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4.1 Introduction

4.1.1 Geography

The Republic of Armenia (RA) is located in the South Caucasus region of Eurasia. It is a high-altitude, plateau-mountainous landlocked country and is the smallest of the three South Caucasus states in both land area and population. The regional and geographical context of the Project study area are shown in Figure 4.1.1 and Figure 4.1.2. Figure 4.1.3 illustrates the landscape which is typical of the study area within which the Project is located.

4.1.2 Social Context

The RA is a sovereign democratic social state governed by civil law. Situated along the Silk Road, it has experienced a number of cultural influences and empires. It is one of the earliest Christian civilisations, being the first country to adopt Christianity as the state religion with the first churches being constructed in the fourth century.

Armenia is a small country (29,800 km^2), with a population of 3.1 million, making it one of the most densely populated countries of the Former Soviet Union (FSU). Eastern Armenian territories became part of the Russian Empire in the early 19th Century. Following a short independence period from 1918 to 1920, Armenia became part of the Soviet Union. Armenia gained independence in 1991 after the collapse of the Soviet Union.

Armenia has good relations with Russia, Georgia and Iran. Relations between Armenia and Turkey remain strained following the massacre of over 1.5 million ethnic Armenians in the period 1915-1917, known as the Armenian Genocide[1].

With a per capita GDP of US$ 3,870 (GNI, 2013) Armenia is a classified as a lower middle income country[2]. The Armenian economy has undergone a major transformation since independence, achieving growth of over 13% prior to the financial crisis of 2008/9. The currency is the Armenia Dram (or AMD) and it is subdivided into 100 lumas. The May 2016 exchange rate was 1 US$ = 479 AMD or 1 € = 546 AMD.

[1] Armenian Genocide http://www.armenian-genocide.org/genocidefaq.html (accessed 14 May 2014)
[2] World Bank, (2012), Armenia Overview, accessible at: www.worldbank.org/en/country/armenia/overview (accessed 14 May 2014)

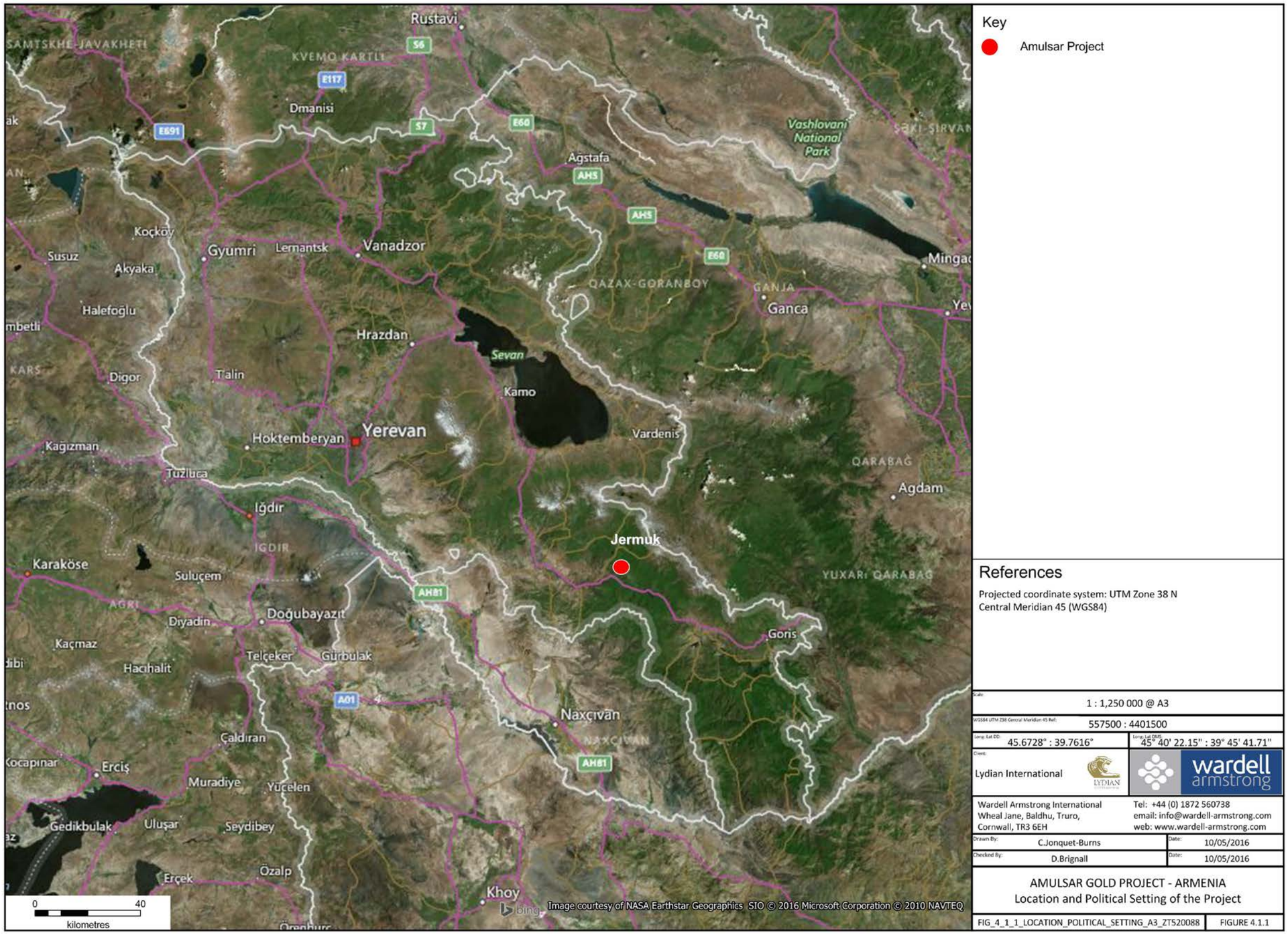


Figure 4.1.1: Location and Political Setting of the Project

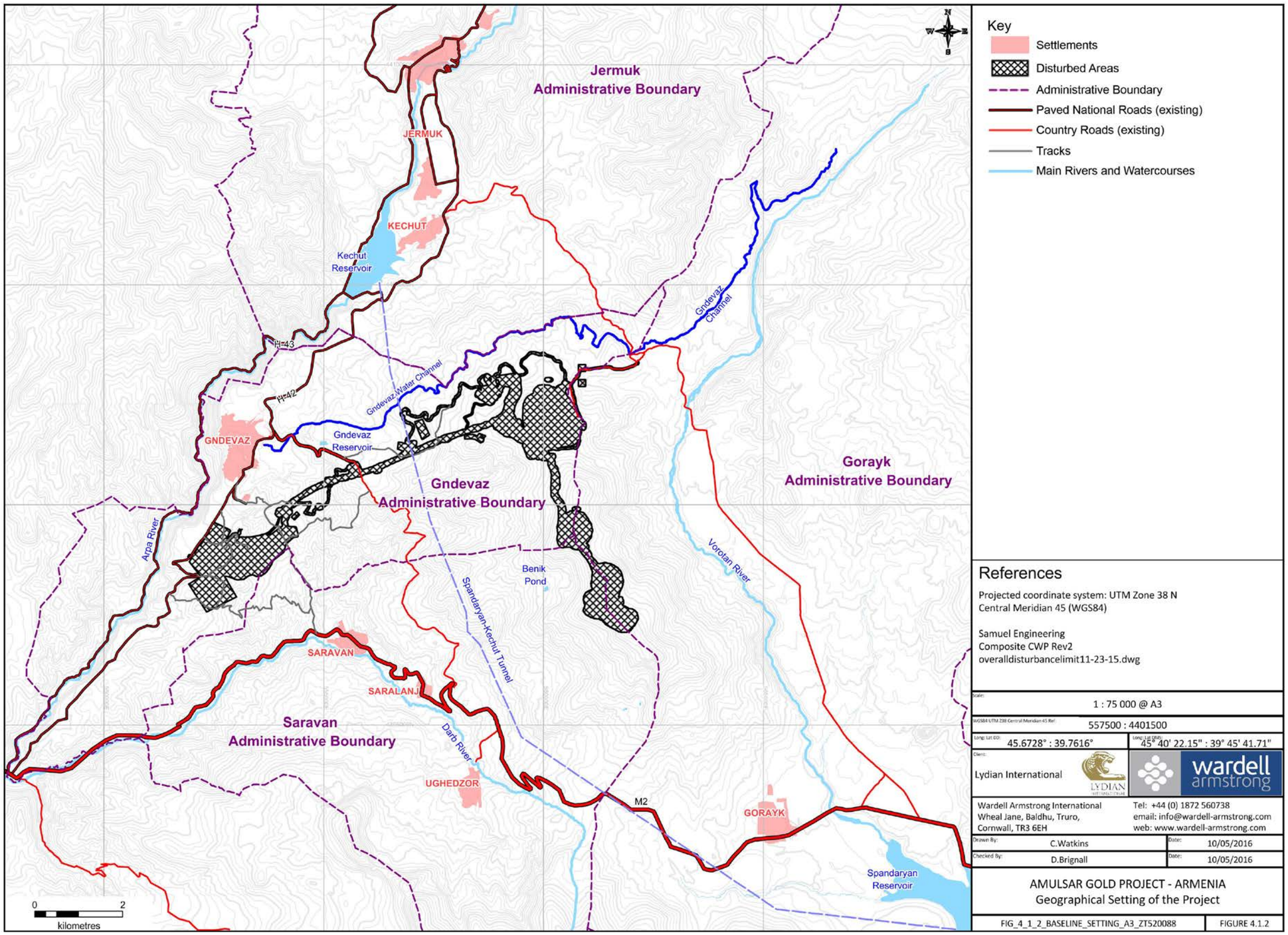


Figure 4.1.2: Geographical Setting of the Project

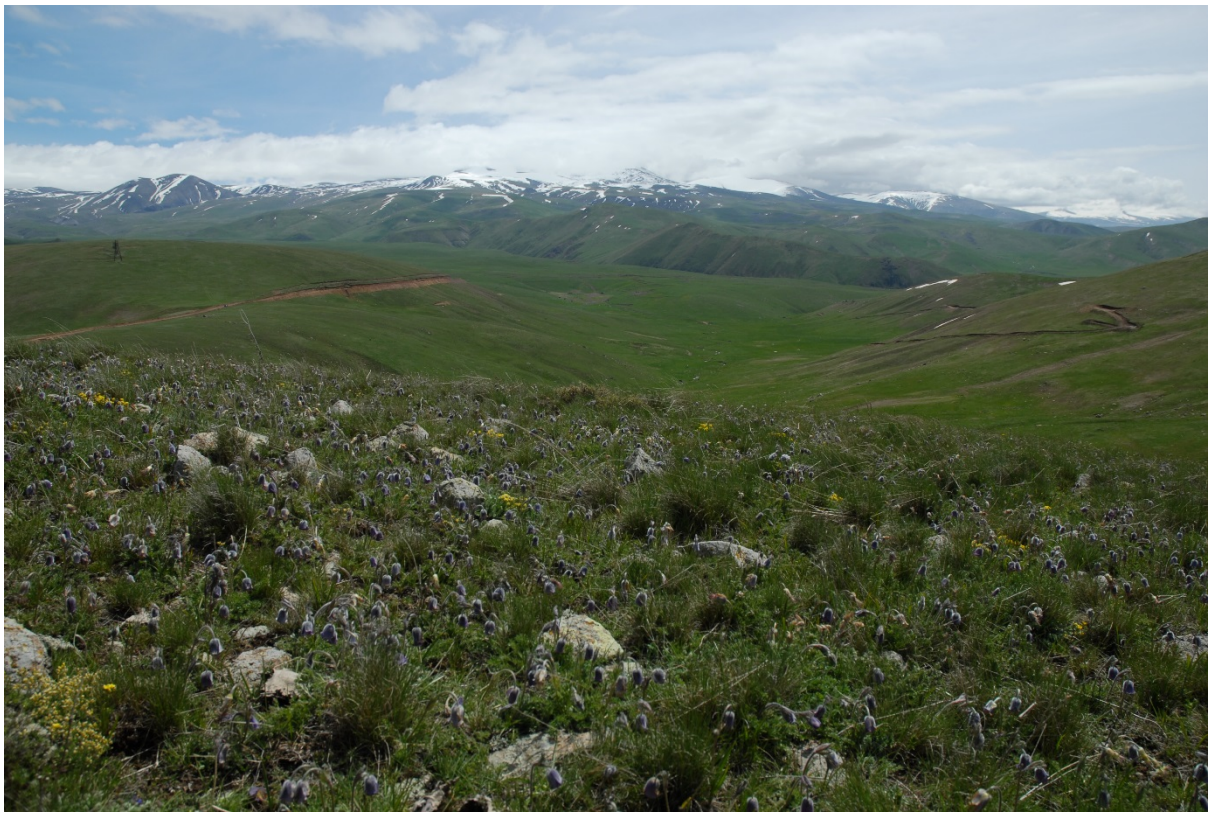


Figure 4.1.3: View from the Amulsar Mountain looking north east from near the Exploration Camp

4.1.3 Format of the ESIA Baseline

For the purpose of the ESIA and the collection and consideration of baseline data, two geographical study areas were defined relative to the Project. The environmental baseline study area (EBSA) is shown in Figure 4.1.4 and the corresponding figure for the socio-economic baseline study area (SBSA) is shown in Figure 4.1.5.

The baseline study stage provides an analysis of the appropriate environmental and social baseline data to enable the detailed characterisation of existing conditions that may be affected through Project development including construction, operation, closure and post-closure. Baseline analysis has been designed to provide a basis for assessing the magnitude of predicted impacts and the development of appropriate mitigation measures. The baseline information and data on the present status and condition of the environment and socio-economic setting were obtained from a range of sources, including:

- Primary field data collected by Geoteam and Armenian and international specialists, (specialists involved are listed in Appendix 1.1);

- Secondary archive data obtained from published sources, local statistical records and other available governmental data;
- Mapping, remote sensing and satellite imagery data and analysis, providing spatial land-based data; and
- Qualitative data and relevant information provided by Geoteam and Armenian experts, based on experience and local knowledge.

4.1.4 Environmental Baseline

Baseline study areas should generally be more extensive than the zones in which Project impacts occur. Therefore, the baseline study areas identified within Chapter 4 do not necessarily represent the zones where impacts will occur. They have been defined to provide appropriate context to the environmental and social setting for the Project. Figure 4.1.4 shows the extent of the study area within which the environmental baseline studies have been focused. However, the exact areas of study did vary between the different environmental aspects, and these variations are identified within the appropriate sections of this Chapter and summarised in Table 4.1.1.

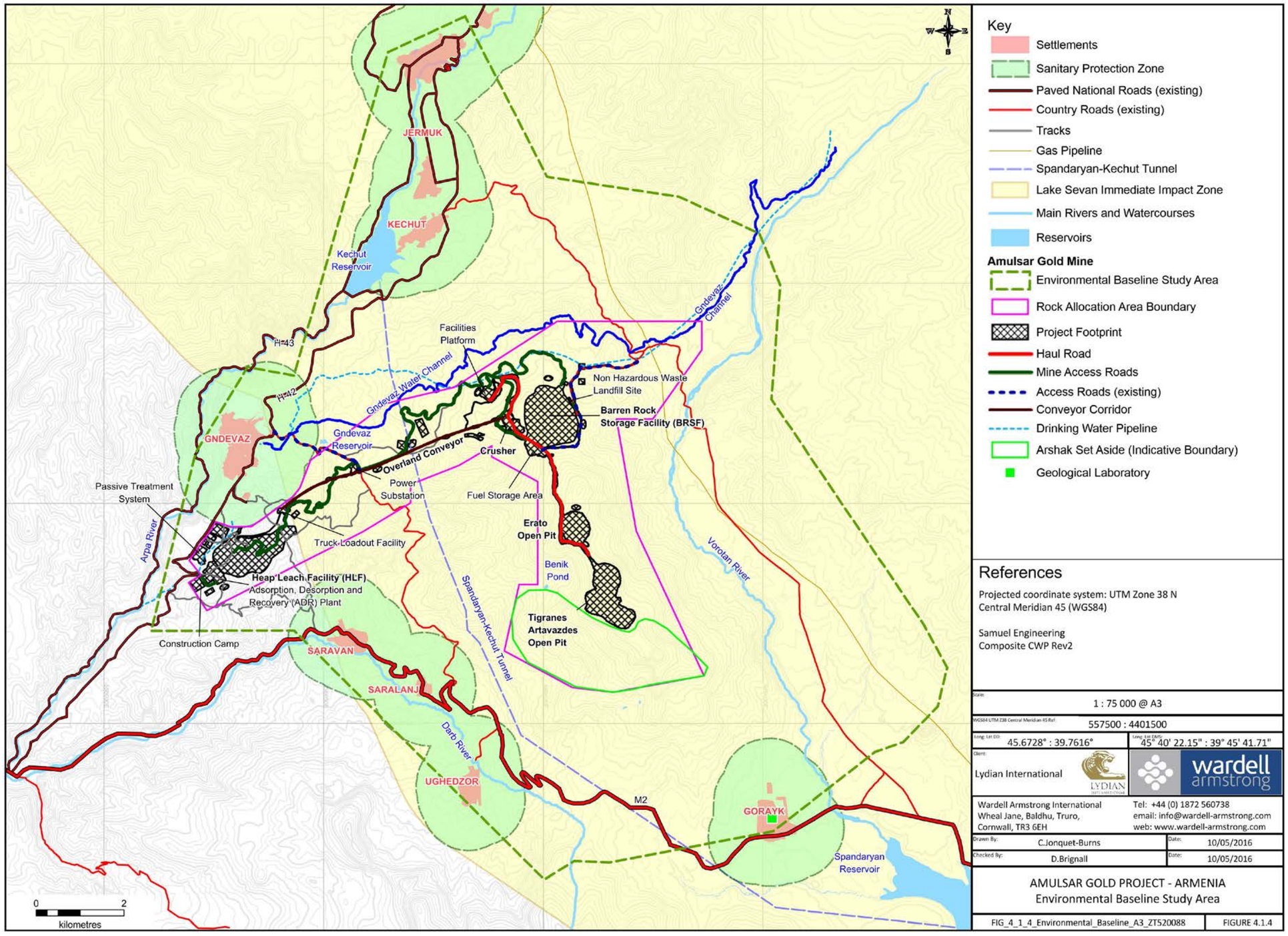


Figure 4.1.4: Environmental Baseline Study Area

4.1.5 Social Baseline

The Project is located in central Armenia straddling the boundary of two Marzes (Vayots Dzor to the west and Syunik to the east).

Social baseline data has been collected over different areas depending on the nature of the baseline data. The collection of primary baseline data focussed on the closest communities to the Project. For this study the term Local Communities refers to a number of settlements as indicated in Figure 4.1.5. Jermuk is approximately 10 km to the north of Amulsar Mountain and Gndevaz is the closest community, located approximately 1.2 km from the nearest part of the Project infrastructure (the Heap Leach Facility, HLF). Saralanj is approximately 3.9 km away from the open pit of Tigranes/Artavazdes. There are four rural villages: Kechut (which is classed as part of Jermuk), Saravan (including Saralanj and Ughedzor) and Gndevaz in Vayots Dzor Marz; and Gorayk in Syunik Marz. Table 3.1 identifies the distance from the individual elements of the Project infrastructure to the nearest boundary of each of the communities.

In contrast, much of the secondary data used to inform the socio-economic baseline has focussed on Marz and national level assessments. The study area for the social baseline and the geographic relationship of the main settlements to the Project considered in the ESIA are shown in Figure 4.1.5.

Further information on the detail of the study area defined for the social aspects is provided in the relevant sections of Chapter 4 and summarised in Table 4.1.1.

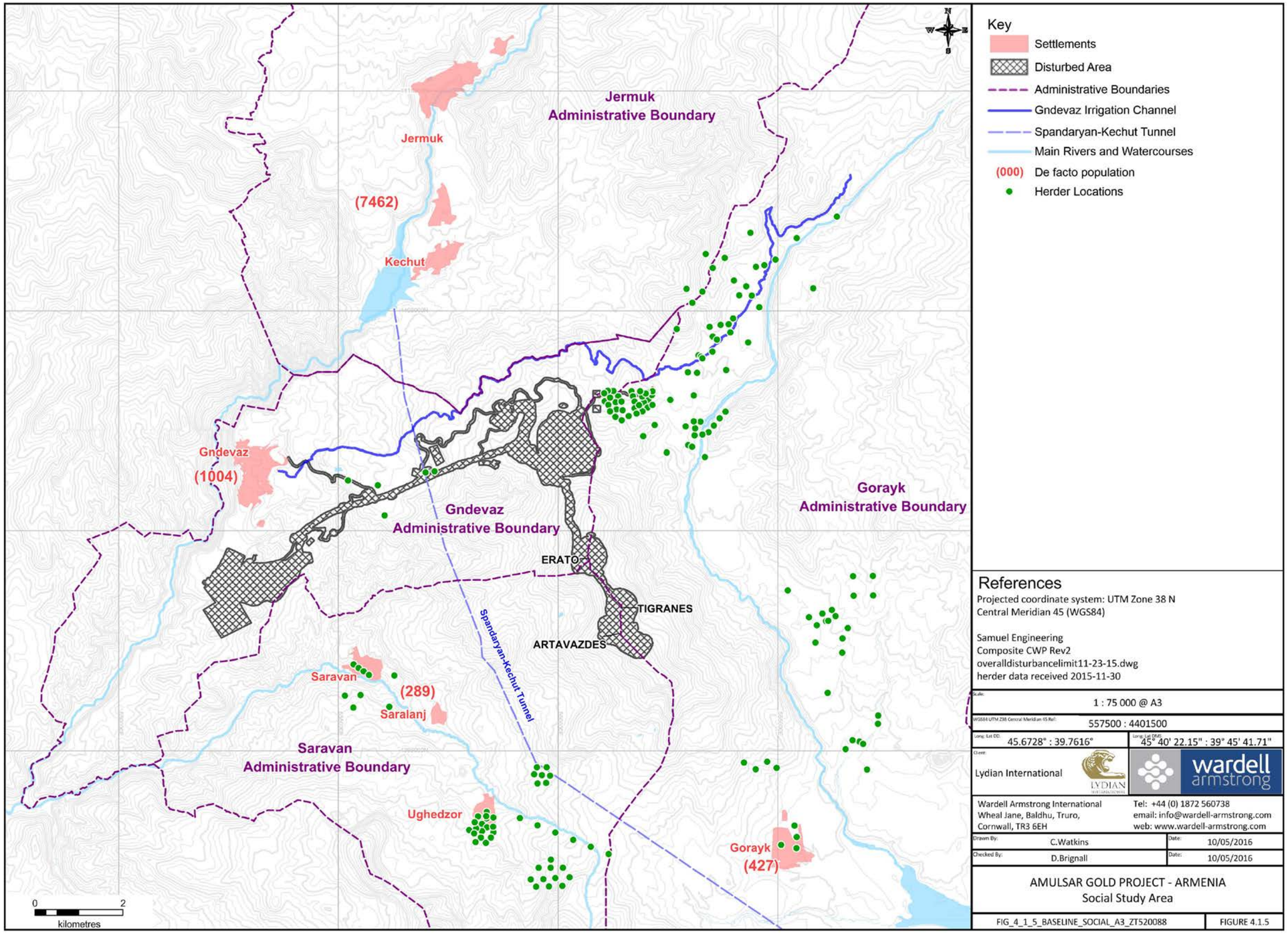


Figure 4.1.5: Social Study Area

Table 4.1.1: Summary of the study areas developed for each environmental and social aspect considered in the baseline (Chapter 4) and impact assessment (Chapter 6)		
Aspect	**Extent of the study area**	**Outline description – key components of the study area**
Climate (& GHG emissions)	National, Regional and Local	National data is based on published sources. The local setting has been based on a comparison between data from two state meteorological stations. From this comparison the climatic data for the Project has been based on Vorotan Pass Meteorological Station. GHG emissions relate to Project specific activities and transport to and from the Project.
Landscape	Regional and Local	The study area has been defined according to UK guidelines for landscape and visual impact assessment, which is a minimum radius of 15km from the outer edge of the Project footprint. The local setting has been defined as the area within which landscape character is potentially affected and defined viewpoints from which the Project is visible.
Air Quality, Noise and Vibration	Local	The local study area is defined as the settlements in closest proximity to the Project footprint, and includes the three closest rural settlements (Gorayk, Gndevaz and Saravan (including Saralanj and Ughedzor)) and Jermuk (including Kechut). Non-residential receptors, including herders, mammals and plant communities are included in the assessment and within the study area delineated by baseline monitoring identified above.
Geology	Regional and Local	The regional geology has been described from published sources, with more detailed characterization of the geological region within which Mount Amulsar is located. Project specific geology has been informed by primary data obtained through site investigation that includes the footprint of the Project and areas adjacent.
Soils & land cover	Local	Primary data has been collected from within the Project footprint. Additional information has been obtained from land adjacent to the Project footprint and has been referred to where this data also informs the assessment.
Groundwater	Regional and Local	The local setting has been defined by the hydraulic boundaries formed by the Arpa, Darb and Vorotan Rivers and the watershed boundaries of their catchments at the northern and southern extents. This area extends from the confluence of the Darb River and Arpa River in the south-west, and the Spandaryan Reservoir in the south-east extending north to approximately UTM Northing 4407500. The Jermuk geothermal park lies outside this hydraulically defined study area, as it is to the north of the Arpa River. However, it has been included in the study area due to the importance of the springs to local and national stakeholders.
Surface water	National, Regional and Local	National data is based on published sources, with primary data collection extending to monitoring points upstream and downstream of the Project footprint.
Biodiversity	International, Regional and Local	International and National data has been based on published sources. Primary data obtained over the period 2008 to 2014 has informed the locally based studies within the Project-affected area, which includes the project footprint and adjacent areas defined by the biology of individual taxa and species studied.

Table 4.1.1: Summary of the study areas developed for each environmental and social aspect considered in the baseline (Chapter 4) and impact assessment (Chapter 6)		
Aspect	**Extent of the study area**	**Outline description – key components of the study area**
Social, political, Demographics and Economics	National, Regional and Local	National data is based on published sources. The regional setting includes the two Marzes (provinces) straddled by the mine layout and footprint, Vayots Dzor and Syunik, and has been derived from published sources. The local study is defined as the settlements in closest proximity to the Project footprint, and includes the three closest rural settlements (Gorayk, Gndevaz and Saravan (including Saralanj and Ughedzor)) and Jermuk (including Kechut).
Education	Local	The study area is defined as the settlements in closest proximity to the Amulsar Project, and includes the three closest rural settlements (Gorayk, Gndevaz and Saravan (including Saralanj and Ughedzor)) and Jermuk (including Kechut).
Community health	Local	National data is based on published sources. The regional setting includes the two Marzes (provinces) straddled by the mine layout and footprint, Vayots Dzor and Syunik, and has been derived from published sources. The local study area is defined as the settlements in closest proximity to the Project footprint, and includes the three closest rural settlements (Gorayk, Gndevaz and Saravan (including Saralanj and Ughedzor)) and Jermuk (including Kechut).
Land use and tenure	Local	The local study area is defined as the settlements in closest proximity to the Project footprint, and includes the three closest rural settlements (Gorayk, Gndevaz and Saravan (including Saralanj and Ughedzor)) and Jermuk (including Kechut).
Livelihoods	National, Regional and Local	National data is based on published sources. The regional setting includes the two Marzes (provinces) straddled by the mine layout and footprint, Vayots Dzor and Syunik, and has been derived from published sources. The local study area is defined as the settlements in closest proximity to the Project footprint, and includes the three closest rural settlements (Gorayk, Gndevaz and Saravan (including Saralanj and Ughedzor)) and Jermuk (including Kechut).
Transport	International, National, Regional and Local	International and National data is based on published sources. The regional setting is defined by the network of national and state roads, namely the M-2 and H-42. The local setting includes the junction from the highway network to the Project and the three closest rural settlements (Gorayk, Gndevaz and Saravan (including Saralanj and Ughedzor)) and Jermuk (including Kechut.
Cultural heritage	Local	The local setting includes land within the Project footprint, together with additional information obtained from land adjacent to the Project footprint that has been referred to where this data also informs the assessment.
Note: See also: Figure 4.1.4 and Figure 4.1.5		

4.1.6 Project footprint, disturbed and restricted areas

Table 4.1-2 defines the likely extent of land that would be affected by the Project (see also Figure 4.1.6).

Table 4.1-2 Land take and description

Land take	Area (ha)	Description
Project footprint	599	The area of land that will be occupied by the mine and related infrastructure (including temporary infrastructure during the construction phase), as defined in Figure 3.1 (the general arrangement of the Project)
Disturbed area	922	The area of land that comprises the Project footprint plus the immediately adjacent land that is considered likely to be affected during both construction (disturbance of topsoil) and operations (as a consequence of dust deposition on vegetation, thereby reducing the value of the land for agricultural use). The project disturbed area includes buffer zones that comprise: • 100m adjacent to the open pits; • 50m adjacent to the BRSF, conveyor and haul roads; • 30m adjacent to the HLP; and • 15m adjacent to mine access roads.
Project ecologically disturbed area	368	Additional buffer of 1km from haul roads and 500m from the mine access roads, within which emissions such as NOx, SOx and particulates generated by mine vehicles, could potentially influence the ecology of the vegetation.
Project restricted area (through operations)	323	A buffer zone that has been defined adjacent to the limits of each of the open pit (Tigranes, Artavazdes and Erato) within which access will be restricted during blasting within the pits for safety reasons, and is also likely to be affected by deposition of dust on vegetation.
Areas restricted by Project fenceline	60	Additional areas of land which will not be occupied by Project infrastructure but will be restricted due to perimeter fencing.
Areas restricted for wildlife	95	Areas of land within which it is predicted that use by fauna may be inhibited due to the barrier effects of the presence of mine infrastructure (including access roads and the conveyor).
Total	1766	

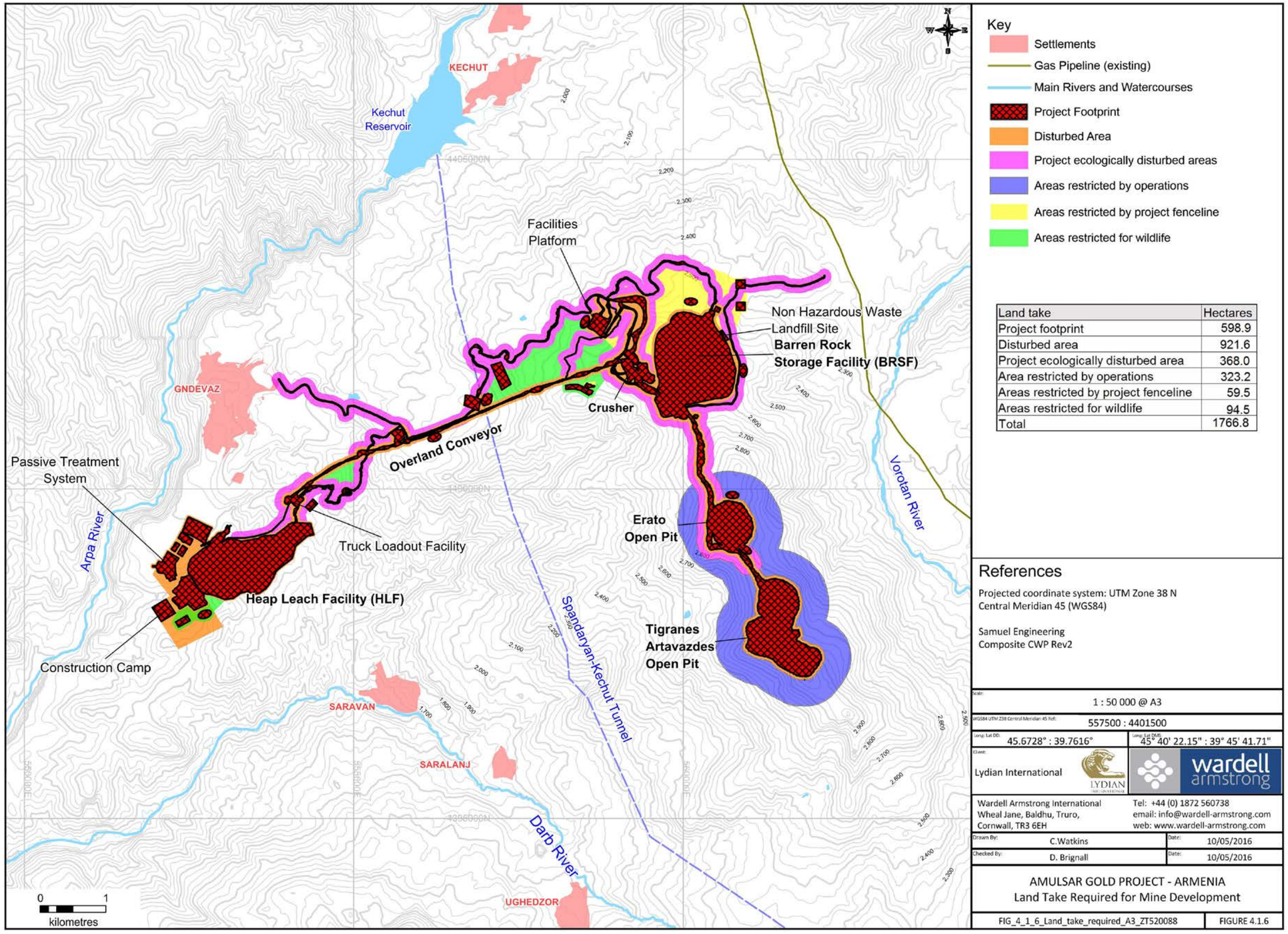


Figure 4.1.6: Land Take Required for Mine Development

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APPENDICES

Appendix 4.2.1 Jermuk climate data
Appendix 4.2.2 On site weather station

4.2 Climate

4.2.1 National climatic conditions

Due to the landlocked location of the RA and the extent of mountain ranges within its borders, the climate is generally dry and continental; however, significant regional variations do occur.

The Köppen-Geiger climate classification groups the RA climate as "*Dfb"*, meaning that the country has a Warm Summer Continental climate. In this designation, the *D* represents the Continental/Microthermal climate group, which has an average temperature over 10°C in the warmest months with a coldest month averaging below -3°C. This climatic type usually occurs in the interiors of continents or on their east coasts, and north of 40°N in latitude. The *f* indicates that there is significant rainfall throughout all seasons and the *b* indicates that the warmest month averages below 22°C; however at least four months average above 10°C.

Regional climate variation across the RA is pronounced, with lower altitudes having longer and hotter summers, averaging around 25°C, with winter temperatures in the foothills dropping to around -5°C rather than the -12°C which can be recorded in the mountains.

Annual rainfall variations occur across the RA and are influenced by topography. The Lesser Caucasus Mountains prevent humid air masses from reaching the inner areas of the country. Elevations between 1400 m and 2000 m above sea level (asl) tend to receive around 800 mm of rainfall per year, with the inland plains only receiving 200 mm to 400 mm.

4.2.2 State Meteorological Stations

Historical climate data have been obtained by Geoteam from the two State meteorological stations nearest to the Project – one located on the Vorotan Pass and another located in Jermuk. Distances of these two meteorological stations from the main components of the mine are identified within Table 4.2.1. The location of these meteorological stations in relation to the Project is shown on Figure 4.2.3.

Table 4.2.1: Geographical data for the Vorotan Pass and Jermuk meteorological stations			
Mine Component	**Approximate Elevation of mine component (m asl)**	**Vorotan Pass**	**Jermuk**
Artavazdes Open Pit	2,975 m	3.7 km	11.9 km
Tigranes –Open Pit	2,925 m	4.4 km	11.1 km
Erato Open Pit	2,900 m	5.6 km	9.8 km
BRSF	2,625 m	7.5 km	6.5 km
HLF	1,800 m	9.2 km	10.0 km
Elevation of met station (m asl)		2392 m	2066 m

As Table 4.2.1 details, the Vorotan Pass station is located at an elevation of 2,392 m asl, which is between the heights of the main Project components and is more representative than the station at Jermuk, which is at a lower elevation. The Vorotan Pass station lies on the northern edge of the Vorotan Pass, within the Zangezur mountain range. The station itself has a south-facing aspect, situated on the exposed footslopes of Mount Amulsar (Figure 4.2.1). This station provides a period of 51 years of continuous data for the majority of measurements (gaps are encountered for the snow dataset) from a proximal location to the Project. The dataset can be considered to provide representative climatic data, albeit lacking the more extreme weather patterns that will be experienced at the higher altitude of Mount Amulsar.

The Vorotan Pass climate data has been analysed for the continuous period from January 1962 to April 2013, at the onset of the Project design. Since the meteorological station remains operational and annual analysis can be maintained during the Project, the baseline climatic dataset can be compared to future weather data from the same meteorological station.



Figure 4.2.1: Vorotan Pass meteorological station, looking south onto the southern Zangezur mountains

The state meteorological station located at Jermuk is situated at an elevation of 2,066 m asl, a much lower elevation than many of the main components of the Project (Table 4.2.1). The station lies on the northern edge of the Jermuk airstrip, which is unexposed flat land, between mountainous areas to the east and west of Jermuk and the airstrip (Figure 4.2.2). Its location is therefore less representative of the more exposed conditions experienced by the Project. Analysis of this data displays trends which are similar to those obtained from the Vorotan Pass dataset. This analysed data is presented in Appendix 4.2.1; however, it is not considered to be 'climate data'.



Figure 4.2.2: Jermuk meteorological station on the northern edge of the airstrip

Vorotan Pass Weather Station

Monthly averages for precipitation and temperature were combined to produce Figure 4.2.4, showing an average of the annual temperature and precipitation rates over the period 1962-2013. Peak rainfall is recorded in May, with an average of 94mm, with September having the lowest rainfall levels at an average of 27mm. Maximum temperatures are in August, with an average of 17^{o}C, while minimum temperatures in January average -14^{o}C. These temperature trends correspond with the monthly averages for evaporation.

Wind data from the Vorotan Pass weather station is available for the period 1966-2013 and Table 4.2.2 illustrates the summary of these results and provides an indication of the mean wind direction.

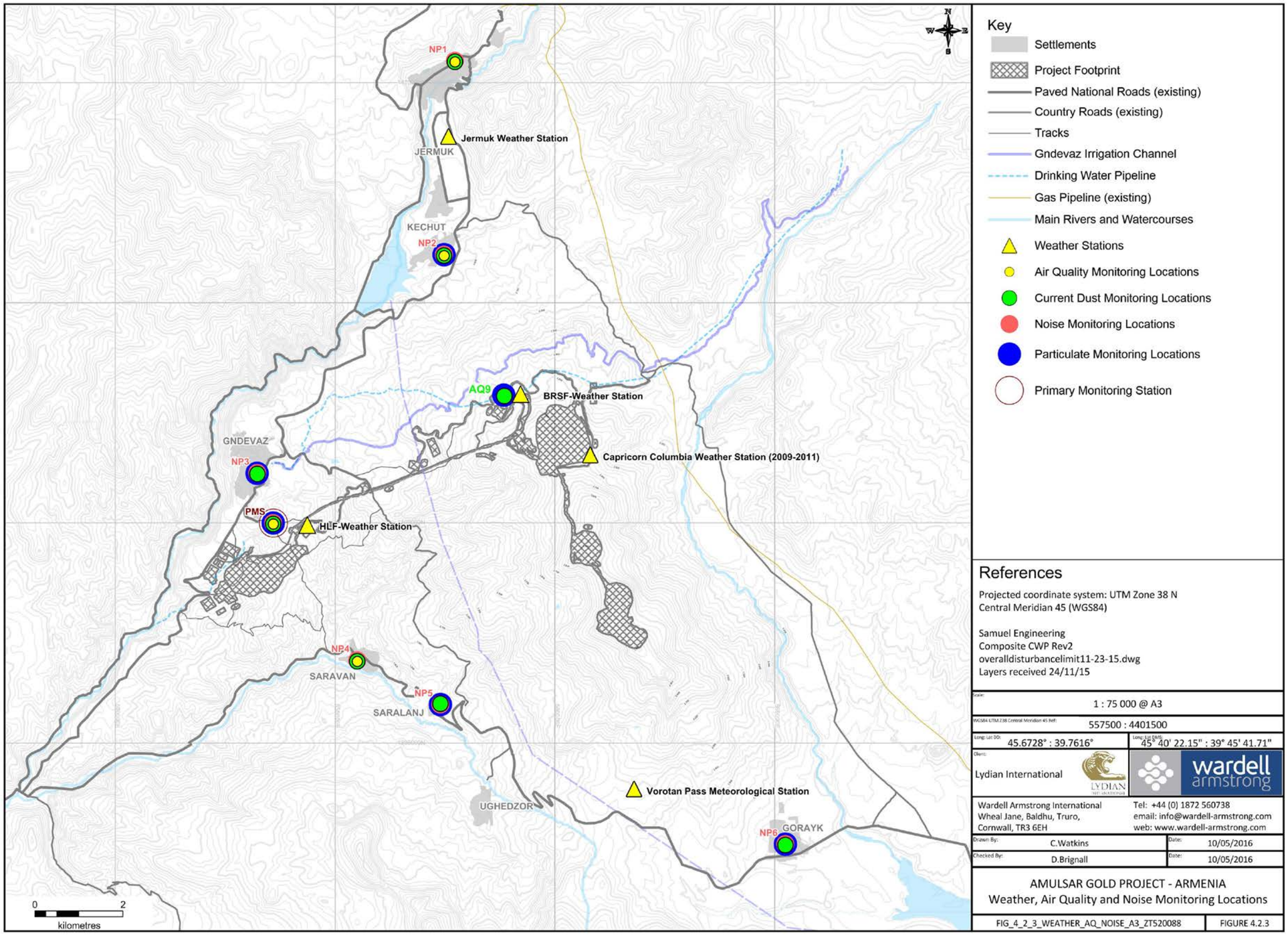


Figure 4.2.3: Weather Station and Air Quality Monitoring Locations

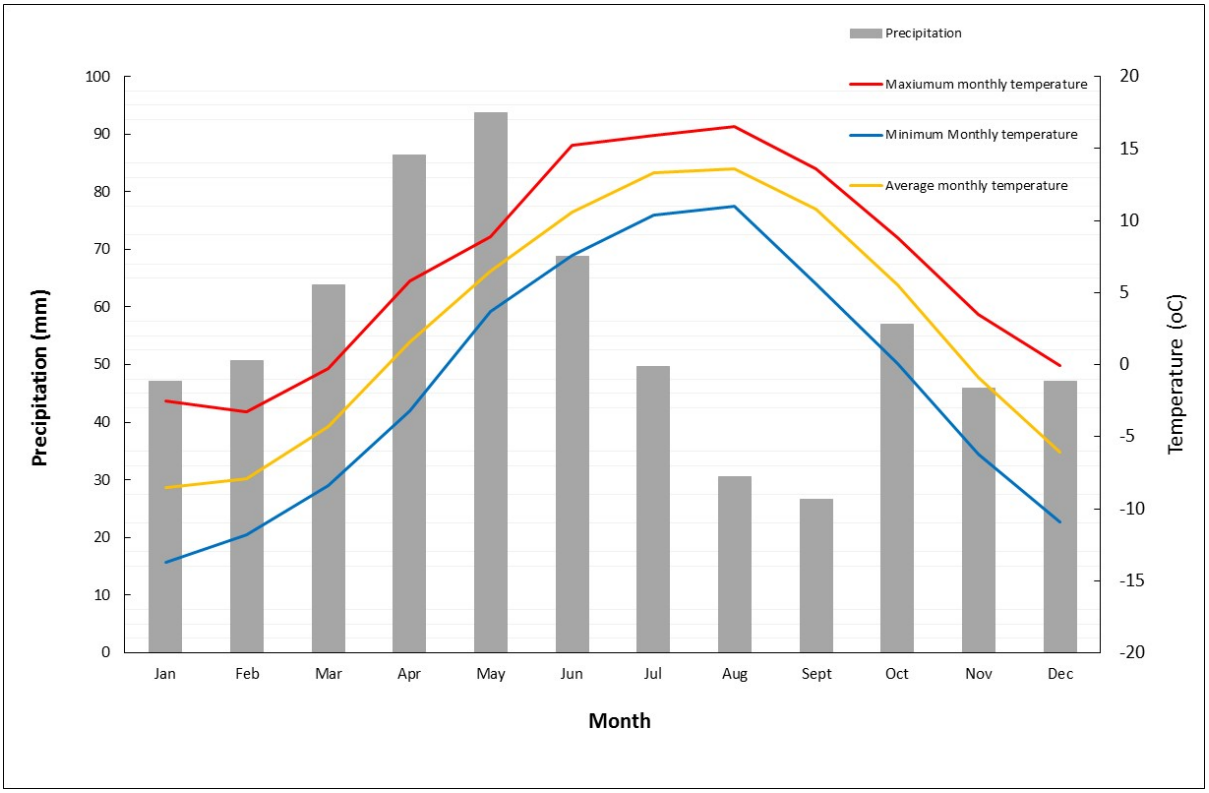


Figure 4.2.4: Summary of Average Precipitation and Temperature Data from the State Weather Station at Vorotan Pass

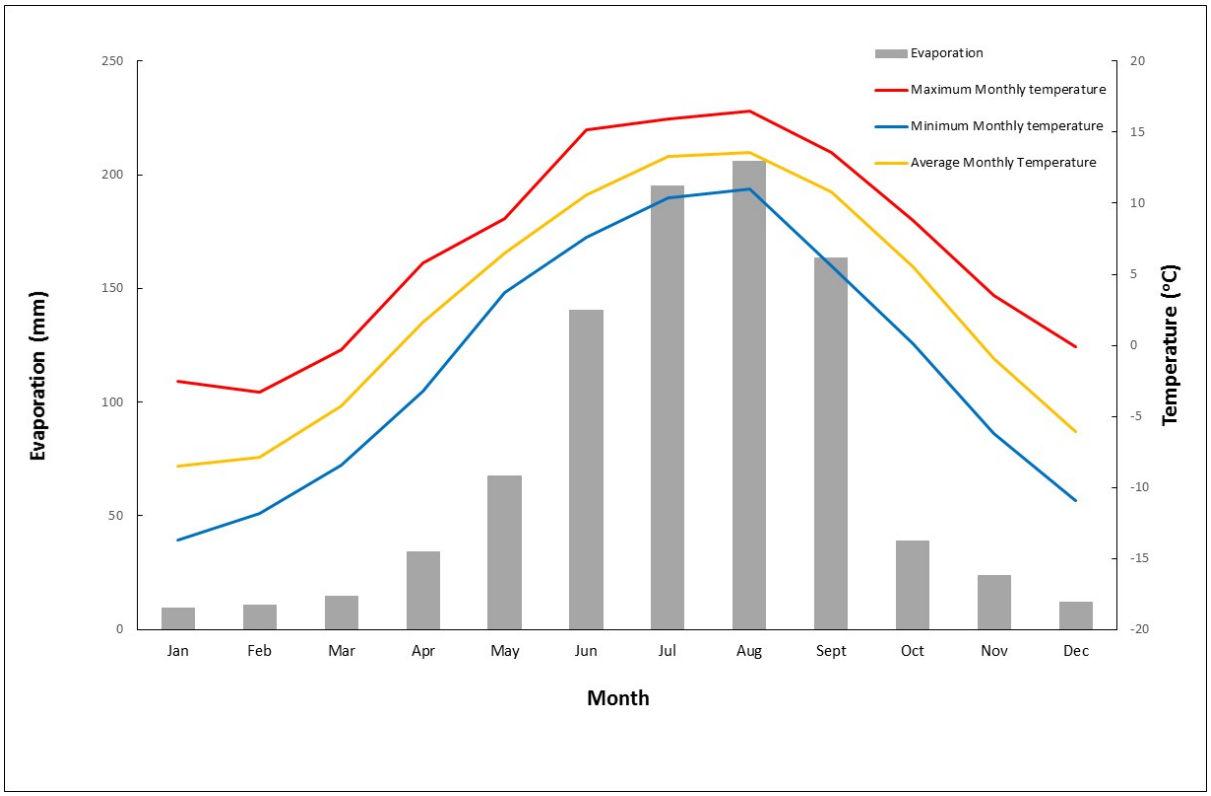


Figure 4.2.5: Summary of Average Evaporation and Temperature Data from the State Weather Station at Vorotan Pass

Table 4.2.2: Monthly Dry Wind Summary 1966-2013												
Mean Wind Direction, shown as a percentage of time												
Month	**346° to 15**	**16° to 45**	**46° to 75**	**76° to 105**	**106° to 135**	**136° to 165**	**166° to 195**	**196° to 225**	**226° to 255**	**256° to 285**	**286° to 315**	**316° to 345**
Jan	13.6	0.6	1.8	16.6*	3.0	2.0	1.8	1.2	2.2	17.5*	21.2*	18.6*
Feb	14.2	0.6	2.1	20.3*	4.2	1.8	2.2	1.0	1.9	16.0*	19.7*	15.9*
Mar	15.7	0.6	2.7	21.4	6.1	2.4	2.6	1.5	3.2	16.8	14.1	13.1
Apr	14.1	1.2	4.0	24.2	6.3	3.3	5.2	2.1	4.3	16.6	9.9	8.9
May	11.8	0.5	3.8	34.0	7.3	3.5	3.6	1.6	2.7	13.3	9.3	8.5
Jun	7.6	0.2	3.8	51.6	9.8	2.8	3.0	1.0	2.0	8.2	5.9	4.0
Jul	2.5	0.2	4.5	67.0	14.3	2.6	1.9	0.7	0.8	3.4	1.5	0.8
Aug	2.5	0.3	4.1	65.0	15.3	2.2	2.1	0.6	1.0	4.1	2.0	0.8
Sep	7.8	0.5	4.0	49.7	9.4	1.8	2.8	1.3	2.3	11.4	5.7	3.2
Oct	17.6	0.5	2.6	29.5	7.0	1.5	2.7	0.9	2.2	14.0	12.3	9.3
Nov	17.8	0.5	1.6	19.9	4.0	1.4	2.7	0.9	2.0	17.8	18.9	12.6
Dec	15.4	0.5	1.9	17.6*	3.7	2.4	2.5	1.4	1.8	19.6*	17.3*	16.0*
Notes: * Indicates the values used in the assessment of the winter seasonal wind speed pattern												

The data has also been analysed for the annual average wind direction and speed (see Figure 4.2.6), which shows the prevailing wind direction from the east (highlighted in orange in Table 4.2.2), with the majority of wind speeds <11.0 m/s. The data also shows that the easterly prevailing wind has a greater proportion of high wind speeds.

The lowest percentage of winds are from a north-north-easterly direction (highlighted blue in Table 4.2.2). This also has the lowest wind speeds with the majority <6.0 m/s. Mean wind speed in all directions is 4.7 m/s.

The data also identifies seasonal wind patterns in the winter months (December through to February), where there is an equal or greater proportion of time in which the wind blows from the east as it does from a westerly/west-north-west to north west direction (indicated by * in Table 4.2.2). This is likely due to the winter westerly winds associated with the North Atlantic Oscillation, which are directed into Eurasia by the Arctic Oscillation.

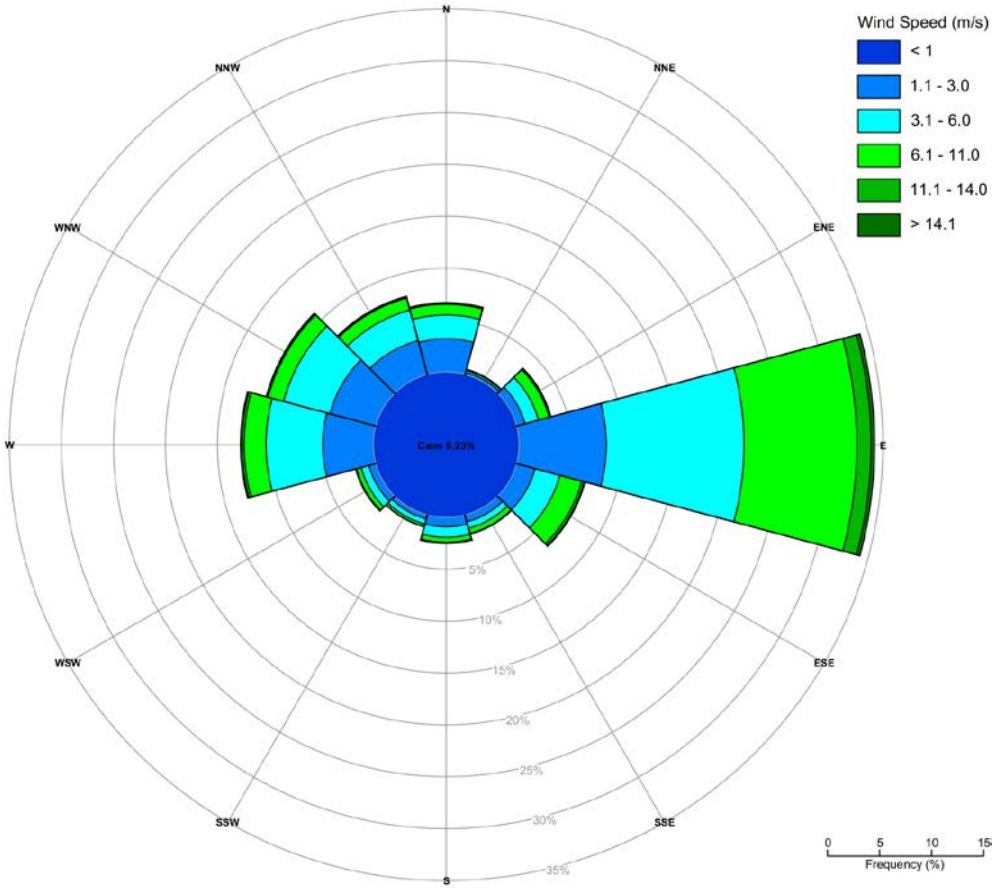


Figure 4.2.6: Average Wind Direction - Vorotan Pass Data

Table 4.2.3 and Figure 4.2.7 present the average monthly snow depth data, based on available information from the Vorotan weather station. This identifies snow accumulation periods between September to March [1], and snowmelt periods between the months of April to June [2], which results in increased runoff and localised flooding. As highlighted in the table, during July and August, the Vorotan Pass weather station is devoid of snow [3].

Table 4.2.3: Snow depth data for the Vorotan Pass Weather Station water year

Month	Minimum Monthly Average (cm)	Average Monthly Average (cm)	Maximum Monthly Average (cm)
October	2	4.2	35.5
November	2.3	14.5	59.4
December	10	34	86.7
January	10	55.9	102.1
February	10	74.2	131.1
March	10	88.1	156.6
April	10.8	62.7	133.5
May	2.5	12.6	66.6
June	2.5	2.9	62
July	0	0	0
August	0	0	0
September	2	5.3	18

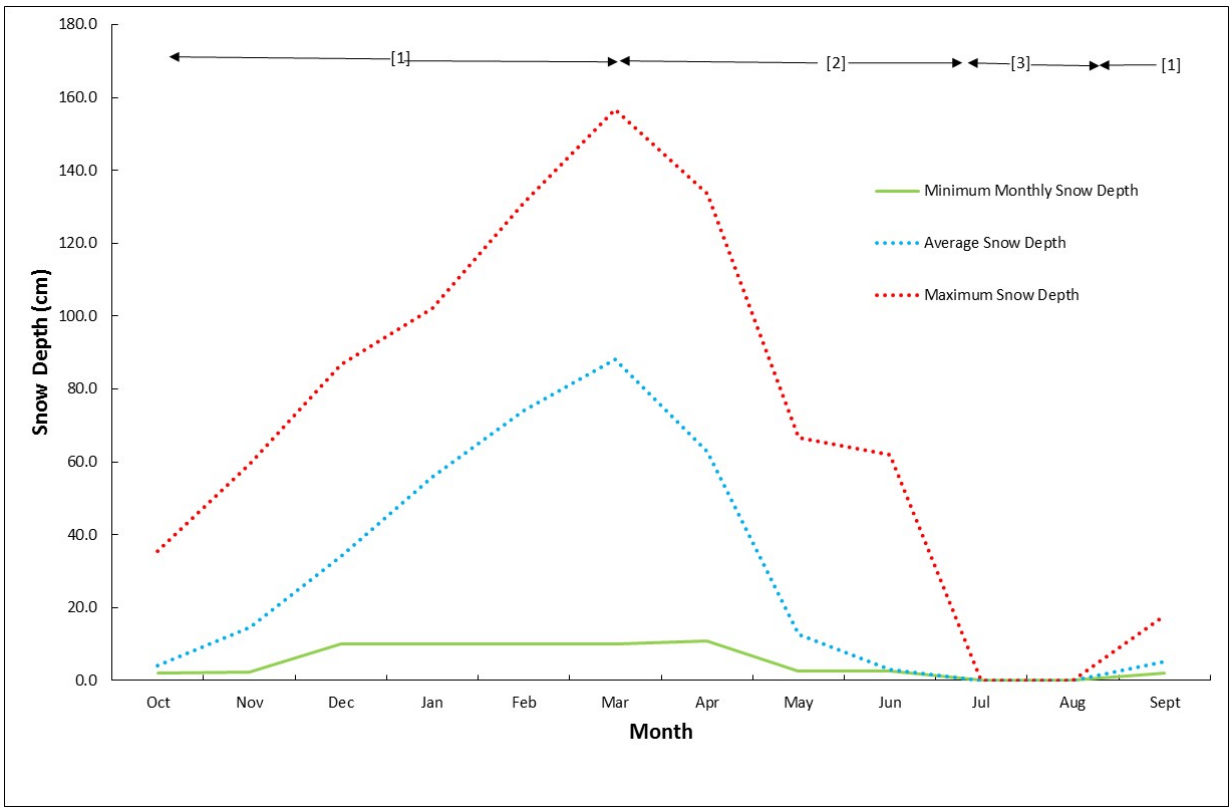


Figure 4.2.7: Monthly Snow depth data for the Vorotan Pass

Jermuk Weather Station

Data from the Jermuk weather station has similarly been analysed. This indicates that peak rainfall is recorded in April, with an average of 133mm, with August having the lowest rainfall levels at an average of 25mm. Maximum temperatures are in August, with an average of 18^{o}C, while minimum temperatures in January average -6.5^{o}C.

The results show differences in the patterns and extent of weather between the two meteorological stations, however no statistical differences have been identified. The Jermuk station shows higher amounts of precipitation (approximately 30% higher) which occurs earlier in the year than that of the Vorotan Pass dataset, and overall warmer temperatures. This is due to its lower elevation and less exposed location on the northern edge of the Jermuk Airfield. As the Vorotan Pass station lies on the exposed footslopes of Amulsar Mountain at an elevation closer to the high terrain of the Project, and provides climate data that is representative within the footprints of the main Project components, it is more appropriate to use this dataset for modelling and design. Consequently, the Jermuk dataset has not been used further within the project design or ESIA.

4.2.3 Capricorn-Colombia on-site weather station (CCWS)

The on-site weather station data has been collected during the period 2009-2011, after installation in 2009 at the exploration camp (see Figure 4.2.3). The CCWS is approximately 4 km from the proposed Erato open pit and lies on the south eastern edge of the BRSF; however, it was subject to a suspected lightning strike which caused technical problems during the downloading of data. As a result, the dataset from the CCWS is incomplete and thus is not included in design or impact assessment calculations. Furthermore, as the data only spans 2 years, it cannot be used as climate data.

The data that has been collected from the CCWS has been analysed (Appendix 4.2.2) and indicates comparable data to that of the Vorotan Pass. This supports the use of Vorotan Pass data for design criteria.

4.2.4 Meteorological Data Used for Design Criteria

Based on the observed trends of the climatic data from the Vorotan Pass provided for the project, the precipitation and evaporation data was manipulated for use in the three water balance model cases performed for the HLF, which are the average climate year case, the typical wet year case, and the typical dry year case. The manipulated climatic data is provided

below; the monthly precipitation data and definitions are provided in Table 4.2.4, and the monthly evaporation data and definitions are provided in Table 4.2.5.

Table 4.2.4: Manipulated Precipitation Data for Use in Water Balance Calculations

Month	Extreme Dry Year (mm)	Typical Dry Year (mm)	Average Climate Year (mm)	Typical Wet Year (mm)	Extreme Wet Year (mm)
January	11.8	47.1	47.1	47.1	81.5
February	11.7	50.7	50.7	50.7	132.3
March	4.5	63.9	63.9	110.6	158.0
April	17.1	86.4	86.4	180.4	180.8
May	26.5	93.7	93.7	213.7	213.7
June	2.0	2.0	68.7	199.7	199.7
July	0	0	49.6	49.6	196.0
August	0	0	30.6	30.6	154.8
September	0	0	26.6	26.6	158.5
October	2.2	2.2	57.0	57.0	172.8
November	0	0	45.9	45.9	100.3
December	5.3	47.1	47.1	47.1	117.6
Totals:	**81.1**	**393.1**	**667.3**	**1,059.0**	**1,866.0**

Notes
1 Extreme dry, average climate and extreme wet year precipitation data reflect the minimum, average and maximum monthly precipitation amounts recorded at the Vorotan Pass weather station over the period of record 1962 – 2013 with gaps.
2 Typical dry year precipitation data includes the minimum precipitation amounts recorded in the six months of June through November, and the average precipitation amounts recorded in the other six months.
3 Typical wet year precipitation data includes the maximum precipitation amounts recorded in the three months of April, May and June, 70% of the maximum precipitation amount recorded in March, and the average precipitation amounts recorded in the other eight months.

The evaporation data in Table 4.2.5 was used in the three aforementioned water balance model cases.

Table 4.2.5: Manipulated Evaporation Data Used in Water Balance Calculations					
Month	**Extreme Dry Year (mm)**	**Typical Dry Year (mm)**	**Average Climate Year (mm)**	**Typical Wet Year (mm)**	**Extreme Wet Year (mm)**
January	18.2	9.4	9.4	3.9	3.9
February	23.4	10.5	10.5	2.6	2.6
March	28.6	14.6	14.6	5.2	5.2
April	53.3	34.1	34.1	22.9	22.9
May	79.5	67.4	67.4	55.2	55.2
June	172.7	172.7	140.3	96.0	96.0
July	252.2	252.2	194.9	194.9	138.0
August	292.4	292.4	206.1	206.1	160.7
September	218.2	218.2	163.6	116.2	116.2
October	46.2	46.2	39.1	32.1	32.1
November	44.3	44.3	23.6	9.7	9.7
December	27.3	12.2	12.2	5.2	5.2
Totals:	**1,256.3**	**1,174.2**	**915.8**	**750.0**	**647.7**

Notes:
1 Extreme dry, average climate and extreme wet year evaporation data reflect the maximum, average and minimum monthly evaporation amounts recorded at the Vorotan Pass weather station over the period of record 1964 – 2013 with a gap.
2 Typical dry year evaporation data includes the maximum evaporation amounts recorded in the six months of June through November, and the average evaporation amounts recorded in the other six months.
3 Typical wet year evaporation data includes the minimum evaporation amounts recorded in the ten months of September through June, and the average evaporation amounts recorded in July and August.

Considering the available precipitation data for the period of record 1962 – 2013 that was used in the water balance calculations, the return period for the annual typical wet year precipitation of 1,059.0 mm was statistically estimated to be 100 years.

Based on the available precipitation and snow depth data, spring snowmelt effects were simulated in the water balance model as described below, and effective monthly precipitation values were estimated and used in the water balance calculations.

Snow generally falls in the Project region in all months except for July and August. Snowfall in June and September/October is rare; during the 50 years of record described above, snow cover was measured in June and October in only five and eight years, respectively. The deepest snow on the ground generally occurs from December through April. Based on an evaluation of the available precipitation and snow depth data, spring snowmelt was simulated in the water balance calculations as follows:

- Since the snowpack will be light and the spring snowmelt effects negligible in a typical dry year, the typical dry year monthly precipitation values in Table 4.2.4 without snowpack effects were used for the typical dry year case for the entire year.
- For June through October when any snowfall will generally not accumulate, the average climate year and typical wet year monthly precipitation values in Table 4.2.4 were used in the model for the average climate year and typical wet year cases, respectively.
- For November through March in an average climate year and a typical wet year, when the snowpack is building and only a fraction of the snowfall is melting, the effective monthly precipitation values used in the model were considered to be 8% of the monthly snow depth water equivalent (SDWE) values, based on the rainfall and snowfall data patterns. The SDWE values are the snow depth values in Table 4.2.3 multiplied by the average snow density of 0.26 gr/cm^3. The average and maximum SDWE values in Table 4.2.3 were used for the average climate year and typical wet year cases, respectively.
- For April and May in an average climate year and a typical wet year, when most of the snowmelt occurs, the effective monthly precipitation values used in the model were considered to be the annual precipitation amounts in Table 4.2.5 for these two cases less the precipitation used in the model for the other 10 months as described above, with 60% of the difference applied in April and 40% in May.

Based on the above, the effective monthly precipitation values used in the three water balance model cases, which account for the spring snowmelt, are provided in Table 4.2.6.

Table 4.2.6: Effective Precipitation Data Used in Water Balance Calculations			
Month	**Typical Dry Year (mm)**	**Average Climate Year (mm)**	**Typical Wet Year (mm)**
January	47.1	12.0	21.2
February	50.7	14.9	24.6
March	63.9	18.9	32.6
April	86.4	227.7	354.4
May	93.7	151.8	236.3
June	2.0	68.7	199.7
July	0	49.6	49.6
August	0	30.6	30.6
September	0	26.6	26.6
October	2.2	57.0	57.0
November	0	2.2	10.0
December	47.1	7.3	16.3
Totals:	**393.1**	**667.3**	**1,059.0**

4.2.5 Long-Term Climate Trends

A climate change impact assessment on Armenia[1] was completed in 2009 by a team of experts from the United Nations Development Programme (UNDP) for Armenia and the Ministry of Nature Protection of the RA (MNPRA). The main focus of this report was socio-economic impacts in the context of different climate change scenarios.

This concluded that a low emission scenario ('B_2' in the IPCC 2007 report[2]) will result in an increase in temperature across Armenia of 3°C, and a precipitation decrease of up to 15% by 2070. The high emissions scenario ('A_2' in the IPCC 2007 report[2]) will result in a temperature increase of 3.4°C and a precipitation decrease of up to 17%.

Conclusions were also made specifically for the Vayots Dzor region, in which by 2070 under the A_2 emissions scenario, temperatures will increase by 3°C, and precipitation will decrease by up to 25%. This represents a significant impact to the region of Vayots Dzor and Armenia as a country, having a major impact upon agriculture, energy generation, biodiversity and water availability.

[1] UNDP et al., 2009, *The Socio-Economic Impact of Climate Change in Armenia*, Yerevan, Armenia, accessed on 03/07/2014 from http://www.undp.org/content/dam/armenia/docs/Report%20SOI%20of%20CC.pdf

[2] IPCC, 2007, *Fourth Assessment Report: Climate Change 2007 (AR4)*, can be accessed at http://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml

Additionally a Regional Climate Change Impacts Study for the South Caucasus Region was completed in 2011 by a team of international consultants and national experts from the RA, Azerbaijan Republic and Georgia[3]. This study was undertaken in cooperation with the MNPRA, the Ministry of Ecology and Natural Resources of Azerbaijan Republic and the Ministry of Environment of Georgia, with technical support from the in-country offices of the Environment and Security Initiative (ENVSEC) and the UNDP.

The report concluded that the whole of the South Caucasus area has demonstrated evidence of increased warming over the last century, with the RA, Azerbaijan Republic and Georgia all exhibiting statistically significant trends with an increase in mean annual temperature and mean daily minimum and maximum temperatures. No overall trends were established for mean annual precipitation or the number of wet days per year. Approximately half of the meteorological stations in the RA included in the study displayed statistically significant trends that verify an increase in annual temperature. This included the State meteorological station at the Vorotan Pass, in which analysis of the readings taken between 1935 and 2008 (the study period) there was sufficient data to indicate that the locality has been subject to an average increase of between 1.1°C to 1.9°C in the annual mean temperature over the 73 year period up to 2008.

[3] UNDP et al., 2011, *Regional Climate Change Impacts Study for the South Caucasus Region* , Tbilisi, Georgia, accessed on 19/09/2012 from http://www.envsec.org/publications/cc_report.pdf

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Note: All figures referred to in this section are presented in A3 flat format and are contained in a separate folder entitled:

The Amulsar Gold Mine Project
Environmental and Social Impact Assessment
Figures
May 2016

4.3 Landscape and Visual Resources

4.3.1 Introduction

Landscape resources and character are considered to be of importance in their own right and are valued for their intrinsic qualities regardless of whether they are seen by people. Impacts on visual amenity as perceived by people are therefore clearly distinguished from, although closely linked to, impacts on landscape resources and character.

4.3.2 Study Area

The environmental baseline study area is shown in Figure 4.1.4; however, the identification of the study area for the assessment of landscape and visual impacts was further refined based on the recommendations contained in the UKs Landscape Institute and the Institute of Environmental Management and Assessment's guidelines[1], and reflects the extent of the Zone of Theoretical Visibility (ZTV), focusing upon the area within an approximately 15 km radius of the outermost components of the Project, but with reference to wider visibility where relevant (Figure 4.3.1).

4.3.3 Regional Topography

The RA covers an area of 29,800 km², with much of the country being mountainous. Elevations are usually greater than 1,500 m asl, rising to a maximum of 4,090 m asl (Mount Aragat).

The Amulsar Mountain deposit ridge is part of the Zangezur mountain range. The Zangezur range is characterised by jagged rock exposures rising above smoother, grass covered or forested mountains, which are separated by deep, steep sided gorges, and valleys cut by rivers, with post-glacial landforms being characteristic across the mountain range. The Zangezur range runs north-south and defines the border between the RA southern province of Syunik and Azerbaijan's Nakhichevan Autonomous Republic, to the west of Syunik. The southern axis of the mountains gradually rises to a maximum height of 3,906 m asl at the peak of Mount Kapoutjough.

4.3.4 Local Topography

The general topography of the LVIA study area is shown on Figure 4.3.2, where the local landform is defined by a central ridge of rounded mountainous summits with craggy outcrops, which runs approximately 7 km north-west – south-east, and incorporates Amulsar, at a

[1] *Guidelines for Landscape and Visual Impact Assessment – Third Edition* (2013) Landscape Institute and Institute of Environmental Management and Assessment

maximum elevation of 2,988 m asl. The ridge of mountains (collectively referred to as Amulsar Mountain), described here from north to south, comprises North Erato, Erato, Tigranes, Artavazdes and Arshak and forms a distinctive low-alpine zone with craggy outcrops and steep grass, rock and scree covered slopes, dropping to more gently sloping and rounded subsidiary hills. Large undulating grassy plateaus are dissected by a network of incised mountain stream tributary valleys, which flow into the broad, flat bottomed valley of the Vorotan River to the east, the watershed of the Spandaryan Reservoir to the south-east, and across gently undulating foothills and plateaus to the steep sided and scenic gorge of the Arpa River to the west and south-west. There is a watershed between Ughedzor and Gorayk, at the top of the Vorotan Pass (Syunik Gates).

Surface and drainage water from the mountainous Project Area flows into the river catchments of the Arpa, Darb (a tributary of the Arpa) and the Vorotan rivers, while feeding the large reservoir of Spandaryan to the east, a small irrigation pond above and to the east of Gndevaz, and the reservoir to the south of Kechut, on the Arpa River. The Darb and Arpa Rivers join near the junction of the M-2 and H-42 roads, to the south-west, from where the river flows west.

4.3.5 Topography and Landscape of the Project Area

The general topography of the Project Area is illustrated in Figure 4.3.1. The locations of the proposed key Project components are also shown on Figure 3.1, including the open pits of Erato, Tigranes and Artavazdes, the Heap Leach Facility (HLF), the Adsorption, Desorption and Recovery (ADR) Plant, the Barren Rock Storage Facility (BRSF), the crushing and screening facility, the overland conveyor and other components of mine infrastructure. These components are proposed at variable elevations within the Project licence area, from the pits located across the peaks of Amulsar Mountain to the HLF and ADR plant located on the lower foothills south-east of the settlement of Gndevaz. The topography and landscape in the area of each component part is described in the following sections.

Open Pits

The open pits will be located along the peaks of the Amulsar Mountain ridge (see Figure 3.1), centred on the summits of Erato, Tigranes and Artavazdes at elevations of approximately 2,917 m asl (Erato), and 2,941 m and 2,988 m asl (Tigranes and Artavazdes). The steep scree slopes are interspersed with craggy summits and stepped rock extrusions, with slope gradients upwards of 35% typical across the proposed open-pit areas. The open pits will be linked by haul roads, which contour around the western flanks of the mountain ridge. At this

altitude, the vegetation is sparse and there is much bare rock. The peaks are snow covered for the majority of the year between November and April. There are seasonally used tracks across the lower areas of the mountains, but generally the slopes and summits have a natural appearance, and are used to an extent for summer grazing.



Plate 4.3.1: Site of Open Pits looking towards North Erato from the north – note the temporary exploratory tracks and drilling pads, now in the process of restoration.

Barren Rock Storage Facility

The Barren Rock Storage Facility (BRSF) will be located approximately 1.5 km north of the Erato open pit and 2.5 km west of the Vorotan River valley (at its closest point, see Figure 3.1). The BRSF site is a naturally enclosed, higher altitude mountain valley north of North Erato (approximately 2893 m asl), which forms the eastern and northern slopes of Little Erato (approximately 2660 m asl). The water catchment of the hanging valley flows to the north via a number of minor mountain streams, and eventually into the water catchment of the Arpa River to the north-west. The slope gradient within this valley is up to 40% in places and varies in elevation between approximately 2450 m and 2660 m asl. The valley has several natural springs and seeps, with surface water flowing at its maximum in the spring, during seasonal snowmelt (April-June). Many of the BRSF site valley slopes exhibit a post-glacial terrain, with

a landcover of grassland and herbs. Again, this area is typically snow covered for the majority of the year between November and April. The area is used for grazing in the summer months.



Plate 4.3.2: Site of Barren Rock Storage Facility (BRSF), from north of North Erato – note the temporary exploration camp located on the ridge east of the BRSF

Crushing and Screening Facility

The crushing and screening facility (primary and secondary crusher building and screening building) and associated infrastructure will be located on the western flanks of Little Erato, west of the BRSF which lies in the hanging valley on the eastern side of Little Erato (see Figure 3.1). The crushing and screening facility will occupy a footprint of 13.9 ha, and will be cut into the hill slopes at an elevation of between approximately 2580 m and 2610 m asl, and with gradients of up to 25%. The crushing and screening facility will be accessed via a haul road, extending from the open pits to the south-east contouring around the western flanks of the mountain ridge. The site of the crushing and screening facility is typically snow covered for the majority of the year between November and April.



Plate 4.3.3: Site of crushing and screening facility, looking west, south-west from the western flanks of Little Erato.

Overland Conveyor Corridor

The overland conveyor will link the crushing and screening facility with the HLF, proposed on the western foothills of Amulsar Mountain, for the purpose of carrying material in a broadly north-east to south-westerly direction (see Figure 3.1). The overland conveyor will start at the crushing and screening facility proposed on the western flanks of Little Erato and follow the broad ridge south-westerly in a roughly straight line to its termination at the truck load-out facility north of the HLF, from where material will be then be moved to the HLF via a haul road. The total length of the proposed overland conveyor is approximately 5.6km. The conveyor will be accompanied by an adjacent utility corridor including an access road for maintenance of the conveyor infrastructure. This west facing grass and scree covered mountain face tends to become free of snow in late April and early May each year, and to be snow covered again from around November. The land uses across this area include grazing of livestock, hay and food cropping, in addition to foraging for wild food.



Plate 4.3.4: Site of central section of Overland Conveyor route, looking south-west from the western flanks of Little Erato.



Plate 4.3.5: Site of lower section of Overland Conveyor route and HLF, looking west from the lower foothills of Amulsar Mountain.

Heap Leach Facility and Adsorption, Desorption and Recovery Plant

The Heap Leach Facility (HLF) will be located approximately 5 km west of the open pit of Erato and approximately 1.2 km south-east of the settlement of Gndevaz (see Figure 3.1). The footprint of the HLF will be within a broad and shallow hanging valley approximately 100 m lower in elevation than the settlement of Gndevaz and east of the Arpa Gorge. The HLF will lie to the east of the H-42 road (the main road to Jermuk) and will be approximately 100 m from the road at the closest point. The topography of the HLF site is defined by the main broad valley which runs broadly north-east to south-west towards the Arpa Gorge and H-42 road, and the smaller valleys of tributaries running south-west into the valley from the foothills of Amulsar Mountain to the east. As the valley reaches the H-42 road and edge of the Arpa Gorge, it narrows and its slopes steepen. The steeper slopes of the foothills to the east drop down to terraced areas of orchard, hay meadows and agricultural land used by the residents of Gndevaz, part of which is ploughed each spring. Some trees, including hawthorn and juniper along the valley are present, mainly in the more rocky areas along the streams, whose flow tends to be ephemeral, peaking during snow melt.

The accompanying Adsorption, Desorption and Recovery (ADR) Plant and contact water and storm water ponds are proposed approximately 2.5km to the south-south-east of Gndevaz at the most south-westerly point of the HLF site, and accessed from the H-42 road at the hairpin bend approximately 2.5 – 3 km south of Gndevaz. An existing electricity transmission line passes from north to south parallel with the H-42 road to the west of the HLF site. A number of additional minor elements of infrastructure are proposed to the west of the HLF alongside the H-42 road, including the passive treatment system and contact water ponds.

The area typically loses its snow cover during the second half of April, when it becomes green and flower-covered. Later in the year the landscape appears brown, as grasses become dried by the hot climate during the summer months at this altitude. The plateau west of the HLF is used for agriculture and is devoid of trees or dense vegetation, affording views towards the HLF site from the H-42 road.



Plate 4.3.6: Site of HLF and ADR Plant location, looking west from the lower foothills of Amulsar Mountain.

Designated Landscapes

The landscape of the LVIA study area is of local importance, with the landscape of the Project licence area not being covered by any international or national landscape designations. There are no areas of landscape within the LVIA study area which are designated for their scenic qualities or special landscape qualities, such as State Reserves or National Parks.

There are a number of Specially Protected Nature Areas, designated for their biodiversity conservation qualities and sensitivities in the LVIA study area. Although primarily designated for nature conservation, specific landscapes and landscape features can be directly linked to the reason for the protected status of such areas. The State Sanctuaries and the key landscape features which form a reason for their designation are outlined below:

- ***Herher Open Woodland State Sanctuary*** is protected for its areas of relict open yew woodland, and remnant pear orchards (established 1958, 6,139 ha) (5km west of the Project);
- ***Jermuk Hydrological State Sanctuary*** to protect Jermuk mineral water sources (established 2009, 17,371 ha) (6km north-west of the Project); and

- ***Jermuk Forest State Sanctuary*** is protected for its native oak woodland which provides vital habitat to a number of protected rare animals (established 1958, 3,865 ha) (6km north-west of the Project).

These State Sanctuaries are shown on Figure 4.3.5, and are described and considered in more detail within Section 4.10 Biodiversity.

Much further away, and not affected by the Project, is the Lake Sevan National Park (located approximately 44km north-north-west of the Project).

4.3.6 Landscape Character

Landscape is primarily concerned with the relationship and interaction between people and place. Landscape is defined by the *Guidelines for Landscape and Visual Impact Assessment*, as an area, which is perceived by people, the character of which is the result of natural and/or human factors. Different components of the environment, both natural (geology, soils, climate, flora, fauna) and cultural (historical, land use, settlement and other human intervention) combine to shape landscape character as perceived and related to by the people who experience it.

Given the absence of a published landscape character assessment for the area, the identification and definition of Landscape Character Types (LCTs) was undertaken, by professional landscape architects within LUC (Land Use Consultants Ltd.), considering topography, geology, soils, land cover, vegetation, land use, cultural and historical features (Figure 4.3.4). Each aspect was considered in drawing up a map showing a series of distinct, yet related, character types, by which the landscape can be categorised. The purpose of this characterisation process was to enable examination to be made of the potential impacts on each type of landscape which is present within the study area. Some landscape types are more sensitive or vulnerable to change than others, and each will respond in a different way, and require a different strategy in terms of mitigation and restoration.

The descriptions of the LCTs should be read with reference to the additional detailed baseline information provided in Section 4.7 Soils and Land Cover and Section 4.10 Biodiversity.

Cultural heritage and archaeological interests have been identified within the Project Area and are considered in more detail in Section 4.19 Archaeology and Cultural Heritage, however

the historical and cultural human influence on landscape change was considered in terms of the development of the present landscape character of the study area.

Landscape Character Types (LCTs)

In order to understand the underlying landscape, six broad landscape character types are described, taking account of both the natural and cultural components which contribute to the landscape. These were defined following desk based study of the baseline information outlined above, along with examination of maps showing topography and land uses, and aerial imagery data. The LCTs were verified and refined further following field visits in early April and early June 2013 (Figure 4.3.5). The six broad character types are listed below:

- Settled Lowland and Rocky Gorges (generally found at elevations below 2,000 m asl);
- Lower Farmed and Settled Foothills (generally found at elevations of 2,000 - 2,300 m asl);
- Forested Upper Gorge and Foothills (generally found at elevations of 2,300 - 2,500 m asl);
- High Steppe and Plateau Grassland (generally found at elevations of 2,000 - 2,300 m asl);
- Highland Hills and Grazing (generally found at elevations of 2,300 - 2,700 m asl); and
- High Rocky Peaks (generally found at elevations over 2,700 m asl).

The geographical distribution and key defining characteristics of each landscape character type is described in detail in Table 4.3.1 to Table 4.3.6 below:

Table 4.3.1: Settled Lowland and Rocky Gorges (generally found below 2,000 m asl)

Settled Lowland and Rocky Gorges

Description:

This LCT, with river gorges enclosed by basalt cliffs and steep slopes, rises from the lowland and the lower valley bottoms, via steep sided gorges, to the edges of and including farmed plateaus above. The gorges are frequently used for road corridors, and are associated with a low density string of human settlement and activity. They are frequently very scenic, with picnic areas and occasional tourist facilities such as restaurants, focused on the fast flowing rocky rivers contained within them.

Key Characteristics:

- Alternate natural and cultivated valley and gorge bottoms, often the focus of transport routes;
- Presence of linear and vertical features, including road corridors, and pylons;
- Partly wooded, with species such as willow, juniper, and areas of cultivated fruit trees, or with wooded sides including juniper, and very sheltered;
- Long distance and usually glimpsed or framed views from valleys and gorges to summits and ridges high above;
- Sense of human influence, but also often highly scenic, with inaccessible basalt cliffs being unaffected by human activities;

- Tourist facilities such as picnic areas, associated with the attraction of fast flowing rocky rivers.

Geographical Extent within Study Area:
This landscape character type is present west of the study area but would not include any of the proposed components, extending to just west of the most westerly components of the Project (the ADR plant and HLF) proposed to the east of the H-42 road, south of Gndevaz. The LCT is widespread across the lower areas of valleys and gorges to the west and south-west of the study area, associated with the watershed of the Arpa and Darb rivers. The landscape type is also found beyond 15 km from the Project, downstream of the Spandaryan Reservoir to the south-east.

Sensitivity to Landscape Change:
Sensitive to the alteration or loss of the scenic qualities of the gorge landscape which attracts visitors and tourists. The presence of man-made features within the landscape character type is common, with linear development focused along road routes, although this landscape is also sensitive to further manmade development. Glimpsed and often framed views to surrounding upland summits and ridges are widely available, these views also being sensitive to change.

The **Herher Open Woodland State Sanctuary – Specially Protected Nature Area** is partly found within this landscape type to the west of the Arpa Gorge. It is protected for its areas of relict open yew woodland and remnant pear orchards.

Table 4.3.2: Lower Farmed and Settled Foothills (generally found 2,000 m - 2300 asl)

Lower Farmed and Settled Foothills

Description:

This landscape character type extends across a varied topography, including broad valleys and plateau to the west and south-west and gentle slopes which form the foothills of surrounding hills and mountains. This landscape type has a predominant land use of pasture, with areas of arable and hay fields across the gentle slopes to the west of Amulsar Mountain, and areas of forest across the steeper slopes surrounding Kechut Reservoir to the north-west and the Herher Open Woodland, west of the Arpa River Gorge. The landscape displays human influences, including the upper parts of the settlements of Gndevaz, Saralanj and Ughedzor. The presence of built elements is widespread within parts of this landscape, including pylons and masts which serve as detractors. The Armenian Silk Road (M2 Road) to Iran also passes through this landscape. Quarries and borrow pits, and small-scale adits and mines are also found on the slopes of the foothills across this landscape type, as evident near Saravan.

Key Characteristics:

- Settled landscape with agricultural villages, roads and industrial remnants;
- Pasture used for grazing, low intensity arable and hay fields across mountain meadows;
- Presence of linear and vertical features, including roads, masts and pylons which serve as detractors;
- Forested steep slopes and wooded gorges to the west (Herher Open Woodland) where juniper woodland is highly characteristic;
- Views from open foothills to summits and ridges and down to lowland valleys;
- Sense of human influence throughout the landscape;
- A large scale, open and extensive landscape from which people can experience open views of the surrounding upland landscape.

Geographical Extent within Study Area:

This landscape character type is present within the study area, with some of the most westerly components of the Project (the ADR plant, HLF and overland conveyor) proposed within this landscape type where it occurs between the Arpa Gorge to the west and Amulsar Mountain to the east. This landscape type extends over the lower western foothills of Amulsar Mountain, southwards to the highpoint of the Vorotan Pass, and the watershed of the Darb River. This landscape type also characterizes the lower slopes of the foothills west of the Arpa River gorge, and areas to the north of the Darb River, above Saravan.

Sensitivity to Landscape Change:

The landscape character type has been subject to areas of extensive landscape change and human influence, which varies throughout this landscape with sensitivities to further development varying. The valley of the Arpa River and the area around Gndevaz is a focus for development. Widespread and panoramic views from this open landscape to the higher summits and ridges are frequently seen, across open plateau and broad river valleys, and are experienced by people concentrated within or travelling through this landscape.

The **Herher Open Woodland State Sanctuary – Specially Protected Nature Area** predominantly encompasses this landscape type, to the west of the Arpa Gorge, extending into adjacent landscape types. It is protected for its areas of relict open yew woodland and remnant pear orchards.

Table 4.3.3: Forested Upper Gorge and Foothills (generally found 2,000 - 2,300 m asl)

Forested Upper Gorge and Foothills

Description:

This landscape character type extends across a varied topography, including broad upper valleys and sub-alpine meadows around Jermuk, the wooded river gorge of the Arpa River and the foothills above it. This landscape has a mixed land use of forested hillslopes, characterized by dense areas of stunted oak and grazed meadows, with areas of arable and hay fields across the areas surrounding the settlements of Kechut and Jermuk. It is being proposed to create a National park including the existing State Sanctuaries which incorporate the forest across the steeper slopes surrounding the Kechut Reservoir and the Jermuk valley in the north of the study area. This landscape displays a multitude of human influences, including the settlements of Jermuk and Kechut. The presence of built elements is extensive within the landscape character type, including pylons and masts which serve as detractors, as does open landfill known as the Kechut landfill. Kechut Reservoir, the disused Jermuk airstrip and the Jermuk ski slope are located within this landscape type.

Key Characteristics:

- Settled landscape with villages and towns, roads, reservoirs and industrial remnants;
- Areas of tourist and recreational interest located around Jermuk;
- Pasture used for grazing, low intensity arable and hay fields across grassland and shrub areas, with pockets of wetland vegetation;
- Presence of linear and vertical features, including roads, masts and pylons which serve as detractors: strong sense of human influence throughout the landscape character type;
- Steep forested slopes and wooded gorges to the north (Jermuk Forest Park), where dense oak woodland is highly characteristic;
- Areas within wooded gorges have a sense of shelter and enclosure;
- A landscape from which people can experience open views of the surrounding upland landscape: views from open foothills to summits and ridges and down lowland valleys.

Geographical Extent within Study Area:

This landscape character type is not present within the central core of the study area, however the existing access track from the H-42 road near Kechut passes through this landscape. This landscape is widespread across the slopes of the north Arpa River and sub-alpine meadow areas of valley plateau to the north of Amulsar Mountain.

Sensitivity to Landscape Change:

Areas of this landscape character type have been subject to extensive landscape change and human influence, which varies throughout the landscape character type. The northern valley of the Arpa River is a focus for development, and the likely location of future built development and expansion of the settlement of Jermuk. Views from this landscape are seen to the higher summits and ridges, across open plateau and elevated slopes on the edge of the landscape character type, and are experienced by people concentrated within or travelling through this landscape character type. Such views are sensitive to change. This landscape would also be sensitive to loss of the oak woodland which is one of its defining features.

The **Jermuk State Sanctuary – Specially Protected Nature Area** is partially encompassed within this landscape type and is sensitive to direct landscape change, given the presence of highly characteristic native oak woodland across the area.

Table 4.3.4: High Steppe and Plateau Grassland (generally found 2,000 - 2,300 m asl)

High Steppe and Plateau Grassland

Description:

This landscape character type is characterized by very open, grazed steppe and pastures which occupy areas of predominantly flat or more gently sloping plateau below the rocky peaks and highland hills, and above the rocky gorges of the study area. It is a landscape dominated by extensive steppe vegetation, with areas of grassland dissected by rivers and streams draining the steeper mountain slopes above. Settlement is found along the roads, but the higher edges of this landscape type, where it blends into the highland slopes and hills above, are largely unpopulated, except by seasonal herders. This steppe landscape lies on the lower edge of the sub-alpine zone. It is extensively used for the seasonal herding of grazing cattle, sheep and goats, and foraging for herbs and mushrooms, with some small-scale arable fields nearer to settlements. The settlements of Gorayk and Tsghuk are located along the route of the Armenian Silk Road (M-2 road) near Spandaryan Reservoir, which runs across this large scale, extensive steppe and plateau landscape to the south-east of the study area. This landscape is continuous with and includes the relatively flat land which extends up the Vorotan valley, east of Amulsar Mountain.

Key Characteristics:

- Flat or undulating meadow and steppe, crossed by streams and rivers flowing from the highlands above;
- Extensive areas of unenclosed open grazing grassland with pockets of wetland vegetation, rising to mountain meadow steppe on its upper fringes;
- Settlement concentrated along the route of the M-2 road to the south and west;
- Minimal human influence away from the main road corridors and the large man-made Spandaryan Reservoir: presence of some built features including gas pipeline, pylons and masts;
- Sense of vastness, openness, perceived naturalness and solitude;
- Lack of tree cover and variation of vegetation cover;
- Long distance views to rocky peaks forming focal points.

Geographical Extent within Study Area:

This landscape character type is not present within the Project disturbed and restricted areas (see Figure 4.1.6), however several components of the Project are proposed close to this landscape, which extends across the floor of the Vorotan valley, and south across the plateau surrounding Spandaryan Reservoir and the foot of Vorotan Pass around Gorayk.

Sensitivity to Landscape Change:

Due to the relatively undeveloped nature of the northern extent of this landscape (with the exception of an unsurfaced road up the Vorotan valley, and a small hydro-electric dam), it is considered sensitive to the introduction of large scale development which will lead to substantial changes in land cover and landform. Although existing development exists within the southern extents of the area, this is predominantly concentrated close to the M-2 road and Spandaryan Reservoir and does not substantially detract from the sense of openness and perceived naturalness of the surrounding landscape. Changes to distant peaks forming focal points may be perceptible from this open landscape.

Table 4.3.5: Highland Hills and Grazing (generally found 2,300 - 2,700 m asl)

Highland Hills and Grazing

Description:

This landscape character type covers the steep sloping sub-alpine zone and forms the transitional zone between the widespread lower mountain foothills, or steppe plateau below, and the low alpine zone of the rocky peaks and high plateau which are found at higher altitudes, above these hills. These highland hills have areas with shallow soils, and there are rocky outcrops at higher altitudes, with scree found on steeper slopes, dropping to mountain streams which drain the high rocky peaks above. The landscape is used for the seasonal herding of grazing sheep, goats and cattle, and foraging for herbs and mushrooms. Extensive areas of forest extend across areas of the landscape character type to the northern extent of the study area, but the highland hills around the Project disturbed area are generally lacking in trees, with grass and low herbs, or prostrate alpine shrubs being the prevailing vegetation types.

Key Characteristics:

- Steep upland slopes of highland summits;
- Sub-alpine meadows with evidence of seasonal herding and shepherding, with remnant shepherd huts and animal enclosures;
- Large scale, extensive, open and unenclosed landscape;
- Unsettled, with an absence of human influence and built features;
- Sense of altitude, remoteness and relative wildness;
- Expansive outlook and views down to and across the surrounding landscape;
- General lack of tree cover within Project disturbed area, and a low or absent vegetation cover;
- Snow covered for 6 months of the year, resulting in sub-alpine vegetation.

Geographical Extent within Study Area:

This landscape character type is present within the Project disturbed area with several components of the Project proposed within this type of landscape. The landscape covers the upland slopes of the Amulsar Mountain and the rounded summit of Little Erato to the north of Amulsar Mountain. Across the study area, the landscape character type also extends across the sub-alpine zone of the Zangezur Mountain range to the north, north-east and south of the Project area.

Sensitivity to Landscape Change:

Visibility of the rocky peaks and ridges above this landscape is characteristic, and as such this landscape would be sensitive to development which will change these views and the sense of remoteness and relative wildness. The sub-alpine mountain vegetation is sensitive to change, as the long period of snow cover means growth rates are slow.

The Jermuk State Sanctuary – Specially Protected Nature Area is predominantly encompassed within this landscape type, and is sensitive to direct landscape change, given the presence of highly characteristic native oak woodland across the area.

Table 4.3.6: High Rocky Peaks (generally found over 2,700 m asl)
High Rocky Peaks **Description:** This landscape character type includes the rocky peaks, and in the wider area the high alpine plateaus, of the low alpine landscape found across the mountain summits of the Zangezur Mountain range. Generally found above 2700 m asl, the summits and skyline ridges consist of volcanic rock extrusions and scree slopes with shallow soils and limited alpine vegetation cover. The rocky summits and peaks form the visible skyline from the surrounding landscape, and represent identifiable landmarks from the lower lying valley landscape below. The landscape displays few signs of human influence, with shepherding of sheep and goats found on the lower slopes in spring and summer. **Key Characteristics:** • Rocky summits and outcrops, with steep slopes, bare ground and areas of scree; • Sub-alpine meadow vegetation and areas of sub-alpine meadow with alpine elements; • A large scale, dramatic, open and unenclosed landscape; • Unsettled with an absence of human influence and built features; • Sense of altitude, exposure, remoteness and relative wildness; • Expansive outlook and panoramic views across the surrounding landscape; • Landmark summits which are locally and regionally recognised. • Snow covered for 6 months of the year. **Geographical Extent within Study Area:** This landscape character type covers a small area of the Project disturbed area and a relatively small proportion of the study area, although it is more widespread further north and south. The linear ridge of summits formed by North Erato, Erato, Tigranes and Artavazdes define the landscape character type within the Project disturbed area, which extends southwards to cover the summit of the subsidiary peak of Arshak to the south. This landscape type is also found across the higher mountain summits of the Zangezur Mountain range to the north-east, south and north-west of the Project disturbed area, at approximately 10km from Amulsar Mountain. **Sensitivity to Landscape Change:** The rocky peaks and ridges of the landscape character type are sensitive to visually intrusive development which could detract from the distinct physical landmarks of the summits, or cause loss of the low alpine landscape. The perceptual qualities of exposure, remoteness and wildness are sensitive to direct landscape change or intervisibility of development within the adjacent landscape. The **Jermuk State Sanctuary – Specially Protected Nature Area** is partly encompassed within this landscape type and is sensitive to direct landscape change, given the presence of highly characteristic native oak woodland across the area.

4.3.7 Visual Amenity

Establishing the visual baseline for the assessment of visual impacts involves three stages:

- Identifying the extent of visual influence of the Project, and the component parts of the Project;
- Identifying the potential visual receptors (groups of people) who may experience views of the Project;
- Establishing representative viewpoints from which receptors will potentially experience views of the Project.

The process of identifying the visual baseline was undertaken with reference to early iterations of the Project design, when visibility of the Project was more extensive, thus representing a maximum case scenario. As the Project evolved, the visual baseline has been updated to reflect modifications to the Project design as a result of the iterative design process and the mitigation which, as such, is embedded within the design.

Identifying the extent of visibility

Evaluation of the theoretical extent to which the Project will be visible across the study area was undertaken by establishing a series of Zone of Theoretical Visibility (ZTV) maps, using computer software capable of calculating intervisibility between points within the terrain model and components of the Project, created within the model.

Computer software (Arc GIS) was used to generate the ZTVs. The programme calculates areas from which the Project components are potentially visible. This is performed on a 'bare ground' computer generated terrain model, which does not take account of potential screening by minor topography (i.e. that below the resolution of the data), buildings or filtering of views by vegetation. The input parameters used were a 50m x 50m grid which means that for each 50m grid point the computer outputs 'visible' or 'not visible' (+1 and -1 values respectively). The receptor grid points used were set at 2m above ground level, as a proxy for human eye height. The +1 and -1 output values are plotted as contours and overlaid onto the base map to illustrate the extent of the ZTV. It should be noted that the programme uses point height data, rather than continuous data, and assumes straight line topography between data points. The software is not able therefore to take account of small scale topographic features. As it uses a 'bare ground' model, it is considered to over emphasise the extent of potential visibility, and therefore represents the maximum potential visibility.

Further ZTVs were generated throughout the iterative Project design process to establish the changing extent of theoretical visibility, identify potential visual receptors indicated within the ZTV and to identify representative viewpoints located within the ZTV.

Identifying Potential Visual Receptors

The following visual receptors were identified during initial desk based study and field visits and were refined throughout the Project design process as the extent of visibility changed:

- Residential receptors including people concentrated within affected communities and in more scattered dwellings;
- Tourists and visitors to the area;
- Recreational receptors using the area, such as the ski-slope in Jermuk;
- People travelling on roads, tracks and paths through the study area including major and minor roads; and
- People at their place of work: including seasonal herders and subsistence farmers.

Identifying Potential Representative Viewpoints

A large number of potential representative viewpoint locations were identified throughout the iterative design process, which were refined as modifications to the Project design were incorporated. The final representative viewpoints used for the assessment of visual impacts were chosen according to the following criteria:

- Being publicly accessible;
- Having a reasonably high potential number of receptors or being of particular importance to the viewers affected;
- Providing a representative range of viewing distances, directions and elevations (short, medium and long distance views);
- Representing a range of viewing experiences (static views, views from settlements and sequential points along routes);
- Representing a range of view types, (panoramas, vistas, glimpses); and
- Representing views with different parts of the Project potentially being visible.

The representative viewpoints are all located within area of theoretical visibility indicated on the final ZTVs, and locations with the clearest views of the Project have been selected. These are listed and their locations shown on maps in Section 6.5. Existing and proposed views across the study area and from each of the representative assessment viewpoints are also described and illustrated in Section 6.5.

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APPENDICES

Appendix 4.4.1 DustScan and Gradko data (2011-2014)

4.4 Air Quality

4.4.1 Introduction

Air quality is defined as a measure of the condition of the atmosphere relative to the requirements of one or more biotic species or to any human need or purpose. Air quality parameters of interest to Project implementation include those which have the potential to affect human health or the environment, namely suspended particulate matter (PM_{10} and $PM_{2.5}$ and larger particle size nuisance dust), nitrogen oxides (NOx) and sulphur dioxide (SO_2).

Particulate Matter (PM_{10} and $PM_{2.5}$) and Dust

Airborne particulate matter varies widely in its physical and chemical composition, source and particle size. Particles up to 10µm that are inhalable into the upper respiratory tract are known as PM_{10} and particles up to 2.5µm, which are respirable deep into the lungs, are known as $PM_{2.5}$. These particles are of concern as they are small enough to enter the respiratory system and at certain elevated concentrations can affect human health. PM_{10} and $PM_{2.5}$ can travel in excess of 1km from the point of release and, unlike larger dust particles, their dispersal is not dependent upon wind direction. As such, monitored $PM_{10}/_{2.5}$ levels tend to be fairly consistent both up and downwind of a source[1]. The principal sources of $PM_{10}/_{2.5}$ are combustion activities, such as vehicle exhausts, woodstoves, power plants, etc. Because particles originate from a variety of mobile and stationary sources their chemical and physical compositions vary widely. $PM_{10}/_{2.5}$ can be directly emitted or can be formed in the atmosphere when gaseous pollutants such as SO_2 and NO_x react to form fine particles.

Larger mineral dust particles, between 10 and 75µm in size, do not pose the same health effects as smaller $PM_{10}/_{2.5}$ particles and are generally referred to as nuisance dust, as human concerns generally relate to the soiling of surfaces. Mineral particles between 30 and 75µm have a relatively high mass and settling velocity and tend to deposit naturally within 100m of the point of release, however 30µm particles can travel up to 300m from the point of release. Particles in the size range of 10-30µm tend to fall out of the atmosphere between 100m and 250m from the point of release, under normal meteorological conditions. Modelling studies have also shown that deposition rates decrease significantly (in an almost logarithmic manner) with increasing distance from the source. Deposition of these larger dusts may have

[1] "Do particulates from open cast mining impair children's respiratory health?" ('The Newcastle Report', HMSO, 1999)

detrimental effects on plant growth due to the obscuring of leaf surfaces leading to reduced photosynthesis and growth rates.

Nitrogen Oxides (NO_x)

Nitrogen oxides (NO_x) is a term used to describe a mixture of nitric oxide (NO) and nitrogen dioxide (NO_2). These are inorganic gases formed when oxygen and nitrogen (both readily available in the atmosphere) combine, and are also a by-product of combustion of fossil fuel by vehicles, industrial processes and power generation. There is some evidence that long-term exposure to NO_2 at concentrations above 40–100 µg/m^3 may decrease lung function and increase the risk of respiratory symptoms. Oxides of nitrogen are also a precursor for ozone formation, which at ground level can have potential effects on human health and damage to vegetation.

Sulphur Oxides (SO_x)

The term sulphur oxides (SO_x) refers to a range of sulphur and oxygen containing compounds, the most common of which is sulphur dioxide (SO_2). The largest anthropogenic source of SO_x is the combustion of sulphur containing fossil fuels (particularly coal and oil); however, SO_x are also produced during metal smelting and other industrial processes. Sulphur oxides also occur naturally through volcanoes, forest fires, the oceans and decaying plant matter. The oceans, wetlands and lakes act as natural sinks for SO_x.

Both chronic and acute exposure to SO_x can cause damage to the respiratory system; there is also a link between chronic high-level SO_x exposure and heart disease. SO_x can dissolve in moisture in the atmosphere forming sulphur acids (commonly known as “acid rain”). These attack the outer protective waxy coatings of leaves, effecting plant growth. Sulphur acids may also acidify soils and waterways, causing wider environmental effects.

Existing Emission Sources

There are no major urban or industrial centres in the region that will have a significant effect on the regional or local air quality. Jermuk is the closest potential source for emissions within the study area, with combustion emissions produced from vehicle exhausts, domestic heating and an operational domestic waste dump (Kechut). Jermuk is located over 10km north-north-west of the proposed open pit at Erato, with prevailing winds from the east. Jermuk has insufficient industrial activity to influence baseline monitoring at the Project.

From visual inspections the villages within 10km of the Project, and land within the Project, have very low levels of emissions. The limited emissions that do exist predominantly result from vehicle exhausts and, in winter, domestic fires for heating.

The most common fugitive emission in the Project and surroundings is dust or particulate matter which is released during various activities such as vehicle traffic on paved and unpaved roads, together with wind erosion from open storage of solid materials, exposed soil surfaces and unpaved roads.

4.4.2 Monitoring Methods and Locations

Gas Monitoring

Baseline monitoring for NO_2 and SO_2 at the site was undertaken by Geoteam, using Gradko diffusion tubes at five locations within residential settlements. The acrylic tubes are designed for passive sampling of airborne gases. The tube contains an adsorbent material which can then be analysed by UV/Visible Spectrophotometry with reference to a UKAS (United Kingdom Accreditation Service) calibration curve, appropriate to this methodology. The tubes have a recommended exposure length typically in the order of 4 weeks, after which time they are removed from their sampling location and returned to the manufacturer's accredited laboratory for analysis.

Two gas Gradko samplers for each parameter (SO_2 and NO_2) were established at five representative locations (see Figure 4.2.1). Each monitoring point had two diffusion tubes that ran concurrently over a period of 4-6 consecutive weeks during autumn and winter periods of 2011/2012 and consecutive monthly periods from December 2013. At the start of the 2013 monitoring, the Saralanj location was replaced by a new residential location in Jermuk. In 2015, the monitoring locations were revised and the equipment was changed to passive samplers supplied by IVL of Sweden, the Gradko samplers having become unavailable (see Section 4.4.3).

Dust monitoring - DustScan DS100

The DustScan DS100 is a directional dust gauge for assessing fugitive dust deposition (all dust 10-75 µm) and indicates from which directions emissions may originate (see Figure 4.4.1). Eight DustScan DS100s were used for monitoring at the site (see Figure 4.2.1 for locations).



Figure 4.4.1: DustScan DS100

The DS100 is a passive sampler, requiring no power, which collects fugitive dust from 360^{o} around the sampling point by trapping it on a sticky surface. The sampling cylinder slots into the monitoring post and is capped with a rain shield. North-facing notches in the sampling cylinder and the post ensure that the alignment of the sticky pad is consistent. The design of the sticky sample pad means that it is quite obvious if dust has been thrown at the pad, or been scratched at, in an attempt to alter results.

The manufacturer recommends that sticky pads are collected after 1 to 14 days exposure in the field. The average time that each sticky pad was left out during monitoring periods at the project is 7.5 days.

Usually the whole sampling cylinder is returned to the manufacturer in a customised transport flask. Geoteam chose to remove and seal the sticky pad on site before returning it to DustScan, due to difficulties associated with international shipping for analysis. The accuracy of this process can be maintained by laminating the sticky pad before submitting for analysis by DustScan.

Particulate monitoring

Osiris Turnkey

Two Osiris Turnkey monitors were used for short and long-term measurement of suspended particulate concentrations in air, in the PM_{10} and $PM_{2.5}$ ranges (see Figure 4.4.2).



Figure 4.4.2: Osiris Turnkey Monitor

The Osiris Turnkey Monitor uses a light scattering technique to determine the concentration and size fraction of airborne particles. The air sample is drawn into the instrument by a pump, beyond which it passes through a laser beam in a photometer and then through a filter. The light scattered by the individual particles is converted into an electrical pulse which is proportional to the size of the particle. The measurements of light scatter are taken at a narrow angle to remove the effects of material composition.

