561171	4394314		
Darb	SP12		561097	4394413		
Darb	SP14		561463	4394468		
Darb	SP19		561101	4394992		
Darb	SP20		560948	4395080		
Darb	SP24		561064	4395285		
Darb	SP28	Ephemeral	561553	4395507		
Darb	SP30		562211	4395748		
Darb	SP31	Perennial	560288	4395766	2353	



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Appendix C (2) - Springs

Catchment	Spring ID	Type	Easting	Northing	Elevation (m)	Notes
Darb	SP33	Ephemeral	562241	4396003		
Darb	SP35		559726	4396080		
Darb	SP36		560194	4396104		
Darb	SP37		559926	4396118		
Darb	SP38		560190	4396210		
Darb	SP39		560925	4396286		
Darb	SP40		561534	4396322		
Darb	SP46		559739	4398049		
Darb	SP48		559608	4398161		
Darb	SP50	Perennial	560769	4398235	2698	
Darb	SP51		560100	4398386		
Darb	SP52		560561	4398432		
Darb	SP53		560366	4398449		
Darb	SP61		558755	4400414		
Darb	SP63		559403	4400504		
Darb	SP64		558801	4400586		
Darb	SP65		559295	4400672		
Darb	SP67		559854	4400942		
Darb	SP68	Perennial	569131	4401149	2453	

Appendix C (2) - Springs

Catchment	Spring ID	Type	Easting	Northing	Elevation (m)	Notes
Darb	SP69		557571	4401172		
Darb	SP70		558963	4401280		
Darb	SP71		558732	4401343		
Darb	SP85		558633	4399846		
Darb	SP86		559191	4399700		
Darb	SP87		557557	4398259		
Darb	SP28.3		554311	4398975		
Darb	SP28.4		553878	4397842		
Darb	SP28.5		553864	4397876		
Darb	Spring4	Perennial	560377	4398236		
Darb	Spring6	Perennial	561270	4398704		
Darb	Spring9		559868	4400912		
Darb	Spring10		562058	4396216		
Darb	Spring11		561411	4396181		
Darb	ERW1	Perennial	559834	4399745		
Darb	ERW2	Perennial	559534	4399409		
Darb	ERW3		560019	4398365		
Darb	ERW4		560381	4398468		
Darb	ERW5		560390	4398354		

Appendix C (2) - Springs

Catchment	Spring ID	Type	Easting	Northing	Elevation (m)	Notes
Vorotan	SP1	Perennial	563893	4392500	2199	
Vorotan	SP2		563820	4392563		
Vorotan	SP3		563772	4392657		
Vorotan	SP4		563635	4392730		
Vorotan	SP5	Perennial	563629	4392761	2206	
Vorotan	SP6	Perennial	562374	4392824	2250	
Vorotan	SP7		564355	4393904		
Vorotan	SP8		562810	4393980		
Vorotan	SP9		564314	4394190		
Vorotan	SP10		562501	4394282		
Vorotan	SP13		564068	4394432		
Vorotan	SP15		564173	4394523		
Vorotan	SP16		563738	4394647		
Vorotan	SP17		563270	4394737		
Vorotan	SP18		563470	4394806		
Vorotan	SP21	Perennial	562849	4395109	2309	
Vorotan	SP22		564131	4395173		
Vorotan	SP23		564652	4395239		
Vorotan	SP25		565384	4395322		

Appendix C (2) - Springs

Catchment	Spring ID	Type	Easting	Northing	Elevation (m)	Notes
Vorotan	SP26		562855	4395349		
Vorotan	SP27		564982	4395355		
Vorotan	SP29		563743	4395554		
Vorotan	SP32		564104	4398808		
Vorotan	SP34		564139	4396050		
Vorotan	SP41		564426	4396526		
Vorotan	SP42		563836	4396826		
Vorotan	SP43		564351	4396918		
Vorotan	SP45		551486	4397535		
Vorotan	SP47		561959	4398192		
Vorotan	SP49		562262	4398198		
Vorotan	SP55		562106	4398931		
Vorotan	SP56	Perennial	563161	4399028	2345	
Vorotan	SP57		561432	4399090		
Vorotan	SP58		563047	4399208		
Vorotan	SP59		562418	4399367		
Vorotan	SP62		562986	4400455		
Vorotan	SP66		562482	4400904		
Vorotan	SP72		562714	4401404		

Appendix C (2) - Springs

Catchment	Spring ID	Type	Easting	Northing	Elevation (m)	Notes
Vorotan	SP74		561778	4401576		
Vorotan	SP75		561049	4401603		
Vorotan	SP76		562288	4401615		
Vorotan	SP77	Perennial	561291	4401764	2513	
Vorotan	SP78		562156	4401844		
Vorotan	SP79	Perennial	563078	4401958	2403	
Vorotan	SP84		562364	4401738		
Vorotan	SP88		562252	4399810		
Vorotan	SP13.1		560891	4402708		
Vorotan	SP13.2		560940	4402220		
Vorotan	SP13.3		561083	4402384		
Vorotan	SP13.4		561088	4402386		
Vorotan	SP13.5		561111	4402518		
Vorotan	SP13.6		560869	4402286		
Vorotan	SP13.7*	Perennial	560908	4402691	2429	
Vorotan	SP13.8		560902	4402638		
Vorotan	SP13.9		560905	4402266		
Vorotan	SP13.10	Perennial	561655	4403067	2416	
Vorotan	SP13.11		561647	4402177		

Appendix C (2) - Springs

Catchment	Spring ID	Type	Easting	Northing	Elevation (m)	Notes
Vorotan	SP13.12		561622	4402141		
Vorotan	SP13.13		561719	4402244		
Vorotan	SP13.14		561726	4402247		
Vorotan	SP13.15		561701	4402249		
Vorotan	SP13.16		561827	4402432		
Vorotan	SP13.17		561885	4402535		
Vorotan	SP13.18	Perennial	561541	4402215	2454	
Vorotan	SP13.19		561464	4402154		
Vorotan	SP13.20		561551	4402669		
Vorotan	SP13.21		561550	4402670		
Vorotan	SP13.22		561551	4402671		
Vorotan	SP13.23	Perennial	561458	4402579	2416	
Vorotan	SP13.24		561467	4402569		
Vorotan	SP13.25		561477	4402561		
Vorotan	SP13.26		560965	4402247		
Vorotan	SP13.27		561193	4402515		
Vorotan	SP13.28		561165	4402516		
Vorotan	SP13.29	Perennial	561141	4402664	2415	
Vorotan	SP13.30		561299	4402713		



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Appendix C (2) - Springs

Catchment	Spring ID	Type	Easting	Northing	Elevation (m)	Notes
Vorotan	SP13.31		561584	4402310		
Vorotan	Spring GA1	Perennial	562181	4399415		
Vorotan	Spring GA2	Perennial	562255	4399053		
Vorotan	Spring GA3	Perennial	562297	4399031		
Vorotan	Spring GA4	Perennial	562316	4399014		
Vorotan	Spring GA5	Perennial	562318	4398967		
Vorotan	Spring1	Perennial	561516	4399068		
Vorotan	Spring2	Perennial	562272	4397950		
Vorotan	Spring3	Perennial	561434	4399102		
Vorotan	Spring5	Perennial	561961	4397927		
Vorotan	Spring7	Perennial	561134	4399920		

* SP 13.7 is also surface water monitoring location AW030 (discharge from adit)

Information obtained from Chapter 4.8 of ESIA and Spring Survey Interpretive Report - Update (Golder Associates, June 2014). Catchment interpreted from various sources. Where "type" is not identified it is assumed to be ephemeral.