SKC EPAM 5000

A portable battery powered EPAM monitor has been purchased to supplement particulate monitoring capability, and can monitor $PM_{2.5}$ or PM_{10} continuously for up to 24hrs.



Figure 4.4.3: EPAM 5000 Monitor

The EPAM uses the principle of near-forward light scattering of an infrared radiation to immediately and continuously measure the concentration in mg/m^3 of airborne dust particles.

Monitoring Locations

Monitoring locations were selected for each type of measurement to establish an understanding of baseline conditions. The choice of monitoring points took into account local sensitive receptors and the development requirements for the Project, and has changed over time. Figure 4.2.1 shows both current and historical locations of the monitoring points.

4.4.3 Monitoring Results

Gas Monitoring

Results from SO_2 and NO_2 monitoring are shown in Table 4.4.1 to Table 4.4.3 (see also Appendix 4.4.1).

Table 4.4.1: Results from Air Quality Monitoring, Using Gradko Diffusion Tubes over the Autumn/Winter Period 2011/12				
SO_2 Monthly (Time Weighted Average µg/m³)				
	Sept/Oct	**Nov**	**Dec**	**Jan**
Gorayk	2.19	1.57	2.37	1.29
Saralanj	1.66	1.25	3.23	2.05
Saravan	1.67	1.69	4.77	2.85
Gndevaz	1.44	-	2.36	1.15
Kechut	1.12	1.39	2.70	-
NO_2 Monthly (Time Weighted Average µg/m³)				
	Sept/Oct	**Nov**	**Jan**	
Gorayk	4.12	12.34	3.35	
Saralanj	5.42	5.83	4.59	
Saravan	4.12	3.42	8.97	
Gndevaz	6.21	3.86	2.74	
Kechut	1.92	9.89	-	

Table 4.4.2: 2014 NO_2 Results from Air Quality Monitoring, Using Gradko Diffusion Tubes												
Location	**2014 Monthly NO_2 Concentration (µg/m³)**											**Average Concentration (µg/m³)**
	Jan	**Feb/Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	
Gorayk	2.11	1.84	2.62	2.94	*1.69*	3.50	2.14	4.79	3.22	3.58	2.58	**2.82**
Saravan	9.71	7.83	5.83	6.13	5.07	4.60	3.79	7.78	9.47	9.59	9.41	**7.20**
Jermuk	4.76	3.08	2.58	3.11	2.34	3.17	2.61	4.79	4.40	4.81	5.61	**3.75**
Kechut	6.99	6.64	4.56	2.98	3.20	3.86	3.20	3.86	5.14	7.31	8.98	**5.15**
Gndevaz	3.82	2.45	1.94	2.50	2.59	3.03	2.19	4.11	3.44	3.97	3.87	**3.08**
Underlined results were below the reporting threshold - therefore the results presented are a worst case concentration												

Table 4.4.3: SO_2 Results from Air Quality Monitoring, Using Gradko Diffusion tubes												
Location	**2014 Monthly SO_2 Concentration (µg/m³)**											**Average Concentration (µg/m³)**
	Jan	**Feb/Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	
Gorayk	1.35	*0.73*	*1.22*	*1.15*	*1.02*	*0.20*	*0.79*	*0.97*	*1.44*	1.22	1.69	**1.07**
Saravan	1.23	*0.98*	*1.22*	*1.22*	*0.95*	*0.20*	*1.38*	*0.97*	*1.08*	1.29	*1.94*	**1.13**
Jermuk	*1.18*	*0.73*	*1.21*	*1.15*	*0.95*	*0.20*	*0.95*	*2.82*	*1.08*	*1.06*	*1.02*	**1.12**
Kechut	2.51	1.51	1.22	*1.15*	*0.95*	*0.20*	1.42	*0.97*	1.53	1.83	3.37	**1.51**
Gndevaz	*1.26*	*1.04*	*1.21*	*1.15*	*0.95*	*0.20*	1.50	*0.97*	*1.07*	*1.06*	*1.11*	**1.05**
Underlined results were below the reporting threshold - therefore the results presented are a worst case concentration												

In 2015, it was no longer possible to use Gradko Diffusion Tubes in non-EU countries and an

alternative passive sampler was identified as a replacement. In August 2015, IVL Diffusion Samplers which operate in a similar way to Gradko Tubes were deployed to the same five residential settlements and an additional six locations, shown on Figure 4.2.1 to continue monthly baseline data collection.

The first results of monthly NO_2 and SO_2 monitoring in 2015 are presented in Table 4.4.4.

Table 4.4.4: Results from Air Quality Monitoring, Using IVL Diffusion samplers for 2015

Location	Monthly Concentration (µg/m³)					
	August		September		October	
	NO_2	SO_2	NO_2	SO_2	NO_2	SO_2
Gorayk	3.0	0.8	3.0	0.7	2.8	0.5
Saravan	3.2	0.8	4.5	1.1	7.7	0.9
Jermuk	3.0	0.6	3.0	0.7	2.7	0.4
Kechut	1.8	0.7	2.2	0.8	3.0	0.6
Gndevaz	1.9	0.7	1.9	0.9	2.5	0.5
AQ1	1.1	0.7	0.8	0.8	0.9	0.4
AQ2	1.2	0.7	1.1	0.8	1.1	0.4
AQ3	1	0.7	0.8	0.9	1.1	0.5
AQ4	1.3	0.8	1.3	0.9	2.0	0.5
AQ5	0.7	0.7	0.5	1.1	0.8	0.5
AQ6	1.2	0.8	1.2	0.8	1.1	0.6

Background concentrations for NO_2, as shown in the preceding tables, are all significantly below WHO guideline levels (Table 4.4.5) for NO_2. As the WHO standard for SO_2 is based on a 24 hour mean, rather than long term averages, it is difficult to make a direct comparison. However, many of the analysis results for SO_2 yielded concentration below the laboratory equipment detection levels, making it highly unlikely that SO_2 levels at the monitoring locations ever came near the WHO 24 hour mean limit of 20 µg/m³. This finding is consistent with what is expected in a rural location with no significant pollution sources within the locality.

Table 4.4.5: World Health Organisation NO_2 and SO_2 guidelines[2].	
	WHO Guideline Value µg/m³
NO_2	40 (annual mean)
SO_2	20 (24 hr mean)
Notes: SO_2 It is not possible to convert the time weighted average concentrations to a 24hr mean; therefore direct comparison is not valid.	

Dust Monitoring

DustScan DS100 data has been collected from eight monitoring locations, as shown in Figure 4.2.1. Monitoring is undertaken only during snow-free period due to the difficulty of accessing monitoring locations in the winter months. It is unknown why monitoring has not been carried out year round at residential receptor sites in Gndevaz and Jermuk, but there is a low likelihood of dust generation during the months when snow cover is present.

The most comprehensive data is for the monitoring points ADE2, ADS3, and ADW4, with data available for consecutive weeks from June 2011 to August 2011, July 2012 to September 2012, and July 2013 to September 2013. ADN1 has the same data coverage as the previously mentioned sampling points, with the exception of data collected during 2011.

Data has been collected from sample points ADJ5, ADG7 and ADHLP8 during April 2013, and consecutive weeks in July, August, and September 2013. Data for ADHLP9 has only been collected during September 2013.

The number of DS100 samples collected each month for each sampling location is tabulated in Table 4.4.6. Since the sampling frequency was typically 6 or 7 days, the maximum number of samples that could be collected from a certain sampling location in any month would be either 4 or 5, depending on when the first sample for the month was collected.

[2] WHO Air quality guidelines for nitrogen dioxide and sulphur dioxide – Global update 2005 (Summary Risk Assessment)

Table 4.4.6: DustScan DS100 Sampling Week Frequency table														
	2011			2011 Total	2012			2012 Total	2013				2013 Total	Grand Total
Sample Points	June	July	August		July	August	September		April	July	August	September		
ADE2	1	3	2	6	2	2	1	5	1	5	4	4	14	25
ADHLP8										5	4	1	10	10
ADJ5									1	5	4	4	14	14
ADN1	1		1	2			1	1	1	5	4	4	14	17
ADS3	1	3	2	6	2	2	1	5	1	5	4	4	14	25
ADW4	1	3	2	6	2	2	1	5	1	5	4	3	13	24
ADG07									1	5	3	2	11	11
ADHLP09												3	3	3

DustScan DS100 samples provide two measurements of dust deposition: Absolute Area Coverage (AAC%) and Effective Area Coverage (EAC%).

According to DustScan's Guidance Note 3[3], AAC% indicates the magnitude and significance of dust sources. This is determined based on the presence of dust on the sticky pad, irrespective of dust colour. EAC% rates the nuisance potential that may be caused by dust, with regard to the darkness or potential soiling of the dust.

The DustScan DS100 is divided into directional segments, which allows one to determine the direction from which the dust deposited on the sticky pads was travelling.

Ranking criteria for dust source significance in terms of AAC% are shown in Table 4.4.7. Ranking criteria for dust nuisance potential in terms of EAC% are shown in Table 4.4.8.

[3] DustScan Guidance Note 3: Directional Dust Data Assessment, http://www.dustscan.co.uk/Portals/0/PDFs/Guidance%20Note3.pdf, Accessed 17/07/2014

Table 4.4.7: AAC% Source Significance		
Source Significance		**AAC% Value per Sampling Interval**
Very Low	0	<80%
Low	1	80% to <95%
Medium	2	95% to <99%
High	3	99% to 100%
Very High	4	100% for 45°

Table 4.4.8: EAC% Nuisance Potential		
Nuisance Potential		**EAC% Value per Day**
Very Low	0	<0.5%
Low	1	0.5% to <0.7%
Medium	2	0.7% to < 2.0%
High	3	2.0 to <5.0%
Very High	4	>=5.0%

Table 4.4.7 and Table 4.4.8 are compiled taking account of the assessment guidance in DustScan's Guidance Note 3, and the sampling result interpretation in each of DustScan's DS100 Directional Dust Flux Reports provided to Geoteam (see Appendix 4.4.1 for examples).

The following pollution roses in Table 4.4.9 provide the percentage frequency counts of source significance levels and nuisance potential of dust coming from 12 directions, for each of the sampling locations. When readings are below the detection limit, the reading is not included in the count. Table 4.4.6 shows the AAC% pollution roses in Table 4.4.9 overlain on the Air Quality Baseline Monitoring map to help provide a spatial representation of baseline dust deposition.

Consideration is first given to AAC%. ADN1 and ADS3 show the greatest frequency of dust deposition with a high source significance, with high significance dust at ADN1 coming predominantly from the south-east (11.3% of the time monitored), and high significance dust at ADS3 coming from the east and east-north-east (5.6% of the time monitored).

The high source significance readings at ADN1 and ADW4 are likely a result of exploration and geotechnical studies being undertaken at Amulsar during the sampling periods. The high readings coming from the east of ADS3 correlate with the prevailing wind direction, and may

be as a result of road traffic along the Vorotan Pass. High frequencies of medium significant sources of dust deposition have been detected at the Jermuk monitoring point (ADJ5), with dust fluxes coming from the south-east. This is likely due to road traffic near the sampling location. Dust deposition at the Gndevaz sampling point shows deposition of low or greater significance coming from the north about 3.4% of the time monitored. This indicates that a minor dust source exists within Gndevaz – possibly as a result of small fires for rubbish disposal.

Considering EAC%, most sampling points show low frequencies (2% or less) of high to very high nuisance potential over the sampling periods, from all wind directions combined. The exception is ADN1 that shows that deposition has a high to a very high nuisance potential for approximately 9% of the sampling period from the south to the east-south-east of ADN1 (9.8% from all directions combined).

Table 4.4.9: Pollution Roses showing frequencies of dust deposition by wind direction, grouped by source significance (AAC%) and nuisance potential (EAC%)

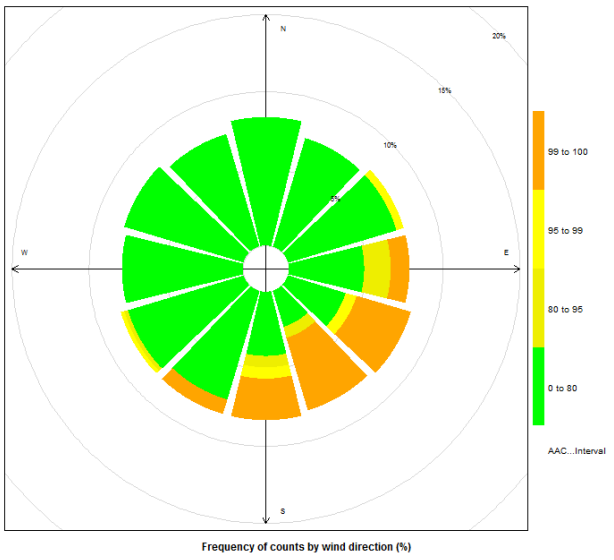
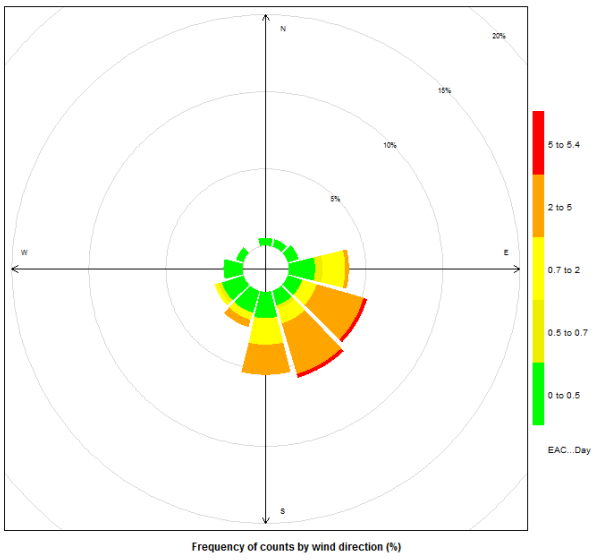
Sample point	AAC% per Interval	EAC% per Day
ADN1		

Table 4.4.9: Pollution Roses showing frequencies of dust deposition by wind direction, grouped by source significance (AAC%) and nuisance potential (EAC%)

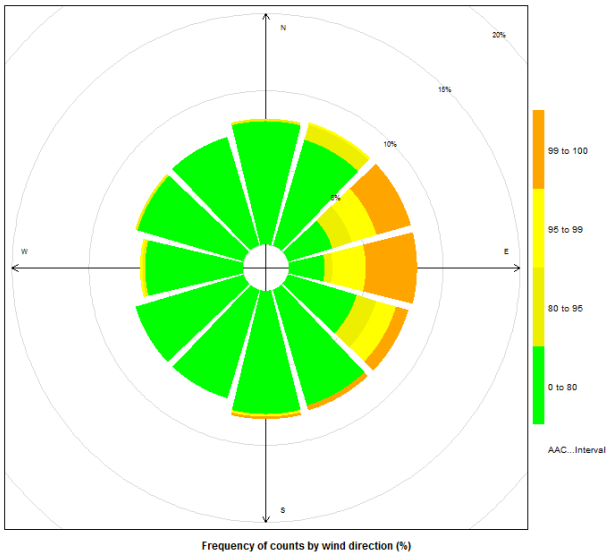
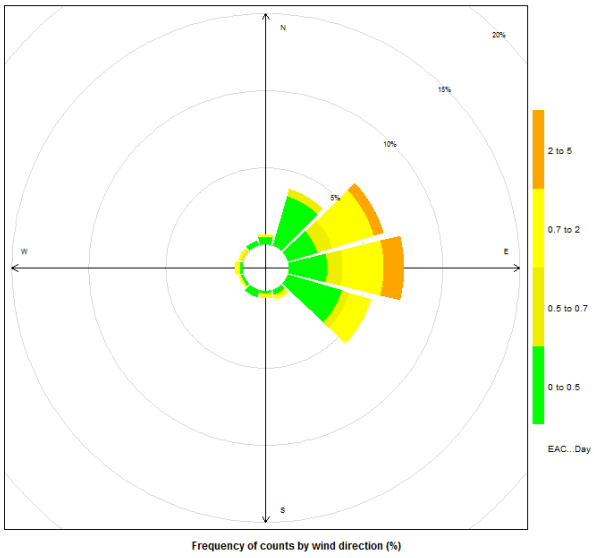
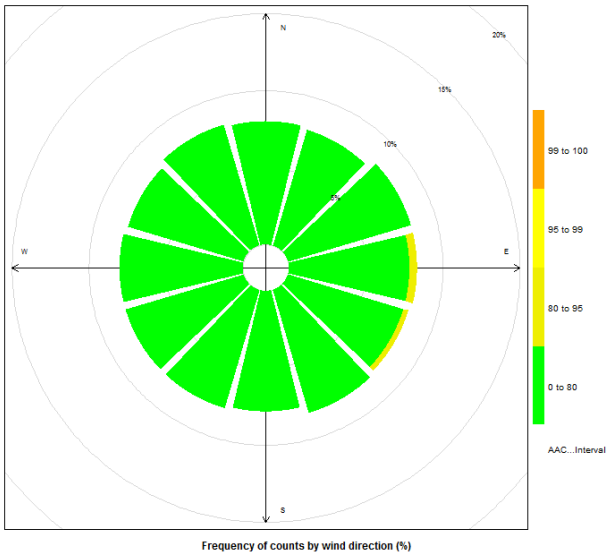
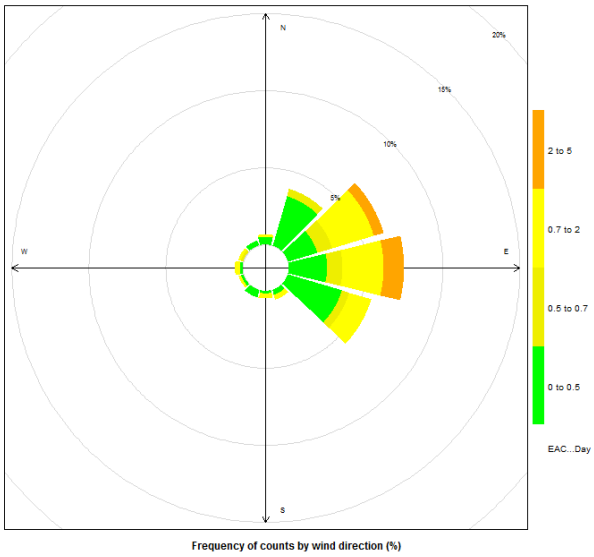
Sample point	AAC% per Interval	EAC% per Day
ADS3		
ADE2		

Table 4.4.9: Pollution Roses showing frequencies of dust deposition by wind direction, grouped by source significance (AAC%) and nuisance potential (EAC%)

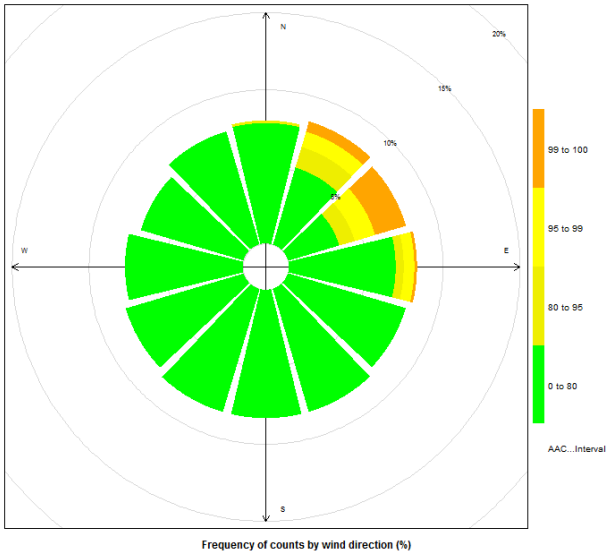
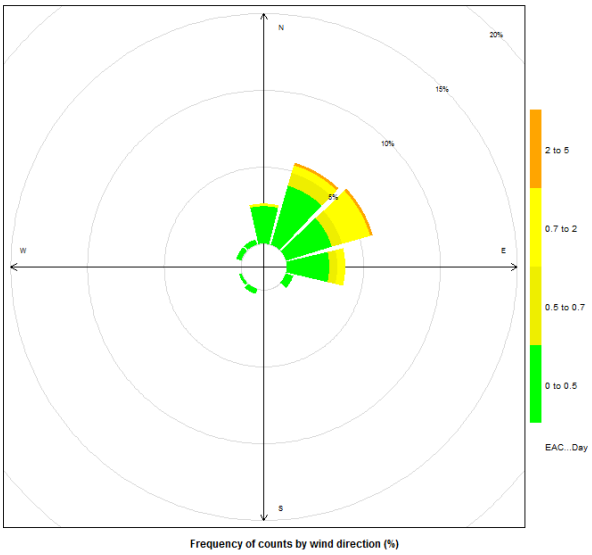
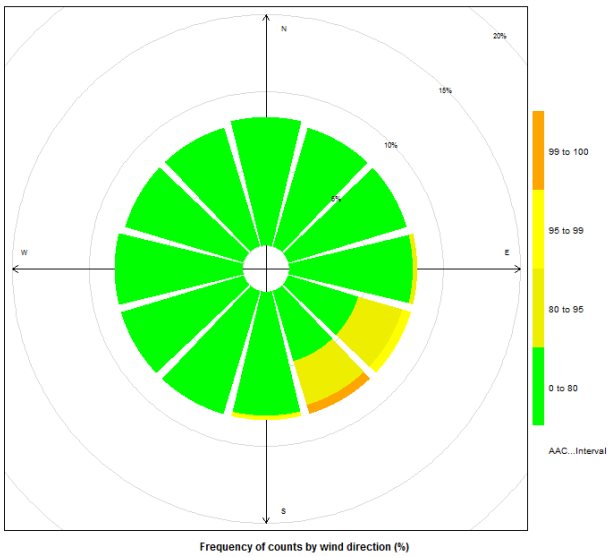
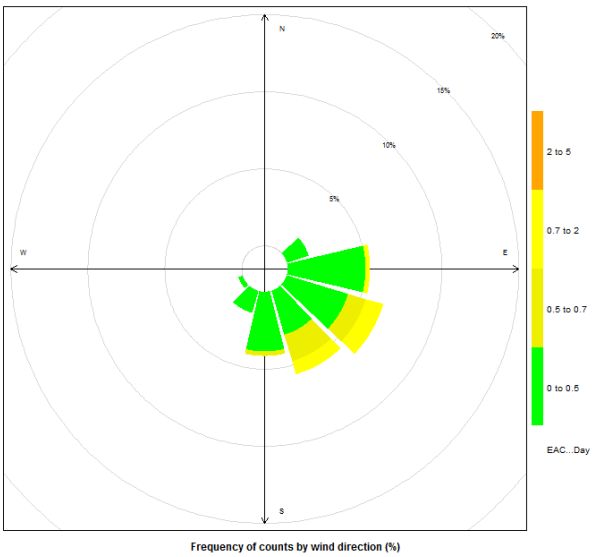
Sample point	AAC% per Interval	EAC% per Day
ADW4		
ADJ5		

Table 4.4.9: Pollution Roses showing frequencies of dust deposition by wind direction, grouped by source significance (AAC%) and nuisance potential (EAC%)

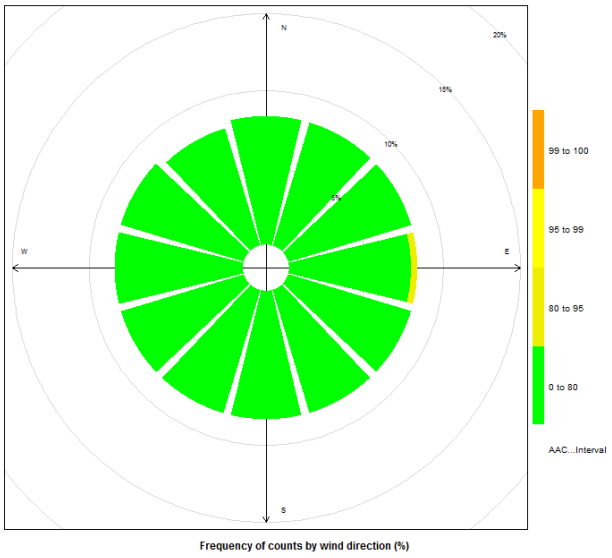
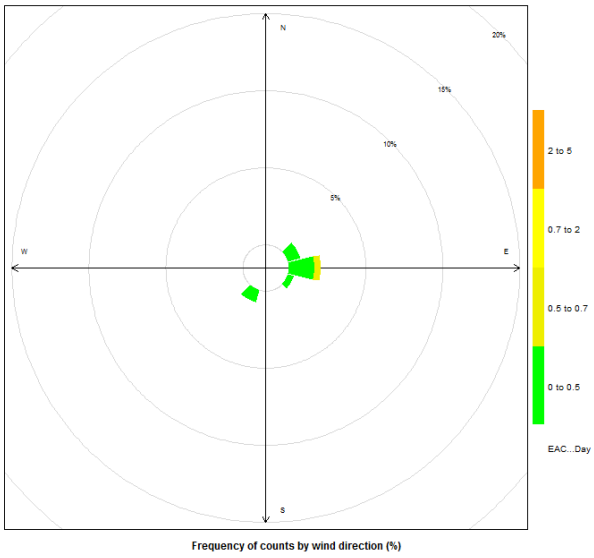
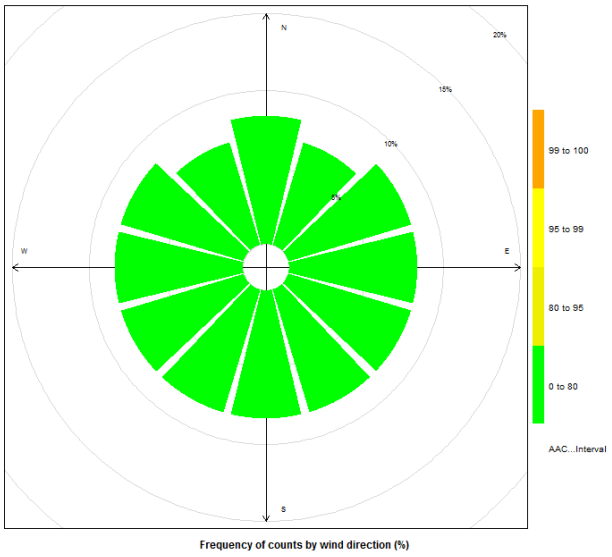
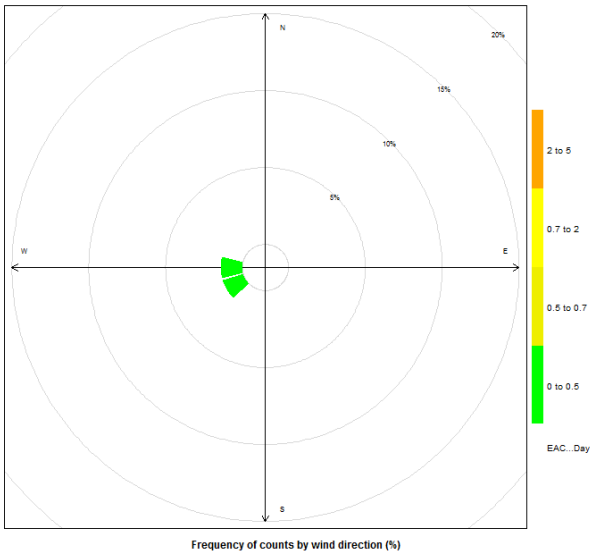
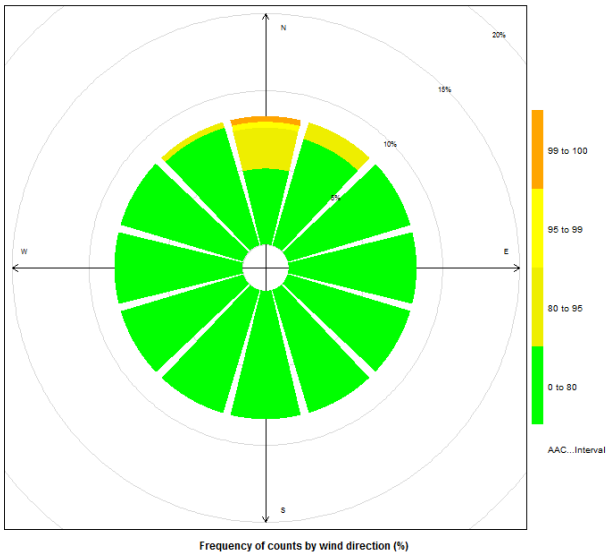
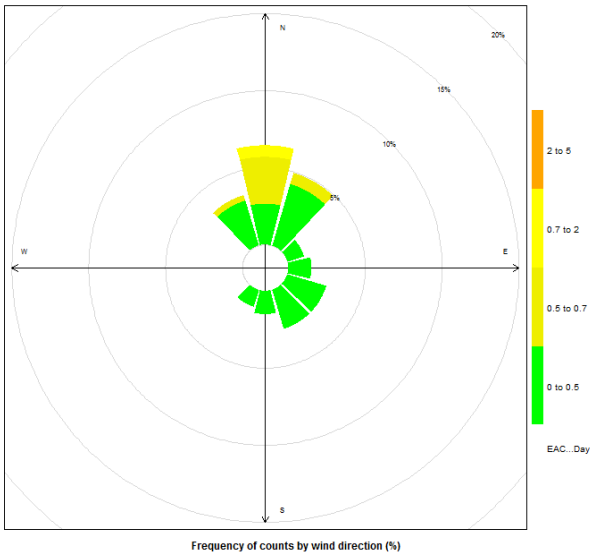
Sample point	AAC% per Interval	EAC% per Day
ADHLP 8		
ADHLP 9		

Table 4.4.9: Pollution Roses showing frequencies of dust deposition by wind direction, grouped by source significance (AAC%) and nuisance potential (EAC%)

Sample point	AAC% per Interval	EAC% per Day
ADG7		

The analysis of AAC% and EAC%, illustrates that dust deposition was usually low during the sampling period and illustrates influence from the prevailing wind direction (prevailing wind was easterly during the monitoring period, see wind rose in Section 4.2, Figure 4.2.6).

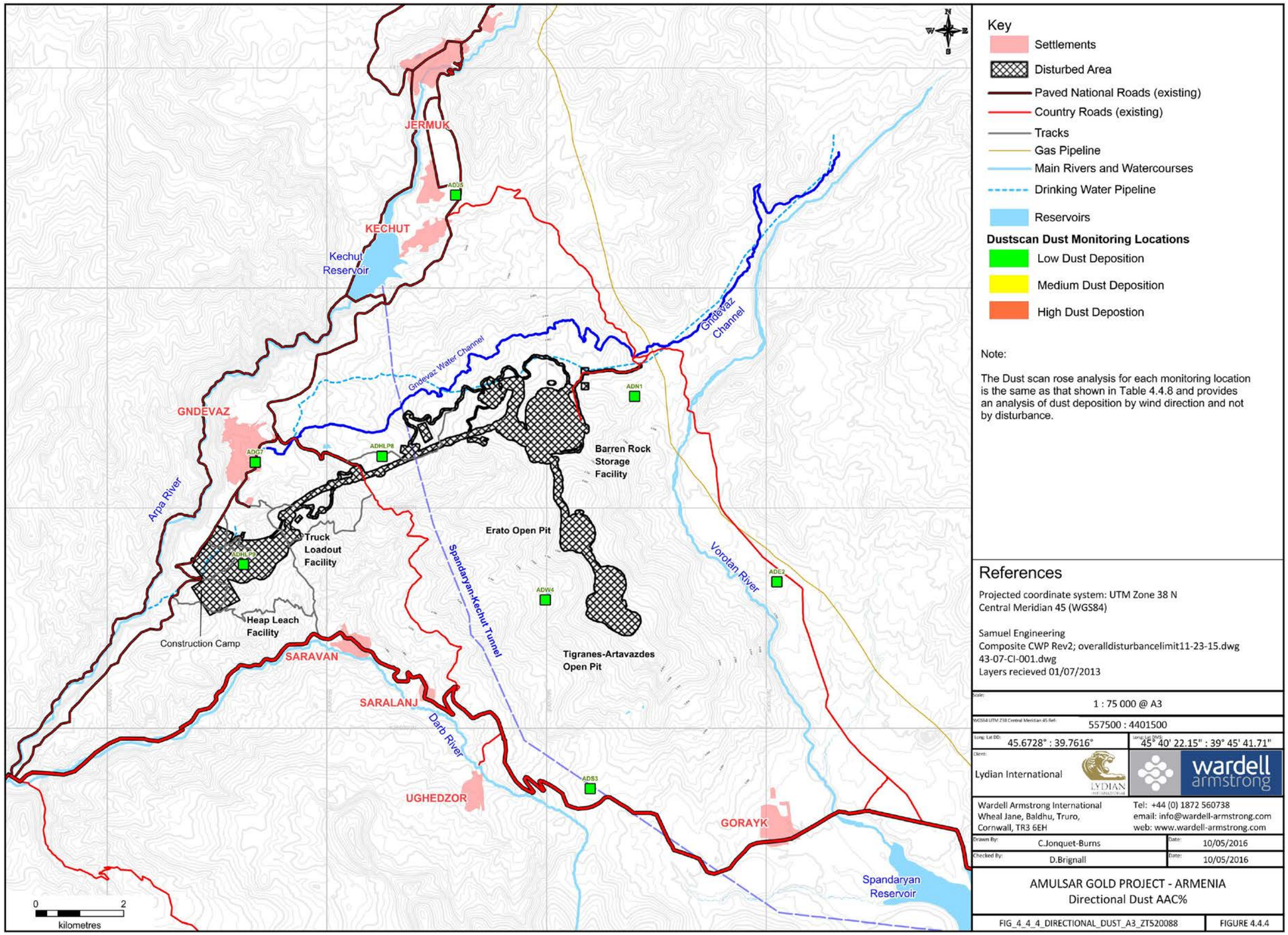


Figure 4.4.4: Directional Dust AAC%

Particulate Monitoring

In 2011, limited baseline particulate monitoring data was collected from locations within the five residential settlements. One-hourly measurements taken between 5 and 30 days from June to November 2011 showed wide variation in background particulate concentrations which were influenced by outlying data samples associated with such short monitoring periods.

In 2014, both Osiris monitors were returned to the manufacturer for calibration and upgrading. Research was carried out to identify a suitable portable monitor capable of accurate 24hr measurement in remote locations without a mains power source to supplement Osiris measurements. In accordance with the Air Quality, Noise and Vibration Management Plan (V2), The Osiris monitors were located in the nearest most sensitive receptor locations to the mine operations, at Gndevaz and Kechut to establish a reliable long-term baseline at these locations. An EPAM monitor was purchased and field tested alongside the Osiris instruments used in Gndevaz and Kechut from June 2015.

The instruments monitored PM_{10} concentrations at Gndevaz and Kechut from June to October and $PM_{2.5}$ concentrations at the same locations from June to mid-July 2015. The 24hr mean results are shown in Figure 4.4.5 to Figure 4.4.8.

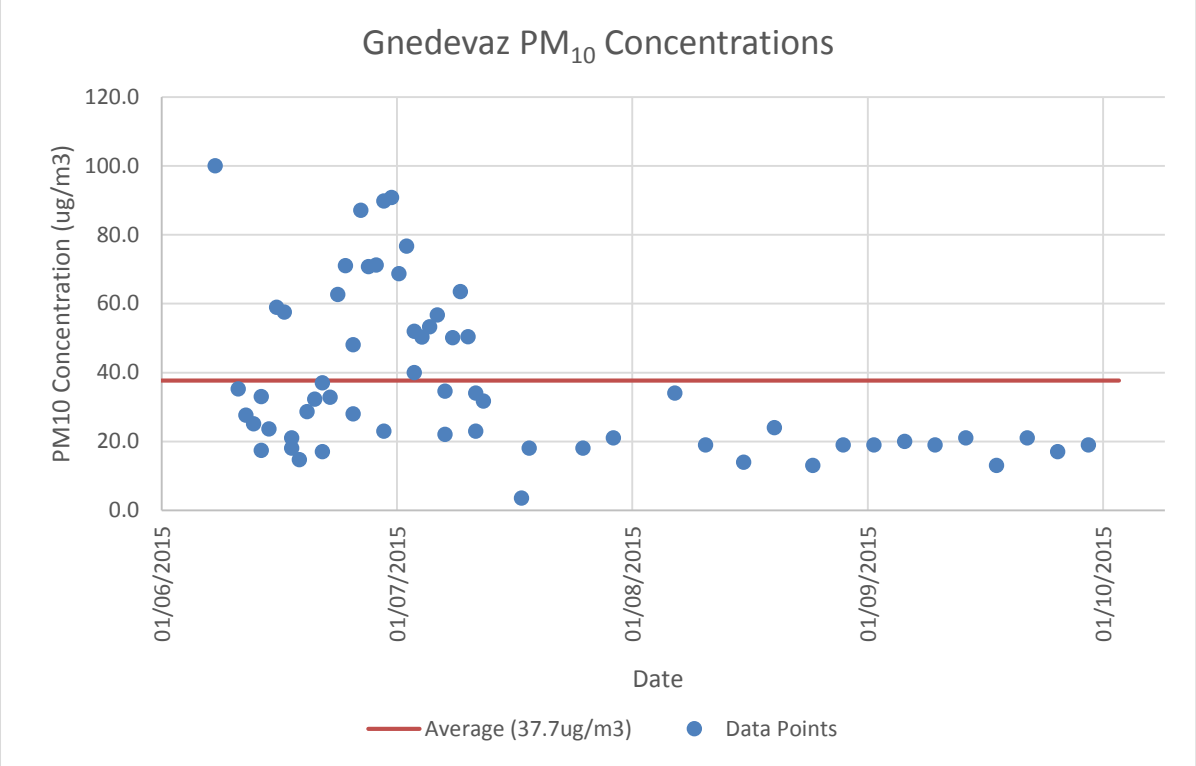


Figure 4.4.5: 24hr mean PM_{10} Concentrations – Gndevaz

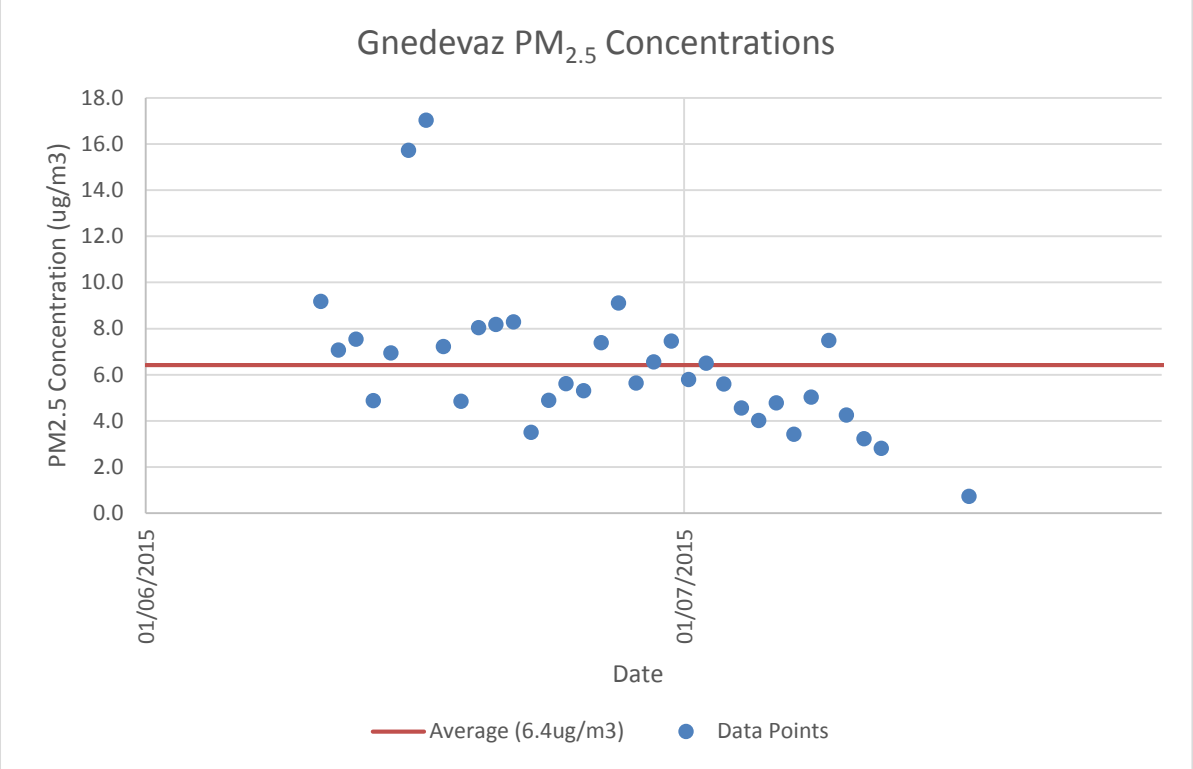


Figure 4.4.6: 24hr mean $PM_{2.5}$ Concentrations - Gndevaz

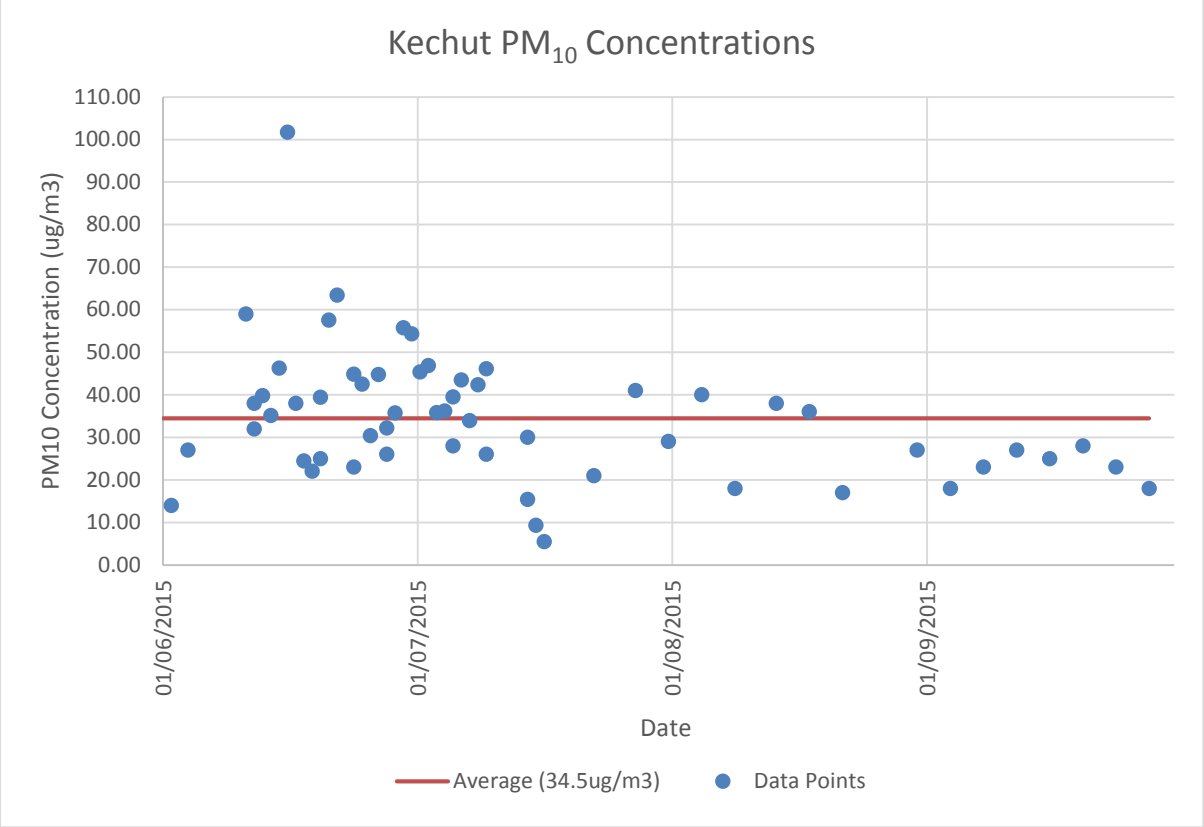


Figure 4.4.7: 24hr mean PM_{10} Concentrations - Kechut

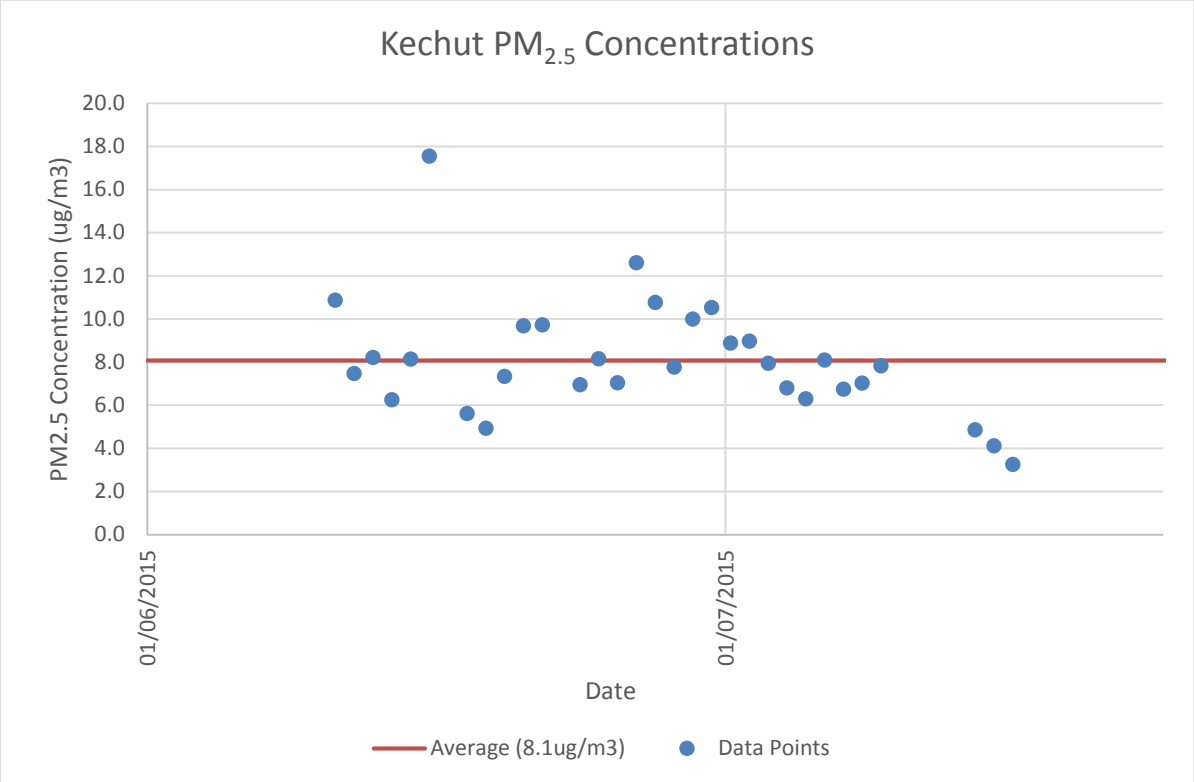


Figure 4.4.8:24hr mean $PM_{2.5}$ Concentrations - Kechut

In addition to establishing long-term monitoring locations in Gndevaz and Kechut, short term (24hr) periodic baseline particulate monitoring has commenced in rural locations within the project footprint. Air Quality monitoring points –AQ9 to the west of Tigranes/Artavazdes and AQ10 to the north of the BRSF were chosen to establish baseline conditions near to operational areas of the project but away from the possible influence of human activities in the settlements (such as domestic fuel burning for heat/cooking purposes). Air quality monitoring locations are shown on Figure 4.2.1. The 24hr mean results for the additional monitoring locations are shown in Figure 4.4.9 to Figure 4.4.12.

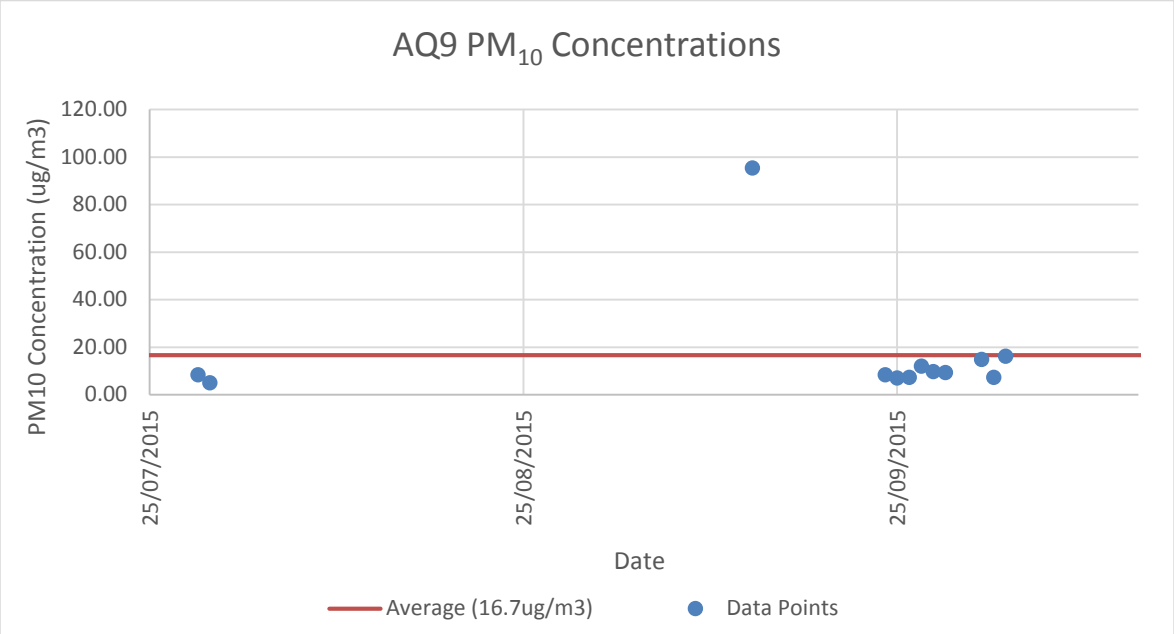


Figure 4.4.9: 24hr mean PM_{10} Concentrations – AQ9 West of Tigranes/Artavazdes

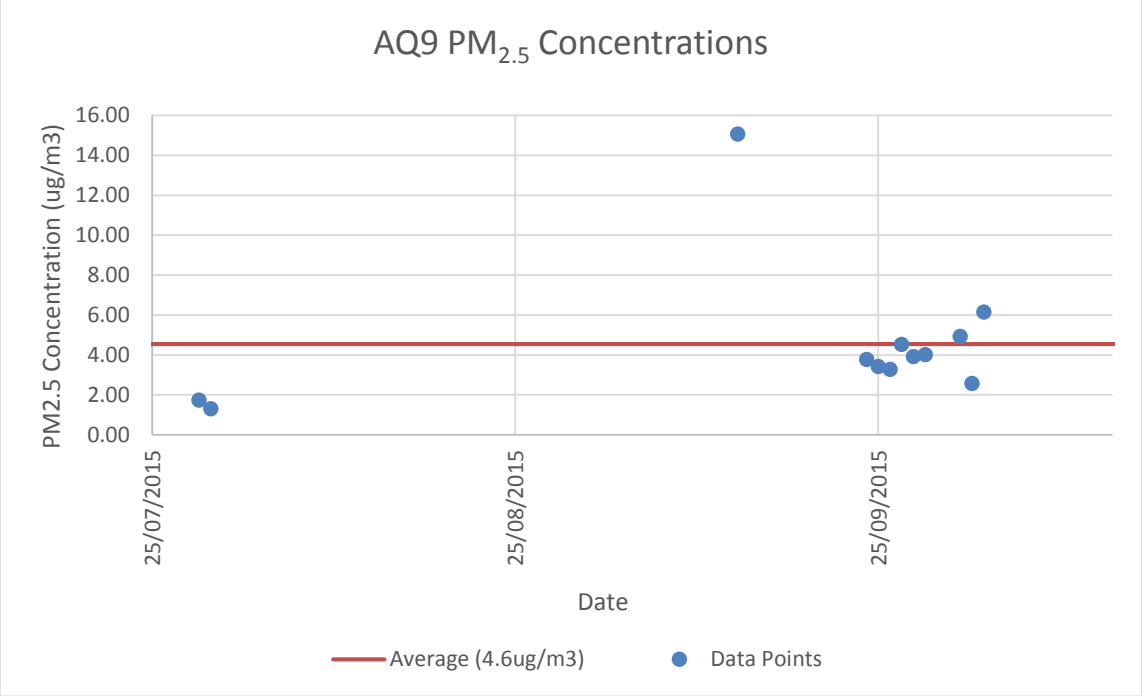


Figure 4.4.10: 24hr mean $PM_{2.5}$ Concentrations - AQ9 West of Tigranes/Artavazdes

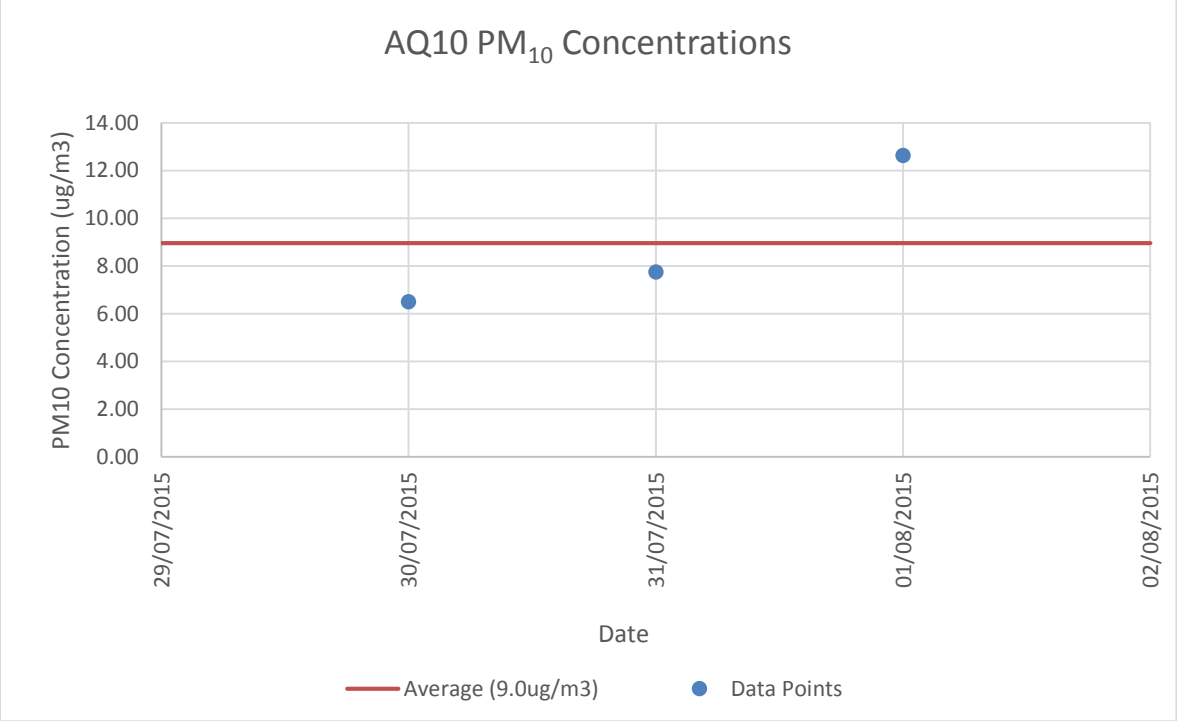


Figure 4.4.11: 24hr mean PM_{10} Concentrations - AQ10 North of BRSF

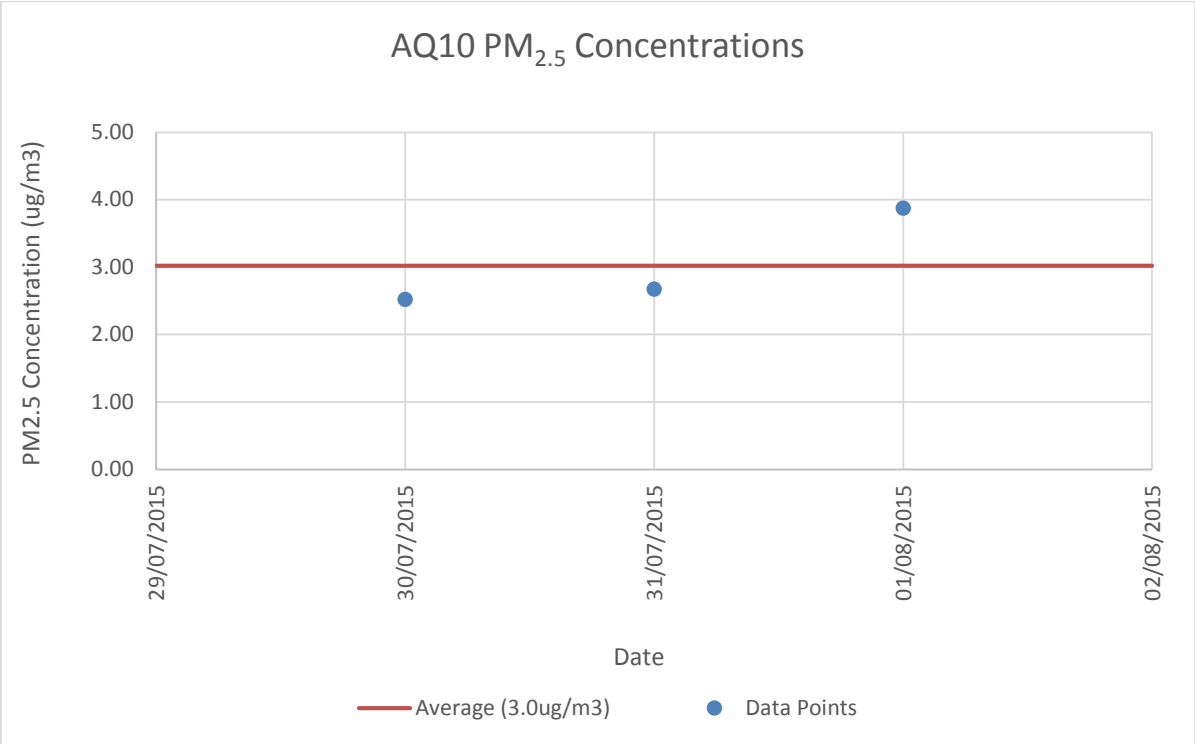


Figure 4.4.12 24hr mean $PM_{2.5}$ Concentrations - AQ10 North of BRSF

The WHO guideline values for particulates are shown in Table 4.4.10:

Table 4.4.10: World Health Organisation PM_{10} and $PM_{2.5}$ guidelines.

	WHO Guideline Value µg/m³	
	24 hour mean	annual mean
PM_{10}	50	20
$PM_{2.5}$	25	10

From the data obtained it can be seen that baseline PM_{10} concentrations exceed the WHO 24hr mean guideline in Gndevaz on 19 days out of 59 days (32%). In Kechut, the PM_{10} guideline value was exceeded on 6 days out of 56 days (11%). There was only 1 day of exceedance at AQ9 and no exceedances at AQ10 during the short period of monitoring to date. There were no exceedances of the WHO $PM_{2.5}$ 24hr mean value at any monitoring location.

The pattern of measured particulate concentrations, over the period monitored to date, indicates that WHO annual mean guidelines will follow a similar pattern in that the PM_{10} guideline is expected to be exceeded in the vicinity of the Project prior to operations commencing. Monitoring suggests that the $PM_{2.5}$ annual guideline value will not be exceeded.

4.4.4 Summary

Air quality monitoring has been carried out in and around the Project area since 2011 to establish the existing baseline conditions.

Monitoring for gaseous NO_2 and SO_2 has been completed in five local communities near to existing houses. Very low results were recorded (with SO_2 levels often below the limits of detection), consistent with what is expected in a rural location with no significant pollution sources within the locality. The monitoring programme is ongoing at these gauges.

Dust deposition was monitored at locations near to the main Project infrastructure locations. Results demonstrate low levels of natural and potentially man-made sources of dust, distributed according to local wind patterns. Fine particulate monitoring (PM_{10} and $PM_{2.5}$) has shown a pattern of elevated PM_{10}, but low $PM_{2.5}$ concentrations. Further monitoring of PM_{10} and $PM_{2.5}$ will ensure that reliable baseline conditions are further established, prior to commencement of construction (see Appendix 8.14).

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APPENDICES

Appendix 4.5.1 Baseline Noise Levels and Noise Monitor Calibration Certificates

4.5 Noise and vibration

Baseline noise surveys were conducted over ten days in September 2012 and April 2013, and updated over seventeen days in May/June 2014 to determine baseline noise conditions at the communities of Gorayk, Ughedzor, Saralanj, Saravan, Gndevaz, Kechut and Jermuk, focussing on the residential receptors within affected communities.

4.5.1 Methodology for Noise Assessment

All measurements have been undertaken using Cirrus Research CR811C and CR821C, Type 1 integrating sound level meters. Copies of the calibration certification documentation are contained in Appendix 4.5.1. The sound level meter was mounted vertically on a tripod 1.2-1.5 m above the ground and more than 3.5 m from any other reflecting surfaces. The sound level meter was field calibrated to a reference level of 94 dB at 1 kHz with no drift in calibration noted. A-weighted L_{eq}[1] and L_{90}[2] noise levels were measured at each location covering several day and night time periods in order to obtain representative data in accordance with IFC noise guidelines.

4.5.2 Noise Baseline

Baseline noise conditions for the affected communities are shown in Table 4.5.1 and Table 4.5.2. Noise monitoring locations are shown in Figure 4.2.1, and photographs showing each monitoring position are presented in Figure 4.5.1 through Figure 4.5.7. Full monitoring results are contained in Appendix 4.5.1.

The communities of Kechut and Jermuk, to the northwest of the Project, are situated off and to the west of the H-42 public highway (see Figure 4.2.1). Jermuk is a commercial and tourist location with numerous hotels and two water bottling factories. The noise environment is quiet and rural in nature, with the main source of noise from traffic and community related activity within the built up area (see Table 4.5.1). The noise monitoring location was within a residential area to the south of the town in an area of open ground adjacent to residential apartments (see Figure 4.5.1).

[1] L_{eq} Equivalent continuous noise level; the steady sound pressure which contains an equivalent quantity of sound energy as the time-varying sound pressure levels.

[2] L_{90} The noise level which is exceeded for 90% of the measurement period (often referred to as 'background').



Figure 4.5.1: Monitoring location in Jermuk
(looking north - towards residential apartments)

Kechut, is located to the south of Jermuk and apart from the community related activities associated with the kindergarten and school, the built environment is quiet and rural (see Table 4.5.1 and Table 4.5.2). The noise monitoring location was located to the south east of the village within an area of open ground, which has a view towards the Project (see Figure 4.5.2).

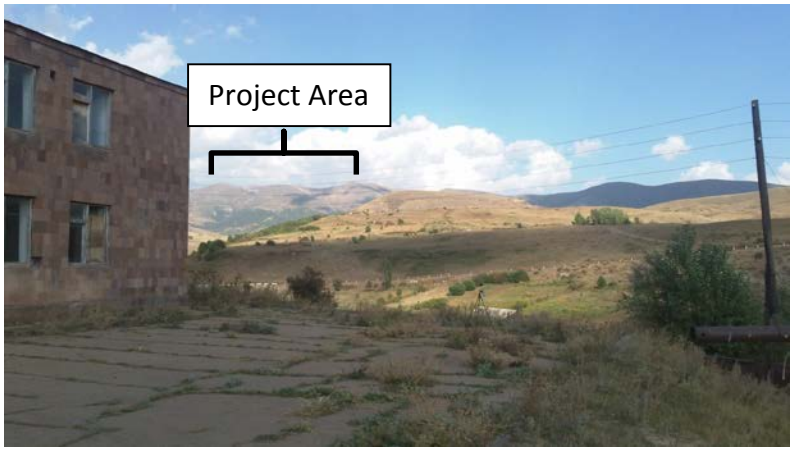


Figure 4.5.2: Monitoring location in Kechut
(looking southeast – towards Project area)

Within the villages of Gndevaz, Saravan, Saralanj and Gorayk the main occupation is agriculture with the baseline noise environment influenced by the presence of animals and the operation of agricultural machinery (tractors). Within the region, there is little evidence of remote individual farmhouses. Instead local farming families live in village houses and their garden or yard is often occupied by chickens, ducks, dogs and sometimes cattle. Baseline

noise monitoring was, therefore, undertaken in residential garden areas within these villages, as representative of residential receptors.

The village of Gndevaz is located to the west of the Project and also to the west of the H-42, with the majority of the village at a lower elevation than the road located with the Arpa River valley to the west. The noise monitoring location was to the east of the village in an orchard within a residential garden (see Figure 4.5.3). The noise environment was quiet, because the residential areas are sufficiently distant from the H-42 diminishing the influence from traffic noise (Table 4.5.1 and Table 4.5.2).



Figure 4.5.3: Monitoring Location in Gndevaz
(looking east – within a residential orchard/garden)

There is a poultry farm located on the edge of the village and to the north, off the H-42, however this is currently closed and is not a source of noise.

The villages of Saravan, Saralanj and Gorayk are all adjacent to the M-2 public highway. Saravan and Saralanj have residential areas adjacent to the M-2, with associated commercial retailers selling a range of fruit, vegetables and consumables. The monitoring location in Saravan was to the south of M-2 and the village settlement within an area of open space next to residential housing that is typical of the village (see Figure 4.5.4). The noise environment was influenced by traffic on the M-2 and agricultural operations as previously identified (see Table 4.5.1 and Table 4.5.2).



Figure 4.5.4: Monitoring location in Saravan (adjacent to residential dwelling)

The monitoring location in Saralanj was to the north of M-2 and on the edge of the village settlement with an outlook towards the Project (see Figure 4.5.5). The noise environment was similar to that experienced in Saravan, and also tends to be influenced by traffic on the M-2 and agricultural operations as previously identified (see Table 4.5.1 and Table 4.5.2).



Figure 4.5.5: Monitoring location in Saralanj

The village of Gorayk is to the north of the M-2 and set back from the road so that vehicle and pedestrian access is via a circular route through the residential part of the village. A milk factory and gas station are the only industry in Gorayk and road traffic flow is very low (see Section 4.18, for further details on the baseline traffic flow). The noise monitoring location was in the west of the village settlement, with Arshak in the background. The meter was situated within a residential plot between homes and agricultural outbuildings (see Figure 4.5.6). The photograph illustrates the agricultural activity that takes place close to the

property and this is reflected in the baseline noise environment (see Table 4.5.1 and Table 4.5.2).



Figure 4.5.6: Monitoring location in yard of house in Gorayk (Amulsar in background)

The village of Ughedzor is a settlement of houses occupied for up to 7 months of the year (May to November) by nomadic cattle herder families. The settlement is accessed via an unpaved track off the M-2 highway. Because Ughedzor is occupied on a temporary basis it has been identified as a sensitive noise receptor and the baseline noise environment has been defined in Table 4.5.1 and Table 4.5.2. Outside of summer, the settlement has virtually no sources of anthropogenic noise, except for the distant sound of occasional Heavy Goods Vehicles (HGVs) on the M-2. In summer, when occupied, the majority of residences look towards the Project. The noise monitoring location was situated in a garden area within the settlement, see Figure 4.5.7.

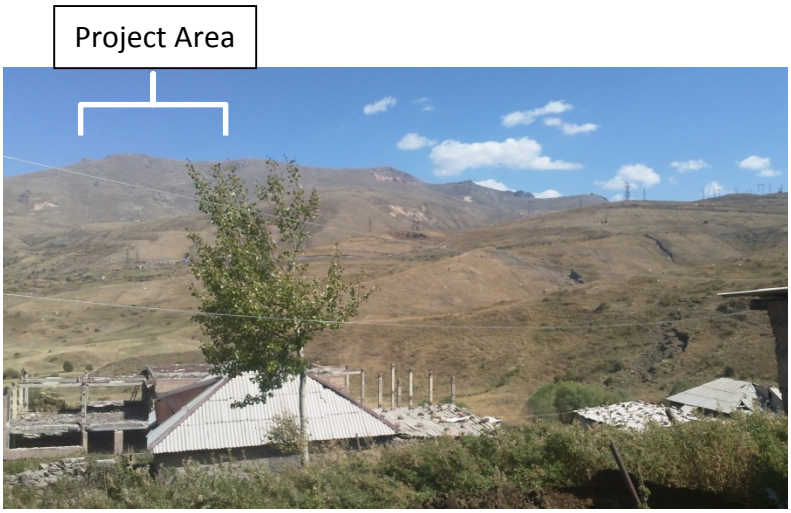


Figure 4.5.7: Monitoring location in Ughedzor (looking north-east towards Mt Amulsar)

Surveys have been carried out in Ughedzor both during periods of occupation and vacancy. The noise levels monitored at Ughedzor (when unoccupied) are considered to be representative of the wider rural area with little or no anthropogenic noise emission. The measured noise levels from Ughedzor (unoccupied) have also been used to assess potential impacts of noise on breeding birds and mammals.

Table 4.5.1: Daytime Baseline Noise Conditions

Community	Measured Noise Level LAeq (dB)	Measured Noise level LA_{90} (dB)
Kechut	43	35
Jermuk	50	38
Gndevaz	40	34
Saravan	48	36
Saralanj	49	38
Ughedzor (occupied)	46	39
Ughedzor (unoccupied)	42	30
Gorayk	47	32
Notes: Measurements made September 2012,April 2013 and May/June 2014		

Table 4.5.2: Night-time Baseline Noise Conditions		
Community	**Measured Noise level LAeq (dB)**	**Measured Noise level LA_{90} (dB)**
Kechut	36	31
Jermuk	42	35
Gndevaz	38	33
Saravan	40	34
Saralanj	43	32
Ughedzor (occupied)	47	42
Ughedzor (unoccupied)	37	28
Gorayk	38	30
Notes: Measurements made September 2012, April 2013 and May/June 2014 See Appendix 4.5.1 for the baseline data obtained for each year		

Vibration and Air Overpressure

Vibration is transmitted through the ground, particularly rock strata and can result from three main sources:

- Instantaneous events such as blasting or a seismic event;
- Some construction activities involving impacts at or within the ground, such as piling; and
- Movement of heavy goods vehicles on roads, especially if travelling at speed.

Baseline vibration monitoring is useful when significant sources of vibrations are present. At the time of the baseline data collection, there were no significant blasting or heavy construction activities in the Project area (see Figure 4.2.3). Therefore, no vibration baseline was required for the ESIA.

Summary

Several noise monitoring surveys have taken place near to residential property in the communities around the Project-affected area to establish the baseline conditions. Generally, low levels of noise were recorded during the day and night time periods; the levels are typical of the rural setting of each community, with no significant road traffic or industrial sources within the baseline conditions. In addition, there are no known, or significant sources of vibration in or near the Project-affected area.

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APPENDICES

Appendix 4.6.1 Earthquake Hazard Assessment and Seimic Parameters

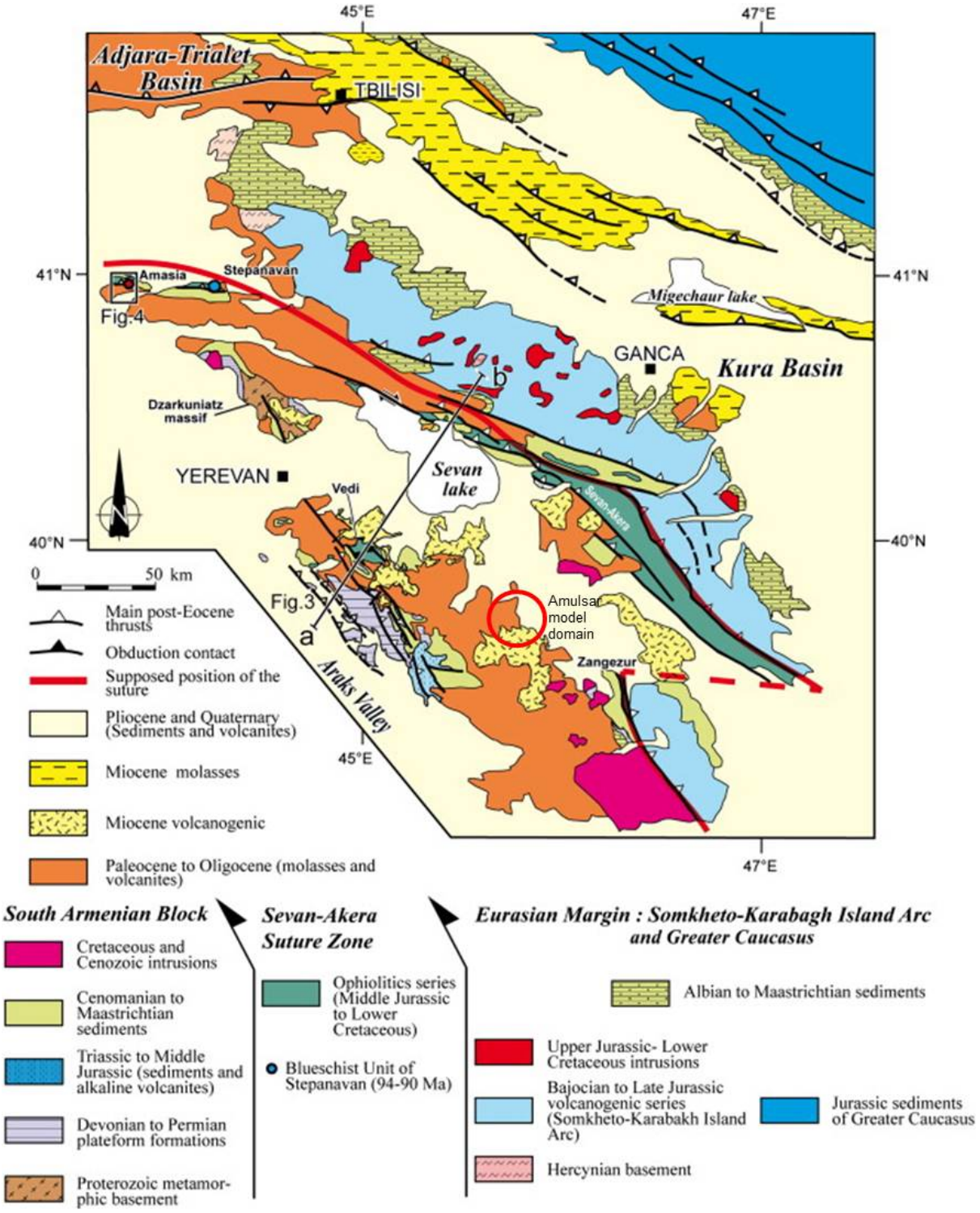
4.6 Geology and Seismicity

4.6.1 Regional Geology

The Amulsar gold and silver deposit is situated in south-central Armenia and is hosted in an Upper Eocene to Lower Oligocene calc-alkaline magmatic-arc system that extends south-west through southern Georgia into Turkey, and south-east into the Alborz-Arc of Iran. The geological structure of Armenia within the Lesser Caucasus is illustrated by Hässig et al (2013)[1] (reproduced in Figure 4.6.1). This map illustrates that at a regional scale the area to the north and east of the Amulsar Mountain project is occupied by recent (Pliocene and Quaternary) sediments and volcanites (igneous rocks and volcanogenic sediments), indicating that older units encountered in the vicinity of Amulsar Mountain do not outcrop in the Syunik Massif further eastward from the Study Area (GSA). The Project area is not within the major zones of tectonic activity in Armenia. However, geologically young basalt scoria cones within the Project area indicate that the area is geologically active.

Volcanic and volcano-sedimentary rocks of this system comprise a mixed marine and terrigenous sequence that developed as a near-shore continental arc between the southern margin of the Eurasian Plate and the northern limit of the Neo-Tethyan Ocean. In the Early Oligocene, the Neo-Tethyan Ocean closed, and subduction ceased along this margin when a fragment of continental crust, known as the Sakarya continent, collided at the trench axis and accreted with the Eurasian plate. The location of Amulsar within this arc is shown in Figure 4.6.2.

[1] Linking the NE Anatolian and Lesser Caucasus ophiolites: evidence for large-scale odbuction of oceanic crust and implications for the formation of the Lesser Caucasus-Pontides Arc. Hassig, M; Rolland, Y; Sosson, M, Galoyan, G; Sahakyan, L; Topuz, G; Celik, O; Avagyan, A and Muller, C. 2013.



(note: for ease of reading this figure has also been duplicated as Figure 4.8.1)

Figure 4.6.1: Structural map of the Lesser Caucasus

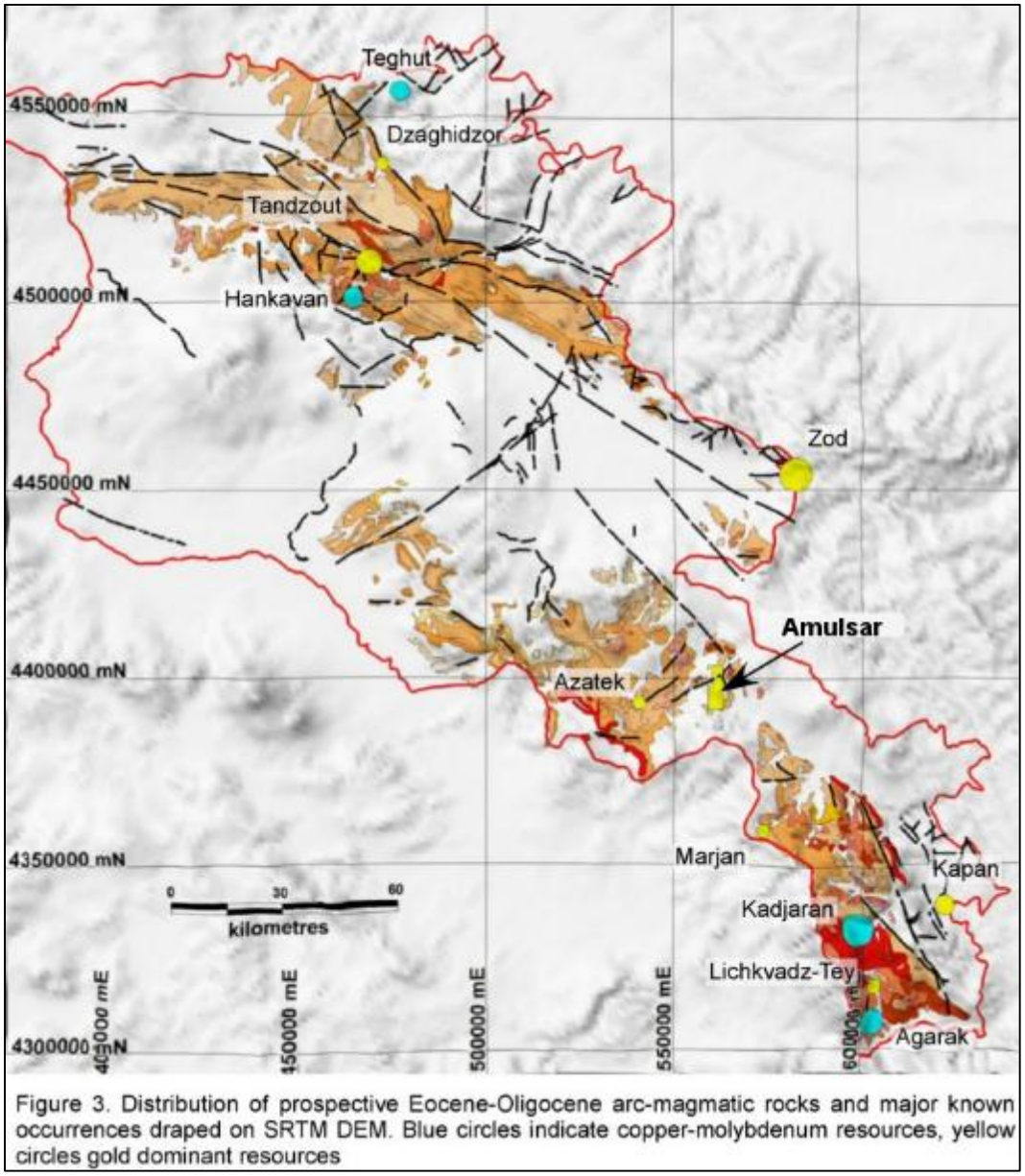


Figure 3. Distribution of prospective Eocene-Oligocene arc-magmatic rocks and major known occurrences draped on SRTM DEM. Blue circles indicate copper-molybdenum resources, yellow circles gold dominant resources

Source: *Lydian, 2013*

Figure 4.6.2: Regional Geology, Upper Eocene to Lower Oligocene Calc-Alkaline Magmatic Arc System

4.6.2 Local Geology

The geological model of Amulsar is based on a division of the geological sequence into two units:

- The Amulsar Mountain upper volcano-sedimentary sequence – "Upper Volcanics" (VC) comprising weakly bedded volcanogenic feldspathic quartzite interbedded with abundant thin and thick lenticular masses and flow masses, andesitic volcanic flows

and volcanic breccia which are strongly silicified throughout, with strong alunite alteration.

- The Amulsar Mountain lower volcano-sedimentary sequence – "Lower Volcanics" (LV), at higher altitudes this unit comprises predominantly pervasively argillically altered porphyritic andesite, most likely dominantly sub-volcanic intrusives (Lydian et al, 2013)[3]. However, it also incorporates the regional Palaogene volcano-sedimentary sequence described above, in which volcanic and volcaniclastic units are only sparsely interspersed lower in the stratigraphy.

The Upper Volcanics outcrop on Amulsar Mountain and on the eastern mountain flank. The Lower Volcanics outcrop to the west of the mountain and occur underlying other units at lower elevations surrounding the mountain. The Lower Volcanics are extremely thick, outcropping from high elevations on the west of Amulsar Mountain (above 2700 m asl) to below 1400 m asl in the gorge of the Arpa River, indicating a total thickness of more than 1300 m.

At lower elevations to the east and west of Amulsar Mountain ridge, and covering the northern face of the ridge, unaltered Cenozoic Flow Basalts overlie the Palaeogene volcano-sedimentary and intrusive rocks forming plateaus along the banks of the Vorotan River and Arpa River gorges.

The Amulsar deposit lies within a thick package of Paleogene volcano-sedimentary rocks. Locally, these rocks flanking Amulsar consist of multiple fining-upward cycles of volcanogenic conglomerate and mass flow breccia fining-upward to volcanogenic and marly mudstones to thin calcilutite limestone. Andesitic to dacitic volcanic and volcaniclastic units are sparsely interspersed low in the stratigraphy, but increase in frequency as higher stratigraphic levels are exposed on the flanks of the Amulsar ridge. Strata peripheral to the deposit are sub-horizontal to gently dipping, with little internal structure except where cut by steep faults.

The Amulsar deposit is hosted within the Amulsar Ridge; the ridge trends north-northeast for about 5 km and rises to a height of 1,000 m from the surrounding land (see Figure 4.6.3). The ridge is a geologically anomalous feature comprising volcano-sedimentary rocks that while broadly similar to lower structural elevations contains a larger component of lenticular mass flow deposits. The Amulsar deposit is associated with a complex alteration system and a

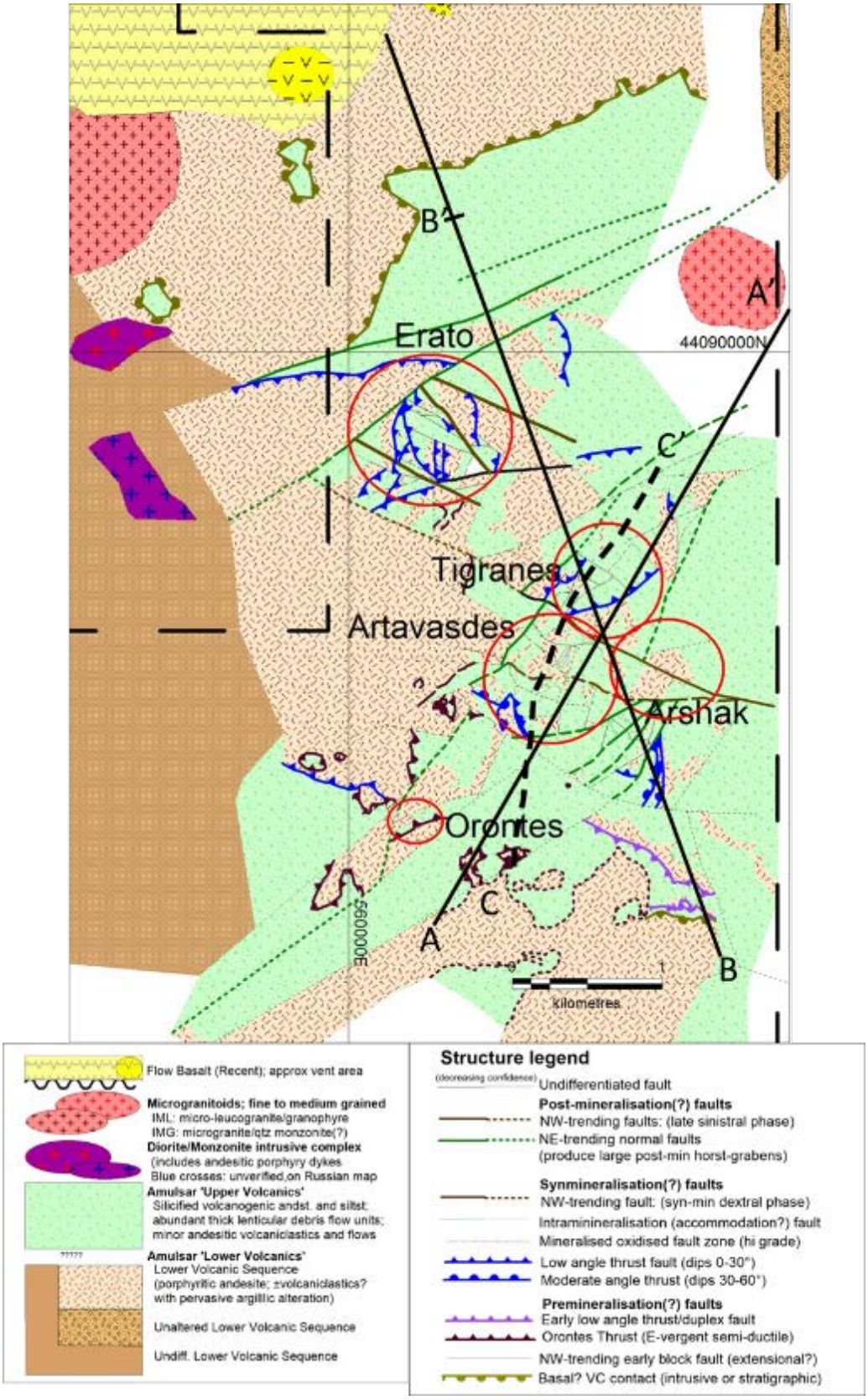
structural complexity that has not been observed in this sub-region. Flanking the deposit is an anomalous cluster of small plutonic and subvolcanic intrusives.

The main rock units recognized by Lydian at the Amulsar project are summarised below (see also Figure 4.6.3 and cross sections on Figure 4.6.4

Upper Volcanics (VC). Sparsely bedded volcanogenic conglomerate, feldspathic sandstone and minor siltstone are interbedded with abundant thin and thick lenticular mass wasting (debris flow) units; minor andesitic flow volcanics and volcanogenic/volcaniclastic breccia. Debris flow units are dominated by pebble and cobble breccia with sparse large boulder components. Significantly, clasts in some of the mass-flow breccias appear to have been silicified prior to deposition. Examples of representative lithologies for VC are provided in Figure 4.6.5

Lower Volcanics (LV). Strong argillic alteration strongly masks the protolith of these rocks, but the dominant rock type is a feldspar-porphyritic andesite, generally without any flow alignment or other flow characteristics. Some rocks contain hornblende phenocrysts. These rocks are most likely subvolcanic intrusives. Locally they contain silicic volcanic fragments or possible xenoliths. Minor pebble to cobble fragmental rocks and indeterminate rock types also occur, as well as minor feldspar-amphibole porphyritic andesite and a single reported occurrence in drill core of amphibole-magnetite andesite. Examples of representative lithologies for LV are provided in Figure 4.6.5

Local intrusive suites. Two different intrusive suites occur within or adjacent to the licence area: small, radiometrically above background, fresh-looking silicic plutons (micro-leucogranite; quartz monzonite); and an extensive suite of slightly altered, quartz-poor, intermediate plutons and subvolcanic dykes (diorite, monzonite porphyritic andesite) that are characteristically magnetite-bearing. The latter are in contact only with argillically altered rocks of the Lower Volcanics; whereas one of the fresh silicic plutons is surrounded by Upper Volcanics. Some of the dykes have similar porphyritic textures to the clay-altered intrusive andesite within the Upper Volcanics, although any connection has not been established.



Source: *Lydian, 2013*

Note: Cross-section lines shown on map

Figure 4.6.3: Geological Map of Amulsar Project

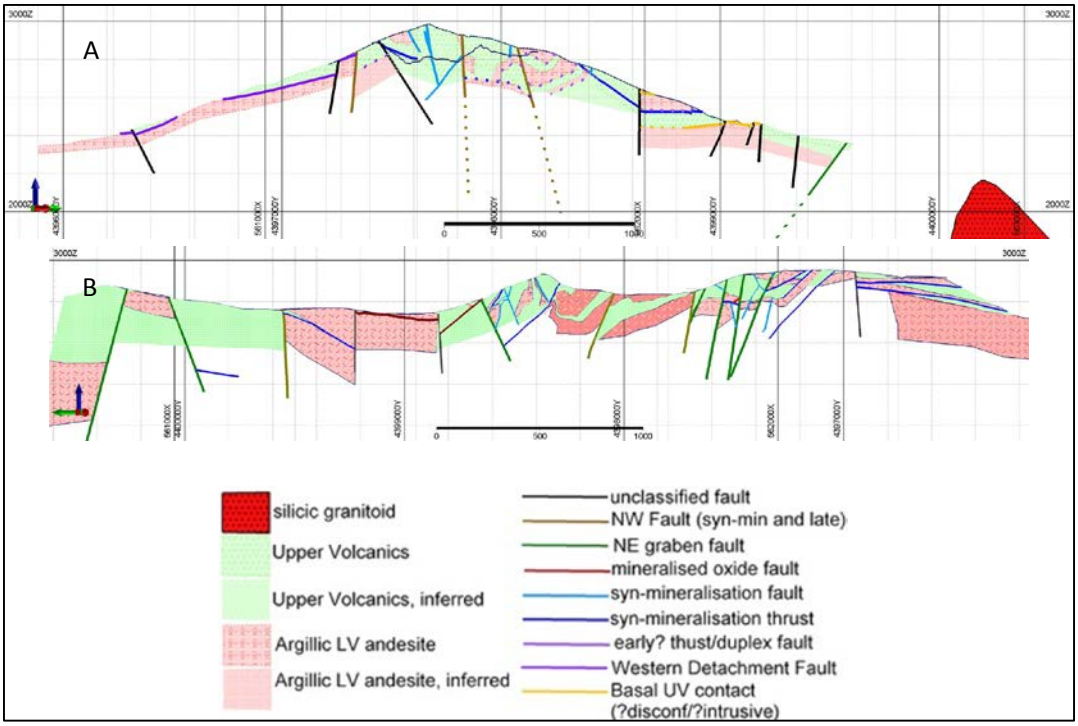
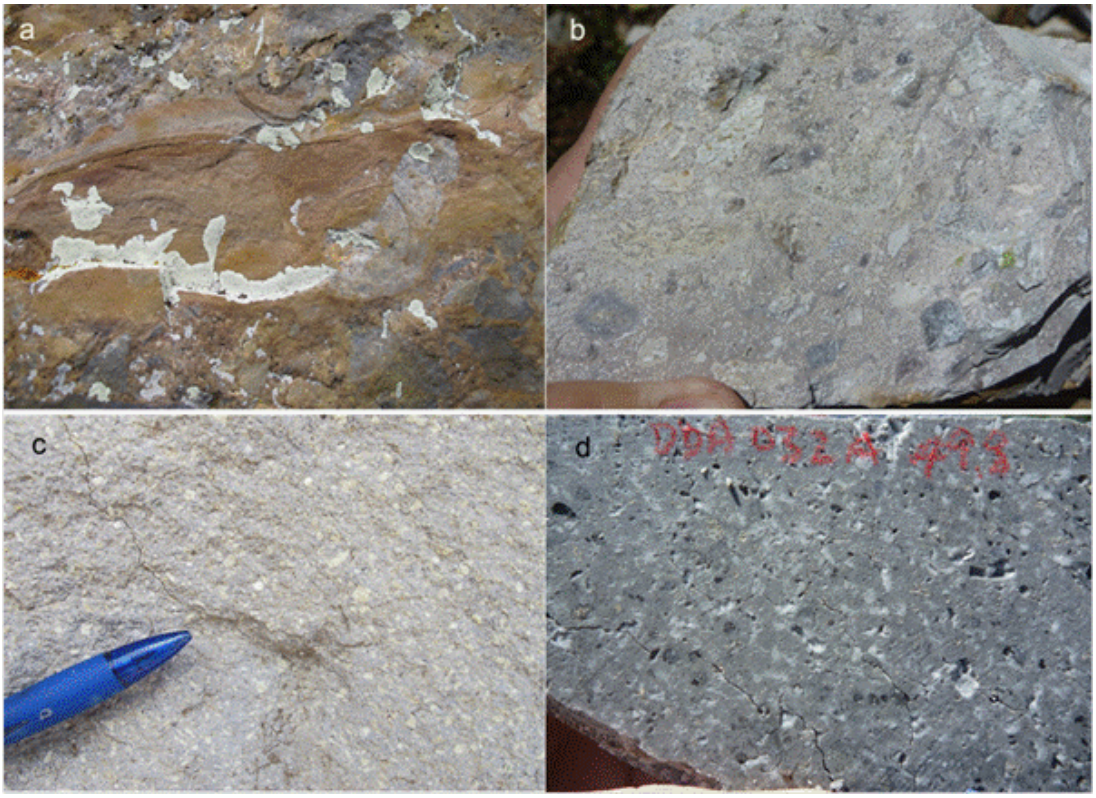


Figure 4.6.4: Amulsar Geological Cross-sections A-A' and B-B'

Alteration

The LV unit is characterized by pervasive argillic alteration in the region of the resource. However, this alteration reduces toward the periphery of the licence area. The argillic alteration is commonly void of gold mineralisation, other than at a contact with the VC unit, or occasionally where through-going faults crosscut the LV unit. In both cases, a marked increase in iron-oxide and weak silicification can also be observed. Alteration within the VC unit is predominantly massive silica or silica-alunite, forming the main host to gold mineralisation. The pervasive argillic alteration of the Lower Sequence appears to be cut by the disconformity, which implies that the two alteration styles are unrelated in time.



Source*: Lydian, 2014.*
a. VC unit, polymictic conglomerate fining upwards to laminated sandstone with small basal loading structures in the overlying conglomerate, west Artavazdes. **b.** VC unit, polymictic matrix supported breccia (primary or volcaniclastic), north Tigranes. **c.** LV unit, strongly altered feldspar-phyric andesite, west Artavazdes. **d.** LV unit, moderately altered feldspar-hornblende porphyritic andesite from core sample, Artavazdes.

Figure 4.6.5: Representative Rock Types of the Amulsar Deposit

Structure

Within the confines of the Amulsar Ridge a structural complexity exists whereby dips become steep and overturned. At least four different sets of structure (shears, folds, and faults) produce the final geometry, with increasingly brittle response in the younger structures. Thick slabs of Lower Volcanics arch into an antiform, before a transition across faults into the highly complex central folded zone. Within the complex zone, the andesitic slabs are more numerous and thinner. The overall pattern appears to be a footwall synform possibly below a southeast-vergent thrust. The formation of the multiple thin panels in the complex zone is that they may be the result of duplexing during this major thrust event. Although mineralization occurs within the complex zone in the core of this large apparent fold structure, it is the further complexity produced by the refolding of an already folded structure that creates the final host structure. Gold mineralization is intimately associated with the variably oriented accommodation faults and the large volume of fractured mineralized rock that links them. These fractures are small-scale accommodation structures that allow local deformation associated with the folding.

Mineralisation

Gold mineralisation at Amulsar is thought to have been a late event in the development of the deposit, occurring dominantly within the silica-alunite-altered volcano-sedimentary breccia units of the VC unit. Mineralisation is also associated with iron oxide-coated fracture surfaces, and heavily oxidized faults that cut the silica-alunite alteration. Based on a structural study of the deposit by Holcombe (2013)[2], gold mineralisation is believed to be associated with iron oxide coatings, fillings, and hydraulic breccias in late stage brittle fractures and faults within a thrust and fold complex.

Three dominant controls of mineralisation have been identified to include the following:

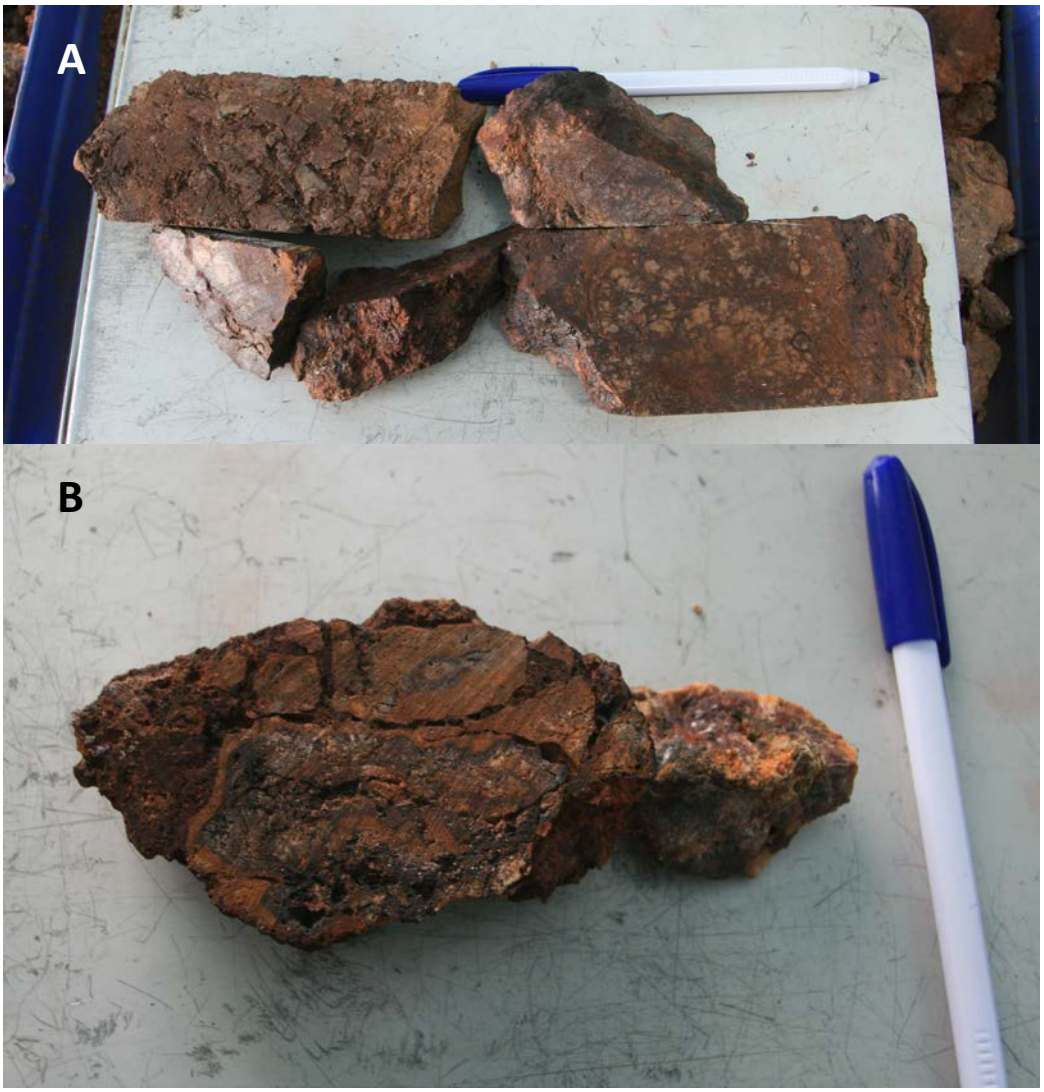
- Faults and fractures acting as conduits for mineralizing fluids, resulting in gold mineralisation as gossanous veins that form broad corridors of closely-spaced high-grade structures;
- Porous and permeable lithological units, including hydrothermal breccias, volcaniclastic breccias, leached vuggy volcanics – allowing lateral migration of fluids away from structurally controlled conduits; and
- Relatively impermeable argillic altered LV rocks formed an impermeable boundary along contact zones with VC rocks, causing 'ponding' of higher-grade gold mineralisation along contacts, often forming as leached or gossanous zones.

Examples of gold mineralisation in the drill core are shown in Figure 4.6.6

Silver mineralisation is also present at Amulsar, but the genesis and distribution of it is not well understood. Silver mineralisation does not correlate with gold mineralisation. Average silver grades range from 2 g/t to 5 g/t and locally can occur in the 100 g/t to 200 g/t range.

A small silver mining project adjoins the Amulsar licence to the north-west, exploiting a structurally controlled argentiferous galena vein. This deposit is located at a lower stratigraphic level than the Amulsar deposit.

[2] Holcombe, R., 2013. Amulsar 3D Geological Model Revision: Summary and Resource Implications November 2013



Notes:
A: Brecciated VC unit, highly altered, strong iron oxidization, 96.1 to 96.5 m, 96.0-97.0 at 5.67 g/t Au.
B: Brecciated VC unit, highly altered, strong iron oxidization, 97.0 to 97.1 m, 97.0-98.0 at 13.7 g/t Au.

Figure 4.6.6: Examples of Gold Mineralisation in Core Samples, Drill hole DDA-047

Ore Mineralogy

The mineralogy of the ore bearing silicified Upper Volcanic unit is very simple, predominantly composed of quartz (typically 60-98%). Fractures and vesicles are infilled with goethite, limonite and haematite and it is within this oxide infill that the gold mineralization occurs. Minor/trace amounts of potassium-feldspar, rutile, chlorite, mica, alunite and jarosite have also be found within the unit.

The gold mineralization modelled at Amulsar is associated with oxide fracture fills and the ore that has been evaluated in the current resource model is oxide in its natural state. Table 4.6.1

illustrates a set of typical ore whole rock analyses conducted by Kappes Cassidy Associates (KCA) from the 2012 Amulsar metallurgy testwork programme.

Table 4.6.1: Whole rock analysis of ore composites (KCA 2012)

Constituent	Unit	KCA Composite No. 61768 DDAM-130	KCA Composite No. 61769 DDAM-137	KCA Composite No. 61770 DDAM-140	KCA Composite No. 61771 DDAM-148	KCA Composite No. 61772 DDAM-169	KCA Composite No. 61773 DDAM-174
SiO2	%	80.59	85.41	84.52	93.74	91.3	68.4
Si	%	37.68	39.93	39.51	43.82	42.68	31.98
Al2O3	%	3.33	1.38	0.92	0.8	0.93	8.96
Al	%	1.76	0.73	0.49	0.42	0.49	4.74
Fe2O3	%	8.53	8.91	10.1	2.59	4.65	8.83
Fe	%	5.97	6.23	7.06	1.81	3.25	6.17
CaO	%	0.05	0.03	0.03	0.02	0.02	0.1
Ca	%	0.04	0.02	0.02	0.01	0.01	0.07
MgO	%	0.04	0.01	0.02	0.02	0.02	0.05
Mg	%	0.02	0.01	0.01	0.01	0.01	0.03
Na2O	%	0.12	0.09	0.06	0.05	0.04	0.37
Na	%	0.09	0.07	0.04	0.04	0.03	0.27
K2O	%	0.62	0.19	0.09	0.08	0.07	1.33
K	%	0.51	0.16	0.07	0.07	0.06	1.1
TiO2	%	1.46	1.31	1.28	1.43	1.21	1.18
Ti	%	0.88	0.79	0.77	0.86	0.73	0.71
MnO	%	<0.01	<0.01	<0.01	0.01	0.02	0
Mn	%	0	0	0	0	0	0
SrO	%	0.03	0.01	<0.01	<0.01	<0.01	0.07
Sr	%	0.03	0.01	0	0	0	0.06
BaO	%	0.04	0.01	0.09	0.02	0.01	0.1
Ba	%	0.04	0.01	0.08	0.02	0.01	0.09
Cr2O3	%	0.02	0.01	0.02	0.02	0.02	0.02
Cr	%	0.01	0.01	0.01	0.01	0.01	0.01
P2O5	%	0.1	0.02	0.02	0.01	0.02	0.21
P	%	0.04	0.01	0.01	0	0.01	0.09
LOI1090°C	%	4.9	2.47	2.46	1.09	1.66	10.22
SUM	%	99.83	99.85	99.61	99.88	99.97	99.84

Barren Rock Mineralogy

There are three potential streams of Barren Rock that have been identified in the Mining Schedule (see also Figure 4.6.3 and Figure 4.6.4; these are Upper Volcanics that do not meet cut-off grade, Lower Volcanics and Colluvium. The three different waste materials have been subjected to a mineralogical evaluation based on x-ray diffraction (XRD) and microscopy (GRE, 2014). Based on this analysis, the summary of the mineralogy is as follows:

- **Lower Volcanics** - In ten LV samples, quartz is present in all samples in amounts ranging from 20 to 77 percent, plagioclase is present in two samples at 8 and 66 percent, pyrite in five samples ranging from trace to 24 percent, alunite in four samples at 6 to 53 percent, natroalunite in a single sample at 45 percent, jarosite in two samples ranging from trace to 10 percent, goethite in a single sample at 2 percent, hematite in four samples ranging from trace to 9 percent, sericite/illite in four samples ranging from trace to 30 percent, illite/smectite in two samples with values of 3 and 5 percent, smectite in a single sample at 1 percent, adularia in two samples with values of 2 and 3 percent, and chalcopyrite, iron oxide, rutile, and gold in varying numbers of samples at trace levels.
- **Upper Volcanics** - In seven VC samples, quartz is present in all samples in amounts ranging from 27 to 99 percent, feldspars are absent from all samples, pyrite is present in four samples at trace levels, alunite in three samples at 9 to 70 percent, jarosite in two samples at trace and 10 percent, goethite in a single sample at 15 percent, hematite in five samples ranging from 1 to 10 percent, hematite/goethite in one sample at 3 percent, adularia in three samples ranging from 1 to 5 percent, rutile in six samples ranging from trace to 2 percent, and chalcopyrite and iron oxide in a small number of samples at trace levels.
- **Colluvium** - In three colluvium samples, quartz is present in all samples in amounts ranging from 57 to 88 percent, feldspars are absent, pyrite is present in all samples at trace levels, chalcopyrite is present in two samples at trace levels, alunite in two samples at trace and 30 percent, jarosite in one sample at 2 percent, hematite in three samples at 3, 3, and 8 percent, adularia in three samples at 1, 2, and 3 percent, kaolinite in two samples at 7 and 30 percent, rutile in three samples all at 1 percent, and gold in two samples at trace levels.