Key to spring ID:

Spring Identified by Geoteam in 2010
SP13.x / SP27.x Identified by Geoteam in April 2011

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GA	Identified by Golder in August 2011
ERW	Identified by Geoteam in July 2012
SP1-SP90	Identified by Geoteam in November 2013 / February 2014

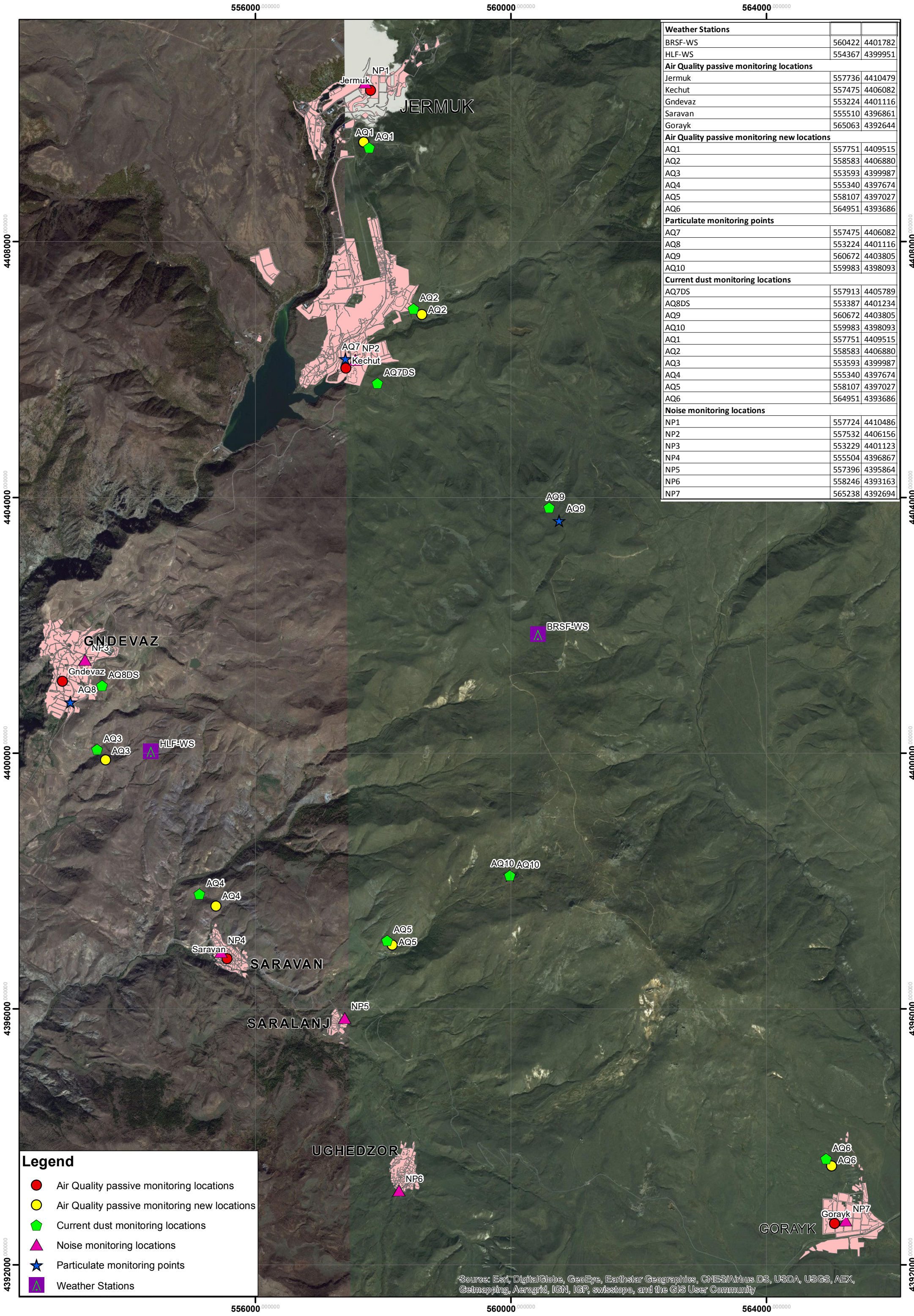
Other springs

DWJ1, DWJ2, DWJ3, DWJ5, DWJ6, DWJ7, DWJ8, DWJ9, DWJ10 and DWJ11 are geothermal springs located in the Arpa catchment around Jermuk. They occur significantly upstream (north) of the point where the Amulsar Project area intersects the Arpa catchment.