Table 4.6.2 and Table 4.6.3 illustrate the X-Ray Diffraction results for 21 samples of barren rock[3].

Table 4.6.2: X-Ray Diffraction (XRD) and Petrography Tigranes/Artavasdes Barren Rock Samples (GRE 2014)

Mineral	Chemical Formula	Lower Volcanics						Upper		
		ARD	ARD	ARD	ARD	ARD	ARD	ARD	ARD	ARD
Plagioclase	NaAlSi3O8 – CaAl2Si2O8	--	--	66	--	--	--	--	--	--
Quartz	SiO2	46	55	20	35	49	75	86	99	27
Alunite	KAl3(SO4)2(OH)6	--	--	--	53	--	21	9	--	70
Natroalunite	NaAl3(SO4)2(OH)6	--	45	--	--	--	--	--	--	--
Goethite	FeOOH	--	--	--	--	--	--	--	--	--
Hematite	Fe2O3	--	--	--	trace	--	3	3	--	--
Hematite/Geo	FeOOH - Fe2O3	--	--	--	--	--	--	--	--	3
Iron Oxide	FeO	--	trace	1	--	--	--	--	trace	--
Rutile	TiO2	4	trace	<1	trace	--	1	2	trace	--
Pyrite	FeS2	10	--	8	--	10	--	--	--	--
Sericite/Illite	K0.5-1(Al,Fe,Mg)2(SiAl)4O10(OH)2 nH2O - (K,H3O)(Al,Mg,Fe)2(Si,Al)4O10[(OH)2,(H2O)]	17	<1	4	--	30	--	--	--	--
Kaolinite	Al2Si2O5(OH)4	23	--	--	12	11	--	--	--	--
Smectite	(Na,Ca)(Al,Mg)6(Si4010)3(OH)6-nH20	--	--	1	--	--	--	--	--	--

[3] Amulsar Project geochemical characterisation and prediction report – update (GRE, 2014)

Table 4.6.3: X-Ray Diffraction (XRD) and Petrography Erato Barren Rock Samples (GRE 2014)													
Mineral	**Chemical Formula**	**Lower Volcanics**					**Upper Volcanics**				**Colluvium**		
		BR-SMA-	**VC-SV-**	**LV-ARGC-**	**LV-ARGC-**	**LV-ARGC-**	**BR-SM-**	**BR-SMV-**	**VC-SA-**	**LV-SA-**	**COL-SM-**	**COL-SA-**	**COL-UN-**
Plagioclase	NaAlSi3O8 – CaAl2Si2O8	--	--	8	--	--	--	--	--	--	--	--	--
K-Feldspar	KAlSi3O8	--	--	--	--	--	--	--	--	--	--	--	--
Quartz	SiO2	77	65	53	45	65	40	97	89	53	63	57	88
Alunite	KAl3(SO4)2(OH)6	17	6	--	--	--	22	--	--	--	30	--	Trace
Natroalunite	NaAl3(SO4)2(OH)6	--	--	--	--	--	--	--	--	--	--	--	--
Goethite	FeOOH	2	--	--	--	--	--	--	--	15	--	--	--
Hematite	Fe2O3	2	6	--	--	9	8	1	5	10	3	8	3
Hematite/Geo	FeOOH - Fe2O3	--	--	--	--	--	--	--	--	--	--	--	--
Iron Oxide	FeO	--	--	--	--	--	--	--	--	--	--	--	--
Rutile	TiO2	Trace	--	1	1	1	Trace	Trace	1	1	1	1	1
Pyrite	FeS2	Trace	--	Trace	24	--	Trace	Trace	Trace	Trace	Trace	Trace	Trace
Chalcopyrite	CuFeS2	Trace	--	--	--	--	--	--	Trace	Trace	Trace	--	Trace
Pyrrhotite	FeS	--	--	--	--	--	--	--	--	--	--	--	--
Gold	Au	--	--	Trace	--	--	--	--	--	--	Trace	Trace	--
Sericite/Illite	K0.5-												
	(K,H3O)(Al,Mg,Fe)2(Si,Al)4O10[(	--	--	--	--	25	--	--	--	--	--	--	--
Kaolinite	Al2Si2O5(OH)4	--	20	25	25	--	30	--	--	10	--	30	7
Adularia	KAlSi3O8	2	3	--	--	--	--	2	5	1	3	2	1
Jarosite	KFe3(OH)6(SO4)2	Trace	--	10	--	--	Trace	--	--	10	--	2	--
Illite/Smectite	(K,H3O)(Al,Mg,Fe)2(Si,Al)4O10[(	--	--	3	5	--	--	--	--	--	--	--	--
Smectite	(Na,Ca)(Al,Mg)6(Si4010)3(OH)6-	--	--	--	--	--	--	--	--	--	--	--	--

The VC is non-acid-generating (NAG) even though some samples contain trace pyrite and the majority of the samples are devoid of neutralization potential. Leachate from VC rocks does not pose a material water quality risk. Therefore, the rock can be safely used as an aggregate for construction, drainage, or to from the "shell" to construct encapsulation cell. The high degree of silicification gives this rock resistance to chemical and mechanical weathering.

The LV barren rock is potentially acid-generating (PAG). However, there is a wide range of sulphide concentrations in the LV, and many LV samples do not produce moderate to severe acidic leachate (defined as a cell with leachate with pH<4.0 and sulphate concentrations >100 mg/L) despite long-term humidity cell testing. The Amulsar LV barren rock has resistance to the formation of ferric iron oxidation conditions even when placed in a humidity cell. On-site kinetics, as exhibited at the historic mine waste piles, suggests that ferric iron oxidation has not taken place despite decades of reaction time.

Metals leaching occurs in strongly acidic conditions (which, as previously identified, are rare in this rock type).

Overall, the Amulsar LV formation would be acid-generating and there is the risk that exposed rock has the potential to degrade water quality by suppressing pH, and by possessing elevated sulphate, iron, copper, selenium, or manganese concentrations.

Schedule of NAG and PAG waste

For the life of the Project, it is envisaged that 60% of the barren rock excavated will be non-acid generating (NAG) Upper Volcanics and colluvium, with 40% being potentially acid generating (PAG) Lower Volcanics. Based on the current Amulsar lithology model, barren rock types were defined in the mining schedule by lithology. The volumes of expected NAG and PAG barren rock are shown by mining period in Table 4.6.4.

Table 4.6.4 In-Situ Volumes of Waste Type by Mining Period			
	Colluvium	**NAG Barren Rock (VC)**	**PAG Barren Rock (LV)**
Period	000's t	000's t	000's t
Year -1	26	699	259
Year 1	175	11,035	7,930
Year 2	373	16,214	7,246
Year 3	291	17,397	10,420
Year 4	438	12,381	11,027
Year 5	399	18,085	8,440
Year 6	18	18,980	2,733
Year 7	273	12,361	11,631
Year 8	318	15,453	17,304
Year 9	0	10,935	12,895
Year 10	0	2,714	635
Total	**2,311**	**136,253**	**90,521**

The NAG/PAG barren rock schedule has been taken into account with the detailed scheduling of encapsulation in the BRSF[4].

Location of Project ancillary infrastructure (see Figure 4.6.7)

Crusher and maintenance

The area selected for the location of the crusher building and associated ramps and connecting conveyors is situated within basaltic lave flow units. There are no potentially mineralised units within the construction footprint required for ore crushing operations. It should be noted that the location of the BRSF also does not host any potentially mineralised units.

HLF and associated infrastructure

The HLF is located at a lower elevation than the open pits and is connected by overland conveyor from the crushing plant. The footprint of the HLF is located on bedrock consisting of an unaltered andesitic volcaniclastic unit. The proposed ADR plant is also located on the andesite unit. Cores removed from the boreholes have been sampled for sterilisation

[4] Ibid. 3, p4.6.13

assessment. This analysis has confirmed that the mineralised units of the Amulsar deposit do not extend into this area.

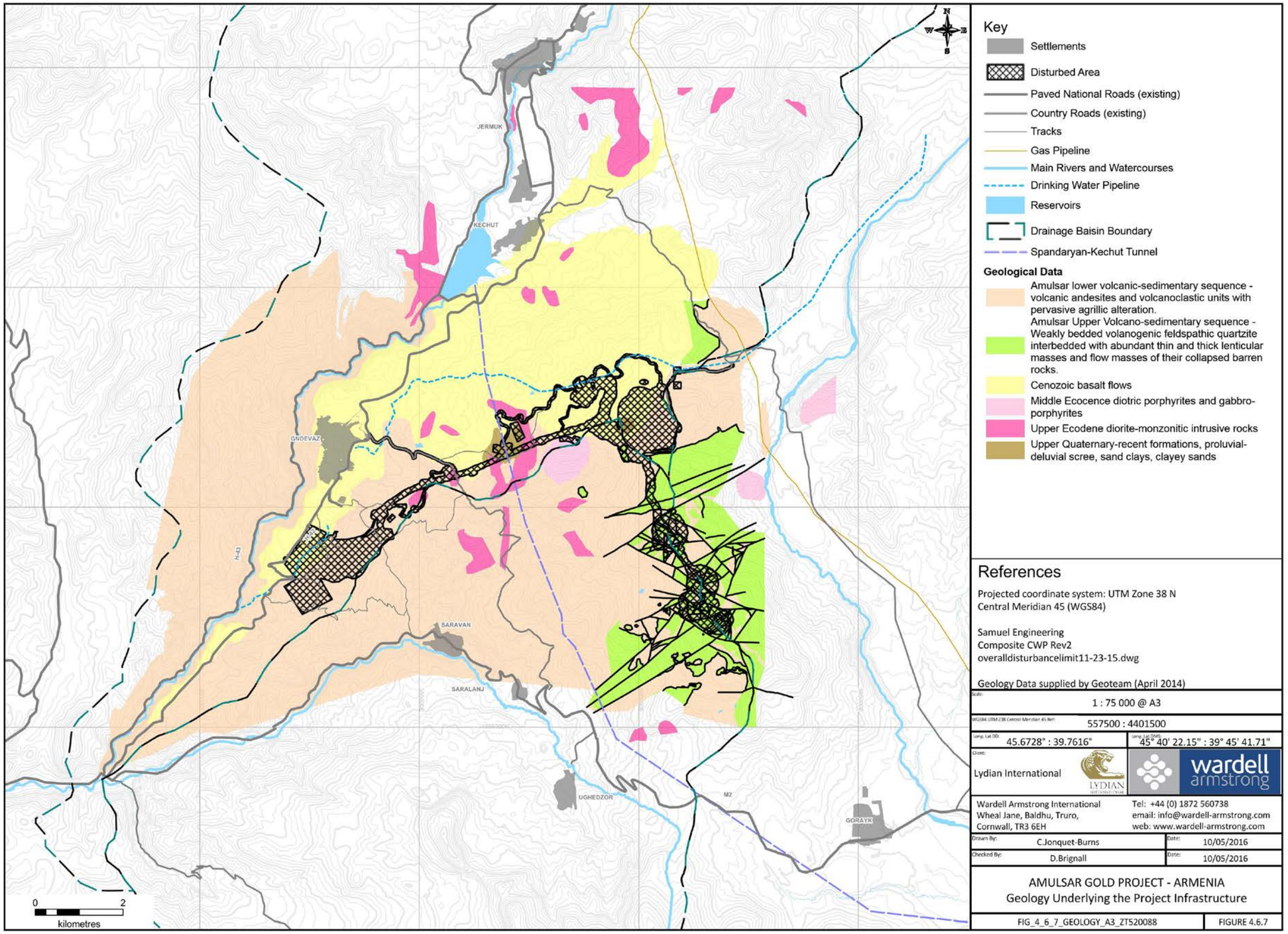


Figure 4.6.7: Geology Underlying the Project Infrastructure

4.6.3 Superficial Deposits

The Project and surrounds was glaciated during the Quaternary. Soils are generally absent at high elevations and are poorly developed on lower mountain slopes. Significant superficial deposits (2m to 10m) are limited to sheltered landforms and lower elevations of the Project and are largely comprised of clay, gravelly clay and clayey gravel with occasional cobbles to boulders of basalt.

Substantial clay deposits are present in the licence area. Widespread clays are thought to be derived from the breakdown of underlying fractured andesite. Localised clay deposits are also found, for example within glacial landforms. These may be lacustrine in origin, forming after volcanic events and flows dammed surface water channels. These clays, such as those beneath the proposed BRSF, are green in colour, indicative of high volcanic ash content. Gravelly clays of up to 15 m thickness were encountered at the centre of the BRSF.

Alluvium (clay, sandy clay and sand) underlies river catchment areas, including the eastern edge of the BRSF, to a depth of approximately 13 m. Bedrock exposures are evident in the Vorotan River; however, alluvial deposits in the Vorotan valley have been confirmed to approximately 8 m below ground level (bgl). Clayey basalt gravels are present up to 26 m bgl in the Vorotan plain. In summary superficial glacial and river flood deposits of up to 30 m thickness underlying the Vorotan plateau in the licence area.

4.6.4 Tectonics and Seismicity

The Project licence is located within a seismically active region of the Arabia-Eurasia plate boundary zone. This plate boundary is a continent-continent collision zone, and studies undertaken by Golder Associates (see Appendix 4.6.1) have shown that there are 17 fault zones with a total of 53 fault segments within approximately 250km of the project site.

Golder's field investigations and review of available literature and satellite imagery found no geomorphic evidence for the trace(s) of faults or other tectonic geomorphology within the Project area, including the proposed sites of the BRSF, HLF, crushing plant, or open pit. There is thus a very low potential for surface fault rupture within the Project.

The Medvedev-Sponheuer-Karnik (MSK) intensity scale widely used in the Former Soviet Union (FSU) is somewhat similar to the Modified Mercalli (MM) scale used today in the United States. Historical records show that there have been 107 relatively well-documented, strongly

felt earthquakes in the RA that have occurred from 600 B.C to 2003[5], the latter is the date of the last, intense earthquake in the RA. Historical records suggest that in the last 900 years the site has experienced strong to very strong (MSK VI to VII) perceivable shaking at least 3 times. Such perceivable shaking can cause Light to Moderate potential damage[6]. Historic earthquakes and seismic sources in relation to the Project are demonstrated in Figure 4.6.8

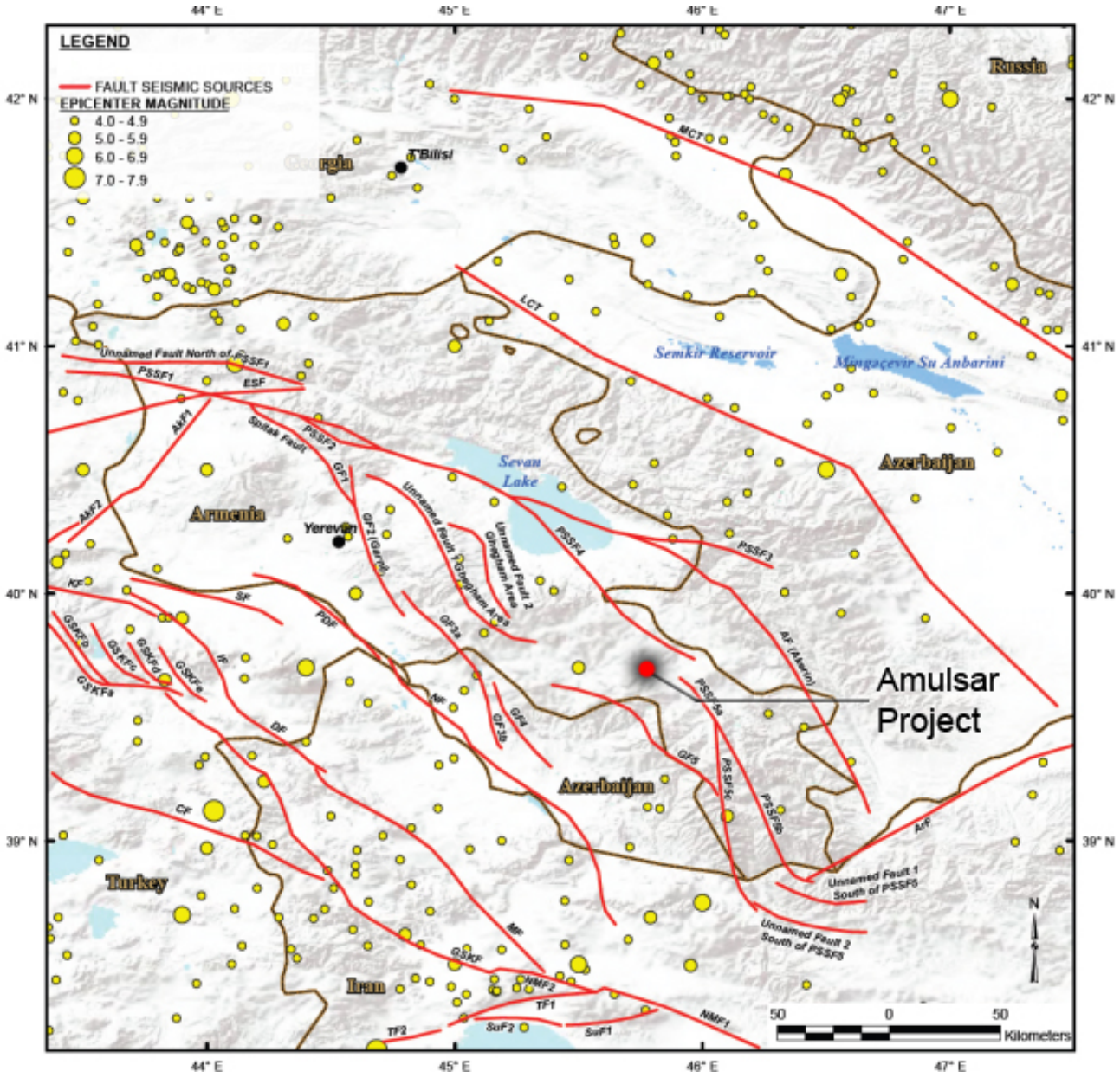


Figure 4.6.8: Historic Earthquakes and Fault Seismic Sources[6]

[5] Babayan, T., 2006, Atlas of strong earthquakes of the Republic of Armenia, Artsakh and adjacent territories from Ancient Time to 2003, National Academy of the Sciences republic of Armenia. 139pp

[6] http://earthquake.usgs.gov/earthquakes/shakemap/global/shake/b0008649/download/tvguide.txt

The 'Pambak-Sevan-Sunik fault Segment 4' (Figure 4.6.8) is located approximately 10km north of the Project licence, and has been calculated to have an average horizontal slip rate of 1.55mm/yr. Based on a seismo-tectonic model it was calculated that the estimated maximum magnitude earthquake from this fault segment would be in the region of M 7.2 (M is the moment magnitude scale, which is essentially the equivalent on the Richter Magnitude Scale).

A probabilistic seismic hazard analysis (PSHA) was conducted for the Project site. PSHA estimates the likelihood that the specified earthquake ground motions will be exceeded during a specified time. The likelihood of being exceeded is determined based on the probability of occurrence of all earthquakes at different locations on each significant seismic source, and the rate at which ground motions attenuate away from the earthquake source.

The PSHA assumed a 10% probability of occurrence over a 50-year time period, which results in the prediction of the effective probability of an event with a 475-year return period[7]. A moderate level of seismic hazard (475-year peak ground acceleration value (PGA)[8] of 0.20 to 0.34 g) has been assigned to the licence area based on the PSHA.

4.6.5 Acid Rock Drainage Characterisation

The characterization of the Acid Rock Drainage (ARD) properties of the Amulsar site was first reported by Golder Associates (see Appendix 8.19). This report has been fully-updated by GRE3 to include the results of additional geochemical testing, and to report predictive modelling associated with the up-to-date mine planning and ARD mitigation measures (see ARD Management Plan). The following sections present a summary of the revised geochemical characterization results.

Static testing of Mine Waste

Static testing defines the ARD-generation and metals leaching potential of a given rock type. The following static geochemical testing was performed on the rock types at the Amulsar Project.

[7] http://www.irmi.com/expert/articles/2003/gould07.aspx
[8] Global Seismic Hazard Assessment Programme (1999), http://www.seismo.ethz.ch/static/GSHAP/

Table 4.6.1: Static Geochemical Testing Program						
Material Type	**ABA**	**NAG pH Testing**	**Bulk Chemistry**	**Mineralogy**	**SPLP Effluent Testing**	**NAG Effluent Testing**
Barren Rock - Tigranes/ Artavazdes	154	-	97	8	8	8
Barren Rock - Erato	80	50	42	12	9	12
Spent ore - Tigranes/ Artavazdes	6	-	-	-	6	-
Spent ore - Erato	7	7	7	-	7	7
Borrow materials	5	5	5	-	5	5

Where:

- ABA: Acid Base Accounting by Modified Sobek
- NAG pH: Net Acid Generating pH test
- Bulk Chemistry: mineral composition by ICP-MS whole rock analysis
- Mineralology: Mineralogy evaluation via XRF followed by mineralogical analysis.
- SPLP effluent: Synthetic Precipitation Leaching Procedure
- NAG Effluent: Testing of the NAG pH effluent.

The characterization of rock types revealed the following:

- The VC is non-acid generating, despite the existence of trace AP;
- The VC has leachate slightly lower than circumneutral, likely due to the weathering of alunite. The weathering of alunite is not significant to water quality due to the very slow reaction kinetics and low total acidity produced;
- The LV is acid generating, but appears to be resistant to ferric iron oxidation under field conditions;
- Colluvium is not acid generating; and
- There is potential for metals leaching for copper, iron, manganese, selenium, and sulphate.

4.7.1 Acid-Base Accounting: Barren Rock

Acid Base Accounting (ABA) is a method by which the total potential for acid generation for a rock sample is compared to the total neutralization potential. It is an industry-standard method for determining the potential for acid generation in a rock type. Table 4.6.6 has a summary of the results of ABA testing for the Tigranes/Artavazdes Barren Rock and Table 4.6.7 shows the ABA summary for Erato Barren Rock.

Table 4.6.2: ABA Summary Tigranes/Artavazdes Barren Rock							
Barren Rock	**Statistics**	**Paste pH**	**AP**	**NP**	**Total S**	**Sulfide S**	**Sulfate S**
			$TCaCO_3$/kT	**$TCaCO_3$/kT**	**%**	**%**	**%**
Lower Volcanics	Mean	4.86	40.94	0.26	2.51	1.31	0.36
	Std. Dev.	1.07	60.00	1.67	2.57	1.92	0.55
Upper Volcanics	Mean	5.54	4.30	0.14	0.76	0.14	0.11
	Std. Dev.	0.70	21.39	0.85	1.40	0.68	0.20
Colluvium	Mean	5.79	0.87	0.20	1.07	0.03	0.13
	Std. Dev.	0.84	1.02	0.41	1.27	0.03	0.11

Table 4.6.3: ABA Summary - Erato Barren Rock								
Barren Rock	**Statistics**	**Paste pH**	**AP**	**NP**	**NAG pH**	**Total S**	**Sulfide S**	**Sulfate S**
			TCaCO3/kT	**TCaCO3/kT**		**%**	**%**	**%**
Lower Volcanics	Mean	5.00	27.44	0.38	4.28	2.16	0.88	0.38
	Std. Dev.	1.04	49.26	0.96	1.12	2.23	1.58	0.60
Upper Volcanics	Mean	5.30	5.48	0.27	4.72	0.83	0.18	0.11
	Std. Dev.	0.60	24.62	0.85	0.50	1.43	0.79	0.15
Colluvium	Mean	5.75	5.33	1.08	4.92	1.69	0.17	0.20
	Std. Dev.	0.19	11.19	0.86	0.15	2.42	0.36	0.28

Table 4.6.6 and Table 4.6.7 identify that the LV formation has the highest potential for ARD generation with an average sulphide sulphur content of 1.3% for the Tigranes and Artavazdes ore body, and 2.1% for the Erato ore body. The Upper Volcanics have some trace sulphides, but its oxidized nature and low total sulphide concentration (around 0.15%) make it so the low AGP of the VC does not realize itself as ARD (see Section 4.6.16) The colluvium, a low-volume waste type, does not have significant acid generating potential.

Table 4.6.8 shows the typical guidelines for determining which samples have ARD potential based on the ABA results.

Table 4.6.4: Screening Guidelines for Acid Generation Potential Prediction		
Material Designation:	**Comparative Criteria**	
	NNP ($TCaCO_3$/kT)	**NPR**
Potentially Acid-Generating (PAG)	< -20	< 1
Uncertain	-20 < NNP < 20	1 < NPR < 2
Non Potentially Acid Generating (NAG)	> 20	> 2
Reference: (INAP, 2009)		

The NNP is total NP minus total AP. The NPR is the ratio of NP to AP. Figure 4.6.9 shows the results of the screening criteria in graphical format.

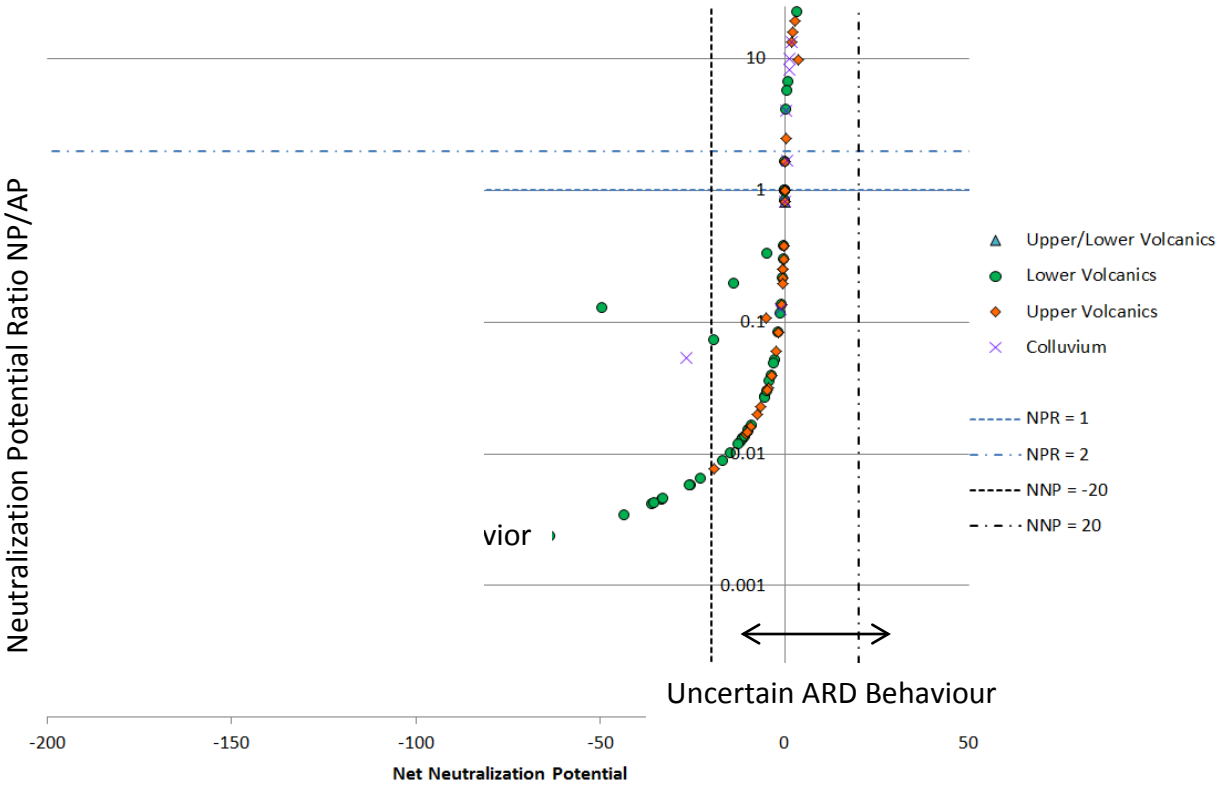


Figure 4.6.1: NNP vs. NPR for Tigranes/Artavazdes and Erato Barren Rock

As demonstrated in Figure 4.6.9, all of the Upper Volcanics samples fall within the "uncertain" range. This signifies that kinetic testing is required to determine if these samples have ARD generation potential. Despite the fact that good portion of the LV samples also fall in the uncertain range, the ABA testing confirms that the LV is an acid-generating rock type.

4.7.2 Acid-Base Accounting: Spent Ore

The spent ore is also a mine waste product and has the potential to produce ARD. The Project conducted ABA tests on spent ore from the Tigranes/Artavazdes pit and the Erato pit (see Table 4.6.9 and Table 4.6.10).

Table 4.6.5: ABA Results - Tigranes/Artavazdes Spent Ore (includes one Erato sample)					
Sample	**Total Sulfur**	**Acid Soluble Sulfate**	**Sulfide Sulfur**	**AP**	**NP**
	%	**%S**	**%**	**T $CaCO_3$/kT**	**T $CaCO_3$/kT**
MPF	0.04	0.02	0.02	0.63	3.06
GSN	0.58	0.05	0.53	16.50	4.31
FG	0.37	0.06	0.31	9.59	2.69
SB	0.38	0.04	0.34	10.66	2.31
MC068[1,2]	1.15	0.03	1.13	35.16	1.37
MC070[1]	0.70	0.05	0.65	20.22	2.50
MC071[1]	0.38	0.01	0.37	11.63	0.69
Notes: 1. Composite sample 2. Erato sample					

Table 4.6.6: ABA Results - Erato Spent Ore					
Sample	**Total Sulphur**	**Acid Soluble Sulphate**	**Sulfide Sulphur**	**AP**	**NP**
	%	**%S**	**%**	**T $CaCO_3$/kT**	**T $CaCO_3$/kT**
DDA-030	0.95	0.24	<0.01	0.31	0.30
DDA-030	0.14	0.11	<0.01	0.31	0.30
DDA-278	0.74	0.20	0.10	3.13	0.30
DDA-276	1.75	0.32	0.09	2.81	0.30
DDA-290	0.00	0.02	<0.01	0.31	0.30
DDA-340	0.53	0.24	<0.01	0.31	0.30

Based on the generally low sulphide sulphur levels, the 100% VC composition of the spent heap, and the abundant residual alkalinity present within the heap leach, it was determined that the spent ore is not an ARD risk.

4.7.3 Acid-Base Accounting: Borrow Materials

Four LV samples and one scoria sample were submitted for geochemical characterization to assess their suitability as potential site borrow materials. Table 4.6.11 provides a summary of the results of the borrow materials testing.

Table 4.6.7: ABA results for Borrow Materials						
Sample ID	**Lithology**	**NNP**	**NPR**	**Sulphide Sulphur (%)**	**NAG pH**	**Paste pH**
BH-305	LV	-0.10	0.83	0.02	5.44	6.65
BH-303	LV	-36.30	0.01	1.16	2.34	4.36
BH-307	LV	1.90	2.73	0.03	5.54	5.54
BH-308	LV	-31.90	0.01	1.02	4.89	5.63
BH-312	Scoria	18.00	60.00	0.01	5.92	8.59

Results indicate that LV should not be used as construction materials due to an ARD and metal leaching potential, unless other mitigation measures are implemented. Scoria, however, appears suitable, although additional characterization work is recommended, as only one sample was included in the testing programme. Some in-pit waste materials are also suitable as construction material. The Upper Volcanics and Colluvium lithologic groups contain geochemically suitable construction

4.7.4 Metals Leaching Potential Summary

An estimate of potential metal leaching behaviour of Amulsar barren rock has been summarised in Table 4.6.12.

Table 4.6.8: SPLP Leaching Summary - Tigranes/Artavazdes and Erato Barren Rock				
Parameter	**Units**	**Arpa Type II Standards**	**Tig/Art SPLP Results (avg)**	**Erato SPLP Results (avg)**
Ammonia as N	mg/L	0.4	0.102	0.172
Arsenic	mg/L	0.02	0.011	0.0007
Barium	mg/L	0.028	**0.027**	**0.073**
Biochemical Oxygen Demand	mg/L		2	2
Cadmium	mg/L	0.001	**0.002**	0.0007
Chemical Oxygen Demand	mg/L		8.2	5.489
Chromium	mg/L	0.011	0.006	0.002
Copper	mg/L	0.021	0.19	**1.837**
Cyanide (total)	mg/L		0.01	0.01
Cyanide (free)	mg/L		0.005	0.01
Cyanide (WAD)	mg/L		0.01	0.01
Final Fluid pH	pH units		5.953	5.25
Hexavalent Chromium	mg/L		0.012	0.012
Iron	mg/L	0.072	**3.423**	**3.002**
Lead	mg/L	0.0101	0.008	0.0005
Manganese	mg/L	0.012	**0.04**	**0.025**

Table 4.6.8: SPLP Leaching Summary - Tigranes/Artavazdes and Erato Barren Rock				
Parameter	**Units**	**Arpa Type II Standards**	**Tig/Art SPLP Results (avg)**	**Erato SPLP Results (avg)**
Mercury	mg/L		0.0002	0.000045
Nickel	mg/L	0.0103	**0.019**	**0.012**
Nitrate/Nitrite as N	mg/L		0.182	0.159
Orthophosphate as P	mg/L		0.01	0.01
Selenium	mg/L	0.02	**0.04**	0.0004
Sulphate as SO4	mg/L		28.273	35.938
Total Suspended Solids	mg/L	6.8		5
Zinc	mg/L	0.1	0.071	0.047

The Net Acid Generating (NAG) effluent test is a test of the effluent from the full oxidation of the sample using hydrogen peroxide. This analysis represents the worst-case for metals leaching potential using aggressive oxidation conditions (see Table 4.6.13).

Table 4.6.9: NAG Effluent Summary - Tigranes/Artavazdes and Erato Barren Rock				
Parameter	**Units**	**Arpa Type II Standards**	**Tig/Art NAG Results (avg)**	**Erato NAG Results (avg)**
Arsenic	mg/L	0.02	0.003	0.001
Barium	mg/L	0.028	**0.045**	**0.109**
Boron	mg/L		0.04	0.003
Cadmium	mg/L	0.001	**0.003**	0.0008
Chloride	mg/L	6.88	0.578	1.162
Chromium	mg/L	0.011	**0.042**	**0.021**
Copper	mg/L	0.021	**0.272**	**0.453**
Iron	mg/L	0.072	**55.144**	**9.251**
Lead	mg/L	0.0101	0.003	0.0009
Manganese	mg/L	0.012	**0.129**	**0.058**
NAG pH	pH units		3.728	4.342
Nickel	mg/L	0.0103	**0.059**	**0.011**
Selenium	mg/L	0.02	**0.049**	0.007
Sulfate as SO_4	mg/L		379.003	83.273
Zinc	mg/L	0.1	0.087	0.015

The analysis demonstrates that there is potential for metals leaching for barium, copper, iron, manganese, nickel, selenium, and sulphate. Chromium and cadmium were only found in trace amounts in the NAG effluent test, and were excluded from concern.

4.7.5 Kinetic Geochemical Testing

Long-term humidity cell geochemical kinetic tests were performed on Amulsar barren rock[9]. This test produces an over-estimate of the acid generation potential and metals leaching potential of a rock over time due to the following issues:

- The cells are held at a constant temperature of 20°F;
- The cells are kept at 100% humidity for a week, then flushed with 1L of distilled and deionized water; and
- The cells require a ¼ inch crush size, far smaller than in Run of Mine (ROM) waste.

Despite these limitations, long-duration kinetic cell tests provide a laboratory conditions to determine the ARD behaviour of rock types. It is generally accepted that a year of kinetic cell testing can prove beyond reasonable doubt that a rock sample will or will not generate acid. The test is a logical extension of the static testing because it demonstrates empirically whether the potential determined in the ABA testing will be reached in site conditions.

4.7.6 ARD Geochemical Reaction Kinetics

The kinetics of an ARD reaction are critical in defining the environmental impacts. Two different chemical reactions typically form ARD from the oxidation of pyrite.

Equation 1 involves the oxidation of pyrite in the presence of water:

$$FeS_2 + 7/2O_2 + H_2O = Fe^{2+} + 2SO_4^{2-} + 2H^+ \text{ [1] } ^{10} \text{ (INAP, 2009)}$$

This reaction commonly occurs at the Amulsar site. However, in the kinetic cells, a second reaction dominated the ARD behaviour of some cells later in the testing period. This equation involves the oxidation of pyrite by ferric iron (Fe3+). This reaction is much faster, and has a higher stoichiometric ratio between pyrite and acidity (listed as H+), Equation 2:

$$FeS_2 + 14Fe^{3}+ + 8H_2O = 15Fe^{2}+ + 2SO_4^{2}- + 16H^+ \text{ [2]}^{10} \text{ (INAP, 2009)}$$

[9] ASTM D5744-07e1. (2007). Standard Test Method for Laboratory Weathering of Solid Materials Using a Humidity Cell. *American Society for Testing and Materials*

[10] Global Acid Rock Drainage Guide. *International Network on Acid Prevention* INAP. (2009).

The reaction is catalyzed by the bacteria *Thiobacillus ferroxidans*. In subsequent sections, the changeover from ARD dominated by Equation 1 to ARD dominated by Equation 2 is referred to as: "ferric iron oxidation" because ferric iron is acting as a reactant in the oxidation of pyrite.

4.7.7 Humidity Cell Results

Figure 4.6.10 shows the pH of the kinetic cell rinsate over time, Figure 4.6.11 shows sulphate production over time, and Figure 4.6.12 shows iron production over time.

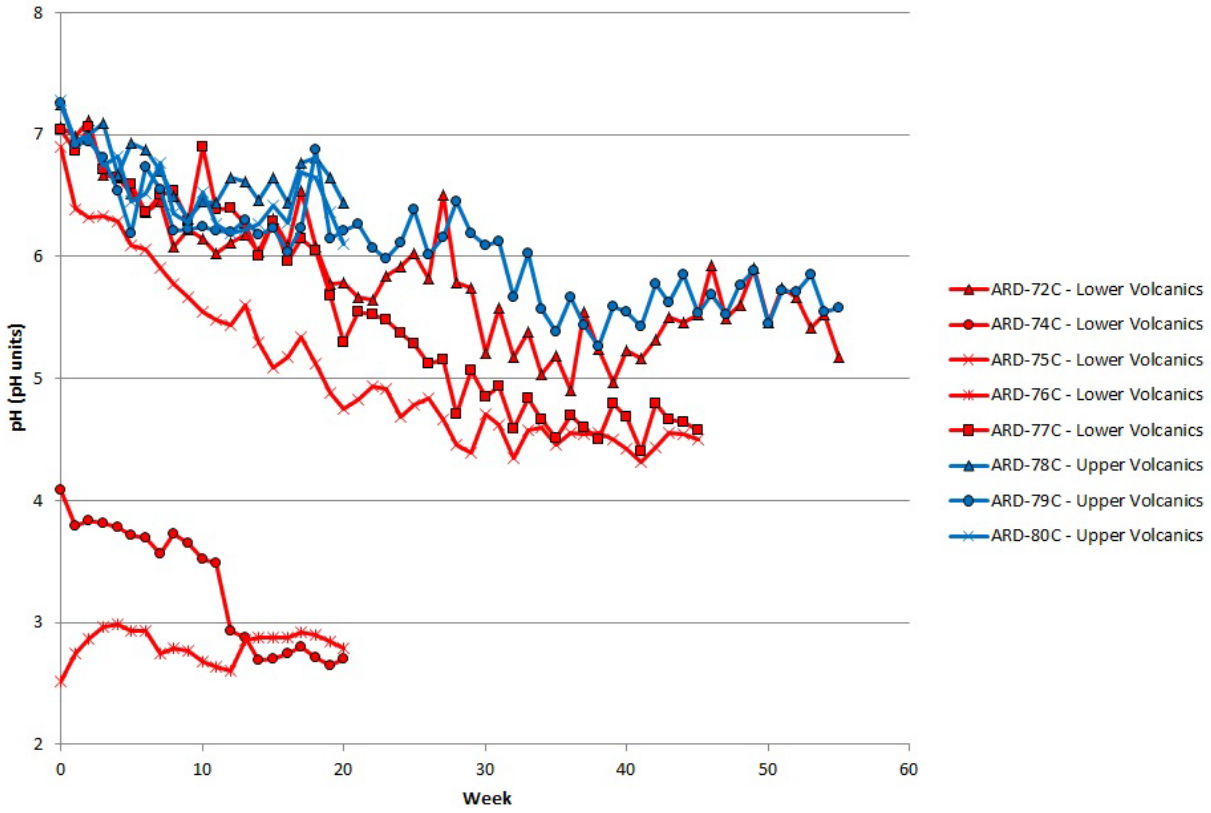


Figure 4.6.2: pH vs. Time in Kinetic Cell Tests

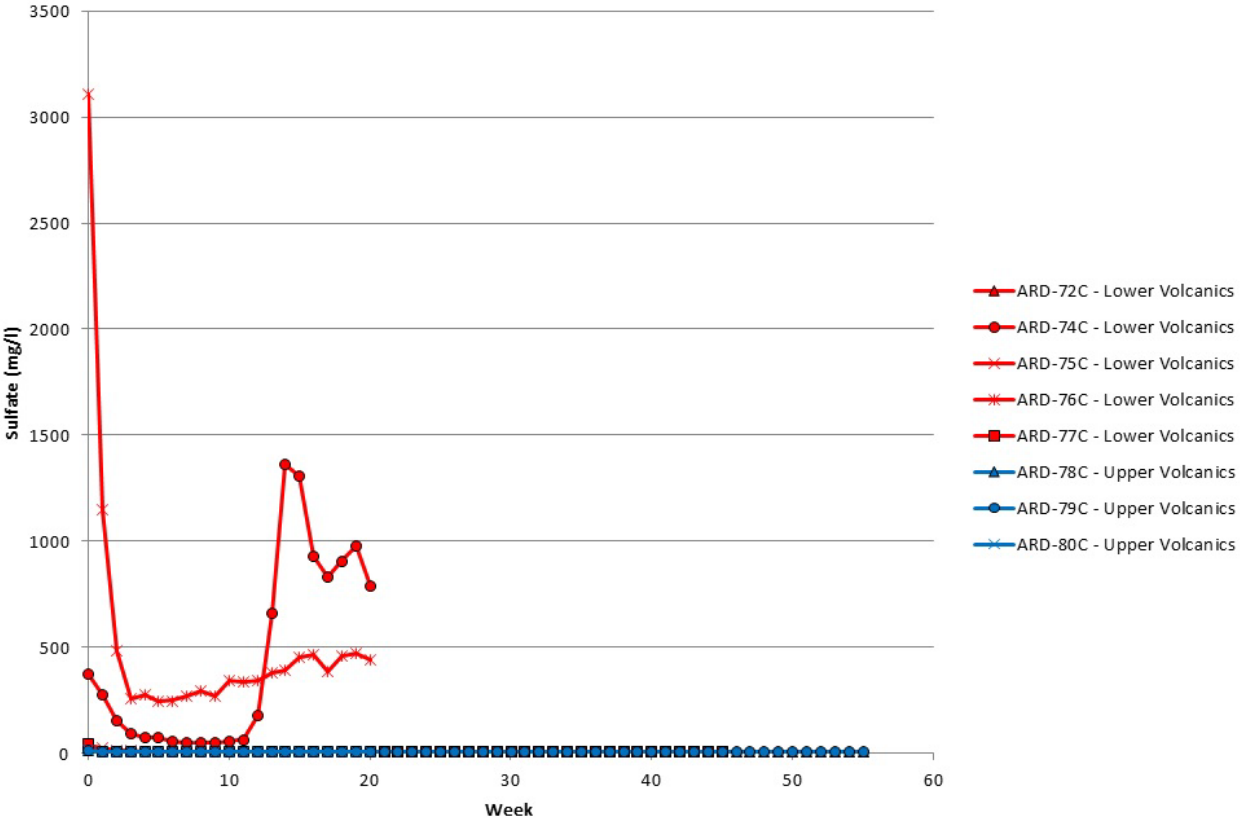


Figure 4.6.3: Sulphate vs. Time in Kinetic Cell Tests

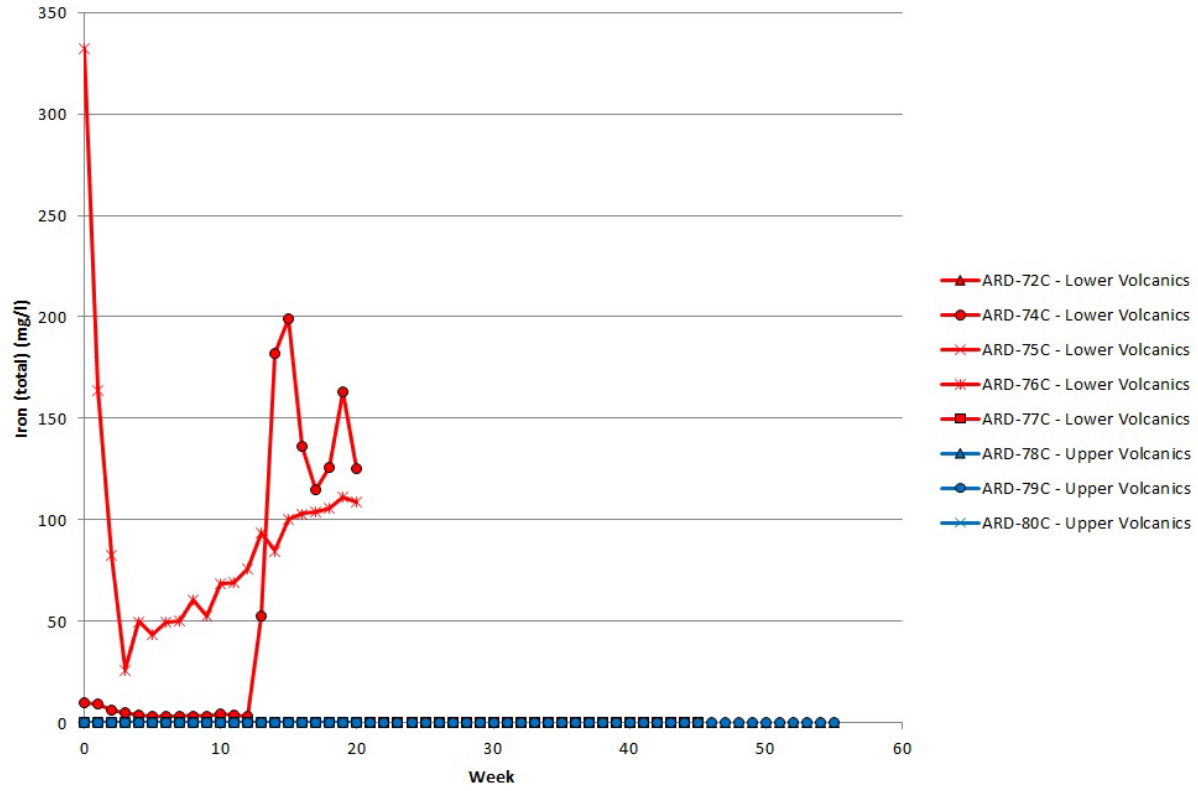


Figure 4.6.4: Iron vs. Time in Kinetic Cell Tests

It is clear from Figure 4.6.10 through Figure 4.6.11 that the ARD potential of the VC does not translate into ARD generation despite the "uncertain" nature of the ABA testing ("uncertain" as defined the analysis in Table 4.6.8). It is also clear that three of the five LV samples generate no significant sulphate or iron in the humidity cell rinsate (the symbols are obscured behind the VC line in Figure 4.6.11 and Figure 4.6.12).

The kinetic testing results reveal three different categories of LV samples tested.

- Samples that were oxidized prior to testing;
- A sample that converted to ferric iron oxidation; and
- Samples resistant to ferric iron oxidation.

These samples are discussed below.

4.7.8 Oxidized LV Samples

ARD-76C was heavily oxidized prior to arriving at the lab. This sample shows the worst-case potential of Amulsar waste, but has little value in determining reaction kinetics.

4.7.9 Sample ARD-74C

ARD 74C is the most useful sample in the sample dataset. For the first 12 weeks of the test, the cell oxidizes in the presence of oxidation (see Equation 1).

After 12 weeks, ferric iron oxidation begins and the rinsate has reduced pH, increased sulphate concentrations, and increased iron concentrations (Equation 2).

4.7.10 LV Samples Resistant to Ferric Iron Oxidation

Three of the five LV kinetic cells showed strong resistance to the formation of ferric iron oxidized ARD. These samples produce consistently mild (pH greater than 4.5) ARD with low sulphate and iron concentrations despite long-duration testing.

4.7.11 Observed Geochemistry

Two mine waste piles are already present within the Project footprint. They are within two of the sites studied for alternatives (see Chapter 5) and known as Site 27 and Site 13 (see Appendices 5.2 and 5.3). These rock piles result from uranium exploration undertaken in the 1950s. The waste piles are made of LV rock and show similar geologic and geochemical

characteristics to the mine waste from the Amulsar pits including sulphidisation, argillization, and occasional silicification. These rock produce ARD; however, the severity of ARD produced can be classified as moderate to mild. It has a water quality signature similar to LV samples that have not undergone ferric iron oxidation (see Section 4.6.11). Samples of the Site 13 and Site 27 mine waste were collected and analyzed. The results, when compared to the total population of LV, are shown in Table 4.6.14.

This updated table counts detection level results as zero for the LV calculations.

Table 4.6.10: Site 13 and 27 Mine Waste ABA Compared with Amulsar Pits

Barren Rock	Sample Count	Statistics	AP	NP
			T/KT	
LV	57	Average	37.44	0.29
		Median	5.60	0.00
		St. Dev.	57.58	1.52
		Range	0 to 204	0 to 14.18
Sites 13 and 27	4	Average	10.62	-0.75
		Median	7.34	-0.95
		St. Dev.	8.70	0.50
		Range	4.37 to 23.43	-1.1 to 0

The average from the LV dataset in the pit is higher, and the median is lower than the Site 13 and Site 27 mine waste. The rock from this exploration programme is not significantly different from LV samples recovered from the footprint of the Tigranes, Artavazdes and Erato pits despite the fact that the rock has been exposed to air and has been subject to oxidation for sixty years.

It is considered, therefore that the exposed rock is relevant to the geochemical study for the Project, and can be considered a long-term on-site kinetic cell test that can inform the conceptual model and management plan.

Table 4.6.15 shows the leachate water quality from the exposed rock in Sites 13 and Site 27.

Table 4.6.11: Site 13 and 27 Mine Waste Leachate, May 2014							
Constituent	**Unit**	**WK 10**	**WK 14**	**SPLP**	**Exposed rock stockpiles Waste**		**Site 13 Baseline Surface Water**
		ARD 74C			**Site 13**	**Site 27**	
pH	pH units	3.52	2.69	4.64	4.78	3.28	6.38
Acidity	mg/L as $CaCO_3$	59	1210	N.S.	15.10	102.00	<D.L.
Sulfate	mg/L	59	1360	46	12.60	43.70	35.70

This leachate water quality has a higher pH, lower sulphate, and lower total acidity than what was observed in the later weeks of the ARD 74C humidity cell test (see Figure 4.6.10 to Figure 4.6.12). It is clear that after 60 years, the waste in the pile has not shifted over into ferric iron oxidation dominated ARD reaction kinetics.

As a result, the waste rock shows that the LV rock has some natural suppression agent that prevents the formation of ferric iron oxidation. The suppression could be any or all of the below:

- *Thiobacillius ferrooxidans* has a much slower sulphide reaction rate in cold climates[11];
- The exposed rock argillic texture (with approximately 10% clay content) inhibits the flow of oxygen within the pile, and therefore, oxidation; and/or
- The LV mineral has some residual natural resistance to ferric iron oxidation that is only overcome in the extraordinary conditions of a long-term humidity cell test.

This natural resistance is a critical to the characterization of Amulsar barren rock and the design of the BRSF (see Appendix 3.1)

[11] Weathering of Waste Rock in Different Cimatic Condtions -- A Kinetic Freeze/Thaw and Humidity Cell Experiment. Sartz, L. (2011). *International Mine Water Association Congress.* Aachen, Germany: IMWA

4.7.12 Summary of Characterization

The characterization of mine waste reveals the following:

- The VC is non-acid generating, despite the existence of trace AP;
- The VC has leachate slightly lower than circumneutral, likely due to the weathering of alunite. The weathering of alunite is not significant to water quality due to the very slow reaction kinetics and low total acidity produced[12];
- The LV is acid generating, but appears to be resistant to ferric iron oxidation under field conditions;
- Colluvium is not acid generating; and
- There is potential for metals leaching for copper, iron, manganese, selenium, and sulphate.

Further details of the test work and test results are provided in Appendix 8.19.

Summary

Extensive geological exploration has been undertaken at the Amulsar Project. The Amulsar deposit is associated with a complex alteration system and a structural complexity that has not been observed in this sub-region, and forms part of the Amulsar Ridge – a geologically anomalous feature within the wider geological context. The main rock types include Upper Volcanics, Lower Volcanics, and two different local intrusive suites.

The Project is in a seismically active region, but there is no geomorphic evidence for traces of faults or other tectonic geomorphology within the footprint of the Project. Thus there is low risk of a surface fault rupture within the Project area.

Various rock types at the Project have potential to generate acid rock drainage. The main potential sources are due to water coming into contact with exposed Lower Volcanics.

[12] *Summary of Geochemical Charaterization and Water Quality Prediction -- Revised: Amulsar Gold Project.* GRE. (2014). Denver, Colorado: Global Resource Engineering

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APPENDICES

Appendix 4.7.1 Soil Reports 2013 & 2014

Appendix 4.7.2 Soil Geochem Data

4.7 Soils and Land Cover

The baseline has been generated using published information relating to the soil and land cover study area (SLC study area) supplemented by field surveys. This information has been used to characterise the land use, pedology, soil quality and quantity that would be influenced by the Project. The published information has been supplemented by:

- Soil mapping of the Project study area, compiled from transect surveys and test pits during 2013 and 2014 (presented in Section 4.7.2, see Appendix 4.7.1 for the field data and interpretative reports);
- An analysis of the soil chemical survey, undertaken by Geoteam (2008-2010), as a part of the geological site investigation programme and from soil samples obtained in 2014 within the main elements of the Project footprint (the data is presented in Section 4.7.6, see Appendix 4.7.2 for the distribution of data points from the SI programme); and
- Land cover and vegetation analysis from satellite image data, dating from 2014 and site walk over studies, see Section 4.7.7.

4.7.1 Soil Classification

A number of published soils reports are available for the RA, which provide sufficient information to establish the baseline dataset for this study. The national soil map identifies the Project to be in an area where brown and black earths (Chernozems) predominate at lower elevations, grading into Mountain Black (Chernozems). Montane Meadows and Montane Meadow Steppe have been classified in the original Russian surveys[1] and confirmed by soil survey (see Appendix 4.7.1). The national distribution of the main soil types in RA is identified on Figure 4.7.1.

[1] Scientific-Research Institute of Pedology and Agro-chemistry (1994) and American University of Armenia (СИСИАНСКИЙ РАИОН, published 1:200,000 soils survey)

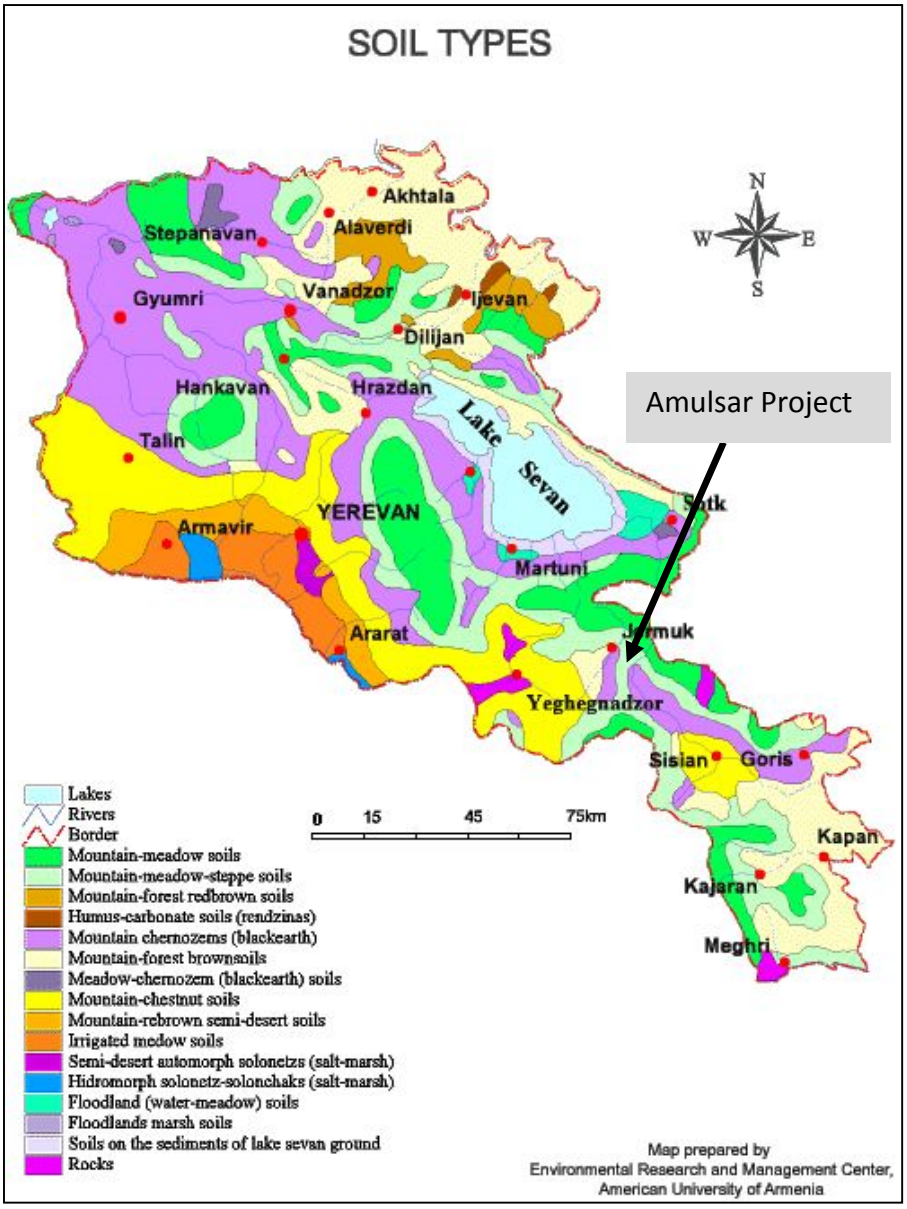


Figure 4.7.1: RA Soil Types and Geographic Distribution

Published soil data is available for the Amulsar region[2] and is shown on Figure 4.7.2, with respect to the Project footprint.

[2] Food and Agriculture Organization of the United Nations (FAO), Country Pasture/Forage Resource Profiles: ARMENIA, (2006)

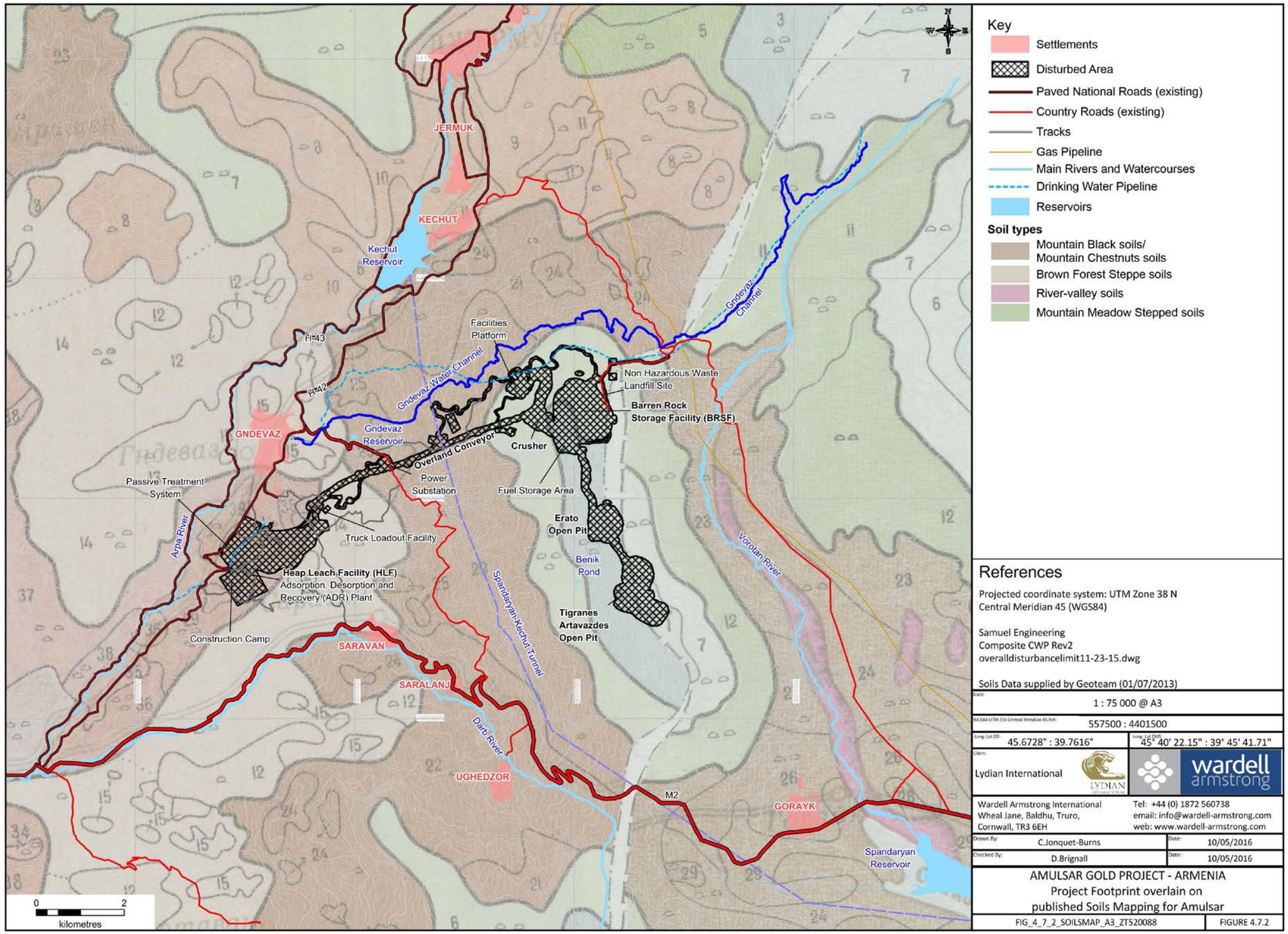


Figure 4.7.2: Project Footprint overlain on published Soils Mapping for Amulsar

Detailed soil profile description

Typical soil profile characteristics of each soil type are as follows, and the description of the landscape type has been cross referenced to the descriptions defined in Section 4.3 and 4.10:

Mountain Meadow soils

Mountain Meadow soils are present on steeper slopes recognised as highland hills and on grazing lands, typically at elevations between 2200 and 4000 m, typically influenced by cold and humid conditions. They typically receive a large excess of moisture resulting in a strong leaching regime which is seen throughout their soil profile. This creates an acidic soil reaction (pH 4.8 to 6.2). They are of a light medium loamy texture, with clay content increasing on shallower slopes and basins. Topsoil profile depths are generally 0.2m, although shallower on steeper slopes, with a generally high organic humus content (17-31%[3]) although this varies depending on the influence of perched groundwater within the subsoil. Topsoil tends to be weakly acidic and generally free-draining to the subsoil that extends to approximately 0.4 m. The open pits and main haul road are located within areas of Mountain Meadow soils; however, due to the altitude and slope constraints in this region these soils tend to be very shallow or absent entirely. Where soil is absent the surface is either bare ground and/or ice/snow. The open pits have a dominant grassland land cover and consequently a larger percentage (Erato 90%; Tigranes-Artavazdes 55%) of Mountain Meadow soils.

The Mountain Meadow soils are influenced by cold, humid, sub-alpine conditions. This limits the topsoil profile formation around the open pits to typically less than 0.15 m depth. It is noted that on the published soil maps of Amulsar Mountain[4], these have been classified locally as a Mining Meadow Turf. The term may relate to the presence of economically valuable minerals in this area, although this is not evident from the published soils maps[4]. The soil survey confirmed that the soil type is that of a Mountain Meadow and that the soil profile is limited in depth, interspersed with rocky outcrops and extensive areas of bare ground (Page 4, Appendix 4.7.1).

[3] Panagos P., Van Liedekerke M., Jones A., Montanarella L. (2012) European Soil Data Centre: response to European policy support and public data requirements Land Use Policy, 29 (2), pp. 329-338.

[4] Ibid. 1, pg4.7.1

Mountain Meadow Steppe soils

Mountain Meadow Steppe soils lie at elevations between 2400 and 2600 m asl (in the Amulsar region), and are characteristically associated with steeper slopes, forested upper gorge, high steppe, plateau grasslands, and foothills. The topsoil profile is generally shallow, and where found on gentle slopes will be on average 0.15 m, overlying a subsoil horizon that varies in depth from very thin to 0.5 m. Soils are black to dark brown, chestnut sandy loam, stony to gravel in places and with a weak structure. Soils are acidic, with little if any limestone content. The transition from subsoil to parent material (C horizon) is vivid with weathered bedrock, and light loamy to stony skeletal soil with little or no structure. Within the Project, the BRSF, crusher, truckshop and administration offices, explosive magazines and the upper part of the conveyor are located within areas that are characterised by Mountain Meadow Steppe soils. The majority of these infrastructure elements are characterised by grassland land cover, and consequently soils will be disturbed in their construction.

To the east of the Project, the field survey encountered Valley Meadow-Steppe soils adjacent to the Vorotan River. These soils will not be affected by the Project; however a description of the profile is given in Appendix 4.7.1.

Mountain Black soils

Mountain Black soils formed on gently sloping and flat valleys of the settled lowlands and are characteristic of the grasslands in the lower farmed and settled foothills of the steppe. They are present at an altitude of 2000 to 2400 m asl. Within the Amulsar region the soil type supports extensive grassland ecosystems, and closer to communities they are also used for a variety of cultivated crops. The soil profile is characterised by a clearly identified A horizon (topsoil), dark in colour from chestnut brown to black, high organic content, medium to heavy loam, stoneless to slightly pebbly, extending to a depth of 0.4 m. There is a noticeable transition to the subsoil that can extend to a depth of 1.1 m, with a slight to medium loamy texture and chestnut with brown shading. This horizon is generally stoneless and overlies a light chestnut coloured heavy loam, which is slightly pebbly and extends to a depth of approximately 1.4 m. The main part of the overland conveyor, access roads and other infrastructure, such as quarries to be developed during the construction phase, are located on this soil type.

Mountain Chestnut soils

Mountain Chestnut soils lie at elevations between 1500 and 1900 m asl and are characteristic of steeper slopes, high steppes and foothills. They have a moderate topsoil organic matter content (2-6%) and are relatively shallow with topsoil depths approximately 0.2 m, although this depth increases into the lowlands. They form under a relatively arid, continental climate which allows the build-up of a humus-rich topsoil horizon, and contributes to the weakly alkaline reaction (pH 7-8). Underlying horizons are greyer in colour, becoming more bleached with depth. Topsoil is of a heavy clay-sandy texture, decreasing in clay content with depth and has a weak profile development. Parts of the HLF and associated roads and access tracks, the ADR plant and offices, water pipeline, part of the conveyor, and the truck load-out facility are all located on this soil type. The HLF facility is located on two different soil types; Mountain Chestnut soils and Brown Forest Steppe soils (see below).

Brown Forest Steppe soils

Brown Forest Steppe soils occur at elevations between 1600 and 1900 m asl and are characteristic of steeper slopes, forested upper slopes, steppes and foothills where there is greater warmth and/or humidity. The topsoil depth is estimated at 0.15 m, overlying a subsoil extending to an average depth of 0.5 m. The relatively high precipitation creates a strong leaching regime, resulting in the translocation of clay vertically through the profile, and the creation of a resulting clay horizon further down the profile. This creates a moderately acidic (pH 4.5-5.9) reaction. Their high topsoil organic matter content (4-8%) is a result of the high organic matter input from the surface vegetation (mainly forest), which also helps to bind the soil's characteristically weak clay-sandy structure together, acting as a preventative measure against erosion. Part of the HLF is located on this soil type.

River-valley soils

Alluvial Brown earths are present in the Vorotan and Apra river basins at an elevation of approximately 2200 m asl. These soils are deeper; the topsoil profile estimated at a depth of 0.25 m, comprising dark chestnut cloddy silty clays. The underlying subsoil is a light chestnut cloddy silty clay, breaking to a fine crumb, and present to a depth of 0.7 m. In river valleys, the soils can be subject to prolonged saturation during spring and autumn. These soil types are widely used for a range of crops and are subject to annual cultivation. These will not be affected by the development of the Project.

Figure 4.7.3 identifies the general arrangement of the Project in relation to the surveyed soil

types in the wider study area. This has been used to estimate potential for soil disturbance (see Table 4.7.1).

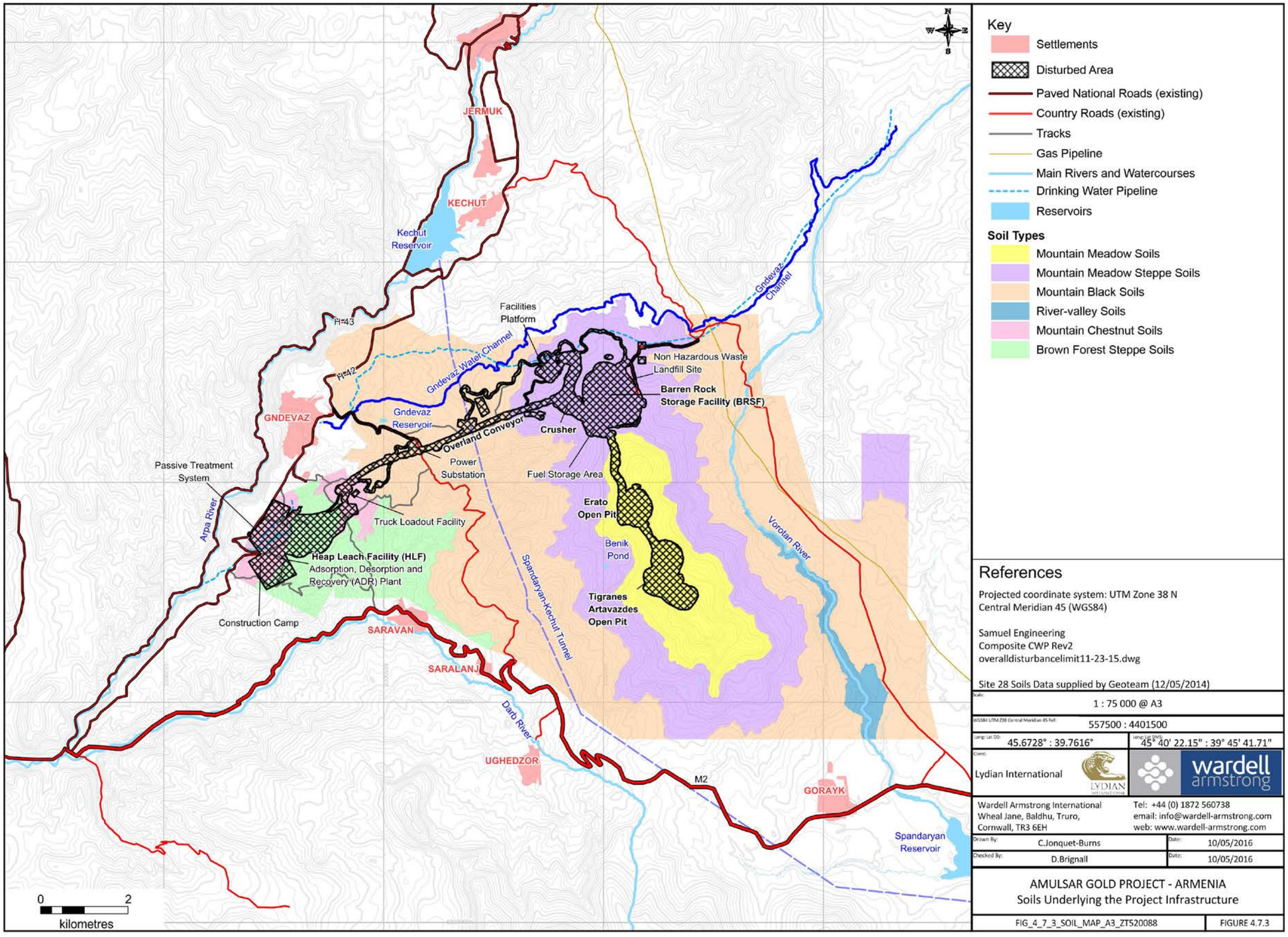


Figure 4.7.3: Amulsar Soil Associations and Project Layout

Table 4.7.1: Primary Soil Associations and Areas Potentially Affected During Development of the Project												
Soil Type	**Area of Potential Disturbance (rounded to the nearest 5 ha)**											
	Tigranes - Artavazdes Open Pit	**Erato Open Pit**	**BRSF**	**Construction Camp**	**HLF, ADR & Ponds**	**Haul & Access Roads**	**Primary & Secondary Crusher**	**Conveyor and load out**	**Facilities platform**	**Quarries**	**Other infrastructure**	**Total**
Brown forest steppe	-	-	-	20	98	2	-	-	-	-	-	120
Mountain black	-	-	162	-	-	43	-	47	-	8	12	272
Mountain chestnut	-	-	-	28	96	2	-	15	-	-	2	141
Mountain meadow	123	47	-	-	-	38	-	13	-	-	2	223
Mountain meadow steppe	-	-	-	-	-	115	15	-	16	5	3	153
Valley river alluvial	-	-	-	-	9	-	-	-	-	-	-	9
Total (ha)	123	47	162	48	203	199	15	77	16	13	17	922

4.7.2 Land Capability Classification

The results of the site investigation together with published soils data can be used to determine an indicative Land Capability Classification, based on the criteria given in Table 4.7.2[5]. Land Capability provides a measure of the capacity of a soil to support a range of economic agricultural activity.

In general, Land Capability Classes I to IV are indicative of suitable soils for growing a range of crops, with increasing limitations with respect to cultivation and crop husbandry. The Class range of V to VIII are more severely limiting through factors such as climate, slope, aspect, and altitude. These may also include factors, such as isolation and lack of infrastructure, which inhibits the economic use of the land for arable agriculture. The use classes are more suited to pasture, woodland or afforestation.

On the basis of the survey data, the soils within the Project area are considered to be predominantly Land Capability Classification V to VII (Limited Arable to Non-Arable), with the exception of the HLF, and surrounding infrastructure (offices, ADR Plant, and water supply pipeline to the Arpa River), which is considered to be Land Capability Classification III.

The land considered to be Land Capability Classification III is used as arable land, particularly orchards (for fruit production, in particular apricots). It is limited to Class III by its soil depth, climate, altitude, and erosion risk. This is generally considered to be high quality agricultural land, and therefore considered to be locally valuable.

The land considered to be Land Capability Classification V to VII has limited agricultural uses as it is limited by slope, climate, altitude, soil depth, and factors such as stone content, that inhibit use for mechanised cultivation which is required for arable agriculture. However, since the grasslands are used by the surrounding communities for grazing and seasonal pasturage (Section 4.16 - Land Use and Tenure), it is clear that Land Capability Classification alone is not sufficient to describe the agricultural/cultural value of land in the Project. In addition, land use has been considered with respect to the national designation of Land Use Capability within the Project (Section 4.3 and 4.16), which identifies the potential of the land in relation to economic use. Land tenure and cadastre has been considered in Sections 4.16.1 and 4.16.2.

[5] Land Capability Classification handbook, 210. Klinbeigal and Montgomery, 1961 (US Govt Print Office).

Table 4.7.2: Land Capability Classification

Land Capability Class		Soil Drainage	Slope %	Depth (m)	Stones % vol	Soil Texture	ECEC Clay	pH Water 1:2.5	K Factor	Erosion Risk	Agricultural Suitability
I	Arable (and irrigable)	Well	<3	>2	<5	Clay loam	>24	6.0 – 7.8	<0.1	None	Arable
II	Arable (and irrigable)	Moderate	<16	>2	<5	Any except sandy	>16	5.3 – 8.5	<0.3	Slight	Arable
III	Arable	Imperfect	<25	>1	<15	Any except sandy	>16	5.3 – 8.5	<0.3	Moderate	Shifting
		Imperfect	<16	>1	<15	Sandy	>12	5.3 – 8.5	<0.3	Moderate	Shifting
IV	Arable	Poor	<25	>0.6	<40	Any except sandy	>12	4.5 – 8.8	<0.5	High	Shifting
		Poor	<16	>0.6	<40	Any except sandy	>12	4.5 – 8.8	<0.5	High	Shifting
V	Limited arable	Very poor	<3	>0.3	<40	Any	4 – 12	4.5 – 8.8	<0.3	Slight	Pasture
VI	Non-arable		<25	>0.3	>40	Any	<4	<4.5		High	Permanent pasture, trees
VII	Non-arable		<40			Sandy				Very high	Permanent pasture and non-agricultural, e.g. forestry
			<60			Any except sandy				Very high	
VIII	Non-arable		>40			Sandy				Very high	Non-agricultural, e.g. forestry
			>60			Any except sandy				Very high	

Notes:

1. LCC assumes good management of mechanised operations. 25% slope is safe limit for mechanised operations. Mechanised operations apply to classes I – VI for arable use and pasture improvements.
2. Soils having >40% stones (volume) are unsuitable for mechanised arable cultivation.
3. Irrigable land should have 2.0m soil depth to allow for any leaching, drainage.
4. Surface irrigation is feasible on slopes <3% and clayey soils.
5. Sprinkler irrigation is feasible on any soil on slopes up to 16%.
6. Erosion risk is a qualitative assessment based on slope, soil texture, ECEC, clay and k value.
7. Sandy soils: Class III at best. Vertisols: Class II at best. Very acid soils (pH<5.3): Class IV at best. Soils with ECEC <4: Class VI at best.
8. Contaminated land (mining, tailings, spoil) is Class VIII.
9. The K factor is a measure of soil erodability and is derived from various physical and chemical parameters in particular the particle size distribution and soil drainage.

Notes continued:

10. Effective Cation Exchange Capacity (ECEC) is a measurement of exchange capacity and is defined as the sum of exchangeable bases and exchangeable hydrogen and exchangeable aluminium.
11. LCC is determined through consideration of the site parameters against criteria identified above with the lowest / worst value determining the overall LCC.
12. Armenian land cadastre categories have been considered in Section 4.16.2
13. Additional areas of disturbance will result from the location of topsoil stockpiles.

Descriptions have been grouped to take account of the main differences between soils within the Project, in particular topography and elevation.

4.7.3 Physical Integrity

The weakly structured Mountain and Mountain Meadow Steppe soils are at risk from sheet and rill erosion, where vegetation cover is reduced, or as a consequence of land slip, resulting in undercutting or exposure of the soil profile on vulnerable steep slopes. In general, where land is maintained with grassland cover, risk of soil erosion can be reduced. Where vegetation cover is removed and the underlying soil profiles are exposed as a consequence of undercutting across steep gradients, there is a risk of incipient and on-going erosion, which requires specific mitigation design.

4.7.4 Sensitivity Criteria

Sensitivity of the soils baseline is established for soil resources based on their agricultural productivity (sensitivity in terms of supporting biodiverse ecosystems is referenced in Section 4.7.5 below). This combines the depth of the soil resource, land capability classification, the economic importance of the agricultural production, and physical integrity of the resource, resulting in a Minor – Very High sensitivity scale (see Table 4.7.3).

Table 4.7.3 Criteria for establishing a sensitivity scale for soils

		AGRICULTURAL PRODUCTIVITY					
		Narrow range of agricultural crops	Versatile – a range of agricultural annual crops	Versatile – a wide range of agricultural crops	Highly versatile – a range of agricultural and horticultural crops		
DEPTH OF RESOURCE	Very Shallow (<0.5 m)	**MINOR**	**MINOR**	**MEDIUM**	**HIGH**	Poor/no structure	**STRUCTURAL STABILITY**
	Shallow (0.5 – 1 m)	**MINOR**	**MEDIUM**	**HIGH**	**HIGH**	Weak Structure	
	Deep (1 – 1.2 m)	**MEDIUM**	**MEDIUM**	**HIGH**	**VERY HIGH**	Moderate structure	
	Very Deep (>1.2 m)	**MEDIUM**	**HIGH**	**VERY HIGH**	**VERY HIGH**	Well Structured	
		Locally Important	Regionally important	Nationally important	Internationally important (for export)		
		GEOGRAPHICAL IMPORTANCE ECONOMICALLY					

4.7.5 Soils and biodiversity

Section 4.7.4 considers the sensitivity of baseline soils in relation to agricultural productivity, depth of the resource and structural integrity. The sensitivity of the baseline soil resource in relation to supporting biodiverse ecosystems is not considered directly in the assessment of

soils and land cover; however, the weakly structured soils, with shallow profiles isolated by crests of bare rock also support the rare and endemic plant species considered in Section 4.10. The soils that have developed in these harsh environmental conditions and that result from a combination of climate, relief, aspect and exposure, have been characterised so that they can be managed separately from the soils that support agriculture and are present at lower elevations.

4.7.6 Soil Chemistry

In the absence of anthropogenic contamination (such as input from agricultural pesticides or factory emissions), metal concentrations in soils are directly related to the chemical composition of the parent material from which the soil is derived, particularly for those soils which are formed from homogeneous or single parent material, or young soils that have been weathered under temperate conditions. In contrast, soils derived from heterogeneous (diverse) parent material, such as glacial tills, soils overlaid by natural parent material, or soils under the influence of anthropogenic activities from various sources, may vary considerably in their metal concentrations.

In the Project-affected area, superficial soils and rock outcrop samples were collected by Lydian as part of the Project's exploration programme. The soil samples indicate that the superficial materials in the Project area have elevated to very elevated concentrations of a number of metals and metalloids. These are naturally occurring metal/metalloid concentrations in soils and superficial materials which reflect the presence of the ore bodies and the related mineralization in the soil parent material and rock outcrops. Concentrations of various metals were found to be present above Armenian MAC guidelines (see Table 4.7.4). MAC values do not account for naturally occurring elevated baseline metal concentrations present in soils from mineralized areas, such as at Amulsar. Topsoil removed from the area overlying the future open pits and other facilities will be stockpiled for use during closure and reclamation. For these reasons, the Project has developed site-specific soil quality guidelines that reflect the naturally occurring elevated concentrations of various substances in the Project-affected area, for soils that will be stockpiled and used during closure and reclamation (See Chapter 2, Table 2.14).

Environmental Baseline Sampling Programme

A total of 152 soil samples were obtained from the Project site across 2008 – 2010 and 2014 as part of the environmental baseline sampling programme, of which 63 sample locations fall

within and adjacent to the proposed Project footprint. These samples were submitted to ALS analytical laboratory in Prague, Czech Republic for chemical analysis. ALS performed a multi-element ICP-MS scan on the soil samples, including analysis for the following elements: As, Ba, B, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, Mg, Mn, Mo, Na, Ni, P, Pb, Sb, Se, Sr, V, W, Zn. Analyses for the following substances were also performed, using various standard methods: ammonia, nitrate, nitrite, carbonates, cyanide, sulphide, chloride, fluorine. Selected samples were analysed for petroleum hydrocarbons; aliphatic and aromatic hydrocarbons were analysed in soil samples collected in 2008 and 2014 (see Appendix 4.7.2).

Mineral Resource Exploration Sampling Programme

A minimum of 2,400 soil and rock chip samples were obtained from the Project site as part of mineral exploration drilling and sampling, which has been on-going since 2006. Although the goals of the mineral exploration programme are different from those of the environmental baseline sampling programme, both programmes document pre-existing soil chemistries and shared sampling sites within the footprint of the open pits. Therefore, the exploration results were examined to see if they provided additional support for adopting site-specific soil standards for reclamation use, that reflect natural mineralization.

The exploration soil and rock chip samples were submitted independently of the environmental baseline samples for chemical analysis for total concentration of metals and metalloids via standard multi-element ICP-MS, including: Au, Ag, Al, As, B, Ba, Be, Bi, Ca, Cd, Ce, Co, Cr, Cs, Cu, Fe, Ga, Ge, Hf, Hg, In, K, La, Li, Mn, Mo, Na, Nb, Ni, P, Pb, Rb, Rh, S, Sb, Sc, Se, Sn, Sr, Ta, Te, Th, Ti, Tl, U, V, W, Y, Zn, Zr.

Analytical Results

Soil samples from both the environmental baseline and the mineral resource exploration programmes showed consistently elevated concentrations of various metals/metalloids across the Project area, generally centred around or adjacent to the ore bodies. For reference, Table 4.7.4 compares the mean values obtained from both sampling programmes against MAC soil values.

Table 4.7.4: Mean Metal Concentrations in Project Area Soils			
Substance(s)	**Soil MAC**	**Environmental Mean**	**Exploration Mean**
Antimony	4.5	12.5	672
Arsenic	2	29.8	31.68
Cobalt	5	19.4	18.7
Copper	3	43.1	60
Manganese	1,500	975.7	896
Nickel	4	44.3	43.7
Nitrates	130	84.4	n/a
Lead	20	33.0	36
Sulphur	160	n/a	848.3

Mean soil concentrations were also compared to the following residential soil screening values:

- United Kingdom General Assessment Criteria (GAC) guidelines; and
- United States Environmental Protection Agency (USEPA) Regional Screening Levels guidelines (risk-based concentrations that are considered by the USEPA to be protective for humans over a lifetime). However, the USEPA values are “regional” and reflect variance in soils/climatic conditions across the US. To adjust for this variance, the Region 9 USEPA preliminary remediation goals (PRGs) have been harmonized with similar risk-based screening levels used by Regions 3 and 6 into a single table on the USEPA database and these USEPA Regional Screening Levels have been adopted in Table 4.7.5.

The mean concentrations for the majority of the metals, metalloids, other inorganics and petroleum hydrocarbons analysed were below all their applicable MAC and screening values. The exceptions were As, Co, Cu, Ni, Pb, Sb, and V; concentrations of these metals exceeded MAC, USEPA, and/or UK GAC/SGV values, as shown in Table 4.7.5.

Table 4.7.5: Soil Metal Concentrations Exceeding MAC and Other Criteria				
Substance	**Mean Soil Concentration**	**MAC**	**USEPA**	**UK GAC**
	mg/kg	**mg/kg**	**mg/kg**	**mg/kg**
As	26.7	2	0.39	32
Co	20.4	5	23	N/A
Cu	42.1	3	3100	2330
Ni	48.6	4	1500	130
Pb	30.8	20	400	450
Sb	10.7	4.5	31	N/A
V	76.6	150	390	75
Note: It should also be clarified that the UK GAC and USEPA RSL's identified in this table relate to residential land use and are therefore conservative given the nature of the development within the Project. Similar standards used for industrial land are also considered not to be applicable due to the requirements of the closure plan that indicates the reclamation, following mining, to be suitable for revegetation to modified grassland habitats.				

Elevated baseline concentrations were found for these metals (As, Co, Cu, Ni, Pb, Sb, and V) in the areas of the Amulsar ore bodies. They are of potential concern to human health and the environment when present in elevated concentrations. The occurrence of these seven metals in the Project-affected area soils is discussed further in this section and the soil/superficial material concentration maps for these elements based on the exploration geochemical data are shown in Appendix 4.7.2.

Environmental soil location drawings are shown in Figure 1, Appendix 4.7.2, which shows the location of soil samples across the sampling period 2008-2014. The following sections and Table 4.7.6 provide information about each of these metals including typical soil concentration ranges worldwide and in the Project-affected area, and a histogram of project sample concentration range frequencies.

Table 4.7.6: Summary of Project Infrastructure in relation to elevated levels of specific elements within the soils.

Element screening values (mg/kg)			Project Infrastructure Component								
			Erato Open Pit	Tigranes-Artavazdes Open Pit	BRSF	HLF, ADR and ponds	Haul and Access Roads	Primary and Secondary crusher	Facilities platform	Conveyor	
As	UK GAC	32		✓							
	USEPA	0.39	✓	✓	✓	✓	✓	✓	✓		
	MAC	2	✓	✓	✓	✓	✓	✓	✓		
Co	UK GAC	-									
	USEPA	23									
	MAC	5	✓	✓	✓	✓	✓	✓	✓		
Cu	UK GAC	2330									
	USEPA	3100									
	MAC	3	✓	✓	✓	✓	✓	✓	✓		
Ni	UK GAC	130									
	USEPA	1500									
	MAC	4	✓	✓	✓	✓	✓	✓	✓		
Pb	UK GAC	450									
	USEPA	400									
	MAC	20	✓	✓							
Sb	UK GAC	-									
	USEPA	31	✓	✓							
	MAC	4.5	✓	✓							
V	UK GAC	75					✓				
	USEPA	390									
	MAC	150									

Arsenic (As)

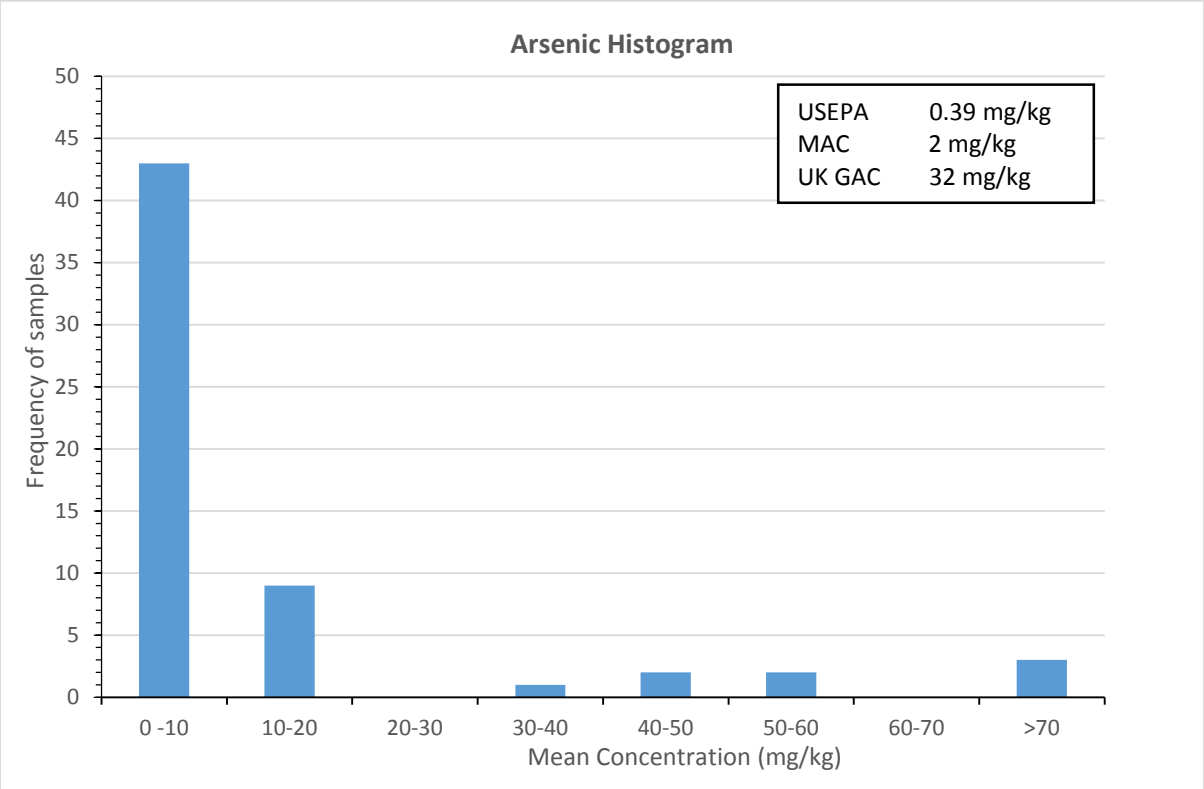


Figure 4.7.4: Frequency of As in Soils of the Project Area

(see Appendix 4.7.2)

Typical naturally occurring As concentrations in topsoil worldwide range from 0.2 to 40mg/kg[6]. Concentrations of As within the soils within the Project-affected area (6.3 – 161 mg/kg) are at the high end of the naturally occurring average range. All of the environmental baseline samples exceeded the MAC (2 mg/kg) and USEPA (0.39 mg/kg) As guideline values with 8 samples (13.3 %) also exceeding the UK GAC (32 mg/kg) value.

As is found in elevated concentrations at all Project infrastructure locations (Table 4.7.6). It was found to be particularly elevated at the Tigranes-Artavazdes open pit location, where it exceeded all 3 screening values, often with a concentration more than double that of the value for the highest screening value (UK GAC 32 mg/kg). Similar trends are seen in the other Project infrastructure components in which the majority of soil samples showed elevated concentrations double that of the MAC screening value (2 mg/kg) (see Table 4.7.6). In general,

[6] Walsh, L.M, M.E. Sumner, and D.R. Keeney, 1977, Occurrence and distribution of arsenic in soils and plants: Environmental Health Perspectives, 19:67-71.

elevated concentrations of As in soils are derived from either anthropogenic sources (e.g. the use of As-bearing pesticides, mineral smelting activities, or coal-fired power plant emissions[5]) or from the weathering of As-bearing parent rock. The latter situation is considered to be the case with the elevated soil As concentrations at Amulsar (see Table 4.7.6).

Average As concentration increases as Project infrastructure components increase in elevation (see Table 4.7.6). This trend can be attributed to the decreasing soil depth with elevation, as factors such as the climate and slope gradient become major limitations to soil formation and structure. Consequently the soil becomes thinner and is more highly influenced by the As-bearing weathered parent rock, allowing As to become more highly concentrated in the soil.

Cobalt (Co)

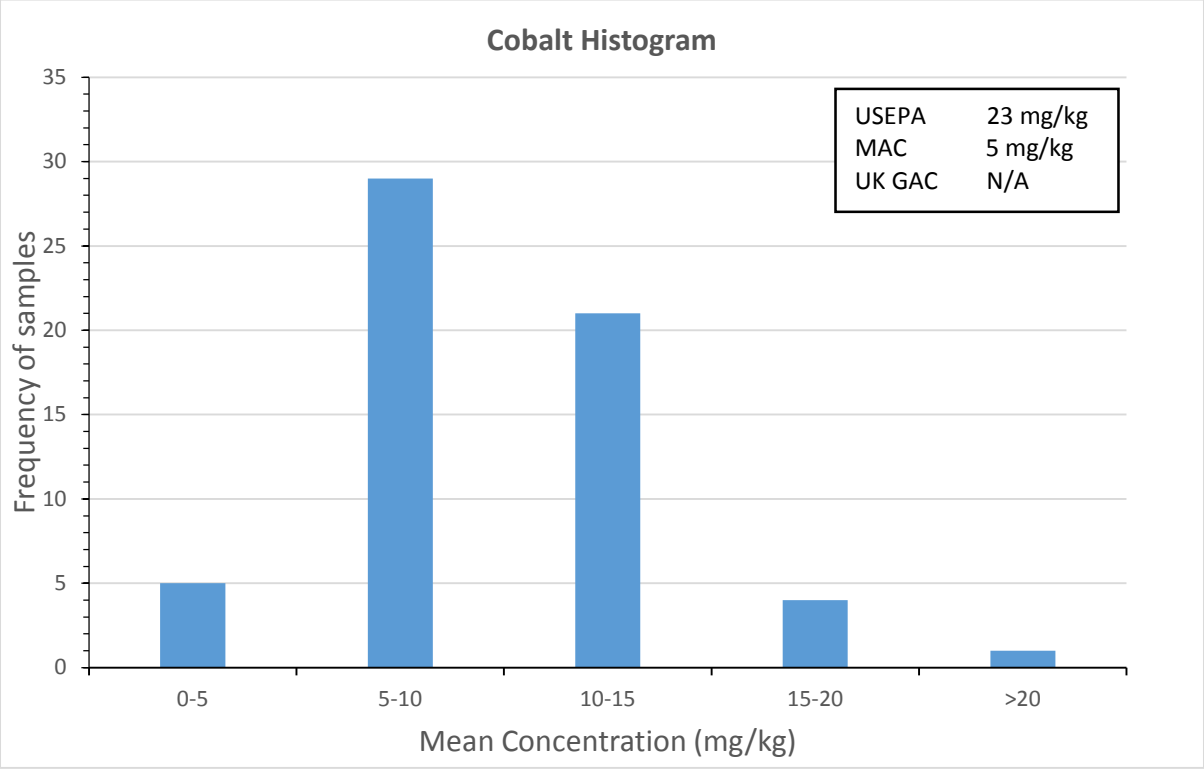


Figure 4.7.5: Frequency of Co in Soils of the Project Area

Cobalt is a relatively rare element in the earth's crust (with an average crustal concentration of 0.0023%) and is usually found in association with other metals such as Cu, Ni, Mn, and As.

In soils it occurs in the divalent Co form[7] with approximately 1 mg/kg to 200 mg/kg and higher with ferromagnesium deposits[8]. Co concentrations ranged from 2.25 to 22.0 mg/kg in Project area soil samples.

Co is found in elevated concentrations at all Project infrastructure component locations (Table 4.7.6) showing widespread existence. 55 environmental baseline samples exceeded the MAC (5 mg/kg) Co guideline value (92%) but none were found to exceed the Co USEPA (23mg/kg) guideline value. Minor Co mineralization from underlying rock is considered to be the main source of soil Co concentrations. Mineralization is likely to be accelerated at the maintenance and storage site, open pits and crushing areas due to their high elevations causing harsher climatic conditions and a stronger relief. Consequently the arid continental climate causes accelerated mineralisation of the Co in the parent rock, which becomes more concentrated in the thinner soils.

Copper (Cu)

In soils, naturally occurring mineralised copper is present as a divalent cation and is bound on inorganic exchange sites within the soil and is thus not readily available for uptake by plants. Concentrations of Cu in soils are typically in the range of 5 to 50 mg/kg worldwide[9]. Soil concentrations of Cu within the baseline study area (14.5 to 79.0 mg/kg) tended to be at the higher end of the natural average range. All of the environmental baseline soil samples exceeded the MAC (3 mg/kg) but the Cu USEPA (3,100 mg/kg) and UK GAC (2,330 mg/kg) guidelines were not exceeded by any sample (Table 4.7.6). Minor copper mineralization is present at Amulsar (see Section 4.6) and it is considered likely that elevated concentrations in soils reflect underlying Cu mineralization in the soil parent material.

[7] Ecological Screening Levels (ECO-SSL), Cobalt and Nickel, USEPA, http://www.epa.gov/ecotox/ecossl/
[8] Mitchell, R. L, Trace Metals in Soil, in Fe Bear, Chemistry of the Soil, 1964
[9] McLaren and Crawford, Studies on Soil Copper, Journal of Soil Science, Vol 24, 2973

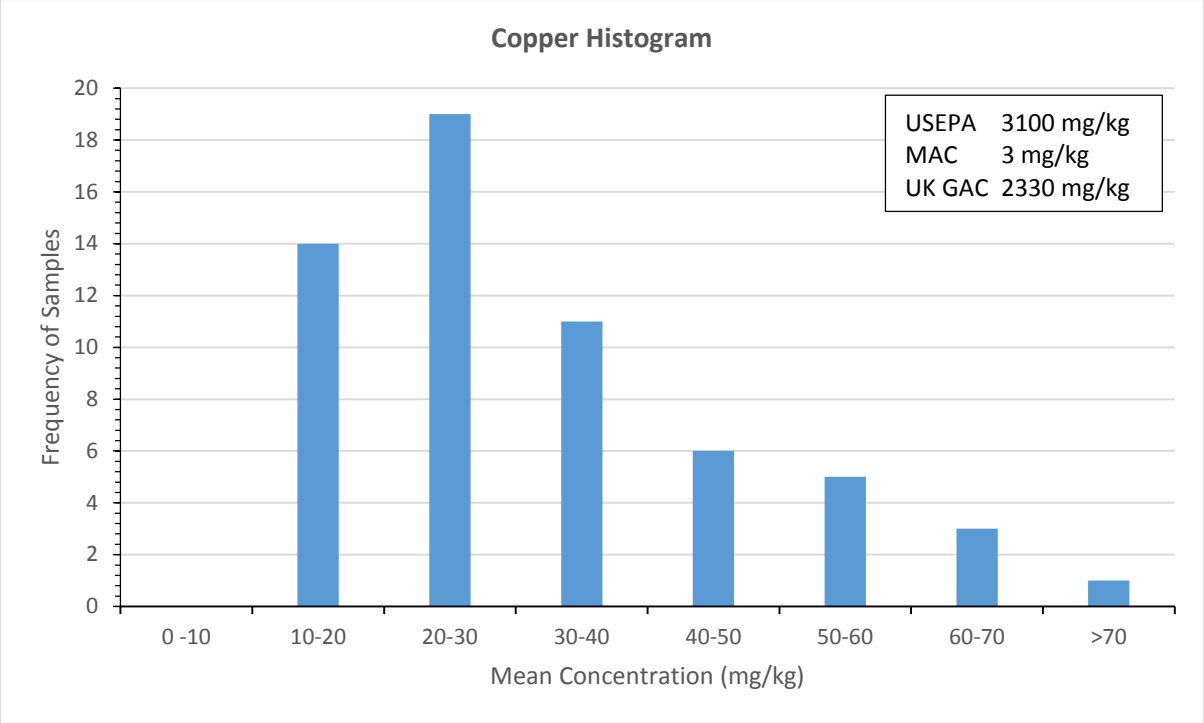


Figure 4.7.6: Frequency of Cu in Soils of the Project Area

(see Appendix 4.7.2)

Nickel (Ni)

Nickel can be found in all environmental media: air, soil, sediment, and water and anthropogenic nickel can be released to the environment through the extraction, processing and use of Ni compounds; concentrations of less than 100mg/kg are typical of soils[10]. Ni concentrations in Project area soils ranged from 5.9 – 57.0 mg/kg (see Table 4.7.6). All of the environmental baseline soil samples exceeded the MAC (4 mg/kg) Ni guideline value but none of the soil samples exceeded the USEPA (1,500 mg/kg) and UK GAC (130 mg/kg) Ni guideline values. Consequently, all Project infrastructure components were found to be located on soils which exceed the MAC guidelines (Table 4.7.6), reflecting the naturally elevated background levels of Ni in the parent rocks.

[10] Mengel, K, Kirkby, EA, Principles of Plant Nutrition, 1978

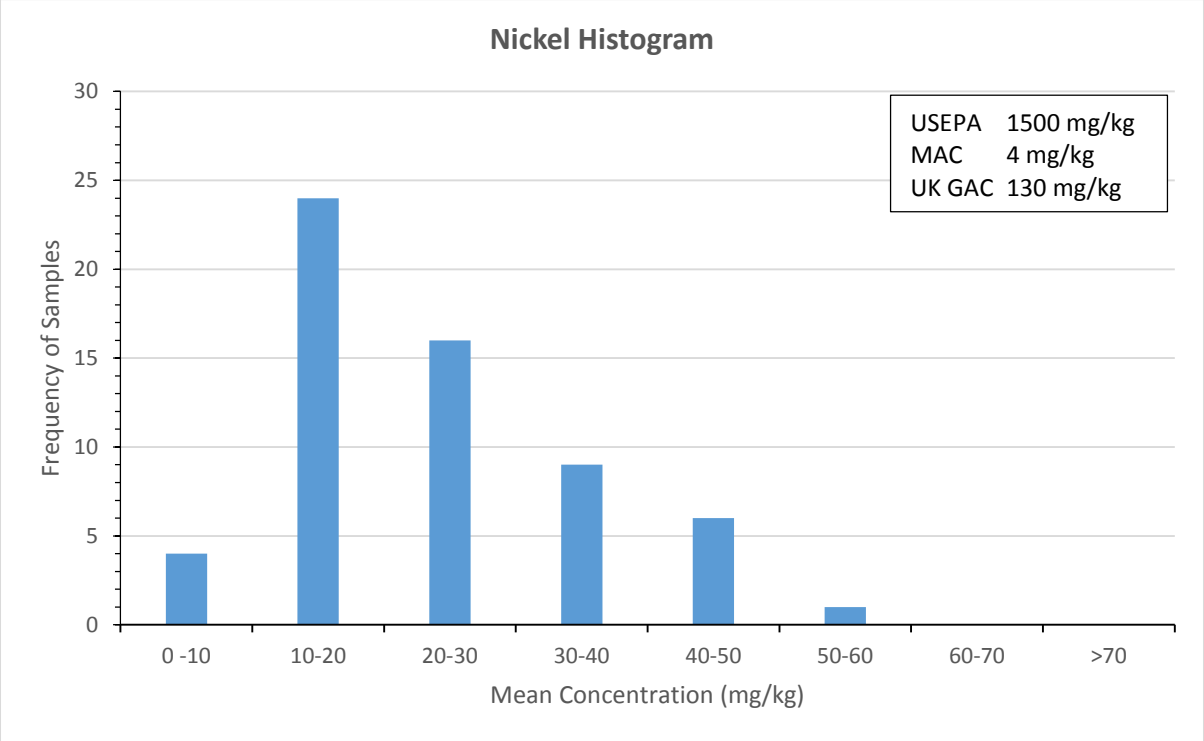


Figure 4.7.7: Frequency of Ni in Soils of the Project Area

(see Appendix 4.7.2)

Lead (Pb)

In the absence of Pb mineral deposits, naturally occurring levels are in the range of 2 to 200 mg/kg[9] in soils worldwide. The distribution of Pb in the biosphere is such that anthropogenic-sourced Pb in soil is common and widespread especially in urban areas, in part from the use of leaded gasoline. Soil Pb concentrations within the environmental baseline study area ranged from 7.1 to 288.0 mg/kg, slightly exceeding the natural average range. Eighteen samples (30%) from the Project footprint area exceeded the MAC (20 mg/kg) Pb guideline value but no baseline samples exceeded the USEPA (400 mg/kg) and UK GAC (450 mg/kg) Pb guideline values (Table 4.7.6). Minor Pb mineralization is present in the Project area, and is considered to be the main source of elevated background soil Pb concentrations.

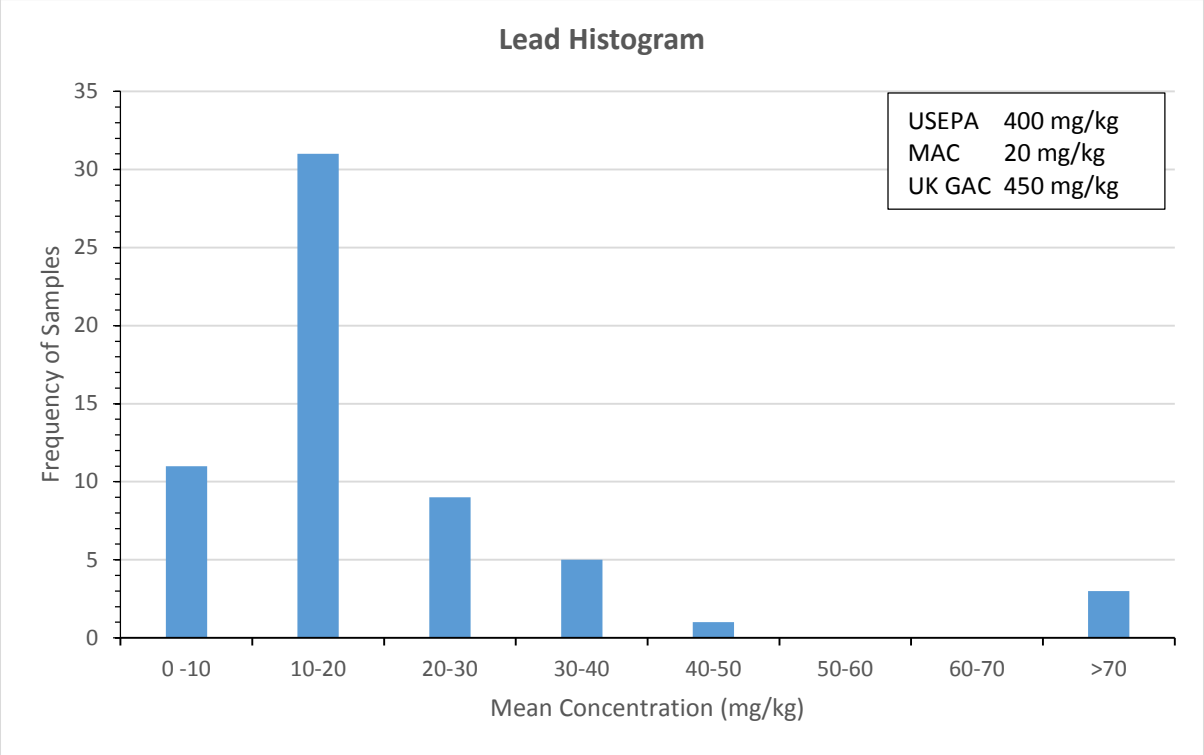


Figure 4.7.8: Frequency of Pb in Soils of the Project Area

(see Appendix 4.7.2)

Antimony (Sb)

Naturally occurring concentrations of Sb in topsoil are generally in the range of 0.3 to 8.6mg/kg worldwide[11]. In Project-affected area soils (Table 4.7.6), Sb concentrations ranged from 0.2 to 137.0 mg/kg, within and significantly exceeding the average global range of soil Sb concentrations. Eleven environmental baseline samples (18 %) exceeded the MAC (4.5 mg/kg) Sb guideline value; 5 samples (8.3 %) also exceeded the USEPA (31 mg/kg) Sb guideline value; there is no UK GAC guideline value for Sb (Table 4.7.6). These elevated concentrations are considered to be the result of soil development from mineralized parent rock with elevated Sb concentrations.

Particularly elevated Sb concentrations were found within the Erato and Tigranes-Artavazdes open pits, and at the BRSF (Table 4.7.6). These are the three highest infrastructure components located on the top of Mount Amulsar. Consequently, the harsher climatic conditions, exposed parent rock, and stronger relief causes accelerated mineralisation of the

[11] Tschan, M., B.H. Robinson, and R. Schulin: 2009, Antimony in the soil-plant system – a review: Environmental Chemistry, 6:106-115.

parent rocks in these locations, which accumulates and produces a higher concentration within the thinner soils present in these areas.

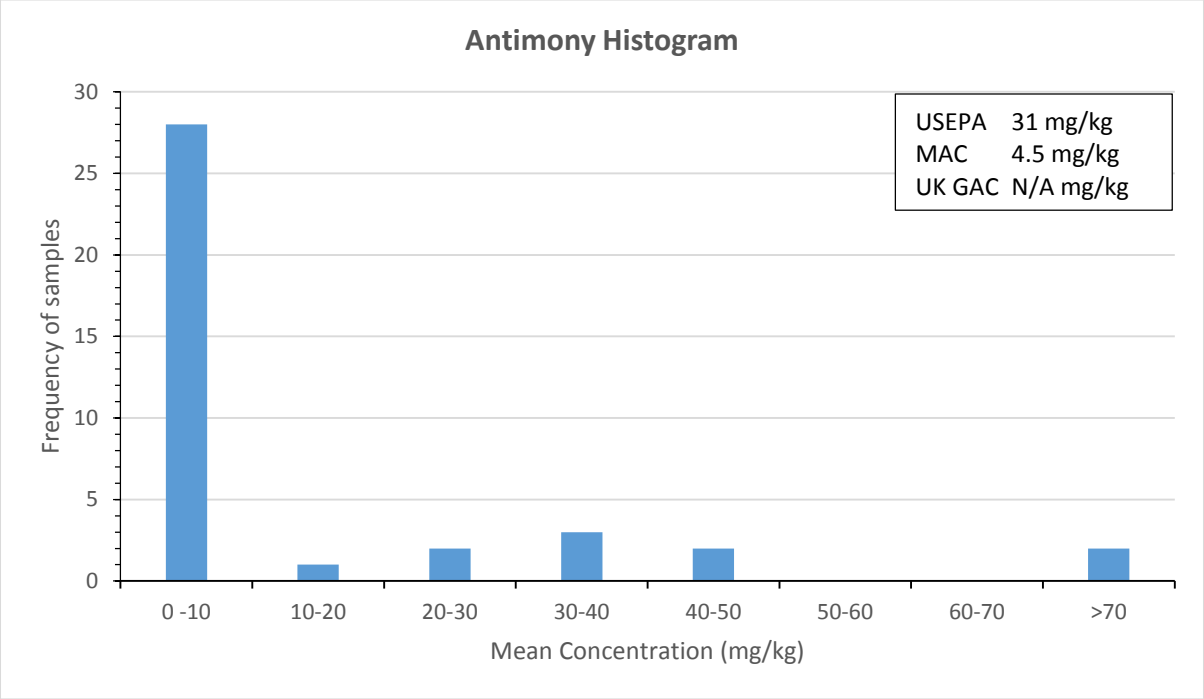


Figure 4.7.9: Frequency of Sb in Soils of the Project Area

(see Appendix 4.7.2)

Vanadium (V)

Naturally occurring concentrations of Vanadium in topsoil are generally within the range of 3 to 310 mg/kg worldwide[12] with some concentrations up to 400 mg/kg in areas found to be polluted by anthropogenic Vanadium sources, such as Uranium mining and steel smelting. In Project-affected area soils (Table 4.7.6), V concentrations ranged from 1.1 to 114 mg/kg, within the average global range of soil V concentrations. Fourteen samples (23.3 %) exceeded the UK GAC guideline value for V (75 mg/kg), but no baseline samples exceeded the MAC (150 mg/kg) and USEPA (390 mg/kg) V guidelines (Table 4.7.6). These elevated concentrations are considered to be the result of soil development in areas where there is a higher than average crustal weathering of basement rocks.

[12] Waters, M.D. Toxicology of vanadium. In: Goyer, R.A. & Mehlman, M.A., ed. Advances in modern toxicology. Vol. 2. Toxicology of trace elements. New York, Wiley, 1977, pp.147-189.

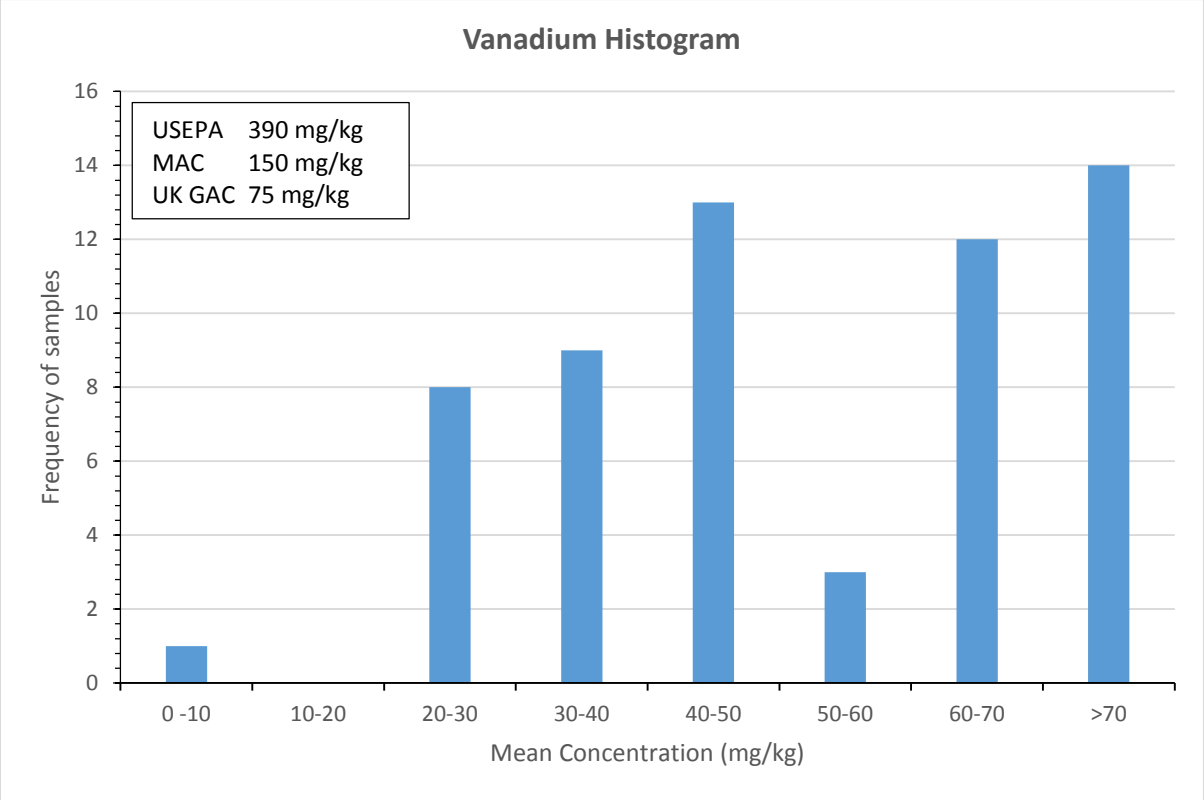


Figure 4.7.10: Frequency of V in Soils of the Project Area

(see Appendix 4.7.2)

Summary

Table 4.7.6 (also see Appendix 4.7.2) identifies where soil with elevated levels of metals, metalloids and other inorganics is located within the Project-affected area. This is intended to inform the working methodology for the Project with regards to soil stripping and storage. This identifies that soil with elevated concentrations of the above elements is found at all major Project infrastructure components, but in all cases they can be attributed to natural sources, rather than anthropogenic sources such as smelting industries. The primary source of these elements within the soil is attributed to the weathering of the parent rock. Studies[13] have found that all of the above elements are considered to be 'pathfinder elements', often occurring in association with each other and with gold mineralisation. This is due to the conditions necessary for gold formation where hydrothermal waters, heated by tectonic activity, deposit gold in solution into fissures within rocks. These hydrothermal waters often

[13] Leia Michele Toovey, 2011, *Indicator Minerals, Pathfinder Minerals and Gold Exploration.* Gold Investing News. R.E.Lett, W. Jackaman and A.Yeow, 1998, *Detailed geochemical exploration techniques for base and precious metals in the Kootenay Terrane*, British Colombia Geological Survey Geological Fieldwork.

also carry other elements in solution such as As, Co, Cu, Ni, Pb, Sb and V, or can cause reactions with elements already present within the rock. Weathering of these rocks allows these elements to accumulate into the surrounding media, in this case the soil, which increases their relative concentrations. Consequently, although these soils have elevated concentrations of these elements, the origin of their source is through the natural weathering processes of the parent rock. The parent rock exhibits background levels of these elements that is naturally high.

4.7.7 Land Cover

Land cover in the wider area that contains the Project was determined using a Normalized Difference Vegetation Index (NDVI) analysis on satellite imagery and field data of the Project area. NDVI analysis utilizes various bandwidths of visible and near-infrared spectral imaging data to calculate an NDVI value between 1.0 and -1.0 representing different types of land cover determined by their reflectance value. Actively growing healthy vegetation produces higher values, with increasingly lower values indicating sparse vegetation cover, barren land, water, ice/snow cover, and cloud cover. The following satellite data was utilized:

- 0.5m resolution WorldView-2 acquired 20/10/2010 and 28/11/2010 – 4 band data (Blue, Green, Red and Near Infra-Red); and
- 50m grid spacing Digital Elevation Model (DEM) produced from the supplied contour dataset.

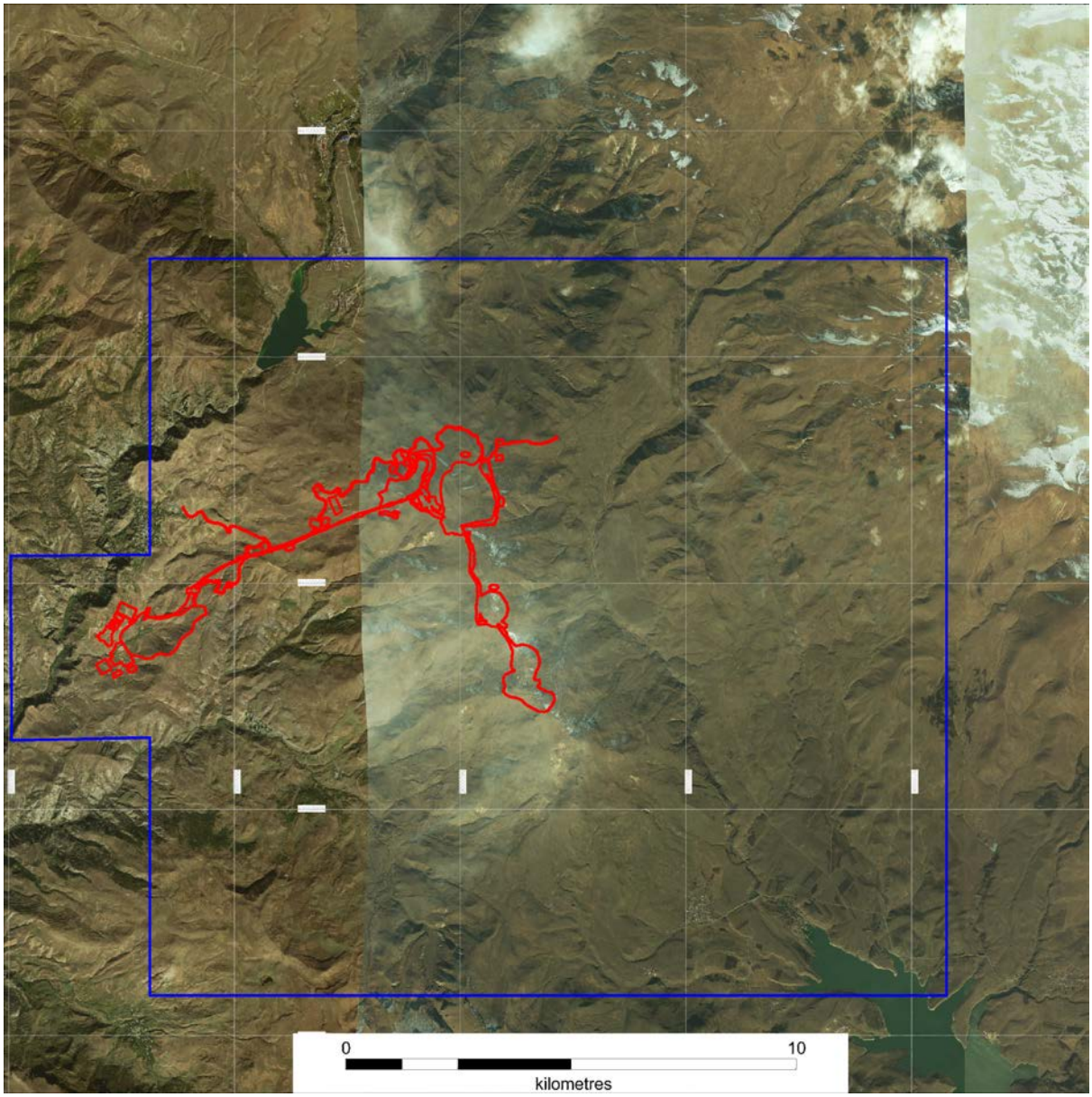


Figure 4.7.11: Area of interpretation for Land Cover data

Land Cover within the Analysis area

The study area for satellite imagery is delineated by the blue line comprising the Project-affected area and surrounding lands (see Figure 4.7.11). Also within the blue line boundary, but not visible at this scale are the settlements of Gorayk (to the southeast), Gndevaz (to the northwest), Saravan (to the southwest) and Kechut and Jermuk (to the north).

The landcover by vegetation for the satellite analysis area is summarized in Table 4.7.7. It is noted that agriculture is defined by the presence of clear field boundaries or recent ploughing and may therefore result in the coverage of agriculture being underestimated and grassland

overestimated in some locations.

Table 4.7.7: Land Cover within the Satellite Analysis Area					
Land Cover		**Wider analysis area ha**	**Wider analysis area %**	**Project disturbed area (ha)**	**Project disturbed area (%)**
Agricultural Lands	Recent evidence of agricultural activity	2793	9%	185	20%
Grassland	Low level vegetation	20,377	68%	602	65%
Scrubland	Intermediate level vegetation, commonly 'woody' shrubs	567	2%	15	2%
Bare ground	Exposed rock and soil, including road surfaces	4785	16%	95	10%
Settlement	Individual building extents	-	0%	-	-
Ice and snow	Ice/snow obscuring land cover	1440	5%	25	3%
Cloud/Shadow	Land cover obscured by shadow	33	0%	<0.1	-
Total analysis area (Figure 4.7.11)		**29,995**		**922**	

The analysis demonstrates that land cover across the wider area around the Project is predominately grassland/pastures (68%), compared to 65% within the Project disturbed area. The agricultural land represents 20% of the Project disturbed area and is generally located within the HLF, access roads, sections of conveyor and within laydown areas for construction. Bare ground, scree and rocky outcrops are increasingly present at higher elevations, such as on the ridgeline of Amulsar Mountain, and is equivalent to 16% of the wider analysis area, compared to 10% of the Project disturbed area.

Individual infrastructure components

The surface cover for each of the infrastructure components is detailed in Table 4.7.8 (Project footprint) and Table 4.7.9 (Project disturbed area), demonstrating that all infrastructure components are located within areas of grassland with an increased diversity of agricultural land management at a lower elevations, for example within the footprint of the HLF.

Where grassland is present at lower elevations, such as at the HLF, BRSF, conveyor, maintenance workshop and haul / access roads, the more fertile Mountain Black, Brown Forest Steppe and Mountain Chestnut soils, have resulted in areas of both seasonal summer pasture and, where both slope and aspect are favourable, the grass crop is conserved as hay for winter feed.

Where agricultural land is present at lower elevations, specifically around the HLF, there is increased agricultural land use, together with apricot orchards and hay fields.

Bare ground is increasingly evident at higher elevations correlating with steeper slopes and harsher climate, characterised by Mountain Meadow and Mountain Meadow Steppe soils, which generally have a weak structure, combined with the shallow depth.

Table 4.7.8: Project footprint (rounded to the nearest 1 ha)											
Vegetation cover or characteristic	**Infrastructure component**										
	Tigranes-Artavazdes	**Erato**	**BRSF**	**HLF, ADR & ponds**	**Haul / Access roads**	**Primary / Secondary Crusher**	**Conveyor and load out to HLF**	**Facilities platform**	**Quarries**	**Construction camp**	**Other infrastructure and ponds**
Agricultural Lands	-	-	8	58	9	-	2	-	2	6	4
Grassland	62	36	102	91	48	14	13	6	7	-	18
Scrubland	-	-	-	10	-	-	4	-	-	-	-
Bare ground	25	2	25	7	22	-	-	-		-	-
Settlement	-	-	-	-	-	-	-	-	-	-	-
Water bodies	-	-	-	-	-	-	-	-	-	-	-
Ice and snow	9	3	4	-	-	-	-	-	-	-	-
Cloud/Shadow	-	-	-	-	-	-	-	-	-	-	-
Total (ha)	96	41	139	166	79	14	19	6	9	6	22

Table 4.7.9: Potential Zone of Disturbance (rounded to the nearest 1 ha) - Project Disturbed Area											
Vegetation cover or characteristic	**Infrastructure component**										
	Tigranes-Artavazdes	**Erato**	**BRSF**	**HLF, ADR & ponds**	**Haul / Access roads**	**Primary / Secondary Crusher**	**Conveyor and load out to HLF**	**Facilities platform**	**Quarries**	**Other infrastructure and ponds**	**Construction camp**
Agricultural Lands	-	-	8	85	9	-	27		5	4	48
Grassland	71	42	120	101	168	15	46	12	8	17	-
Scrubland	-	-	-	10	-	-	4	-	-	-	-
Bare ground	33	2	30	7	22	-	-	-	-	-	-
Settlement	-	-	-	-	-	-	-	-	-	-	-
Water bodies	-	-	-	-	-	-	-	-	-	-	-
Ice and snow	19	3	4	-	-	-	-	-	-	-	-
Cloud/Shadow	-	-	-	-	-	-	-	-	-	-	-
Total (ha)	123	47	162	203	200	15	77	12	13	21	48

4.7.8 Summary

This chapter has identified five soil types within the Project footprint; Mountain Meadow, Mountain Meadow Steppe, Mountain Chestnut, Mountain Black and Brown Forest Steppe. All soils within the Project footprint were identified to have naturally high background concentrations of As, Co, Cu, Ni, Pb, Sb, and V attributed to mineralisation of the parent material.

Mountain Chestnut and Brown Forest Steppe soils occur at lower elevations around the HLF, access and haul roads, and correlate with areas of agricultural land use and rotational grassland which is utilised for hay and pasture. Consequently, these soils have high agricultural productivity value, are considered to be sensitive, and therefore require mitigation to minimise both loss and potential for degradation off site.

Mountain Black soils are found across the majority of the Project area; however, only the conveyor, haul roads and access roads are located on these soils. These support rotational grassland for hay and grassland use and are of medium sensitivity due to their capability to support agriculture. Consequently these too require mitigation measures to ensure they are properly handled and stored as they can be used post-closure.

Mountain Meadow and Mountain Meadow Steppe soils are found at the highest elevations. The BRSF, open pits, haul and access roads, conveyor, crushers, maintenance areas, and construction camp are all located on these soils. These soils are thin, poorly structured and weak, and therefore do not support agricultural land. The land use on these soils is grassland, bare ground and ice/snow; however, they do support critical habitats as considered in Section 4.10. Consequently, although these soils are identified as being of minor sensitivity in relation to agricultural production, they require appropriate consideration with respect to their support for critical habitats.

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4.8 Groundwater Resources

The groundwater baseline is based on information provided by Geoteam/Lydian and data collected by Golder during site visits and investigations between 2011 and 2014, including:

- Description and cross sections of the Amulsar Mountain geological model described in Holcombe[1] and Lydian et al[2] (2013);
- Lydian geological map, received April 2014;
- Geological logs, hydraulic testing data and post-installation groundwater levels from geotechnical and hydrogeological investigations supervised by Golder (full time onsite supervision for geotechnical investigations, part time oversight and off site guidance for hydrogeological investigations) with assistance from Geoteam in Summer 2011, Autumn 2012, Spring 2013 and Autumn 2013. Geological logs for boreholes drilled in Autumn 2012 and Autumn 2013 were provided by Geoteam;
- 1:50 000 scale geological map[3] J-38-8-B, Масштао (USSR, 1981). In Russian, translation provided by Lydian;
- Groundwater level and groundwater quality data from 2010 through to August 2015 collected as part of the baseline monitoring programme, undertaken by Lydian/Geoteam; and
- Spring surveys completed by Geoteam in November 2013 through to February 2014 and in May 2014 informed the interpretative report by Golder, 2014e[4].

The groundwater quality and groundwater level dataset collected by Geoteam has been provided to Golder in the form of a Monitor Pro MP5 database (data through to May 2014) and Word and Excel files; continuous groundwater level data have been supplied as Excel files. Geoteam completed quality assurance of the dataset prior to submittal to Golder.

Hydrogeological and geotechnical investigations have been completed at the sites of the proposed mine facilities (the open pit areas, BRSF and HLF sites), and at a number of alternative sites which provide hydrogeological data for the Project area. The alternative sites investigated include sites located to the east of the HLF, further to the east on the east bank

[1] Amulsar 3D Geological Model Revision: Summary and Resource Implications, Holcombe, R., 2013 November 2013
[2] Lydian International et al, 2013. Presentation summary entitled "Amulsar, Armenia: An IOCG chameleon?" by Rod Holcombe, Tim Coughlin, Nick Oliver, Mentor Demi, Hayk Aloyan, Fabian Baker, and Alan Turner, dated September 2013
[3] USSR, 1981. 1:50 000 scale geological map J-38-8-B, Масштао. In Russian, translation provided by Lydian
[4] Spring Survey Interpretative Report – Update. Golder Associates, 2014e. June 2014

of the Vorotan River in the north of the current Project area, an area south-east of Amulsar Mountain on the east bank of the Vorotan River and an area west of Amulsar Mountain and north-east of the HLF. Data collected at these alternative sites are therefore included in the discussion and evaluation of baseline conditions.

The hydrogeological conceptual model for the Project area forms the basis for the understanding of groundwater resources and is described in the following sections. For the purposes of this chapter, the Groundwater Study Area (GSA) is the area within the hydraulic boundaries formed by the Arpa, Darb and Vorotan Rivers and the watershed boundaries of their catchments at the northern and southern extents. The GSA extends from the confluence of the Darb River and Arpa River in the south-west, and the Spandaryan Reservoir in the south-east extending north to approximately UTM Northing 4407500. The Jermuk geothermal park, which lies outside this hydraulically defined GSA to the north of the Arpa River, is discussed for completeness due to the importance of the springs to local and national stakeholders.

4.8.1 Geology

The geology of the Project area is described in Chapter 4.6. Further detail is provided below regarding those elements of the geological conceptualisation relevant to groundwater flow and the units/layers within the groundwater flow model.

Regional Geology and Structure

The geological structure of Armenia within the Lesser Caucasus is illustrated by Hässig et al (2013) and reproduced in Figure 4.8.1. This map illustrates that at a regional scale the area to the north and east of the Amulsar Mountain project is occupied by recent (Pliocene and Quaternary) sediments and volcanites (igneous rocks and volcanogenic sediments), indicating that older units encountered in the vicinity of Amulsar Mountain do not outcrop in the Syunik Massif further eastward from the GSA. The Project area is not within the major zones of tectonic activity in Armenia. However, geologically young basalt scoria cones within the Project area indicate that the area is geologically active.

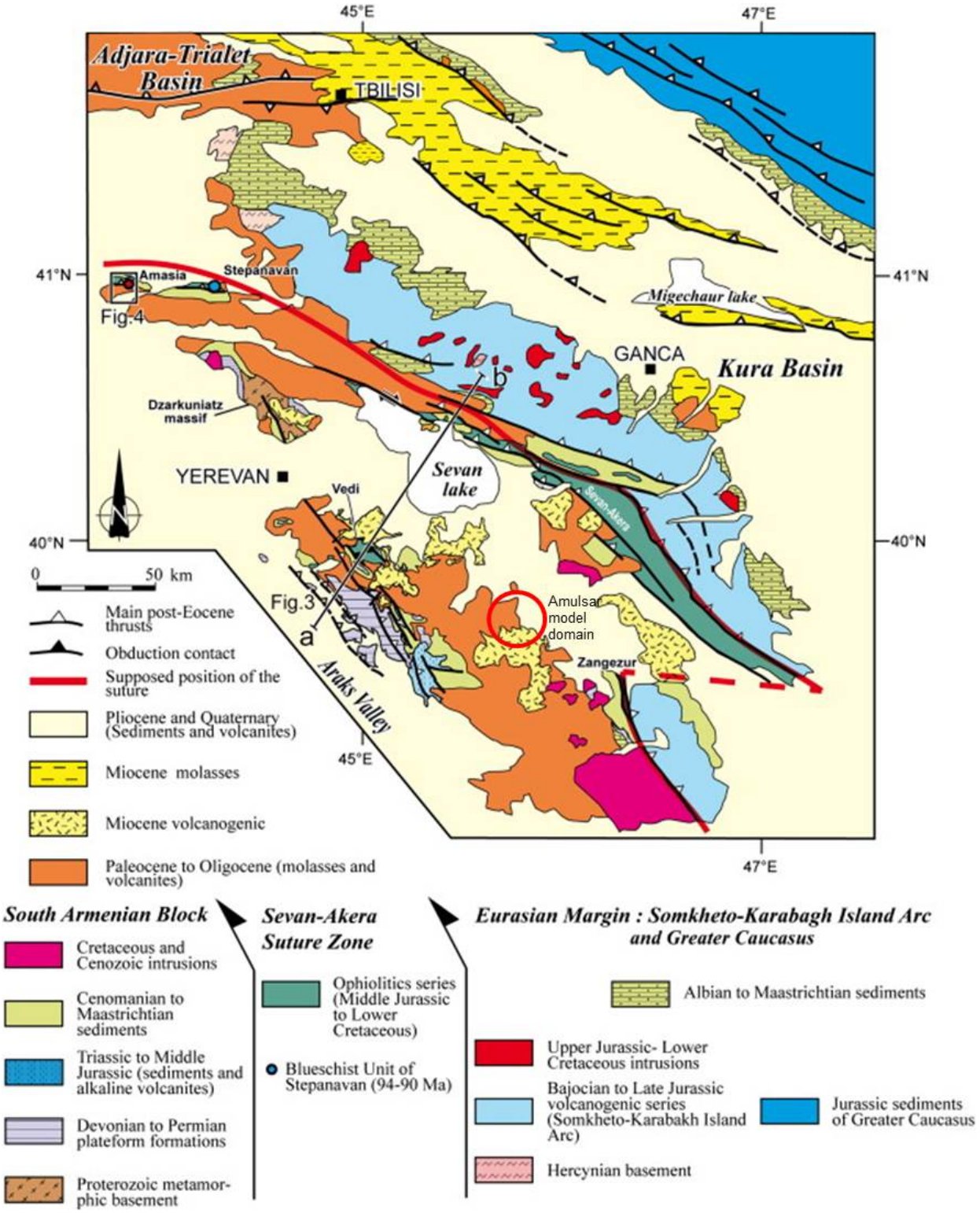


Figure 4.8.1: Structural map of the Lesser Caucasus, Hassig et al (2013)

Project Area

The Lydian geological map of the Amulsar Project area is presented in Chapter 4.6. Away from the ore bodies, the geological structure of the Amulsar Project area is relatively simple, as, described by Holcombe[1]:

"Regionally, Amulsar Mountain lies within a very thick package of Palaeogene volcanosedimentary rocks. Locally, those flanking Amulsar Mountain, consist of multiple fining-upward cycles of volcanogenic conglomerate and mass flow breccia fining up to volcanogenic and marly mudstone and, locally, thin calcilutite limestone. Andesitic to dacitic volcanic and volcaniclastic units are sparsely interspersed low in the stratigraphy, but increase in frequency as higher stratigraphic levels are exposed on the flanks of the Amulsar Mountain ridge. The structure of these peripheral rocks is very simple; the strata are sub-horizontal and gently dipping, with little internal structure except where cut by steep faults".

As described in Holcombe (2013)[1], Lydian et al (2013)[2] and the 2014 Lydian geological map, the geological model of Amulsar is based on a division of the geological sequence into two units:

- The Amulsar Mountain upper volcano-sedimentary sequence – "Upper Volcanics" (UV) comprising weakly bedded volcanogenic feldspathic quartzite interbedded with abundant thin and thick lenticular masses and flow masses, andesitic volcanic flows and volcanic breccia which are strongly silicified throughout, with strong alunite alteration.
- The Amulsar Mountain lower volcano-sedimentary sequence – "Lower Volcanics" (LV), at higher altitudes this unit comprises predominantly pervasively argillically altered porphyritic andesite, most likely dominantly sub-volcanic intrusives (Lydian et al, 2013)[3]. However, it also incorporates the regional Palaogene volcanosedimentary sequence described above, in which volcanic and volcaniclastic units are only sparsely interspersed lower in the stratigraphy.

The Upper Volcanics outcrop on Amulsar Mountain and on the eastern mountain flank. The Lower Volcanics outcrop to the west of the mountain and occur underlying other units at lower elevations surrounding the mountain. The Lower Volcanics are extremely thick, outcropping from high elevations on the west of Amulsar Mountain (above 2700 m asl) to

below 1400 m asl in the gorge of the Arpa River, indicating a total thickness of more than 1300 m.

At lower elevations to the east and west of Amulsar Mountain ridge, and covering the northern face of the ridge, unaltered Cenozoic Flow Basalts overlie the Palaeogene volcano-sedimentary and intrusive rocks forming plateaus along the banks of the Vorotan River and Arpa River gorges. Not all of these flows are mapped in the current Lydian geological model, but the outcrops of the basalts are shown on the regional USSR geological map (Figure 4.8.2)[3]. Recorded basalt thicknesses are shown in Figure 4.8.3.

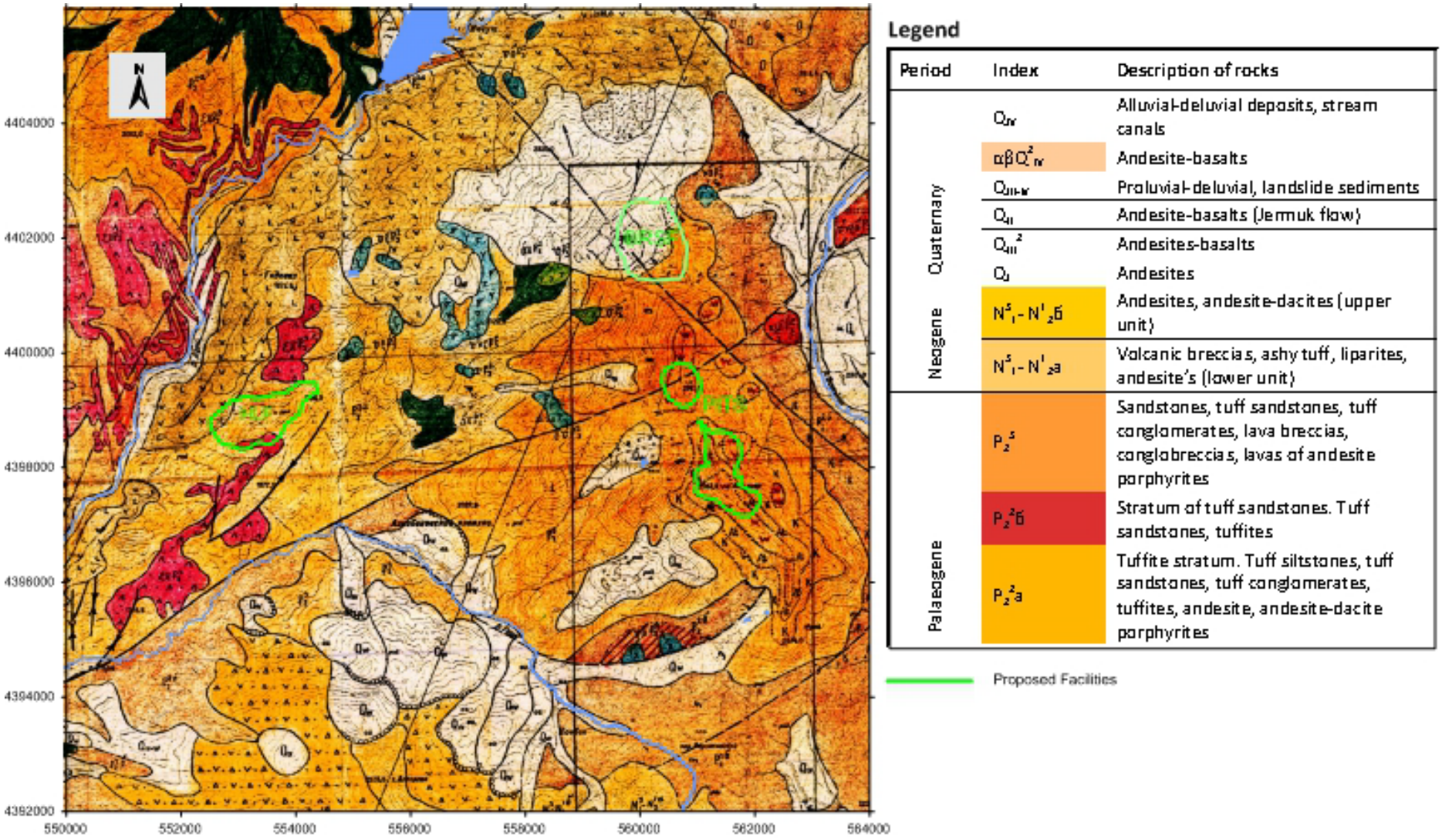


Figure 4.8.2: Regional Geological Map of the Amulsar Project Area (USSR, 1981)

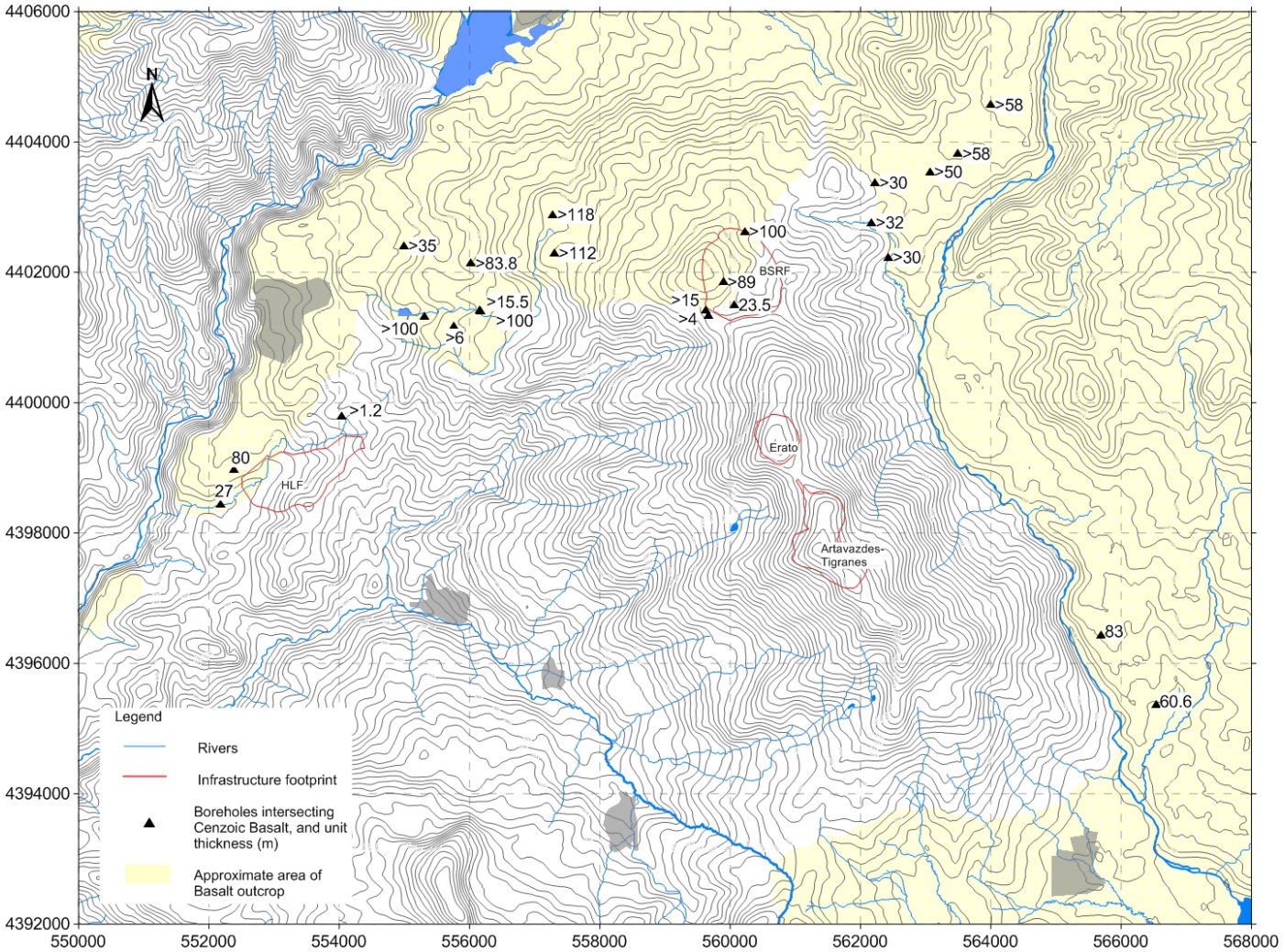


Figure 4.8.3: Depth to Base of the Cenozoic Flow Basalts, Geotechnical and Hydrogeological Borehole Records from Golder Site Investigations and Geoteam Coreholes

Throughout the Project area, colluvium (glacial-fluvial deposits) occurs overlying bedrock, ranging between tens of centimetres in thickness to greater than 10 m in some valleys. In general, this colluvium is described as sandy, silty, clay with gravel/boulders. On the steep hillslopes of Amulsar Mountain, the colluvium contains a greater component of fragmented rock. In the valley bottoms (such as the lower elevations of the BRSF site, the base of the valley to the east and the lower elevations of the HLF site) the deposits are silty clay alluvium.

Ore Body

A 3-D geological model has been developed by Holcombe (2013)[1] with subsequent modification by Lydian. Cross-sections (Holcombe, 2013[1] and Lydian et al, 2013)[2] illustrate the geological model (Figure 4.8.4 and Figure 4.8.5).

The Amulsar Mountain geological model (Holcombe, 2013)[1] is similar to a low temperature, low sulphide IOCG (iron oxide, copper, gold) deposit with some high temperature, high sulphide features. The result is a "chameleon" which looks superficially like an epithermal high temperature deposit (Lydian et al, 2013)[2]. Holcombe (2013)[1] summarises the concept as follows:

"The rock units used to define the geological model are very simple; a two-part division of the local rocks into siliceous host rocks (dominantly volcanogenic sediments) and clay altered rocks (dominantly porphyritic andesite) that are generally devoid of mineralisation. These two alteration-based lithologies are thought to reflect primary rock unit differences, although the original stratigraphic relationships between them are uncertain and blurred. The clay-altered rocks form sheet-like bodies of various thicknesses distributed through the silica-altered host rocks".

The concept is that of regional scale alteration, with many phases of tectonic activity resulting in complex faulting of originally bedded or pseudo-bedded formations, and mineralisation associated with later phases of faulting. The faulting, and associated alteration and mineralisation as a result of geothermal fluids, is most intense (locally) along the Amulsar Mountain ridge, resulting in argillic alteration of the Lower Volcanic Andesites (LVA). Although not indicated on the Lydian geological map, at lower elevations the Lower Volcanic unit is unaltered. In places the transition from altered to unaltered rock is clearly visible in aerial imagery of the site; furthermore waste piles generated by construction of the Kechut-Spandaryan tunnel (at an elevation of approximately 2000 m asl) comprise unaltered rocks.

In the vicinity of the ore bodies, the argillic altered Lower Volcanic Andesites (LVA) form sheet like bodies of varying thickness distributed throughout the silica altered host rocks. The distribution of the two primary lithologies is associated with original depositional relationships (the silica-altered rocks overlying the argillically altered rocks), and the many phases of subsequent brittle deformation. Holcombe (2013)[1] describes that "*prior to the deformations producing locally complex fold-thrust geometry, there was a set of at least four LVA bodies interleaved within the VC host (irrespective of the mechanism by which they were interleaved)*". The sequence is highly structurally complex and has been affected by at least four phases of deformation, including early stage east-vergent low angle thrust faulting (the Orontes Thrust), syn-mineralisation abundant faulting resulting in non-ductile fold structures and syn-mineralisation low angle faults, and late stage (post-mineralisation) north-east oriented horst and graben structures cross-cutting the resource.

The geological model extends generally to around 300 m depth. Holcombe (2013)[1] notes that "*structures apparently associated with mineralisation continue to depth below the current drilling levels*", suggesting that the highly fractured silicified sequence may persist to greater depth, and the alteration of the main units in this area is not confined to the near-surface. Lydian et al (2013)[2] describe the interleaved argillic and siliceous sequence as bounded by a lower 'basal contact' below which clay altered rocks persist below present drilling depths. Holcombe (2013)[1] describes the thickness of this basal LVA unit as unknown, but exceeding 150 m. The rocks below the basal contact in the resource zone are predominantly argillically altered porphyritic andesite, but away from the Amulsar Mountain ridge, the clay alteration merges into stratified and unaltered rocks.

Lydian et al (2013)[2] note that the greater prevalence of lenticular mass flow deposits in the volcano-sedimentary sequence surrounding Amulsar Mountain, combined with an anomalous cluster of plutonic and subvolcanic intrusives flanking the deposit provide strong indication that Amulsar Mountain evolved from "*a localised volcanogenic edifice which, at some time in its history, had an associated subvolcanic core".*

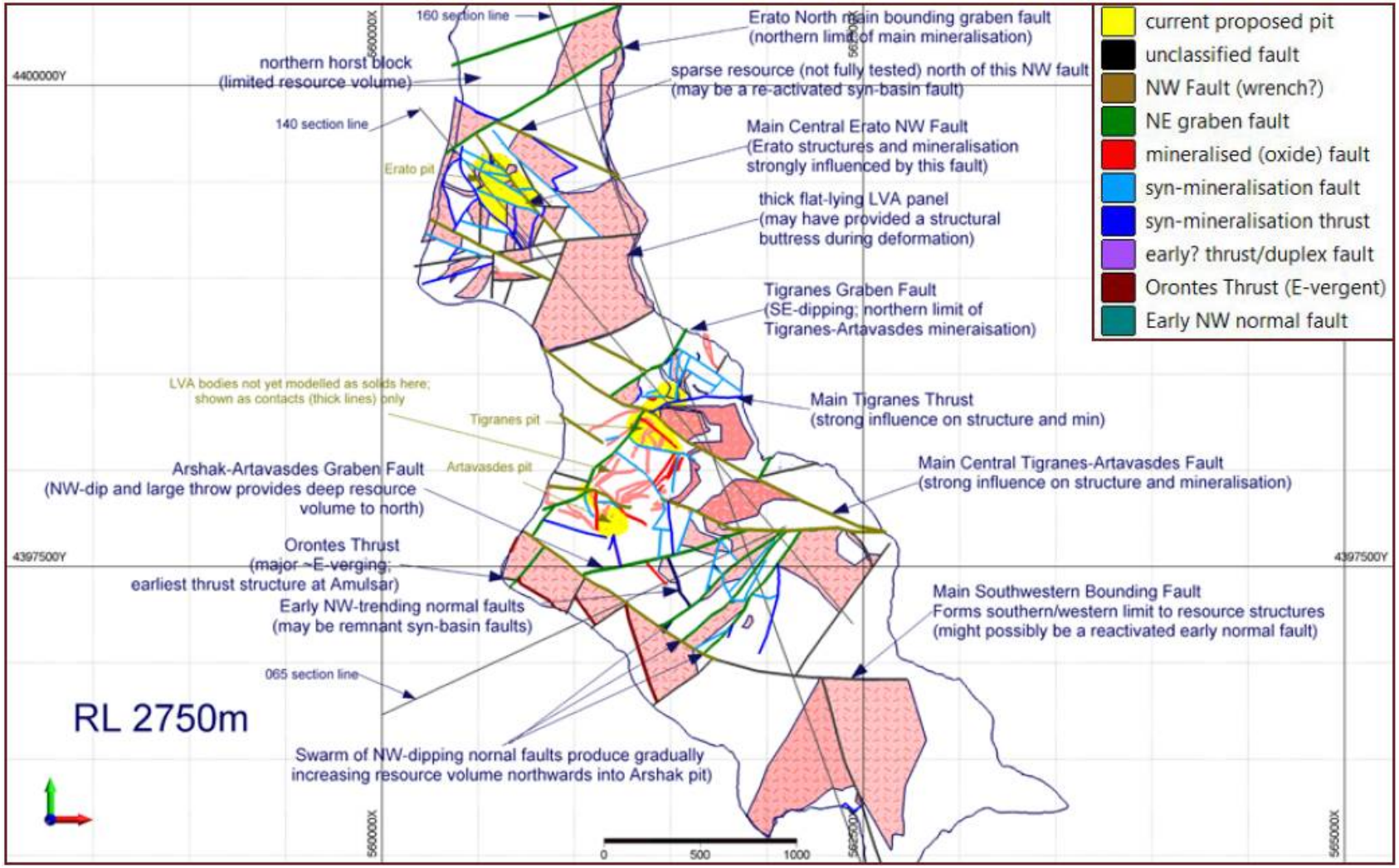
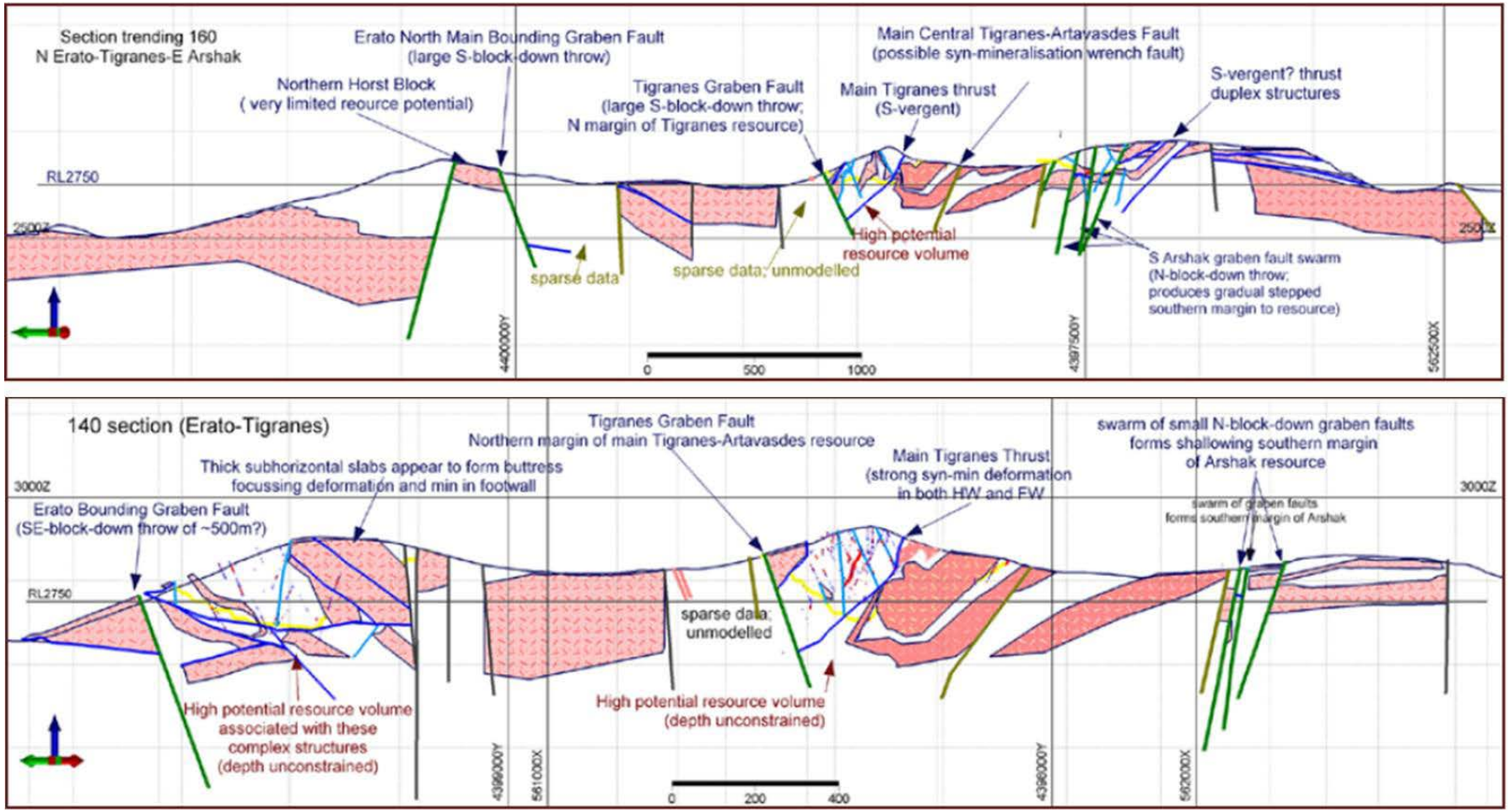


Figure 4.8.4: Plan section at 2750 m asl reproduced from Holcombe (2013), panels of the LVA unit are highlighted in pink, section lines are shown relating to sections reproduced below


Section trending 160
N Erato-Tigranes-E Arshak
Erato North Main Bounding Graben Fault
(large S-block-down throw)
Northern Horst Block
(very limited reource potential)
Tigranes Graben Fault
(large S-block-down throw;
N margin of Tigranes resource)
Main Central Tigranes-Artavasdes Fault
(possible syn-mineralisation wrench fault)
Main Tigranes thrust
(S-vergent)
S-vergent? thrust
duplex structures
RL2750
2500Z
sparse data
sparse data; unmodelled
High potential
resource volume
S Arshak graben fault swarm
(N-block-down throw;
produces gradual stepped
southern margin to resource)
4400000Y
4397500Y
562500X
0
500
1000
140 section (Erato-Tigranes)
Tigranes Graben Fault
Northern margin of main Tigranes-Artavasdes resource
Thick subhorizontal slabs appear to form buttress
focussing deformation and min in footwall
Main Tigranes Thrust
(strong syn-min deformation
in both HW and FW
swarm of small N-block-down graben faults
forms shallowing southern margin
of Arshak resource
3000Z
Erato Bounding Graben Fault
(SE-block-down throw of ~500m?)
RL2750
sparse data;
unmodelled
High potential resource volume
associated with these
complex structures
(depth unconstrained)
High potential resource volume
(depth unconstrained)
4396000Y
561000X
562000X
0
200
400

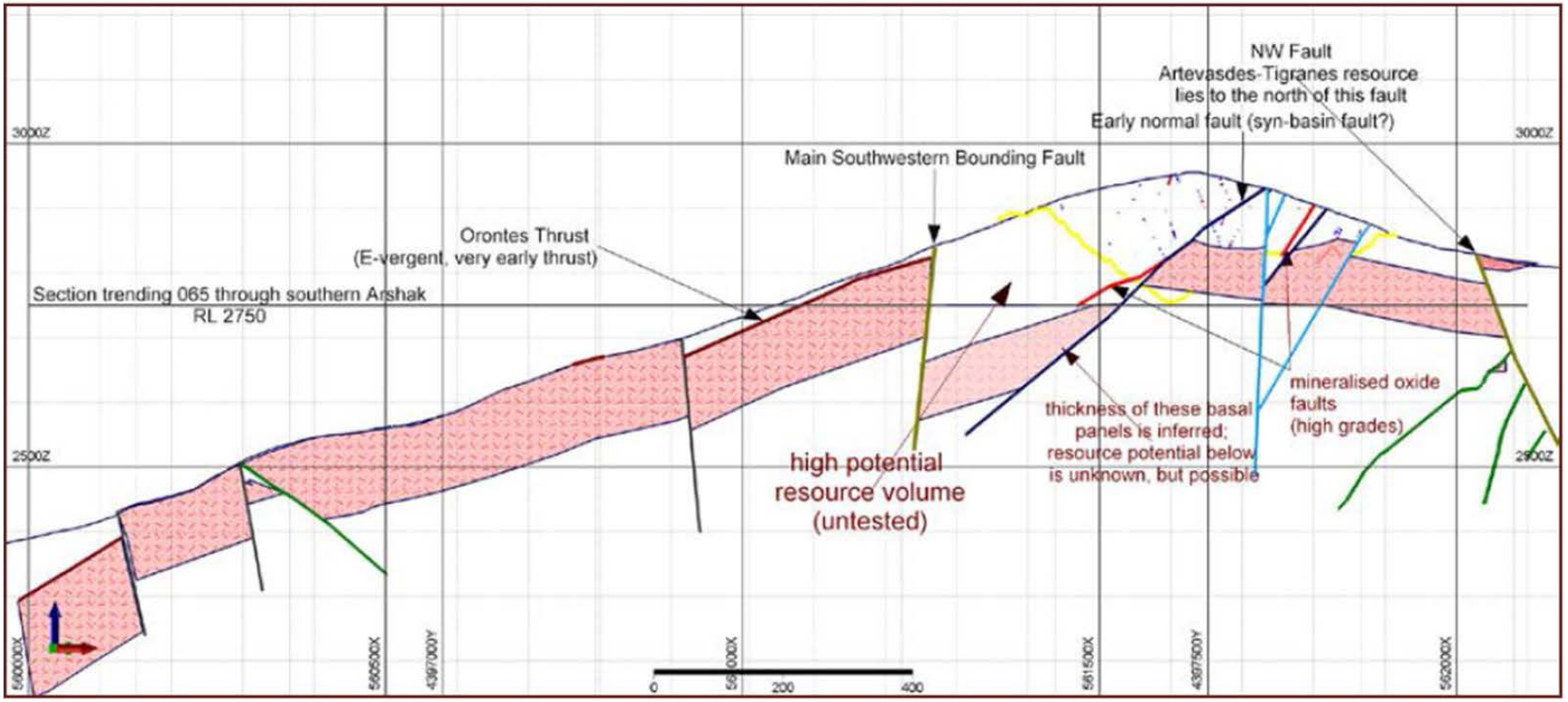


Figure 4.8.5: Sections trending 160, 140 and 065 reproduced from Holcombe (2013)[1]. The 150 m thickness of the western panel is conjectural

Crusher and Barren Rock Storage Facility (BRSF)

The BRSF site occupies a valley which steepens northward between North Erato and the peak of a basalt scoria cone which forms the north-west valley flank. At its north-eastern extent the BRSF laps onto the ridge forming the margin of a second valley basin opening east. The southern portion of the BRSF site contains relatively flat slope with thicker soil deposits, which narrows to form the main, relatively steep-sided valley, which runs south to north through the northern half of the site (Figure 4.8.6). This geological description is based on data from geotechnical investigations, Golder (2014a)[5].

The BRSF overlies a contact between saprolitic argillically altered andesite of the Lower Volcanics and the Cenozoic Basalts (Figure 4.8.6). A scoria cone is located on the northwest side of BRSF; the BRSF footprint incorporates the eastern flank of the cone.

The majority of the andesite has been both weathered and hydrothermally altered to the extent that it behaves similarly to clay. This argillically altered andesite has a saprolitic texture, in that the structure of the original rock is clearly visible but many of the minerals have weathered to clays. There are outcrops of this material in several locations along the south side of BRSF and along the ridge forming the eastern boundary to the site. In addition to the argillic andesite, there are outcrops of more competent andesite in the northeast portion of the site. Fresh unweathered andesite outcrops on the eastern side of the main drainage, in the vicinity of the proposed eastern abutment for the toe embankment. Fresh (unaltered) andesite was encountered in borehole DDAW004 in the north-eastern corner of BRSF, and in borehole RCAW400, 200 m to the north-east. Fresh andesite also occurs in boreholes situated on the western perimeter of the valley adjacent to the BRSF, approximately 200 m north of BRSF. Borehole data suggests that the ridge forming the margin between the two valleys has a core of more competent unaltered andesite.

The altered bedrock is overlain by colluvium comprising clay with varying amounts of silt, gravel, sand, and cobbles. Total thickness of colluvium ranges from less than 1 m along the sides of the scoria cone to greater than 10 m in the valley. In some geotechnical boreholes (e.g. along the western perimeter of BRSF), clayey soils are logged likely unconsolidated superficial deposits/colluvium and argillic andesite.

[5] Site 28 Waste Dump Facility Scoping Study. Golder Associates, 2014a; January 2014

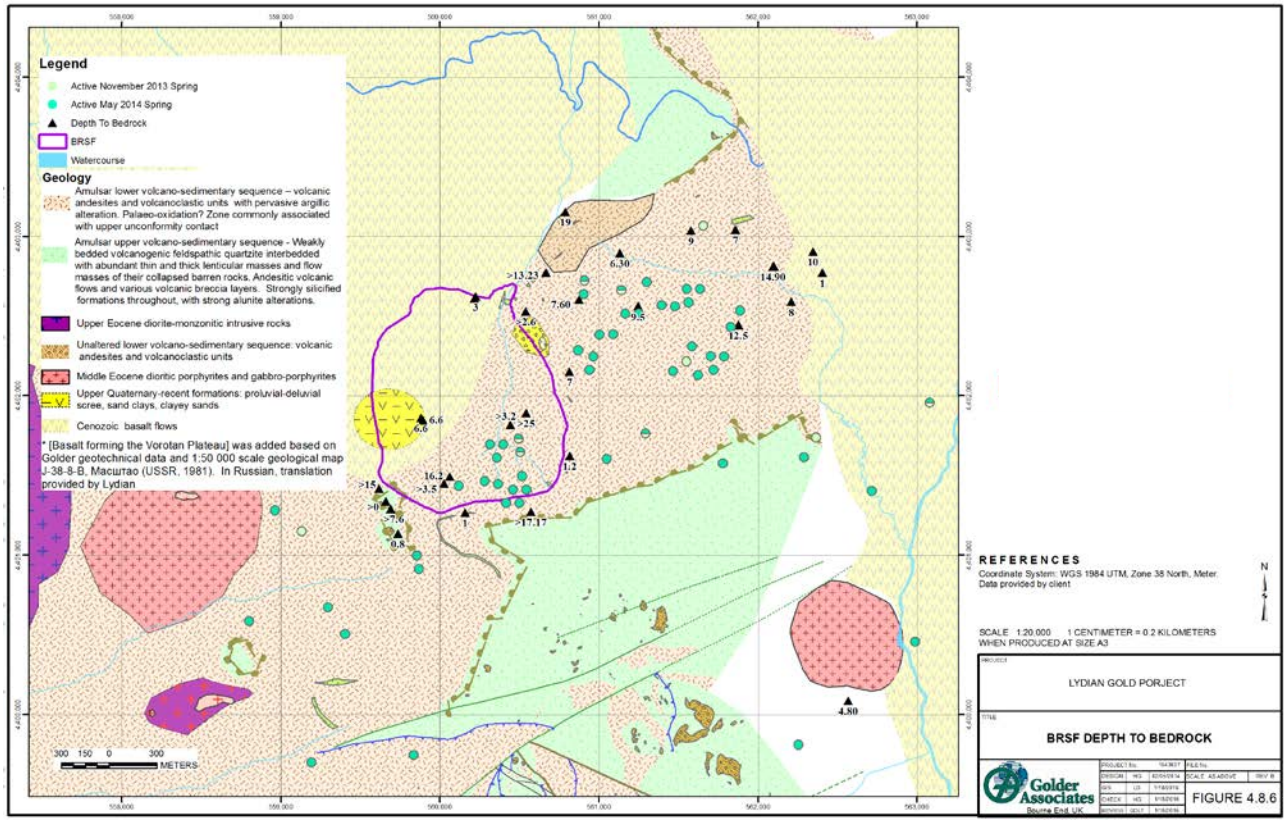


Figure 4.8.6: Depth to Bedrock (m) and Local Geology, BRSF

The geotechnical investigations did not determine the full thickness of the Cenozoic Basalt Flow. The basalts thicken to the north and are at least 90 m in thickness on the western margin of BRSF and 100 m in thickness in borehole DDAW013, located within the basalts immediately north of the BRSF (Figure 4.8.3). Clayey material was encountered at 98 m to 100 m at the base of DDAW013 which may represent either a sedimentary interbed in the basalt sequence, or the contact between the basalts and the underlying deposits. In other parts of the Project area, the basalt sequence is about 100 m thick. Within the basalt, there are lenses of scoria material and some areas where thicker scoria deposits exist. For example, notable scoria deposits exist near the proposed crusher area and also along the north end of the ridgeline on the east side of the main BRSF drainage.

To the south, the BRSF footprint follows the outcrop of the contact between the Upper (silicified) and Lower (argillic) Volcanics. The contact dips south-east at this location, and silicified rocks occur to the south-east. The argillic Lower Volcanics occur outcropping along the mountain flank to the west of BRSF. The Lydian geological model identifies this contact as the base of the interleaved silicified and argillic sequence, such that BRSF is anticipated to be underlain by argillically altered porphyritic andesite to a depth of at least 150 m.

Heap Leach Facility (HLF)

The description of geological conditions at the HLF is based on the findings of the geotechnical investigation Golder (2014b)[6].

The HLF is located overlying a geological contact between competent, slightly to moderately weathered andesite and younger slightly weathered to highly weathered basalt. The basalt is in general more uniform in texture and composition than the andesite. The basalt is dark grey to black, hard, and is columnar. The basalt forms steep outcrops along the northwest side of the main HLF drainage. The andesite-basalt contact is found on the southwestern portion of the site along the main drainage that runs roughly north/northeast to south/southwest. Shallow bedrock (<2m) is found below the ridges at the HLF site. The overburden soil in the centre of the valley consists mostly of clay with varying amount of sand, gravel, cobbles, and boulders. The overburden soil along the ridges and in the bottom of the valley contains more sand with varying amount of clay, gravel, and cobbles. Total soil thickness ranges from 0.3 m on some ridges to approximately 14 m in the centre of the valley.

The depositional environment of the andesite (shallow sub-marine volcanic activity) has produced relatively horizontal beds, which have remained near their original orientation. There are textural and mineralogical differences in the andesite. Some beds contain relatively uniform, relatively small plagioclase phenocrysts (1-3mm), within the mafic groundmass, while others contain larger xenoliths (up to several centimetres in size). The quantity of plagioclase phenocrysts varies between beds as well. Outcrops with higher quantities of plagioclase appear blue/grey in colour, while those beds with fewer plagioclase phenocrysts have a darker colour. In addition, the andesite contains frequent intrusions of harder, more competent rock at various orientations.

The andesite is slightly to highly weathered with highly weathered zones generally occurring in the upper 10 m. Strength values range between very weak rock and medium strong rock, with most andesite having medium strengths and occasional very weak rubble zones. The joint sets within the andesite are generally planar with calcite and iron oxide staining. Golder (2014b)[6] reports an RQD of as high as 90 to 100 percent, and generally above 60 percent in the slightly weathered zones below 10 m indicating that the andesite is generally relatively

[6] Site 28 Heap Leach Facility Scoping Study, Amulsar Gold Project, Central Armenia, Golder Associates, 2014b

competent.

Within the andesite, there are also thin beds of clastic sedimentary rock. These beds were deposited during periods with an extended lull in volcanic activity, allowing accumulation of non-volcanic materials. Outcrops of a cherty mudstone were observed within the eastern portion of HLF, at an elevation of approximately 1780 m. The outcrop trends from the south to the north to northwest across the site, and appears to increase in elevation slightly as the bed extends to the north. The mudstone has a distinctive red/purple colour, and is hard and very well cemented.

Outcrops of limestone are visible in the two valleys south of HLF at elevations between approximately 1750 and 1770 m. There is no evidence of limestone beds within HLF. The limestone beds are believed to either pinch out or transition into the cherty mudstone beds observed within HLF. There were observations of some secondary carbonate infilling in joints within the andesite.

As shown in Figure 4.8.3, the basalt flow underlying the western part of HLF varies in thickness, thinning to the south-west (proven at 27 m depth in GGDW016 approximately 200 m south-west of the site perimeter), and recorded at 80 m at the western perimeter. The basalt flow underlies Site 14, situated to the north-east and in this area the flow is considerably thicker, (more the 100 m). In the HLF, the basalt is relatively competent (RQD greater than 50%) at depths greater than 10m but is more extensively weathered and fractured in the upper 10 m.

Superficial deposits (colluvium) in the HLF generally comprise sandy clay to clayey sand. Due to the topography, the soil thickness on ridges is much less (0.3 – 5 m) than the thickness in the valleys (up to 14 m). One exception was BH-407, where 11 m of sand was identified on a ridge.

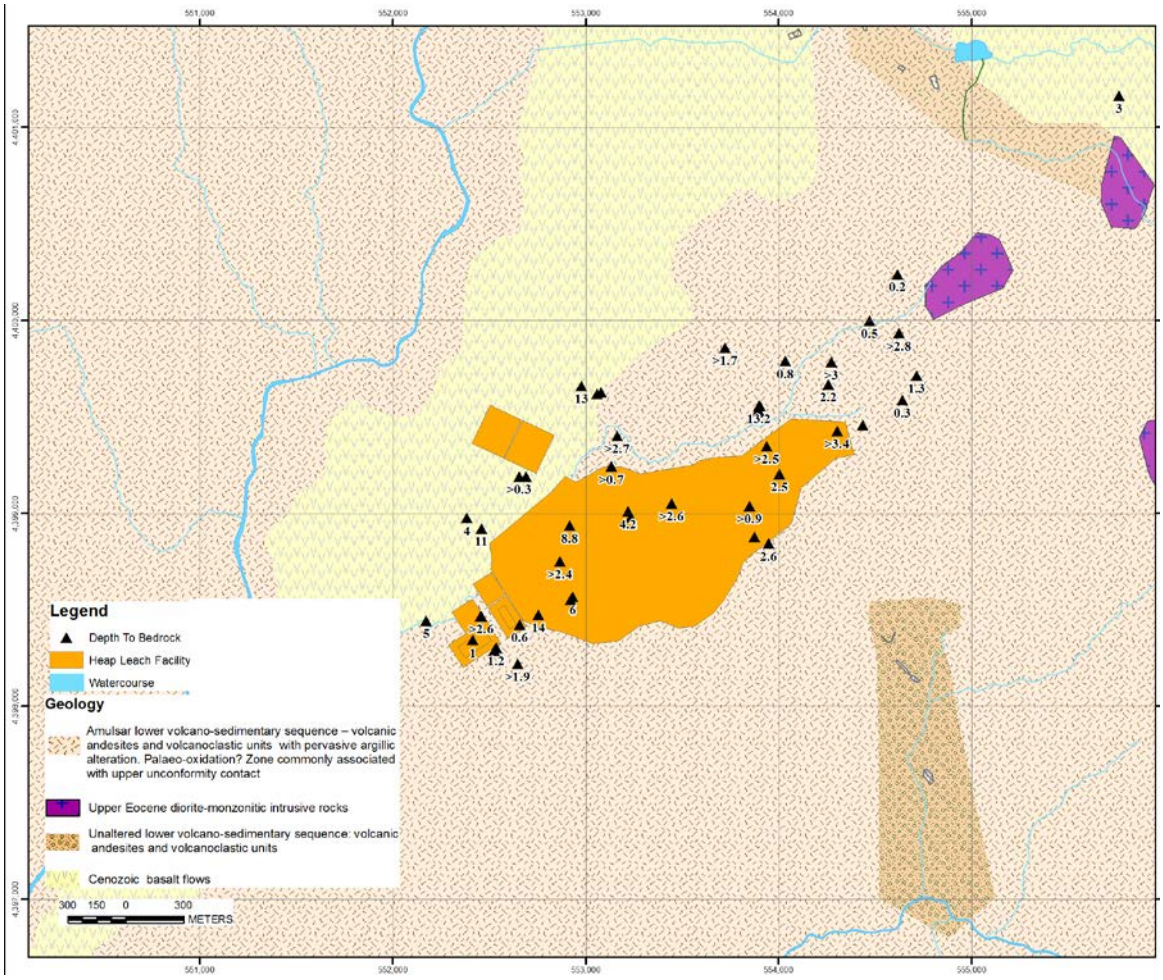


Figure 4.8.7: Depth to Bedrock (metres), HLF Site

4.8.2 Hydrogeological Units

Based on the geological conceptualisation described above, five hydrogeological units are delineated in the Amulsar Project area.

Colluvium

Colluvium overlies the bedrock throughout the Project area varying between less than 1 m and up to 20 m in thickness. The properties of the colluvium are variable, ranging between cobbles with some silt and clay, and silty clay with little gravel or cobbles with associated variation in permeability. The colluvium is saturated in some parts of the Project area. In stream valleys at lower elevations in the Project area, the silty clay colluvium acts as an aquitard, supporting perched groundwater (such as the valley north-east of the HLF) or confining underlying units (such as in the valley east of the BRSF, where groundwater discharge results in flowing artesian (above ground surface groundwater elevation) conditions observed in groundwater wells in the valley bottom). In other areas, such as on

the mountain flanks where coarser-grained colluvium overlies the argillic LVA, it is more likely that the colluvium supports shallow groundwater flow. The colluvium behaves as a porous medium, with flow in the primary porosity of the sediments.

Upper Volcanics

The silicified Upper Volcanics (VC) hosting the ore body outcrops along the mountain ridge and on the eastern flank of Amulsar Mountain. It includes both perched and seasonal groundwater bodies where blocks are isolated by surrounding faults or LVA panels, and fully saturated year-round groundwater as part of the larger-scale groundwater flow system. The Upper Volcanics have minimal primary porosity; porosity and permeability is associated with secondary fracturing. The VC extend to a depth of at least 300 m beneath Amulsar Mountain, with interspersed layers of the LVA (Figure 4.8.5). Given the extensive silicification and intense faulting of this unit, the VC are more permeable than the surrounding argillically altered LVA.

Altered Lower Volcanics

The argillically altered Lower Volcanic Andesite (LVA) occurs in layered 'panels' within and beneath the highly faulted ore bodies (Figure 4.8.5), and outcrops to the west and north of Amulsar Mountain. As described above, the argillic alteration fades out at lower elevations, and is absent typically below around 2000 m asl, though the elevation of the transition is variable. The geological model indicates that the argillically altered LVA extends to considerable depth beneath the ore bodies (Figure 4.8.5, at least 200 m to 300 m), but the maximum depth is unconstrained.

Although the extent of argillic alteration varies spatially, the LVA unit predominantly comprises an amorphous clay at Amulsar Mountain with a large total porosity, but low drainable (effective) porosity. In areas where the argillic Lower Volcanics occur as part of the VC/LVA sequence beneath the Amulsar Mountain ridge, this unit is likely to act as an aquitard, potentially supporting perched groundwater.

Unaltered Lower Volcanics

The unaltered Lower Volcanics, comprising a thick, sub-horizontally bedded sequence of andesite, volcanic sediments (tuffs) and sedimentary rocks, outcrops at lower elevations surrounding Amulsar Mountain. The Lower Volcanics is at least 1300 m in thickness in the Amulsar Project area. Particularly at lower elevations the unaltered Lower Volcanics is

heterogeneous, comprising a layered sequence with varying hydraulic properties. Andesites within the sequence have minimal primary porosity and relatively low fracture porosity and low to moderate permeability. Tuffs may also be well cemented and fractured, or may have significant matrix porosity. Mass flow breccia and volcanogenic conglomerates at the base of the sequence may be highly permeable. The deposition of the sequence is understood to be sub-marine and as such, sedimentary horizons deposited during intervals between volcanic events typically have low permeability due to relatively high clay contents.

On a large scale the unaltered Lower Volcanics is likely to have significantly greater horizontal than vertical permeability, as low permeability horizons within the sequence will restrict vertical flow. This interpretation is supported by the observation of springs within this unit, for instance, in the vicinity of the HLF site.

Cenozoic Basalt Flows

The Cenozoic Basalt Flows overlie the Lower Volcanics on plains to the east, west and south of Amulsar Mountain, and extending north-west from the scoria cone which forms the peak north of the BRSF. The basalts are at least 120 m in thickness. In places, the basalts are intensely fractured and relatively permeable. Drilling has encountered very highly fractured 'rubble' zones within the basalt sequence (possibly flow tops or flow bottoms or scoria zones) which are interpreted to be permeable. Where saturated, the "rubble zones" within the basalts will act as an aquifer. Columnar sections of basalts or entablature sections are typically lower permeability. The permeability of sedimentary interbeds depends on their composition.

Man-made Features

Man-made features have the potential to significantly influence groundwater flow in the Amulsar Project area. The following features have been identified within the GSA:

- The Kechut-Spandaryan tunnel, which connects the Spandaryan Reservoir in the south with the Kechut Reservoir in the north of the GSA (Figure 4.9.3). The start of the tunnel is assumed to be at approximately 2033 m asl, based on topographic information. The end of the tunnel is assumed to be at approximately 1998 m asl, a drop of 35m over a

length of 21.1 km. Design information (Babayan et al, 1988)[7] suggests that the tunnel was concrete lined at the time of construction, potentially restricting interaction with groundwater. Under current conditions, the tunnel is not operational (gates at the Spandaryan Reservoir are closed, preventing inflow), but significant discharge from the tunnel occurs. Water chemistry (Section 4.8.7) suggests current flow discharging from the tunnel is groundwater. It is assumed that the concrete lining of the tunnel has been damaged and groundwater is able to enter the tunnel. Groundwater modelling (see Appendix 6.9.1) indicates that the tunnel is at or just below the regional water table over much of its length, but only significantly below the water table in the north of the GSA. Groundwater can thus enter the tunnel along its full length.

- A former mineral exploration adit (the "AW030 adit") extends from monitoring location AW030 (also known as SP13.7) at an elevation of 2429 m asl in the valley to the east of the BRSF travelling south-west beneath the BRSF. A permanent groundwater discharge is observed from this adit; the flow rate and quality of the discharge is monitored at location AW030 (the adit entrance). Lydian indicates that the adit extends to beneath approximately the centre of the BRSF valley, with a number of branches[8]. This suggests that the adit is approximately 80 m below ground in the centre of the BRSF site, and more than 650 m in length.
- Three former mineral exploration adits are located immediately to the north of the BRSF site (entrances at approximately 2480 m asl) extending east. Lydian indicates that these adits do not intersect the adit described above[8]. Given the elevation of the adit entrances and local topography, these adits are unlikely to lie more than 40 m below ground. These adits are understood to be less extensive than the AW030 adit. No continuous flow is observed to discharge from these smaller adits.

4.8.3 Hydraulic Properties

Hydraulic Conductivity

Packer testing and falling and rising head tests in wells at the ore body, HLF, BRSF and other locations have been completed to estimate the hydraulic conductivity of the geological units. The hydraulic testing data are presented in Appendix 4.8.1. Statistical summaries of the hydraulic conductivity of the hydrogeological units is presented in Table 4.8.1 and shown

[7] Engineering design and production efficiency – Arpa-Sevan Tunnel. Babayan, et al. 1988. Translated from Gidrotekhnicheskoe Stroitel'stvo, No.10, pp.18-25, October 1988 and published in Power Technology and Engineering, Vol.22, No.10 (1988), pp.574-583.

[8] A. Turner, Pers. Comm., 2014

graphically in Figure 4.8.8. Figure 4.8.9 and Figure 4.8.10 show the distribution of permeability test results with depth. Hydraulic conductivity tests from screened well sections (falling/rising head tests) are likely to report a positive bias in comparison to packer tests as wells will preferentially target permeable zones. However, at the large scale, the permeability of the lithological units will be dominated by permeable zones in the lithological sequence.

Table 4.8.1: Summary of Hydraulic Properties, Amulsar Hydrogeological Units

Unit	Areas Tested	Hydraulic Conductivity (m/s)			Number of Tests*
		Minimum	Maximum	Geometric Mean*	
Upper Volcanics (VC)	Ore body	$1.0x10^{-10}$	$3.0x10^{-4}$	$2.3x10^{-8}$	10
Lower Volcanics (unaltered)	HLF, Wider Project Area	$1.1x10^{-8}$	$2.0x10^{-4}$	$2.6x10^{-6}$	21
Lower Volcanics (argillically altered)	Ore body, BRSF/Crusher, Wider Project Area	$1.0x10^{-9}$	$3.0x10^{-5}$	$8.5x10^{-8}$	10
Cenozoic Basalt Flows**	BRSF, HLF, Wider Project Area	$1.0x10^{-9}$	$5.5x10^{-5}$	$1.1x10^{-6}$	31
Colluvium	BRSF	$5.3x10^{-9}$	$1.4x10^{-5}$	$2.7x10^{-7}$	2

Notes:
* Where a range was reported from test analysis, both the minimum and maximum have been included in summary statistics. A total of 59 tests were completed, 55 of which could be interpreted, 26 in the LV, 20 in the Cenozoic Basalts and 6 in the VC.
**Two tests reported no observable change over the test monitoring period. These have been included in the summary statistics as a hydraulic conductivity of $1x10^{-9}$ m/s.

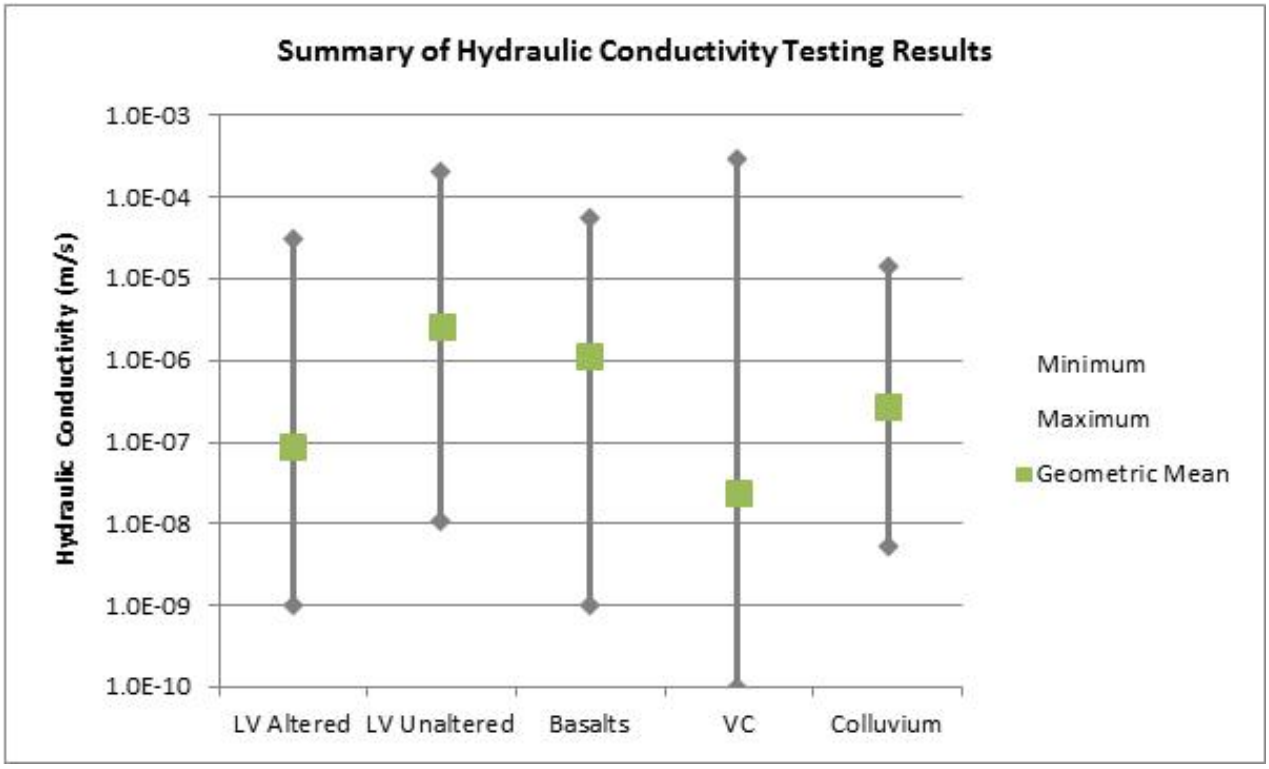


Figure 4.8.8: Summary of Hydraulic Conductivity Testing Results, Aggregated by Hydrogeological Unit

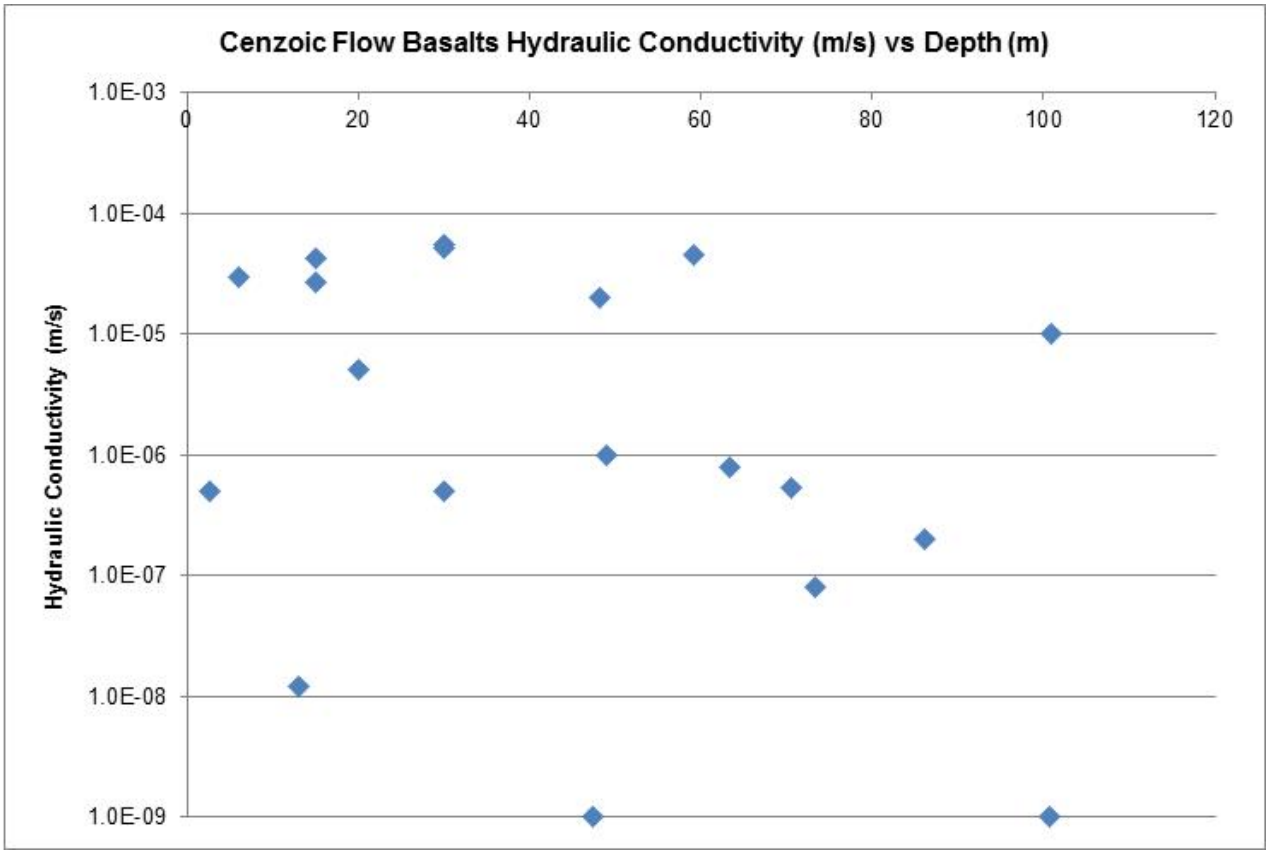


Figure 4.8.9: Cenozoic Flow Basalts, Hydraulic Conductivity with Depth

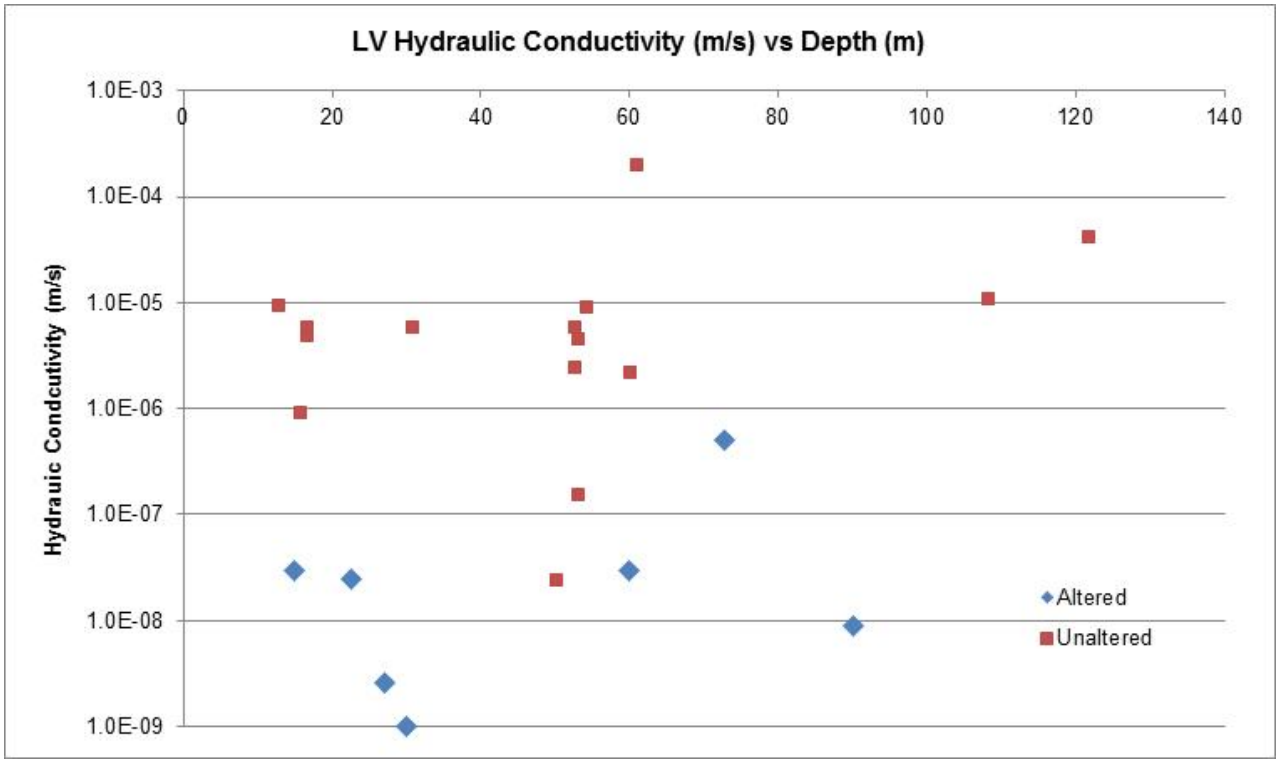


Figure 4.8.10: Lower Volcanics, Hydraulic Conductivity with Depth

The Upper Volcano-sedimentary sequence (upper volcanics, VC) is highly silicified, resulting in the formation of a strong, hard, fractured rock. The geometric mean from the testing work suggests a hydraulic conductivity of 2.3 x 10^{-8} m/s, which is less permeable than the altered LVA. Given the rock properties, the testing is believed to have under-estimated the hydraulic conductivity of the VC and over a larger scale the hydraulic conductivity is likely in the range of the unaltered LV, or slightly higher.

The unaltered Lower Volcanic sequence is distinctly more permeable than the argillically altered LVA surrounding Amulsar Mountain. In general, the material tested comprises fractured andesites and some tuff deposits, encountered in the HLF area and the valley to the north-east of this site. No significant sedimentary or volcanogenic conglomerate sequences were encountered in the areas investigated.

The Cenozoic Basalts are relatively similar in structure, degree of fracturing and permeability, at all locations encountered in the Project area, though this unit has the potential for considerable internal heterogeneity, because of sedimentary deposition during volcanic interludes, scoria deposits, and more permeable 'flow top/flow bottom' zones within the basalt sequence. As a result, there can be a wide range of hydraulic conductivities in units logged as "basalt". Test results shown in Figure 4.8.9 include tests completed in different parts of the internal geological structure of the basalt flow and are likely to reflect a range of material properties depending on position within the flow, ranging from intact to highly fractured 'flow tops'.

Both the flow basalt sequence (which contains interflow sedimentary horizons, and more permeable 'flow top and flow bottom' fractured zones), and the underlying Lower Volcanics (which here incorporate andesites, tuffs and sedimentary units) are relatively horizontally bedded. Therefore, the horizontal hydraulic conductivity may be greater than the vertical hydraulic conductivity. This interpretation is supported by observation of spring seepages associated with lithological changes within the Lower Volcanics and at the contacts with sedimentary horizons in the basalts (Section 4.9.2).

The hydraulic property values which are considered appropriate for risk assessment/modelling purposes as part of the groundwater impact assessment in each of the main facility areas is summarised in Table 4.8.2. These values are estimated representative

values at the Project area scale, the influence of variation within the range indicated by hydraulic testing will require further consideration through sensitivity analysis.

Table 4.8.2: Summary of Hydraulic Conductivity Values for Application in Impact Assessment

Hydrogeological Unit	Site Area	Hydraulic Conductivity (m/s)	Anisotropy (Kh:Kv)	Justification/Comment
Colluvium	All	$2x10^{-6}$	10	Golder experience. The properties of the Colluvium are likely to be variable across the Project area and little site specific testing is available. This value is a conservative estimate of permeability for a silty sandy clay and is the estimate of the hydraulic conductivity of this unit based on the calibrated groundwater flow model (see Appendix 6.9.1). Given variability across the Project area, alternative values could be justified at specific locations based on local data.
Argillic Lower Volcanics	All	$8.5x10^{-8}$	1	Geometric mean of all test values. Given the size and variance of the testing data set, it is not appropriate to use single values to estimate more localized properties.
Unaltered Lower Volcanics	All	$2.6x10^{-6}$	100	Geometric mean of all test values, the majority of these data are for the HLF area, testing east of the BRSF in unaltered Lower Volcanics does not significantly alter the geometric mean. The composition of the Lower Volcanics allows potential for high vertical anisotropy.
Upper Volcanics	All	$2x10^{-7}$	1	Estimated hydraulic conductivity based on the calibrated groundwater flow model (Golder, 2014c). As described above, the hydraulic testing data set is considered to under-estimate the permeability of this unit and observed groundwater flow behaviour is consistent with a higher permeability.
Cenozoic Flow Basalts	All	$1.1x10^{-6}$	10	Geometric mean of hydraulic conductivity testing. Although internally heterogeneous, the morphology and permeability of the basalt flows is relatively similar across the Project area.

Hydraulic Conductivity at BRSF Site

The hydraulic properties for the geological units underlying the BRSF and the adjacent valley are presented in Table 4.8.3 and Figure 4.8.11.

Table 4.8.3: Hydraulic Conductivity Test Results, BRSF and Surrounding Area					
Lydian ID	**Test interval top (mgbs)**	**Test interval bottom (mbgs)**	**Test Type**	**Tested Lithology**	**Hydraulic Conductivity (m/s)**
RCAW401	Annulus not sealed, response zone includes the saturated water column		Falling head	Andesite with advanced argillic alteration (LVA)	$3x10^{-5}$
RCAW399			Falling head	Fresh andesite porphyry (LVA)	$2x10^{-5}$
RCAW400			Falling head	Argillic altered and (fractured) fresh andesite porphyry (LVA)	$1x10^{-4}$
GGSC049	13	19	Falling head	Clay (13 - 16 m) and Basalt (16 - 19 m)	$1.2x10^{-8}$
GGSC050	10	16	Falling head	Sandy clay (Colluvium?)	$1.4x10^{-5}$
GW-501B	23	29	Falling head	Cenozoic Flow Basalt	Unable to analyse data
DDAW011A	30	49	Packer test	Cenozoic Flow Basalt	$1.2x10^{-5}$ to $5.5x10^{-5}$
DDAW011A	48.1	89	Packer test	Basalt and scoria (80 - 89 m)	$8.9x10^{-6}$ to $2.0x10^{-5}$
DDAW013	30	60	Packer	Cenozoic Flow Basalt	$5.2x10^{-5}$
DDAW013	59.1	85	Packer test	Cenozoic Flow Basalt	$4.5x10^{-5}$
DDAW012	27	33	Falling head	Argillic andesite (MW, R2) (LVA)	$2.6x10^{-9}$
DDAW012	22.6	34	Packer test	Argillic andesite (MW, R2) (LVA)	$2.5x10^{-8}$

In the south of the BRSF, the moderately weathered argillic andesite was low permeability (10^{-8} to 10^{-9} m/s). In the adjacent valley, boreholes intersecting fracture zones in the fresh unaltered andesite (e.g. RCAW400, RCAW399) reported moderate to high permeability, as did RCAW401, which was logged as andesite with advanced alteration (though indicated by the Lydian geological map to lie at the margin of a less altered zone). Lower hydraulic conductivity is expected in the unfractured andesite at greater depth. In general the basalts were found to be moderately permeable (10^{-5} to 10^{-6} m/s). It is considered likely that much of the argillic andesite which underlies the BRSF valley and occurs in the bottom of the valley to the east is significantly less permeable.

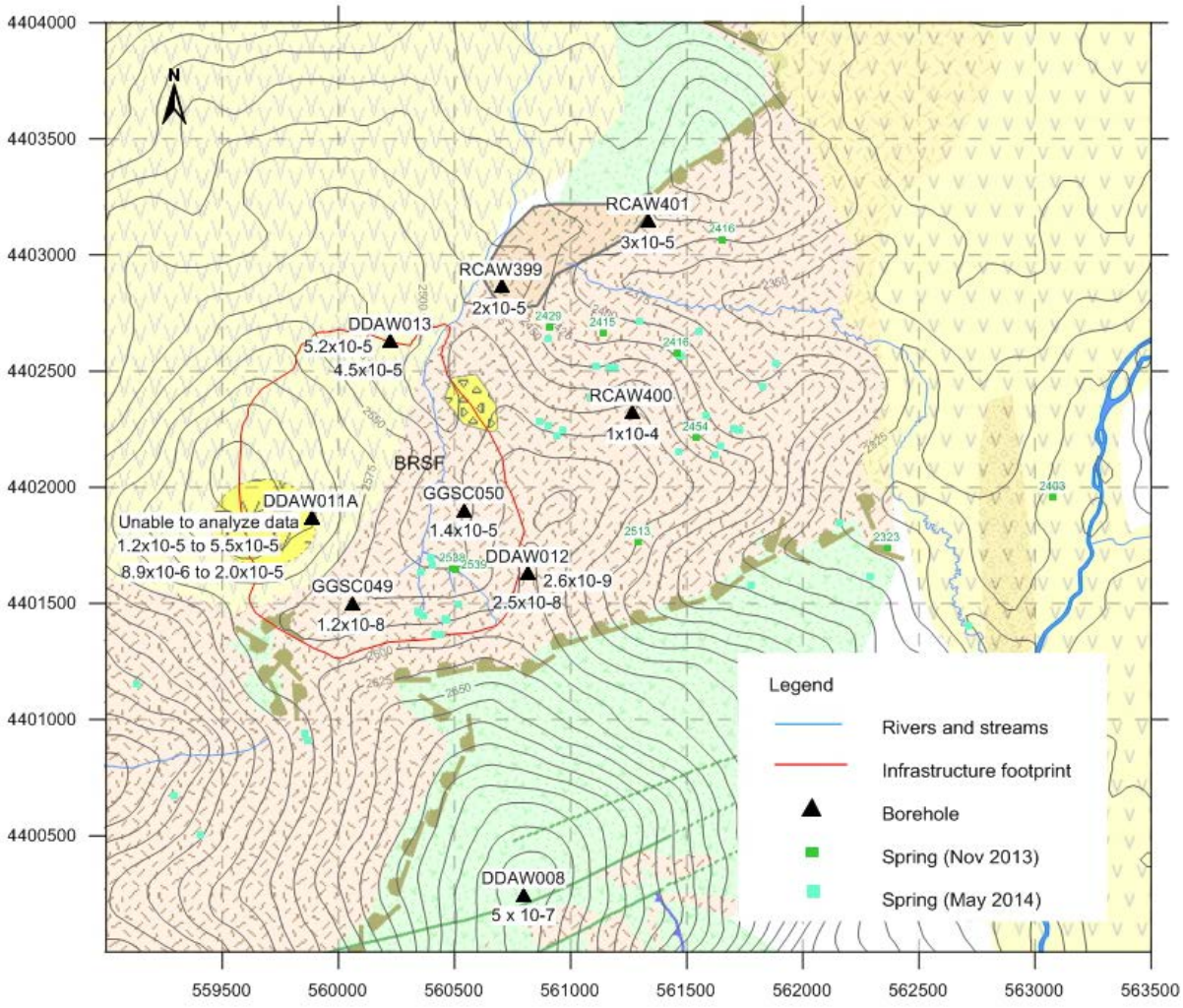


Figure 4.8.11: Distribution of Hydraulic Conductivity Test Results (m/s), BRSF and Surrounding Area

Note: the legend for the Lydian geological map shown in Figure 4.8.11 is shown in Figure 4.8.6.

Hydraulic Conductivity at HLF Site

The hydraulic properties for the geological units underlying the HLF site are presented in Table 4.9.1. Both the Cenozoic flow basalts and tuff/andesite units have primarily secondary fracture porosity with low matrix porosity. The Lower Volcanic Andesite in the HLF site has only minor alteration and is essentially unaltered fractured rock. In fractured rock, permeability will be highly variable, depending on the frequency and size of fractures intersected in each borehole.

Table 4.9.4: Hydraulic Conductivity Test Results, HLF Site					
Lydian ID	**Test interval top (mgbs)**	**Test interval bottom (mbgs)**	**Test Type**	**Tested Lithology**	**Hydraulic Conductivity (m/s)**
GGSC035	4	11	Falling head	Gravelly clay (colluvium)	$5.3x10^{-9}$
GGDW016A	6	12	Falling head	Cenozoic Basalt	$3.0x10^{-5}$
GGDW016	53	59	Falling head	Andesite (SW, R3) (LVA)	$4.6x10^{-6}$
GGDW016	15	29.2	Packer test	Cenozoic Basalt	$6.2x10^{-7}$ to $4.2x10^{-5}$
GGDW016	15	30	Packer test	Cenozoic Basalt	$1.2x10^{-5}$ to $2.7x10^{-5}$
GGDW014	70.5	79.5	Falling head	Cenozoic Basalt	$5.3x10^{-7}$
GGDW013	54	60	Falling head	Andesite (SW, R2) (LVA)	$8.9x10^{-6}$ to $9.1x10^{-6}$
GGDW013	15.6	34.5	Packer test	Andesite (SW, R2) (LVA)	$1.1x10^{-8}$ to $9.3x10^{-7}$
GGDW010A	16.6	22.6	Falling head	Argillic tuff-andesite (LV)	$4.9x10^{-6}$
GGDW010A	16.6	22.6	Falling head	Argillic tuff-andesite (LV)	$6.0x10^{-6}$
GGDW010B	60	69	Falling head	Argillic andesite (SW, R2) (LVA)	$2.2x10^{-6}$
GGDW015	53	59	Falling head	Andesite (SW, R3) (LVA)	$1.6x10^{-7}$
GGDW015	12.6	30	Packer test	Andesite (SW, R3) (LVA)	$2.0x10^{-7}$ to $9.5x10^{-6}$
GGDW015	30.6	60	Packer test	Andesite (SW, R3) (LVA)	$1.2x10^{-8}$ to $5.9x10^{-6}$
GGDW007	121.5	127.6	Falling head	Andesite (LVA)	$4.3x10^{-5}$
GGDW008	52.5	58.5	Falling head	Andesite (SW, R3) (LVA)	$2.5x10^{-6}$
GGDW008	52.5	58.5	Falling head	Andesite (SW, R3) (LVA)	$6.0x10^{-6}$
GGDW011	50	59	Falling head	Argillic andesite (SW, R3) (LVA)	$2.5x10^{-8}$
GGDW012	60.9	69.9	Falling head	Argillic andesite (LVA)	Unable to analyse data
GGDW012	60.9	69.9	Falling head	Argillic andesite (SW, R2) (LVA)	$2.0x10^{-4}$
GGDW009	108	117	Falling head	Argillic andesite (SW, R4) (LVA)	$1.1x10^{-5}$

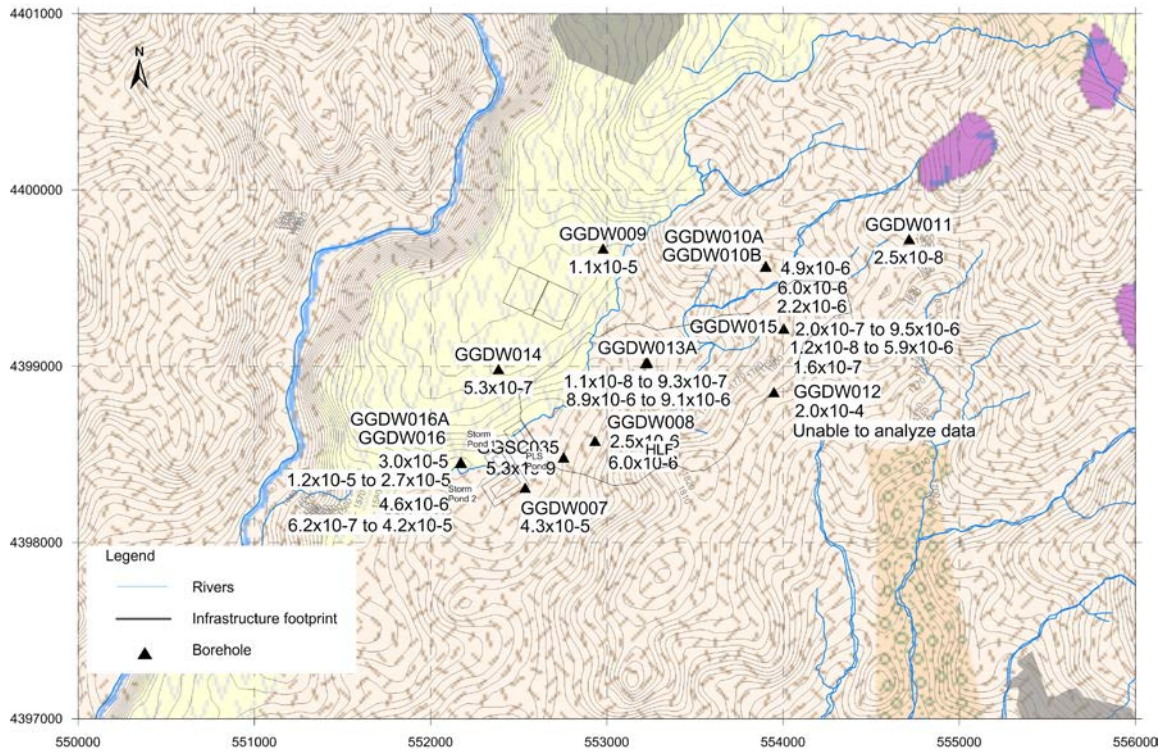


Figure 4.9.12: Hydraulic Conductivity Test Results (m/s), HLF Site

Note: the legend for the Lydian geological map shown in Figure 4.9.1 is shown in Figure 4.8.6.