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Appendix D

Drawings

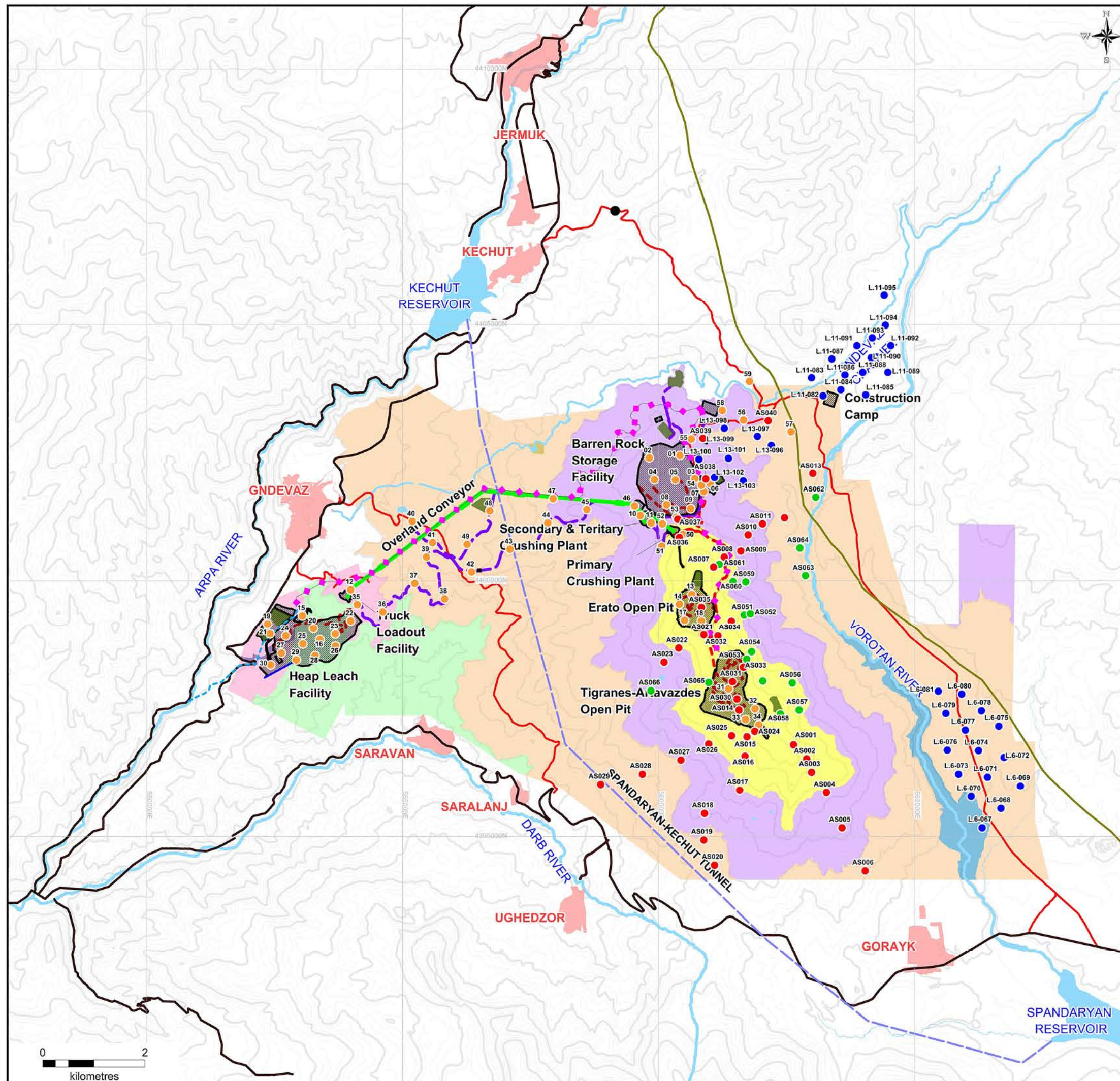


Weather Stations		
BRSF-WS	560422	4401782
HLF-WS	554367	4399951
Air Quality passive monitoring locations		
Jermuk	557736	4410479
Kechut	557475	4406082
Gndevaz	553224	4401116
Saravan	555510	4396861
Gorayk	565063	4392644
Air Quality passive monitoring new locations		
AQ1	557751	4409515
AQ2	558583	4406880
AQ3	553593	4399987
AQ4	555340	4397674
AQ5	558107	4397027
AQ6	564951	4393686
Particulate monitoring points		
AQ7	557475	4406082
AQ8	553224	4401116
AQ9	560672	4403805
AQ10	559983	4398093
Current dust monitoring locations		
AQ7DS	557913	4405789
AQ8DS	553387	4401234
AQ9	560672	4403805
AQ10	559983	4398093
AQ1	557751	4409515
AQ2	558583	4406880
AQ3	553593	4399987
AQ4	555340	4397674
AQ5	558107	4397027
AQ6	564951	4393686
Noise monitoring locations		
NP1	557724	4410486
NP2	557532	4406156
NP3	553229	4401123
NP4	555504	4396867
NP5	557396	4395864
NP6	558246	4393163
NP7	565238	4392694

Legend

- Air Quality passive monitoring locations
- Air Quality passive monitoring new locations
- ⬠ Current dust monitoring locations
- ▲ Noise monitoring locations
- ★ Particulate monitoring points
- ⬠ Weather Stations

Sources: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community



- Legend**
- Settlements
 - Project Infrastructure
 - Topsoil Location
 - Access Roads (proposed)
 - Haul Roads (proposed)
 - Paved Roads (existing)
 - Gravel Roads (existing)
 - Gas Pipeline (existing)
 - Conveyor (proposed)
 - Water Pipeline (proposed)
 - Contact Waterline (proposed)
 - Main Rivers and Watercourses
- Soil Geochemistry Survey Locations (by Year)**
- 2008
 - 2009
 - 2010
 - 2014
- Soil Types**
- Brown Forest Steppe Soils
 - Mountain Black Soils
 - Mountain Chestnut Soils
 - Mountain Meadow Soils
 - Mountain Meadow Steppe Soils
 - River-valley Soils
 - Strong Oblique,strict Erosion, Source/mother Rock Desertification