The Cenozoic Basalt Flows underlying the BRSF site are moderately permeable ($5x10^{-7}$ to $5x10^{-5}$ m/s) and are marginally more permeable than the underlying unaltered Lower Volcanics. Hydraulic conductivity of the Lower Volcanics is highly variable, as would be expected for a fractured rock. The mean hydraulic conductivity of the Lower Volcanics beneath the HLF is $1.9x10^{-6}$ m/s; this is similar to the mean value for the Project area as a whole. A single test completed in the Colluvium within the proposed HLF footprint reported a relatively low hydraulic conductivity (10^{-9} m/s). However, the lithology of the Colluvium is variable across the site (as described in Section 4.8.1). This single test value is unlikely to be applicable to the site as a whole, and it is considered that for the purposes of impact assessment it is conservative to assume that the permeability of the Colluvium across the entire site may be higher than this value.

Effective Porosity and Storativity

Estimates of porosity and storativity of the five hydrogeological units based on literature values and experience in similar environments are presented in Table 4.9.2. Section 4.8.6 includes discussion of porosity values based on groundwater recharge and water level changes.

Table 4.9.5: Effective Porosity and Storativity, Hydrogeological Units		
Unit	**Parameter Value**	**Source**
Compressibility (m^2/N)		
Argillically altered LV Andesite (LVA)	$2x10^{-7}$	Domenico and Schwartz (1990)
Unaltered LV	$3x10^{-10}$	Domenico and Schwartz (1990)
Cenozoic Basalt Flows	$3x10^{-10}$	Domenico and Schwartz (1990)
Silicified Upper Volcanics (VC)	$5x10^{-10}$	Domenico and Schwartz (1990)
Colluvium	$8x10^{-9}$	Domenico and Schwartz (1990) dense sandy gravel
Specific Storage (1/m)		
Argillically altered LV Andesite (LVA)	$2x10^{-3}$	Calculated from compressibility and porosity
Unaltered LV	$3x10^{-6}$	Calculated from compressibility and porosity
Cenozoic Basalt Flows	$3x10^{-6}$	Calculated from compressibility and porosity
Silicified Upper Volcanics (VC)	$5x10^{-6}$	Calculated from compressibility and porosity
Colluvium	$8x10^{-5}$	Calculated from compressibility and porosity
Specific Yield (Drainable Porosity)		
Argillically altered LV Andesite (LVA)	0.03	Johnson, 1967[9]
Unaltered LV	0.04	Golder experience
Cenozoic Basalt Flows	0.015	Golder experience
Silicified Upper Volcanics (VC)	0.04	Golder experience
Colluvium	0.25	Golder experience
Total Porosity		
Argillically altered LV Andesite (LVA)	0.4	Golder experience (Domenico and Schwartz, 1990)
Unaltered LV	0.05	Golder experience
Cenozoic Basalt Flows	0.02	Golder experience (Domenico and Schwartz (1990) values for fractured crystalline rocks, and based on observed RQD* average of 0.19 in the 2010 to 2013 dataset. This value is considered applicable as a 'bulk' value for the entire basalt flow, the porosity of highly fractured 'flow tops' will be significantly higher.
Silicified Upper Volcanics (VC)	0.05	Golder experience (Domenico and Schwartz (1990) and based on observed RQD average for the silicified volcanics 0.4 in the 2010 to 2013 dataset.
Colluvium	0.3	Golder experience
Notes: *RQD – rock quality designation		

[9] *Specific yield — compilation of specific yields for various materials*. Johnson, A.I. 1967. U.S. Geological Survey Water Supply Paper 1662-D

4.8.4 Groundwater Elevation

Monitoring Network

The locations and installation details of 69 boreholes and groundwater monitoring wells utilised to record groundwater levels in the Amulsar Project area over the 2010 to 2015 period are described in the Environmental Monitoring Plan (EMP, Appendix 8.12; see also Appendix 4.8.7) and shown on Drawing 4.8.1. Locations which are open boreholes were monitored only once during active site investigations and are not part of the longer term monitoring network. The continuing monitoring schedule is described in the EMP (Appendix 8.12)[10].

Project Area

Discrete (manual) measurement of depth to groundwater has been undertaken by Geoteam since 2011. A groundwater monitoring plan has been in place since November 2013, and groundwater monitoring has been undertaken in wells across the Project area on a frequency indicated by the EMP since March 2014.

In addition to discrete measurements, pressure transducer data loggers were emplaced in six wells in the valley east of the BRSF between November 2012 and May 2013 (one of these wells was dry throughout the monitoring period, and two data files could not be interpreted due to lack of initial and/or final manual water level measurements). Data loggers were also placed in 20 wells distributed across the Project area starting in November 2013. It is noted that in 2015 due to an increasing rate of theft it was necessary to remove the data loggers. Locations with continuous water level records are summarised in Table 4.9.3.

Table 4.9.6: Groundwater Locations with Continuous Data Records

Location ID	Easting	Northing	Area	Campaign 1		Campaign 2		Notes
				Installation Date	Removal Date	Installation Date	Data included in ESIA	
RCAW403	562431	4402224	Wider Study Area	Dec-11	May-12	Nov-13	Yes	
DDAW002	562169	4402759	Wider Study Area			Nov-13	No	

[10] Environmental Monitoring Plan. Geoteam, 2015

Table 4.9.6: Groundwater Locations with Continuous Data Records								
Location ID	Easting	Northing	Area	Campaign 1		Campaign 2		Notes
				Installation Date	Removal Date	Installation Date	Data included in ESIA	
DDAW004	560814	4402150	Wider Study Area			Nov-13	No	
RCAW400	561265	4402317	Wider Study Area			Nov-13	No	
DDAW003	561486	4402811	Wider Study Area			Nov-13	Yes	
RCAW408	560869	4397976	Art/Tig open pit			Nov-13	No	
DDAW008	560798	4400232	Erato open pit			Nov-13	Yes	
DDAW012	560800	4401600	BRSF/ Crusher			Nov-13	No	
DDAW013	560225	4402622	BRSF/ Crusher			Nov-13	Yes	Dry in March
GGSC037	560789	4403156	BRSF/ Crusher			Nov-13	Yes	
DDAW009	559341	4399817	Erato open pit			Nov-13	No	
GGDW010A	553920	4399547	HLF			Nov-13	Yes	
GGDW010B	553920	4399547	HLF			Nov-13	Yes	
GGDW011	554337	4399689	HLF			Nov-13	Yes	
GGDW012	553968	4398825	HLF			Nov-13	Yes	
GGDW013	553232	4398961	HLF			Nov-13	Yes	
GGDW013A	553232	4398961	HLF			Nov-13	Yes	
GGDW007	552532	4398296	HLF			Nov-13	Yes	
GGDW009	553009	4399612	HLF			Nov-13	Yes	
GGDW016A	552163	4398400	HLF			Nov-13	Yes	
DDAGLP267	561252	4402552	Wider Study Area	Dec-11	May-12			
DDAGLP268	561886	4402447	Wider Study Area	Dec-11	May-12			No reference water level

Table 4.9.6: Groundwater Locations with Continuous Data Records								
				Campaign 1		Campaign 2		
Location ID	Easting	Northing	Area	Installation Date	Removal Date	Installation Date	Data included in ESIA	Notes
DDGG001	566044	4395779	Wider Study Area	Dec-11	May-12			Dry
DDGG002	566143	4395433	Wider Study Area	Dec-11	May-12			No reference water level
RCAW401	561336	4403138	Wider Study Area	Dec-11	May-12			
Note: "Yes" = data received prior to May 31, 2014								

The discrete measurement depth to groundwater and groundwater elevation data set used in the groundwater baseline and summary statistics for the 69 monitored wells and boreholes are presented in Appendix 4.8.3. Depth to groundwater is reported by Geoteam as vertical depth in inclined wells. Hydrographs for wells with sufficient record to characterise seasonal or long term change are also presented.

Groundwater elevation contours for the Project area are interpreted and based on the mean of the elevation data set for each location, and discrete measurements made between 15 May and 15 June 2014 (Figure 4.9.2 and Figure 4.9.3). Elevations of perennial springs identified in the November 2013 spring survey (Section 4.9.2) have also been used to interpret the groundwater elevations. The wells used in the groundwater monitoring network are shown in Appendix 4.8.7 on Drawing 4.8.1. It is noted that data collected from June 2014 to August 2015 are consistent with the earlier data.

The following adjustments have been made in calculating mean groundwater levels in the bedrock water table presented in Figure 4.9.2.

The lower 60 m of the well in borehole RCAW405A collapsed between November 2013 and June 2014. The water level measurements made after this time are assumed to represent perched water, while those made prior to the collapse indicate the regional water table.

The lower 30 m of the well in borehole DDAW007 collapsed prior to June 2014, possibly soon after installation. The existing water level (50 m higher than that originally recorded) most likely reflects perched groundwater.

A water level elevation of 2824 m asl was recorded in Well DDAW008 following installation in June 2013. Subsequently, this well has been dry on three monitoring occasions over the period of a year (including June 2014). The first measurement is interpreted to represent residual drilling water in the well following completion, and the well base is above the water table. The first measurement has been disregarded.

A well was installed in borehole DDAW011 to a depth of 77 m but collapsed during installation. Water levels measured in this borehole most likely represent perched groundwater within the colluvium (a perched water table was observed during drilling).

The groundwater level measurements in well DDAW009 have been relatively consistent since installation but the lower 40 m of the well appears to have collapsed. Given that the measured water levels are similar to those made at the time of drilling, the data have been retained for analysis.

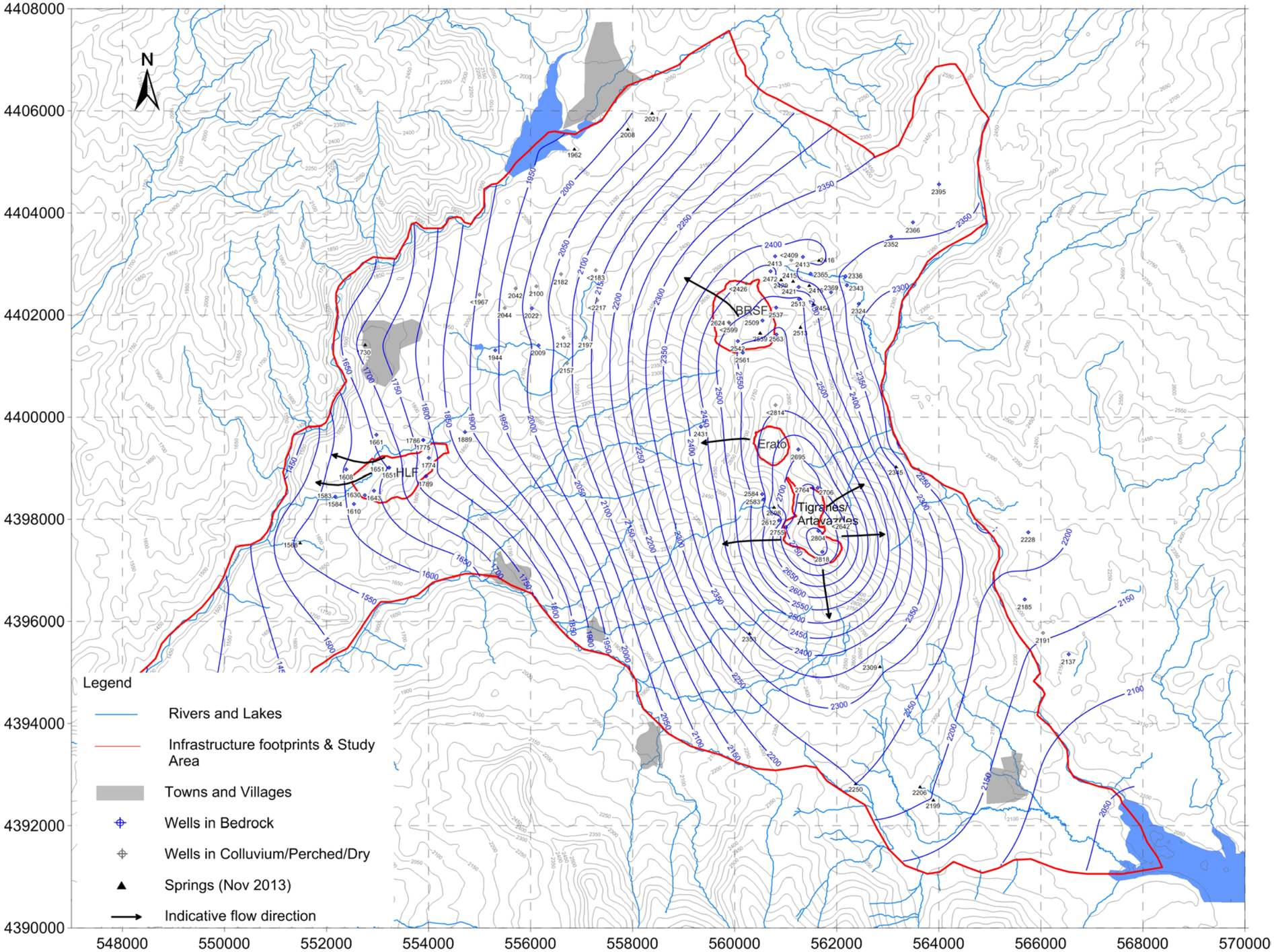


Figure 4.9.13: Interpreted Groundwater Elevation Contours, Average Groundwater Level (m asl)

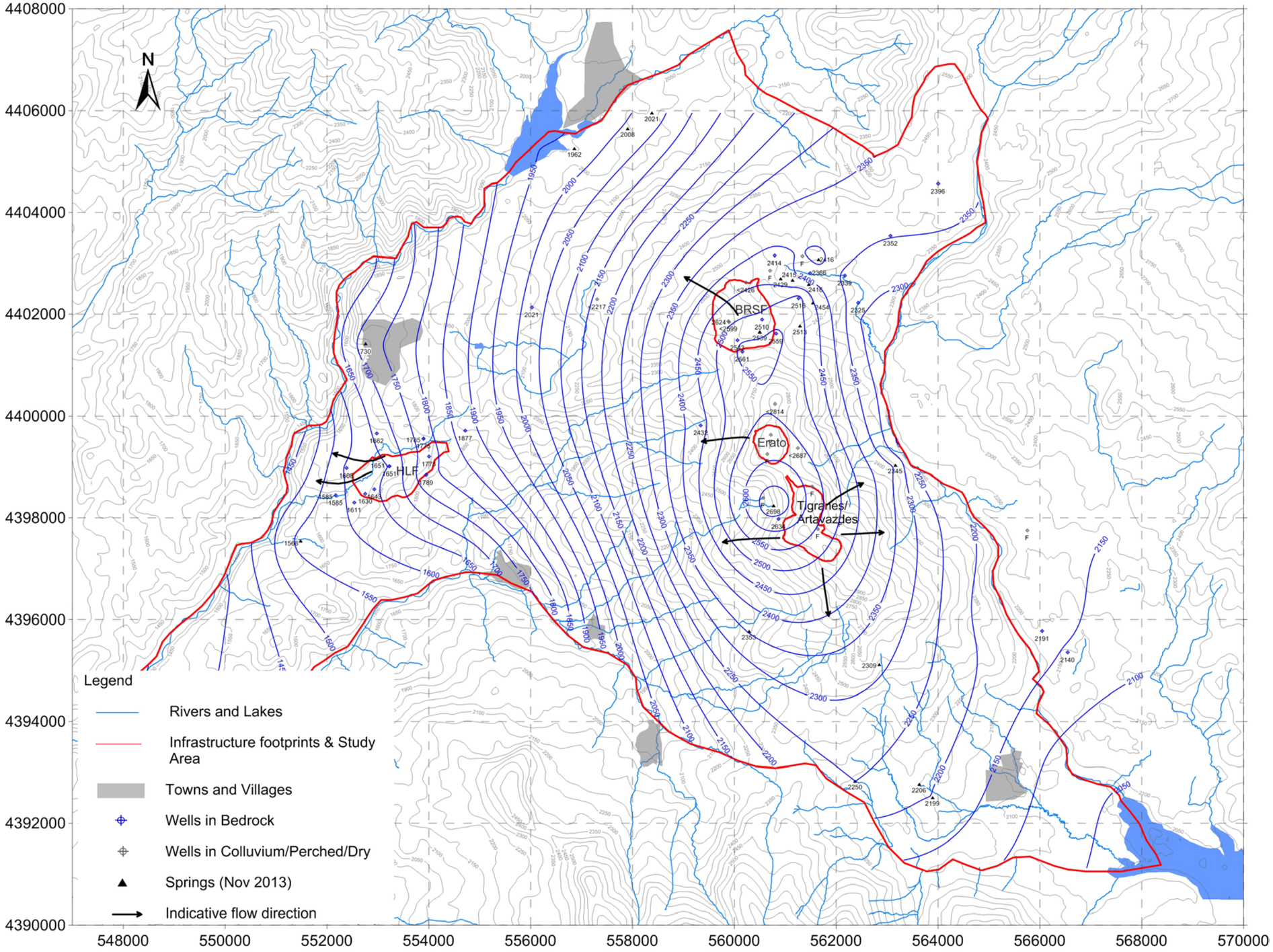


Figure 4.9.14: Interpreted Groundwater Elevation Contours, May/June 2014 (m asl)

Groundwater elevation broadly mirrors topography across the GSA. The highest groundwater elevations are observed beneath the southern end of the Amulsar Mountain ridge, and elevations decline east and west from the ridge toward the major rivers. Where higher resolution data are available, the influence of groundwater discharge to streams within the GSA is clear, such as in the BRSF, the valley to the east of the BRSF and the HLF valley. It is likely that groundwater discharges occurs in other major stream valleys to the south of the HLF, and to the south of Amulsar Mountain ridge.

Depth to groundwater is highly variable within the Project area. Groundwater discharge occurs even at high elevations on Amulsar Mountain, such that the water table is close to surface near the ore bodies (such as RCAW288 and the adjacent spring cluster) and in the centre of the BRSF site, as well as at lower elevations along stream valleys. Average depth to groundwater at the monitored locations is shown in Figure 4.9.4. The water table is deepest beneath the Amulsar Mountain ridge, up to 140 m bgs beneath the Artavazdes pit. In addition, the water table is deep (up to 100 m below ground) beneath the basalt plain to the west of Amulsar Mountain. A deep water table is also interpreted to exist within the basalts to the north-west of the BRSF. The water table below the BRSF site and nearby east-draining valley is relatively shallow.

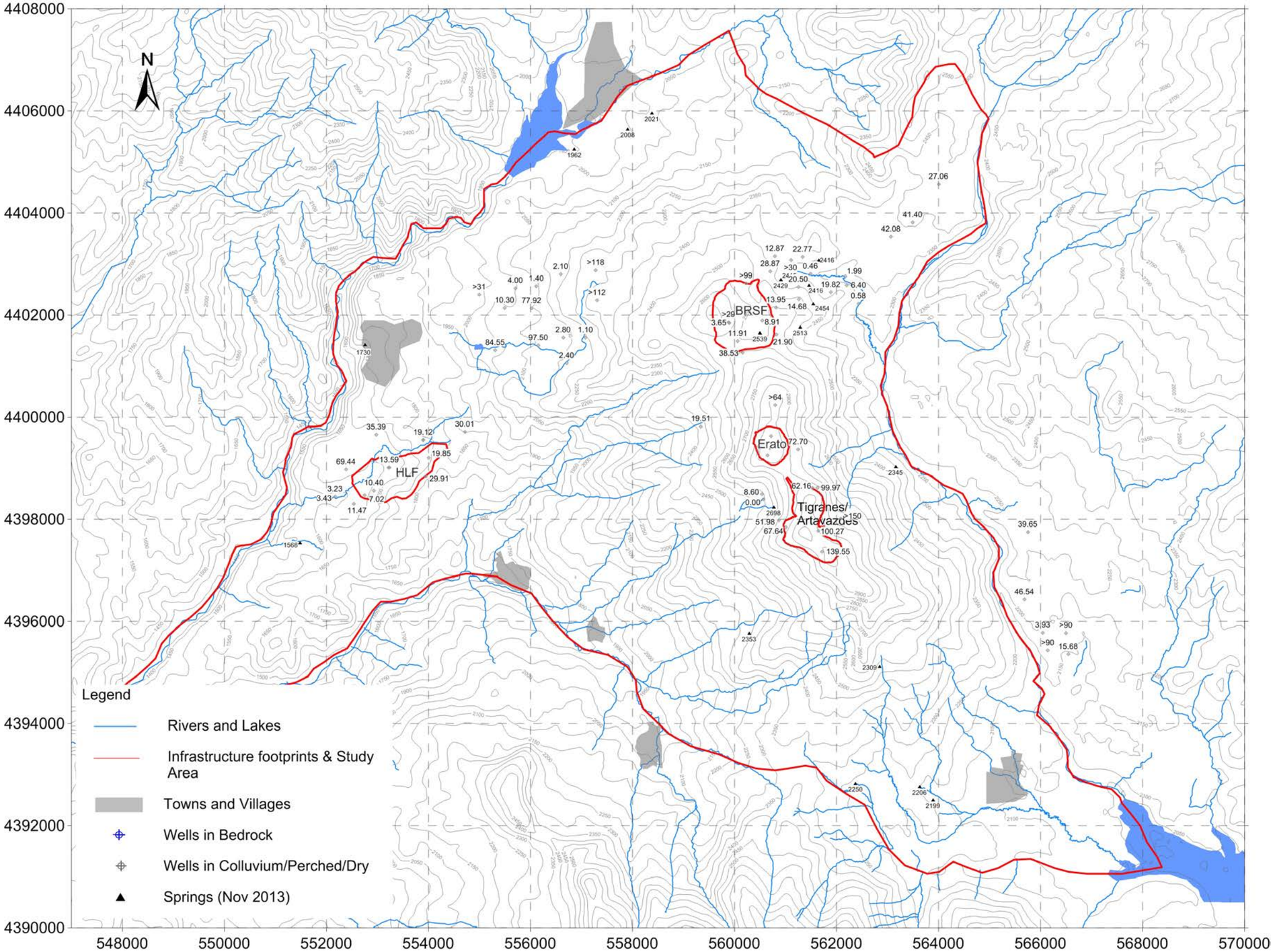


Figure 4.9.15: Average Depth to Groundwater (Greater than symbol indicates dry well)

Groundwater level monitoring data are available for at least three seasons in 36 wells. These data provide information regarding the seasonal groundwater level fluctuations in response to recharge and discharge. Hydrographs from continuous water level records over the Winter and Spring 2013/14 season provide additional data (Appendix 4.8.3).

The range in groundwater elevation in wells with records sufficient to characterise the seasonal range (including spring recharge) is summarised in Table 4.9.4; the distribution of the data set is illustrated in Figure 4.9.5. Seasonal range is influenced by the groundwater recharge rate, by the effective/connected porosity of the rock or sediment matrix and by proximity to features controlling groundwater flow (discharge locations, streams and rivers). Table 4.9.4 shows that there is a wide variation in seasonal groundwater level range, between centimetres and tens of metres. Data indicates that seasonal range is strongly influenced by proximity to points of discharge, with a smaller range observed closer to springs and streams.

Data presented in Table 4.9.4 represents fluctuation in the water table (continuously saturated zone) with the exception of:

- The inclusion of the value of 2.2 m from well GGDW010A monitoring the shallow groundwater body beneath the HLF site in the data set for the Unaltered Lower Volcanics. The shallow groundwater body is potentially perched (separated from the deeper water table by an unsaturated zone) at this location.

Table 4.9.7: Summary of Water Table Seasonal Range

	Minimum (m)	Average (m)	Max (m)	Data Count
Summary by Hydrogeological Unit				
Unaltered Lower Volcanics	0.8	8.4	48.0	13
Altered Lower Volcanics	0.0	6.2	22.5	7
Upper Volcanics	3.5	19.0	39.9	5
Cenozoic Basalt Flows	0.6	8.0	22.0	9
Colluvium	0.9	5.2	12.0	4
Summary by Project Area				
Ore Bodies	0.0	11.5	39.9	9
BRSF and adjacent valley	0.8	8.3	22.5	9
HLF	0.8	7.9	48.0	12
Wider Project Area	0.6	8.4	22.0	8
All Data	0.0	9.0	48.0	38

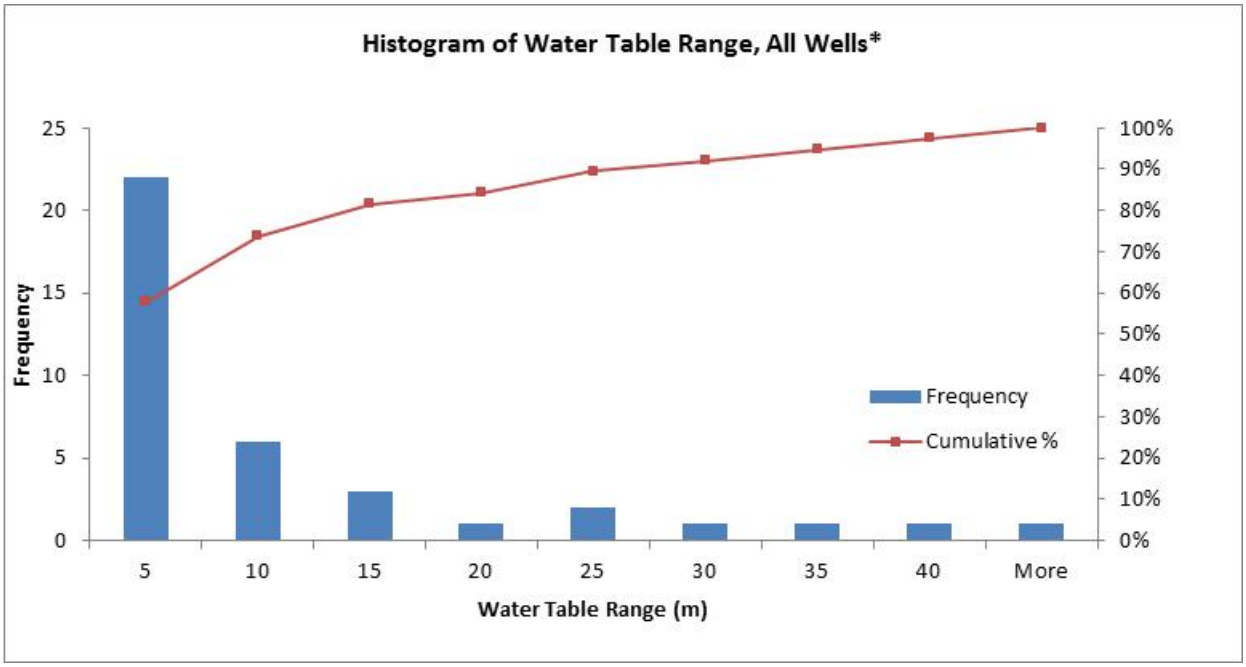


Figure 4.9.16: Histogram of Water Table Range, All Wells

The range of topographic elevation within the GSA is large, and topography is a strong control on groundwater flow direction throughout the Project area. As such, seasonal groundwater level fluctuations have little influence on overall groundwater flow direction, but hydraulic gradients may change slightly over the course of the year.

Perched groundwater has been identified within the colluvium at a number of locations across the GSA, including in the valley to the north-east of the HLF, in the north-eastern quadrant of the HLF site and on the northern flank of the BRSF site. Furthermore, hydrographs for wells installed along Amulsar Mountain ridge (Appendix 4.8.3) also indicate transient water entering the borehole(s) during the Spring period and draining rapidly. This is interpreted to represent transient seasonal perched water resulting from snow melt infiltration, which also feeds numerous ephemeral springs on and around the Amulsar Mountain ridge. Perched groundwater is discussed in more detail with respect to groundwater flow in Section 4.9.2.

Ore Bodies

Groundwater elevation in the vicinity of the ore bodies is shown in Figure 4.9.6, which shows minimum and maximum water table elevation recorded at each location, and contours of the mean groundwater elevation. Contours of the proposed final pit shell are also shown. The collar elevation of groundwater wells surrounding the Tigranes-Artavazdes pit (wells

commencing with the prefix RCA) have been determined using a GPS. The groundwater elevations measured in these boreholes may have an error of up to +/- 20 m from the values shown. Wells surrounding Erato, and the BRSF, have been surveyed by professional surveyors using differential GPS and are thus considered accurate.

The base of the Erato pit (2620 m asl) is likely to be at or above the permanent water table, which is interpreted to be between 2600 m asl on the west of the pit and 2650 m asl on the east. Wells to the east of Tigranes-Artavazdes (in the Upper Volcanics) are periodically or continuously dry, and indicate that the water table is between 2700 m asl and 2800 m asl and may be above the base of the Tigranes-Artavazdes pit over parts of the year. Wells to the west of the Tigranes-Artavazdes (in the Argillic LVA) generally have more stable groundwater levels, and indicate that the water table may be above the pit base on the western side (between 2750 m asl and 2820 m asl), potentially by as much as 80 m in the base of the Tigranes pit. Groundwater elevations decline very rapidly with distance to the east and west of the proposed pits, particularly Tigranes-Artavazdes, due to the steep topography surrounding the pits.

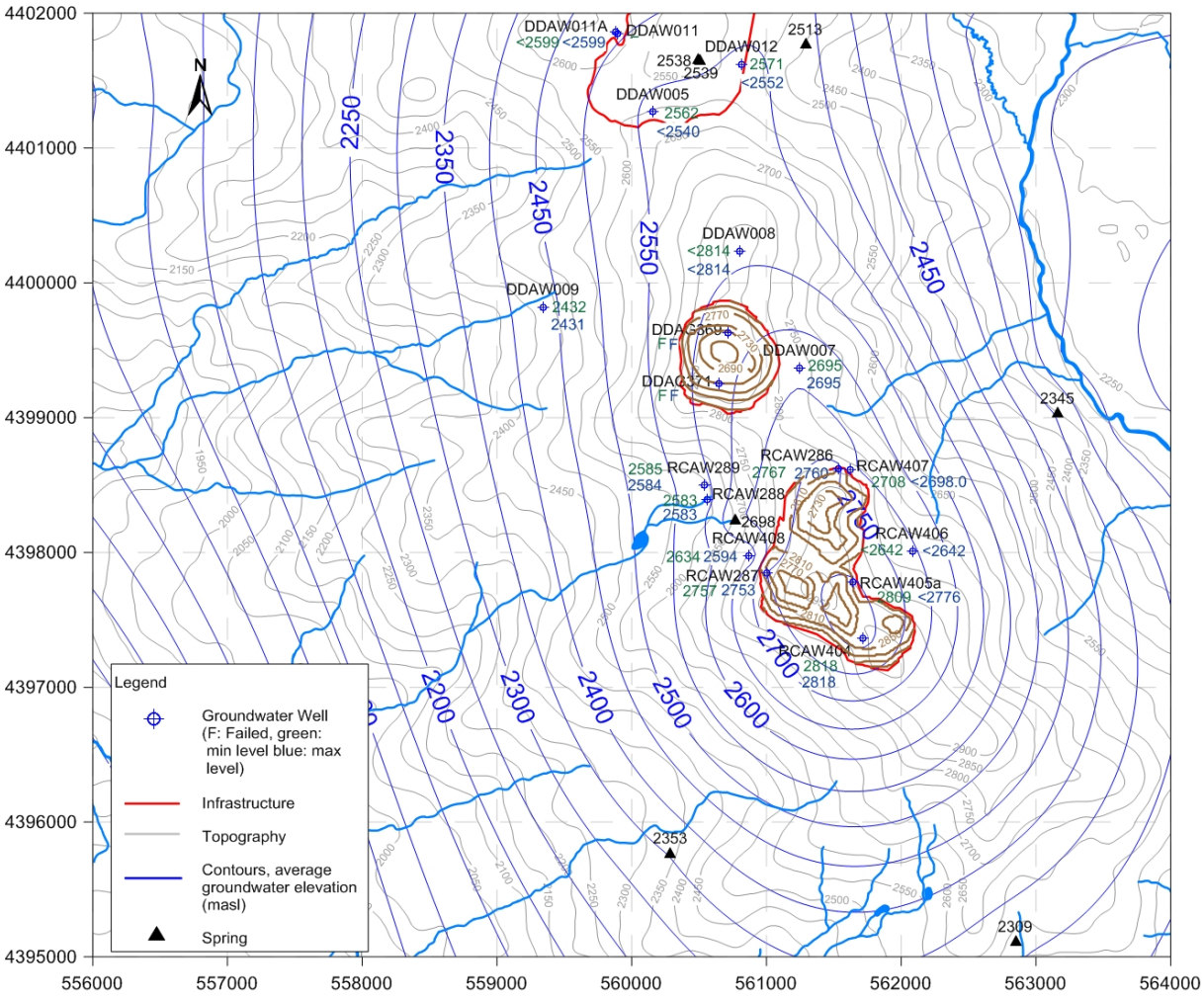


Figure 4.9.17: Groundwater Elevation, Ore Bodies

Groundwater to the west of Amulsar Mountain peak sustains continuous year-round flow to the springs immediately downgradient (Spring 4 and others (see Appendix 4.8.7, Drawing 4.8.3)). With the exception of RCAW408, wells to the west of the Artavazdes and Tigranes pit show relatively small seasonal ranges. The water level in RCAW408 declined rapidly following installation and remained low for a period of at least three months, but has subsequently returned to close to its initial level; this may suggest that this well typically records/is currently recording a perched water level.

Hydrographs (Appendix 4.8.3) indicate that transient perched water is present in wells further north along the ridge in Spring (DDAW008, DDAW013, and GGSC037). This transient perched water supports flow to numerous ephemeral springs surrounding the ore bodies in Spring, as identified in recent spring surveys[4]. The ephemeral springs which are fed by the Spring snow melt are not confined to particular hydrogeological units, but occur across the Amulsar area.

This suggests that the occurrence of seasonal perched water is widespread on Amulsar Mountain.

Two wells on the east of Amulsar Mountain ridge, RCAW405A and DDAW007, have collapsed in the basal screen sections, but continue to record permanent or semi-permanent water levels (assumed to be due to groundwater inflow in to the broken well casing). In both cases, the water level following the well collapse is 50 m to 60 m higher than prior to the collapse. This potentially reflects the presence of more perched water bodies in the intensely deformed sequence which hosts the ore bodies.

Groundwater observed during exploration drilling on Amulsar Mountain peak is likely to reflect the influence of both perched water (seasonal and year-round) and the perennially saturated groundwater system. Water is observed as a result of significant inflow in more permeable zones (fractures, fault zones or permeable horizons); rotary drilling through lower permeability horizons is unlikely to identify groundwater inflow as the rate of inflow is very small. The distribution of water encountered during exploration drilling of the main ore bodies is illustrated in Figure 4.9.7, Figure 4.9.8 and Figure 4.9.9.

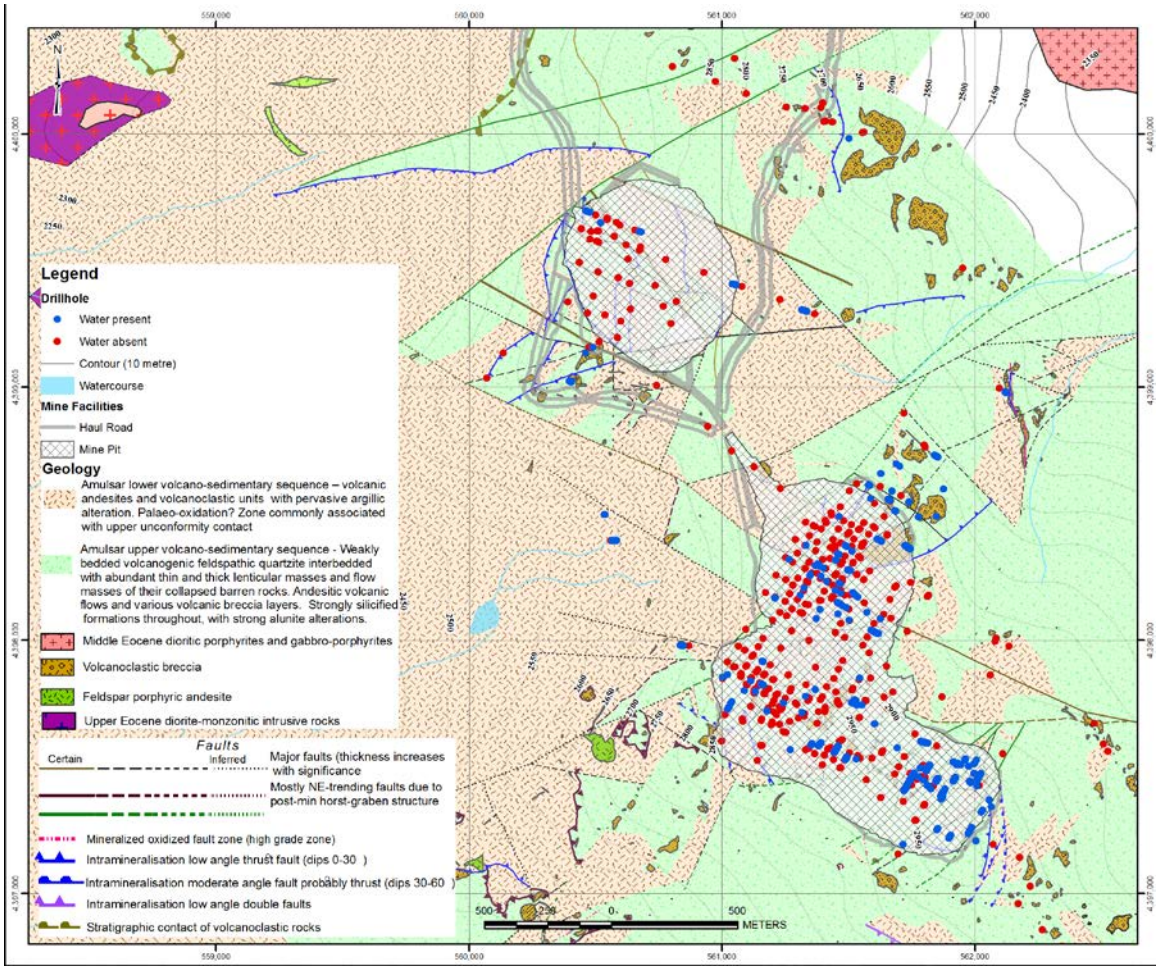


Figure 4.9.18: Distribution of Exploration Drill Holes Recording Groundwater

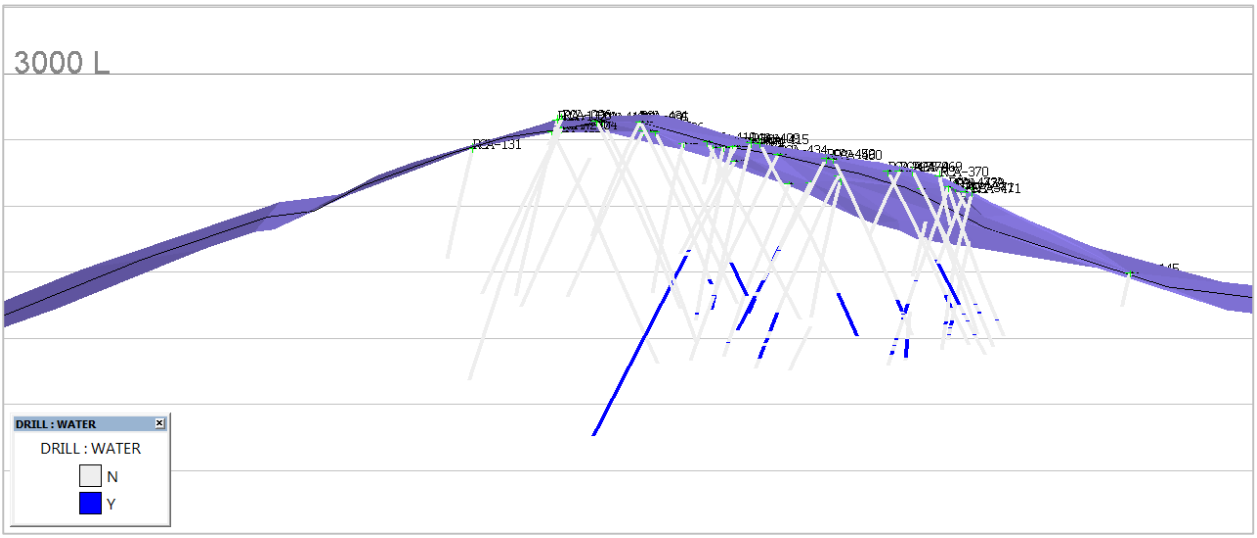


Figure 4.9.19: Cross section west-east through Artavazdes showing drill holes recording zones of saturation

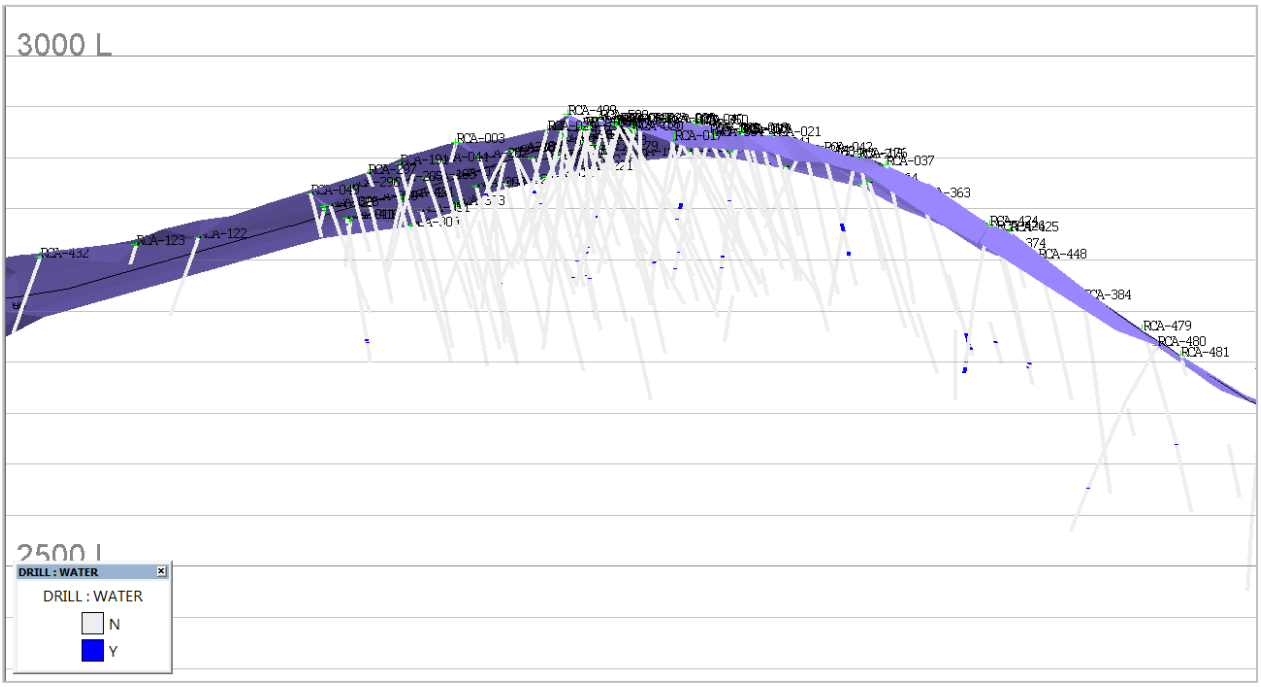


Figure 4.9.20: Cross section west-east through Tigranes showing drill holes recording zones of saturation

Crusher and BRSF

Groundwater elevations and depth to groundwater beneath the BRSF site in October and November 2013 are provided in Table 4.9.5. Groundwater elevation contours based on mean groundwater elevation, overlain on the Lydian geological map are shown in Figure 4.9.10.

Table 4.9.8: Depth to Groundwater and Groundwater Elevation, BRSF and Surrounding Area, Oct/Nov 2013

Lydian ID	Easting	Northing	Depth to Groundwater (m)		Groundwater elevation (m asl)	
			Oct-13	Nov-13	Oct-13	Nov-13
DDAGLP267	561252	4402552	-			
DDAGLP268	561886	4402447	Failed (base of well has collapsed)			
DDAGLP269	562201	4402587	-			
DDAW001	561107	4403076	-			
DDAW002	562169	4402759	-	0.43	-	2337.57
DDAW003	561490	4402807	-	0.50	-	2364.50
DDAW004	560814	4402150	-	17.10	-	2533.90
DDAW011A	559883.7	4401861	dry (>29)	-	<2599	-
DDAW012	560800	4401600	14.05	26.00	2571.00	2559.05
DDAW013	560220	4402610	-	dry (>99)	-	<2426.3
GGSC049	560063.3	4401493	12.80	-	2540.82	-
GGSC050	560542.5	4401892	11.19	-	2506.77	-
RCAW399	560702	4402856	Failed (base of well has collapsed)			

Table 4.9.8: Depth to Groundwater and Groundwater Elevation, BRSF and Surrounding Area, Oct/Nov 2013						
Lydian ID	**Easting**	**Northing**	**Depth to Groundwater (m)**		**Groundwater elevation (m asl)**	
			Oct-13	**Nov-13**	**Oct-13**	**Nov-13**
RCAW400	561263	4402314	-	18.10	-	2509.90
RCAW401	561336	4403139	Failed (base of well has collapsed)			
RCAW403	562432	4402226	-	0.54	-	2324.46
GGSC037	560789.8	4403154	14	dry (>16.7)	2411.84	<2409.1
Note: - indicates well not monitored.						

In general groundwater is relatively close to surface across the BRSF site and the adjoining valley to the east. The Winter and Spring 2014 spring surveys (Golder, 2014e)[4], identified a number of perennial springs in the BRSF site and the valley to the east. Groundwater elevation contours indicate that these springs represent where the water table intersects ground surface. Groundwater elevation is highest below the ridges and declines toward the centre of the valleys.

Hydrographs for wells in the BRSF site indicate that groundwater levels rise rapidly in Spring in response to snow melt (e.g. GGSC027, DDAW013). Groundwater levels then decline rapidly following snowmelt. In DDAW013 groundwater was recorded above the borehole base for only a few days, before dissipating. The groundwater level response in April is consistent with a relatively permeable system. Perched groundwater is also observed in the colluvium overlying basalts to the west of the BRSF footprint.

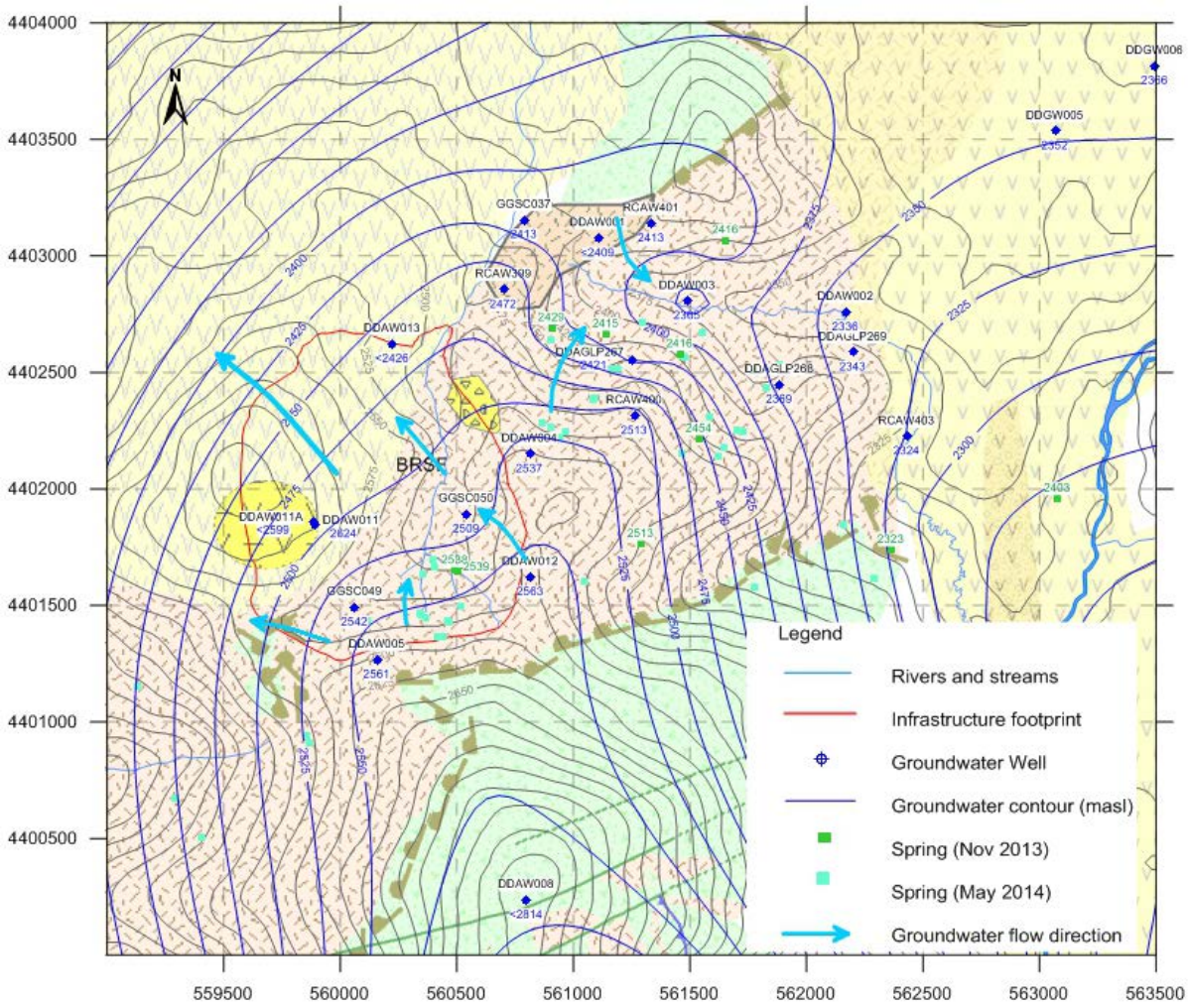


Figure 4.9.21: Groundwater Elevation Contours, Mean Groundwater Level, BRSF

(Geology, Legend as Previously Shown)

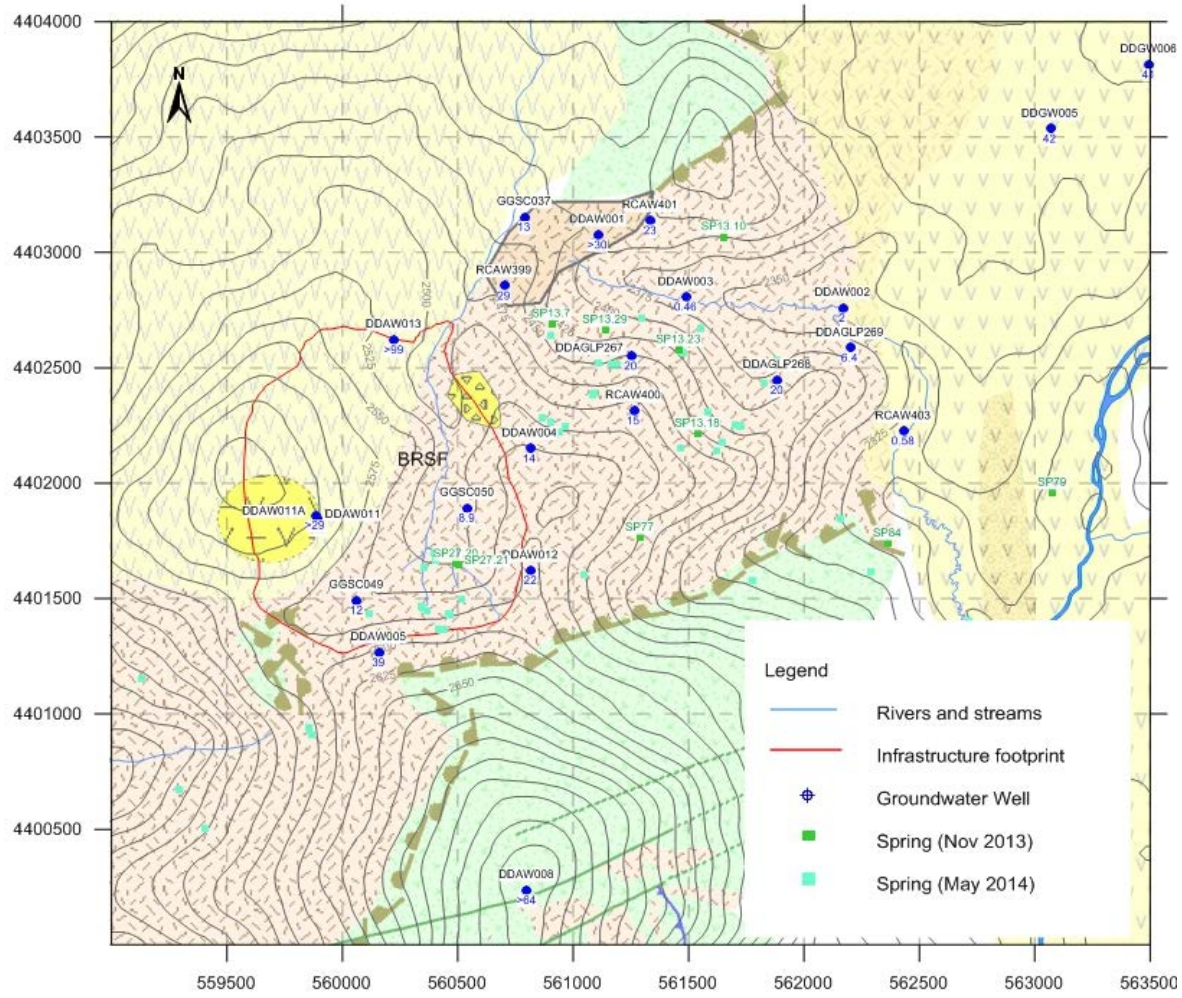


Figure 4.9.22: Average Depth to Groundwater, BRSF

(Geology Legend as Previously Shown)

Boreholes (blue dots) show depth to groundwater in metres. Depths marked with a greater than symbol indicate dry wells and the depth to well base.

HLF

The HLF is situated in the west of the GSA in close proximity to the Arpa River and at a lower elevation than the other mine facilities. The site occupies a stream valley which flows south-west toward the Arpa River, which passes to the west of the site. A significant thickness of colluvium is present along the stream valley. Paired groundwater monitoring wells have been installed within the HLF to record shallower groundwater levels in the upper bedrock, and in the deeper bedrock. In the centre and toward the south of the site, groundwater elevations in shallow wells are similar to those in deeper wells. A small downward vertical head gradient is recorded between the pairs, indicating some degree of hydraulic separation between the

shallow and deeper bedrock likely as a result of a lower permeability horizon within the lithological sequence between the two screens. Toward the north of the site groundwater levels in the shallower well are significantly above the deeper well, suggesting that the shallower water body in this area is perched, either supported by the colluvium or by a low permeability horizon within the upper Lower Volcanics, and the water table lies within the colluvium. Groundwater elevation in shallower and deeper bedrock indicates an unsaturated zone may be present underlying the perching horizon. Groundwater flow and vertical hydraulic gradients in this area are described further in Section 4.9.2.

Groundwater elevation and depth to groundwater in the HLF site during October 2013 and May 2014 are presented in Table 4.9.6. Well locations are shown in in Appendix 4.8.7 on Drawing 4.8.1. Average depth to groundwater beneath the HLF site is shown in Figure 4.9.4. The depth to groundwater is greatest beneath higher ground to the north-east of the HLF site and on the flanks of the valley. The groundwater elevation declines to the west and south-west, toward the Arpa River. Data collected from May 2014 – 2015 are consistent with that from 2013 and 2014.

Table 4.9.9: Groundwater Elevation and Depth to Groundwater, HLF Site, October 2013 and May 2014

Lydian ID	Unit monitored	Easting	Northing	Depth to Groundwater (m)		Groundwater Elevation (m asl)	
				15/10/2013	30/05/2014	15/10/2013	30/05/2014
GGDW007	Deeper Unaltered LV	552536	4398302	10.9	10.3	1610	1611
GGDW008	Deeper Unaltered LV	552932	4398566	10.9	9.9	1642	1643
GGDW009	Deeper Unaltered LV	552978	4399660	35.0	34.0	1661	1662
GGDW010A	Shallow Unaltered LV	553902	4399558	8.3	9.1	1786	1785
GGDW010B	Deeper Unaltered LV	553898	4399557	19.2	18.8	1775	1775
GGDW011	Deeper Unaltered LV	554714	4399713	16.6	41.2	1902	1877
GGDW012	Deeper Unaltered LV	553947	4398843	29.1	29.5	1790	1789
GGDW013	Deeper Unaltered LV	553220	4399010	11.8	12.1	1652	1651
GGDW013A	Shallow Unaltered LV	553231	4399013	-	13.2	-	1651
GGDW014	Deeper Basalt	552385	4398975	68.8	69.1	1609	1608

Table 4.9.9: Groundwater Elevation and Depth to Groundwater, HLF Site, October 2013 and May 2014							
Lydian ID	**Unit monitored**	**Easting**	**Northing**	**Depth to Groundwater (m)**		**Groundwater Elevation (m asl)**	
				15/10/2013	**30/05/2014**	**15/10/2013**	**30/05/2014**
GGDW015	Deeper Unaltered LV	554003	4399203	18.7	20.8	1775	1773
GGDW016	Deeper Unaltered LV	552174	4398443	2.4	2.3	1585	1585
GGDW016A	Shallow Basalt	552170	4398445	2.3	2.4	1585	1585
GGSC035	Colluvium	552754	4398474	7.3	6.4	1629	1630
Note: Elevations are rounded. Boreholes GGDW010A and B area well pair, as are GGDW013 and 13A and GGDW016 and 16A. The definition of GGDW016A and GGDW016 here assigned is opposite to that applied by Geoteam in 2015.							

Groundwater elevation contours in deeper bedrock and in the shallow bedrock/colluvium beneath the HLF are shown in Figure 4.9.12 and Figure 4.9.13.

In general, the seasonal range in groundwater elevation within the HLF site is relatively small (based on monitoring data between October 2013 and May 2014), ranging between 0.5 m and 2 m.

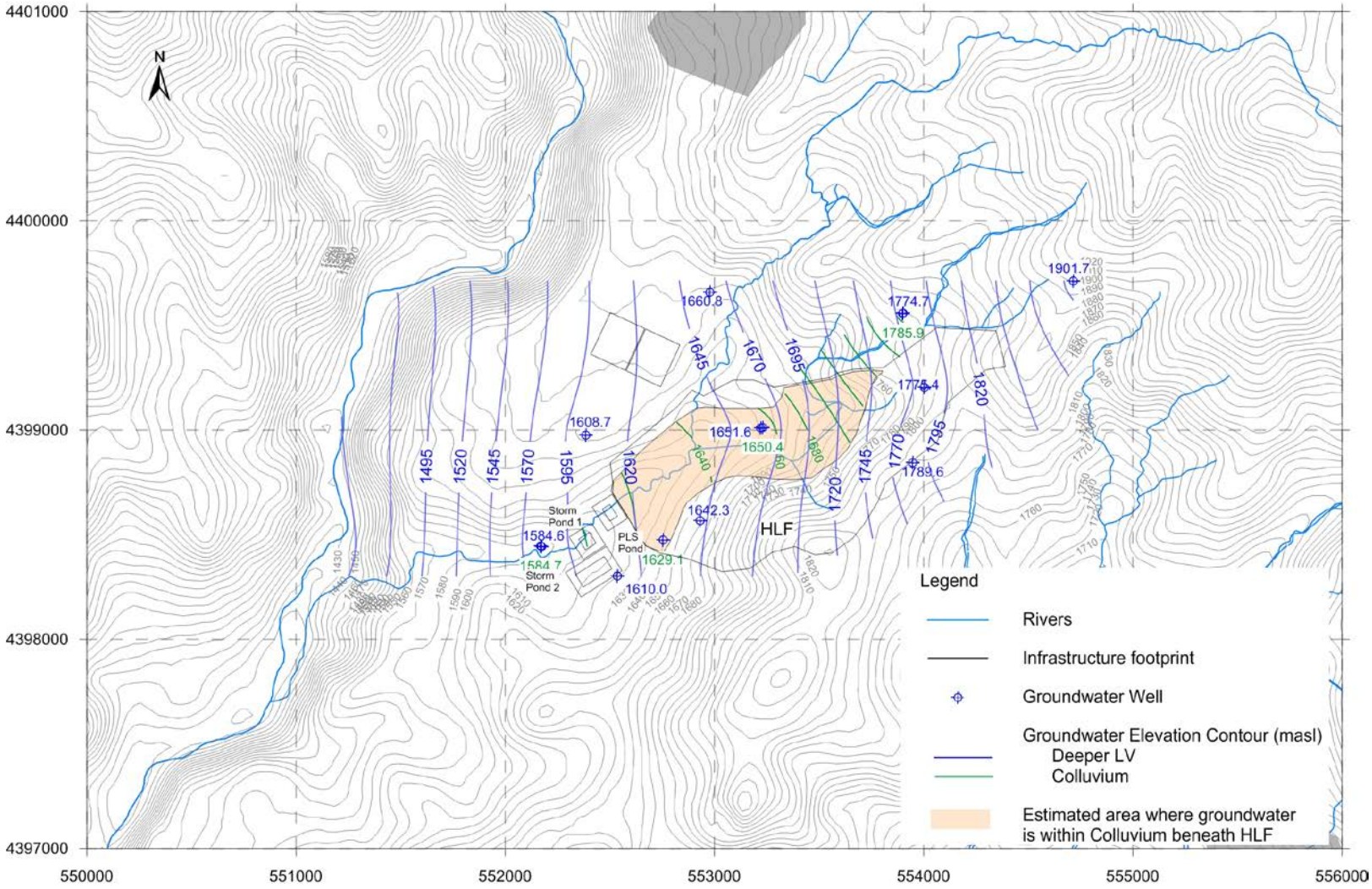


Figure 4.9.23: HLF Groundwater Elevation Contours, October 2013

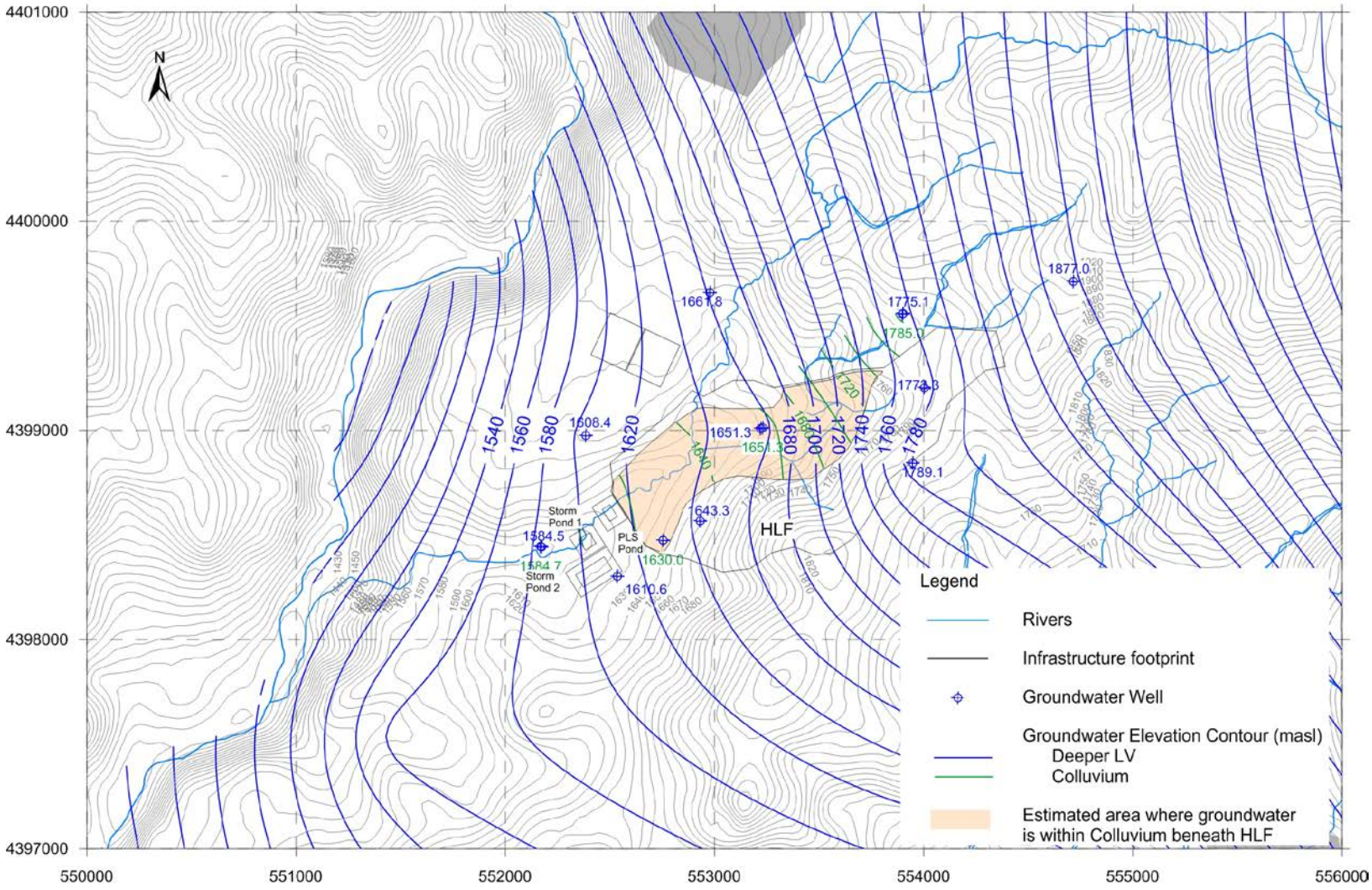


Figure 4.9.24: HLF Groundwater Elevation Contours, May 2014

4.8.5 Groundwater Flow

Project Area

Groundwater flow in the Amulsar Mountain area is driven by the Spring snowmelt. Groundwater levels in the mountain area (Appendix 4.8.3) rise rapidly in the Spring and early Summer indicating recharge from snowmelt. In general a more muted groundwater level response is observed at lower elevations which may in part be due to the locations of the wells near groundwater discharge locations.

Following the Spring snowmelt, groundwater levels decline rapidly in early Summer, and then continue to decline more steadily through the dry Summer and Autumn months. At elevations where temperatures remain above freezing in October, limited recharge from rainfall or early season snowmelt may occur. Groundwater levels continue to decline over the Winter in response to the lack of recharge. The lowest groundwater elevations are recorded just prior to the onset of the Spring snowmelt.

- Groundwater recharge rates are a function of precipitation (snowfall) (which is related to elevation), topography/aspect, geology and soils. The highest recharge occurs associated with higher elevation areas where snowfall accumulates and then melts slowly in the Spring. Recharge is least in open windswept areas where there is limited accumulation of snow. Measurement of spring flows and surface drainage patterns suggests that in areas underlain by the argillic LV andesite, much of the recharge is rapidly discharged via shallow flow systems to nearby springs and streams (such as the spring systems in the BRSF and adjacent valley, and to the west of the Amulsar Mountain ridge). Groundwater recharge occurs to the unaltered LV since this unit is more permeable than the argillic LV, but likely at lower rates since this unit is found at lower elevations. Groundwater discharge from the unaltered LV sustains baseflow at lower elevations on Amulsar Mountain and where in hydraulic contact with the major rivers.
- The basalt outcrop areas are typically devoid of surface water because of the greater infiltration potential of the soils and underlying bedrock. As a result, recharge over the permeable Cenozoic Flow Basalts infiltrates and sustains groundwater flow. Groundwater in the basalt discharges at seepage faces where the basal contact of the basalt is exposed in incised valleys (Golder, 2014e)[4] and discharges as baseflow to the incised valleys of the major rivers (Vorotan, Arpa, etc.).

Groundwater flow is predominantly topographically controlled, flowing radially away from the Amulsar Mountain ridge toward the Arpa River to the north and west, toward the Vorotan River to the east and toward the Darb River to the south-west. Groundwater discharge to sub-catchments within these large scale catchments results in local scale deviations in flow toward smaller tributaries, such as the influence seen on local groundwater flow in the valley east of the BRSF site. Groundwater elevation contours indicate groundwater discharge to local streams at the BRSF site, the HLF site and the valley east of the BRSF. Based on observed surface water flows and groundwater elevations, discharge from the groundwater system below Amulsar Mountain supports year-round base flow to the three major rivers, and tributaries to these rivers. Groundwater discharges to the Arpa River in the north-west of the GSA; groundwater from the GSA does not flow north of the Arpa River, or to Jermuk (further evidence for this interpretation is discussed in Section 4.8.7).

The four major bedrock hydrogeological units within the GSA, the argillic LV andesite, the unaltered LV, the silicified VC and the Cenozoic Flow Basalts have widely varying hydraulic properties. The argillic LV andesite acts as an aquitard in the vicinity of the ore bodies, potentially supporting localised bodies of perched water, restricting infiltration of snowmelt in the Spring, and promoting groundwater discharge in areas where this unit is at or near surface. On a larger scale within the Project area, there does not appear to be any variation in the overall topographically-driven groundwater flow system from the underlying geology. Perched groundwater is localized and there are no extensive shallow aquifers. Hydraulic gradients in the groundwater flow system are steepest surrounding Amulsar Mountain (in response to topography) and are flattest at lower elevations and in stream valleys.

The Kechut-Spandaryan tunnel passes through the GSA connecting the Spandaryan Reservoir in the south and the Kechut reservoir in the north. Under current conditions, sluice gates in the Spandaryan Reservoir are closed and there is reportedly no surface water inflow to this tunnel, but significant discharge is observed (Section 4.8.6). Water chemistry, as well as circumstantial evidence, suggests that this discharge is groundwater (Appendix 4.9.1 and Section 4.8.7). The tunnel therefore has the potential to influence groundwater flow west of Amulsar Mountain. Groundwater modelling indicates that the tunnel is below the water table elevation and thus groundwater flows into the tunnel where the lining is damaged.

Flowing artesian groundwater conditions have been observed in the valley to the east of the BRSF. This area is a groundwater discharge zone, but thick colluvium (alluvial deposits) acts

to confine the underlying bedrock groundwater. Similar conditions are observed overlying the Cenozoic Flow Basalts in the stream flowing south-east from this site to the Vorotan River where the colluvium confines groundwater in the bedrock, leading to flowing conditions in RCAW403.

Groundwater originating on Amulsar Mountain and flowing northward discharges to the Arpa River at or downstream of Kechut and does not reach Jermuk. Groundwater chemistry (Appendix 4.9.1, Section 4.8.7, and Golder (2014e)[4]) indicates that the geothermal springs in Jermuk are distinct in origin and chemistry from groundwater and springs in the GSA and are fed by a deeper (older and more chemically evolved) groundwater flow system, likely recharged by waters originating north-east of Jermuk.

Ore Bodies

The hydrogeological regime surrounding the ore bodies comprises a faulted interleaved sequence of relatively permeable fractured silicified VC and less permeable argillically altered LV andesite (see Appendix 4.8.7, Drawing 4.8.4). Given its lithological composition, the argillically altered andesite (LVA) is of low permeability, whilst the silicified and fractured volcanoclastics are more permeable.

Based on observations during drilling, perched water bodies are present where zones of silicified rocks are underlain and surrounded by argillaceous panels. Faulting may also result in zones of perched water, where clay gouge is present within fault zones. The combination of numerous steep and shallow angle faults in the vicinity of the ore bodies has the potential to support isolated bodies of perched water within fault blocks. Fault zones with little clay content will act as conduits for groundwater flow.

The geological model suggests that at the base of the interleaved argillic LV andesite/silificied VC sequence argillic andesite extends to depth, such that groundwater flow at depth beneath the ore bodies is restricted by the low permeability of the LV andesite. Groundwater modelling (see Appendix 6.9.1) suggests that this geological model sustains the observed groundwater conditions beneath the Amulsar Mountain ridge. Groundwater is interpreted to flow through the more permeable fractured rocks of the VC unit on the east of Amulsar Mountain.

Three groundwater flow conditions are observed in the vicinity of the ore bodies:

1. Ephemeral/transient perched snow melt infiltration, which discharges as ephemeral flows from springs surrounding the mountain peak in Spring (Golder, 2014e)[4]; this flow is also evident in groundwater hydrographs for wells on the mountain peak and in the BRSF site (DDAW008, DDAW013, GSC0037);
2. Isolated zones of year-round perched groundwater within the argillically altered LV andesite/silicified VC sequence; perched groundwater is evident both during drilling and in deeper groundwater wells which have collapsed; and
3. Groundwater associated with a continuously-saturated groundwater flow system extending from the water table below Amulsar Mountain ridge to discharge to the surrounding river valleys.

Groundwater flow pathways associated with Spring snow melt recharge and discharge at nearby springs surrounding the mountain peak are predominantly short, as evidenced by the relatively unevolved chemistry of the ephemeral spring waters (Golder, 2014e), and are likely to be broadly controlled by topography with discharge occurring slightly downslope of the ore bodies. Groundwater modelling indicates that recharge infiltrates to a saturated groundwater system beneath Amulsar Mountain ridge to sustain the water table elevations observed. This recharge contributes to surface water baseflow in the major rivers or tributaries of those rivers surrounding Amulsar Mountain.

A number of perennial springs have been identified surrounding the ore bodies (Golder, 2014e). These springs predominantly fall into two types: springs occurring in topographic low points in areas of outcrop of the argillic LV andesite; and springs occurring associated with geological features (faults, geological contacts). A number of springs also occur on the lower parts of the eastern slope of Amulsar Mountain, associated with seepage faces developing at ground surface as a result of the steep slope in proximity to the regional groundwater discharge to the Vorotan River. These springs reflect intermediate length flow paths in the groundwater flow system.

Groundwater flows both east and west from the Amulsar Mountain ridge toward the Vorotan and Darb Rivers. Regionally, hydraulic gradients are steeper surrounding Amulsar Mountain than in the wider GSA, and are steeper on the eastern slope of Amulsar Mountain than the western slope, as a result of the steep topographic gradient on the east slope. Groundwater elevations indicate hydraulic gradients of approximately 0.26 to the east from the ridge to the

Vorotan River and 0.22 to the west and south-west toward the Darb River.

Groundwater flow from the proposed Erato pit is to the west and the north toward the Arpa River. Hydraulic gradients surrounding Erato are slightly lower than those surrounding Tigranes-Artavazdes, with a typical hydraulic gradient of approximately 0.15 westward. Northward hydraulic gradients are flatter. At all locations at and surrounding the mountain ridge, there are strong downward vertical components of hydraulic gradient.

Crusher and BRSF Site

Groundwater flow beneath the central, southern and eastern portions of the BRSF footprint is controlled by the topography and the nature and extent of the low permeability argillically altered LV andesite. In this area, the water table is shallow (particularly in the valley centre), with local groundwater flow toward spring discharges at the centre of the valley, as illustrated in Figure 4.9.11 and in cross-section in Appendix 4.8.7 on Drawings 4.8.5 and 4.8.6. On the western side of the BRSF, groundwater flow is influenced by the basalt which forms the scoria cone bounding the valley to the west and which is significantly more permeable than the argillic andesite. It is probable that the westerly trending water table reflects the buried surface of the LV unit underlying the basalts.

Some groundwater flow from the southern and eastern portions of the BRSF is likely to discharge as springs in the centre of the valley centre. The groundwater that does not discharge to springs and baseflow is interpreted to flow in a north-westerly direction. Wells installed in the basalt are dry to depths of up to 100 m (DDAW013) showing that the regional water table is deeper than the depth of the wells. The ridge separating the BRSF site from the Vorotan surface water catchment appears to be a groundwater divide, so that groundwater flow from the BRSF site is toward the Arpa River rather than the Vorotan.

A spring survey was completed at the BRSF site in November 2013 which included collection of field parameters and samples for chemical analysis from two springs in the BRSF site. The chemistry of these springs was found to be relatively evolved, suggesting a significant flow in the subsurface prior to discharge and a degree of interaction with the rock. Based on the available groundwater elevation and chemistry data, these springs reflect groundwater discharge and not perched water.

The hydraulic gradient of the groundwater flow system north-west from the BRSF is unknown

and is estimated based on the gradient between the wells on the south and east of the BRSF site, wells 1.5km to the east, and springs adjacent to the Kechut reservoir 2 km to the north. Based on available data the typical hydraulic gradient to the north-west from the BRSF is approximately 0.12.

HLF Site

Groundwater flow beneath the HLF site in the deeper unaltered LV and in the basalts is generally to the west toward the Arpa River. Groundwater levels suggest that some groundwater discharge occurs to streams in the centre of the valley. This conclusion is supported by the shallow depth to groundwater observed south-west of the HLF and spring seeps observed within and south-west of the HLF during site investigations in October 2013. The hydrogeological regime beneath the HLF is illustrated in cross-section in Appendix 4.8.7 on Drawing 4.8.7.

The hydraulic gradient to the east of HLF is relatively steep (gradient of 0.14 in October/November 2013), and decreases (hydraulic gradient of 0.05 in October/November 2013) in the lower portions of the HLF and to the west of the HLF. The hydraulic gradient likely steepens further west of the HLF site mirroring the steep escarpment on the eastern bank of the Arpa River. The piezometric surface in the deeper groundwater unit at the most westerly recorded location (GGDW016) approximately 500 m east of the Arpa River is approximately 160 m above the river elevation. Groundwater discharges to the Arpa River.

During the 2013 site investigation, drilling water strikes indicated that perched groundwater was present within the colluvium and/or shallow Lower Volcanics underlying the HLF site, overlying a water table/piezometric surface in the underlying basalt and andesite. At the location of the GGDW010A/B well pair, perched groundwater in the upper bedrock and colluvium is found at an elevation 10 m higher than the bedrock water table. These vertical head differences decrease to the south-west to less than 1 m in the centre of the site, and are virtually absent in the GGDW016/A pair to the south-west of the HLF site. This suggests that a local shallow groundwater flow regime is present within the upper bedrock and colluvium at the HLF site, with flow to the south-west, discharging to the stream south-west of the HLF footprint at or upstream of GGDW016/A.

The area of the HLF footprint in which groundwater is present within the colluvium and local flow to the south-west occurs is indicated in Figure 4.9.12 and Figure 4.9.13. Vertical

components of hydraulic gradient calculated in the three well pairs in the HLF area are shown in Table 4.9.7. It is probable that groundwater to the north of the HLF in GGDW10A/B is perched, such that the upper system is free draining. Vertical components of hydraulic gradient further down-gradient are small, and are significantly smaller than the horizontal component of hydraulic gradient, indicating that horizontal flow dominates groundwater movement. The vertical component of hydraulic gradient is almost uniformly downward, with flow from the colluvium to the lower bedrock, driven by local recharge.

Table 4.9.10: Vertical Head Difference and Vertical Component of Hydraulic Gradient, HLF Well Pairs*

Well Pair	15/10/2013	16/11/2013	12/02/2014	26/02/2014	19 & 20/03/2014	30/05/2014	08/05/2015	14/08/2015
Vertical Head Difference								
GGDW010A/B	11.14	12.54	-	10.19	9.64	9.96		
GGDW013/A	-	0.49	-	0.44	0.09	-0.01	0.14	-0.05
GGDW016/A+	0.12	-	0.37	-	-0.08	0.17	0.20	0.39
Vertical Component of Hydraulic Gradient								
GGDW010A/B	0.248	0.279	-	0.227	0.215	0.222		
GGDW013/A	-	0.011	-	0.010	0.002	0.000	0.003	-0.001
GGDW016/A+	0.002	-	0.008	-	-0.002	0.004	0.004	0.008

Note: *Positive difference/gradient is downward flow (upper head above lower head)
+In the ESIA, GGDW016A is the shallow well of this pair. This differs to the definition applied by Geoteam in 2015.

Groundwater-Surface Water Interaction

Spring Discharge

Comprehensive spring surveys were undertaken in the GSA in November 2013 and in May 2014. The findings are presented in Golder (2014e)[4] and are summarised here. Active (flowing) springs identified during the surveys, in the context of the geology of the Project area are shown in Appendix 4.8.7 on drawing 4.8.3. Three spring hydrology systems have been identified based on the work. These spring systems are:

- **Type 1:** Year-round flowing (perennial) springs fed by groundwater discharge with regional-scale groundwater flow paths from geothermal sources. These springs are located in and around Jermuk and while their exact origin is uncertain (but clearly from great depth), they are not related to the hydrology in the Project area;
- **Type 2:** Year-round flowing (perennial) springs fed by groundwater discharge with

either short or intermediate-length groundwater flow paths. These springs are typically located on the flanks of the Amulsar Mountain ridge and at lower elevations in the wider river catchments (Vorotan, Arpa, and Darb). Those springs at lower elevations are representative of broader-scale hydrogeological characteristics. Snow melt increases the flow at these locations in the Spring and may also influence water quality; and

- **Type 3:** Seasonally flowing (ephemeral) springs fed by snowmelt recharge with short (and rapid) groundwater flow paths from recharge areas to discharge. These springs are often located at high elevations on Amulsar Mountain and are most likely localized perched groundwater flow systems or discharge of surface water interflow from colluvial deposits and shallow weathered rock horizons.

Each spring type is discussed below.

Type 1 Springs

A cluster of geothermal springs occurs in the Arpa catchment in and surrounding the town of Jermuk, close to the Arpa River gorge. The Jermuk geothermal spring cluster occurs significantly upstream (north) of the point where the Amulsar Project area intersects the Arpa catchment. These springs include DWJ1, DWJ2, DWJ3, DWJ5, DWJ6, DWJ7, DWJ8, DWJ9, DWJ10 and DWJ11.

These springs are permanently flowing and are used both to supply hydrothermal baths and spring galleries, and to supply mineral water bottling plants. The Jermuk geothermal springs generally have higher specific conductivity, TDS and metal concentrations than springs encountered in the Amulsar Project area. The geothermal springs also generally have a much more evolved water chemistry (longer groundwater residence times) and are not influenced by snow melt. The springs have higher temperatures than springs in the Amulsar Project area. The chemistry and higher temperatures of the Jermuk springs suggests that these springs are fed by a different source than the springs on Amulsar Mountain.

Type 2 Springs

At the time of the Winter 2013/2014 survey, 25 flowing springs and 38 “wet” (standing water, but no flow) springs were identified in the GSA out of 140 potential spring locations visited; most of the potential spring locations (77) were dry. Those that were flowing during the Winter are perennial, fed by groundwater, and are also likely to flow during dry periods in the

Summer.

Two groups of perennial Type 2 springs have been identified from the Winter 2013/14 spring survey:

- Springs which occur in close proximity to rivers toward the lower elevations of surface water catchments. These include a cluster located in the north of the project area close to the Kechut reservoir, and a number of springs along the western perimeter of the Project area close to the Arpa River; and
- Clusters of springs at higher elevations (above 2300 m asl) surrounding the Amulsar Mountain ridge.

During the Winter survey, the per unit area discharge from springs in catchments to the east and west of the Amulsar Mountain ridge (the Vorotan and Arpa catchments), taken as a whole, was similar. However, within each catchment there are sub-catchments with higher per unit area flows, where perennial surface discharge from springs is more concentrated. These springs are located in the BRSF site and the adjacent valley at the north of the Amulsar Mountain ridge, and at the foot of the Cenozoic Basalt Flow extending north from Amulsar Mountain where springs discharge from the base of the Basalt.

Spring waters that discharge from the Cenozoic Basalts close to Kechut Reservoir at lower elevations in the Arpa catchment occur in an area where the water table is generally close to surface and are likely to arise where locally the eroded topography intersects a lower permeability horizon within the sequence, such as a sedimentary horizon. The greater per unit area spring discharge in this catchment suggests a higher recharge into the basalt flow north of Amulsar Mountain than in the wider catchment (though without evaluation of surface water base flow, reliable conclusions cannot be drawn regarding comparative recharge). The springs occurring in this area have a water chemistry that is characteristic of recent recharge and short residence times with little interaction with the host rock. Some limited geochemical processes may have taken place between groundwater and calcium rich plagioclase feldspars to account for the proportion of calcium, and higher specific conductivities of these springs than rainfall or meltwater dominated springs. The chemistry of these springs is consistent with the geological setting: they occur at the base of a catchment dominated by basaltic flows which are likely to be of relatively high permeability, allowing rapid flow through fractures or interbeds.

Springs originating at lower elevations close to the Arpa River in the far west of the GSA are generally associated with discharge from the base of the Cenozoic Basalts at the contact with the lower permeability Lower Volcanics. They represent groundwater springs at points where vertical flow is restricted by lithological (permeability) contrasts. Where springs to the west of Amulsar Mountain ridge occur away from the Cenozoic Basalt contact, layered lithologies within the unaltered Lower Volcanic sequence (andesite flows, volcanoclastic sediments and sedimentary horizons) result in localised restriction in vertical flow, causing isolated spring discharges in areas where the water table is close to surface at lower elevations. These springs are not generally associated with mapped fault structures. The catchment areas of these western springs predominantly include altered and fresh andesites of the Lower Volcanics. The lower hydraulic conductivity and weathered composition of the andesite results in both a slower flow and greater chemical influence than in the northern springs which intersect only the more permeable Cenozoic Basalts. The springs have relatively high specific conductivities suggesting a more evolved groundwater chemistry.

Perennial springs that occur at relatively high elevations (above 2300 m asl) to the east and west of the Amulsar Mountain ridge generally occur in areas where the argillically altered Lower Volcanic andesite outcrops or underlies superficial colluvium. Spring discharge mechanisms are likely variable with local influences. Several springs are associated with mapped fault structures, but faults do not appear to be the dominant control on surface spring discharge. It is considered likely that, at high elevations surrounding Amulsar Mountain ridge, the advanced argillic alteration renders the Lower Volcanic andesites less permeable than at greater distance from the ridge. The low permeability of the argillic andesite, combined with high recharge, results in a relatively shallow water table, such that springs develop in topographic lows or associated with localised changes in vertical hydraulic conductivity. With the exception of Spring SP13.29, the perennial springs surrounding the Amulsar Mountain ridge have a more evolved chemistry and higher specific conductivity than those discharging from the basalts to the north. This indicates that these springs are influenced by a longer (or shorter, but slower flowing) flow path through the altered Lower Volcanic andesite resulting in sodium and sulphate enrichment.

Type 3 Springs

Type 3 springs are ephemeral, fed by snow melt interflow, and typically do not flow during the Winter. Historical anecdotal observations, hydrogeological studies completed in 2010 and a spring mapping survey at the BRSF site and adjacent valley in April 2011 indicate that

many ephemeral springs occur across the Project area. These springs are found at high elevations on Amulsar Mountain, but also as a spring clusters surrounding perennial springs leading to much greater spring flow in these areas in Spring.

The Spring survey completed in April/May 2014 confirms the distribution of ephemeral springs in the Project area and supports the anecdotal observations. The April/May 2014 data indicates a significant number of flowing springs in the Project area during the snow melt period. Of the 148 'SP' spring locations visited in April/May 2014, 102 were recorded as flowing and a further 24 (16 %) were wet. The quality of water from these springs shows more influence from dilution by snowmelt than the water from Type 2 springs.

In addition to the springs identified in the 2013/14 Spring surveys, two surficial springs were identified during the 2013 site investigation in the vicinity of the HLF site. A spring was observed located on top of the cherty mudstone bed in the east central portion of the HLF footprint. It appears that the cherty mudstone acts as a confining layer, creating a thin locally elevated water table. Water exiting the spring was at the time seeping back into the ground and disappearing approximately 20 m downgradient from the source. The second spring was located near the northwest side of the main HLF drainage adjacent to the highway. At this location, there is an outcrop where the base of the basalt flow is exposed. Old alluvial sediments are visible below the basalt, consisting of semi-rounded gravel/cobbles interbedded with finer grained layers. The spring is located at the base of the basalt, on top of the paleosol. Flow appeared to be concentrated in two spots, but there is a zone approximately 10 m long which exhibits slow seepage as evidenced by presence of green moss, wet soil on the face, and localized soil erosion. Neither of these springs was identified as active in the November 2013 spring survey; however a spring in relatively close proximity to that described by the highway was observed, suggesting that seepage along this contact and at the boundary of the Arpa Gorge may be more extensive. These springs are considered to fall within Type 2 identified above.

Surface Water Baseflow

Perennial spring flows such as those identified surrounding Amulsar Mountain peak and in particular in the BRSF site and the adjacent valley to the west will contribute to a year round baseflow in high altitude mountain streams originating in those seepage areas. However, most of the groundwater discharge to surface water across the GSA occurs to the main,

deeply incised, river valleys of the Arpa, Darb and Vorotan Rivers and to the major tributaries of these rivers at lower elevations.

Flowing artesian conditions in the base of the valley east of the BRSF, groundwater contours, and observed flows all indicate that groundwater discharge occurs to streams in the BRSF site, the HLF site and the valley east of the BRSF. It is unlikely that these streams are isolated cases and groundwater discharge is also likely to occur to similar streams across the GSA and to streams on the lower portions of the eastern face of Amulsar Mountain which have not been the direct subject of monitoring and investigation.

Surface water baseflow is further quantified with regard to the water balance described in Section 4.8.6.

4.8.6 Groundwater Recharge Estimation

The components of the groundwater flow system which contribute to the overall water balance within the GSA are as follows:

- Groundwater recharge;
- Surface water baseflow, contributed by spring discharges and direct discharge to streams and rivers; and
- Groundwater discharge to man-made features.

Groundwater consumption associated with industrial or domestic water use in the GSA is minimal. Groundwater recharge in the Project area, which cannot be measured directly, is by definition in balance with the discharge to wells and surface water features within the GSA. Information regarding surface water baseflows, discharge to man-made features and fluctuation in groundwater levels have been used to support estimate of groundwater recharge. There is no well use in the GSA.

Spring Discharges

The November 2013 survey identified only a small number of flowing springs (see Table 4.9.8, and Appendix 4.8.7, Drawing 4.8.3); a further five flowing locations had no flow estimate. Several potentially significant springs were not visited during the survey (e.g. Springs GA1 to GA5, ERW1, ERW2, Springs 1 to 7). All these springs are considered to be perennial, groundwater fed springs. The total measurable flow reported in this survey from springs was

18.2 L/s; 11.5 L/s into the Arpa catchment, 6.5 L/s into the Vorotan catchment and 0.2 L/s into the Darb catchment. These values represent flows at a specific time in the year and are not representative of year round spring discharge.

Table 4.9.11: Springs with Recorded Flow, November 2013 Spring Survey

Location	Easting	Northing	Elevation (m)	Flow rate (L/s)	Temp°C	pH	EC (uS/cm)	Catchment
SP1	563893	4392500	2199	<0.1	8.86	7.76	189	Darb
SP5	563629	4392761	2206	<0.1	10.33	7.71	201	Darb
SP6	562374	4392824	2250	<0.1	5.61	7.53	164	Darb
SP13.7*	560908	4402691	2429	0.6	4.11	3.89	376	Vorotan
SP13.10	561655	4403067	2416	1	7.54	7.2	53	Vorotan
SP13.18	561541	4402215	2454	<0.1	7.01	6.24	98	Vorotan
SP13.23	561458	4402579	2416	0.5	8.14	6.89	102	Vorotan
SP13.29	561141	4402664	2415	1.2	8.01	6.61	148	Vorotan
SP21	562849	4395109	2309	0.2	5.44	6.73	142	Vorotan
SP27.20	560494	4401650	2538	1	3.02	6.83	122	Vorotan
SP27.21	560504	4401647	2539	1.4	3.16	6.44	234	Vorotan
SP31	560288	4395766	2353	<0.1	5.22	6.84	132	Darb
SP44	551486	4397535	1568	0.2	8.98	7.93	354	Arpa
SP50	560769	4398235	2698	<0.1	6.53	5.73	97	Darb
SP56	563161	4399028	2345	<0.1	6.22	6.51	184	Vorotan
SP68	569131	4401149	2453	0.2	1.78	7.65	95	Darb
SP73	552757	4401419	1730	1.8	8.27	7.7	455	Arpa
SP77	561291	4401764	2513	0.3	4.19	3.92	207	Vorotan
SP79	563078	4401958	2403	0.3	8.92	6.96	86	Vorotan
SP80	556861	4405248	1962	2.2	8.38	7.25	179	Arpa
SP83	558382	4405951	2021	1.9	8.91	7.45	101	Arpa
SP89	557907	4405643	2008	5.4	7.83	7.61	125	Arpa
Total Measurable Flow				18.2	L/s			

Note:
*This is believed to be surface water monitoring location AW030.

Location SP13.7 is the same as surface water monitoring location AW030. This location is discharge from a historical trial mine adit. The recorded flow (0.6 L/s) at this location is similar to the flow rate of 0.53 L/s recorded from the adit in August 2011.

The survey conducted following the Spring snow melt identified a much greater number of springs, and larger flows. Many of these springs are ephemeral springs fed by the snow melt. At the time of the April/May 2014 survey, the spring discharges in the Arpa/Darb catchment totalled 145.6 l/sec (12,580 m^3/day), which is approximately ten times as much as during the

Winter survey. The increase in spring flow occurred primarily at higher elevations, whilst the discharge recorded from springs SP80, SP83 and SP89, at lower elevations in the catchment adjacent to the Kechut Reservoir, reduced to 4.5 l/sec. The greatest discharges in April/May 2014 were recorded from spring ERW2 located west of Erato, spring SP27.18 in the BRSF site, springs SP28 and SP33 located south of the Tigranes/Artavazdes peak and spring SP44 located near the Arpa River at the base of the Cenozoic Basalts. Flow from these five springs totalled 69 l/sec (47 % of the total April/May 2014 discharge). Of these springs, ERW2 was not visited in November 2013, SP27.18, SP28 and SP33 were dry and SP44 was flowing at the time of the Winter 2013/2014 survey, but the flow increased in April 2014 by 70 times. The data indicate that the May 2014 flows at SP27.18, SP28, SP33 and SP44 are predominantly fed by snow melt recharge.

The spring discharges on the eastern (Vorotan) side of the ridge during the Winter 2013/2014 survey was at least 4.1 l/s (approximately 354 m^3/day). The discharges predominantly originate in the valley east of the BRSF. Five springs in the Vorotan catchment were flowing at the time of the survey, but had discharges of less than 0.1 l/s. At the time of the April/May 2014 survey, the discharges from springs in the Vorotan catchment increased from at least 4.1 l/s (354 m^3/day) to 106 l/sec (9,158 m^3/day). This indicates that spring discharges in the Vorotan catchment are also dominated by snow melt. Over 20 % of the discharge from the eastern (Vorotan) side of Amulsar Mountain ridge at the time of the Spring 2014 survey originated from springs in Site 13.

Table 4.9.9 summarises the spring discharges in each of the main catchments during the Winter 2013/14 survey and the April/May 2014 survey. Areas with a group of springs with particularly high discharges have been addressed separately as well as within a total larger catchment. Full details of the flows and catchment calculations are provided in Golder (2014e)[4].

Table 4.9.12: Catchment Spring Discharges

Catchment	Approximate Catchment Area within Survey Zone (m^2)	Survey Period	Approximate Spring Discharge (l/s)	Approximate Spring Discharge (m^3/day)	Approximate Spring Discharge (l/s/km^2)
Vorotan (entire catchment within Study Area East of the Amulsar ridge)	41,958,800	Winter 2013/2014	4.6	397	0.11
		April/May 2014	106	9150	2.52
Vorotan catchment area excluding Site	40,346,900	Winter 2013/2014	1.2	104	0.03

Table 4.9.12: Catchment Spring Discharges					
Catchment	**Approximate Catchment Area within Survey Zone (m^2)**	**Survey Period**	**Approximate Spring Discharge (l/s)**	**Approximate Spring Discharge (m^3/day)**	**Approximate Spring Discharge (l/s/km^2)**
13 catchment		April/May 2014	83	7163	2.05
Site 13 catchment (sub-catchment in Vorotan catchment)	1,611,900	Winter 2013/2014	3.4	294	2.11
		April/May 2014	23	1987	14.27
Darb/Arpa (entire catchment within Study Area West of the Amulsar ridge)	94,943,200	Winter 2013/2014	14.3	1,236	0.15
		April/May 2014	146	12,580	1.53
Darb/Arpa catchment area (excluding northern catchment - Site 27 and Springs SP80, SP81, SP82, SP83, SP89 and SP90)	76,171,200	Winter 2013/2014	2.4	207	0.03
		April/May 2014	93	8035	1.22
Northern catchment - Site 27 and Springs SP80, SP81, SP82, SP83, SP89 and SP90 (sub-catchment in Darb/Arpa catchment)	18,772,000	Winter 2013/2014	11.9	1028	0.63
		April/May 2014	53	4545	2.80

Spring flow, surface water flow and groundwater elevation data indicates that infiltration rates during the snow melt period are high and that the majority of the infiltration is discharged to springs or baseflow shortly following the snow melt.

The total measureable perennial spring discharges recorded in the Winter 2013/2014 spring survey (18.2 L/s) is small in comparison to surface water baseflow in streams and rivers (described further below). Perennial spring discharge is a not a large component of the water balance for groundwater system in the Project area.

Surface Water Baseflow

Groundwater discharges to surface water along the channels of the major rivers and at the lower elevations of their tributaries.

Spot Flow Measurements

Baseflow estimates have been made based on spot flow measurements during late Summer along the major rivers, with the exception of the Arpa River, where the estimate is based on continuous flow records in Winter 2012/13. Baseflow discharge is estimated as follows:

- A baseflow increase between AW001 to AW003 (10.9 km) on the Vorotan River of 0.7 m^3/s based on measurements in August and Sept 2010 and August and Sept 2011. This is equivalent to a baseflow rate of 0.064 $m^3/s/km$. Based on a contributing catchment of approximately 77.4 km^2 between the two points, this is equivalent to a distributed recharge rate of approximately 290 mm/yr.
- A baseflow increase on the Darb River between AW005 to AW006 (2.9 km) of 0.6 m^3/s to 0.7 m^3/s based on measurements in August and Sept 2010 and August and Sept 2011. This is equivalent to a baseflow rate of between 0.21 $m^3/s/km$ and 0.24 $m^3/s/km$. It is notable that the flow at AW004, on a tributary to the Darb River 1 km upstream of AW005 is almost identical to that at AW005. The contributing catchment between AW004 and AW006 is more than double that between AW005 and AW006. Based on a contributing catchment of approximately 50.2 km^2 between the AW004 and AW006, the baseflow increase in the upper Darb River is equivalent to a distributed recharge rate of approximately 400 mm/yr to 460 mm/yr.
- Spot flow data suggest that the upper reach of the Arpa River may be losing immediately downstream of the Kechut Reservoir. However, accretion baseflow increase is observed in the lower reaches within the Project area. The median baseflow increase between Arpa 2 to Arpa 3 (3.9 km) over the period November 2012 and February 2013 was 0.1 m^3/s (average 0.11 m^3/s). This is equivalent to accretion baseflow of 0.026 $m^3/s/km$.

Spot flow measurements were undertaken during and following the Spring snow melt in the tributary to the Vorotan River located in the valley east of the BRSF in 2012. Reported flows are shown graphically in Figure 4.9.14. The snow melt water discharge peak passes relatively rapidly, and flow in the stream in late June is between 7 L/s and 9 L/s. The topographic catchment of this valley is approximately 1.61 km^2; assuming the June 2012 discharge is representative of the annual mean base flow, this is equivalent to a recharge rate of between 140 mm/yr and 180 mm/yr.

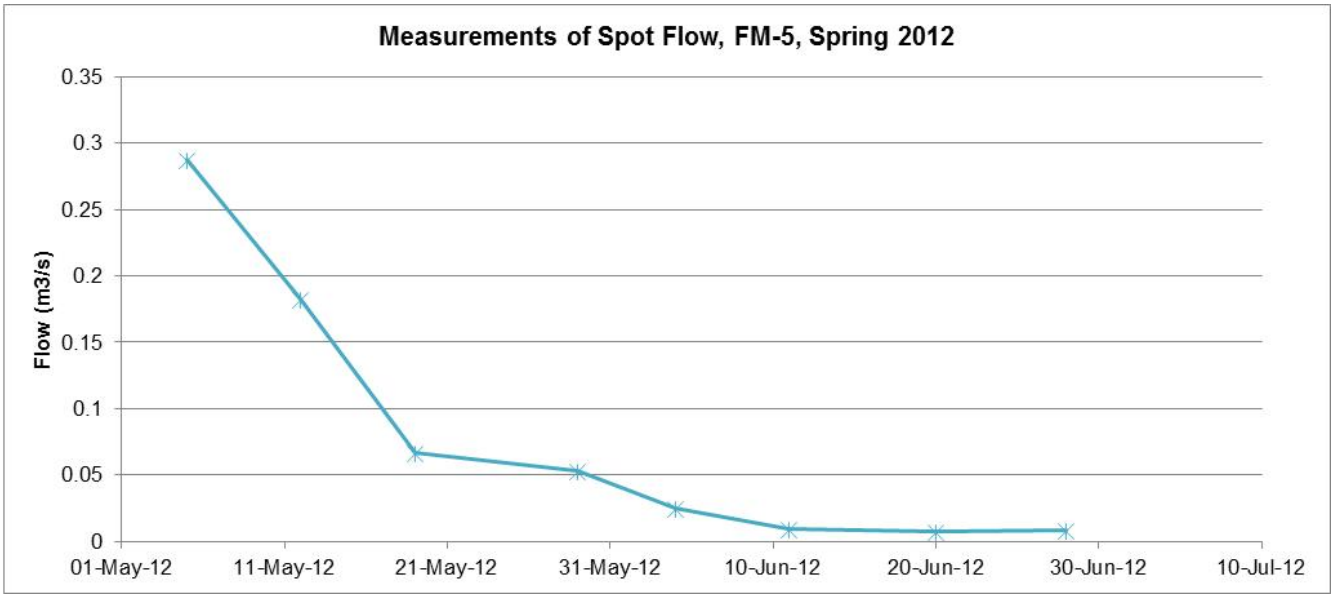


Figure 4.9.25: Stream Flow at FM-5, Spring 2012

Continuous Flow Data

Surface water unit area runoff (yield) for each catchment with continuous flow monitoring over the 2012/2013 and 2013/2014 monitoring periods is presented in Chapter 4.9. Monthly catchment yields are presented for the monitoring period, included for the Winter months (December, January and February) when surface water flows are low. Flows recording during this period may include some precipitation events at lower elevations, but in general represent low surface runoff input due to frozen ground conditions and approximate groundwater baseflow discharge.

These catchment yields have been used to estimate annual average rates of groundwater recharge in the monitored catchments, presented in Table 4.9.10. For this calculation, it is assumed that there is no riparian evapotranspiration. Groundwater baseflow is not uniform over the year and is likely to be higher in spring, therefore extrapolation of winter surface water baseflow measurements to estimate annual recharge may underestimate annual values. Groundwater discharge from the catchments via other means (such as to the Kechut-Spandaryan tunnel in catchments west of Amulsar Mountain) will result in an underestimation of recharge rates considering surface water flows in isolation.

Table 4.9.13: Estimates of Annual Groundwater Recharge from Winter Catchment Yield, 2012/2013 and 2013/2014

Location	Point ID	Calculated Catchment Yield (mm/month)			Average Winter Yield (mm/month)	Annual Equivalent Recharge (mm/year)
		December	January	February		
2012/2013 Period						
Arpa	Arpa 2	24	23	21	23	272
Arpa Tributary	Site_27	67	18	16	33	401
	Site_28_G1	25	N/A	0	-	-
Darb Tributary	MP_3	8	12	N/A	10	124
Vorotan Tributary	FM-6-HI	10	5	7	8	90
	FM-6-WEIR	14	13	13	13	161
	MP_1	59	49	45	51	610
	MP_2	19	16	15	17	202
2013/2014 Period						
Arpa	Arpa 1	25	25	22	24	286
	Arpa 2	25	24	21	24	283
	Arpa 3	22	21	18	20	244
Arpa Tributary	Site 14	N/A	N/A	N/A	-	-
Darb Tributary	North Erato	11	15	15	14	162
Vorotan	Vorotan	37	33	28	33	392
Vorotan Tributary	FM-6-HI	19	17	12	16	190
	FM-6-WEIR	8	12	14	11	136

Notes:
N/A Data not available/monitoring station not yet installed
1) Limited calibration data was available for the 2012-2013 monitoring period at the Arpa river stations. Discrepancies in upstream/downstream measurements may arise from this source or may relate to operation of the Kechut Hydroelectric Power Plant adjacent to Arpa 1.
2) Unit discharge for the Arpa is based on total upstream catchment; this may not be meaningful due to the presence of the Kechut reservoir. On receipt of the Arpa 4 data, a comparison between these sites may allow the yield for the area of catchment between the locations to be calculated.

There is considerable variation in recharge rates calculated for the monitored catchments. Some of this variation will be attributable to variation in geology, soil type, elevation, steepness and aspect of the monitored catchments. Discrete geological features (faults or fracture zones) could also create large local variations in groundwater discharge. Some of the observed variation is also likely to be attributable to measurement error associated with calibration of the surface water flow records and influence of ice accumulation on measurements. However, overall the calculated values suggest recharge rates are typically between 150 mm/yr and 300 mm/yr.

Discharge to Man-Made Features

Kechut-Spandaryan Tunnel

Flow in the Spandaryan-Kechut Tunnel has been recorded via spot flow measurements between 2012 and 2015 as shown in Figure 4.9.15. The mean flow recorded at AWJ6, the discharge of the tunnel at Kechut Reservoir, over the monitoring period is 0.19 m^3/s; the minimum flow was 0.07 m^3/s in March 2014 and the maximum flow recorded was 0.29 m^3/s in July 2013. Measurement during 2014 (February to June 2014) recorded lower flows than during 2012 to 2013.

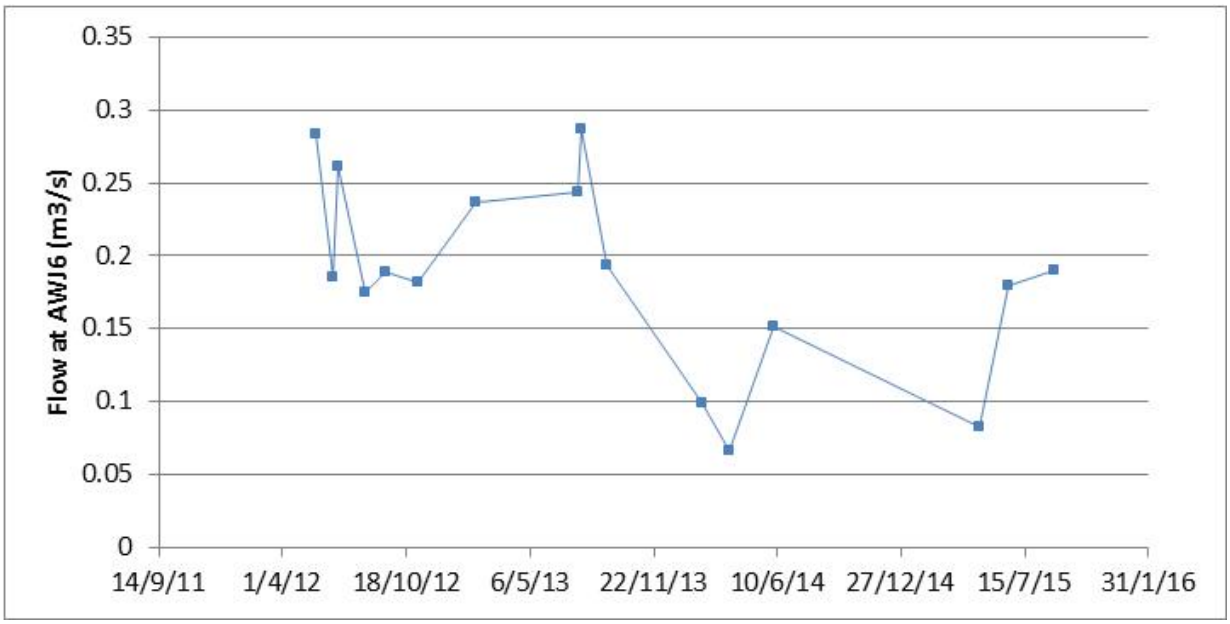


Figure 4.9.26: Spot Flow Measurements at the Kechut-Spandaryan Tunnel Outfall, AWJ6

Assessment of the chemistry of water samples from surface waters and groundwaters sampled in June 2013 below indicates that the chemistry of the water discharging from the Spandaryan-Kechut tunnel has a calcium sulphate signature, similar to the more evolved spring and groundwaters in parts of the Project area (RCAW403, AW030, Site 27 springs). The waters have a specific conductivity between 300 µS/cm and 400 µS/cm, consistently higher than surface waters and more consistent with groundwater. The chemistry of the tunnel discharge is discussed in more detail in Section 4.8.7.

Adits

A historical exploration adit in the valley east of the BRSF extends westward beneath the BRSF site. Three additional adits have been identified north of the BRSF site, extending east.

A number of spot flow measurements have been made from the adit outfall location AW030

in the valley east of the BRSF, presented in Table 4.9.11. Spot flows vary between 0.2 L/s and 13 L/s with the lowest flow recorded in late spring 2015 and the highest flow in Spring 2013.

Table 4.9.14: Recorded Spot Flows, AW030/SP13.7	
Date	**Flow rate (L/s)**
20/08/2011	0.5
10/03/2013	13
22/11/2013	0.6
26/05/2014	1
06/05/2014	0.9
03/05/2015	1.6
09/06/2015	0.45
19/06/2015	0.2

There was no discharge from adits north of the BRSF in August 2011.

Groundwater Recharge Estimates - Water Balance Methodology

Groundwater recharge has been calculated using average climatic values presented in Table 4.9.12 and Table 4.9.13, according to the method described by Rushton (2003)[11] and using the following assumptions consistent with those applied by the Amulsar Project engineering team (see Section 4.2.4):

- Precipitation falls as snow between November and March;
- During this period, precipitation is assumed to be 8% of the SDWE (snow depth water equivalent) calculated based on a snow density of 0.26 g/cm^3 (based on snow density data for the Vorotan Pass weather station (GRE, 2014));
- During the Winter months, sublimation is 10% of SWDE;
- The remaining 82% of SDWE, accumulated as a total between January and March is assumed to melt in April and May with 60% of the volume release in April and 40% in May. No effective snow melt is assumed between the months of June and December;
- Runoff on the mountain slopes is 67%, coefficient for a 0.6 slope on clay loam soil with uncultivated heathland vegetation (NCB, 1982)[12];
- Runoff on the lower valleys is 55%, coefficient for a 0.085 slope on clay loam soil with

[11] Groundwater Hydrology. Rushton, K.R. 2003. Wiley, Chichester
[12] Technical Management of Water in the Coal Mining Industry. UK National Coal Board (NCB); 1982

uncultivated heathland vegetation (NCB, 1982); and

- On the mountain peak, 30% of effective precipitation bypasses the soil zone due to flow through fractures and infiltration into exposed bare rock. In lower valleys, 15% of effective precipitation is assumed to form bypass recharge.

The approach adopted for baseline weather data has been considered in Chapter 4.2.4, which also provides the background to the range of data used for Project design and constructing the site wide water balance (see Appendix 6.10.1). This site wide water balance has been derived from Vorotan Pass dataset, and includes a number of synthetic scenarios to generate the range of runoff volume estimates to inform both the model predictions and Project design criteria. These include a "wet year", "average year" and "dry year scenario" that have been used to test the design philosophy for pit water management, the BRSF design and the HLF design. Additional assessment of runoff management will be completed for the final engineering design work, including further rainfall analysis and a daily time step water balance.

Table 4.9.15: Monthly Precipitation, Vorotan Pass[1]

	Jan	Feb	Mar	April	May	Jun	July	Aug	Sept	Oct	Nov	Dec
Average	47.1	50.7	63.9	86.4	93.7	68.7	49.6	30.6	26.6	57.0	45.9	47.1
Maximum	81.5	132.3	158.0	180.8	213.7	199.7	196.0	154.8	158.5	172.8	100.3	117.6
Minimum	11.8	11.7	4.5	17.1	26.5	2.0	0.0	0.0	0.0	2.2	0.0	5.3

Note:
[1]Summary of monthly precipitation (mm) calculated from daily data recorded 1962 to 1994 and 2000 to 2013.

Table 4.9.16: Monthly Evaporation, Vorotan Pass[1]

	Jan	Feb	Mar	April	May	Jun	July	Aug	Sept	Oct	Nov	Dec
Average	24.5	27.9	44.9	59.3	93.3	128.1	150.8	154.7	122.9	72.3	40.2	28.4

Note:
[1]Evaporation for the grass reference crop calculated using the Penman-Monteith Equation from records for the Vorotan Pass weather station.

Based on these assumptions, this calculation yields an estimate of the recharge rate on Amulsar Mountain of approximately 100 mm/yr, and an estimate of the recharge rate in the lower valleys of approximately 50 mm/yr. This recharge predominantly occurs in April and May as a result of snow melt recharge, with a second pulse occurring in late Autumn.

Comparison to observed flows in the GSA described above strongly suggest that the soil

moisture balance approach underestimates recharge in this area. This is likely to be the result both of the strongly seasonal recharge processes, thin soil cover, elevation and climate related effects and potentially other processes which are not captured by this simplistic approach. Surface water base flows suggest that recharge rates are considerably higher, potentially more than 200 mm/yr.

The sensitivity of the groundwater flow system to recharge rate has been evaluated in the regional groundwater model (see Appendix 6.9.1), indicating that both heads and flows in the system are highly sensitive to recharge rate. Calibration of the groundwater model found that a reasonable match to flows in the Kechut-Spandaryan tunnel and discharge in the valley east of the BRSF could be achieved with a regional recharge rate of 200 mm/yr, with a slightly higher recharge rate of 250 mm/yr in the BRSF and adjacent basins where the restricted entrance to both valleys promotes snow capture and restricts runoff.

A recharge rate of 200 mm/yr to a fractured rock aquifer with low porosity will result in a large seasonal fluctuation in groundwater level. In order to validate the estimates of recharge generated through modelling, calculations of equivalent porosity of the hydrogeological units have been made for those wells with reasonably well characterised season range (Table 4.9.14) based on an assumed 90% of the annual recharge rate occurring following the Spring snow melt. This calculation method assumes that the difference between observed maximum and minimum groundwater levels is attributable to change in water table elevation following the Spring snow melt.

With the exception of the colluvium, calculated porosities are similar to the initial estimates and are generally within ranges that would be reasonable for the geological conditions at Amulsar Mountain. The estimated porosity for the colluvium is consistent with a material with a higher clay content than initially assumed.

Table 4.9.17: Calculated Porosity Based on Estimated Recharge and Seasonal Range

Hydrogeological Unit	Initial Estimate (Table 4.9.2)	Minimum Calculated Value	Average Calculated Value	Median Calculated Value	Maximum Calculated Value	Data Count
Unaltered Lower Volcanics	0.04	0.004	0.076	0.083	0.240	13
Argillically altered andesite	0.03	0.010	0.140	0.099	0.360	6
Upper Volcanics	0.04	0.005	0.020	0.018	0.052	5

Cenozoic Basalt Flows	0.015	0.008	0.087	0.038	0.300	9
Colluvium	0.25	0.019	0.079	0.051	0.194	4

A single numerical groundwater flow model has been developed, to evaluate groundwater flow with the Project-affected area. This model (described above), together with observations from monitoring and the baseline characterisation and hydrogeological conceptualisation, have been used to predict the response to mining, dewatering and reclamation/closure (see Chapter 6.9). The saturated groundwater flow model does not provide a suitable method to calculate ephemeral groundwater (snow melt water) flows that originate near the summit of Amulsar Mountain. Therefore, the potential impacts associated with these flows have been calculated and assessed in Section 5.5.2 of Appendix 6.9.1.

Summary

The Amulsar Project area is located in a region where annual evaporation exceeds annual precipitation, and Summers (at low elevations) are warm and dry. A soil moisture balance based approach to estimate groundwater recharge in this environment suggests that recharge rates will be low, with the majority of precipitation lost to evapotranspiration and runoff. However, surface water flows, groundwater hydrographs and discharge to man-made features indicate that soil moisture balance calculations under-estimate groundwater recharge in this environment. Based on observed flows and groundwater hydrographs, recharge is considered to be between 200 mm/yr and 250 mm/yr across much of the Project area, with greatest rates of infiltration occurring at the higher elevations within the Project area.

4.8.7 Groundwater Chemistry and Composition

Water Types

Water typing diagrams for springs and groundwaters based on the methodology presented in Lloyd and Heathcote, 1985[13] for the Amulsar GSA and the Jermuk Hydrothermal Park are presented in Appendix 4.8.4. Water typing has been used to evaluate the origin of springs and groundwater and to differentiate between groundwater flow systems.

[13] Natural inorganic hydrochemistry in relation to groundwater: An Introduction. Lloyd, J. W. and J. A. Heathcote; 1985 Oxford University Press, New York

Spring Waters – Amulsar Mountain

A number of springs sampled during the November 2013 and May 2014 spring surveys plot in Field 1 of the extended Durov diagram; these are bicarbonate and calcium dominant and are typically indicative of "recharging waters" (Lloyd and Heathcote, 1985)[12]. The springs with this chemistry include those discharging from the Cenozoic Basalt Flows adjacent to Kechut Reservoir, and springs surrounding Amulsar Mountain ridge sampled in May 2014. The unevolved chemistry of springs discharging from the basalts is consistent with rapid flow through fractures in the permeable basalts, with little time for interaction between groundwater and the rock mass. The fresh spring water sampled on Amulsar Mountain ridge in Spring 2014 is indicative of springs influenced by snow melt recharge, representative of discharge of recent waters infiltrating locally to the springs.

Spring water samples falling into Fields 2, 4 and 5 on the extended Durov diagrams are similar to the Field 1 samples, but are slightly more evolved with respect to sodium and/or sulphate concentrations. They typically have a TDS concentration of 20 mg/l to 100 mg/l and a specific conductivity of less than 400 µS/cm. The springs that plot in Fields 4 and 5 are sulphate-enriched and include those that originate in the BRSF site, the valley to the east, or to the west of the Amulsar Mountain ridge. These springs tend to be those that are located in the argillically altered Lower Volcanics. The geochemical characterisation of the argillic andesites (Golder Associates, 2013b)[14] indicates that they contain high concentrations of pyrite. Weathering of pyrite likely accounts for the sulphate-enriched groundwater. These waters have a relatively 'evolved' chemistry and higher specific conductivities indicating significant interaction with the rocks through which they have passed and a longer groundwater flow path. This is consistent with the interpretation, based on flows observed in November 2013, that perennial springs flow in valleys underlain by the argillic andesite on the west and to the north of the Amulsar Mountain ridge.

Spring Waters - Jermuk

The Jermuk geothermal springs plot in Fields 3 and 6 of the extended Durov diagram (Lloyd and Heathcote, 1985)[12]. These waters are bicarbonate and sodium dominant and have chemistry indicative of ion exchange, although, under certain circumstances, generation of carbon dioxide at depth can produce bicarbonate where sodium is dominant (Lloyd and

[14] Summary of Geochemical Characterization and Water Quality Prediction. Golder Associates, 2013b;

Heathcote, 1985)[12]. The higher specific conductivity and higher TDS measurements at these locations suggest that water discharging at the Jermuk springs has had sufficient groundwater travel time such that mineral dissolution has occurred. These spring waters have higher concentrations of metalloids/metals such as arsenic, lithium, molybdenum and thallium, and lower concentrations of aluminium, than the 'ERW' and 'SP' locations, and DWJ4, suggesting a different source of the spring water and contact with different rock types. The spring water in Jermuk is geochemically different from the spring water around Amulsar Mountain. This is discussed in more detail in the Golder Technical Memorandum (see Appendix 4.9.1).

The Jermuk geothermal springs (DWJ locations) have higher temperatures than springs in the Amulsar Project area and are significantly warmer than the mean annual temperature of the area, indicating that the Jermuk springs are geothermal. Both data presented in Golder (2014e)4 and field data presented in Appendix 4.8.5 suggests that springs within the GSA are at ambient temperatures (in Summer, warmer temperatures are recorded where slow seepages may have been warmed by the sun). There is no evidence of geothermal springs within the GSA. This indicates that the Jermuk geothermal springs are different in origin to the Amulsar Project area springs.

Groundwaters

Groundwater samples in Appendix 4.8.4 are from locations distributed across the GSA, surrounding Amulsar Mountain peak, the valley to the north-east of the HLF site, the valley east of the BRSF site, and also from wells installed in the Cenozoic Basalt Flows on the eastern bank of the Vorotan River.

Groundwater from RCAW408 (adjacent to Tigranes-Artavazdes), wells immediately east of the BRSF site, wells installed in the Cenozoic Basalt Flows adjacent to the Vorotan River and wells in the HLF area show a 'fresh' calcium-bicarbonate signature typical of shallow recently recharged groundwater. The majority of the monitoring locations surrounding the ore bodies and springs on the mountain peak also show low electrical conductivities which are indicative of fresh, recently recharged groundwater.

Groundwater at monitoring locations on the argillic andesite further east of the BRSF site (DDGW004, RCAW403) show higher conductivities than the majority of samples, indicating a more evolved groundwater (which has travelled further or slower allowing greater dissolution of minerals). The chemistry of these well samples is similar to the spring samples collected at

the BRSF site, but have a greater sulphate-rich signature indicative of pyrite oxidation.

Groundwater from the Cenozoic Basalt Flows north-east of the HLF site are characterised by slightly magnesium- and potassium-enriched waters typical of more evolved groundwater than that in the pit area, which has been subject to ion exchange during transport.

Major Ion Composition of the Kechut-Spandaryan Tunnel and Adits

The comparison of surface water major ion chemistry and groundwater major ion chemistry completed as part of the 2013 isotope study (see Appendix 4.9.1) indicates that the groundwater discharging from the Kechut-Spandaryan tunnel is similar to the evolved sulphate enriched groundwaters seen in springs near Erato and in the valley to the east of the BRSF rather than surface water.

Little distinction in chemistry is apparent between the Spandaryan and Kechut reservoirs on a water typing basis, both plot as 'fresh' waters as would be expected for surface water. Waters taken from the upstream catchment of the Arpa River have a stronger groundwater signature.

The comparison also demonstrates, as is evident in plots for the full springs dataset described above, that water quality in the Jermuk geothermal springs is much more evolved and distinct from both groundwaters and surface waters in the Amulsar Project area.

Isotopic Composition

A study of the major ion and isotopic composition of groundwater and surface waters in the Amulsar Project area and surrounding the Jermuk Hydrothermal Park was undertaken by Golder (see Appendix 4.9.1). The objectives of this study were to determine:

- The source of water currently discharging from the Kechut-Spandaryan tunnel at its outfall to the Kechut Reservoir; and
- The source of waters flowing to the Jermuk thermal springs.

Water sampling was completed by Geoteam in June 2013 and samples were analysed for major ions and natural isotopes (Deuterium - $\delta 2H$, Oxygen 18 - $\delta 18O$, Carbon 13 - $\delta 13C$ and Tritium). Sampling and analysis was completed at five surface water locations, at the Jermuk hydrothermal springs and two groundwater wells, one located at the peak of Amulsar Mountain, and one on the mountain flank. Sampling locations are summarised in Table

4.10.1, locations are shown in Appendix 4.8.7 on Drawings 4.8.2 and 4.9.6.

Table 4.10.18: Water Sampling Locations, Isotopic Composition Analysis, June 2013

Location	Easting	Northing	Water Type	Description
AW003a	568095	4391558	Surface water	Spandaryan Reservoir
AWJ001	559354	4411527	Surface water	Arpa river, upstream of Jermuk
AWJ4a	556330	4406912	Surface water	Kechut reservoir, upstream end
AWJ006	556312	4404800	Surface water	Kechut-Spandaryan tunnel outfall at Kechut
AW042	554978	4401388	Surface water	Gndevaz pond
DWJ6	*557900**	*4409900**	Drinking water	30° Gallery
RCAW408	560868	4397977	Groundwater	Amulsar Mountain
GGDW002	555310	4401315	Groundwater	Lower mountain slopes

Note:
*Indicative general location of the mineral water springs

The major ion composition of these samples is discussed above. Oxygen-18 and deuterium in the water samples is illustrated in Figure 4.10.1. Figure 4.10.1 also indicates the World Meteoric Water line (Craig, 1961)[15] and the Mediterranean Meteoric Water line (Lloyd and Heathcote, 1985)[12].

[15] Isotopic variations in meteoric waters. Science 133 (3465) pp. 1702–1703. Craig, H., 1961. Domenico, P.A. and Schwartz, F.W. 1990. *Physical and Chemical Hydrogeology*, 1st Edition. J. Wiley & Sons, New York

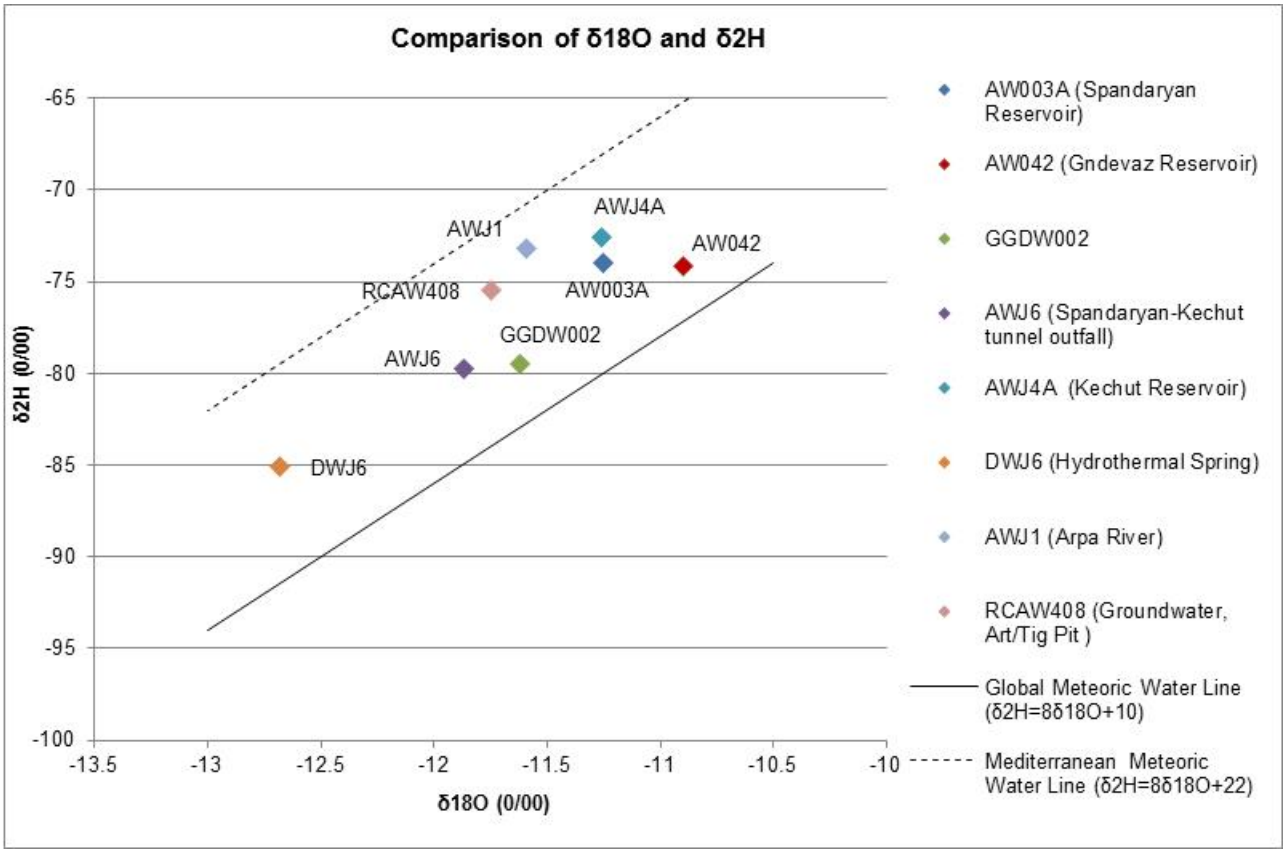


Figure 4.10.27: Oxygen-18 and Deuterium in Water Samples

The isotopic composition of the spring water sample from Jermuk, DWJ6, has a depleted 18O which is typical of highly evolved hydrothermal waters. The δ2H:δ18O ratio is consistent with the major ion data and is indicative of a more evolved "older" water and the δ2H:δ18O ratio for surface water samples are consistent with a "younger" water suggestive of more recent recharge. The composition of AWJ6, from the Spandaryan-Kechut tunnel outfall, is distinct from that of the Spandaryan reservoir and is more depleted with respect to deuterium and 18O suggesting a different origin.

The results of δ13C and tritium analysis are shown in Table 4.10.2. Tritium was not detected in any water samples. This finding is consistent with water that is either modern (recent rainwater/snowmelt) or originated pre-1950. Surface waters reflect the modern tritium signature. In combination with the major ion chemistry shown above, the groundwater sample from well RCAW408 on Amulsar mountain is modern (recently recharged water), whilst the water at Jermuk springs is more than 50 years old.

The majority of water sources studied are depleted in 13C in comparison to reference standards. In comparison, ratios of δ13C:δ12C are enriched in the Jermuk hydrothermal springs and are clearly distinct from other surface waters and groundwater sampled. This enrichment may indicate contact with metamorphosed carbonate rocks, or in an environment where carbonates are absent, contact with deep, metamorphic fluids containing CO_2 of mantle origin (Marques et al, 2003)[16]. δ13C values indicate that the source of the Jermuk spring waters is distinct from groundwaters in the vicinity of Amulsar Mountain.

Groundwater from Amulsar Mountain has a highly depleted δ13C:δ12C ratio. This is likely to be due to the absence of carbonate in rocks in the mountain area, such that the little carbonate present in groundwater on the high mountain peak derives from breakdown of organic material.

Table 4.10.19: Tritium and δ13C Analysis Results, June 2013 Samples

Sample ID	Location	Tritium Bq/l	$\delta^{13}C$(‰)
AW003A	Spandaryan Reservoir	<10	-10.75
AW042	Gndevaz Reservoir	<10	-9.34
GGDW002	Groundwater	<10	-11.61
AWJ6	Spandaryan-Kechut tunnel outfall	<10	-6.86
AWJ4A	Kechut Reservoir	<10	-8.12
DWJ6	Hydrothermal spring	<10	5.54
AWJ1	Arpa River	<10	-7.30
RCAW408	Groundwater, pit area	<10	-16.66

The geochemical analysis presented in Appendix 4.9.1 suggests that water discharging from the Spandaryan-Kechut tunnel is chemically distinct from waters in the Spandaryan Reservoir and represents a more evolved water chemistry suggestive of groundwater.

The analysis also indicates that the chemistry of waters in the Jermuk thermal springs is characteristic of hydrothermal waters, with a Na-HCO3 signature and depleted δ18O. The spring waters also have an enriched δ13C signature which is clearly distinct from other

[16] Questions and answers about the evolution of CO2-rich thermomineral waters from Hercynian granitic rocks (N-Portugal): a review. Marques, J. M., Andrade, M., Carreira, P.M., Graca, R.C., Aires-Barros, L... *In* Krasny, J. and Sharp, J.M. (Ed), Groundwater in fractured rocks: selected papers from the Groundwater in Fractured Rocks International Conference, Prague, 2003.

groundwater sampled. This water type is not similar to groundwater encountered in the vicinity of Amulsar Mountain.

Spring and Groundwater pH

The field pH of the spring waters monitored within the Project area is generally weakly acidic to neutral (i.e. between 5 and 8). Of the 26 Winter 2013/2014 survey field measurements of pH that were made at flowing or wet springs, the pH at 24 locations ranges from 5.61 to 7.93. Measurements were made at two spring locations that gave naturally lower pH values (3.89 at SP13.7, and 3.92 at SP77). Of the 128 April/May 2014 survey field measurements of pH that were made at flowing or wet springs, 113 had a pH that ranged between 5 and 8, five had a slightly alkali pH of between 8 and 9, and ten had a naturally lower pH of between 3.22 and 4.75. The locations where a slightly alkali pH was measured are SP32, GA2, GA3, GA4 and AW035. All of these locations, except SP32, are located in a similar area to the east of Amulsar Mountain ridge at an elevation of between 2,400 m asl and 2,500 m asl. The locations where a naturally lower pH was measured in April/May 2014 include SP29, SP33, ERW3, ERW5, Spring 1, Spring 6, Spring 7, Spring 8, Spring 9 and Spring 10. These do not appear to be located in any particular part of the survey area.

Of these locations where naturally lower pH values have been measured, the location with the most data available for interpretation is SP13.7. The pH measurement taken in November 2013 at Spring SP13.7 was 3.89; however, the pH measurement taken in February 2014 was near neutral, as was the pH recorded in May 2014. This location is also known as surface water location AW030 and measurements of pH taken at this location between May 2012 and November 2012 range between 6.59 and 7.23 (Lydian International Ltd, 2013c). These data may indicate that there are seasonal fluctuations in pH at the springs, or that the November 2013 measurement was in error.

Geochemical characterisation completed to date for the Amulsar project (Golder Associates, 2013b)[13] indicates that the high pyrite/jarosite materials from the Lower Volcanics lithologic group are highly acid generating due to sulphide oxidation and produce acidic leachates with pH as low as 2.5. High alunite materials from all of the lithologic groups generate leachates with a pH ranging from 4.5 to 6.5, but with low metals and sulphate concentrations. Therefore, the acidic pH measured in some of the spring water is considered to be indicative of naturally occurring acid rock drainage (ARD) from the hydrothermally altered resource. Historical mining activity, as evidenced by the old Soviet mine adit located in Site 13, may

have enhanced ARD resulting in sporadically acidic conditions and high metals concentrations in water discharging from the adit at AW030/SP13.7.

Groundwater samples collected from wells in the GSA are typically circum-neutral (pH 6.5 to 9). Mildly acidic pH values below 6.5 are only recorded on two occasions in field pH measurements of groundwater well samples (Appendix 4.8.5), in well DDGW003 on the Cenozoic Flow Basalts east of the Vorotan River in March 2014, and in well GGDW016a in the Lower Volcanic Andesites south-west of the HLF in March 2014. The flush of water in springs arising from snow melt infiltration may cause temporary acid conditions as the products of sulphide oxidation that has accumulated over the Winter period are 'washed through'. However, given the sporadic nature of the observed acidity, it is equally probable that these are anomalous pH recordings.

Seasonal Water Quality in the Tunnel and Adits

As noted above, the chemistry of water samples from surface waters and groundwaters sampled in June 2013 indicates that that the water discharging from the Spandaryan-Kechut tunnel has a calcium sulphate signature, similar to the more evolved spring and groundwater in parts of the Project area (RCAW403, AW030, BRSF springs). Furthermore the waters have a specific conductivity between 300 µS/cm and 400 µS/cm, this is consistently higher than surface waters in the major rivers monitored in the Project area and more consistent with groundwater.

Analysis of the full sampling dataset for location AWJ6, the tunnel discharge location (Figure 4.10.2) indicates that the chemistry of the discharge varies seasonally. Waters are more sulphate rich in the Winter months up to the time of the spring snow melt, and are more carbonate rich in the Summer and Autumn months, prior to the Winter freeze. The more sulphate-rich Winter flow has a higher electrical conductivity and higher arsenic concentration whilst the Summer flow has a lower electrical conductivity and higher aluminium concentrations. Although field data for the Winter period are limited, data suggests that the pH of the waters is circum-neutral throughout the year, but is slightly lower (pH 7.5 to 7.7) during the Summer and slightly higher (pH 7.8 to pH 8) during the Winter. The mechanism(s) for the seasonal variation in water quality at this location are not known. Similar fluctuations in sulphate, arsenic and aluminium, also occur at AW030, the adit discharge located east of the BRSF (Figure 4.10.3), but do not occur on a seasonal basis at this

location, suggesting that the response may not be attributable solely to recharge driven changes in water chemistry.

The tunnel also receives inflow from a small lead mine located in proximity uphill to the village of Saravan, which uses one of the construction accesses of the Spandaryan-Kechut Tunnel as the adit to the mine. Little is known regarding this mine or the inflow from it, it is possible that seasonal fluctuations in the rate of discharge from this mine could influence the chemistry of the water discharging from the tunnel.

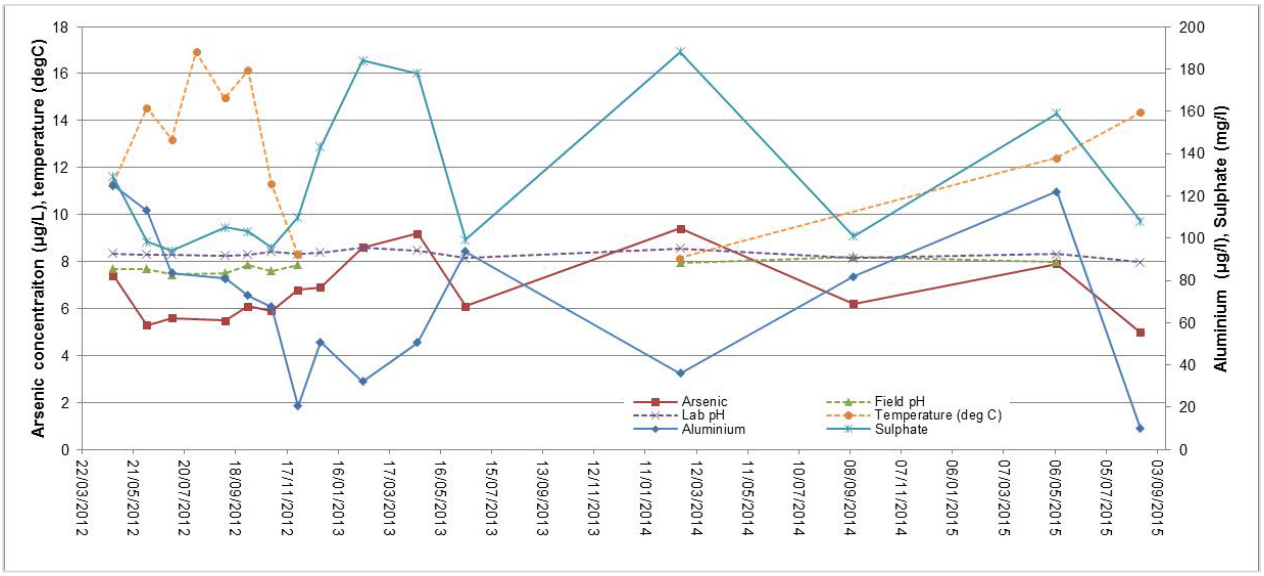


Figure 4.10.28: Water Chemistry, AWJ6

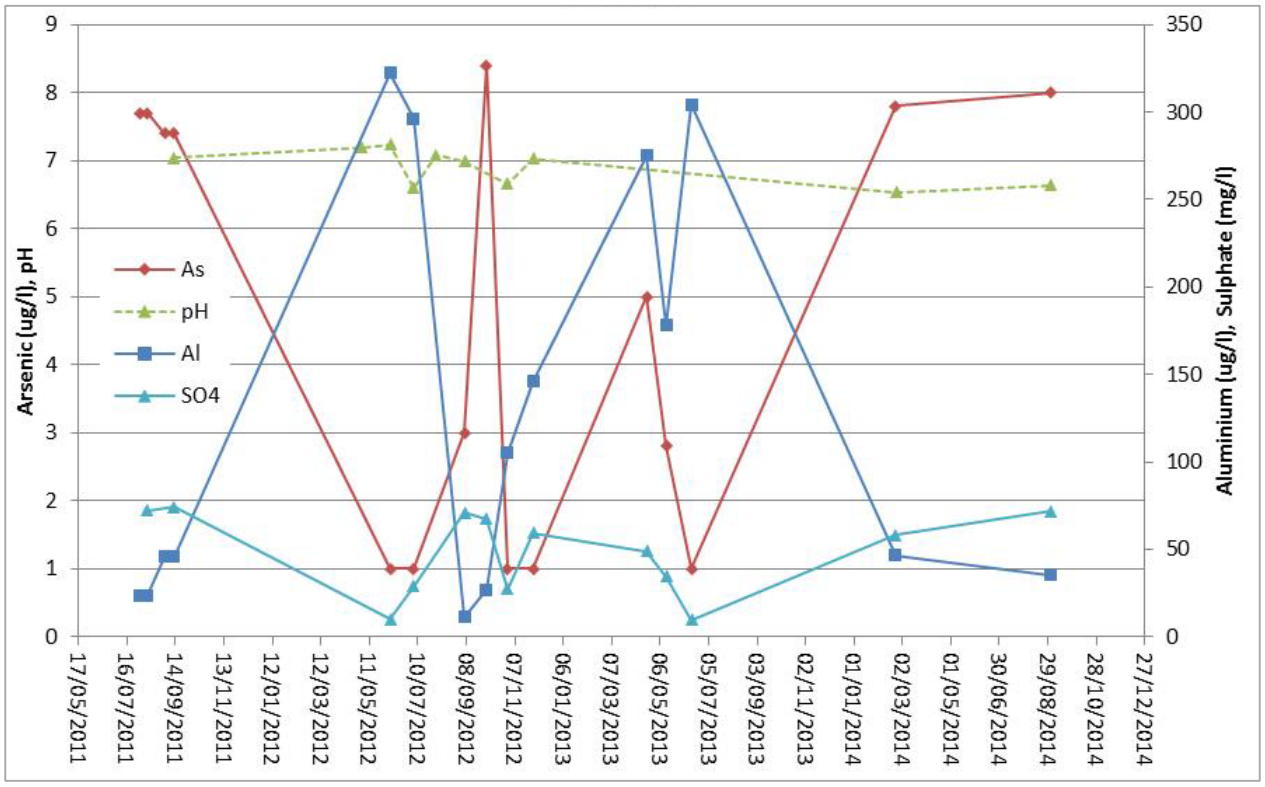


Figure 4.10.29: Water Chemistry, AW030

Relationship between the Jermuk and Amulsar Groundwaters

Physiochemical properties (conductivity, temperature), major ion chemistry, and isotopic chemistry all indicate that the Jermuk groundwaters are chemically and physically distinct from the groundwaters in the Amulsar Project area[17] (see also Appendix 4.9.1). This indicates that the Jermuk spring water is from a different source, with a longer, and deeper flow path than groundwater flow and spring flow within the Project area.

4.8.8 Hydrogeological Conceptual Model Summary

The primary features of the hydrogeological conceptual model in the vicinity of each of the key facilities associated with the proposed mine development are illustrated in Appendix 4.8.7 on Drawings 4.8.4 to 4.8.7.

The key features of the hydrogeological conceptual model of the Amulsar Project area are summarised as follows:

- An isolated mountain ridge forming the boundary of three river catchments, the Arpa

[17] Technical Memorandum on the Major Ion and Isotope Analysis In Waters. Golder Associates, 2013a

River to the north-west, the Vorotan River to the east and the Darb River to the south-west;

- Groundwater recharge occurring at higher elevations where precipitation (snowfall) is greatest and soils are thin or absent, with baseflow discharge to the incised Arpa, Darb and Vorotan River valleys;
- High groundwater recharge rates predominantly arising from high infiltration rates in April, May and June during and following the Spring snow melt;
- Predominantly topographically driven groundwater flow, resulting in groundwater flow from the Amulsar Mountain ridge west and north-west toward the Arpa River, east toward the Vorotan River and south-west toward the Darb River;
- Five hydrogeological units:
    1. Colluvium consisting of low to moderately permeable silty clay with variable quantities of gravel and cobbles and overlying bedrock throughout the Project area at thicknesses varying between less than 1 m and up to 20 m;
    2. The silicified Upper Volcanics (VC) hosting the ore body and outcropping along the mountain ridge and on the eastern flank of Amulsar Mountain. This unit is moderately permeable and has minimal primary porosity; porosity and permeability is a result of secondary interconnected fracture porosity;
    3. The argillically altered Lower Volcanic Andesite (LVA) occurring in layered 'panels' beneath, within and below the highly faulted ore bodies, and outcropping to the west and north of Amulsar Mountain. Although the extent of alteration varies, this unit predominantly comprises a low permeability amorphous clay in the mountain area and has a high total porosity, but low effective (drainable) porosity;
    4. The unaltered Lower Volcanics (LV), outcropping at lower elevations surrounding Amulsar Mountain. The Lower Volcanics as a whole is at least 1300 m in thickness and comprises low to moderately permeable fractured andesites with some interbedded tuffs and sedimentary sequences;
    5. Cenozoic Basalt Flows, overlying the Lower Volcanics on plains to the east, west and south of Amulsar Mountain, and extending north-west from the scoria cone which forms the peak north of the BRSF. The basalts have been proven at up to 120 m in thickness. The basalts are relatively permeable.
- Low vertical permeability of the argillically altered andesite on Amulsar Mountain, promoting groundwater discharge as springs at high elevations, particularly immediately to the west of the mountain ridge, and in valleys to the north and north-

east of the ridge in the vicinity of the proposed BRSF;

- Intense faulting and juxtaposed 'panels' of argillically altered andesite sustaining localised areas of perched saturated conditions in comparatively higher permeability fractured rocks in the Upper Volcanics surrounding Amulsar peak;
- Low permeability argillically altered andesite forming the base of the VC/LVA sequence that hosts the ore body;
- More permeable unaltered rocks of the Lower Volcanics, also incorporating a greater proportion of sedimentary and volcano-sedimentary rocks, at lower altitudes;
- Groundwater flow influenced by groundwater discharge to the Kechut-Spandaryan tunnel which passes at approximately 2000 m asl to the west of Amulsar Mountain connecting the Spandaryan Reservoir to the south of the Project area with the Kechut Reservoir in the north of the Project area; and
- Artesian conditions and groundwater discharge at the base of the valley immediately east of the BRSF, where discharge to surface is restricted by alluvial clays.

The BRSF and HLF sites comprise colluvium overlying Cenozoic Basalt Flows on the margins of both sites and overlying argillically altered andesites and unaltered andesite of the LV unit, respectively. Both sites occupy valleys with groundwater discharge along the valley centre. At the HLF site, groundwater discharge occurs at the lower end of the valley, potentially beyond the footprint of the HLF. Beneath the BRSF site, groundwater discharge occurs from the centre of the site northward, and during the late Spring and early Summer, ephemeral springs discharge along the southern flank of the valley.

Beneath the HLF site, shallow groundwater occurs within the colluvium along the central stream valley, resulting in a localised groundwater flow within the colluvium to the south-west discharging to surface water at the lower end of and downstream of the HLF footprint. Deeper groundwater flow in the bedrock is westward, toward the Arpa River.

The BRSF site is characterised by a shallow groundwater flow system within the thick argillically altered LV andesite underlying much of the site. Groundwater flow is locally toward discharge points in the centre of the valley (from the southern and south-eastern portions of the site) and to north-west toward the Arpa River in the Cenozoic Flow Basalts. A former adit is present at a depth of about 80 m extending from the valley to the east of the

HLF site towards the centre of the site. This adit does not appear to affect the local groundwater flow beneath the BRSF.

The hydrogeological regime surrounding the ore bodies comprises a heavily faulted interlayered sequence of relatively permeable fractured silicified VC and less permeable argillically altered LV andesite. Following the Spring snow melt, significant infiltration occurs, resulting in perched water, which discharges locally to ephemeral springs surrounding the mountain peak. More permanent isolated bodies of perched water are also likely to occur within the geological sequence, supported by the argillically altered LV andesite, or within fault blocks. Groundwater flow away from the ore bodies is broadly topographically controlled, discharging to perennial springs on the mountain flanks, to the larger mountain streams and ultimately to the Arpa and Vorotan Rivers. Geological controls influence groundwater flow, as observed in the fault/geologically controlled discharge to Springs GA2 to GA5.

Hydrogeological Setting of the Jermuk Hydrothermal Area

Groundwater elevation contours for the GSA and modelling of baseline groundwater conditions indicate that groundwater originating in the Amulsar Project area discharges to the Arpa River at or downstream of the Kechut Reservoir, downstream and to the east of the Jermuk Hydrothermal Park. Groundwater flow information therefore indicates that the Jermuk Hydrothermal Park springs are not fed by groundwater recharge from the Amulsar Project area.

This conclusion is supported by data regarding the physical and chemical properties of the springs, which indicate that based on temperature, specific conductivity, major ion composition and isotopic composition, the Jermuk spring waters are markedly different to groundwater in the Amulsar Project area, and are therefore derived from a different groundwater source. Geochemical data indicates that the Jermuk springs are fed by groundwater which is more evolved in composition, indicating a deeper and longer groundwater flow path, likely originating in the geological domain to the north-east of Jermuk.

4.8.9 Groundwater Quality

Groundwater quality sampling from wells and springs has been undertaken in the Amulsar Project area between 2010 and 2015. Groundwater quality sampling for the purpose of

baseline characterisation is ongoing in accordance with the Environmental Monitoring Plan (Appendix 8.12). Additional groundwater samples for key facilities will be supplied as an addendum to the ESIA at a future date. Methods of sample quality assurance are described in the Environmental Monitoring Plan.

The distribution of groundwater and spring quality samples in the Lydian/Geoteam monitoring database is shown in Table 4.10.3. Sample locations are shown in Appendix 4.8.7 on Drawing 4.8.2. Groundwater samples taken in 2011 were collected between August and December. Groundwater samples in ERW (Geoteam location prefix) springs in 2012 were collected in July. Groundwater samples at other locations were collected in October 2012. Samples in 2014 were collected between February and May. Samples in 2015 were collected between May and August. As discussed in Section 4.8.7, water discharging at AWJ6 (the outfall of the Kechut-Spandaryan tunnel) is considered likely to be groundwater. This sampling location is treated as a surface water monitoring location in the database and water quality for this location is presented in Chapter 4.9. Water quality samples collected from the geothermal springs and other locations in Jermuk are presented under drinking water.

Table 4.10.20: Summary of Groundwater Baseline Samples, 2010 - 2015

Area	Location	Hydrogeological Unit	Type	2010	2011	2012	2014	2015	Total
Ore Bodies	DDAW007	Argillic LV	Well				2	2	4
	DDAW009	Argillic LV	Well				2	2	4
	ERW1	Argillic LV	Spring			1	2		3
	ERW2	Argillic LV	Spring			1	1		2
	ERW3	Argillic LV	Spring			1	1		2
	ERW4	Argillic LV	Spring			1	1		2
	ERW5	Argillic LV	Spring			1	2		3
	RCAW286	Argillic LV	Well	1					1
	RCAW287	VC	Well	1					1
	RCAW289	Argillic LV	Well	1					1
	RCAW408	VC	Well		1		1	2	4
	Spring GA1	VC	Spring				1		1
	Spring GA2	VC	Spring				2		2
	Spring GA3	VC	Spring				2		2
	Spring GA4	VC	Spring				2		2
	Spring GA5	VC	Spring				2		2
	Spring1	Argillic LV	Spring	1			1		2
	Spring2	VC	Spring	1			2		3
	Spring3	Argillic LV	Spring	1			2		3

	Table 4.10.20: Summary of Groundwater Baseline Samples, 2010 - 2015								
Area	**Location**	**Hydrogeological Unit**	**Type**	**2010**	**2011**	**2012**	**2014**	**2015**	**Total**
	Spring4	Argillic LV	Spring	1			2		3
	Spring5	VC	Spring	1			2		3
	Spring6	Argillic LV	Spring	1			1		2
	Spring7	Argillic LV	Spring				2		2
	Spring8 Quality	Argillic LV	Spring				2		2
	Spring9	Argillic LV	Spring				1		1
	Spring10	VC	Spring				1		1
	Spring11	VC	Spring				1		1
	AW035	VC	Spring	2	1		2		5
	DDAGLP268	Argillic LV	Well		1				1
	DDAGLP269	Argillic LV	Well		1	1			2
BRSF and Adjacent Valley	DDAW002	Cenozoic Flow Basalts	Well	1	1	1	2		5
	DDAW003	Unaltered LV	Well	1					1
	RCAW399	Unaltered LV	Well		4				4
	RCAW400	Argillic LV	Well		2	3	2		7
	RCAW401	Argillic LV	Well		4	2			6
	RCAW403	Cenozoic Flow Basalts	Well		3	2	2		7
	SP13.29	Argillic LV	Spring				2		2
	SP13.7	Unaltered & argillic LV	Spring				2		2
	SP27.20	Argillic LV	Spring				2		2
	SP27.21	Argillic LV	Spring				1		1
	AW030	Unaltered & argillic LV	Spring	3	6	3	1		13
HLF and Surrounds	GGDW005	Cenozoic Flow Basalts	Well				1		1
	GGDW007	Unaltered LV	Well				2		2
	GGDW009	Unaltered LV	Well				2		2
	GGDW011	Unaltered LV	Well				2	2	4
	GGDW012	Unaltered LV	Well				2		2
	GGDW013	Unaltered LV	Well				2	2	4
	GGDW013a	Unaltered LV	Well				1	2	3
	GGDW016	Unaltered LV	Well				2	2	4
	GGDW016a	Cenozoic Flow Basalts	Well				2	2	4
Wider Project Area	DDGW001	Cenozoic Flow Basalts	Well	2					2
	DDGW002	Cenozoic Flow Basalts	Well	1	2	3	1	1	8

	Table 4.10.20: Summary of Groundwater Baseline Samples, 2010 - 2015								
Area	**Location**	**Hydrogeological Unit**	**Type**	**2010**	**2011**	**2012**	**2014**	**2015**	**Total**
	DDGW003	Cenozoic Flow Basalts	Well		5	3	1		9
	DDGW004	Unknown	Well	1					1
	DDGW005	Cenozoic Flow Basalts	Well				1	1	2
	SP34	Unknown	Spring				1		1
	SP80	Cenozoic Flow Basalts	Spring				2		2
	SP83	Cenozoic Flow Basalts	Spring				2	1	3
	SP89	Cenozoic Flow Basalts	Spring				1		1

Statistical summaries for all analytes are presented in Appendix 4.8.5 (based on full data set in the Geoteam Monitor Pro database). Time history graphs for key constituents for those locations with a temporal record are presented in Appendix 4.8.5.

Groundwater quality has been screened against Project assessment criteria presented in Chapter 2. These are Maximum Acceptable Concentrations (MACs) prescribed under Category II of the Republic of Armenia Decree N-75N (2011), with the exception of the standard for cyanide, which is based on the lowest practicable laboratory method detection limit. These standards have been applied in screening of both groundwaters and surface waters. No separate drinking water standards exist in Armenia. The number of exceedances for each constituent are tabulated in Appendix 4.8.5. The database does not indicate whether metals concentrations are total or dissolved, but laboratory reports for recent data (2013) indicate that recent analysis is for total metals. Exceedances of the MACs are summarised in Table 4.10.4. Analyses for hydrocarbons (total aliphatics, total aromatics and other total hydrocarbon variants) have not been screened against the 'oil products' standard as its value (0.1 µg/L) suggests it applies to specific hydrocarbon compounds. It is therefore unclear to which compounds this standard is applicable.

Table 4.10.21: Summary of MAC Exceedances in Groundwater					
Parameter	**Locations Where MAC is Exceeded**	**No of Locations Exceeding MAC**	**No. of Locations analysed**	**No. of analysis results above MAC**	**Total Number of Analyses**
Aluminium	AW030, AW035, DDAW011, ERW2, ERW3, ERW4, ERW5, GGDW005, GGDW007, GGDW009, GGSC049, GGSC050, SP13.29, Spring GA2, Spring GA3, Spring GA4, Spring10, Spring11, Spring3, Spring8 Quality, Spring9	21	56	45	187
Ammonium (aggregated)	DDAW002, GGDW007, GGDW011, RCAW403, RCAW408, GGDW016, GGDW016a, GGDW013, DDAW011, DDGW002	10	68	12	173
Ammonia (aggregated)	GGDW007, GGDW011, RCAW403	3	106	3	234
Antimony	AW030, AW035, DDAGLP268, DDAGLP269, DDAW002, DDAW007, DDAW009, DDAW011, DDGW002, DDGW003, DDGW005, ERW1, ERW2, ERW3, ERW4, ERW5, GGDW005, GGDW007, GGDW009, GGDW011, GGDW012, GGDW013, GGDW013a, GGDW016, GGDW016a, GGSC049, GGSC050, RCAW400, RCAW401, RCAW403, RCAW408, SP13.29, SP13.7, SP27.20, SP27.21, SP34, SP80, SP83, SP89, Spring GA1, Spring GA2, Spring GA3, Spring GA4, Spring GA5, Spring1, Spring10, Spring11, Spring2, Spring3, Spring4, Spring5, Spring6, Spring7, Spring8 Quality, Spring9	55	56	177	187
Arsenic	DDAW007	1	59	1	195
Barium	AW030, AW035, DDAGLP268, DDAGLP269, DDAW002, DDAW007, DDAW011, DDGW002, DDGW003, ERW3, ERW4, ERW5, GGDW005, GGDW007, GGDW011, GGDW012, GGDW013, GGDW013a, GGDW016, GGDW016a, GGSC050, RCAW400, RCAW401, RCAW403, RCAW408, SP13.29, SP13.7, SP27.20, SP27.21, SP34, Spring GA2, Spring GA3, Spring GA4, Spring GA5, Spring1, Spring2, Spring10, Spring3, Spring 4, Spring5, Spring6	41	56	113	187

Table 4.10.21: Summary of MAC Exceedances in Groundwater					
Parameter	**Locations Where MAC is Exceeded**	**No of Locations Exceeding MAC**	**No. of Locations analysed**	**No. of analysis results above MAC**	**Total Number of Analyses**
Beryllium	AW030, AW035, DDAGLP268, DDAGLP269, DDAW002, DDAW007, DDAW009, DDAW011, DDGW002, DDGW003, DDGW005, ERW1, ERW2, ERW3, ERW4, ERW5, GGDW005, GGDW007, GGDW009, GGDW011, GGDW012, GGDW013, GGDW013a, GGDW016, GGDW016a, GGSC049, GGSC050, RCAW400, RCAW401, RCAW403, RCAW408, SP13.29, SP13.7, SP27.20, SP27.21, SP34, SP80, SP83, SP89, Spring GA1, Spring GA2, Spring GA3, Spring GA4, Spring GA5, Spring1, Spring10, Spring11, Spring2, Spring3, Spring4, Spring5, Spring6, Spring7, Spring8 Quality, Spring9	55	56	156	187
BOD	Spring1	1	6	1	6
Boron	GGDW009	1	56	2	173
Cadmium	DDAW007, DDGW002	2	55	3	125
Chloride	DDAW011, GGDW007, GGDW009, GGDW013	4	55	4	181
Chromium	DDGW001, DDGW002, DDAW011, GGDW013a, GGSC050, RCAW408	6	62	6	188
Cobalt	AW030, AW035, DDAGLP268, DDAGLP269, DDAW002, DDAW007, DDAW009, DDAW011, DDGW002, DDGW003, DDGW005, ERW1, ERW2, ERW3, ERW4, ERW5, GGDW005, GGDW007, GGDW009, GGDW011, GGDW012, GGDW013, GGDW013a, GGDW016, GGDW016a, GGSC049, GGSC050, RCAW286, RCAW287, RCAW289, RCAW400, RCAW401, RCAW403, RCAW408, SP13.29, SP13.7, SP27.20, SP27.21, SP34, SP80, SP83, SP89, Spring GA1, Spring GA2, Spring GA3, Spring GA4, Spring GA5, Spring1, Spring10, Spring11, Spring2, Spring3, Spring4, Spring5, Spring6, Spring7, Spring8 Quality, Spring9	58	62	185	199
COD	GGDW011, DDGW002	2	10	2	10
Copper	AW035, DDAW007, DDAW011, DDGW002, GGDW013a, GGSC050, RCAW286, RCAW287, RCAW289, RCAW408, Spring GA2, Spring GA3, Spring10	13	59	22	201
Specific Conductivity	DDAW002, DDAW007, DDAW009, DDAW011, DDGW001, DDGW002, DDGW004, GGDW016, GGDW016a, GGDW013, GGDW013a, GGDW011,GGSC050, RCAW289	14	23	17	25

Table 4.10.21: Summary of MAC Exceedances in Groundwater					
Parameter	**Locations Where MAC is Exceeded**	**No of Locations Exceeding MAC**	**No. of Locations analysed**	**No. of analysis results above MAC**	**Total Number of Analyses**
(Lab)					
Specific Conductivity (field)	DDAW002, DDAW007, DDAW009, DDAW011, DDGW001, DDGW002, GGDW011, GGDW012, GGDW013, GGDW013a, GGDW016, GGDW016a, RCAW399, RCAW400, RCAW401, RCAW403, RCAW404, AW030	18	43	63	171
Iron	AW030, AW035, DDAGLP268, DDAGLP269, DDAW002, DDAW007, DDAW009, DDAW011, DDGW001, DDGW002, DDGW003, DDGW005, ERW1, ERW2, ERW3, ERW4, ERW5, GGDW005, GGDW007, GGDW009, GGDW011, GGDW012, GGDW013, GGDW013a, GGDW016, GGSC049, GGSC050, RCAW286, RCAW287, RCAW289, RCAW400, RCAW401, RCAW403, RCAW408, SP13.29, SP13.7, SP27.20, SP27.21, SP34, SP83, Spring GA2, Spring GA3, Spring GA4, Spring GA5, Spring1, Spring10, Spring11, Spring2, Spring3, Spring4, Spring5, Spring6, Spring 7, Spring8 Quality, Spring9	55	62	143	202
Lead	DDAW007, DDAW009, DDAW011, DDGW002, GGDW005, GGDW007, GGDW009, GGDW011, GGDW012, GGDW013, GGDW013a, GGDW016, GGSC050, RCAW286, RCAW287, RCAW408	16	60	28	198
Lithium	AW035, DDAGLP268, DDAW002, DDAW007, DDAW011, DDGW002, DDGW003, GGDW005, GGDW007, GGDW009, GGDW011, GGDW012, GGDW013, GGDW013a, GGDW016, GGSC050, RCAW401, RCAW403, SP13.29,	19	56	40	187
Manganese	AW030, AW035, DDAGLP268, DDAGLP269, DDAW002, DDAW007, DDAW009, DDAW011, DDGW001, DDGW002, DDGW003, DDGW005, ERW1, ERW2, ERW4, ERW5, GGDW005, GGDW007, GGDW011, Spring GA2, Spring GA3, Spring GA4, Spring GA5, Spring1, Spring10, Spring2, Spring3, Spring4, Spring5, Spring7, Spring8 Quality, Spring9, GGDW012, GGDW013, GGDW013a, GGDW016, GGDW016a, RCAW286, RCAW287, RCAW289, RCAW400, RCAW401, RCAW403, RCAW408, SP13.29, SP13.7, SP27.20, SP27.21, SP34, GGSC049, GGSC050	51	62	143	202
Molybdenum	AW030, DDAW002, DDAW009, DDAW011, DDGW002, DDGW003, ERW1, ERW2, ERW3, ERW4, ERW5, GGDW005, GGDW007, GGDW009, GGDW011, GGDW012, GGDW013, GGDW013a, GGDW016, GGDW016a, GGSC049, GGSC050, RCAW286, RCAW403, RCAW408, SP13.7, SP27.20,	36	60	99	200

Table 4.10.21: Summary of MAC Exceedances in Groundwater					
Parameter	**Locations Where MAC is Exceeded**	**No of Locations Exceeding MAC**	**No. of Locations analysed**	**No. of analysis results above MAC**	**Total Number of Analyses**
	SP27.21, SP80, SP83, SP89, Spring10, Spring11, Spring4, Spring8 Quality, Spring9				
Nickel	DDAW007, DDAW011, DDGW002, GGSC050, RCAW289, RCAW403, RCAW408	7	62	13	201
Nitrate as N	DDAW007, DDAW011, GGDW005, GGDW011, GGDW016, GGDW016a, GGSC049, RCAW408, SP80, SP83, Spring5	8	61	17	198
Nitrite as N	DDAW011, GGDW007, GGDW011, GGDW012, GGDW013, GGDW016, GGDW016a, RCAW400, SP13.29	5	56	13	187
Laboratory pH (aggregated)	AW035, AW030, AW035, DDAW007, DDGW005, ERW3, ERW5, GGSC050, SP13.7, Spring GA2, Spring GA3, Spring GA4, Spring GA5, Spring10, Spring7	15	74	20	234
Field pH	DDAW007, DDAW009, DDGW003, ERW1, ERW2, ERW1, ERW2, ERW2, GGDW016a, RCAW400, RCAW403, AW030, AW035	13	43	23	170
Phosphate	GGDW016a, SP83	2	10	2	10
Phosphorus, total	DDAW007, DDAW009, DDGW002, GGDW013a, GGDW016	5	10	5	10
Potassium	AW030, DDAW002, DDAW011, ERW5, GGDW016, GGDW016a, GGSC050, RCAW289	8	62	11	202
Silicate	DDAW009	1	10	1	10
Silicon	DDAW009, DDAW011, GGSC050	3	55	4	172
Sodium	AW030, DDAW002, DDAW009, DDAW011, GGDW005, GGDW007, GGDW009, GGDW011, GGDW013, GGDW013a, GGDW016, GGDW016a, RCAW403, Spring GA2	14	62	58	203
Sulphate	AW035, DDAW002, DDAW007, DDAW009, DDAW011, ERW5, GGDW009, GGDW011, GGDW016, GGDW016a, GGSC049, RCAW403, SP13.7, SP34, Spring 4, Spring GA2, Spring GA3, Spring GA4, Spring GA5	19	55	78	182
Tin	DDAW007, DDAW009, DDGW002, GGDW011, GGDW013, GGDW013a, GGDW016, GGDW016a,	10	10	10	10

Table 4.10.21: Summary of MAC Exceedances in Groundwater					
Parameter	**Locations Where MAC is Exceeded**	**No of Locations Exceeding MAC**	**No. of Locations analysed**	**No. of analysis results above MAC**	**Total Number of Analyses**
	RCAW408, SP83				
TSS	DDAW002, RCAW286, RCAW287, RCAW289, Spring1, Spring2, Spring3 ,Spring4, Spring5, Spring6	10	14	18	25
Vanadium	DDAW0078, DDGW002, GGDW013a, GGDW016	4	10	4	10
Zinc	AW035, RCAW289	2	62	4	203

Groundwater quality across the GSA consistently exceeds Project assessment criteria with respect to antimony, barium, beryllium, cobalt, iron and manganese. The laboratory detection limits for antimony, beryllium and cobalt, in the majority of cases, exceed the MAC for these constituents, such that 100% of the analyses are reported to exceed the MAC. Concentrations of these constituents may be below the MAC in groundwater, but this cannot be determined from existing data.

The data set demonstrates that concentrations of iron, manganese and barium are naturally elevated in groundwater in comparison to surface water quality (on which the MACs are based) in the Project area, resulting in exceedances for these constituents.

Sporadic exceedances are reported for ammonium, nickel, nitrate, potassium, boron, chromium, BOD and zinc. In general concentrations of these constituents are not elevated across the wider Project area and the exceedances reported represent local issues specific to the well setting or local sources of contamination. Ammonium and nitrate is observed in some wells in valleys at lower elevations (to the east of the BRSF and in the HLF valley) which are used for cattle grazing during the Summer.

The remaining inorganic constituents which are less frequently but more broadly detected above MACs in groundwater (aluminium, copper, lead, lithium, molybdenum, and sodium) are more likely to be discriminatory in recognising trends in groundwater quality which occur at the Project area scale, such as those associated with changes in water quality between hydrogeological units.

Aluminium is elevated in springs surrounding the ore bodies (generally but not solely in springs overlying the argillic andesites), in the adit drainage east of the BRSF (AW030) and in wells on the west of the Arpa catchment (installed in the Lower Volcanics). Not all wells analysed in the Lower Volcanics are reported to have high aluminium, and those with high aluminium concentrations include both locations sampling from the argillic and unaltered Lower Volcanic Andesites. Furthermore, sampling at AWJ6 (Section 4.8.7) suggests that aluminium concentrations vary seasonally. Aluminium may be present in groundwater as a result of feldspar weathering, particularly in the argillic andesite.

Copper concentrations slightly above the MAC are reported in wells sited to the east of the BRSF, installed in the Cenozoic Basalt Flows east of the Vorotan River. The cause of the slightly elevated copper concentrations is unknown.

Lead concentrations exceed the MAC in well DDAW007 adjacent to Erato, well DDGW002 to the east of the Vorotan River, wells RCAW286 and RCAW287 adjacent to Tigranes-Artavazdes and in wells at the HLF site. There is no clear lithological or spatial association of these exceedances, though data suggests that lead concentrations are generally higher in the vicinity of the HLF site than elsewhere in the Project area. Lithium and sodium concentrations show a similar distribution to lead concentrations, exceeding MACs sporadically across the Project area and more consistently at the HLF site.

Molybdenum concentrations exceed MACs at many groundwater sampling locations distributed across the Project area, including all wells sampled at the HLF site, springs within the BRSF site footprint, springs surrounding the ore bodies, and in the wider Project area. A greater proportion of wells and springs reporting MAC exceedances for molybendum are located on the Lower Volcanco-sedimentary sequence or Cenozoic Flow Basalts, but no unique relationships are apparent.

The time series data available for groundwater in the Project area suggests seasonal variability. Graphs presented in Appendix 4.8.5 suggest concentrations tend to be higher in Autumn/Winter than during the Spring, but few consistent trends are apparent.

4.8.10 Groundwater Users

A springs and water users study was undertaken in 2013, see Appendix 4.9.5. The study covered water users and water usage in the Project area and surrounding communities of Jermuk, Kechut, Gndevaz, Saravan, Saralanj, Ughedzor and Gorayk, as well as water use by seasonal herders.

There is no information to suggest groundwater is abstracted from boreholes for any form of water supply. All of the communities were found to utilise (groundwater fed) springs as their main water supply source; typically drawing water from a number of different springs in order to meet demand and to assure year-round water supply.

Many of the springs in the Project area are ephemeral (i.e. do not flow all year round and are only present in the months following snow melt) and originate from shallow perched water following snow melt infiltration. Some springs in the Project area are perennial (i.e. flow all year round) and are considered to be sourced from groundwater. Discussion of the source of the spring waters is in Section 4.9.2.

The spring water is used for drinking water supply, domestic water use (i.e. cooking and cleaning), some irrigation, and water supply for animals by seasonal herders. Information on the spring sources, water collection, water distribution and volumes of supply is presented below.

Groundwater feeds surface water through baseflow and spring discharges. Surface water is used for a range of purposes that are discussed below. Groundwater discharge also supports aquatic habitats and associated flora/fauna. This is discussed below.

Water Supply

The information available regarding water supply sources, water collection, water distribution and volumes has predominantly been obtained from the Gone Native LLC springs and water users study (see Appendix 4.9.5).

Domestic/Municipal

Domestic and municipal water supplies are predominantly sourced from spring water originating from shallow perched water or from groundwater.

The residents of Jermuk are supplied with drinking and domestic water from four main groups of springs providing approximately 89 l/sec. Most of the flow (approximately 65 l/sec flow) is provided year-round by the SpitakJur group of springs, located approximately 3 km north of the town. A water collection system at the spring heads is used to pipe the water to Jermuk and then on to individual users.

The residents of Kechut are supplied with domestic water from the Madikenc group of springs located approximately 2 km east of the town. Perennial springs were identified in this area during the spring survey work, which appear to be sourced from groundwater within the Cenazoic Basalt Flows. These springs occur in an area where the groundwater table is generally close to surface and the springs are present where the eroded topography intersects

a lower permeability horizon within the basalt sequence, such as a sedimentary horizon. The springs flow into concrete catchment basins, into a central reservoir, and then into a gravity-fed 220 mm-diameter pipeline for 2 km, before entering the local water supply network. The springs support a supply of approximately 5 l/sec to 7 l/sec.

The residents of Gndevaz are supplied with domestic water from two groups of springs: the Seven springs located 17 km northeast of the village; and the Darayurt springs located 11 km north of the village, west of Kerchut reservoir. Water from both spring groups is conducted to Gndevaz via gravity-fed pipelines. Darayurt spring flow is consistent year-round and is the preferred drinking and domestic water source; flow from the seven springs decreases in Winter. Neither of these spring clusters were included in the Project area spring survey.

Drinking and domestic water for Saravan, Saralanj, and Ughedzor is sourced from a series of springs. Residents of Saravan use water from the Pluskandyal springs located to the southeast of the community between Ughedzor and Gorayk. Water flows via gravity from the springs through a 6 km long pipeline at a rate of approximately 5 l/sec. The water feeds into a small reservoir from which it is distributed via pipes to the residents. Water for the residents of Saralanj is collected from the Shlak springs, located south-east of Ughedzor. A 5 km long pipeline provides 5 l/sec to the community. Water for Ughedzor is collected from the CheyratiDuz springs located 2 km south of the community. Two pipelines transport the water 2.5 km to Ughedzor, where it is distributed to individual households via a smaller pipeline network.

Water for drinking and domestic use for the community of Gorayk is provided from a network of three springs called Zuygaghbyur, SrbasarAghbyur and Tsaghkunq (or Bardzr sari). Gravity-fed pipelines transport water from the springs to two central reservoirs in Gorayk.

The location of the community springs is shown in Figure 4.10.4. Only the Madikenc spring lies within the Project study area.

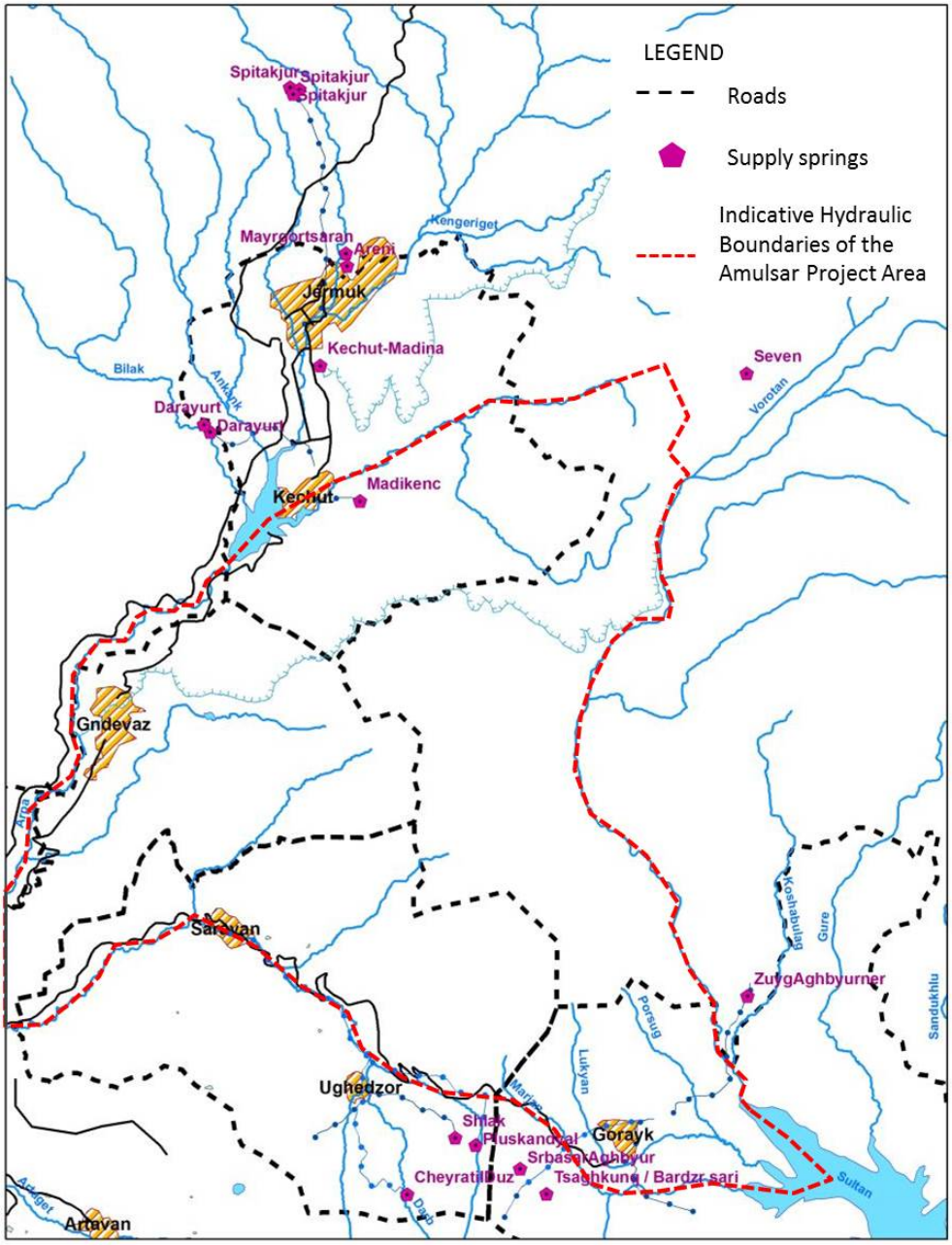


Figure 4.10.30: Community Spring Locations (After Gone Native (2013))

Drinking water for the communities surrounding the Amulsar Project and for the town of Jermuk have been monitored over the 2011 to 2014 period by Geoteam as part of the baseline monitoring program at the locations and frequencies as indicated in Table 4.10.5.

Locations with names commencing “AW05” are drinking water supplies to the village of Gndevaz, Gorayk and Saravan, and two supplies in Jermuk. Locations with names commencing “DWJ” are bottled waters from Jermuk and the thermal mineral spring waters from the Jermuk gallery. Geoteam has not confirmed the actual sampling locations; the

location described in Table 4.10.5. In 2012, locations AW050 and AW050a were sampled almost monthly, as was DWJ2. Other points were sampled between February and April. Samples analysed in 2013 and 2014 were collected in February and those analysed in 2015 were collected in August.

Table 4.10.22: Drinking Water Sampling Locations and Number of Samples Collected

Location	Description	2011	2012	2013	2014	2015	Total
AW050	Gorayk drinking water	1	11	1			13
AW050a	Gorayk drinking water	1	11	1			13
AW050b	Proposed source of drinking water for Gorayk		1				1
DWJ010	Bjni, bottled water brand		1				1
DWJ-1	Mayr Gorcaran, tap water source	1	2		3		6
DWJ11	45° Gallery, Mineral Spring		1				1
DWJ2	Jermuk group, bottled water brand	1	9		3		13
DWJ3	50° Gallery, Mineral Spring	1	1				2
DWJ4	Byuregh, bottled water brand		3				3
DWJ5	Milenium, unknown, may be a brand name		2				2
DWJ6	30° Gallery , Mineral Spring		2				2
DWJ7	53° Gallery, Mineral Spring		2	1			3
DWJ8	35° Gallery , Mineral Spring		2		3		5
DWJ9	Jermuk- Vayk, tap water source		1				1
AW051	Saravan drinking water	1	10	1			12
AW052	Gndevaz drinking water	1	9	1	1	1	13
AW052a	Gndevaz drinking water from Darayurd		2				2
AW053	Left Jermuk drinking water		8	1			9
AW054	Right Jermuk drinking water		3				3
AW070	Spring above Gorayk used for drinking water					1	1

The drinking water quality data set has been screened against the Project assessment criteria. The screening is presented in Appendix 4.8.6 (based on the full dataset from the Geoteam Monitor Pro database).

Industry and Power Supply

Springs in the Jermuk area are also used as a water supply for commercial mineral water bottling plants. Bjni brand (spring reference DWJ10 from the baseline study), Jermuk Group brand (spring reference DWJ2 from the baseline study), Byuregh brand (spring reference DWJ4 from the baseline study) and Milenium brand (spring reference DWJ5 from the baseline study) mineral water is sourced from various springs in the area.

Surface water flow is used to generate power. There is a hydroelectric power plant located on the Arpa River west of Gndevaz and south of the Kechut reservoir. There is also a smaller power plant located in the Vorotan River due east of the BRSF location (see Chapter 7).

Recreational / Therapeutic

There are a series of springs in Jermuk that are also used for recreational/therapeutic purposes in this spa town where local residents and visitors receive treatments using, bathe in, and drink, the waters.

Irrigation

Residents of Gndevaz village use surface water from nearby rivers for irrigation purposes. A pipeline also diverts water from Kechut Reservoir to Gndevaz and other downstream communities for irrigation purposes. The water in the Kerchut reservoir is sourced from a combination of direct precipitation, surface water (from the Arpa River and other watercourses) and spring flow from groundwater.

Springs are also used as sources of irrigation water supply. Irrigation water for Saravan, Saralanj, and Ughedzor is collected from springs and the Benik Pond and transported to the point of use via open channels and pipes. Household gardens and small plots are irrigated by water from the nearest springs.

Household gardens and small plots in Gorayk are irrigated using water from the same springs as the domestic water supply.

Stock Watering

Water is used by herders for livestock during seasonal cattle breeding. The water users study indicates that water is used by the herders between May and October each year. The water supplies come from springs and surface water courses. Information on the seasonal herder's and their water supply that is presented in the Gone Native LLC water users study is presented in Table 4.10.6. Volumes of water used are not reported.

Table 4.10.23: Water Use by Seasonal Herders

Water Users	Locality	Domestic water source	Stock water supply source	Time period
Herders of Shaki village and their families	Koshabulakh tributary of River Vorotan, in Sites 6, 8 and 9	Upper reaches of Koshabulakh River	Koshabulakh River	June-September
Herders of Khndzoresk village and their families	River Vorotan, in Sites 11 and 13	Potable water pipeline to Gndevaz	Vorotan River	June-September
Herders of Gorayk village	North from Gorayk, in Site 5	Springs, north from Gorayk village	Vorotan River	May-October
Herders of Saravan and Saralanj villages	South from Saravan, near Site 1	Water pipelines of Saravan and Saralanj villages	Darb River near Saravan village	May-October

A survey of herders (daily and seasonal) was also undertaken by Geoteam in 2012 (see Appendix 4.16.1). Daily herders from Gorayk, Saravan and Saralanj take their cattle to pasture at lower altitudes in the Summer until they dry out, and then move to higher altitudes. Seasonal herders come into the Project area for better pasturing than they have access to elsewhere, or because they are returning to traditional pasturing locations. The report presents details on the herders in the Project area. Eighty percent of the surveyed herders currently get their water from natural springs or streams (storing some in man-made water tanks).

Fisheries

There is a fish farm located on the Arpa River approximately 3 km south of Gndevaz. The location is shown in Appendix 4.8.7 on Drawing 4.8.1. Water for this fish farm is diverted from the Arpa River, runs through the tanks at the fish farm before being returned to the river. The fish farm is a non-consumptive user of water, but does rely on the water flow in the rivers, which is provided by a combination of run-off, direct rainfall, baseflow from groundwater and spring discharges.

Ecosystem Services

Rivers and wetlands are partially fed by groundwater and spring discharges. Baseline ecological studies indicate a range of fauna are present in the Project area. Examples of species that rely on water include:

- Aquatic invertebrates that may be dependent on specific flows and quality in watercourses;
- Amphibian species present in wetlands, which can be dependent on spring water supply;
- Native species of fish that are present in surface watercourses; and
- Bats foraging in areas of open water relying on flying insects for food, which in turn often rely on water for breeding.

The species identified as part of the ecology baseline are generally abundant and widespread and are not included in the Armenian Red Book, the IUCN red list, and are not identified as critical habitat species according to IFC PS6/PR6 (Section 4.10).

The plant species recorded during baseline surveys are regional endemics. The only plant species recorded in the Project area that is included in the Armenian Red Book is *Potentilla porphyrantha, which* grows on rock outcrops and boulders on the Amulsar Mountain massif above 2450 m asl. No obvious pattern to the plant location was identified, but they were often found on the top of boulders and associated with mosses, so are most likely sustained by precipitation.

The habitat survey mapping presented in Section 4.10 shows that much of the habitat above 2,600 m asl comprises 'Sub-alpine Meadow' or 'Sub-alpine Meadow with Alpine Elements'. Below 2,600 m asl the habitat largely comprises a mixture of 'Montane Meadow' and 'Montane Meadow Steppe', with some areas of shrub and some areas of cultivation. The Montane Meadows and Meadow Steppe are largely maintained by Summer grazing and/or harvesting of hay. Land use mapping (Section 4.10) shows that cultivation generally occurs below 1,900 m asl and hay cutting occurs between 1,800 m asl and 2,100 m asl. Grazing take place in the Spring and early Summer between 1,800 m asl and 2,700 m asl, with Summer grazing taking place as high as over 2,700 m asl on the Sub-alpine Meadow.

Grazing meadows and hay meadows represent an important ecological/economic resource.

These meadows may be supported by water from springs, surface water and near surface perched water. Vegetation moisture mapping indicates that the very highest Sub-alpine Meadow around the pit locations is likely to be fed by snow melt. The rest of the Sub-alpine Meadow, Montane Meadow and Montane Meadow Steppe have been identified as being fed by seepages or streams.

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4.9 Surface Waters

A surface water baseline investigation was conducted for the Project by Golder, and includes the area bounded by the Vorotan River valley to the east, the Arpa River to the west, the Kechut Reservoir to the north and Spandaryan Reservoir to the south. The study focused particularly on the Vorotan valley catchment to the east of Amulsar, the Arpa catchment to the west of Amulsar and the Darb catchment (a tributary of the Arpa) to the southwest of Amulsar.

Baseline data sets were compiled from various sources:

- Readily available (public) technical reports and data;
- Information provided by Lydian from environmental monitoring between 2007 and 2015; and
- Results of site visits in August 2011, November 2012, March 2013 and March 2014 by Golder technical staff.

For the purposes of this chapter, the Project area is defined as encompassing those parts of Amulsar and surrounds where project facilities or infrastructure are to be constructed. The surface water baseline study area extends beyond this to include those areas which lie downstream of the Project area in each catchment as well as some points upstream of the potentially influenced watercourses. Areas covered by water quantity (flow and stage) and water quality monitoring are identified in Section 4.9.6 and 4.9.7 of this chapter.

4.9.1 National Surface Water Regime and Regional Setting

There are 14 major river basins in Armenia, including the Arpa and Vorotan basins which the Project area straddles. Figure 4.9.1 shows the major river basins, as well as the country's largest river, the Araks (also called Arax and Aras), which lies on the country's border with Iran and forms a large proportion of the border with Turkey. The major tributaries of the Araks are the Akhurian, Kasagh, Hrazdan, Azat, Arpa, Vorotan and Voghdji rivers. The Araks River flows towards the south and east, discharging to the Caspian Sea. The Republic of Armenia (RA) has prepared a set of ecological norms for each of the 14 major river basins (see Chapter 2).

Lake Sevan lies in the Caucasus Region and is the largest lake in Armenia, with its basin making up one sixth of the total territory of Armenia. During the Soviet era, outflows from the lake

were artificially increased, leading to a dramatic fall in lake surface area and a decline in biodiversity and water quality. Measures to restore the quality and size of the lake have been on-going since the late 1960s and include a flow-augmentation tunnel connection with the Arpa River system in 1981 (Sevan – Kechut Reservoir tunnel). The Kechut Reservoir on the Arpa River is also linked to the Spandaryan Reservoir on the Vorotan River by the Spandaryan-Kechut tunnel, although this tunnel has never operated. Lake Sevan remains a nationally important resource for water supply, electricity, fishing, and recreation. Lake Sevan is protected by Armenian law, and has a specific Law governing its protection, as discussed in Chapter 2. The Law includes the Lake Sevan catchment basin, its ecosystems and zone of economic activity, and states that no activity may be permitted which may negatively impact on the Lake and its ecosystem. Article 10 of the Law prohibits ore processing in the central zone and the immediate impact zone of the lake. The proposed HLF and ADR plant and Passive Water Treatment (PWT) facility will be located within a tributary catchment draining to the Arpa River, downstream of the Kechut Reservoir and therefore any discharges from these facilities will not be within the portions of the Vorotan and Arpa river basins that fall within the 'immediate impact zone' of Lake Sevan (see Chapter 2 for a discussion on the legal situation relating to the Lake Sevan).

The Project area related to the BRSF, which is located adjacent to the Darb and Vorotan catchment, naturally drains to the catchment of the Arpa river basin, upstream of the Kechut Reservoir (see Figure 4.9.2). The BRSF lies within the 'immediate impact zone' of Lake Sevan.



Figure 4.9.1: Rivers of the Republic of Armenia (UN Cartographic Section, 2013)

4.9.2 National Surface Water Quality Guidelines

The Government of Armenia has developed a methodology based on use of the Water Quality Canadian Index for designation of surface water quality. The water quality of a water body may be classified from Category I to Category V, reflecting a range from excellent, good, moderate, and poor to very poor[1].

The methodology provides an opportunity to present large-volume measurements of various water quality indicators by index values. These index values mathematically combine all the water quality measurements and provide for a simple description of water quality. European Union Water Framework Directive water management plans require water bodies to meet

[1] Model Guidelines for River Basin Management Planning in Armenia' (USAID, 2008)

biological, chemical/physical and hydrological objectives, which in combination, reflect a desired "good water status." The Government of Armenia has focussed for now primarily on chemical/physical and hydrologic objectives, because Armenia has limited data available on biological conditions.

4.9.3 Regional Surface Water Regime

The major watercourses within and surrounding the Project area are shown in Figure 4.9.2. The Project area is bisected approximately north-south by a catchment divide, with the Arpa basin (shown in magenta/red for upstream and downstream of the Kechut Reservoir respectively) to the west and the Vorotan catchment (shown in green) to the east.

On a regional scale, the Arpa and Vorotan catchments are of similar size, as summarised in Table 4.9.1. These data relate to the greater Arpa and Vorotan basins at their outfall to the Araks/Arax and not just those catchments related to the Project area. As these catchments include lowland areas, their hydrological characteristics may not be wholly representative of conditions within the largely upland study area. In particular, higher evaporation would be expected in the warmer lowlands and the snow pack-melt cycle does not have as immediate an effect on runoff.

Table 4.9.1: Relevant Regional Catchments (FAO, 2009)

Catchment characteristics*	Arpa	Vorotan
Area (km^2)	2306	2476
Precipitation over total area ($Mm^{3)}$	1643	1828
Calculated Annual Precipitation (mm)	712	738
Evaporation (Mm^3)	768	811
Calculated Annual Evaporation (mm)	333	327
Total Annual Flow (Mm^3)	764	725
Total Annual Flow as Precipitation (mm)	331	293
Average flow at maximum extent (m^3/sec)	24.2	22.9
Notes: ** Refers to catchment areas within Armenia only.*		

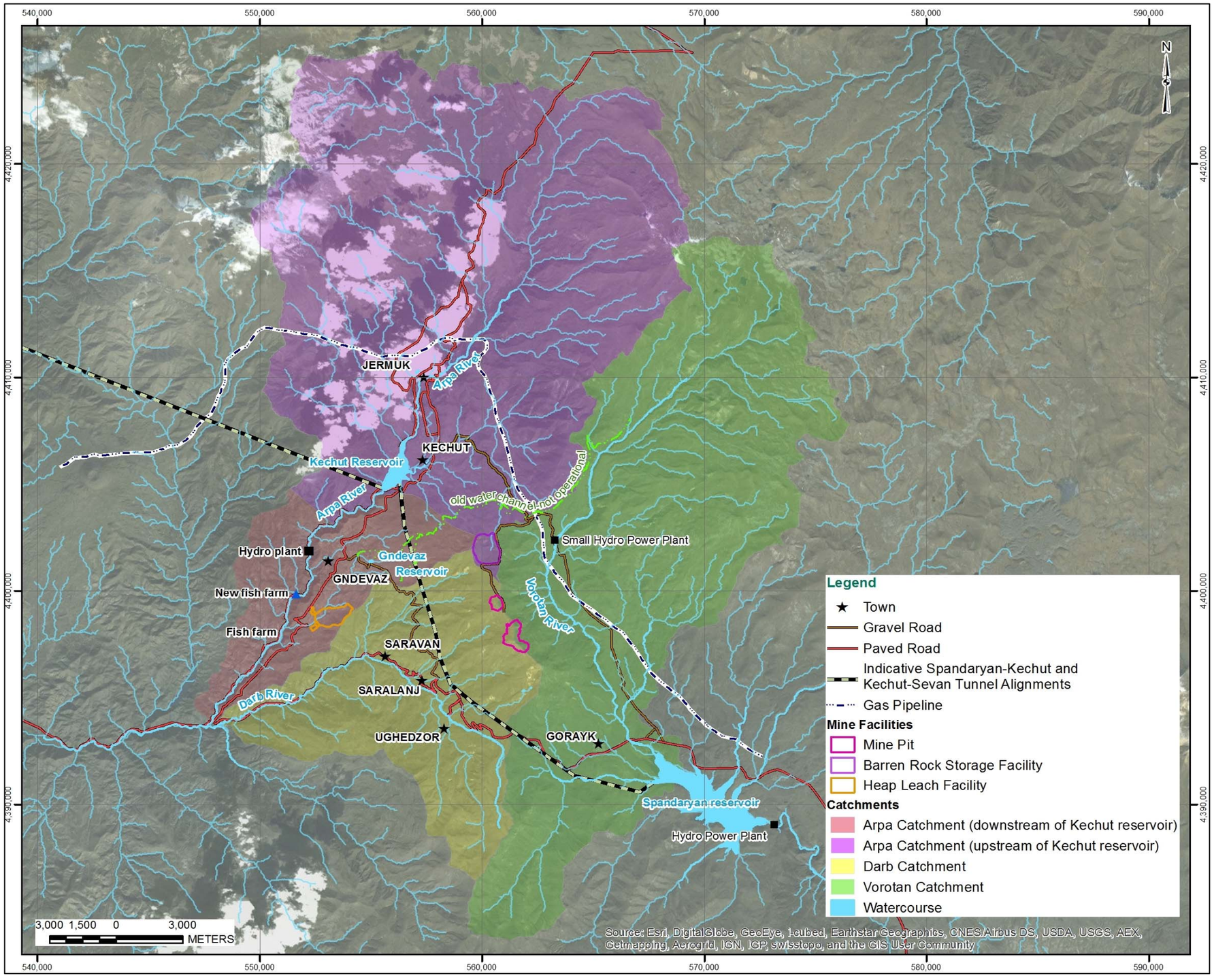


Figure 4.9.2: Project Location and Major Surface Water Features

Arpa and Darb Catchment

Amulsar forms the watershed (hydrologic divide) between the Vorotan and Arpa river catchments. The Arpa River flows northeast to southwest, passing northwest of Amulsar and is approximately 0.6 km from the mine infrastructure at its nearest point. The Darb River flows initially northwest along the south-western flank of Amulsar before turning southwest to join the Arpa River 14 km downstream of the Kechut Reservoir.

Kechut Reservoir is situated on the Arpa River north-west of Amulsar and lies approximately 4.5 km at its nearest point from the mine infrastructure. The Kechut Reservoir is artificially linked to Lake Sevan by two tunnels with a combined total length of approximately 48 km. This scheme of interconnected tunnels between reservoirs/river basins is part of the RA's national water supply strategy. The outfall from the Kechut Reservoir to the Sevan tunnel system is located at the southwest corner of the reservoir. In addition, discharges from the reservoir are used at a hydroelectric plant near Gndevaz and for water supply.

The Jermuk Hydrothermal Springs lie upstream of the Kechut Reservoir around the town of Jermuk. Chemical analysis of water from these springs in comparison to groundwater within the Project area shows them to be chemically distinct and thus of different origin than groundwater within the Amulsar Project area. This is discussed in more detail in the groundwater baseline (Section 4.8.8).

The Gndevaz Reservoir (Figure 4.9.2) is located within the Arpa catchment, to the east of Gndevaz village and to the northeast of the HLF. The reservoir was originally designed to be supplied by a man-made channel diversion known as the Gndevaz Channel but is currently supplied by snow melt and drainage from above the reservoir. A land drain diversion flowing northwards does however direct natural flow from a small area of the adjacent valley to the south into the Gndevaz Reservoir, discharging to the reservoir via a piped outflow (see Figure 4.9.5, adjacent to Site 14 Gauge).

The reservoir does not provide a potable supply to Gndevaz village. The area supplied by the reservoir is restricted to the fields below where it provides a source of water for livestock during the summer months, when the surrounding grasslands are used by herders. The reservoir discharges immediately below the dam wall into a stream channel which runs through a gorge (see Appendix 4.9.5).

The Gndevaz Channel is located to the north and west of Amulsar, sourced from the Vorotan River and running westwards towards Gndevaz village, approximately 1km north of the BRSF. A second arm of the channel branches off and runs south-westwards towards the Gndevaz Reservoir. The channel was an open, concrete-lined structure originally designed to supply irrigation water to Gndevaz from Arkhashan to the north of Amulsar. The channel, which reportedly has not been used for many years, has sections observed to be either infilled with soil or absent. Currently, any water found in the channel is thought to be derived from snow melt and local runoff which is diverted through short sections of the channel. The channel is currently being reinstated and is planned to be servicible by mid-2016. A water supply pipeline for Gndevaz, sourced from the Arkashan springs in the upper reach of the Vorotan, runs along part of the channel route.

The Darb River is the largest tributary of the Arpa within the study area. Due to its significance to the Project, the Darb catchment is shown (yellow) in Figure 4.9.2, lying southwest of the Project area. Part of the footprint of the proposed open pits fall within the Darb catchment. The Darb catchment is not subject to the Lake Sevan Law as it joins the Arpa downstream of Kechut Reservoir.

A small cirque lake referred to as 'Benik's Pond' (Figure 4.9.5) is located in a topographic depression on the western side of Amulsar, within the Darb catchment. This pond is approximately 1 ha in area and has been used as a water supply for the exploration programme at Amulsar. The pond is underlain by superficial deposits and is fed by surface water runoff and a number of springs on the western side of the peak. 'Benik's Pond' is noteworthy for its naturally low pH (reportedly as low as 3). It has an average depth of 8 m.

Of the main infrastructure associated with the Project, only a portion of the open pits will be located within the Darb sub-basin of the Arpa catchment. The BRSF is located in the Arpa catchment, discharging to the Arpa upstream of Kechut reservoir; the HLF, ADR and PWT facilities will be situated wholly within the Arpa catchment, draining downstream of the Kechut Reservoir. The crusher is situated in the Arpa catchment and straddles the water divide between the catchment discharging upstream of the Kechut reservoir and that draining to downstream of the reservoir.

Vorotan Catchment

The Vorotan River flows south past the eastern flank of Amulsar, and in the vicinity of the Project area is up to approximately 10 m wide and 0.3 m to 0.8 m deep. The river flows through a grassed incised valley typically 30 m to 80 m below the surrounding plateau. This valley is more steeply incised to the north of the Project area. The underlying basalt bedrock is observed to outcrop in the river bed in the area adjacent to Amulsar.

Flowing south through the Project area, the Vorotan discharges to the Spandaryan Reservoir approximately 6.3 km south-east of the proposed Tigranes-Artavazdes open pit and south-east of Gorayk (Figure 4.9.2). The Spandaryan Reservoir is connected to the Kechut Reservoir on the Arpa River by the Spandaryan-Kechut tunnel. It is reported that no water transfers take place through the tunnel at the present time. Those parts of the Vorotan and Arpa rivers downstream of the Spandaryan and Kechut reservoirs respectively are not subject to the Lake Sevan law.

The Spandaryan-Kechut tunnel is approximately 22 km-long and runs approximately 3 km to the west of the footprint of the open pits and the BRSF and approximately 3 km east of the HLF footprint. Although tunnel construction was completed in 2003, the intake from the Spandaryan Reservoir is closed and the tunnel is not operational. The observed flow from the tunnel (Figure 4.8.26 in Groundwater section) is a result of groundwater infiltration into the tunnel, rather than direct flow from the Spandaryan Reservoir. This conclusion is supported by an environmental isotope analysis study (Golder 2013a, Appendix 4.9.1) and by results of chemical analysis of samples collected at the outfall to the reservoir (Section 4.8.1). The approximate tunnel alignment is shown on Figure 4.9.3.

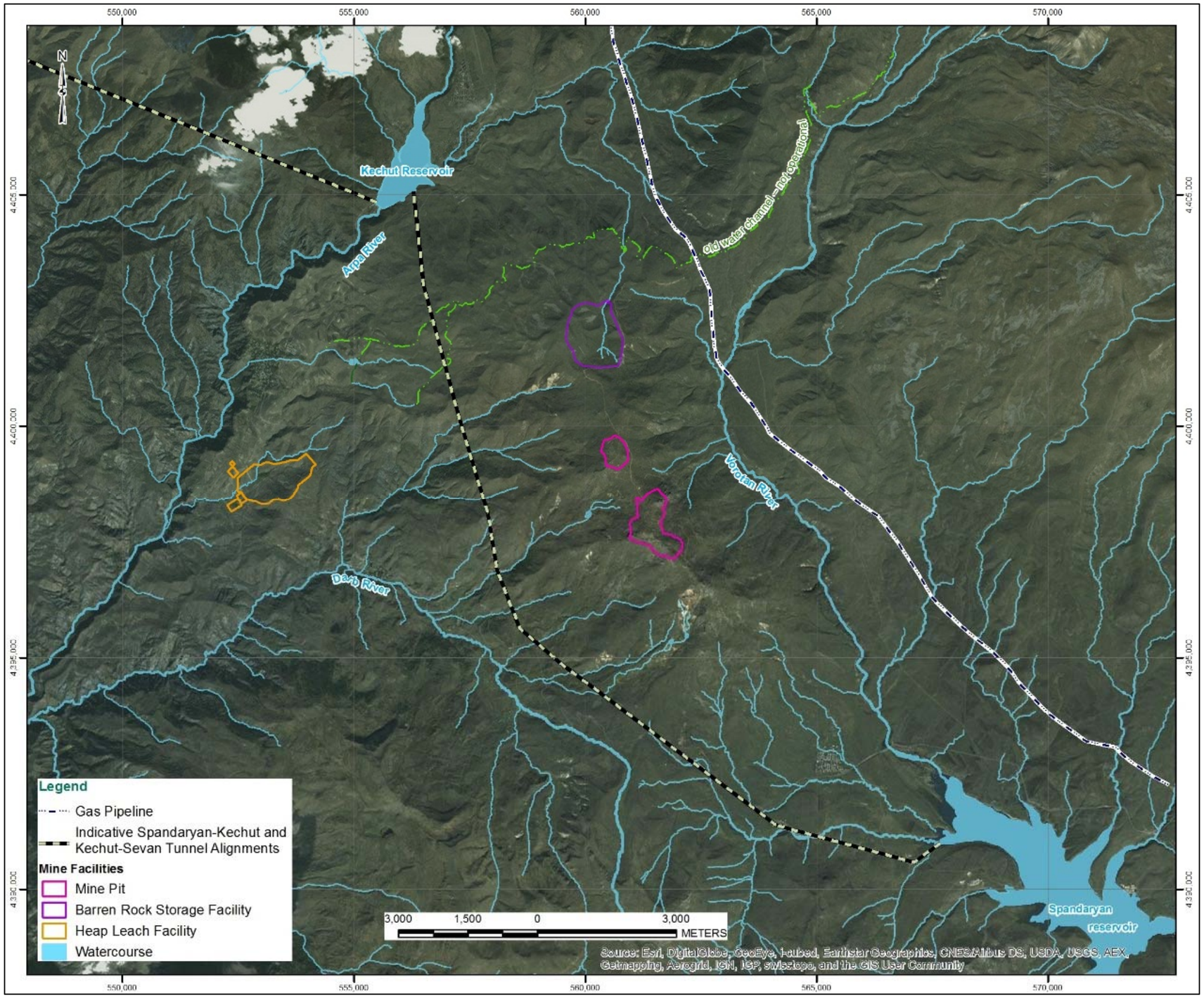


Figure 4.9.3: Spandaryan-Kechut Tunnel Location (approximate alignment)

Several reservoirs located within the Vorotan River basin, including the Spandaryan Reservoir, Angeghakot, Tolors, and Shamb have primarily been constructed to support hydropower plants; all but Spandaryan are outside of the study area. The Spandaryan Hydro Power Plant is located at the reservoir's downstream (southern) end (Figure 4.9.2).

4.9.4 Long Term Flow Data

There are limited available public long term data to characterise the flow regimes of the main rivers draining the Project area. Some historical data have been obtained for the Vorotan River upstream of the Spandaryan catchment as described below. No data or records have been found regarding the operation of the Kechut Reservoir spillway, HEP discharge and Lake Sevan transfer (aside from some anecdotal evidence, see below). The Darb catchment is significantly smaller than the Arpa and Vorotan and it does not appear that there is any long term gauging or flow monitoring on this river.

Vorotan Catchment

The annual average flow of the Vorotan River, in common with all rivers in Armenia, fluctuates considerably year to year. During dry years, the river flow decreases to reportedly very low levels. The maximum flow is observed in spring months during the annual snow melt and the co-incident wettest period of the year. At other times of the year, the flow is sustained by groundwater baseflow, from precipitation including storms during the summer months, and frontal rainfall during the autumn period.

A small hydro-power project (SHPP), the "MANE" project is currently being developed on the Vorotan River due east of the BRSF. Flow analysis has been carried out for that project (ERA, 2011) based on a set of historic flow data for the Vorotan. The historic Vorotan-Borisovka gauge (previously located within the footprint of the Spandaryan Reservoir) recorded Vorotan River flow measurements for the 45-year period from 1943 – 1987; this corresponds to a 507 km^2 catchment. When the Spandaryan Reservoir was commissioned, the gauging station was relocated to Gorayk, which significantly reduced the catchment size (to 268 km^2 – 26,800 ha) reporting to the new gauge location, called Vorotan-Gorayk. Historical data from the Vorotan-Gorayk gauging station (1987 – 2006) were combined with scaled flow data for the Borisovka gauge to produce a more complete dataset for the smaller Gorayk gauge catchment area, which encompasses the Vorotan valley upstream of Spandaryan Reservoir as shown on Figure 4.9.2.

Table 4.9.2: Total Annual Vorotan Flow vs Concurrent Precipitation (1962-1987)				
Statistic	**Annual Precipitation (mm)**	**Total Annual Volume (m^3/yr)**	**Implied Runoff (Yield) (mm/yr)**	**Yield/Precipitation (%)**
Mean	737.1	122,716,895	458	62%
5%	570.7	63,020,104	235	41%
25%	666.8	91,668,560	342	51%
50%	739.3	119,732,936	447	60%
75%	798.7	148,791,570	555	70%
95%	925.4	195,483,780	729	79%
Notes: Percentiles based on total monthly precipitation (Vorotan Pass) and average monthly flow rate (Vorotan Gorayk Gauge) both for the 1962-1987 concurrent flow/precipitation record. Gauge catchment is 268 km^2 as per Figure 4.9.5.				

Table 4.9.2 compares the catchment runoff (yield) for a range of percentile flows based on the Gorayk Gauge catchment from 1962-1987. This is compared to the percentile annual precipitation for the concurrent period of record at the Vorotan Pass station. The table shows the percentage yield (i.e. fraction of surface water runoff) increases in response to increasing precipitation. This response is a result of rainfall intensity exceeding the infiltration rate, be it very intense storms or antecedent soil moisture.

Based on the same dataset, Figure 4.9.4 compares percentile monthly flows to percentile monthly precipitation presented on an annual water year basis. The annual snow melt is often augmented by concurrent peak rainfall in May/June. Notably, relatively high monthly total rainfall for the 95th percentile of monthly rainfall totals (low probability of occurrence) in October-January are not reflected in the flow figures for the same months. When considered on a monthly time frame, relatively low groundwater levels, baseflow and high soil moisture deficit (following the dry summer months) would tend to attenuate the effects of a wet month on flow in the major watercourses. As the winter advances, precipitation falls as snow, largely stored until the spring snow melt.

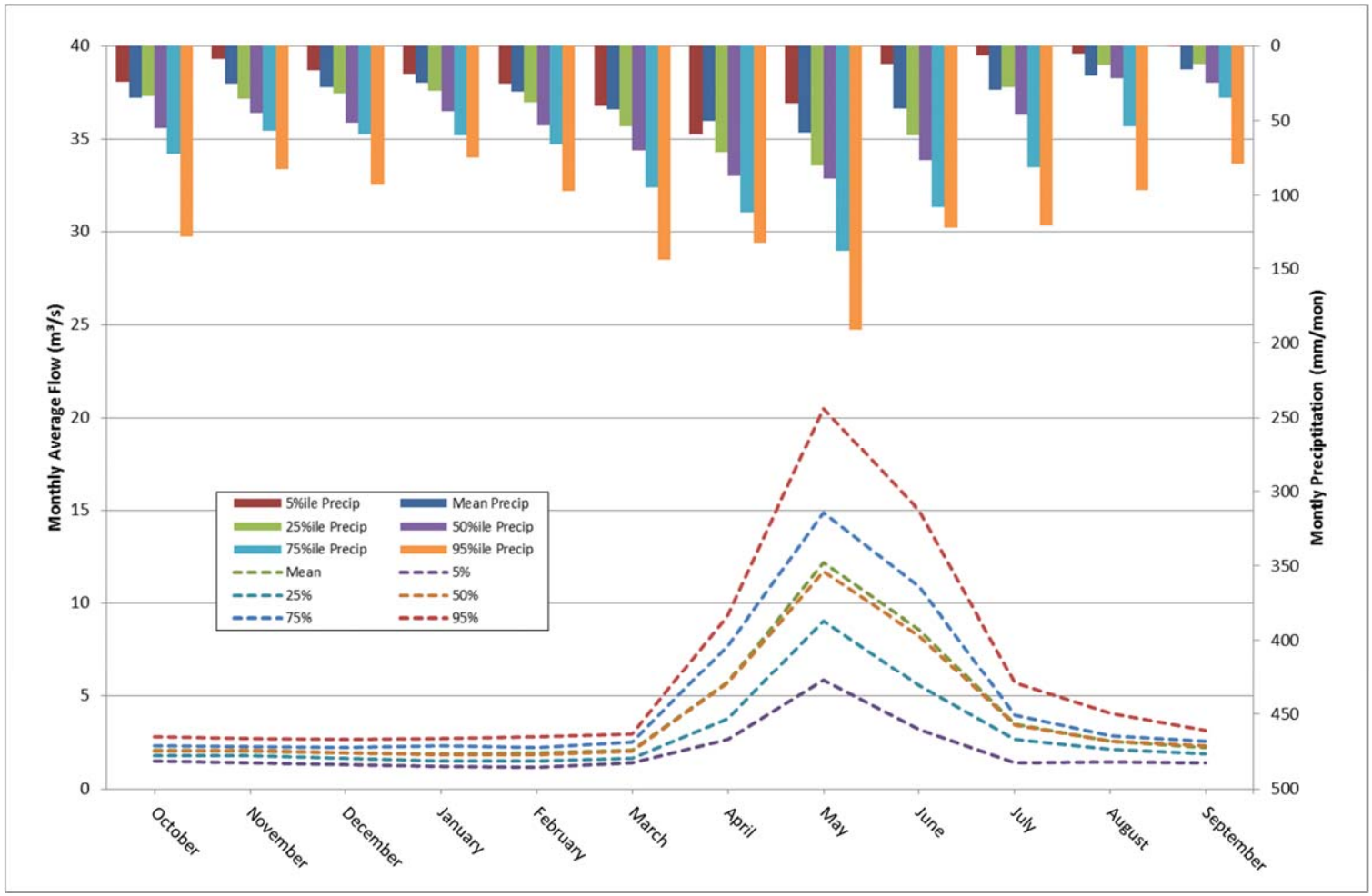


Figure 4.9.4: Comparison of Percentile Average Monthly Flows at Gorayk Gauge against Percentile Total Monthly "Vorotan Pass" Precipitation (1962-1987 Concurrent Record)

Arpa and Darb Catchment

Historical flow records for the Arpa and Darb rivers are not available and no historic gauging stations have been identified on the reach of the Arpa adjacent to the Project area, upstream or downstream of the Kechut Reservoir. The reach downstream of the Kechut Reservoir is a regulated waterway whose flow regime does not reflect the natural channel flow patterns. Data regarding the regulation of the spillway at the Kechut Reservoir are not available.