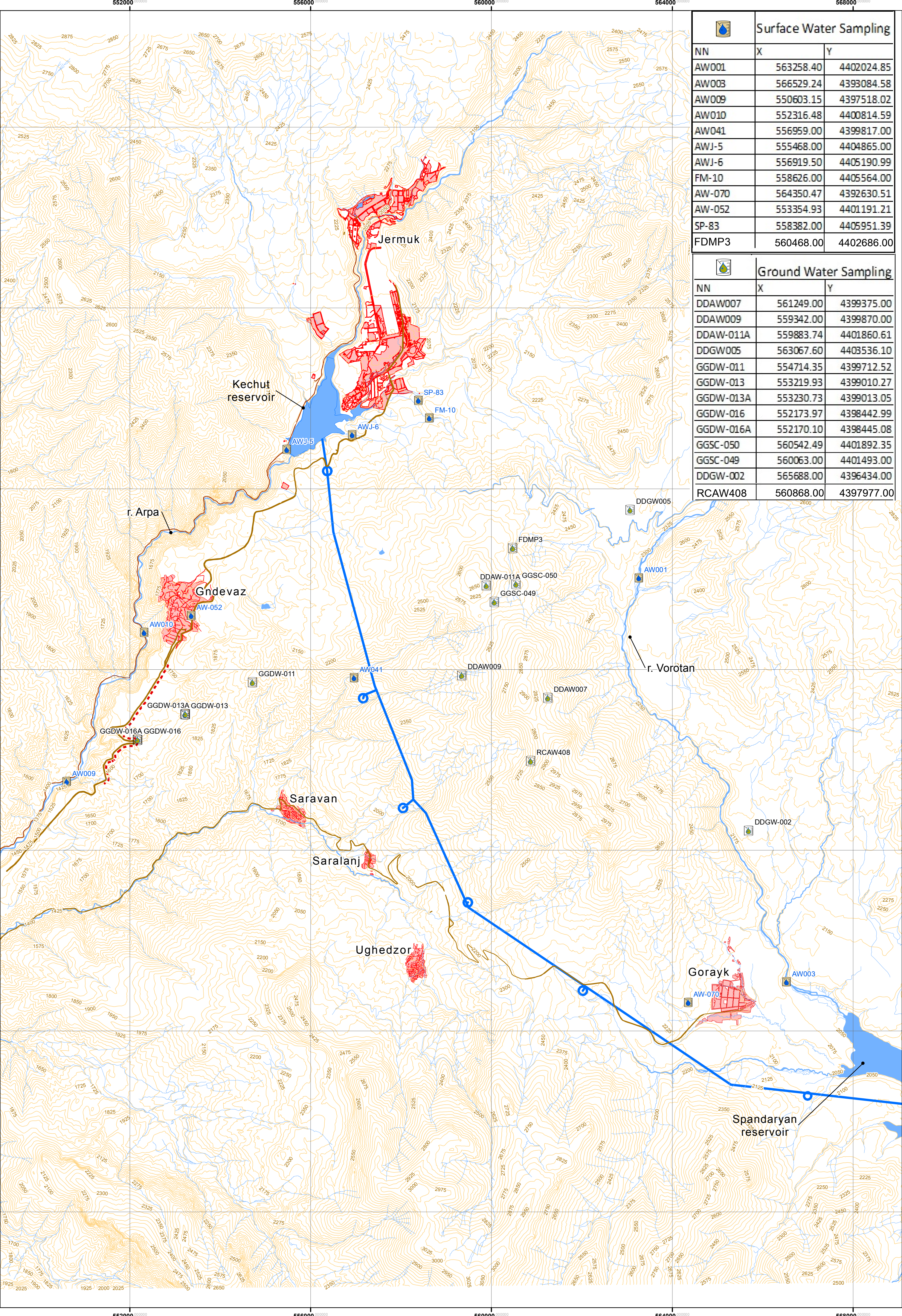
References

Projected coordinate system: UTM Zone 38 N
Central Meridian 45 (WGS84)

KD Engineering
43-07-CI-001.dwg
Geochem data 2008-2014.xlsx
Site 28 soils data received (12/05/2014)

Scale:		1 : 75 000 @ A3	
WGS84 UTM 238 Central Meridian 45 Ref:		557500 : 4401500	
Long: Lat DD:	45.6728° : 39.7616°	Long: Lat DMS:	45° 40' 22.15" : 39° 45' 41.71"
Client:	 		
Lydian International		Wardell Armstrong International Wheal Jane, Baldhu, Truro, Cornwall, TR3 6EH	
Tel: +44 (0) 1872 560738 email: info@wardell-armstrong.com web: www.wardell-armstrong.com		Drawn By: J.S.English Checked By: D.Brignall	
Date: 26/08/2014		Date: 26/08/2014	

AMULSAR GOLD PROJECT - ARMENIA
Soil Geochemistry Survey Locations and
Soil Associations



	Surface Water Sampling	
NN	X	Y
AW001	563258.40	4402024.85
AW003	566529.24	4393084.58
AW009	550603.15	4397518.02
AW010	552316.48	4400814.59
AW041	556959.00	4399817.00
AWJ-5	555468.00	4404865.00
AWJ-6	556919.50	4405190.99
FM-10	558626.00	4405564.00
AW-070	564350.47	4392630.51
AW-052	553354.93	4401191.21
SP-83	558382.00	4405951.39
FDMP3	560468.00	4402686.00

	Ground Water Sampling	
NN	X	Y
DDAW007	561249.00	4399375.00
DDAW009	559342.00	4399870.00
DDAW-011A	559883.74	4401860.61
DDGW005	563067.60	4403536.10
GGDW-011	554714.35	4399712.52
GGDW-013	553219.93	4399010.27
GGDW-013A	553230.73	4399013.05
GGDW-016	552173.97	4398442.99
GGDW-016A	552170.10	4398445.08
GGSC-050	560542.49	4401892.35
GGSC-049	560063.00	4401493.00
DDGW-002	565688.00	4396434.00
RCAW408	560868.00	4397977.00