Possibly due to its relatively small size, no long term flow data are available for the Darb.

The hydropower plant west of Gndevaz may divert additional flow directly from the Kechut Reservoir to its discharge point, potentially increasing flows in the Arpa downstream of that location during low flow periods. Two fish farms, which are located downstream of the hydropower plant, are not consumptive water users of the Arpa. The hydropower plant and fish farms are presented in Figure 4.9.5 and also discussed in Section 4.9.7.

4.9.5 Surface Water Flow Monitoring

Spot Flow Measurements

Flow measurements taken on the three main rivers and on several tributaries within the study area in 2008, 2010 and 2011 are available in Geoteam Monitor Pro Database (Lydian, 2008-2011) (see also Appendix 4.9.2). Monthly average flows for late summer and early autumn are provided in the reports.

In parallel to and in support of continuous monitoring during the winter-spring seasons of 2012-2013 and 2013-2014, spot flow measurements were collected at stations throughout catchment (both at gauged and ungauged points and available in the Geoteam Monitor Pro Database). The locations of both the 2008-2011 phase of flow monitoring and the 2012-2015 continuous and spot flow monitoring are shown on Figure 4.9.5.

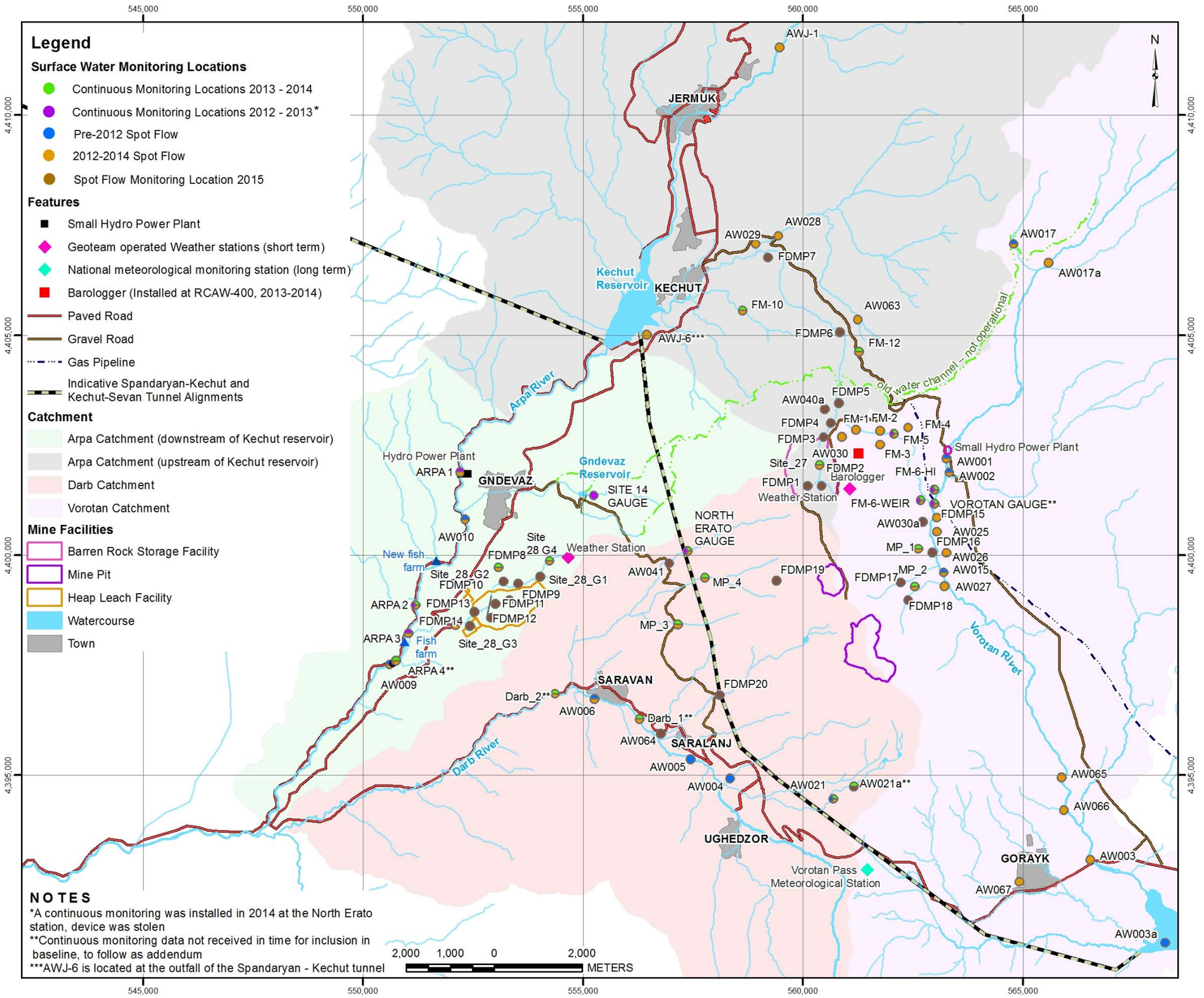


Figure 4.9.5: Surface Water Stage/Flow Monitoring Locations

Table 4.9.3 describes the seasonal flow patterns and Table 4.9.4 presents average flow measurements over the monitoring period on a quarterly basis.

Table 4.9.3: Seasonal Hydrologic Patterns

Quarter	Months	Flow and Hydrological Pattern
Q1	January - March	High elevation sites may freeze, low flow in main rivers, some precipitation driven events at lower elevation
Q2	April – June	Spring snow melt period generally commences April-May, peak flows in June/July dependent on elevation
Q3	July – September	July may include latter parts of spring snow melt. Low flow in smaller watercourses experienced during August-September, lowest precipitation months.
Q4	October - December	Frontal rainfall and lowering temperatures lead to increased runoff driven flow in smaller catchments; snowpack accumulation commences, high elevation sites may freeze.

Table 4.9.4 indicates the number of spot flow measurements collected at each location and also the number of flow readings in each quarter at all locations. Flow data from smaller watercourses during the low flow periods in Q3 are limited to 2010 and 2011 at a select number of sites. The main rivers have a more complete spot flow monitoring record.

The spot flow measurements for the 2012-2015 monitoring period are included in Appendix 4.9.2 along with monthly average measurements from Lydian annual monitoring reports.

Table 4.9.4: Average Seasonal Flow Monitoring Summary 2008-2015. Flows in m^3/s

Location	Year	2008	2010				2011				2012				2013				2014				2015				Data Count Per Location
	Quarter	??	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	
Arpa (downstream of Kechut Reservoir)	Arpa 1														3.140												1
	Arpa 2														2.670			2.605	3.212	4.411				4.573	3.617		6
	Arpa 3														2.960												1
	Arpa 4																		3.772	4.502				4.661	4.152		4
	AW009			3.060	2.823	2.740		2.910	2.600							7.679								5.283	3.872		12
	AW010			3.045	2.857	2.750		3.000	2.800							3.937											10
Arpa (upstream of Kechut reservoir)	AWJ1														1.065	3.009											2
Arpa Tributary (downstream of Kechut Reservoir)	FDMP10																							0.000	0.000		8
	FDMP11																							0.000	0.000		8
	FDMP12																							0.000	0.000		8
	FDMP13																							0.000	0.000		8
	FDMP14																							0.001	0.000		8
	FDMP8																							0.000	0.000		4
	FDMP9																							0.001	0.000		8
	Site 28 G1																		0.000	0.000				0.001	0.000		10
	Site 28 G2																	0.000	0.000	0.000				0.000	0.000		11
	Site 28 G3																	0.000	0.000	0.000				0.002	0.001		11
	Site 28 G4																							0.001	0.000		8
Arpa Tributary (upstream of Kechut Reservoir)	AW028												0.082		0.048												2
	AW029												0.069											0.431	0.071		3
	AW063																			0.022							1
	FDMP1																							0.183	0.000		4
	FDMP2																							0.000	0.000		4
	FDMP3																							0.060	0.000		5
	FDMP4																							0.001	0.000		5
	FDMP5																							0.003	0.000		4
	FDMP6																							0.000	0.000		4
	FDMP7																							0.008			2
	FM10																	0.006	0.003	0.015				0.071			4
	FM12																	0.004	0.001	0.022							3
	Site 27																	0.006		0.059				0.002	0.000		5
Darb	AW005	0.000		0.205	0.207	0.220		0.200	0.205															1.318	0.188		13
	AW006	0.006		0.965	0.887	0.780		1.080	0.900				0.230											1.107	0.189		13
	Darb1																		0.432	0.408				1.760			3
	Darb2																		0.828	1.193				1.873			3
Darb Tributary	AW004	0.005		0.165	0.160	0.180		0.200	0.175																		10

Table 4.9.4: Average Seasonal Flow Monitoring Summary 2008-2015. Flows in m^3/s

Location	Year	2008	2010				2011				2012				2013				2014				2015				Data Count Per Location
	Quarter	??	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	
	AW021																	0.002	0.004	0.028							3
	AW021a																							0.019			1
	AW041																							0.205	0.023		4
	AW064																							0.278	0.000		3
	FDMP19																							0.006	0.000		4
	FDMP20																							0.300	0.000		3
	MP3																	0.002	0.000	0.005							3
	MP4																	0.005	0.051	0.070							4
	North Erato															0.063		0.004	0.022	0.028				0.012	0.002		7
Vorotan	AW001	0.003		3.480	0.677	0.700		1.700	0.800				2.591		2.095									3.604	2.742		14
	AW003	0.001		6.995	1.347	1.540		4.700	1.500						3.776	6.018			6.054					6.708	3.246		17
	AW007	0.009																									1
	AW008	0.005																									1
	AW015			5.305	1.127	1.180		4.300	1.300				2.934							2.803					4.109		12
	AW017a														1.786	4.069											2
	AW065																			0.016							1
	Vorotan														2.550	5.954		2.498						3.903	2.007		5
Vorotan Tributary	AW002	0.000											0.189														2
	AW017			0.095	0.087	0.080		0.100	0.080				0.012							0.237							11
	AW025												0.019		0.015	0.077											3
	AW026												0.024		0.008	0.102											3
	AW027														0.002	0.109											2
	AW030														0.013					0.001				0.001			6
	AW030a																0.061								0.005		2
	AW040a																							0.081	0.000		4
	AW066																			0.006							1
	AW067																		0.151	0.318							5
	FDMP15																							0.002	0.000		2
	FDMP16																							0.000	0.000		2
	FDMP17																							0.008	0.002		2
	FDMP18																							0.006	0.002		2
	FM1											0.070		0.062													4
	FM2											0.091		0.138													4
	FM3											0.031		0.031													4
	FM4											0.001		0.001													4
	FM5											0.136		0.182			0.049	0.004	0.003	0.060							8
	FM6											0.199		0.196				0.006									5

Table 4.9.4: Average Seasonal Flow Monitoring Summary 2008-2015. Flows in m^3/s

Location	Year	2008	2010				2011				2012				2013				2014				2015				Data Count Per Location
	Quarter	??	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	
	FM6WEIR																			0.280							1
	MP1																	0.004		0.114				0.084			4
	MP2																	0.009		0.147				0.164			3
Data Count Per Quarter		8		18	27	9		9	18			18	9	6	13	10	2	15	22	26				136	39		

Continuous Monitoring

Continuous flow monitoring has been undertaken at selected locations on watercourses within the Vorotan, Arpa and Darb catchments in the Project area from November 2012 to May 2013 and December 2013 to May 2014 (available at Geoteam Monitor Pro Database).

Continuous monitoring sites are shown on Figure 4.9.5, which indicates monitoring year and identifies spot flow monitoring locations. Figure 4.9.6 and Figure 4.9.7 identify the main river and mine area stream catchments which have been continuously monitored.

Table 4.9.5 provides details of the station type and characteristics (catchment area, channel slope, station elevation) as well as some catchment characteristics (average catchment elevation, slope and aspect) and monitoring year.

Two types of flow monitoring station were installed: weir stations and open channel monitoring stations. Stations included pressure transducer devices with built-in data loggers, which were installed in weirs or in sections of conduit buried in the banks of the stream. Gauge boards were also installed to enable manual measurement of water level ("stage") and calibration of the transducer records.

On the smaller streams, rectangular notch weirs stations were constructed on site using local materials. These weirs were sized based on the physical channel dimensions, spot flow measurements and with reference to British Standard ISO 1438 (BS, 2008) and field measurement references (WMO, 2010).

The larger watercourses and selected smaller tributaries were monitored with open channel stations, and field data and topographic surveys of the monitoring reach were used to develop cross-sectional profiles. The continuous stage record for these stations was converted into a flow estimate as described below.

Golder staff installed the stations included in the 2012/2013 monitoring period with the assistance of Geoteam field staff. The stations installed for the 2013/2014 monitoring period were installed by Geoteam staff based on instructions and method statements provided by Golder. These method statements and the proposed monitoring plan are detailed in the Environmental Monitoring Plan (see Appendix 8.12).

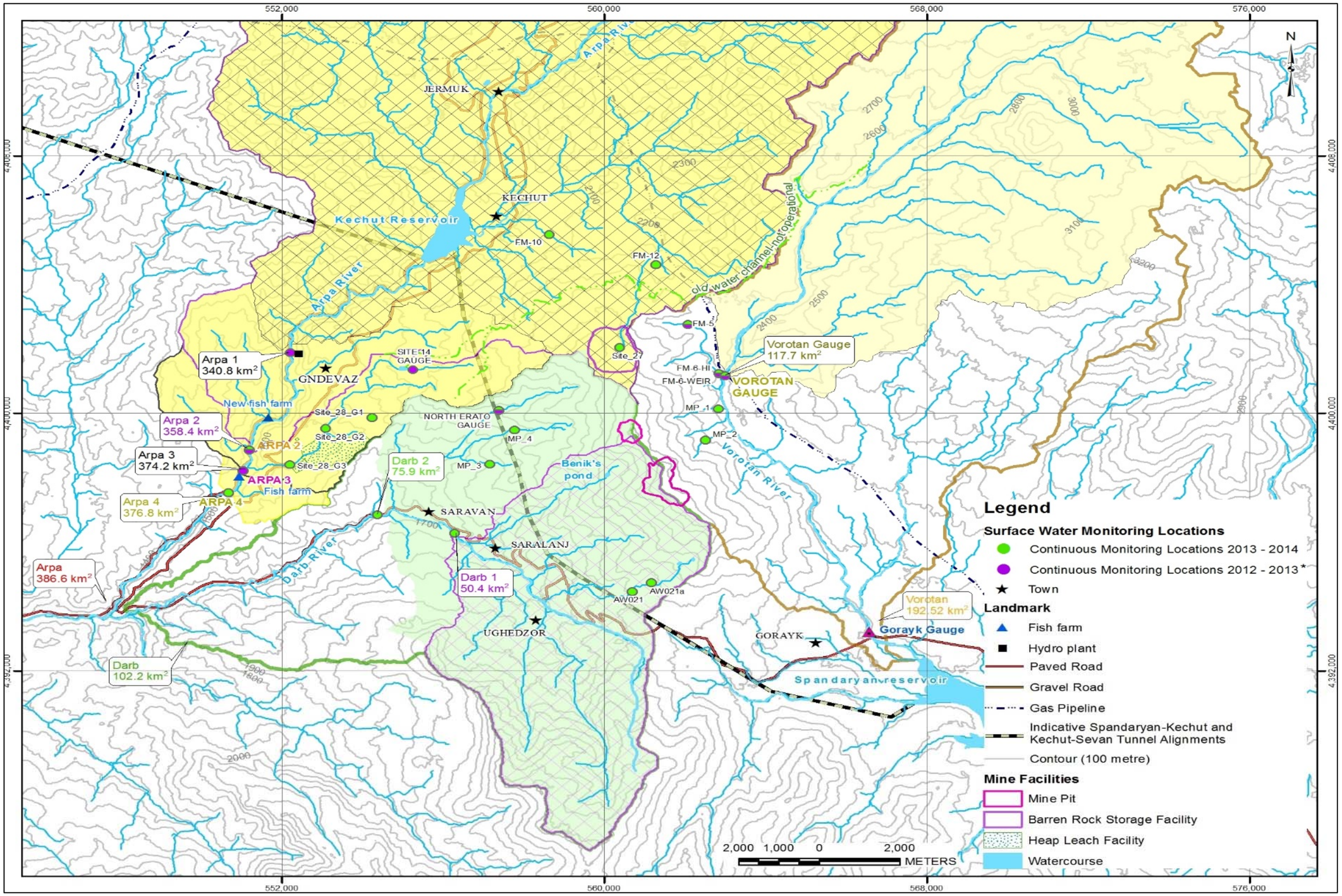


Figure 4.9.6: Continuously Monitored Gauged Catchment Extents on Major Watercourses in the Project Area

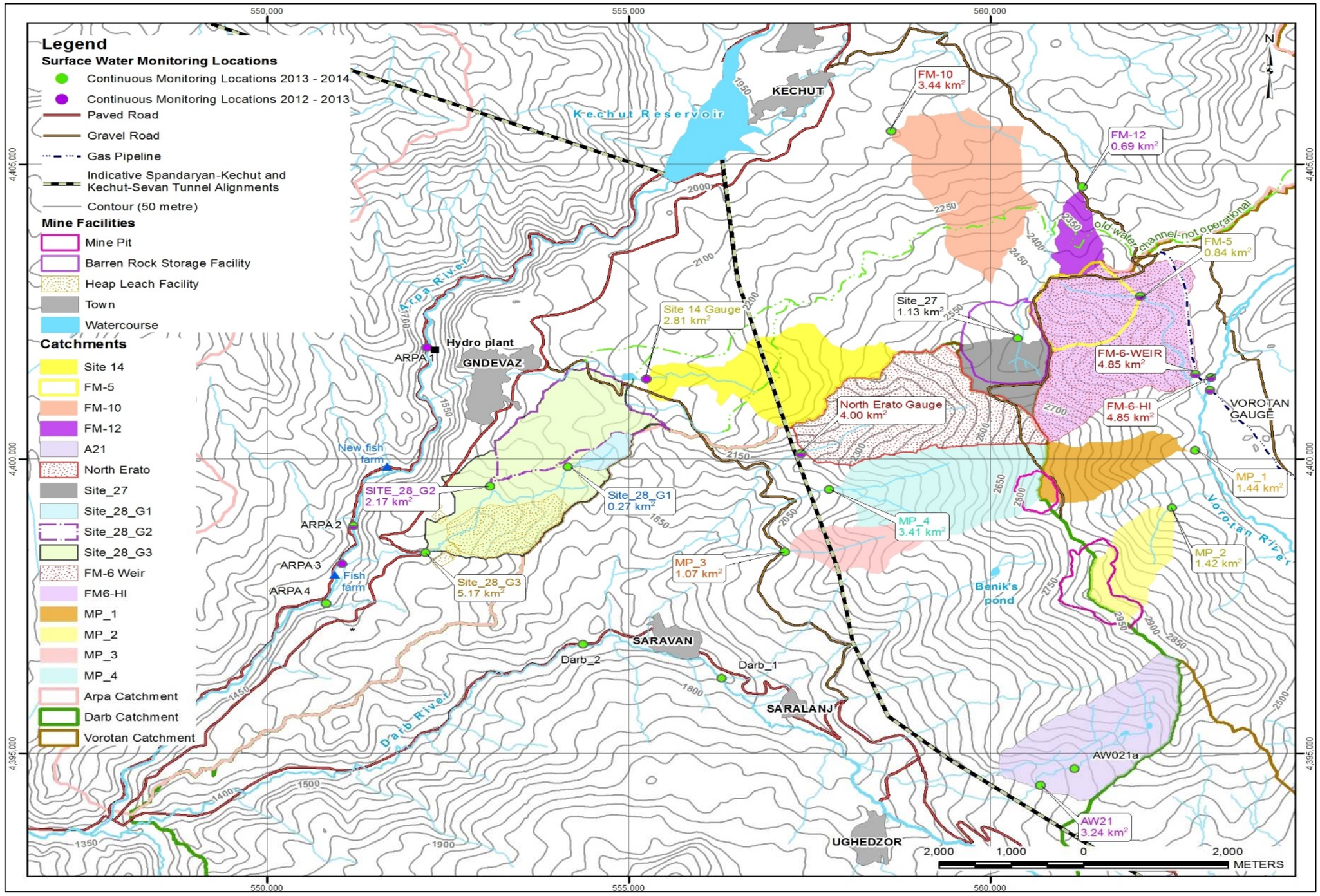


Figure 4.9.7: Continuously Monitored Gauged Catchment Extents on Smaller Mine Area Watercourses

Table 4.9.5: Summary of Continuous Monitoring stations and gauged catchment characteristics

Location	Point ID	Continuous Stage Monitoring		Station Characteristics				Catchment Characteristics (Average)			Mine Facility
		2013 - 2014	2012 - 2013	Station Type	Station Elevation (m AOD)	Local Channel Slope (m/m)	Upstream Catchment (Km²)	Aspect (8 point)	Upstream Slope (m/m)	Elevation (m AOD)	
Arpa	Arpa 1	N	Y	Open	1525	0.015	340.8	S	0.071	2760	Wider Site Area
	Arpa 2	Y	Y	Open	2300	0.011	358.4	S	0.077	2716	Wider Site Area
	Arpa 3	N	Y	Open	2075	0.017	374.2	S	0.075	2685	Wider Site Area
	Arpa 4	-	N	Open	1950	N/A	376.8	S	0.075	2668	Wider Site Area
Arpa Tributary	FM-10	-	N	Weir	2050	0.065	3.44	NW	0.089	2267	Wider Site Area
	FM-12	Y	N	Weir	2227	0.023	2.88	NE	0.082	2514	Wider Site Area
	Site 14*	N	Y	Open	2029	0.051	2.81	W	0.091	2293	Wider Site Area
	Site_27	Y	N	Weir	2529	0.016	1.13	N	0.067	2618	BRSF / Crusher
	Site_28_G1	Y	N	Open	1850	0.064	0.27	W	0.065	1943	Valley Leach Facility
	Site_28_G2	Y	N	Weir	1675	0.011	2.17	SW	0.067	1908	Valley Leach Facility
	Site_28_G3	Y	N	Weir	1600	0.035	5.17	NW	0.086	1849	Valley Leach Facility
Darb	Darb_1	-	N	Open	1750	0.016	50.4	S	0.078	2571	Artavazdes / Tigranes Open Pit
	Darb_2	-	N	Open	1600	0.029	75.9	S	0.081	2501	Artavazdes / Tigranes Open Pit
Darb Tributary	AW021_A / AW021	-	N	Weir	2310	0.030	3.24	S	0.053	2577	Artavazdes / Tigranes Open Pit
	MP_3	Y	N	Open	2000	0.123	1.07	NW	0.050	2282	Erato Open Pit
	MP_4	Y	N	Weir	2125	0.057	3.41	W	0.050	2538	Erato Open Pit
	North Erato	N	Y	Open	2150	0.060	4.00	NW	0.059	2515	BRSF / Crusher
Vorotan	Vorotan	-	Y	Open	2275	0.005	117.7	NE	0.102	2964	Wider Site Area
Vorotan Tributary	FM-5	Y	Y	Weir	2350		0.84	NE	0.083	2472	Wider Site Area
	FM-6-HI	Y	Y	Open	2275	0.015	4.86	NE	0.076	2499	Wider Site Area
	FM-6-WEIR	Y	Y	Weir	2275		4.85	NE	0.076	2500	Wider Site Area
	MP_1	Y	N	Open	2268	0.071	1.45	E	0.044	2617	Erato Open Pit
	MP_2	Y	N	Open	2375	0.137	1.42	NE	0.041	2747	Artavazdes / Tigranes Open Pit

Y = Continuous monitoring carried out
- = Contuous Monitoring carried out, data not available for 2014 baseline presentation
N = Continuous Monitoring not carried out

As identified in Table 4.9.5, some of the stations at which monitoring was carried out during the 2013-2014 period could not be reported in this baseline document generally due to access issues in obtaining the transducer records. Data for these remaining stations will be included in addenda to the ESIA. A summary of continuous monitoring records is presented in Table 4.9.6

Table 4.9.6: Summary of Continuous Monitoring records

Monitoring Period:	2013/2014	2012/2013
Available station records	13	9
Total number of station records:	19	9
Available station records covering both periods:	4	
Number of stations covering both periods:	5	

The stage dataset is presented graphically as instantaneous and daily average hydrographs in Appendix 4.9.2. Approximate discharge and flow velocity for each monitoring location were calculated by applying Manning's calculation (Shaw, 1994) or using empirical weir equations (BS, 2008) applied to the stage dataset. The record of estimated flow is also presented graphically in Appendix 4.9.2.

Table 4.9.7 and Table 4.9.8 present flow and unit area runoff (yield) for each monitored catchment over the 2012 and 2013 monitoring periods respectively. Maximum and average flows for the monitored period have been calculated for each location, allowing estimation of catchment yield based on the gauged catchment size. Average flows were used to estimate the yield on a monthly basis. Stage/flow data for high elevation stations on tributaries within the mine area generally present a poor record during the winter period as freezing conditions result in the gaps for those months.

Table 4.9.7: Flow Statistics and Catchment Yield, 2012-2013 Monitoring Period

Location	Point ID	Gauged Area (km^2)	Maximum Flow (m^3/s)	Average Flow (m^3/s)	Average Unit Discharge (mm/month)	Monthly Unit Discharge (mm/month)						
						November	December	January	February	March	April	May
Arpa	Arpa 1	340.8	7.625	3.417	26	N/A	25	25	22	28	27	32
	Arpa 2	358.4	9.180	3.535	26	N/A	25	24	21	28	26	33
	Arpa 3	374.2	6.731	2.959	20	N/A	22	21	18	22	19	24
Arpa Tributary	Site 14	2.813	0.703	0.079	73	N/A	N/A	N/A	N/A	12	90	26
Darb Tributary	North Erato	4.005	1.139	0.053	34	13	11	14	15	26	58	87
Vorotan	Vorotan	117.7	4.511	2.083	46	34	37	33	28	36	62	84
Vorotan Tributary	FM-6-HI	4.856	0.541	0.092	49	10	19	17	12	32	127	153
	FM-6-WEIR	4.852	0.841	0.193	103	6	8	12	14	47	214	253

Notes:
1) Average Unit Discharge for a nominal 30 day month, length of valid monitoring data record varies from site to site.
2) Limited calibration data was available for the 2012-2013 monitoring period at the Arpa river stations. Discrepancies in upstream/downstream measurements may arise from this source or may relate to operation of the Kechut HPP adjacent to Arpa 1.

Table 4.9.8: Flow Statistics and Catchment Yield, 2013-2014 Monitoring Period

Location	Point ID	Gauged Area (km^2)	Maximum Flow (m^3/s)	Average Flow (m^3/s)	Average Unit Discharge (mm/month)	Monthly Unit Discharge (mm/month)						
						November	December	January	February	March	April	May
Arpa*	Arpa 2	358.4	19.399	3.656	26	19	24	23	21	21	30	67
Arpa Tributary	Site_27	1.133	0.630	0.023	53	32	67	18	16	23	144	N/A
	Site_28_G1	0.274	0.021	0.001	9	N/A	25	N/A	0	4	11	31
Darb Tributary	MP_3	1.069	0.051	0.007	17	11	8	12	N/A	4	29	38
Vorotan Tributary	FM-6-HI	4.856	0.589	0.091	48	7	10	5	7	31	139	110
	FM-6-WEIR	4.852	0.718	0.090	48	9	14	13	13	33	142	44
	MP_1	1.445	0.205	0.056	101	69	59	49	45	79	166	178
	MP_2	1.424	0.493	0.045	82	16	19	16	15	16	197	460

Notes:
N/A - Data not available/monitoring station not yet installed
1) Average Unit Discharge for a nominal 30 day month, length of valid monitoring data record varies from site to site.
2) Data was collected but not available for presentation in the baseline for sites: Vorotan, FM-10, Darb 1, Darb 2, AW021 and Arpa 4.
3) Data collected for Sites 28 G2 and Site 28 G3 was of insufficient quality for presentation. Site 28 G2 appeared dry for the monitoring period
4) North Erato gauge was installed but the device was removed/stolen
5) Unit discharge for the Arpa is based on total upstream catchment; this may not be meaningful due to the presence of the Kechut reservoir. On receipt of the Arpa 4 data, a comparison between these sites may allow the yield for the area of catchment between the locations to be calculated.

Interpretation of the Baseline Data

The 2012-13 monitoring data demonstrates that the FM-6 tributary to the Vorotan River and the Vorotan station have a relatively steady flow during the winter months, which increases rapidly during the spring snow melt. The Arpa, in comparison to the Vorotan, appears to have a steadier flow in the 2012-2013 snow melt months, reflecting the artificial control at the Kechut Reservoir. Low flows are reached in these rivers late in the winter, recorded at approximately 2.5 m^3/s at the Arpa stations for both years and at approximately 1.4 m^3/s for the corresponding period at the Vorotan gauging station. No data are available for the Darb during the 2013/2014 monitoring period. Data for the 2014/15 monitoring period are generaly consistent with previous years.

There are no surface watercourses or springs within the footprints of the proposed open pits. Watercourses and springs are present within the footprints of the BRSF and the HLF.

Numerous minor perennial tributaries feed the Darb and Vorotan rivers originating on the slopes of Amulsar and the plateau to the east of the Vorotan. Perennial tributary FM-6 drains the valley to the east of the BRSF, Tributary Site 27 drains the BRSF location and Tributary Site 28 G1 and G2 drain two tributaries upstream of the HLF site.

Downstream of stations Site 28 G1 and G2, Site 28 G3 (a weir station) was damaged and failed to record usable data during the monitoring period. It appears that Site 28 G1 catchment feeds the majority of flow arising downstream at Site 28 G3 (Table 4.9.8), however water abstraction for irrigation of nearby orchards may account for the lack of flow at Site 28 G2. Despite the relatively small of the catchment to Site 28 G1, in comparison to Site 28 G2 catchment, observed flows suggest the stream is sustained by groundwater during low flows. Springs in this catchment were not monitored during 2013, 2014 or 2015.

Tributaries to the Vorotan MP-1 and MP-2 on the slopes below the proposed Erato and Tigranes Artavazdes pits show a relatively constant flow throughout the winter period indicative of groundwater discharge.

During the spring snow melt these tributaries are fed by ephemeral streams which are dry in the late winter period. The gauge at Site 14 shows a marked increase in flows during the spring melt, being a dry channel for the remainder of the year. Site 28 also on the west of the mountains was largely dry during the monitoring period; however the northern extent of Site 28 may be influenced by local water users.

Low Flow and Environmental Flow Conditions

In temperate or continental climates (such as Armenia), the 95th percentile of minimum average daily flows (Q_{95}) is used to describe low flow. A Q_{95} value of 0.4 m^3/s has been identified[2] for the SHPP (estimated catchment area, 85.2 km²) on the Vorotan east of the BRSF based on frequency analysis of available data for the Vorotan Borisovka (estimated catchment area, 507 km²) and Vorotan Gorayk gauging stations (268 km²), adapted through catchment area-scaling.

The environmental flow (or ecological flow) differs from the low flow, and is the minimum level of river flows required to maintain the proper functions of river network ecosystem[1]. This approach specifies the ecological flow as 75% of the average flow of 10 consecutive days with minimum flow in the winter period (normally the lowest flow of the year in Armenia). For the proposed hydropower project (ERA, 2011), a minimum environmental flow of 0.3 m^3/s for the Vorotan has been set.

In the absence of long term flow data, the equivalent low flow value for the Arpa at location Arpa 4 (catchment area of 376.8 km^2) was determined using baseline flow data from the Arpa and historical data from the Vorotan. A synthetic flow time series for the Arpa was created by scaling the Vorotan-Borisovka (1943-1987) gauge data based on relative catchment size. The "Q_{95}" for the synthetic daily time series data is 1.85 m^3/s. However the estimate of low flow in the Arpa is subject to error using this method because the Arpa is regulated at the outlet from the Kechut Reservoir.

The point flow data recorded in 2008-2011 and the continuous monitoring data collected from 2012-2014 have been analysed and low flows identified. Analysis of the field data suggests low flows in the range of 2 to 2.5 m^3/s for the period of record. This is comparable to the low flow derived from the synthetic time series described above.

In reference to low flows, water levels in the rivers of southern Armenia were reported to have been reduced by 40-50% below normal levels during the 2000-2001 droughts[3].

[2] ERA Ltd., 2011 MANE SHPP Design Document - Yerevan, Armenia
[3] World Bank, November 2001. Technical Paper "Armenia - Towards Integrated Water Resources Management" Environmentally and Socially Sustainable Department, Europe and Central Region

Flood Risk

The spring snowmelt and associated high flows typically last for three months and do not result in major human impacts, as flows tend to build slowly and decrease rapidly, with major floods confined to the base of the deeply incised river valleys.

The maximum monthly average flow recorded at the Vorotan-Borisovka gauge (estimated catchment 507 km^2) downstream of Spandaryan Reservoir from the 45-year period from 1943 – 1987, was 43.93 m^3/s; the average monthly flow at this location for the month of May was 23.3 m^3/s. As a point of comparison, the minimum monthly average flow occurred each January, averaging 3.7 m^3/s.

These flow estimates are for a significantly larger catchment than that adjacent to the Project area at the Golder installed Vorotan gauging station. At that station (AW015), the highest flow recorded during the baseline period was approximately 6 m^3/s.

Physical infrastructure, both existing and proposed, is not threatened by natural flooding from the Vorotan River upstream of the Spandaryan Reservoir. Regular spring snow melt flood waters in the Vorotan valley are anecdotally reported to rise above the level of the bridge near the hydropower plant, inundating the road along the side of the valley.

Historical flow data are not available for the Arpa and Darb. An indication of typical spring high flows in these rivers based on the two years of point flow monitoring is presented in this section. In addition the Arpa River is a managed watercourse; hence natural flood risk has already been mitigated; the presence of the Kechut Reservoir upstream of the reach adjacent to the Project area means that natural flooding is buffered and managed.

As no major infrastructure or facilities associated with the Project are proposed within the natural flood plain of the Vorotan, Darb or Arpa rivers, a fluvial flood risk assessment for the main rivers is not required. The proposed mine facilities are all located several hundreds of metres above the adjacent Vorotan, Darb and Arpa rivers. Fluvial modelling of the Vorotan River on the reach east of the BRSF as presented in Appendix 4.9.3 and indicate flood levels for the 1 in 1000 year flood could reach an elevation of 2293 m asl on the main channel; the nearest proposed mine facilities are at an elevation of over 2400 m asl.

Perennial and ephemeral streams (many fed by springs) drain the areas proposed for the mine facilities. The mountain slopes and valleys where the proposed mine facilities will be located do not contain major surface watercourses.

4.9.6 Surface Water Quality

Water quality monitoring has been conducted since 2007 by Geoteam and the local Ministry of the Environment. Surface water quality samples were collected as shown in Table 4.10.1 and Table 4.10.2 While monitoring during the first quarter (of each year) is less frequent, there is a relatively good spread of data across the seasons (final column in table).

Surface water quality sampling locations are shown on Figure 4.10.1. The parameters analysed in each year are summarised in Table 4.10.1**.**

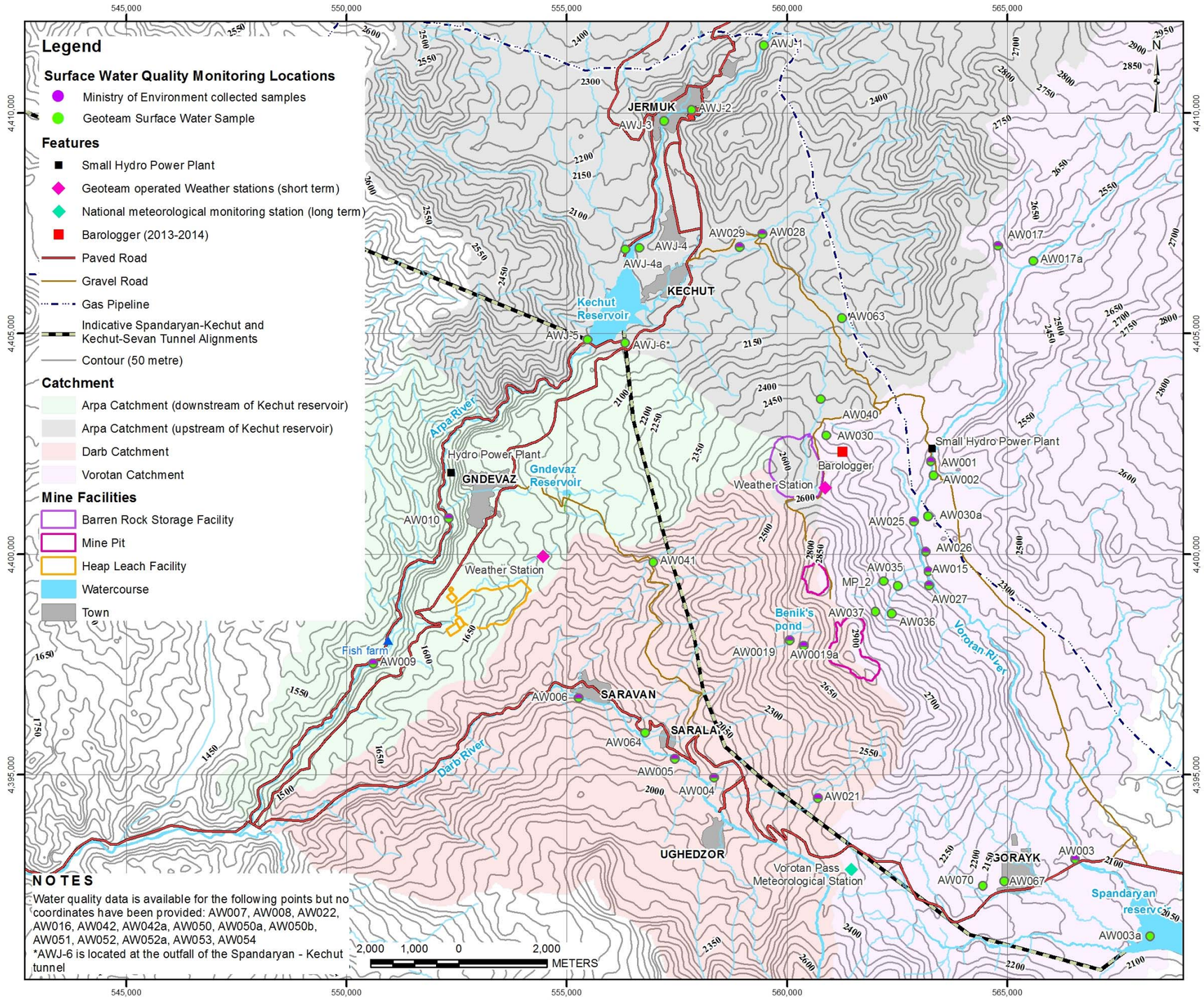


Figure 4.10.1: Surface Water Quality Sampling Locations

Table 4.10.1: Summary of Surface Water Quality Analysis Suites, 2007 to 2015										
Parameter Analysed	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015 Q2**	**2015 Q3**
Acid Neutralising Capacity (Alkalinity pH 4.5)							■	■	■	
Acid Neutralizing Capacity (Alkalinity pH 8.3)		■				■		■	■	
Actinium 227					■	■	■			
Aggressive CO2					■	■	■	■	■	■
Aluminium		■			■	■	■	■	■	■
Ammonia	■				■	■	■	■	■	
Ammonia and Ammonium ions	■	■	■	■	■	■	■	■	■	■
Ammonia as N					■	■	■	■	■	■
Antimony		■			■	■	■	■	■	■
Arsenic	■	■	■	■	■	■	■	■	■	■
Barium		■			■	■	■	■	■	■
Base Neutralising Capacity (Acidity pH 4.5)						■	■	■	■	
Base Neutralising Capacity (Acidity pH 8.3)						■		■	■	
Benzene		■								
Benzo(a)pyrene		■								
Beryllium		■			■	■	■	■	■	■
Bismuth		■			■		■	■	■	■
Boron		■			■		■	■	■	■
Bromide					■	■	■	■	■	
BTEX Sum		■								
BTEXS Sum		■								
Cadmium		■		■	■		■	■	■	■
Caesium 134					■					
Caesium 137					■	■				
Calcium	■	■	■	■	■	■	■	■	■	■
Calcium Hardness					■	■	■	■	■	■
Carbonates		■			■	■	■	■	■	■
Chloride	■	■	■	■	■	■	■	■	■	■
Chromium	■	■	■	■	■		■	■	■	■
Cobalt	■		■	■	■	■		■	■	■
Colour (True)										■
COD	■	■								■
Copper	■	■	■	■	■	■		■	■	■
Dissolved silicate as H_2SiO_3										■
Dissolved silicate as SiO_2										■
Dissolved silicate as SiO_3										■
Easily Released Cyanides		■			■	■	■	■		
Ethylbenzene		■								
Fluoride		■			■	■	■	■	■	
Free CO_2 as CO_2					■	■		■	■	■
Gross Alpha		■			■	■	■			

Table 4.10.1: Summary of Surface Water Quality Analysis Suites, 2007 to 2015

Parameter Analysed	2007	2008	2009	2010	2011	2012	2013	2014	2015 Q2	2015 Q3
Gross Beta		■			■	■	■			
Hardness	■	■	■	■	■	■	■	■	■	■
Hardness as CaCO3					■	■	■	■	■	■
Hexavalent Chromium		■			■	■		■	■	
Hexavalent Chromium - Soluble										■
Hydrogen Carbonates		■			■	■	■	■	■	■
Iodine 131					■	■	■			
Inorganic Nitrogen as N										■
Iron	■	■	■	■	■	■		■	■	■
Lead	■	■	■	■	■	■		■	■	■
Lead 210					■	■	■			
Lithium					■	■		■	■	■
m.p-Xylene		■								
Magnesium	■	■	■	■	■	■		■	■	■
Magnesium Hardness					■	■	■	■	■	■
Manganese	■	■	■	■	■	■		■	■	■
Mercury		■			■	■		■	■	■
Molybdenum	■	■	■	■	■	■		■	■	■
Nickel	■	■	■	■	■	■		■	■	■
Niobium					■	■		■	■	
Nitrate as N					■	■	■	■	■	■
Nitrates	■		■	■	■	■	■	■	■	■
Nitrite as N					■	■	■	■	■	■
Nitrites	■		■	■	■	■	■	■	■	■
Non Polar Aliphatics		■			■					
Orthophosphate										■
Orthophosphate as P										■
pH	■	■			■	■		■	■	■
Phosphorus										■
Potassium	■	■			■	■		■	■	■
Potassium 40					■	■	■			
Protactinium 231					■	■	■			
Radium 223					■	■	■			
Radium 226					■	■	■			
Radium 228					■	■	■			
Selenium		■			■	■		■	■	■
Silicon					■	■		■	■	
Silver		■			■	■		■	■	■
Sodium	■	■		■	■	■		■	■	■
Styrene		■								
Strontium										■

Table 4.10.1: Summary of Surface Water Quality Analysis Suites, 2007 to 2015										
Parameter Analysed	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015 Q2**	**2015 Q3**
Sulfide as S^{2-}					■	■	■	■	■	■
Sulfides as H_2S	■				■	■		■	■	■
Sulphate as SO_4^{2-}	■	■	■	■	■	■		■	■	■
Sum of Hydrocarbons					■					
Suspended solids dried at 105 °C										■
Tellurium					■	■		■	■	■
Thallium					■			■	■	■
Tin										■
Thorium 227					■	■	■			
Thorium 228					■	■	■			
Thorium 230					■	■	■			
Thorium 234					■	■	■			
Titanium					■	■		■	■	■
Toluene		■								
Total CO_2 as CO_2					■	■		■	■	■
Total Cyanide		■			■	■	■	■		
Total Extractable Aliphatics		■			■			■		
Total Extractable Aromatics		■			■	■		■		
Total Phosphorus as P										■
Tungsten		■			■	■		■	■	
Unpolar Aliphates						■		■		
Uranium					■	■		■	■	■
Uranium 235					■	■	■			
Vanadium										■
Xylenes		■								
Zinc	■	■	■	■	■	■		■	■	■

Statistical summaries for the water quality data are presented in Appendix 4.9.4 (the full data set is available from the Geoteam Monitor Pro database).

Elevated Water Quality Parameters – General Trends

The results of the water quality analyses for the period 2007-2014 (also available from the Geoteam Monitor Pro database) were compared with Maximum Allowable Concentrations (MAC) prescribed under Category II of the Republic of Armenia Decree N-75N (2011) for the Vorotan and Arpa Rivers with the exception of standards for cyanide, which are derived from the IFC EHS Guidelines for Mining (discharge standards). These project criteria are described in Chapter 2.

Parameters recorded above MAC standards for the Vorotan and Arpa rivers in the surface water samples described above are summarised in Table 4.10.2

The laboratory detection limits for antimony, beryllium, cobalt and molybdenum typically exceed MACs; consequently there are a number of locations where 100% of the analyses exceed the MAC. Throughout much of the study area concentrations of aluminium, iron and manganese appear to be naturally elevated above the MACs. Elevated sulphate and barium concentrations are apparent in the Darb River, its tributaries and tributaries of the Vorotan. Elevated lithium concentrations are also apparent within each of the major catchments.

Time-history concentration graphs for selected parameters and locations are presented in Appendix 4.9.4. The graphs clearly indicate seasonal water quality patterns in the Vorotan and its tributaries, where the concentration for a number of parameters (aluminium, barium, copper, iron, lithium, manganese and sulphate) increase during the autumn and winter period, when flow in the catchment is dominated by baseflow. Concentrations decrease in spring due to the influx of snow melt. Seasonal trends are particularly noticeable in the smaller catchments that are in close proximity to seepage inflows (springs). Similar albeit less pronounced seasonal patterns for lithium and sulphate are also observed in the Arpa and tributaries. There is no clear seasonal pH pattern in the Arpa or Vorotan.

Table 4.10.2: Summary of Exceedances in Surface Water of MAC for Vorotan and Arpa Rivers – Geoteam Sampling

Location in Catchment		Monitoring Location	Aluminium	Ammonia as N	Ammonium ions	Antimony*	Arsenic	Barium	Beryllium*	Cadmium	Calcium	Chloride	Chromium	Cobalt*	Copper	Hardness	Hardness as CaCO3	Iron	Lead	Lithium	Manganese	Mercury	Molybdenum*	Nickel	Nitrate as N	Nitrates	Nitrite as N	Nitrites	Ortho-phosphate	pH	pH Value	Potassium	Sodium	Sulphate as SO4 2-	Tin*	Total Phosphorus	TSS	Vanadium	Zinc
	Arpa MACs		144	0.4	0.51	0.28	20	28	0.038	1.014	100	6.88	11	0.36	21	10	10	0.072	10.14	3	12	0.3	0.82	10.34	2.5	11.1	0.06	0.2	0.1	6.5 - 9	6.5-9	3.12	10	16.04	0.08	0.2	6.8	0.01	100
	Unit		µg/l	mgN/l	mgN/l	µg/l	µg/l	µg/l	µg/l	µg/l	mg/l	mg/l	µg/l	µg/l	µg/l	mg/l	mg/l	mg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	mgN/l	mg/l	mgN/l	mg/l	mg/l			mg/l	mg/l	mg/l	µg/l	mg/l	mg/l	µg/l
Arpa Catchment	Arpa (downstream of Kechut reservoir)	AW009	2		2	24	1		24	1		11	1	29	9	51	21	35	1	20	27	2	36	1	1	1			1			1	22	12	1		6		
		AW010	1		2	13	1		13	1		6	1	18	9	39	10	26	1	10	19		24	1	1	1			1			1	12	6	1		6		
	Arpa (upstream of Kechut reservoir)	AWJ1	2			7			7					7		7	7	6			4		7		1	1													
		AWJ2	2			7			7					7		6	6	4		2	1		7																
		AWJ3	1			3			3	1				3		3	3	3		1	1		3																
	Arpa Tributary (upstream of Kechut reservoir)	AW028	4			20			20					20		20	20	19		2	19		20										2						
		AW029	3			18			18					18		18	18	18		8	18		18																
		AW040				6			6					6		5	5						6																
		AW063	2			3		1	3					3		2	2	3			2		3		1	1													
		AWJ4	2			7			7					7		6	6	6		3	5		6																
		AWJ4a	2			5			5					5		5	5	4			1		5																
		AWJ5	2	1		14			15					14		12	12	12		14	12		16				1	1						1					
		FDMP3	1			1			1					1				1					1																
		FM10	1			2			2					2				2					3						1					1		1			
	Arpa (upstream of Kechut reservoir) Tunnel	AWJ6				16			16					15		13	13	16		14	14		17				1	1	1			7	16	14	1	1			
	Darb	AW005	1		2	16	1	15	16	1		1	1	26	9	43	15	31	1		27	2	23	1						1		6	3	20			8		
		AW006	5		2	20	1	18	20	1		3	1	26	9	48	19	35	1		33	2	31	1			1	1				16	4	26			10		
	Darb Tributary	AW0019				9		4	9					12	4	14	9	13			12		9											3			2		
		AW0019A	4			11		6	11					14	4	14	10	15			15		11											11			2		
		AW004	1		2	15	1	6	15	1			1	29	9	38	14	26	1		32	2	20	1						2	1		4	27			7		
		AW021	12		1	13		2	13				1	20	17	19	12	20	5	8	20		13	15						14	11			16			4		
		AW041	7			9			9					8		6	6	8			9		10							2	2			9	1				
		AW064	1			3		2	3		1			3		2	2	2			3		3										1	3					
	Vorotan MACs		284	0.4	0.51	0.5	20	12	0.054	1.01	100	8	10.5	0.28	22	10	10	0.16	10.14	2	8	0.3	2	10.45	2.5	11.1	0.06	0.2	0.1 mg/l	6.5-9		4.46	8.46	17.02	0.16	0.2	5.5	0.016	100
	Unit		µg/l	mgN/l	mgN/l	µg/l	µg/l	µg/l	µg/l	µg/l	mg/l	mg/l	µg/l	µg/l	µg/l	mg/l	mg/l	mg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	mgN/l	mg/l	mgN/l	mg/l	mg/l			mg/l	mg/l	mg/l	µg/l	mg/l	mg/l	mg/l	µg/l
	Vorotan	AW001			2	19	1	1	19	1		1	1	23	8	38	16	5	2	2	14	2	2	1					1	1			1	1	1	1	5	1	
		AW003			2	25	1		25	1		1	1	28	9	46	22	15	2	6	26	1	2	1					1	1	1		1	3	1		8		
		AW015	1		2	12		1	12			1		17	9	33	12	7	1	2	17		2					1		1						7		
		AW017a				6			6					6		5	5																						
	Vorotan Tributary	AW002				3			3					3		3	3			3	1																		
		AW003a	3			7		4	7					7		6	6	5		1	6				2	2	1	1		1	1								
		AW007				1	1	1	1	1		1				2		1	1		1	1		1						1									
		AW008				1	1	1	1	1		1				2			1		1	1		1						1			1	1					
		AW017			1	8		1	8				1	12	6	15	7	5	1		4		1	1	1					1	1						5		
		AW025	9	1	1	9		9	9					9	8	9	9	9		5	9									8	6			7					
		AW026	7	1	1	9		9	9					9		8	8	6		1	8									7	5			6					
		AW027	4			9		9	9					9		7	7	5		5	8									7	5			6					
		AW030	3			14		12	14					14		14	14	14			14		3							4	4	2	2	12					
		AW030a	1			8		5	8					8		7	7	8			8													4					
		AW035	5			5		5	5					5	5	5	5	5		4	5									4	3			5				1	
		AW036	2			3		2	3					3	2	3	3				2									2	1			2					
		AW037				3		3	3					3		3	3	1			3																		
		AW067	3			3		3	3					3		2	2	3			3													1					
		MP2	1			3		3	3					3		2	2	2			2									1	1								
		AW070	1			2		1	2					2				1					1		1	1			1					1					

Data bar illustrates percentage of samples exceeding MAC and the value represents the number of exceedances.
* Laboratory detection limit typically exceeds MAC.

In addition to laboratory analysis, in-situ field measurements were also collected (which are available in the Geoteam Monitor Pro database) and presented in Appendix 4.9.4. The average pH at monitored locations based on field measurements taken between 2010 and 2014 is summarised in Table 4.10.3 with low pH locations identified on Figure 4.10.2. These low pH locations are indicative of naturally occurring acid rock drainage as described in groundwater Section 4.8.7.

Table 4.10.3: Surface Water pH, Summary of Field Measurements 2010 – 2015

	Monitoring Location	Average	Minimum	Maximum	Data Count
Arpa (downstream of Kechut reservoir)	Arpa 2	7.8	7.8	7.8	1
	Arpa 4	7.4	7.4	7.4	1
	AW009	7.5	6.0	9.5	49
	AW010	7.4	3.2	9.2	34
Arpa (upstream of Kechut reservoir)	AWJ1	7.4	6.7	8.0	7
	AWJ2	7.3	6.8	8.1	6
	AWJ3	7.4	7.1	7.9	3
Arpa (upstream of Kechut reservoir) Tributary	AW028	7.3	6.2	7.9	21
	AW029	7.3	6.4	8.3	20
	AW040	6.9	6.1	7.6	5
	AW040a	7.2	7.2	7.2	1
	AW063	7.4	7.4	7.4	1
	AWJ4	7.5	7.0	8.4	6
	AWJ4a	7.5	7.1	8.0	3
	AWJ5	7.9	7.1	10.6	12
	FDMP3	7.9	7.9	7.9	1
	FM10	7.9	7.7	8.2	3
	FM12	7.1	7.1	7.1	1
Arpa (upstream of Kechut reservoir) Tunnel	AWJ6	7.8	7.4	8.2	11
Darb	AW005	7.2	4.6	8.6	43
	AW006	7.3	5.1	9.7	53
	Darb 1	7.9	7.9	7.9	1
	Darb 2	7.7	7.7	7.7	1
Darb Tributary	AW0019	6.5	4.6	7.6	16
	AW0019A	6.3	4.6	7.4	16
	AW004	6.6	5.2	8.0	38
	AW021	3.8	2.9	9.6	23
	AW041	6.8	6.1	7.4	4
	AW064	7.0	7.0	7.0	1

Table 4.10.3: Surface Water pH, Summary of Field Measurements 2010 – 2015					
	Monitoring Location	**Average**	**Minimum**	**Maximum**	**Data Count**
	MP 3	7.7	7.7	7.7	1
	MP 4	7.8	7.8	7.8	1
	North Erato	7.2	7.2	7.2	1
Vorotan	AW001	7.0	4.9	8.7	38
	AW003	7.0	2.2	8.6	50
	AW015	7.3	5.5	9.3	28
	AW017a	7.1	7.1	7.2	2
Vorotan Tributary	AW002	8.1	7.5	8.5	3
	AW003a	6.7	6.1	7.3	6
	AW017	6.7	4.8	8.1	20
	AW025	4.1	3.5	5.2	12
	AW026	4.8	4.2	5.7	11
	AW027	6.4	4.8	7.4	11
	AW030	6.6	4.7	7.2	12
	AW030a	7.2	5.8	8.0	6
	AW035	3.6	3.5	3.7	3
	AW036	4.3	3.7	5.5	3
	AW037	5.8	5.0	6.6	3
	AW067	7.2	6.8	7.6	2
	AW070	7.6	7.6	7.6	2
	FM5	6.9	6.9	6.9	1
	FM6WEIR	7.0	7.0	7.0	1
	MP 1	6.6	6.6	6.6	1

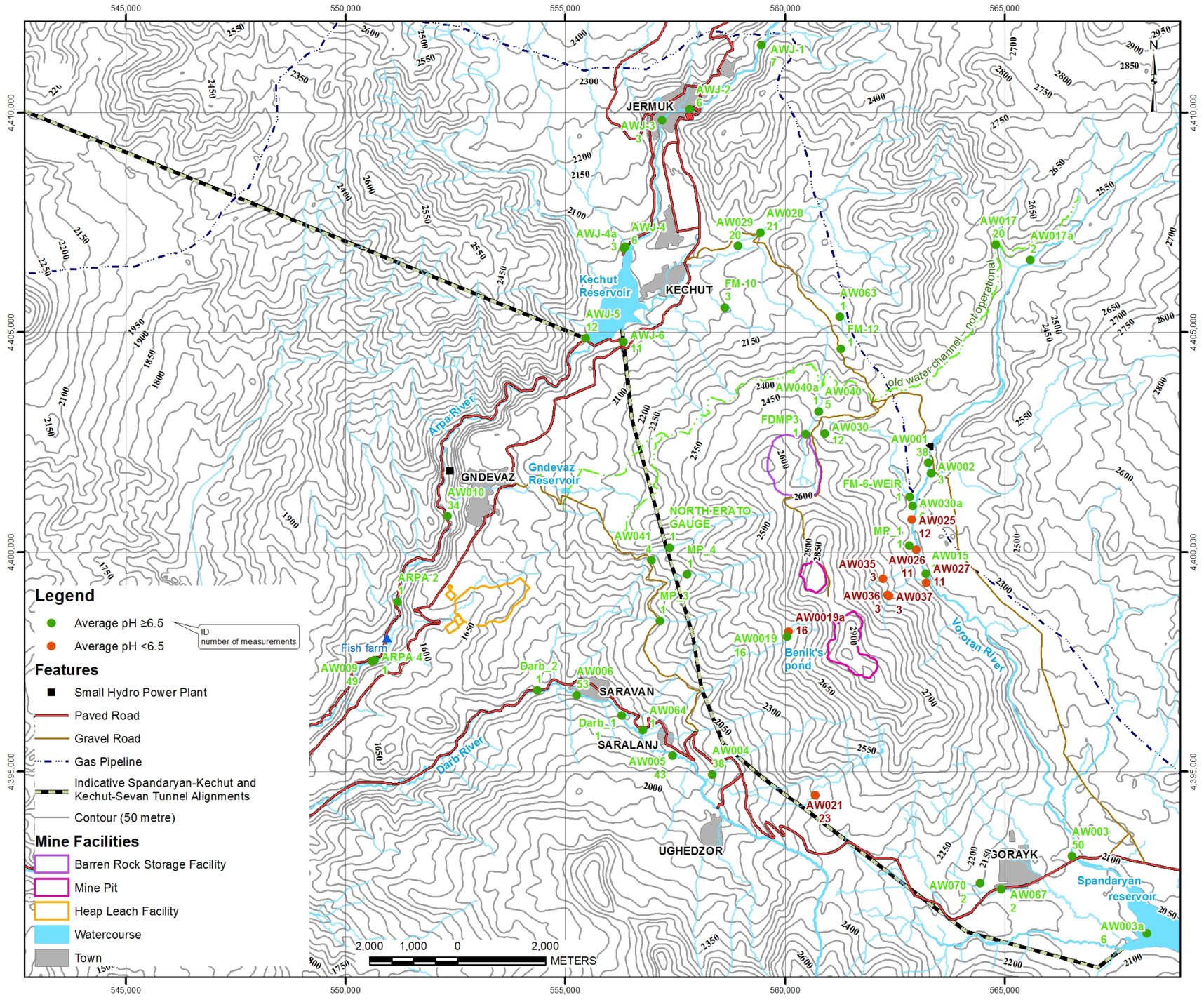


Figure 4.10.2: Surface Water Locations – Average pH

Surface water quality shows significant temporal and spatial variability. Figure 4.10.2 shows sampling locations where an average pH of less than 6.5 has been measured. The majority of these low pH sites are found on the flanks of Amulsar reflecting the geochemical influence of ore-bodies.

Analysis indicates low or undetectable levels of substances typically associated with agricultural or anthropogenic sources (e.g. ammoniacal nitrogen, nitrate, chloride and hydrocarbons). Cyanide was detected at concentrations below MACs in the Vorotan River (AW001, AW003 and AW015) in 2011; in Benik's Pond adjacent to Amulsar peak (AW019) in 2011; and in a stream feeding Benik's Pond (AW019a) in 2011. Cyanide was not detected at all locations in all other years. Although gross beta analysis indicated low but detectable activities, speciated analysis of radioactive substances has not identified any substances above specific laboratory detection limits. It is noted that the variations in water quality cannot be linked to activities (natural or anthropogenic) in the vicinity of Amulsar and may reflect changes in sampling and/or laboratory methodologies (including detection limits) and reporting, as well as environmental changes.

The key trends in water quality are outlined in the following sections.

Arpa River and Tributaries

All surface water monitored at stations along the Arpa River and Arpa tributaries have a near neutral pH. With the exception of AW040, all locations exhibit iron and manganese concentrations above MACs.

Water quality around Kechut Reservoir is generally similar for the various monitoring locations, with iron and manganese frequently above MACs. Lithium and aluminium concentrations also exceed MACs at most locations around Kechut Reservoir. Potassium, sodium and sulphate concentrations are elevated at AWJ6, exceeding MACs throughout most of the monitoring rounds.

Downstream of the Kechut Reservoir, water quality in the Arpa River at AW009 and AW010 is broadly consistent with upstream water quality. However, exceedances of MACs are also regularly observed for sodium and sulphate, and to a lesser extent chloride and copper.

Darb River and Tributaries

The two monitoring locations in the Darb River (AW005 and AW006) are reported to have near neutral pH over the monitoring period. The monitoring location on the main tributary (AW004), monitored further upstream, shows a slightly acidic pH below the MAC pH value; however, data indicate that low pH occurs more frequently in recent years of monitoring, and decreases through the summer months as flow declines. AW021 located in a separate tributary of the Darb on the south-west flank of Amulsar, indicates consistently acidic surface water, averaging pH 3.8 (field measurements). Laboratory analysis also indicates the pH at AW021 is consistently less than the MAC pH value.

Water quality is slightly poorer moving downstream along the main channel of the Darb, between stations AW005 and AW006, which may be attributed to villages located between the two monitoring locations. Exceedances of MACs include ammonium, cadmium, chromium, chloride, lead, nitrite, mercury, potassium and sodium. Water quality in a tributary of the Darb at AW021 frequently exceeds MACs for aluminium, lead, lithium, nickel, sulphate and copper. Exceedances also occur downstream at AW004, although less frequently.

Water quality in Benik's Pond (AW019) and in a stream draining to Benik's Pond (AW019a) below Erato Peak are characterised by slightly acidic pH. Laboratory analysis determined predominantly elevated concentrations of metals above MACs with respect to barium, copper, iron and manganese. Sulphate has frequently been recorded above MACs in AW019a and to a lesser degree at AW019.

Vorotan River and Tributaries

The pH of surface water in the Vorotan River is near neutral at all three monitored locations (AW001, AW003 and AW015) with slightly lower pH at upstream location AW001 and downstream location AW003 than in the area immediately adjacent to Amulsar (AW015). The pH at all three monitoring locations shows considerable variability between monthly monitoring rounds but no clear seasonal trend. In comparison, a number of monitored mountain streams and tributaries entering the Vorotan from the eastern flank of Amulsar are consistently acidic (pH less than 6.5).

Water quality is typically better in the Vorotan River than in its tributaries. There is no clear change in water quality between upstream location AW001 and downstream location AW003 (at the Spandaryan Reservoir). Water in the Vorotan River exceeded MACs consistently (in

more than one year and at multiple locations) with respect to aluminium, barium, iron, lithium, manganese, and sulphate. The pH also falls below the lower limit of the MAC range for pH on at least one occasion at each location in most years.

Tributaries flowing into the Vorotan from the eastern flank of Amulsar (AW025, AW026, AW027, AW030, AW035, AW036 and AW037) exhibit low pH, typically containing concentrations of aluminium, barium, iron, lithium, manganese and sulphate above the MAC's.

4.9.7 Surface Water Users

National Water Supply

The Kechut Reservoir and Spandaryan Reservoir both form part of the Sevan scheme and thus their waters will indirectly be used to supply irrigation needs, municipal water supply and environmental maintenance of Lake Sevan. The Kechut-Sevan tunnel system is currently in operation while the Spandaryan-Kechut tunnel is not a functional system at present. No detailed records have been obtained to quantify the abstraction (water extraction/withdrawal) schedule employed under the Sevan scheme. However, a World Bank technical paper (World Bank, 2001) has identified a planned inter-basin transfer of 250-300 million m^3 of water annually from the Arpa River to Lake Sevan. The report states that the Spandaryan tunnel, when operational, will divert 165 million m^3/yr to Kechut.

Agriculture and Stock Watering

Within the study area, the Vorotan River's main channel and tributaries and the Darb River near Saravan, are used as a water source by herders as described in the Springs and Water Users Study (see Appendix 4.9.5). Table 4.8.22 in the Groundwater chapter describes the various locations of these water supplies (see Sections 4.8.9 & 4.8.10)

Numerous minor diversions of smaller watercourses are employed in the Vorotan, Darb and Arpa to supply water to agriculture and horticulture in the Project area. Many of these are ad-hoc and will vary from year to year, particularly those employed by the herders in the Vorotan valley to supply water to meadows for grazing cattle. This is in addition to more permanent arrangements in relation to the Gndevaz Reservoir to irrigate crops and horticulture in the adjacent foothills.

Aquaculture

Two fish farms, located approximately 6.5 km and 8 km downstream of the Kechut Reservoir, are adjacent to the Arpa River and within the study area. The fish farms are supplied with water directly from the Arpa via intakes on the adjacent channel. The fish farms are not consumptive water users of the Arpa; they simply circulate water through their facilities and discharge to a downstream location. Water quality at monitoring sites up and downstream of the fish farms (AW010 and AW009) are comparable, indicating no adverse water quality impacts. Water quality impacts typically associated with fish farm discharges, such as increased nutrient loading, lower dissolved oxygen, and increased TSS, may be discernable in the discharge mixing zone.

Ecosystem Services

Surface water and spring fed ecosystems are described in detail in Chapter 4.10. In general, the ecology baseline has not identified any Armenian Red Book or IUCN red list species present in the surface water courses within the Project area. Some plant species are regionally endemic but not directly dependant on surface water supply for their wellbeing. Habitat and land-use survey mapping has identified a number of alpine and montane meadow-type habitats in the upper parts of Amulsar (>1,900 m asl) with grazing meadows in these areas. Below this elevation, cultivation and hay cutting occur. Sub-alpine and alpine meadows in the upper slopes of the mountain are fed by snow melt; the lower montane meadows are supported by groundwater seepage, springs and watercourses.

Reservoirs

Arpa Catchment - Kechut Reservoir

Kechut Reservoir is used for water supply (Sevan scheme), fishing and as outlined previously, flow regulation and hydroelectric power production.

A hydroelectric power plant is located immediately west of Gndevaz village, and is reportedly supplied directly from the Kechut Reservoir and not directly from the Arpa itself. Discharge from the hydropower plant is approximately 2km upstream of the proposed water abstraction point for the Project. Further details of the operational regime of this hydropower plant are not available.

Arpa Catchment - Gndevaz Reservoir

The Gndevaz Reservoir was designed to be supplied by the defunct Gndevaz channel. At present, the reservoir is filled largely by natural runoff, through the diversion channel from

the catchment immediately to the southeast and, on occasion, through the diversion channel from the north east which formerly connected the Gndevaz channel to the reservoir. The Gndevaz channel is currently being reinstated and is planned to be operational by mid-2016. The potable water supply pipeline from the Vorotan that runs along the Gndevaz channel and passes the reservoir to the north has a distribution point and periodically, when there is excess supply, water is redirected from this distribution point to the reservoir. The reservoir is reported to be used only for agricultural irrigation downstream of the dam. Irrigation is achieved by discharging from the reservoir to the natural channel in the gorge immediately downstream of the reservoir.

Vorotan River and Spandaryan Reservoir

Water from the Vorotan River and its tributaries is used for hydroelectric energy production, fisheries, stock watering and irrigation. There are a number of hydroelectric plants located along the Vorotan River ("The Vorotan Cascade"); the power generated from these plants constitutes approximately 25% of Armenia's total energy supply. The Spandaryan Reservoir's primary function is for this use (until the potential activation of the Spandaryan-Kechut tunnel), but it is also used for fishing, irrigation and watering of stock. A small run-of-river power plant is located upstream of the road crossing on the Vorotan River to the east of the BRSF.

Local Water Supply

It is understood that direct abstraction from surface water sources is not used to supply potable water to any of the municipalities in the vicinity of the mine. Section 4.8.10 describes the origin of these municipal supplies from spring and ground water sources.

Gndevaz Channel

As discussed in Section 4.9.3, the Gndevaz Channel (part of a soviet era inter-basin transfer scheme) is no longer serviceable and has not been used for many years, although works to re-instate the channel are scheduled for completion by mid-2016. Some minor flows accumulate along the channel where intact sections remain; these may be used as sources for irrigation and stock watering.

Arpa Gorge Irrigation Pipeline

The Arpa Gorge irrigation pipe supplies Gndevaz and eight other communities together with a hydroelectric plant with water from the Kechut Reservoir. The supply is reported to be unreliable and does not operate in winter. The pipe is controlled by a water user's

cooperative and abstraction requires a permit from the Armenian Government.

Drinking Water Analysis

Potable water has been sampled from pipelines and spring and groundwater sources during the baseline period as presented in Section 4.8.10. The samples were screened against Project criteria as defined in Chapter 2.4. Screening is presented in Appendix 4.9.4 (the full dataset is available in the Geoteam Monitor Pro database).

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4.10 Biodiversity

4.10.1 Approach and Methods

Development of the baseline for biodiversity and ecosystems that might be affected by the Project was informed by the requirements of national laws relating to nature conservation and protection, relevant international conventions and agreements signed by the RA and other international policies and standards related to biodiversity and ecosystems. In line with IFC's Performance Standard 6 (2012) (PS6) and EBRD's Performance Requirement 6 (PR6), Lydian International aims to achieve 'no net loss' of natural habitat and a 'net gain' outcome for any residual impacts on critical habitat.

Searches of existing information were carried out to identify the biodiversity and ecosystems likely to be affected by the Project and to establish the potential presence of:

- Legally protected areas for nature conservation within a potential zone of influence of the Project and areas which are internationally recognised as having high biodiversity, including Key Biodiversity Areas, Global 200 Ecoregions, Endemic Bird Areas and Important Bird Areas;
- Species which are protected in the RA (listed in the RA Red Book);
- Species which are considered by specialists to be threatened or declining either in the RA or in the region and for which the Project-affected area might be considered core habitat;
- Areas of natural habitat according to the definition in PS6/ PR6;
- Species which might suggest or trigger the presence of critical habitat according to PS6/ PR6. This includes species listed by IUCN as Endangered (EN) or Critically Endangered (CR) at a global and European level as well as species meeting other criteria listed in the Performance Standards; and
- Habitats or ecosystems which might be considered "critical" according to PS6/ PR6.

The Integrated Biodiversity Assessment Tool (IBAT) was also used to obtain information on internationally recognised Key Biodiversity Areas, legally protected areas and known distributions of species included in the IUCN Red List.

Surveys in the field were designed on the basis of literature review and consultation with relevant biodiversity specialists (national and international, scientific institutions and

biodiversity Non-Governmental Organisations (NGOs)), including, but not exclusively limited to:

- The Armenian Society for the Protection of Birds (ASPB);
- The Caucasus Nature Fund;
- The World Wide Fund for Nature (WWF);
- The American University of Armenia (between 2011 and 2012);
- The Institute of Botany of the National Academy of Sciences of the Republic of Armenia (NAS RA); and
- Institute of Zoology and Hydroecology of the NAS RA.

Literature sources consulted for background information on the RA's biodiversity included:

- The RA Red Book, 2010;
- Chemonics International Inc, 2000, Biodiversity Strategy and Action Plan for Armenia;
- Ministry of Nature Protection, 1999a, Biodiversity Strategy and Action Plan for the Republic of Armenia, Yerevan, 1999;
- Ministry of Nature Protection, 1999b, First National Report to the Convention on Biological Diversity incorporating A Country Study on the Biodiversity of Armenia, Yerevan, 1999; and
- Khanjyan N., 2004, Specially Protected Nature Areas of Armenia, Ministry of Nature Protection, Yerevan, 2004.

Online resources consulted included:

- Millennium Ecosystem Assessment: http://www.maweb.org/en/index.aspx (accessed on 04.07.2014);
- Biodiversity of Armenia - http://enrin.grida.no/biodiv/biodiv/national/armenia/index.htm (accessed on 04.07.2014); and
- The IUCN Red List of Threatened Species - http://www.iucnredlist.org/ (accessed on 04.07.2014).

Overview of field surveys

Information on the biodiversity baseline at Amulsar has been built up over many years, beginning shortly after the gold discovery was made. Table 4.10.1 summarises the ecological surveys undertaken between 2008 and 2015, and Appendices 4.10.1 and 4.10.2 list, respectively, the plant and animal species recorded during all of the surveys. Surveys during

winter are difficult or impossible due to deep snow cover. This, and the fact that many species are hibernating, inactive or dormant in winter, means that field surveys were generally carried out in the period between spring and early autumn, though some limited observations were made of winter tracks.

Preliminary baseline surveys in the field carried out between 2008 and 2011 identified the need for more detailed surveys for some biodiversity components. Supplementary field surveys were carried out in 2012 to obtain more details about the plant species composition of vegetation within the Project-affected area. The additional botanical surveys carried out in 2012 revealed the presence of *Potentilla porphyrantha* Juz. on Amulsar Mountain. This species is listed as Critically Endangered in the Red Book of Armenia and was previously known from only two other sites in Armenia. Specialist advice was therefore sought with respect to this species from the NAS RA Institute of Botany. Areas proposed for the open pit, barren rock storage facility (BRSF) and processing plant were surveyed by the Head of Department of Physiology and Environmental Geo-botany at the NAS RA Institute of Botany, Sc.D. (Professor G.M.Fayvush) to obtain some indication of population distribution and size. Searches were carried out by Geoteam in the surrounding region during August 2012 to see if further populations could be found. A more detailed census of plants on Amulsar Mountain was carried out in 2013 by a botanist from the University of Cambridge, UK. Additional areas on the borders of the population distribution were searched in 2014.

During 2013, a detailed census of migratory raptors passing over and/or using the Project-affected area was also carried out due to the presence of potential critical habitat for Egyptian Vulture (*Neophron percnopterus*), listed as Endangered by the IUCN, as well as the possibility that the Project-affected area might form part of a significant migratory stopover.

During 2014, further botanical surveys were conducted for the revised Project-affected area, as well as surveys of breeding birds, aquatic species and bats. Use of the Project-affected area by raptors was also monitored, focusing on foraging patterns of the breeding pair of Egyptian Vulture in Jermuk Gorge and hunting patterns of Lesser Kestrels. Ongoing monitoring surveys were carried out by the NAS RA Institutes of Botany and Zoology.

In 2015, a detailed baseline survey for Brown Bear (*Ursus arctos*) was conducted on Amulsar Mountain and in the wider region. The focus on this species reflects its protected status under the European Union Habitats Directive, with which the Project has committed to align as a

result of its shareholder relationship with EBRD. Also in 2015, a supplementary amphibian and reptile baseline survey was undertaken on Amulsar Mountain due to the presence of suitable habitat for species listed in the RA Red Book.

Previous drafts of the Amulsar Project ESIA committed to the establishment of an offset to compensate for the Project's impacts on natural habitat. For the purposes of offset planning, preliminary ecological surveying was undertaken in an area north and west of Jermuk which has been proposed for National Park status. The results of these surveys are summarised in this baseline chapter. The rationale for and details of the proposed offset are described later in Chapter 6.11.

Section 4.10.2 describes the international and national context for biodiversity which might be affected by the Project, as determined through review of existing literature and data including that available from IBAT.

Section 4.10.3 provides an explanation of the survey methods used for vegetation and plants and describes the main plant communities and species observed in baseline studies. Subsequent sections describe the approach taken for each taxonomic group of animals, together with a description of their baseline situation in the Project-affected area.

Table 4.10.1: Summary of Ecological Surveys Undertaken

Year	Survey
Between 2008 and 2010	Review of literature to identify species likely to be present in all taxonomic groups and preliminary surveys of vegetation, plants, birds and mammals by Geoteam
Between 2008 and 2011	Surveys for reptiles and amphibians by Geoteam and birds and terrestrial invertebrates with American University of Armenia
August 2011	Freshwater ecology including incidental comments on fish by Golder
October 2011	Mammals by Geoteam with Institute of Zoology and Hydroecology/ Scientific Center of Zoology
February 2011 to March 2012	Breeding and migratory birds and terrestrial invertebrates (butterflies, moths, dragonflies, damselflies and beetles) by American University of Armenia
2012	Ethnobotanical review (plants used for herbs and medicine) by Geoteam
	IBAT search
	Satellite image and multispectral data analysis, including NDVI and land cover by Astrium Ltd
	Additional vegetation transects and quadrats to identify plant communities by Geoteam with input from Treweek Environmental Consultants and Wardell Armstrong

Table 4.10.1: Summary of Ecological Surveys Undertaken	
Year	**Survey**
	Special surveys to determine the extent of Armenian Red Data Book plant species *Potentilla porphyrantha* in the Project's area of influence as well as a wider search for additional populations (Geoteam and Institute of Botany)
2013	Detailed census of *Potentilla porphyrantha* sub-population in Project-affected area and further surveys of surrounding mountains
	Natural Vegetation Mapping by Dr Peter Carey (University of Cambridge) and Treweek Environmental Consultants
	Surveys to determine presence and distributions of RA Red Book plant species and plant species endemic to the Caucasus and Trans-Caucasus Regions within the Project-affected area
	Surveys of fish and benthic fauna by Golder Associates and the Institute of Zoology and Hydroecology
2013	Further surveys of mammals, reptiles, amphibians and terrestrial and aquatic invertebrates by Institute of Zoology and Hydroecology/ Scientific Center of Zoology
2014	Further botanical surveys of revised project layout
	Further breeding bird surveys and surveys of raptors, in particular use of the Project-affected area by Egyptian Vulture
	Follow-up observations on freshwater ecological impacts and use of the Project-affected area by Brown Bear
	Follow-up survey of use of the Project-affected area by bat species
2015	Regional camera/hair-trap survey of Brown Bear baseline by TEC, Alberta Innovates and RA Institute of Zoology (survey is ongoing; to be concluded in 2016).
	Amphibian and Reptile survey on Amulsar Mountain.
	General ecological baseline surveys in the proposed Jermuk National Park area, to inform Project offset planning.

4.10.2 Biodiversity Context

In common with the Caucasus Region as a whole, the RA supports a high diversity of plants and animals of which a relatively high proportion are endemic or considered to be important for national, regional or global nature conservation. The RA's rich biodiversity reflects:

- Its varied geology, topography, altitudinal range and climate (seven main landscape types are represented across the different altitudinal zones of Armenia within a relatively small territory);
- Its location at the junction of major biogeographic zones;
- A long history of traditional, relatively low-intensity land uses; and
- Its position with respect to an international fly-way for birds, in particular migrating raptors.

The whole of the RA is within an area of global significance for biodiversity - the Caucasus Biodiversity Hotspot (one of 34 in the world identified by Conservation International as being the richest and most threatened reservoirs of plant and animal life on earth) - which spans 500,000 square kilometres of mountains in Eurasia between the Black and Caspian seas, including Armenia, Azerbaijan and Georgia as well as small parts of Russia, Iran and Turkey. The Hotspot has very high animal and plant diversity as well as high levels of endemism in several taxonomic groups. The RA is particularly important as a centre of endemism for wild relatives of domestic crops and has long been a centre for breeding and selection of cultivated plants and livestock. There are also relatively high proportions of endemic mammal, reptile and fish species: of the 90 species of reptile found in the region, for example, 20 are endemic. An IUCN project to create a complete plant list for the Caucasus is nearing completion. Currently, there are thought to be approximately 1600 endemic plants within the Caucasus Hotspot.

The Caucasus Hotspot is also one of WWF's 35 'priority places' for conservation in the world. The Project lies on the southern edge of the Caucasus Mixed Forest Ecoregion, which is designated as a Global 200 Ecoregion by WWF, within the larger Caucasus Ecoregion. The Global 200 ecoregions have been identified by WWF as priorities for global conservation due to their conservation importance and exposure to threat. The list of 238 Global 200 ecoregions includes all major habitat types, ecosystem types and species from every major habitat type. The Caucasus Mixed Forest Ecoregion covers an area of 170,300 km^2 including portions of Georgia, Russia, Azerbaijan as well as Armenia. The Ecoregion has been assigned a status of 'critical/endangered' due to rapid land use changes, including widespread deforestation. The Project-affected area does not support forests of the type prioritised within the Ecoregion, but scattered remnants occur in the surrounding landscape, which potentially offer scope for restoration.

The whole of the RA is within a Birdlife International Endemic Bird Area (EBA)[1] which covers an area of 170,000 km^2 and includes portions of Azerbaijan, Georgia, Iran, Russia and Turkey. The EBA is important for several restricted-range species as well as breeding populations of raptors and reflects the importance of the Caucasus as a centre of bird endemism. Armenia also provides important habitat for many migratory bird species as part of an international

[1] BirdLife International (2014) Endemic Bird Area factsheet: Caucasus. Downloaded from http://www.birdlife.org on 04/07/2014

flyway between Africa and Europe, notably migratory raptors.

There are two Important Bird Areas (IBAs) in the vicinity of the Project: Jermuk and Gorayk IBAs (see Figure 4.10.1). The IBAs constitute Key Biodiversity Areas (KBAs)[2] according to the definition in IFC PS6 and have been identified at national level using the globally standardised criteria which underpin the KBA methodology[3]. An earlier Project design involved physical footprint and direct impacts within Gorayk IBA. This is avoided in the current design; however, the Lesser Kestrels which are the primary designated feature of the IBA hunt in the Project-affected area.

Gorayk IBA

The boundary of the Gorayk IBA represents the limits of an assumed hunting area around the Lesser Kestrel breeding colony, which is the only one in Armenia. The status of Lesser Kestrel (*Falco naumanni)* has decreased from Vulnerable to Least Concern on the IUCN Red List, though it is still listed as Vulnerable on the Armenian Red List and the fact that it is the only breeding colony in the country makes it important in a national context: it is the focus of ongoing monitoring and research by ASPB as well as public interest. Gorayk IBA also was identified because of a large number of other species associated with the surrounding mountains, the Vorotan River Valley and the wetlands at the confluence of the Vorotan River with Spandaryan Reservoir (see Table 4.10.2). Other trigger species are listed in Table 4.10.3. They include Egyptian Vulture (*Neophron percnopterus*) which is listed as Endangered by IUCN as well as several other raptor species and a large number of passerine and wetland birds.

Table 4.10.2: Details of Gorayk IBA

Location	RA, Syunik
Central co-ordinates	45° 46.73’ East 39° 41.05’ North
IBA Criteria	A1, B2
Area	5,923 ha
Altitude	2,028 – 2,871m
Year of IBA Assessment	2002

[2] Key Biodiversity Areas (KBAs) are sites of global significance for the conservation of biodiversity, identified nationally using simple, globally standardised criteria and thresholds.

[3] To meet the KBA criteria, a site must contain: One or more globally threatened species; One or more endemic species which are globally restricted to the site or surrounding region; Significant concentrations of a species (e.g. important migratory stops, nesting sites, nurseries or breeding areas); and/or Globally significant examples of unique habitat types and species assemblages.

Table 4.10.3: IBA Trigger Species for Gorayk IBA						
Species	**Season**	**Period**	**Population Estimate**	**Quality of Estimate**	**IBA Criteria**	**IUCN Category**
Falco naumanni Lesser Kestrel	breeding	1995-2006	10-20 breeding pairs	Good	A1, B2	Least Concern
Neophron percnopterus Egyptian Vulture	breeding	1995	1-2 breeding pairs	Medium	A1	Endangered
Buteo rufinus Long-legged Buzzard	breeding	1995	5-6 breeding pairs	Medium	B2	Least Concern
Aquila chrysaetos Golden Eagle	breeding	1995	2-3 breeding pairs	Medium	B2	Least Concern
Notes: BirdLife International (2014) Important Bird Areas factsheet: Gorayk[1].						

Jermuk IBA

Jermuk IBA has very varied habitats for birds, including mountains, montane meadows and meadow steppes and also Jermuk Gorge, which provides important raptor nesting habitat, as well as being important for the conservation of other taxonomic groups, notably mammals. Jermuk IBA, together with other existing protected areas adjoining it, forms part of the proposed new Jermuk National Park (see Table 4.10.4 for details of the Jermuk IBA). Breeding raptors include Egyptian Vulture, for which 2-3 nest locations were thought to be present in 2002, though there is now only one.

Table 4.10.4: Details of the Jermuk IBS	
Location	**RA, Vayots Dzor**
Central co ordinates	45° 38.24' East 39° 47.59 North
IBA Criteria	A1, B2, B3
Area	9,467 ha
Altitude	1,369- 2,685m
Year of IBA Assessment	2002

The populations of IBA Trigger species for Jermuk are listed in Table 4.10.5.

Table 4.10.5: Populations of IBA Trigger Species for Jermuk						
Species	**Season**	**Period**	**Population Estimate**	**Quality of Estimate**	**IBA Criteria**	**IUCN Category**
Alectoris chukar Chukar	breeding	1995	1,500-2,000 individuals	medium	B2	Least Concern

Table 4.10.5: Populations of IBA Trigger Species for Jermuk						
Species	**Season**	**Period**	**Population Estimate**	**Quality of Estimate**	**IBA Criteria**	**IUCN Category**
Pernis apivorus European Honey-Buzzard	breeding	1995	2-3 breeding pairs	medium	B3	Least Concern
Neophron percnopterus Egyptian Vulture	breeding	1995	2-3 breeding pairs	medium	A1	Endangered
Accipiter brevipes Levant Sparrowhawk	breeding	1995	3-5 breeding pairs	medium	B2	Least Concern
Aquila chrysaetos Golden Eagle	breeding	1995	2-3 breeding pairs	medium	B2	Least Concern
Crex crex Corncrake	breeding	1995	10-25 males only	medium	B2	Least Concern
Notes: BirdLife International (2014) Important Bird Areas factsheet: Jermuk.						

Legally Protected Areas

The RA has the following types of legally recognised protected area:

- **State Reserves** – Protection status equivalent to IUCN Category 1 protected areas, established to protect the natural course of dynamic processes and rare species of flora and fauna;
- **National Parks** – IUCN Category 2, areas of ecological, historical-cultural, aesthetic significance; and
- **State Reservations/Sanctuaries** – can be protected areas of national or local significance, protection status close to IUCN Category 6 protected areas.

Natural monuments are also protected and are selected according to international criteria, IUCN Category 3. Figure 4.10.1 shows the distribution of protected areas within 10 km of the Project.

The closest National Park to the site is the Sevan National Park located approximately 44 km to the north-north-west of the Project. Three specially protected State Sanctuaries are located in the vicinity, as illustrated in Figure 4.10.1: Jermuk Forest (2.9 km north), Herher Open Woodland (5.1 km west) and Jermuk Hydrological (6.4 km north). These are state sanctuaries. WWF has put forward proposals to develop a new National Park centred on Jermuk, which would encompass the State Sanctuaries mentioned above and the Jermuk IBA.

Proposals are still under discussion.

Various initiatives have been developed to strengthen the RA's protected area system. These have aimed *inter alia* to increase the area of land under protection, address gaps in the level of protection afforded to different habitats and species and develop capacity for monitoring and management. Montane meadow steppe grassland such as that found over much of the Project-affected area is acknowledged to be under-represented within the country's protected area system and is relatively well represented in the area identified for a potential new Jermuk National Park.

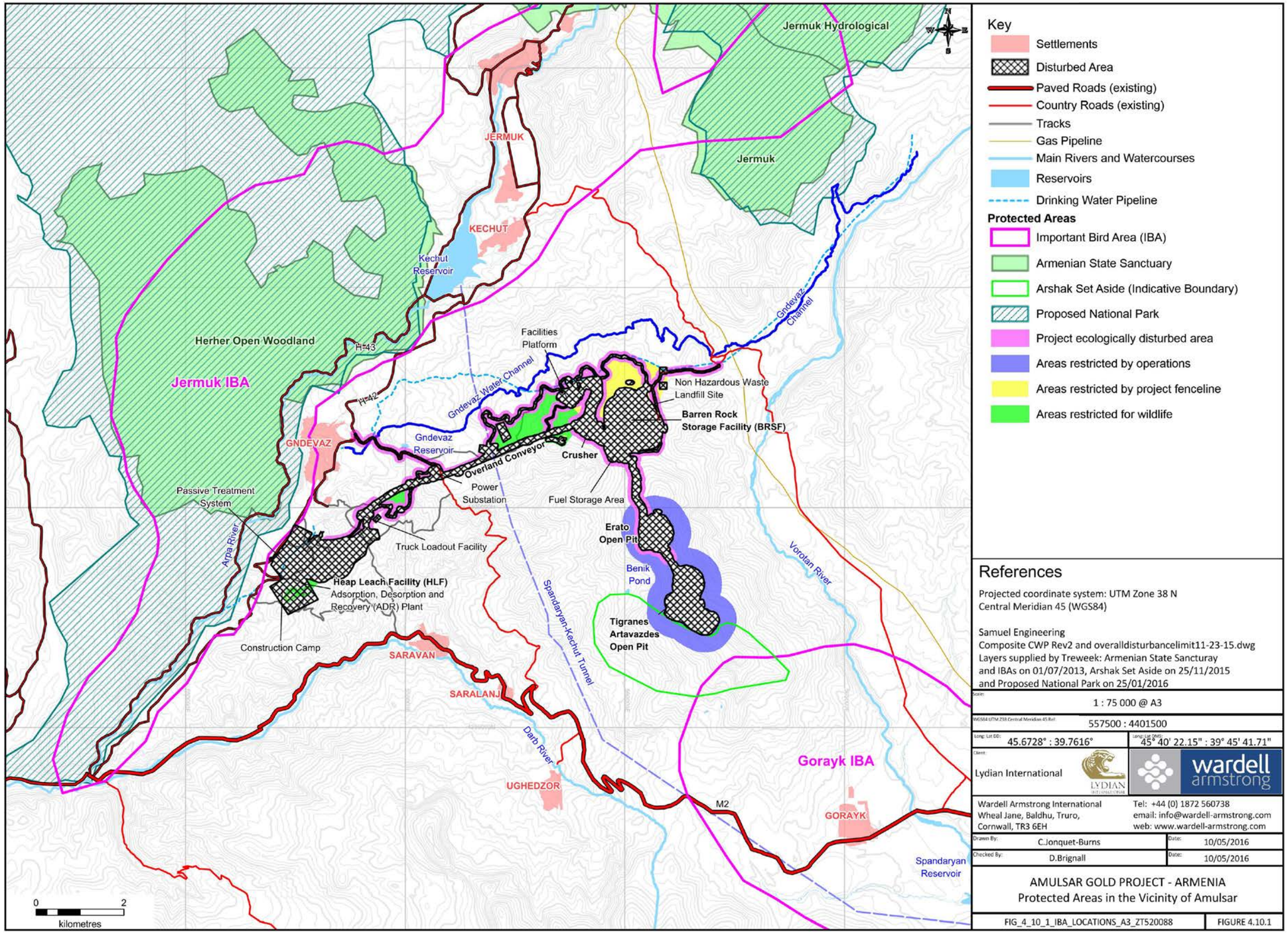


Figure 4.10.1: Protected Areas in the Vicinity of Amulsar

Species of Conservation Concern

The 2015 IUCN Red List of Threatened Species identifies around 50 species of globally threatened animals in the Caucasus region as a whole. Review of desk-top information and IBAT indicated the possible presence of several IUCN listed and Armenian Red Book (updated in 2010) species in the Project-affected area.

IBAT provides species information in the form of 'Threatened species grids' which are derived directly from the species distribution maps produced as part of each individual IUCN Red List assessment. Distribution maps show the distribution of the species within its native range. A polygon displaying the limits of a species distribution is essentially meant to communicate that the species potentially occurs within this polygon, but it does not mean that it is distributed equally within that polygon or occurs everywhere within that polygon.

The Project lies within grid cell 34991. Globally threatened species which potentially occur within this polygon (but not necessarily recorded within the Project-affected area) are listed in Table 4.10.6. Of these species, the following are prioritised for action in the wider region[4]:

- ***Panthera pardus tulliana*** **(Leopard)** - RA Red Book species and IUCN Red List – Near Threatened.
- ***Ovis orientalis Gmelin*** **(Mouflon)** – RA Red Book and IUCN Red List – Vulnerable.
- ***Capra aegagrus erxleben*** **(Bezoar Wild Goat)** – RA Red Book and IUCN Red List - Vulnerable.
- ***Ursus arctos*** **(Caucasian Brown Bear)** RA Red Book – Vulnerable and IUCN Least Concern.

These species are all threatened throughout the region by loss and fragmentation of habitat and also by hunting. Consultation and literature searches carried out prior to field surveys suggested the possible presence of Bezoar Wild Goat and Caucasian Brown Bear in the Project-affected area. There had not been any recent sightings of Mouflon or Leopard though both reputedly occurred in the area in the past.

[4] Conservation Plan for the Caucasus Ecoregion (WWF 2012)

Table 4.10.6: Globally Threatened Species (IBAT) according to the IUCN Red List			
Birds		***Mammals***	
Aegypius monachus (Cinerous Vulture)	NT	*Mesocricetus brandti* (Brandts Hamster)	NT
Anser erythropus (Lesser White Fronted Goose)	VU	*Miniopterus schreibersii* (Common Bentwing Bat)	NT
Aythya nyroca (Ferruginous Duck)	NT	*Panthera pardus ciscaucasica* (Leopard)	NT
Branta ruficollis (Red Breasted Goose)	EN	*Rhinolophus Euryale* (Mediterranean Horseshoe Bat)	NT
Coracias garrulous (European Roller)	NT	*Rhinolophus mehelyi* (Mehely's Horseshoe Bat)	VU
Falco cherrug (Saker Falcon)	EN	*Capra aegagrus* (Bezoar)	VU
Falco naumanni (Lesser Kestrel)	LC	*Hyaena Hyaena* (Striped Hyaena)	NT
Ficedula semitorquata (Semi-collared Flycatcher)	NT	*Lutra Lutra* (Eurasian Otter)	NT
Tetrao mlokosiewiczi (Caucasian Black Grouse)	NT	*Ovis orientalis* (Mouflon)	VU
		Ursus arctos arctos (Brown Bear)	LC
Marmoronetta angustirostris (Marbled Teal)	VU	*Barbastella barbastella* (Western Barbastelle)	NT
*Milvus milvus (*Red Kite)	NT		
Neophron percnopterus (Egyptian Vulture)	EN		
Otis tarda (Great Bustard)	VU		
Note: LC is Least Concern; NT is Near Threatened; VU is Vulnerable; EN is Endangered.			

4.10.3 Vegetation Surveys and Results

Vegetation and Botanical Survey Methods

There was no documented information on the vegetation of the Project-affected area in the available literature. Vegetation types were therefore identified and classified based on interpretation of satellite imagery and the results of field surveys. Preliminary "walk over" surveys were conducted between May and October 2010 over a 4 km^2 area followed by more intensive sampling in sample areas of 100 m^2 selected at random. Some plant specimens (and photos) were taken to provide a reference collection in collaboration with the National Herbarium and to obtain information needed to understand conservation requirements for the Project's rare and Armenian Red Book species. The plants were collected from different altitudinal zones within the Project-affected area.

Further surveys were undertaken in 2012 to clarify the species composition of vegetation within the proposed Project physical footprint (not including the conveyor or access roads). A set of transects was identified with a series of survey points designed to cover a range of altitudes and soil types and to encompass the main vegetation types affected (see Figure

4.10.2). At each survey point, information on environmental parameters was collected and a set of three 4x4m quadrats was sampled to determine plant species composition and percentage cover. This information was used to help classify the main vegetation types present.

Although satellite imagery provided an adequate map of landcover, it could not be used to distinguish or identify the different habitats or vegetation types accurately. A detailed vegetation classification was also needed for the entire Project-affected area. A ground survey was therefore carried out in May-June 2013 and May 2014 using GPS to improve interpretation ability. This was supplemented by inspecting photographs taken during the survey. Each polygon was given attributes for the vegetation type identified, moisture and slope. In total, an area of 13,538 ha of vegetation was mapped, 1,765 ha of this area lying within the footprint for infrastructure, associated buffer zones and restricted areas.



Figure 4.10.2: Locations of Vegetation Transects and Survey Points

The vegetation surveys carried out in 2012 revealed the presence of a previously unknown population of *Potentilla porphyrantha* on Amulsar Mountain. A preliminary population count

was made. Searches for the plant were also carried out in similar habitat on surrounding mountains.

Because of the global importance of the sub-population discovered on Amulsar in 2012 and its conservation importance in Armenia, a second survey was carried out in 2013 to verify the distribution and size of the population and confirm the extent of critical habitat according to PS6/ PR6. A team of four people spent three days searching the mountain rigorously for *Potentilla porphyrantha* plants, led by Dr Pete Carey, a botanical specialist and plant population ecologist and assisted on the first two days by S. Arevshatyan (the Geoteam environmental specialist who had carried out the survey in 2012). The southernmost part of the massif towards the village of Gorayk was left unsurveyed due to a lack of time. The only other areas unsurveyed were steep cliffs on the east side of Tigranes Peak which were too dangerous to survey without climbing equipment.

Locations of outcrop or boulders with *Potentilla porphyrantha* plants were recorded using ArcPad GIS with built in GPS. The GPS had been previously verified in February 2013 and had accuracy to within approximately 5m on all days. Outcrops without plants were mapped as 'absences' and a distribution map of presences and absences across the mountain was created.

Specimens were collected during surveys to carry out preliminary research on translocation and restoration methods. Herbarium materials were dried and transported for storage in the herbaria of the NAS RA Institute of Botany. As the population biology and environmental requirements for *Potentilla porphyrantha* are unknown, a programme of research has been designed to investigate ecological requirements and propagation techniques. This research will also provide information needed to model the viability of the affected population so that an effective restoration strategy can be developed and ability to achieve a net gain in population can be tested. A permit to translocate *P.porphyrantha* plants was granted in August 2015. In September and October 2015 1685 plants were collected and translocated to the Sevan Botanical Garden of the National Academy of Sciences RA.

Monitoring surveys carried out in 2014 and 2015, and further searches carried out while reviewing potential topsoil storage locations, revealed additional rocks with *Potentilla porphyrantha* on the eastern flank of Amulsar. The distribution map was updated accordingly. The baseline population was set as 2014 because new plants were discovered in 2015 in

places that had been searched previously. The assumption is that these are truly new plants which could have been spread around the mountain by human activity.

During 2013, surveys of surrounding areas were carried out to identify suitable source locations to harvest seed and turves for potential restoration of natural vegetation as part of an ongoing programme of research into reliable and effective techniques to feed into closure planning.

Results of Terrestrial Vegetation Surveys

Vegetation types

Based on the results of the vegetation transects and habitat survey, the main vegetation types found in the Project-affected area were defined as shown in Table 4.10.7. These types are largely determined by altitude, levels of moisture and land use and reflect the Armenian vegetation or biotope classification. Further detail on the characteristics of each vegetation type may be found within the Natural and Critical Habitat Assessment (Appendix 4.10.3).

Table 4.10.7: Vegetation or Habitat Types in the Project-affected area

Habitat	Altitude	Moisture	Land Use
Cultivated land	Low (<2100masl)	Moist to average	Arable and/or pasture
Montane Meadow	Low to medium (<2450masl)	Moist to average	Pasture
Montane Meadow Steppe	Low to medium (<2450masl)	Average to dry	Pasture or unused
Sub-alpine Meadow	High (>2450masl)	Average	Pasture or hay
Sub-alpine Meadow With Alpine Elements	Very high (>2700masl)	Average	Pasture or hay or unused
Rocks/Scree	All Altitudes	Dry	Unused
Vegetation With Shrubs	Low to medium (<2450masl)	Moist to dry	Sparsely used as pasture
Wetland	Low to medium (<2450masl)	Moist	Within pastures
Riparian	Low (<2100masl)	Moist to saturated	Pasture or unused
Gorge	Low (<2100masl)	Dry	Unused

Following discussions with the NAS RA Institute of Botany it was concluded that Amulsar does not support alpine vegetation as defined within the Armenian classification, though plant species do occur which are typical of the alpine zone. The presence of these plant species makes the vegetation important for biodiversity despite its non-typical nature and a new description ("Sub-alpine Meadow with Alpine Elements") was defined to describe the type of

vegetation found on the highest areas of the mountain. Typically, the alpine plants are found in rocky areas.

A vegetation type including shrubs was also included because of the conservation importance of remaining shrub habitat and the fact that it is one of the characteristic vegetation types of the Caucasus Mixed Forest Ecoregion. Shrubs grow extremely slowly and tend to disappear from grazed areas. They are therefore difficult to restore or replace.

Figure 4.10.3 is a map of the main habitat types occurring in the area surrounding the Project. The "mapped area" was designed to incorporate all areas expected to be affected by mine infrastructure or by mining-related activity and to be extensive enough to support comparisons of affected vegetation with some unaffected examples of the same types of vegetation. In addition to the nine habitat types listed in Table 4.10.7, small areas of urban development were identified and there were many polygons that had combinations of the different habitats forming mosaics, e.g. 'Sub-alpine Meadow/Rocks' would be a polygon with both Sub-alpine Meadow and Rocks but where the Sub-alpine Meadow covered a larger area and was considered 'dominant'. In total, thirty-two distinct habitats and habitat mosaics were identified. To enable the habitat map to be interpreted easily this list was reduced to the nine most pertinent categories. The map shows the dominant habitat (by area) identified for each polygon. All habitat mosaics containing shrubs were included in the Vegetation with Shrubs category, and habitat mosaics where rocks were dominant have been assigned to the second-most dominant vegetation type, if there was one. Wetland is found largely in the Vorotan Valley but there are also small ponds and some perched mires on the western side of the mountain.

Table 4.10.8: Extent of Different Habitat Types Within the Mapped Area

Habitat	Area in ha	% Area
Cultivated	462.00	3
Montane Meadow Steppe	4,914.00	36
Montane Meadow	2,814.00	21
Sub-alpine Meadow	1,885.00	14
Sub-alpine Meadow with Alpine Elements	147.00	1
Vegetation with Shrubs	1489.00	11
Rocks	81.00	1
Wetland	433.00	3
Urban	2.00	0
Orchard	8.00	0
Gorge	1301.00	10

The wider Project area is dominated by Montane Meadow Steppe alone or in combination with other types, including species-rich Sub-alpine Meadows. Montane Meadow Steppe accounts for 44% of the mapped area and Sub-alpine Meadow for 18% (see Table 4.10.8). Sub-alpine Meadows in "good condition", such as those found at the summits of Tigranes, Artavazdes and Arshak, are relatively rare in Armenia. They retain high endemic species richness and are considered to be relatively important in a national context by specialists. Alpine species considered to be noteworthy within Amulsar's Sub-alpine Meadows with Alpine Elements include: *Potentilla porphyrantha*, *Aetheopappus caucasicus*, *Arabis caucasica, Aster alpinus, Campanula bayerniana, Cystopteris fragilis, Erigeron venustus, Helichrysum plicatum, Huynhia pulchra* (endemic), *Jurinea moschus* and *Potentilla crantzii.*

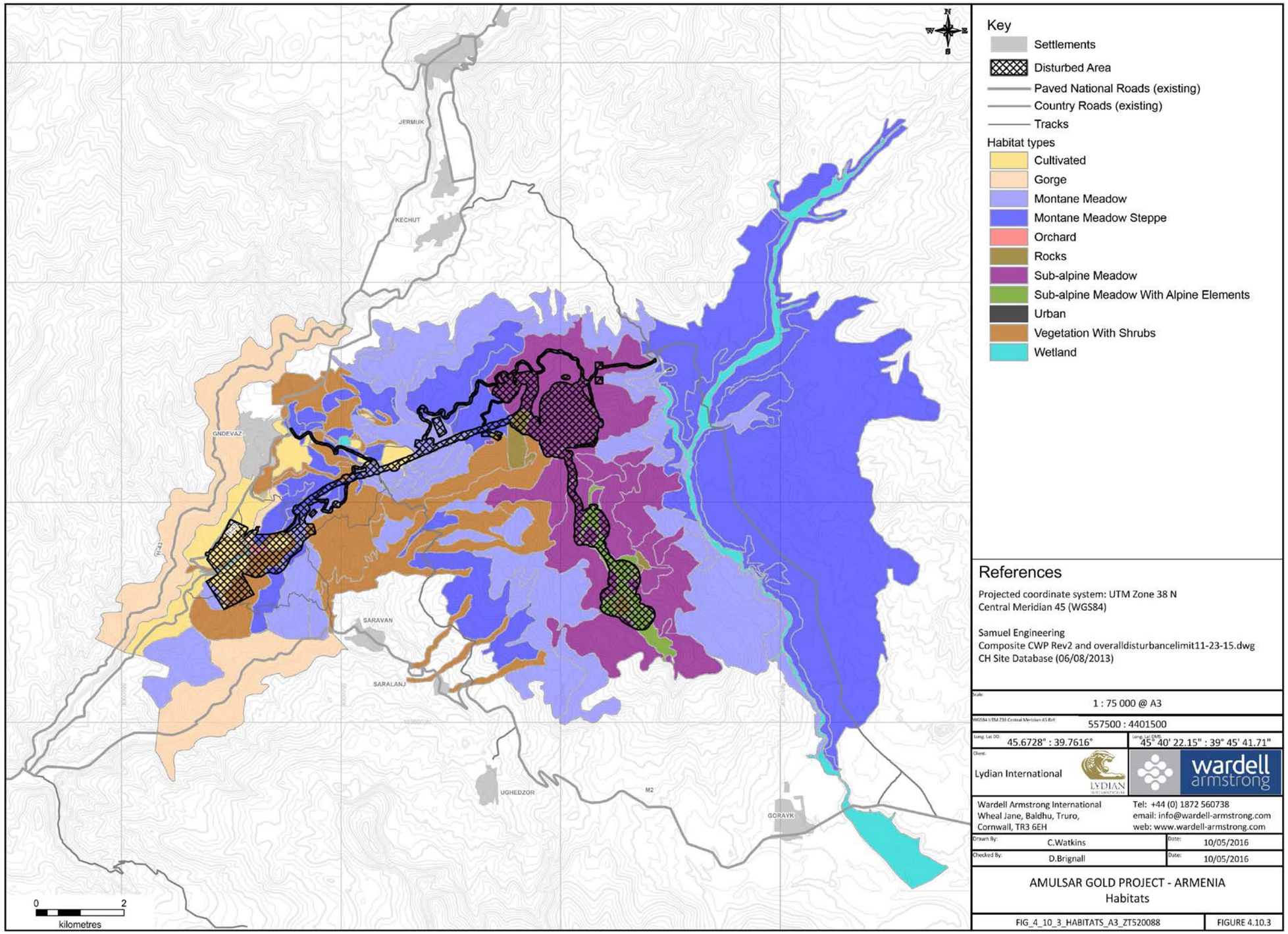


Figure 4.10.3: Habitat Map of the Amulsar Area

Results of vegetation surveys: natural and modified habitat

A detailed assessment was undertaken to assign the vegetation encountered in the area to "natural" and "modified" categories according to the guidance in PS6 and PR6. Full details are included in the Natural and Critical Habitat Assessment (Appendix 4.10.3) and a summary is included here.

Sub-alpine Meadow with Alpine Elements is found at the highest areas of the mountain that are not rock outcrops. It is seldom grazed or used and can be considered entirely natural.

Sub-alpine Meadows are found on flat or sloping ground (sometimes very steep) above 2450 m above sea level (asl). They have native species and are only grazed lightly (usually in mid-summer) due to late snow lie, or sometimes used for a late hay cut. The Project has chosen to take a conservative approach and define these as natural.

Prior to the Soviet era, Montane Meadows and Montane Meadow Steppes in the Project area were managed as a transhumant grazing and hay meadow system. Botanically diverse vegetation with characteristic native species developed over centuries (and possibly millennia) of traditional management under this system, which has disappeared from most areas of the world where it used to be widespread, and is also declining throughout the Caucasus Region. The associated cultural landscapes have become increasingly rare as a result. The Project area is in a recovery phase following more intensive use during the Soviet era and traditional management practices have become re-established. Transhumance is still practised with animals coming with their herders from long distances away or on a daily or seasonal basis from local villages. Montane Meadows and Montane Meadow Steppes are currently managed by relatively extensive summer grazing and/or harvesting for hay.

These habitats have been defined as natural where they have predominantly native species and where species-rich communities have persisted under traditional land management without significant modification due to addition of inorganic fertilisers or reseeding. They meet the definition of 'semi-natural' used in European conservation programmes where allowances have been made for some mechanisation and the evolution of grazing animals and systems.

Vegetation with Shrubs occurs in both the Mountain Meadow and Mountain Meadow Steppe zones. The characteristic species of shrub are *Juniperus communis*, *J.polycarpus* and

Crataegus meyeri. Juniper scrub is one of the characteristic vegetation types of the Caucasus Mixed Forest Ecoregion and is of conservation importance. Small fragmented examples of this vegetation type remain which would be classed as truly natural. Where the vegetation type is more affected by grazing and has sparse presence of characteristic shrub species, it has been defined as modified.

Areas immediately surrounding seasonal herder camps are heavily grazed and have become dominated by agricultural weed species. Local communities also have land holdings within the Project-affected area used for grazing and for hay. These are defined as modified but are generally too localised to indicate on the habitat map.

Figure 4.10.4 illustrates the distribution of natural and modified habitat types in the mapped area.

A large part of the wider Project area constitutes “natural” habitat according to the definition in PS6/ PR6.

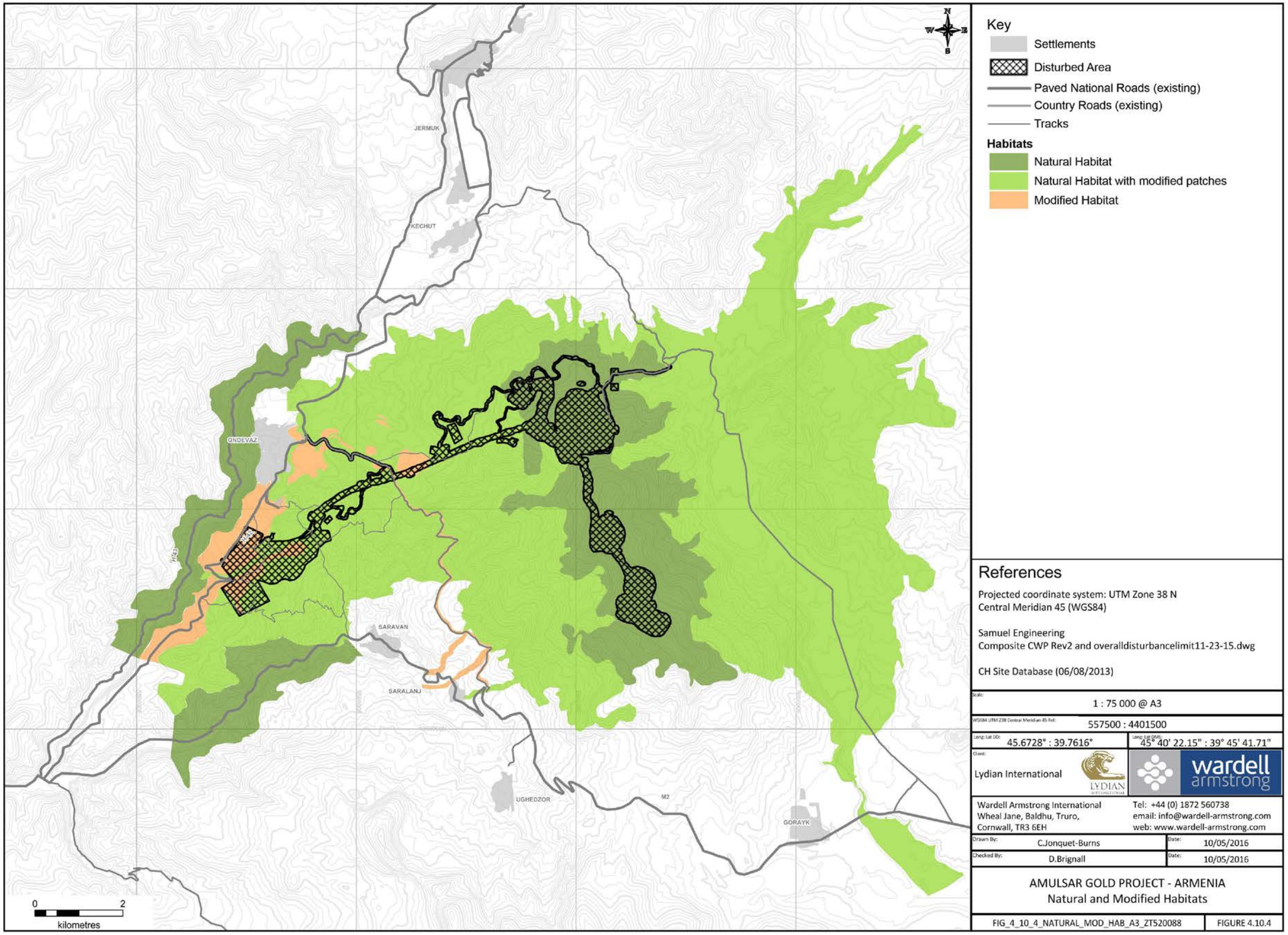


Figure 4.10.4: Natural and Modified Habitats

Endemic Plants within the Project-affected area

A number of species within affected vegetation types are regional endemics, either within the Trans-Caucasus (TC) or the Caucasus (C). In addition to *Potentilla porphyrantha*, endemic plant species recorded during surveys included the following 21 species: *Astrantia maxima Pall*., (C) *Huynhia pulchra* (Willd. ex Roemer & Schultes) Greuter & Burdet (Syn.: *Macrotomia echioides* (L.)(C), *Noccaea tatianae* (Bordsz.) F.K. Mey. (= *Carpoceras tatianae* (Bordz.) Grossh.) (TC), *Cerastium szowitsii Boiss*. (Syn.: *C. araraticum Rupr*.)(TC), *Hylotelephium caucasicum* (Grossh.) *H. Ohba* (= *Sedum caucasisum* (Grossh.) Bor.)(C), *Sedum gracile* C.A. Mey (C)., *Sempervivum transcaucasicum* Muirhead (C), *Cephalaria gigantea* (Ledeb.) Bobrov (C), *Scabiosa caucasica* M. Bieb.(C), *Anthyllis lachnophora Juz*. (= *Anthyllis boissieri* (Sagorski) Grossh)(C), *Vicia alpestris Steven*(C), *Tulipa Julia* k. Koch (TC), *Iris demetrii* (TC), *Papaver orientale* L. (C), *Delphinium flexuosum* (C), *Delphinium freynii conrath* (TC), *Crataegus caucasica* C. Koch (C), *Saxifraga cartilaginea* Willd. ex Sternb. (C), *Linaria schelkownikowii* Schischk. (TC), *Rhynchocorys orientalis* (L.) Benth. (C). and *Fritillaria armena* Bois. var lucida Hausskn. et Bornm *(also called Fritillaria caucasica* Adam and *F.tulipifolia* M.Bieb.). These species are sparsely, but widely distributed throughout the landscape apart from *Potentilla porphyrantha* which has only three populations in Armenia (see next section). *Fritillaria armena* is rare within the Project-affected area but does occur elsewhere in the surrounding landscape. It has a localised, small population near to the proposed conveyor route and does not occur anywhere else within the Project-affected area.

At least 22 plant species recorded during baseline surveys are regional endemics, either within the Trans-Caucasus (TC) or the Caucasus (C) region. Species potentially affected by the Project are *Potentilla porphyrantha* and *Fritillaria armena* .

Rare Plants within the Project-affected area

Appendix 4.10.1 lists all the plant species recorded in the Project-affected area or referred to in relevant literature sources. The only plant species recorded in the Project-affected area included in the Armenian Red Book of Plants (2010) is *Potentilla porphyrantha* (juz). The species is classified as Critically Endangered by criteria D 1 ab(iii) + 2 ab(iii), which reflects the fact that the area occupied by the species in Armenia is less than 10 km^2 in total.

The species has not hitherto been evaluated against IUCN Red List criteria at global level. Therefore, in accordance with PS6 guidance, a provisional assessment was made against the latest version 3.1 criteria, by botanical experts in consultation with IUCN Red List specialists

and the Missouri Botanical Garden. This assessment concluded that *Potentilla porphyrantha* meets two criteria for Endangered status (EN), based on its small area of occupancy and a perceived threat of significant population size reduction (see the Natural and Critical Habitat Assessment in Appendix 4.10.3 for further details).

The distribution of the plant is highly fragmented and the extent and quality of the habitat in which it occurs is generally considered to be declining. In addition to degradation of habitat, climate change is a possible additional threat. The population discovered on Amulsar is important because it is one of only five known sub-populations globally (a sixth is known from historical records). The population on Amulsar brings the number in Armenia to three (others are at Mets Ishkhanasar and Geghama Mountains (Sevsar and Agusarka)). Other sub-populations are in northern Iran. The other known sites for the species are all at higher altitudes than Amulsar, at 3300-4000 masl. *Potentilla porphyrantha* grows on rock outcrops and boulders on the Amulsar massif above 2450 masl. There is no global estimate for the population of *P. porphyrantha* but its known global distribution extends from northern Iran to Yerevan. None of the sub-populations had been counted or mapped before the Amulsar population in 2012-2013. The 2012 survey suggested that the plant grew on rocky outcrops at an altitude of 2800-3000 masl. The plant was only found on large rock outcrops as shown in Figure 4.10.5, often associated with a moss, *Grimmia sp*.



Figure 4.10.5: Examples of large rocky outcrops below Arshak where *P. porphyrantha* was found in 2012

In 2013 additional plants were found on relatively small boulders down to an altitude of 2450 masl on the southwestern slopes (Figure 4.10.6), and a few individuals were observed growing on scree. The 2013 survey revealed the population of *P. porphyrantha* on the Amulsar Massif to be approximately 7,500 (± 1000) as shown on Figure 4.10.7. The distribution was further extended on the eastern side of the mountain following additional survey in 2014 (see Figure 4.10.7). In 2015, plants were found growing on tracks created by the mine exploration and on boulders searched previously. These plants must be less than 4 years old.

The population includes a large number of plants on the southern end of Amulsar mountain, which are now included in a set-aside (see Chapter 6.11). Some areas supporting numerous plants could not be counted due to steep cliffs and inaccessible terrain. The total count for the Project-affected area is therefore a conservative estimate. The plant grows in small cracks and crevices of the boulders of various rock types and is often associated with the moss *Grimmia* which seems to provide a form of 'soil' or substrate for the plant to grow in. Plants flower in June and July and flowers are approximately 15 mm across (Figure 4.10.8). There is no obvious pattern to the aspect that the plants face, but they are often found on the top of

boulders or where they get a lot of sunlight. Access to water from cracks on the top of boulders and mosses could be an important factor in supporting the plants of *P.porphyrantha.*



Figure 4.10.6: Small boulder with 50 plants of *P.porphyrantha*

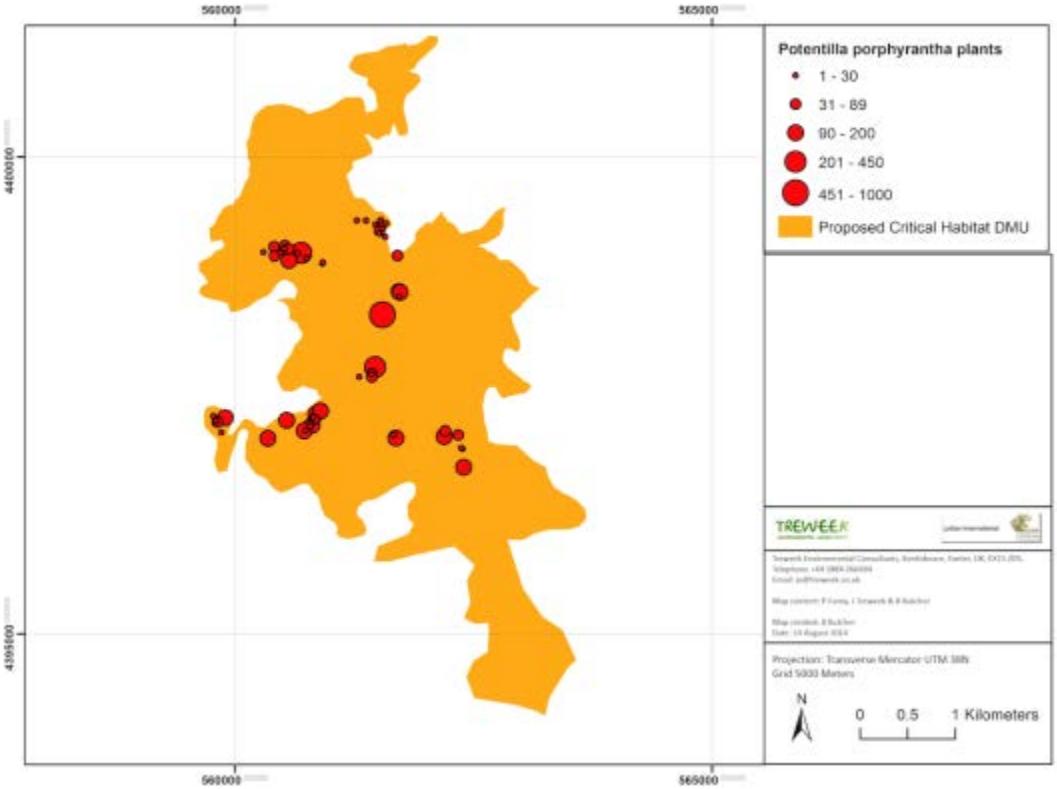


Figure 4.10.7: Amulsar Sub-Population of *P. porphyrantha*



Figure 4.10.8: *P. porphyrantha* plant

Critical habitat

Critical habitat is a category of natural or modified habitat defined under paragraph 16 of IFC PS6 as having high biodiversity value, due to the presence of CR or EN species, endemic or restricted-range species, migratory or congregatory species, highly threatened or unique ecosystems, or a number of other qualifying criteria. As required by IFC PS6, a detailed critical habitat assessment was carried out for the Project. The full report is presented as Appendix 4.10.3, and the key results are summarised within this chapter.

As described above, *Potentilla porphyrantha* is believed to meet two IUCN Red List criteria for EN status, and the sub-population discovered on Amulsar is important because it is one of only five known sub-populations globally. The Amulsar sub-population is therefore believed to meet one of the threshold for Tier 1 critical habitat - habitat with known, regular occurrences of CR or EN species where that habitat is one of 10 or fewer discrete management sites globally for that species (for further detail see Appendix 4.10.3). The Amulsar sub-population may meet a second criterion for critical habitat - if it sustains greater than 10% of the global population of the species - although this cannot be confirmed based on current information (however, Amulsar represents approximately 60% of the currently known global Area of Occupancy for the species).

The only RA Red Book plant species found in baseline surveys was *Potentilla porphyrantha* which is listed as Critically Endangered in the RA Red Book. The species has not been formally evaluated for the IUCN Red List. Therefore, in accordance with PS6 guidance, a provisional assessment was made against the latest version 3.1 criteria, by botanical experts in consultation with IUCN Red List specialists and the Missouri Botanical Garden. This assessment concluded that *Potentilla porphyrantha* meets two criteria for Endangered status (EN).

The population of *P. porphyrantha* on Amulsar is one of only five known sub-populations globally (a sixth is known from historical records) and brings the number in Armenia to three (others are at Mets Ishkhanasar and Geghama mountains – Sevsar and Agusarka). Other sub-populations are in northern Iran.

The Amulsar sub-population is believed to meet at least one of the thresholds for Tier 1 critical habitat - habitat with known, regular occurrences of CR or EN species where that habitat is one of 10 or fewer discrete management sites globally for that species.

Invasive species

Three species of plant, *Astragalus aureus*, *Verbascum laxum* and *Cirsium arvense* (Creeping Thistle), are found in the Project-affected area particularly within Sub-alpine Meadow and Montane Meadow habitats. These are not alien species, but they do have invasive properties and can return to dominate quickly if an area is cleared of vegetation.

4.10.4 Mammal Surveys and Results

Survey Methods

A review of available scientific literature provided limited specific information on the presence of mammal species and their populations in the Amulsar region. Reports from the WWF Armenian office were also reviewed along with the 2012 revised and amended Ecoregion Conservation Plan for the Caucasus.[5]

Field surveys took place in autumn 2011 along 5-7km long linear routes or transects designed to include all biotopes considered to form suitable habitat for both large and medium sized animals in the Project-affected area. Small mammal traps were also used in five areas (400m x 500m) considered likely to be inhabited by rodents and insectivores in order to determine

[5] Available at: http://69.195.124.72/~caucasu1/wp-content/uploads/2012/11/ECP_Ecoregion_Conservation_Plan_Caucasus_2012.pdf

the species composition of small mammal populations. Further surveys were undertaken by the NAS RA Institute of Zoology and Hydroecology during 2013. Incidental sightings of mammals during surveys between 2008 and 2014 for other taxonomic groups were noted.

In 2015, a detailed survey looking at the presence and behaviour of *Ursus arctos* (Brown Bear) at Amulsar and in the wider region was undertaken by TEC, Alberta Innovates (AI), and the Institute of Zoology (IoZ) of the Armenian National Academy of Science (NAS). The survey work began in early 2015 with IoZ monitoring bear activity around Amulsar at the end of the hibernation season. Between April and October 2015, a network of 34 motion-activated, infrared camera traps established across a survey area of 733 km^2 was monitored continuously, and hair samples were collected from specially designed traps. Results from the camera traps have provided information on presence of suitable habitat for bears. Genetic testing of the hair samples will be completed in April 2016 and will be used together with the photographs to estimate the number, gender and age of bears. The photographs obtained also provided information on the presence of other mammals (and birds) in the area. An interim report on the survey is included as Appendix 4.10.9, and the preliminary observations and results are discussed below.

Results

Twelve species of smaller mammals were identified during the early surveys on Amulsar. These were *Erinaceus concolor* (Hedgehog), *Sorex volnuchini* (Caucasian Pygmy Shrew), *Lepus europaeus* (Hare), *Critetulus migratorius* (Grey Hamster), *Chionomys nivalis* (Snow Field Mouse), *Sylvaemus (apodemus) sylvaticus* (Forest Mouse), *Apodemus sylvaticus* (Wood Mouse), *Microtus arvalis* (Common Vole), *Chionomys nivalis* (Snow Vole), *Martes foina nehringi* (Stone Marten), *Mustela nivalis* (Least Weasel) (see Figure 4.10.9) and *Meles meles* (Badger). These species are all regarded as relatively widespread throughout the Project-affected area and the surrounding region, with stable populations.



Figure 4.10.9: *Mustela nivalis* (Least Weasel)

Larger mammal species present in the Project-affected area include *Vulpes vulpes* (Red Fox), *Canis lupus* (Grey Wolf), *Capra aegargos* (Bezoar Goat), *Lynx lynx* (Eurasian Lynx), *Sus scrofa* (Wild Boar), *Felis chaus* (Jungle Cat), and *Ursus arctos* (Brown Bear). Of these, Red Fox is widely distributed, has stable populations, and is observed regularly within the Project-affected area. The others are more rarely seen; in some cases their presence was confirmed only by the detailed Brown Bear survey undertaken in 2015.

Wolf tracks were observed in both 2011 and 2013 within the Project-affected area. The species is reported by locals as occurring regularly but relatively infrequently, particularly in winter. It was photographed by six cameras during the Brown Bear survey.

Bezoar Goat is listed as Vulnerable by IUCN and is included in Annexes II and IV of the European Habitats Directive, as well as in the RA Red Book. It is one of the species targeted for action in this part of Armenia in the recently issued Conservation Plan for the Caucasus Ecoregion (WWF 2012). It was observed twice on the northwestern slopes of the Jermuk Gorge in May 2013 (groups of 11 and 3) and in the area proposed for Jermuk National Park in June 2013 (a group of 5). Two individuals were photographed on the southern slopes of Amulsar (Arshak) on 8 September 2015 (Figure 4.10.10).



Figure 4.10.10: *Capra aegagrus* (Bezoar Goat) photographed on Amulsar in September 2015

The global IUCN Red List of Threatened species identifies six sub-species of Lynx. Those in the Project-affected area are Caucasus Lynx *L. l. dinniki*, occurring in the Caucasus Mountains south to Turkey, Iraq and Iran. In Armenia the Lynx is "thought to be a common species, especially in some protected areas but the population trend is unknown" (IUCN, 2015) and few surveys have been carried out. Numbers are unlikely to be high. Although classified as Least Concern by IUCN, it is listed in Annex IV of the EU Habitats Directive, which means that degradation of its habitat is prohibited under EU law. This is of significance to the Project because of its commitment to comply with the EBRD PRs - which assume compliance with EU law. It was photographed in five squares during the Brown Bear survey, including three times at Arshak (June 20, July 24 and July 31 2015).

Wild Boar was photographed in seven squares during the 2015 Brown Bear survey, and Jungle Cat on one occasion.

Panthera pardus ciscaucasica (Leopard) and *Ovis orientalis Gmelin* (Mouflon) were not recorded during any surveys and are not thought likely to be present in the Project-affected area. The main stronghold for *Panthera pardus ciscaucasica* in Armenia is now in the far South[6].

Brown bear (Ursus arctos)

The Brown Bear (*Ursus arctos*) is a protected species in Armenia and is included in the national Red Data Book with a status of Vulnerable. Although classified as Least Concern by IUCN, it is listed in Annex IV of the EU Habitats Directive, which means that degradation of its habitat is prohibited under EU law. This is of significance to the Project because of its commitment to comply with the EBRD PR - which assume compliance with EU law.

Some of the scientific literature on bears in Armenia refers to two sub-species: Caucasian Brown Bear (*Ursus arctos meridionalis*) and Syrian Bear (*Ursus arctos syriacus*). Caucasian brown bear is considered to be restricted to the northern part of the country, tends to be larger than the Syrian subspecies and has a more uniform, darker colour. The Syrian subspecies is restricted to the South and has a greater variation of coat colours, from almost greyish to blond and even black.

The International Association for Bear Research and Management and the Bear Specialist Group (BSG) of the IUCN Species Survival Commission (SSC) do not recognize these distinct sub-species of Brown Bear, partly because there has not been sufficient genetic testing in relevant geographic areas to provide the firm evidence needed to confirm their existence. Nevertheless, communication with the IUCN SSC suggests that differences between sub-populations (in terms of level of isolation and exposure to risk) are recognised. There are three populations in the South Caucasus Region that are now considered to be effectively isolated from one another. As one of these isolated sub-populations, the Armenian population of Brown Bear is considered to be of conservation concern, with an emphasis on re-establishing historical corridors and preventing further fragmentation of habitat. Brown Bear is therefore one of the species targeted for action in this part of Armenia in the recently issued Conservation Plan for the Caucasus Ecoregion (WWF 2012).

[6] Khorozyan, I. (2003). The Persian Leopard in Armenia: Research and Conservation. Proceedings of the Regional Scientific Conference "Wildlife Research and Conservation in South Caucasus 7-8 October, pp 161-163, Yerevan, Armenia

Initial baseline ecological surveys in 2008 noted the presence of Brown Bear but concluded that individuals were passing through the Project-affected area occasionally. Further ecological surveys carried out as part of the ESIA for Amulsar since 2011 confirmed that a breeding population of bear is present. Initial field surveys took place in autumn 2011 along 5-7 km long linear routes or transects designed to include all biotopes considered to form suitable habitat for both large and medium sized animals in the Project-affected area. Further surveys were undertaken by the Armenian Institute of Zoology during 2013.

Tracks and faeces of *Ursus arctos* were observed in the 2011 transect survey, along the banks of the Vorotan River and on the slopes of Amulsar Mountain above Saravan and Saralanj villages. Tracks and faeces were also observed frequently during the 2013 field surveys especially around the proposed mine pits on the summit of Amulsar and the mine exploration camp, but also throughout the entire Project-affected area. Tracks of a presumed female with two cubs were photographed near the mine exploration camp in April 2013 and there were sightings in 2014 of two different females with cubs (see Figure 4.10.11). A mature male bear was observed and photographed by the bird survey team on the south side of Amulsar using a cave during the day during surveys in 2013 (see Figure 4.10.12). Based on these findings, the Project-affected area is determined to be critical habitat for Brown Bear in relation to EBRD PR6 and its reference to the EU Habitats Directive.



Figure 4.10.11: Female bear with cubs, Amulsar, May 2014



Figure 4.10.12: Brown Bear observed on the south side of Amulsar Mountain, June 2013

The survey of Brown Bear was designed to enable the relative importance of the Project-affected area to be established in terms of availability of foraging and breeding habitat in a regional context. A large survey area of 733 km^2 (see Figure 4.10.13) was therefore used, with 34 cameras. Bear sightings in the early part of the season in 2015 are shown in Figure 4.10.14. It was also necessary to estimate the number of individuals potentially affected by the Project compared with the overall population. From mid-May to the end of September 2015, 2,422 pictures of Brown Bears were taken. Of the 34 camera sites, 28 were visited by at least one bear, 23 more than once, and 15 by more than one bear. Females with cubs were photographed in nine locations overall. Figure 4.10.15 shows where hair samples were collected.

Based on these results, a preliminary assessment of bear activity throughout the study area is presented in an interim survey report (Appendix 4.10.9) in terms of the number of "bear days" for each camera location or square. This is the number of days on which the camera took photographs of a bear (Figure 4.10.16). This statistic does not distinguish between visits on three consecutive days (a temporary visit) or three days spread over a period of several months (indicating continued presence of bears) but it does give an idea of the parts of the study area where bear activity was concentrated. Repeated bear activity was mainly found in the following areas (in order of importance):

Herher State Sanctuary (Squares 16-17, with 39 "bear days" in the latter);

- The southern slopes of Amulsar (Arshak set-aside, square 23, with 24 "bear days"); and
- Woodlands between Amulsar and Saravan (square 22, with 17 "bear days").

To a lesser extent, bear activity was also notable in:

- The wooded valley west of Kechut lake (squares 8 and 12, with 8 "bear days" in the latter);
- The Arpa River valley in Jermuk Hydrological State Park (square 5, with 6 "bear days"); and
- The wooded valley along Artavan Road, and the mountains southeast of Artavan village (squares 24 and 30, with 5 "bear days" in the latter).

The above six areas also appear to be important for reproduction, as bear cubs were photographed in all of them. Cubs were also photographed around Spandaryan reservoir (squares 28 and 32), but it is not clear where they had come from. The shores of the reservoir

do not offer suitable bear habitat, and there is a lot of human activity (herders, farmers) in the mountain range to the south.

Between early June and 1 October 2015, a total of 203 hair samples were collected from 23 squares (in some squares, bears were photographed but did not leave any hairs). Most samples were collected in the wooded valley west of Kechut Lake (especially at the southern edge of square 8), in the woodland between Amulsar and Saravan, in Herher State Park, and on the southern slopes of Amulsar (Arshak set-aside). These are the areas that showed the most evidence of bear activity from the camera traps. In addition, quite a lot of samples were collected in the woodlands east of Jermuk/Kechut (e.g. 13 samples in square 14). A large number of hair samples in a square possibly signifies territorial behaviour, and therefore continuous presence of bears, suggesting that these woodlands are important habitat for the species. Likewise, the area around Shaghat village (square 38) may be more important than suggested by the camera trap results. However, until the results of genetic testing are available in April 2016, the possibility that a large number of hairs may simply have been the result of one or a few visits by a heavily moulting bear cannot be discounted.

Whilst the population size, density and exact distribution of Brown Bear in the study area cannot be determined until the genetic analysis is complete, numerous observations and photographs already demonstrate that the southern slopes of Amulsar are important for the species. Similarly, the woodland between Amulsar and Saravan (square 22) appears to be an important area for bears.

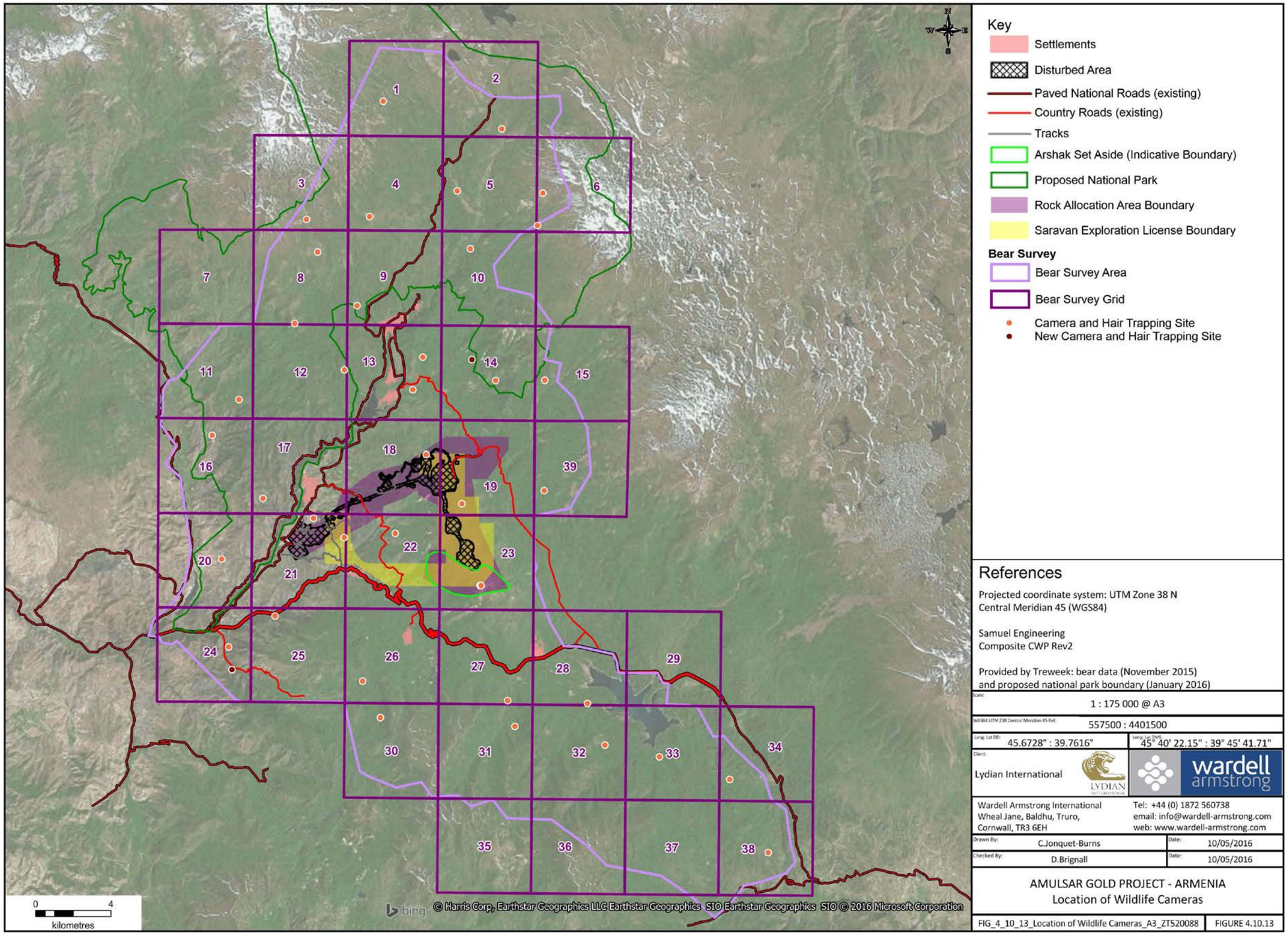


Figure 4.10.13: Location of Wildlife Cameras

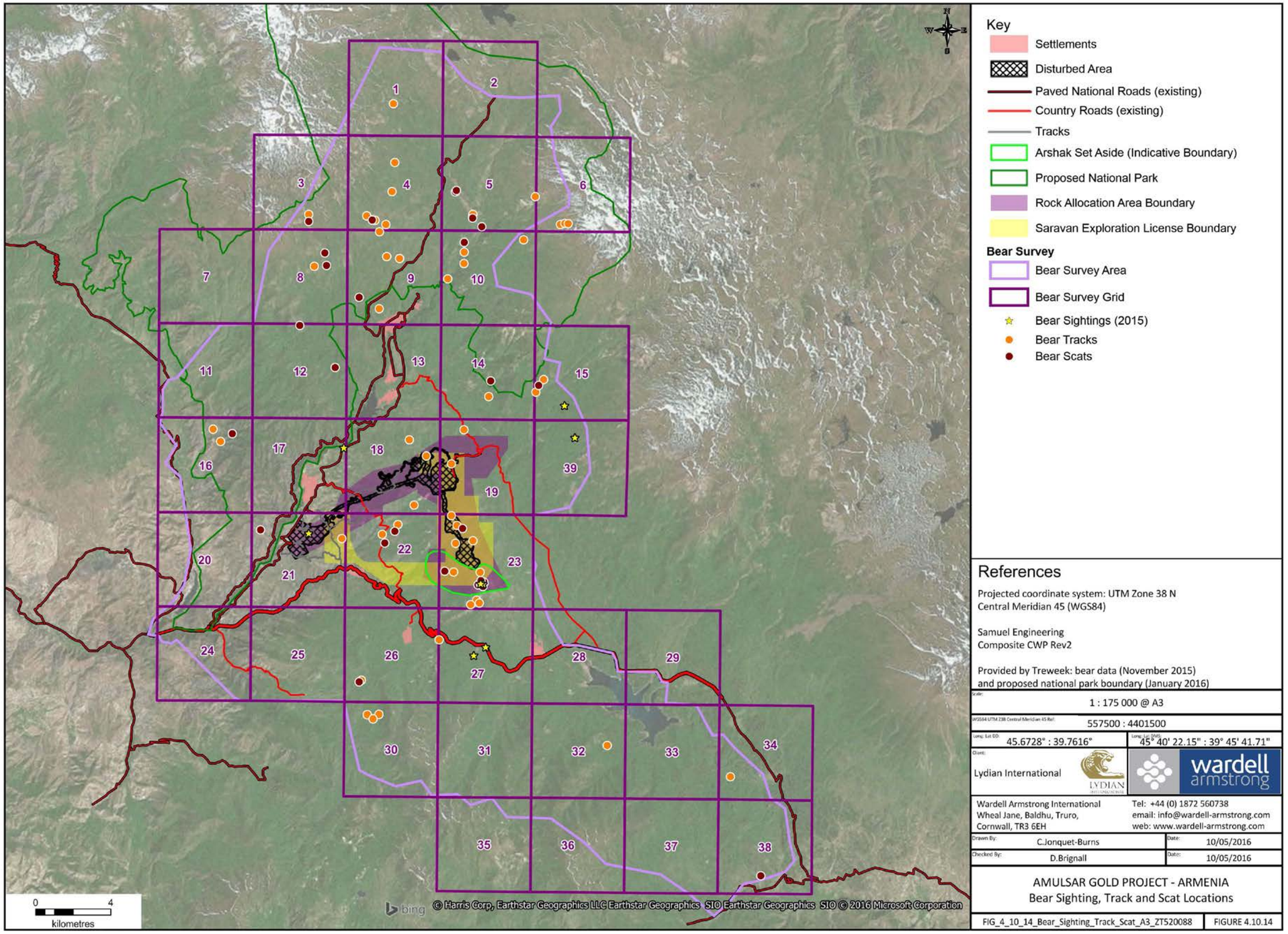


Figure 4.10.14: Bear Sightings and Tracks

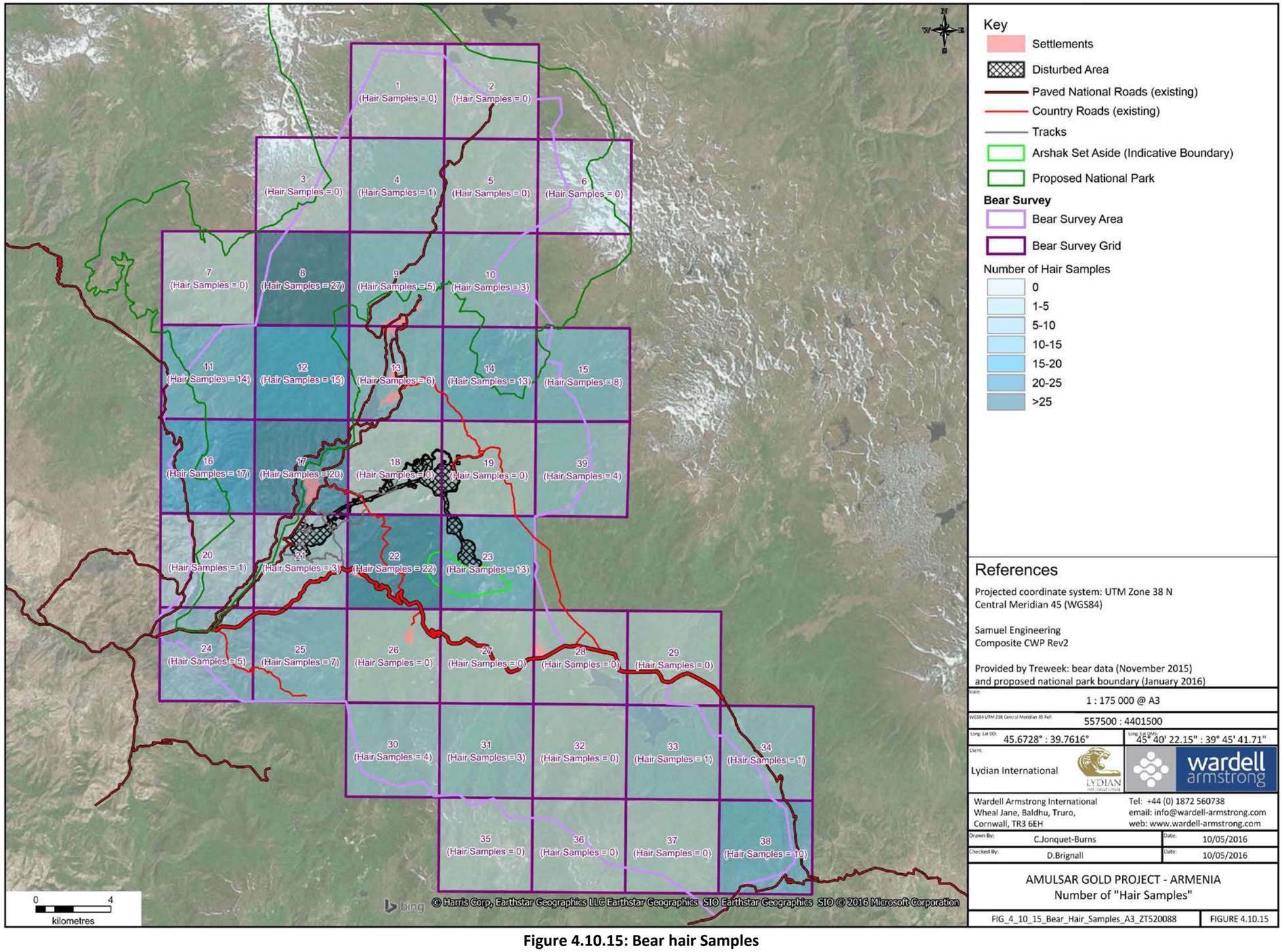


Figure 4.10.15: Bear hair Samples

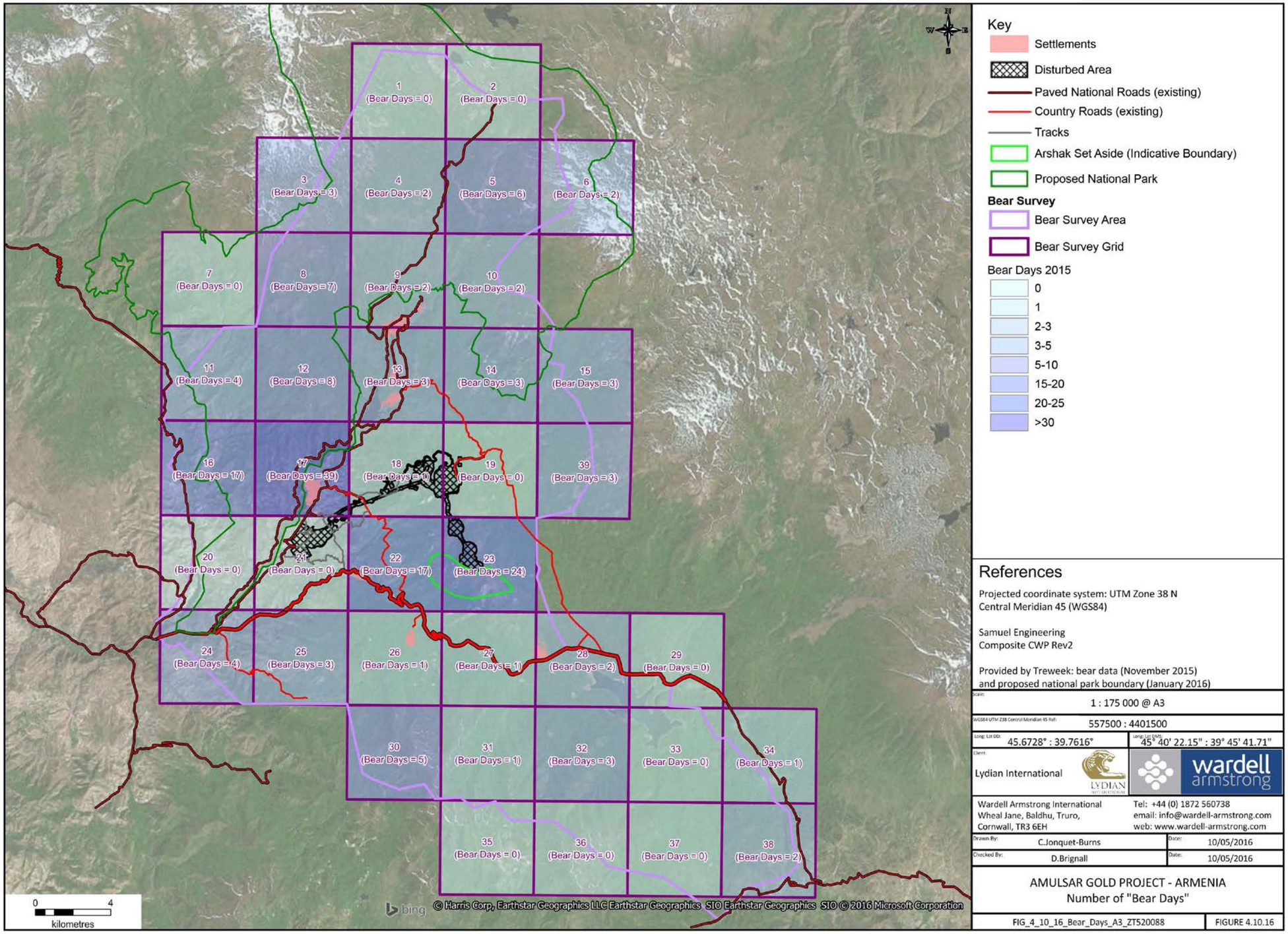


Figure 4.10.16: Bear Days

Critical habitat

Although classified as Least Concern by IUCN, and listed as Vulnerable in the RA Red Book, Brown Bear is considered to be a trigger species for critical habitat due to its status as an Annex IV species of the EU Habitats Directive, with which the Project has commited to comply in accordance with its intended adherence to the requirements of EBRD's PR6. Under the EU Habitats Directive, degradation of brown bear's resting or breeding habitat is prohibited. As IFC's PS do not require adherence to the EU Habitats Directive, this species does not trigger critical habitat requierements under PS6.

The results of genetic testing of hair samples collected in 2015 will clarify the size of the Bear population and their use of the Project-affected area and enable identification of the appropriate Discrete Management Unit (DMU) for the species (see Appendix 4.10.3 for further detail).

Small mammal species identified during baseline surveys are widespread in the region and have abundant populations. Larger mammal species include *Vulpes vulpes* (Red Fox), *Canis lupus* (Grey Wolf), *Capra aegargos* (Bezoar Goat), *Lynx lynx* (Eurasian Lynx), *Sus scrofa* (Wild Boar), *Felis chaus* (Jungle Cat), and *Ursus arctos* (Brown Bear). Both Bezoar Goat, which is listed as Vulnerable by IUCN and is included in the RA Red Book, and Eurasian Lynx, which is listed as Least Concern by IUCN but is also included in the RA Red Book, have been sighted in the Arshak area on Amulsar, albeit rarely.

On the other hand, Amulsar and particularly Arshak have been confirmed as important breeding habita for Brown Bear. *Ursus arctos* is listed as Vulnerable in the RA Red Book and is also an Annex IV -listed species in the EU Habitats Directive, which means that degradation of its habitat is prohibited under EU law. The presence of Brown Bear is interpreted to trigger critical habitat due to its EU-protected status. Analytical work is ongoing to enable more detailed definition of the critical habitat designation.

4.10.5 Bat Survey and Results

Survey Methods

Available literature was consulted for information on bats in Armenia[7,8]. Yavruyan, *et al*. (2008)[9] noted that the general area within which the Project is proposed provides a rich mosaic of habitats suitable for bat species and identified 28 species for which suitable habitat might be present, including five species listed in the Armenian Red Book. Key habitat features include abundant standing water provided by reservoirs, running water offered by the Vorotan, Arpa and Darb river systems and extensive gorge and basalt batholith habitat which ensures plenty of foraging and roosting habitat.

Bat distribution is affected by air temperature and concentrations of flying insects, and tends to decline with increasing altitude, with few species in the Caucasus region occurring at altitudes higher than 1,500 masl (Yavruyan, *et al*., 2008)[9]. Much of the Project-affected area is too high for intensive bat activity to be likely, but the potential presence of Red Book bat species in the area made further surveys necessary.

Further bat surveys were therefore conducted in May and June 2013 and 2014 by specialists from Golder Associates, Geoteam and the Armenian Institute of Zoology (IoZ). These were carried out in accordance with good practice guidance including Mitchell-Jones and McLeish (2004)[9], Hundt (2012)[10] and the Guidelines for Surveillance and Monitoring of European Bats (EUROBATS, 2010)[11]. Golder undertook an initial field visit and habitat scoping survey from 7 to 18 April 2013, followed by a bat activity survey, static monitoring and walked transect survey from 12 May to 15 June. The IoZ undertook a bat trapping survey in June 2013 with the assistance of Geoteam. Habitat assessment, static monitoring and walked transects were undertaken by Geoteam during April, May and June 2014.

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7 Yavruyan *et al* (2008) Bats – Conservation Action Plan for the Caucasus: http://www.cepf.net/Documents/bat_cons_action_plan.pdf (accessed on 25 May 2013)

8 Update to the National Report on the implementation of the EUROBATS Agreement in the Republic of Armenia: http://www.eurobats.org/sites/default/files/documents/pdf/National_Reports/nat_rep_Arm_2008.pdf (accessed on 10 June 2013)

9 Mitchell-Jones and McLeish. Bat Workers Mannual (3rd Edition), 2004

10 Hundt, L. Bat Surveys: Good Practice Guidelines (2nd Edition), 2012

11 The Agreement of the Conservation of Populations of European Bats (www.eurobats.org), 2010

Walked Transects

The transect routes were walked slowly with a four minute stop at each of ten 'listening stations'. The surveys began at sunset and lasted for approximately two hours. An Anabat SD1 was used to record numbers and species of bats. Any bat calls which were unidentifiable during the survey were later analysed using the 'Analook' software program.

During 2013 three walked transects were undertaken to determine how bats were using the Project-affected area. These crossed the areas proposed for mine infrastructure and also the Arpa Gorge, as shown in Figure 4.10.17. The latter was used for comparative purposes, to provide a benchmark of habitat considered to provide optimal roosting and foraging opportunities for bat species.

During 2014 two walked transects were surveyed to determine how bats were using Project-affected areas (Sites 27 and 28). In addition to these walked transects, Geoteam undertook a survey within the Arpa Gorge to provide a 'control' result for quality assurance purposes. The intention of this survey was to attempt to generate bat sonograms for calibration purposes, using *Anabat* software in a habitat that was considered to be optimal, outside of the Project-affected area.

Ground Level Static Monitoring

Locations of proposed mine infrastructure were also surveyed using static monitoring during May and June 2013 and 2014 using the methods recommended by Hundt, 2012. Locations of monitoring points are shown on Figure 4.10.17. *Anabats* were positioned at proposed infrastructure locations and adjacent to features likely to be used by bats e.g. streams, gorges, built structures etc.

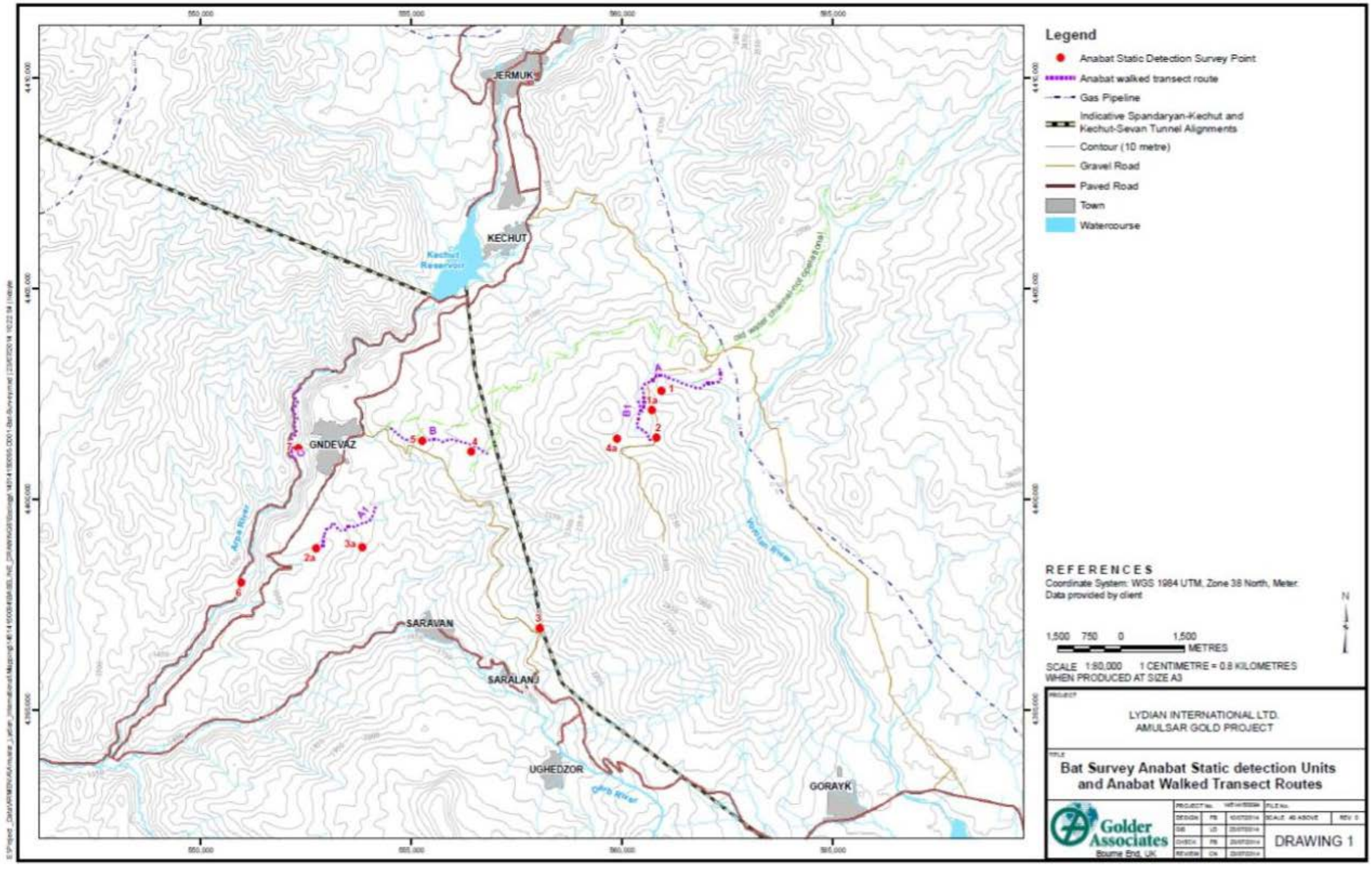


Figure 4.10.17: Bat Survey Monitoring Points

Trapping Survey

The Armenian IoZ carried out trapping surveys during June 2013, led by Eduard Yavruyan[12]. Surveys focused on areas considered to represent suitable bat roosting and foraging habitat within the Project-affected area. Mist nets were used and wing tissue samples were taken from captured bats for DNA sampling. In addition, bat droppings were gathered at roost sites in order to determine the extent and seasonality of roost usage. Bat detectors (Peterson D 230 and Peterson D 240 X) were also utilised during dusk surveys.

Potential roost sites

A scoping assessment was undertaken on 6-18 April 2013 and during May 2014 to search for potential roosts such as:

- Caves and mine adits;
- Cracks and fissures within bedrock features;
- Missing roof or ridge tiles in buildings;
- Holes in the roof or gable ends of buildings; and
- Gaps under the eaves of building roofs.

Results

Detailed findings of the bat surveys are included in Appendix 4.10.4.

Eight species were recorded during the bat surveys, almost entirely in the Arpa or Jermuk Gorge. Figure 4.10.18 is an example of the *Anabat* sonogram recorded in Jermuk Gorge. This may be an important migratory feature for a number of bat species, with abundant foraging and commuting habitat as well as permanent and transient roosts providing safety for bats resting during migratory passage. Species recorded there were *Myotis blythii* (Lesser mouse-eared bat), *Myotis emarginatus* (Geoffrey's bat), *Myotis mystacinus* (Whiskered bat), *Barbastella Barbastella* (Eurasian Barbastelle), *Pipistrellus pipistrellus* (Common pipistrelle), *Tadarida teniotis* (European free-tailed bat), *Nyctalus leisleri* (Leisler's bat) and *Eptesicus serotinus* (Serotine). This number represents around 30% of the bats predicted as being 'likely' to be present in accordance with Yavruyan *et al,* 2008.

[12] Professor of Yerevan State University and Russian-Armenian (Slavonic) who co-authored *Bats, Conservation Action Plan for the Caucasus* (Yaruran *et al*. 2008)

The control results undertaken by Geoteam within the Arpa Gorge revealed the presence of a Pipistrelle species. This result and sonogram generation provides confidence and quality assurance in the negative results that were obtained within the Project-affected area.

Levels of bat activity in the immediate Project-affected area were very low. Although surveys were carried out in sometimes sub-optimal weather conditions, habitats were concluded to be generally sub-optimal for bat species, due to high altitude and lack of structural diversity, linear commuting features or roosting habitat.

None of the species of bat listed within the Armenian Red Book were recorded during the surveys of 2013 or 2014. The eight species of bat recorded are classified by IUCN as being of LC (Least Concern), with the exception of the European barbastelle which is classified as NT (Near Threatened). According to Yavruyan *et al.* 2008, this species is generally restricted to altitudes of <1,900 m in the Caucasus and as such is likely to be absent from the Project-affected area.

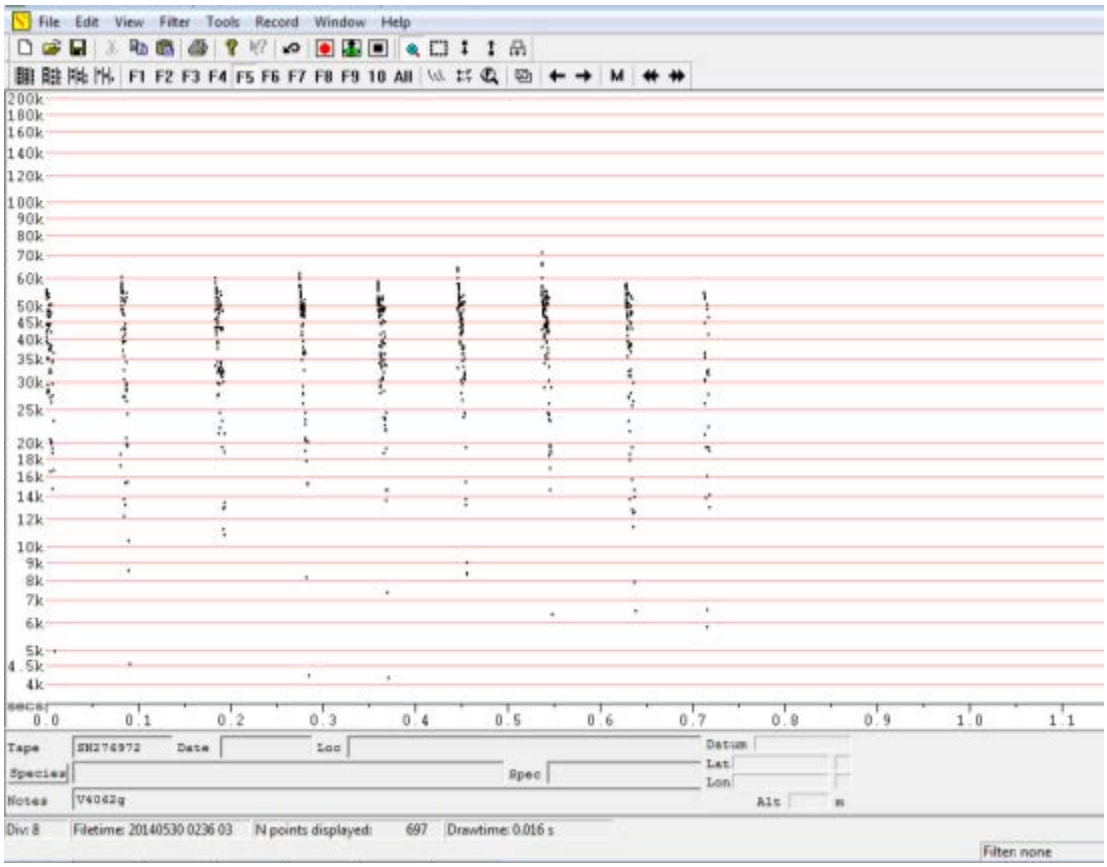


Figure 4.10.18: *Anabat* Sonogram recorded in Jermuk Gorge by Geoteam during 2014 baseline surveys

The Arpa Gorge and the areas proposed for inclusion in the proposed Jermuk National Park provide high quality habitat for bats and are important for maintaining regional populations of several RA Red Book species.

No bats were recorded using the immediate Project-affected area. Habitats were concluded to be generally sub-optimal for bat species, due to high altitude and lack of structural diversity, linear commuting features or roosting habitat.

The species recorded in surveys and those which could potentially use the Project-affected area, despite not being observed in 2013/2014, are 'widespread and abundant' and are not considered to be of conservation concern.

4.10.6 Bird Survey and Results

Survey Methods 2013-14

Six expeditions with a total duration of 16 days were undertaken by the Acopian Center for Environment of the American University of Armenia between February 2011 and March 2012, to collect data on both breeding and migratory birds in and around the Project area. Migratory raptors were observed but not systematically counted. Consultation with representatives of the Armenian Society for the Protection of Birds (ASPB) suggested that the Project-affected area could be important as a stop-over location for migratory raptors. This, together with the regularly observed presence of a species listed as Endangered by IUCN meant that the need for further surveys was identified. A comprehensive survey of migratory birds was undertaken between 15th April and 29th May 2013 by a team of 11 international and Armenian specialists (see Ornithological Report in Appendix 4.10.5) with 466 hours of observation. The autumn migration was also surveyed by six surveyors. The surveys attempted to ascertain the numbers of migratory raptors passing through the Project-affected area and the amount of time they spent feeding, roosting or otherwise using the proposed mine site and its immediate vicinity. Special consideration was given to Egyptian Vulture and other globally threatened raptor species. Migrant raptors were counted from fixed watch points located either side of the main Amulsar massif on hills which gave panoramic views along the Vorotan Valley, and over the western slopes of Amulsar and the Arpa Gorge (see Figure 4.10.19). Slight adjustments had to be made in autumn to observe birds coming from the opposite direction. Counts were made by teams of two to four persons between 08.00 and 17.00 or as weather permitted. Surveys of bird species breeding in the Project-affected area were carried out in

the spring of 2013 and 2014. In spring 2013, detailed searches were carried out for signs of breeding raptors, remaining in the Project-affected area after the migration period was over.

A roving two-man team surveyed the Project-affected area to assess the use of habitats within it by bird species in general or for breeding. The team included surveyors from the ASPB and international surveyors. The Project-affected area was divided into tetrads (2km x 2km survey squares) and these were surveyed to identify any bird species using it for foraging, resting or breeding (see Figure 4.10.20) Each tetrad was visited at least twice, with a minimum of three days between the two visits. For most tetrads, at least one visit was made shortly after sunrise, when bird activity is at its peak. Visits were always made on foot, in a crisscross manner, covering all of the different habitat types present in each square.

All tetrads were surveyed in Spring 2013 and a slightly reduced sub-set in Spring 2014, due to the need for reliable information about new Project-affected areas (more details are provided in Appendix 4.10.5). From 24 May to 2 June 2014 and 6 to 8 June 2014, daily searches were made in tetrads B5, B6, B7, C5 and C6 west of Amulsar ("Site 28"), as well as F7, F8, G7 and G8 south of the massif (set-aside area). In addition, a night drive was made through tetrads B5, B6 and C5 specifically to search for Corncrakes which tend to show nocturnal activity.

Species' breeding status was determined by a simplified and slightly modified version of the British Trust for Ornithology's Bird Atlas 2007-2011[13] as summarised in Table 4.10.9. Presence of a breeding pair of Egyptian Vulture was confirmed in Jermuk Gorge in 2013. In 2014, detailed observations of feeding behaviour were made to determine whether the breeding success of the pair could be affected by development of the Project.

Table 4.10.9: Indicators of breeding status (after BTO 2007 – 2011)
Non-breeding
• Species flying over • Species observed but suspected to be still on migration • Species observed but suspected to be summering non-breeder
Possible breeder
• Species observed in breeding season in suitable nesting habitat • Singing male present in suitable breeding habitat

[13] http://www.bto.org/volunteer-surveys/birdatlas/taking-part/breeding-evidence

Table 4.10.9: Indicators of breeding status (after BTO 2007 – 2011)
Probable breeding
• Pair observed in suitable nesting habitat in breeding season • Permanent territory presumed through registration of territorial behaviour (song, etc.) on at least two different days a week or more apart at the same place • Bird visiting probable nest site • Agitated behaviour or anxiety calls from adults • Nest building or excavating nest-hole • Courtship and display in or near potential breeding habitat
Definite breeding
• Nest building • Adults entering or leaving nest-site in circumstances indicating occupied nest • Recently fledged young (nidicolous species) or downy young (nidifugous species) • Adult carrying faecal sac or food for young • Nest containing eggs or young

In 2013 and 2014, surveyors noted preferred hunting locations for Lesser Kestrel from the breeding colony in Gorayk IBA and a subsidiary colony with approximately eight breeding pairs located in a disused military tower near tetrad F8.

In 2015, incidental sightings of birds were recorded during the Brown Bear survey (see Section 4.10.4) and ecological surveying of the proposed Jermuk National Park.

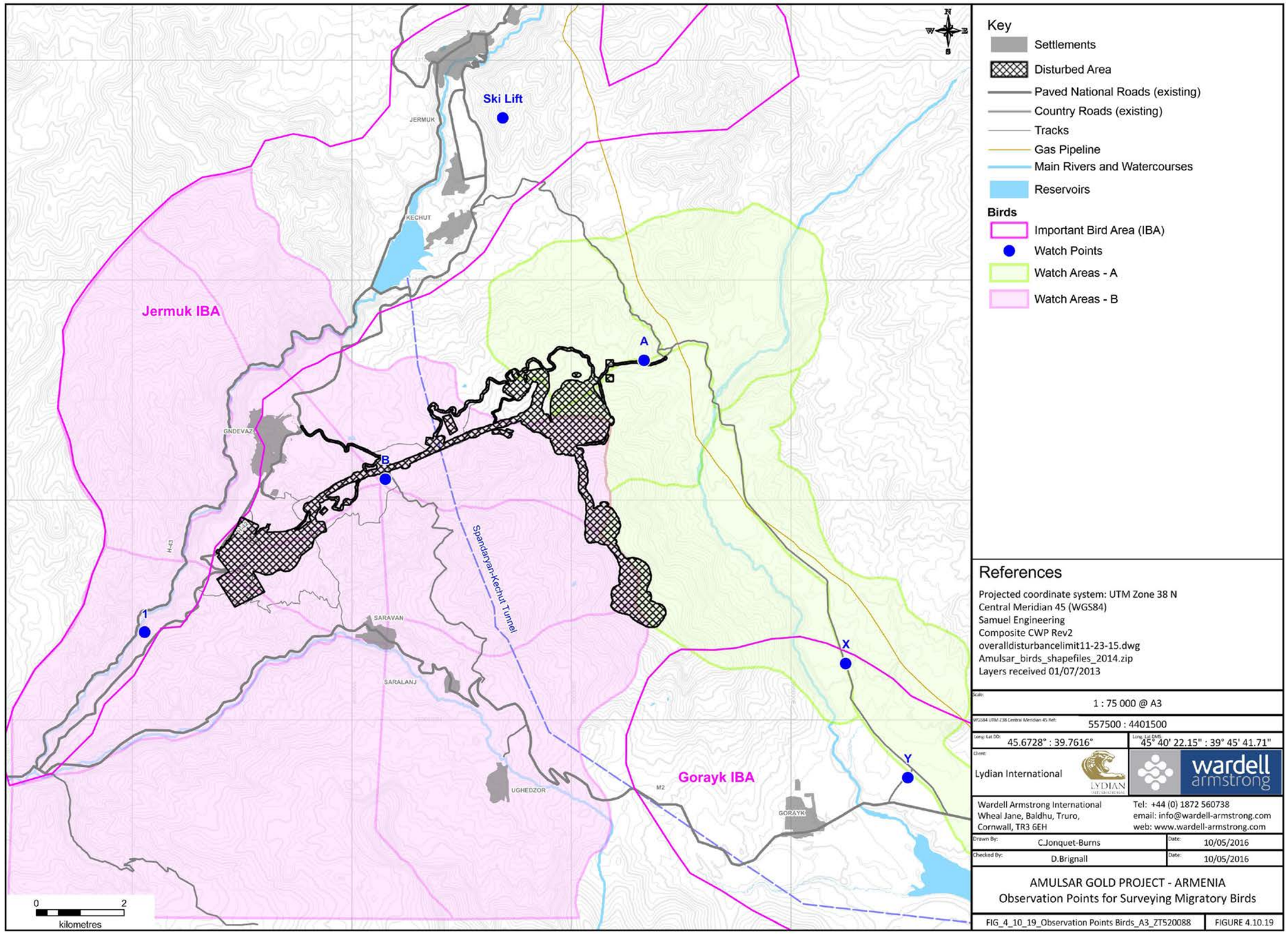


Figure 4.10.19: Observation Points for Surveying Migratory Birds

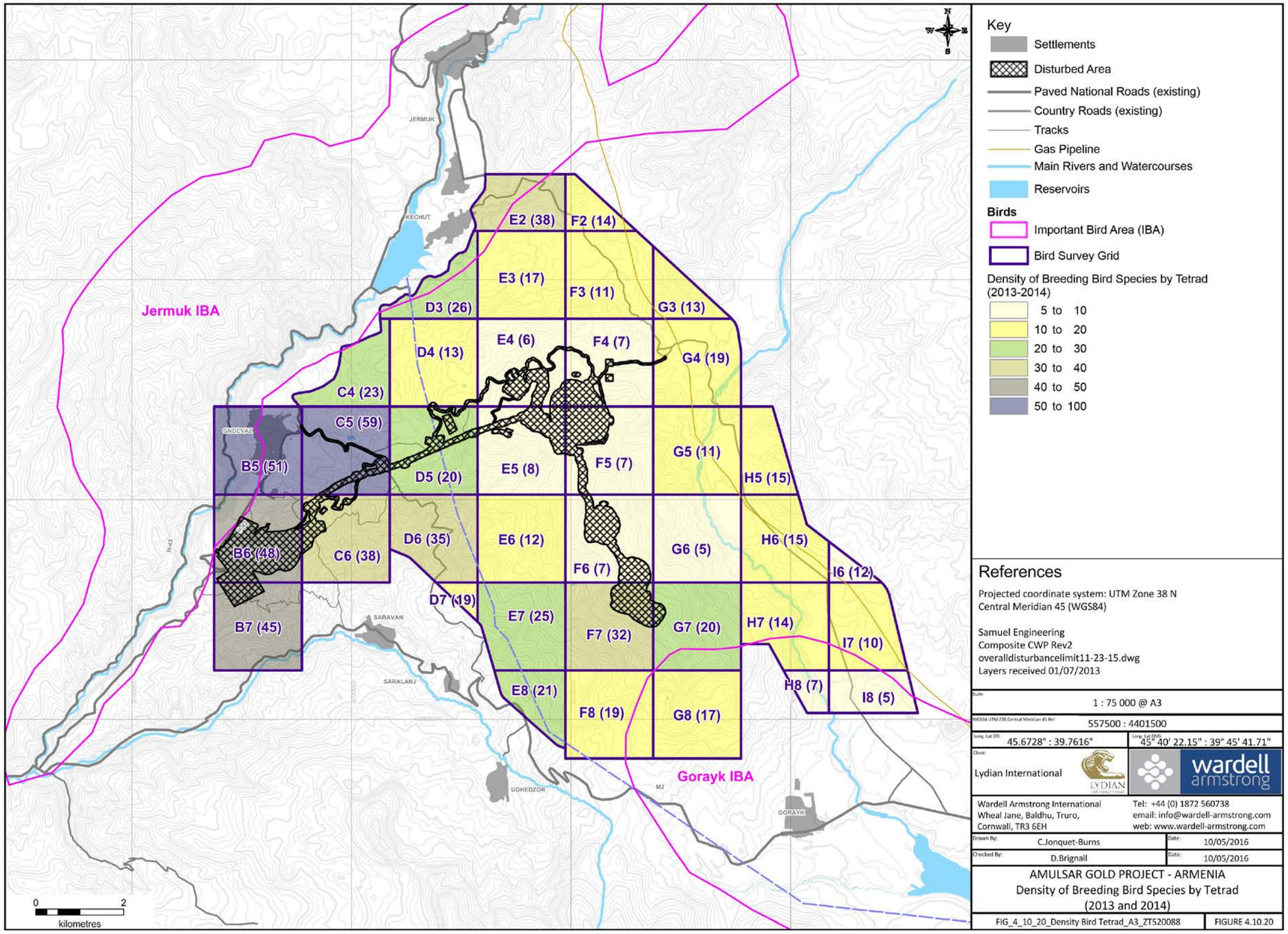


Figure 4.10.20: Density of Breeding Bird Species by Tetrad (2013 and 2014)

Survey Results 2013-14

More detailed descriptions of results can be found in the Bird Survey Reports from spring and autumn in 2013 and spring in 2014, provided as Appendix 4.10.5.

The Project-affected area has high diversity of bird species and has resident and breeding populations of several species which are threatened at national and international level (see Figure 4.10.21). The Project-affected area also provides food and resting areas for species passing through on migration.

Resident and breeding birds

Species composition

Species composition and numbers varied between surveys. A total of 102 species were observed during tetrad surveys of which approximately 85 showed evidence of breeding and 14 are listed in the RA Red Book. Based on both spring surveys, up to 23 species of raptor breed in the Project-affected area (see Table 4.10.10).

Species diversity of breeding birds is particularly high in all of the western tetrads (near the Village of Gndevaz) (see Figure 4.10.21). These include a variety of habitats such as wooded valleys, scattered Juniper shrubs, rocky gorges and small agricultural fields, as well as small water bodies. Tetrad B5 had over 50 species recorded with evidence of breeding, for example. This borders the Arpa Gorge (an Important Bird Area) and has part of another gorge in its south-eastern corner which appears to be an important landscape feature and is affected by the proposed conveyor and access road. Several species listed in the RA Red Book use this for breeding.

There are relatively fewer species breeding on Amulsar Mountain itself, but in some tetrads the assemblage of breeding birds is characteristic of particular habitats. There is a relatively species-rich assemblage of alpine species associated with the area around Arshak Peak which has been less disturbed by exploration activities, for example, and there are several raptor species which nest in a small rocky gorge in close proximity to the proposed conveyor route in tetrad C6.

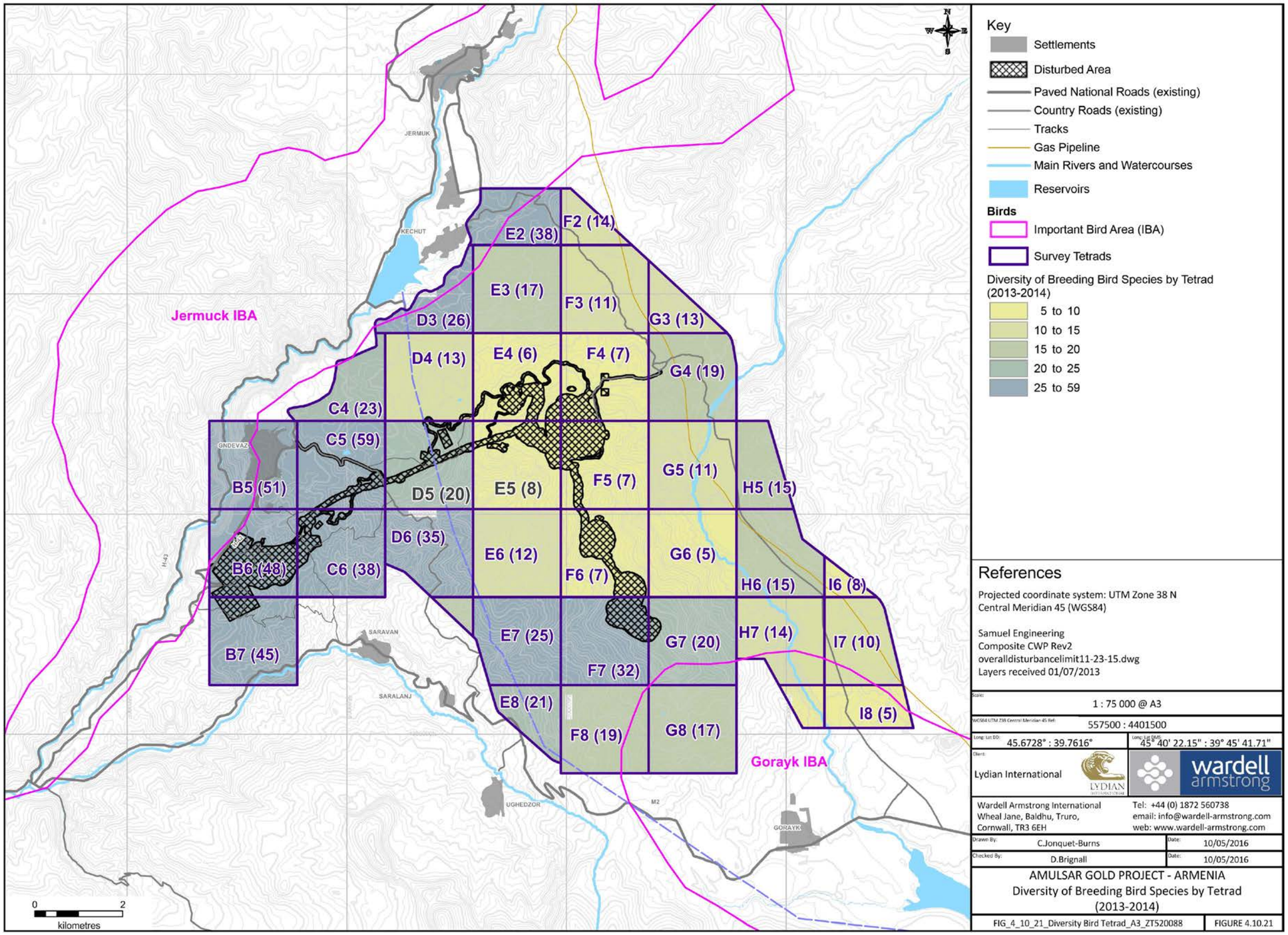


Figure 4.10.21: Diversity of Breeding bird Species recorded by tetrad

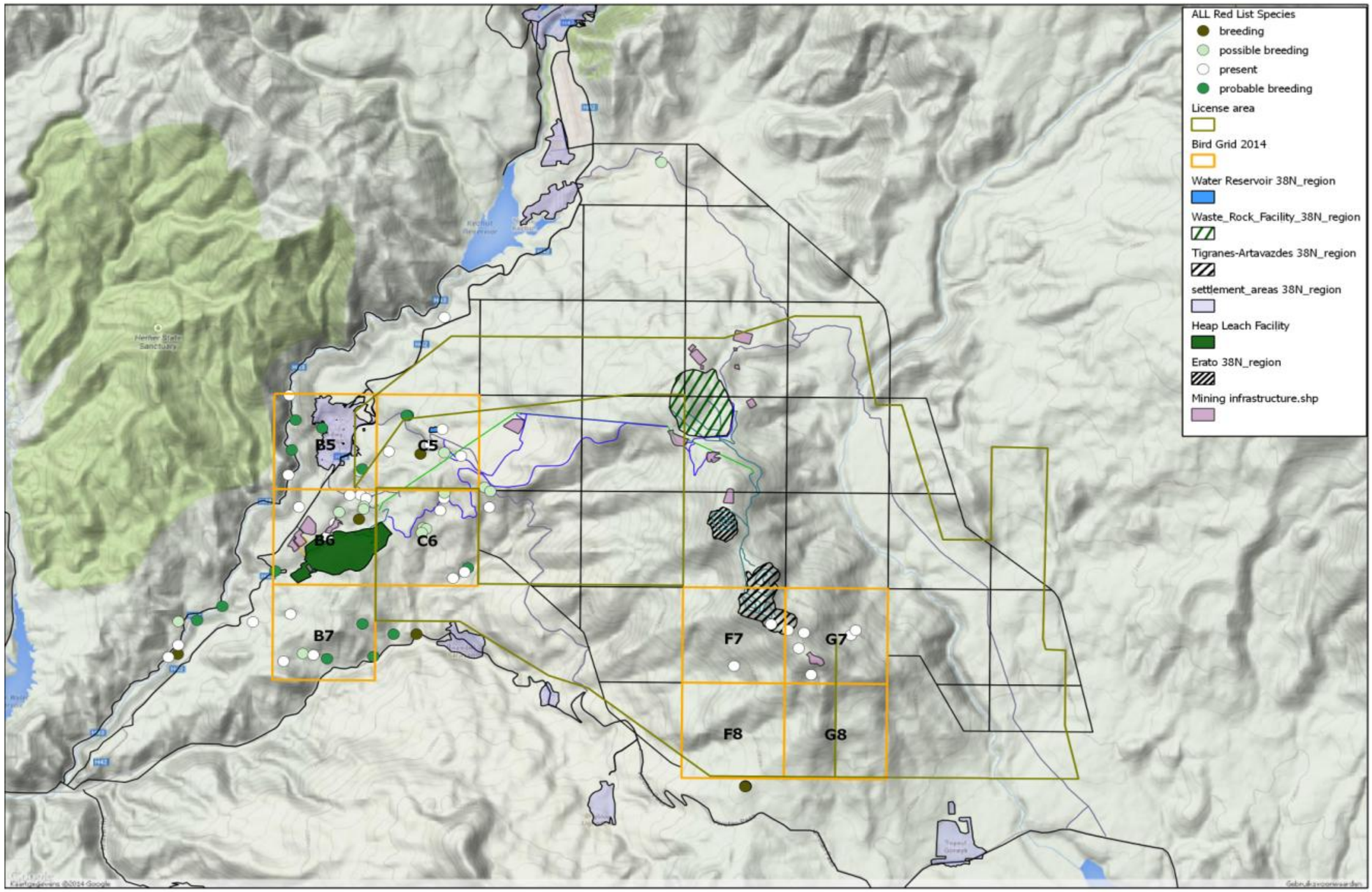


Figure 4.10.22 Point Locations of Red List species observed in Spring 2014

Table 4.10.10: Bird species recorded in the Project-affected area during breeding bird surveys 2013-14 which are included in the RA Red Book, with evidence of breeding activity (see Figure 4.10.21 and Figure 4.10.22)	
Species	**Evidence of breeding**
Booted Eagle (IUCN LC; RA Red Book Vu)	A paired dark phase and pale phase bird seen regularly over Watch Point B and two other pale phase birds present repeatedly suggest there were at least two pairs present in 2013: one probably breeding on steep wooded slopes near Jermuk or in Jermuk/ Arpa Gorge, and another on the wooded slopes near Ughedzor. In 2014, two pairs were probably breeding in Arpa Gorge: one in B5 just west of Gndevaz, and one along the western edge of B6. Single birds were seen hunting in C6 as well as in B6, where one was seen flying around with a snake in its talons. Single birds were also observed around the vulture watchpoint (outside of the survey squares).
Caspian Snowcock (IUCN LC; RA Red Book Vu)	No evidence of breeding in 2013 or 2014 but recorded in both years in the Set-Aside Area on Arshak Peak.
Eastern Rock Nuthatch (IUCN LC; RA Red Book Vu)	This species was found breeding in three survey tetrads: a singing pair was present on the upper slopes of Arpa Gorge just outside the village of Gndevaz (B5), a pair was found at the entrance of the craggy gorge in B6 (where it was also present in 2013), and a singing bird was near the main road in the south-eastern corner of B7. Furthermore, an occupied nest was found along the main road just west of Saravan (tetrad C7) and a family party was present in Jermuk/ Arpa Gorge just northwest of the vulture watchpoint.
Egyptian Vulture (IUCN EN; RA Red Book EN)	A single pair nest in Jermuk/ Arpa Gorge (see more detailed discussion below).
Eurasian Griffon Vulture (IUCN LC; RA Red Book Vu)	No nests found, even in Jermuk Gorge. Maximum of four birds over the western slopes of the massif suggest two pairs, but these appeared to be nesting further north in the Jermuk IBA. Further exploration of this area in 2015 failed to find any signs of breeding, however.
Golden Eagle (IUCN LC; RA Red Book Vu)	Two nests located in Jermuk Gorge in 2013. Heavy use of the north-eastern part of the Vorotan Valley suggests that a third pair were nesting somewhere in that area. In 2014, at least two pairs of Golden Eagles were breeding in Arpa Gorge: a pair was also present in square B5 just west of Gndevaz, and a displaying pair was observed just north of the vulture watchpoint. Single adult birds seen hunting in B6 and C5 probably belonged to either of these two pairs. An adult was also seen perched on a pylon between the H42 road and square B7.
Great Snipe (IUCN NT; RA Red Book Vu)	Observed during breeding bird surveys on top of Tigranes Peak in June 2014, but as the species does not breed in Armenia (Adamian & Klem 1997), concluded to be a late migrant. Several birds on migration also recorded in the Vorotan valley and the valley northeast of the mining exploration camp in spring 2013.

Table 4.10.10: Bird species recorded in the Project-affected area during breeding bird surveys 2013-14 which are included in the RA Red Book, with evidence of breeding activity
(see Figure 4.10.21 and Figure 4.10.22)

Species	Evidence of breeding
Lammergeier (IUCN LC; RA Red Book Vu)	One nest located in Jermuk Gorge. One other pair and possibly another present in 2013 but information provided by ASPB suggests that only one pair breed in the Gorge in any given year despite the presence of multiple pairs. In 2014 single adult birds were observed in tetrads F7, G7, B6 and B7. At least in B7 the bird was using the ground, and was seen feeding (dropping a bone to shatter it on the rocks and eat the bone marrow). A pair was present in Arpa Gorge north of the vulture watchpoint. In March they were seen nesting in the Egyptian Vulture cave (M. Ghasabian *pers. comm.*), but their breeding attempt must have been unsuccessful as no juveniles were observed in spring 2014. They abandoned the nest cave when the Egyptian Vultures returned from their wintering quarters.
Lesser Kestrel (IUCN NT, RA Red Book Vu)	Colony present in the old TV tower east of Gorayk (within Gorayk IBA). Further breeding pairs located in the TV tower west of Gorayk, in Gorayk itself, and in Sisian. ASPB monitors the main breeding colony in Gorayk. As in spring 2013, a small colony of probably eight pairs of Lesser Kestrels was located in a military tower just south of tetrad F8 in 2014. These birds were regularly seen flying into the tetrad and coming back with food for their young (mainly voles). In addition, 8 birds were observed hunting on the grassy slopes of Tigranes (tetrad G7) on 8 June, and a female was seen hunting over the grassy slopes on the eastern side of Arshak (G7 also) on 19 June. Clearly, this small colony uses the grassy slopes of Amulsar to hunt for voles for the young. In this survey, the craggy corrie in G7-G8 seemed particularly important, but also the grassy slopes around it. In 2013, Lesser Kestrels were observed near square F4 (previous location of Barren Rock Storage Facility) hunting intensively in the spring. This was not the case in 2014. The birds appear to use different grassy slopes on the Amulsar massif from year to year depending on availability of prey. In 2013, a lot of effort was made to try to establish a link between the birds feeding near F4 and the birds of the main colony, the TV tower east of Gorayk. A team of observers was posted in the Vorotan Valley to this purpose, but they failed to prove a clear link. It now seems that not enough attention was given to the other, smaller colony in the military tower between Gorayk and Saralanj. It is entirely possible that most of the birds feeding in or near square F4 in spring 2013 were from that small colony, and were also feeding on various grassy slopes on the Amulsar massif, between the colony and the previous location of the barren rock storage facility.
Lesser Spotted Eagle (IUCN LC; RA Red Book Vu)	One nest located in woodland north of ski lift. In 2013 there was a strong indication of two pairs breeding in wooded valleys on south-western slopes of Amulsar (pair mating, adult carrying food into woodland) in tetrad F7; plus two pairs in display flights simultaneously and a territorial interaction between two birds in same area. Repeated presence of a pair over upper part of Vorotan Valley suggests a fourth pair present. This species seemed surprisingly scarce in spring 2014. There was a probable breeding pair in tetrad B7, and one bird was seen hunting frogs in C5. The species was also seen above the Arpa Gorge, south of the vulture watchpoint, but those were the only observations. The species was completely absent from tetrad F7 where it bred in 2013.

Table 4.10.10: Bird species recorded in the Project-affected area during breeding bird surveys 2013-14 which are included in the RA Red Book, with evidence of breeding activity
(see Figure 4.10.21 and Figure 4.10.22)

Species	Evidence of breeding
Montagu's Harrier (IUCN LC; RA Red Book Vu)	In 2013 small numbers were seen and in 2014, only one: an adult male hunting over the grassy slopes of Tigranes Peak (tetrad F7) on 7 June. The ground use and the late date suggest that this was a bird breeding somewhere in the vicinity, but the possibility of a late migrant cannot be excluded.
Northern Goshawk (IUCN LC; RA Red Book Vu)	A few present – no nests located; no estimate of breeding pairs possible but behaviour suggests the species breeds locally.
Peregrine Falcon (IUCN LC, RA Red Book Vu)	A pair of Peregrine Falcons was seen hunting in the southern part of B7 on 27 May 2014. These birds were at 3 km from Arpa Gorge, where a pair bred on cliffs south of the vulture watchpoint and produced two juveniles. Quite possibly the pair in B7 was the same as the one in the gorge as the feeding territory can extend for many miles. In Spring 2013 there was no clear evidence of breeding anywhere near the survey area. The species is a rare breeding bird in Armenia (Adamian & Klem 1997).
Ruddy Shelduck (IUCN LC; RA Red Book Vu)	While in Spring 2013 this species was found breeding in tetrads C5, F7 and G7, it was only present in square C5 in spring 2014, without indication of breeding. Only one bird was observed, near the small water reservoir in the tetrad C5.
Short-toed Snake Eagle (IUCN LC; RA Red Book Vu)	A single pair displaying and hunting regularly over the western slopes of Amulsar in 2013. In 2014, observed in tetrads C5, C6, B7, and G7. A pair was observed hunting over the green valley in the south-eastern corner of C6 and must have been breeding nearby though the nest could not be located. The arid, rocky area north and west of Saravan appears suitable breeding habitat, and there is no shortage of reptiles as a food source.
Spanish Sparrow (IUCN LC; RA Red Book Vu)	A female was seen (and videoed) just west of the H42 road in B6 on 1 June. It was also heard calling. There was no firm evidence of breeding.
White-throated Robin (IUCN LC; RA Red Book DD)	This species was much more numerous in 2014 than the previous year. While the Spring 2013 atlas work only produced three breeding pairs in the whole survey area (35 tetrads), no less than 14 were found in Spring 2014 - in only nine tetrads. Three more pairs were found just outside these tetrads: one in D5, one in D6 and one in C7. As in Spring 2013, the distribution was limited to the western part of the Amulsar region. Here, the species finds wooded valleys, rocky gorges and scattered Juniper trees that form the ideal breeding habitat. In particular, the craggy gorge winding its way through tetrads B6, B5 and C5 seems important to this species; it held four breeding pairs in 2014 and one in 2013.

- During baseline surveys for birds, 102 - 138 species were recorded in spring surveys in 2013 and 2014, with approximately 85 showing evidence of breeding.
- 14 species which are listed in the RA Red Book are believed to breed in the Project-affected area or nearby.
- The areas most important for breeding birds are Arpa Gorge, the area around the southern and western flanks of the mountain and a small rocky gorge east of Gndevaz Village. The area proposed for the HLF shows as having quite a high number of breeding bird species but these are largely concentrated in small wooded valleys towards the edges of the relevant tetrad and not within the HLF location itself.
- There are at least 23 resident raptor species, 14 of which are in the RA Red Book. Seven of these breed in the Project-affected area. Two species are listed as Endangered in the IUCN Red List: Egyptian Vulture and Saker Falcon.
- Some alpine bird species breed on Amulsar mountain, largely in the Set-Aside area on Arshak Peak.

Additional observations of Armenian Red Book bird species in 2015, with evidence of breeding

A) Project-affected area

Observations during the 2015 mammal survey confirmed the continued presence of the species listed in Table 4.10.10. However, Caspian Snowcock, Great Snipe and Spanish Sparrow were not recorded. One pair of Ruddy Shelduck successfully bred in the small gorge east of Gndevaz (bird tetrad C5) raising 10 chicks, and one pair of Montagu's Harrier was breeding close to Gorayk village. The Lesser Kestrels breeding in the TV tower west of Gorayk used the southern slopes of Amulsar for feeding and hunting as in previous years. White-throated Robins were only found in the small gorge east of Gndevaz (tetrads C5-C6): seven pairs were concentrated there. A Red-List species that is under-recorded because it is mainly nocturnal is Eagle Owl *Bubo bubo*. Occasional observations in 2013-15 indicate that this species may breed near the mining exploration camp (bird tetrad F5).

B) Proposed National Park area

The following RA Red Book species were recorded within the boundary of the proposed National Park area in 2015 and could potentially breed:

- Ruddy Shelduck: This species bred at Pokr Al Lake, Azerbaijan, just north of the park boundary. At least two pairs (with ducklings) were present.

- Saker Falcon: One adult was seen near the eastern edge of the park boundary in May 2015, and a second calendary year bird was photographed approximately 7 km north of Jermuk in June. As both observations were in the middle of the breeding season for the species and as suitable habitat is present in the park area the species could potentially breed, but it is also a wide-ranging hunter so the breeding area could be well outside the park.
- Lanner Falcon: One second calendar year bird was photographed near the eastern border of the park area in July 2015. It may have been a wandering or dispersing individual; no signs of breeding were found.
- Lammergeier: Regularly observed throughout the whole park except for the Herher area.
- Egyptian Vulture: Three birds observed together in the northeastern part of the park in June 2015. Lack of further observations suggests that these may have been wandering or dispersing birds though, rather than breeding nearby.
- Griffon Vulture: Small numbers of this species were observed throughout the whole park area in July – August. No evidence of local breeding.
- Black (Cinereous) Vulture: Occasional birds observed in Herher State Sanctuary, west of Jermuk, and approximately 7 km north of Jermuk in July – August. These may have been post-breeding wanderers from other parts of Armenia (or even further away), although suitable habitat is present in the Herher area, where the species formerly bred.
- Lesser Spotted Eagle: Small numbers present, mainly in the northern half of the park area. Probably breeds in the wooded valley west of Kechut Lake as well as in the wooded Arpa valley north of Jermuk.
- Golden Eagle: Small numbers present, especially in the northwestern part of the park. Continued presence of several birds throughout the breeding season suggests breeding somewhere in this area.
- Booted Eagle: Small numbers present. May breed in the wooded valleys west of Kechut Lake and north of Jermuk. Suitable habitat is also present in the southeastern part of the park area.
- Great Snipe: Three birds seen together in the northern part of the park area in May 2015 were probably migrants.
- Armenian Gull: Small flocks of this species were found feeding near herder's camps in the northern part of the park area. The species is not known to breed in the area

but it seems attracted to the lakes full of fish in Azerbaijan, just north of the park, and to disperse from there.

- Eurasian Eagle Owl: This species was recorded by one of our cameras west of Kechut Lake. Also, one bird was found dead just north of Jermuk town. There is a lot of suitable habitat in the park but nocturnal surveys would be needed to get an idea of the number of breeding pairs.
- Eastern Rock Nuthatch: At least one breeding pair was present, in Arpa gorge just west of Gndevaz village.

Individual species

Some individual species were considered in more detail to enable impacts on their populations to be predicted. This included Lesser Kestrels (from Gorayk IBA and a smaller colony established in a disused military tower beween Gorayk and Saralanj), Egyptian Vulture and Saker Falcon.

Lesser Kestrels from the small colony between Gorayk and Saralanj appear to depend on the high, grassy slopes of the Amulsar massif for food, also using other areas on the western slopes of Amulsar in autumn. Lesser Kestrels from the main colony in Gorayk IBA appear to depend more on hunting within the Vorotan Valley and may concentrate their activity more on the eastern side of Amulsar Mountain. Birds from both colonies therefore hunt in Project-affected areas. The ASPB is exploring options to fit radio-trackers to some birds to improve monitoring ability, in partnership with Lydian / Geoteam.

Both Egyptian Vulture and Saker Falcon are classified on the IUCN Red List as Endangered and therefore need careful consideration. The ASPB estimates the population of Egyptian Vultures breeding in Armenia to be around 55-60 pairs, though reliable monitoring data are not available. Historical data suggest that 2-3 pairs of Egyptian Vultures nested in Jermuk IBA in 1995[14] and 1-2 pairs in Gorayk IBA also in 1995[15]. Numbers of pairs breeding in the area appear to have declined since, to the point where only one pair was found in this survey. The closure of the chicken farm in Gndevaz in 2011 and the removal of this source of food (discarded carcases) from the area may have been a factor in this decline. Increasing levels of

[14] http://www.birdlife.org/datazone/sitefactsheet.php?id=19757
[15] http://www.birdlife.org/datazone/sitefactsheet.php?id=19755

disturbance during mine exploration is another possible factor. The national population is currently estimated at 50-55 pairs.

A single active nest of Egyptian Vulture was located in Jermuk Gorge in May 2013. The Natural and Critical Habitat Assessment (Appendix 4.10.3) concluded that the Project-affected area was not within critical habitat for Egyptian vulture, as the affected population does not meet the thresholds in PS6. However detailed observations of feeding patterns were made to determine whether the breeding success of the pair could be adversely affected, in line with a precautionary approach, as the number of breeding pairs appears to have declined from three to one.

The breeding pair occasionally searches for food in the Project-affected area. In total, 23 "bird-days" of observations were made for this species during the Spring 2013 survey period. In addition, a single bird, believed to be a migrant, was seen low over the ground on 6th May, and single birds were seen migrating at altitude on 7th and 9th of May. In Spring 2014 detailed observations were made of the feeding patterns of the adult birds. The pair of vultures spent most of their time (71%) in the Arpa gorge, near the nest site. They only used the areas proposed for Project infrastructure for 10% of the time they were observed being active, even less than the 18% recorded in Spring 2013. In Spring 2014, the birds were seen using the ground within the survey area on only three occasions. On seven more occasions birds were seen soaring above the survey area, sometimes quite low, but never picking up food from the ground. By contrast, the birds were seen perched or landing in Arpa Gorge or in fields nearby on 26 occasions. The ground use locations and observed flight paths were mapped and are provided in Appendix 4.10.5. When looking for food, the adult birds seemed to prefer flying above Arpa Gorge or above the H42 road, although the male was also seen flying off north to northwest into the hills of Herher State Sanctuary on four occasions.

- There is one remaining pair of Egyptian Vulture breeding in Jermuk/ Arpa Gorge. The Project-affected area is not considered to be within critical habitat for this species according to the criteria in PS6. Detailed observations suggest that the birds use the areas proposed for project infrastructure a very small proportion of the time, concentrating their activity on the Jermuk/ Arpa Gorge and areas within Jermuk IBA. This was estimated as 18% in 2013. In 2014, the pair of vultures spent most of their time (71%) in Jermuk/ Arpa Gorge, near their nest site and only used the Project-affected area for 10% of the time they were observed being active.
- No nests of Saker Falcon were found. There was a small number of infrequent sightings of birds which may be resident.
- The Lesser Kestrel breeds in a main colony in Gorayk IBA and a subsidiary colony between Gorayk and Saralanj. Breeding colonies will not be affected, but birds from both colonies hunt in Project-affected areas including grassy slopes at higher elevations on Amulsar Mountain.

Significance of the raptor migration

Species and numbers of birds flying over the Project-affected area or using it to feed or rest were counted in spring and autumn of 2013.

The species observed were similar in both seasons. In terms of the national and IUCN Red Lists species observed were the same, apart from Red Kite, which was not observed in the Autumn survey. A detailed breakdown of the species observed is available in the Spring and Autumn 2013 Bird Survey Reports included in Appendix 4.10.5.

In both seasons, species migrating over the Project-affected area included several species which are included on the IUCN or RA Red Lists. Four species are listed as Endangered in the RA Red Book (*Neophron percnopterus, Aegypius monachus, Circus macrourus* and *Falco cherrug*) and two of these are also listed as Endangered in the IUCN Red List (*Neophron percnopterus* and *Falco cherrug*). Thirty-one species recorded on migration in Autumn 2013 are listed as Vulnerable in the RA Red Book (see Table 4.10.11).

Table 4.10.11: Bird Species recorded on migration in autumn 2013 and their status in the IUCN Red List and RA Red Book				
	Scientific name	**Common name**	**IUCN Status**	**ARDB Status**
1.	*Phalacrocorax carbo*	Great Cormorant	LC	VU
2.	*Pelecanus onocrotalus*	Great White Pelican	LC	VU
3.	*Ciconia nigra*	Black Stork	LC	VU
4.	*Tadorna ferruginea*	Ruddy Shelduck	LC	VU
5.	*Gypaetus barbatus*	Lammergeier	LC	VU
6.	*Neophron percnopterus*	Egyptian Vulture	EN	EN
7.	*Aegypius monachus*	Black Vulture	NT	EN
8.	*Circaetus gallicus*	Short-toed eagle	LC	VU
9.	*Circus macrourus*	Pallid Harrier	NT	EN
10.	*Circus pygargus*	Montagu's Harrier	LC	VU
11.	*Accipiter gentilis*	Northern Goshawk	LC	VU
12.	*Accipiter brevipes*	Levant Sparrowhawk	LC	VU
13.	*Aquila pomarina*	Lesser Spotted Eagle	LC	VU
14.	*Aquila clanga*	Greater Spotted Eagle	VU	VU
15.	*Aquila nipalensis*	Steppe Eagle	LC	VU
16.	*Aquila heliaca*	Imperial Eagle	VU	VU
17.	*Aquila chrysaetos*	Golden Eagle	LC	VU
18.	*Hieraaetus pennatus*	Booted Eagle	LC	VU
19.	*Pandion haliaetus*	Osprey	LC	VU
20.	*Falco naumanni*	Lesser Kestrel	LC	VU
21.	*Falco vespertinus*	Red-footed Falcon	NT	VU
22.	*Falco biarmicus*	Lanner Falcon	LC	DD
23.	*Falco cherrug*	Saker Falcon	EN	EN
24.	*Falco peregrinus*	Peregrine Falcon	LC	VU
25.	*Crex crex*	Corncrake	LC	VU
26.	*Anthropoides virgo*	Demoiselle Crane	LC	VU
27.	*Glareola pratincola*	Collared Pratincole	LC	VU
28.	*Glareola nordmanni*	Black-winged Pratincole	NT	VU
29.	*Numenius arquata*	Eurasian Curlew	NT	VU
30.	*Larus armenicus*	Armenian Gull	LC	VU
31.	*Bubo bubo*	Eurasian Eagle-owl	LC	VU
32.	*Coracias garrulus*	European Roller	NT	VU
33.	*Motacilla citreola*	Citrine Wagtail	LC	VU
34.	*Sitta tephronota*	Eastern Rock-nuthatch	LC	VU
35.	*Lanius senator*	Woodchat Shrike	LC	VU

In terms of numbers, 4,536 individual raptors of 28 species migrated through the Project-affected area between 15th April and 29th May 2013 inclusive. Between 22 August and 14 October 15, 110 birds were counted (see Appendix 4.10.5, Spring 2013 Survey Report for further details). This included 8,508 migrating raptors of 27 different species. The total number of birds migrating past the Project-affected area in Spring and Autumn was considered to be below the thresholds needed to identify the area as critical habitat, as

defined by IFC PS6 and EBRD PR6. A similar number of birds on migration passes through Batumi (a confirmed international "bottle-neck") each day. The Project-affected area does not constitute critical habitat in terms of the numbers of migratory birds it supports or in terms of the numbers of any individual species.

The surveys also looked at the proportion of time birds spent on the ground in the Project-affected area in both migrations. Although the Project-affected area is of undoubted importance for migratory birds, it does not constitute critical habitat per PS6/ PR6 in terms of the significance of the habitat it provides for birds on migration in relation to the overall habitat available. In Autumn 2013, for example, 476 birds out of 15,110 migrating birds were noted as using the survey area to feed and rest: 3% of individuals from all species and 6% of migrating raptors. Use of the Project-affected area varied between species, however, with harriers and falcons using the area regularly, notably Lesser Kestrel, Pallid Harrier, Montagu's Harrier, Red-footed Falcon and Merlin. Pallid Harrier (listed as Endangered in the RA Red Book) showed preferential use of the Vorotan Valley and the revised Project layout is preferable for this species.

Egyptian Vulture and Saker Falcon (IUCN Endangered) on migration spent a negligible amount of time using the Project-affected area.

Key areas for bird species

Certain key areas for birds have emerged from the ornithological survey (see Appendix 4.10.5). These are:

- An area of montane habitat about 1km south of Arshak with craggy rock outcrops and a mountain lake. This area holds an assemblage of montane species not observed anywhere else in the Amulsar area including Ruddy Shelduck, Caspian Snowcock, Asian Crimson-winged Finch, White-winged Snowfinch, Alpine and Radde's Accentors, Red-billed Chough, Eurasian Crag Martin, Common Rock Thrush, Horned Lark, and Ring Ouzel.
- The lower slopes of the western side of the massif, below an altitude of about 2,300m. In particular, the wooded valleys and associated shrublands and flower-rich meadows support a high diversity of birds.
- A rocky gorge south east of Gndevaz Village in which a number of species listed in the RA Red Book breed.

- Pools and wetlands with birds such as Corncrake and Ruddy Shelduck breeding.
- Arpa Gorge where Egyptian Vulture and other raptor species nest.

In both Spring and Autumn of 2013, migrating raptors preferred to pass west of Amulsar Mountain, with approximately three times as many birds counted from watchpoint B to watchpoint A. Only three species were more numerous on the eastern side of the mountain: Eurasian Sparrowhawk, Northern Goshawk and Pallid Harrier. At least on a national level, the Vorotan Valley appears to be an important migration corridor for Pallid Harrier, though on a global level, the number of birds using the ground did not meet the 1% threshold for determination of critical habitat (see Appendix 4.10.3).

4.10.7 Terrestrial Invertebrate Surveys and Results

Survey Methods

Terrestrial invertebrate surveys took place in both Spring/Summer of 2011 and May/June 2013. Traditional methods of entomological surveying were used for determining the species composition of test taxons: hand collection from vegetation, collection from under stones and the soil surface, net collection, shaking out of plants, etc. In 2011, surveys were conducted to establish the presence of:

- Butterflies: 17 counts were made on nine routes following the technique known as the 'Pollard Walk' (Pollard 1977, Pollard & Yates 1993) as shown in Appendix 4.10.6 and on Figure 4.10.23;
- *Odonata* spp. (dragonflies/damselflies): three counts along three transects in July 2011 following the sampling technique of Smallshire & Beynon (2010) as shown in Appendix 4.10.7;
- *Carabidae* beetles were sampled using soil trapping (25 traps used) and additional searches under stones (see Appendix 4.10.7);
- *Cerambicidae* beetles following the same routes as used for butterflies; and
- Willow hawk-moth: quadrat sampling of five patches of the species' host plant (*Epilobium* sp.).

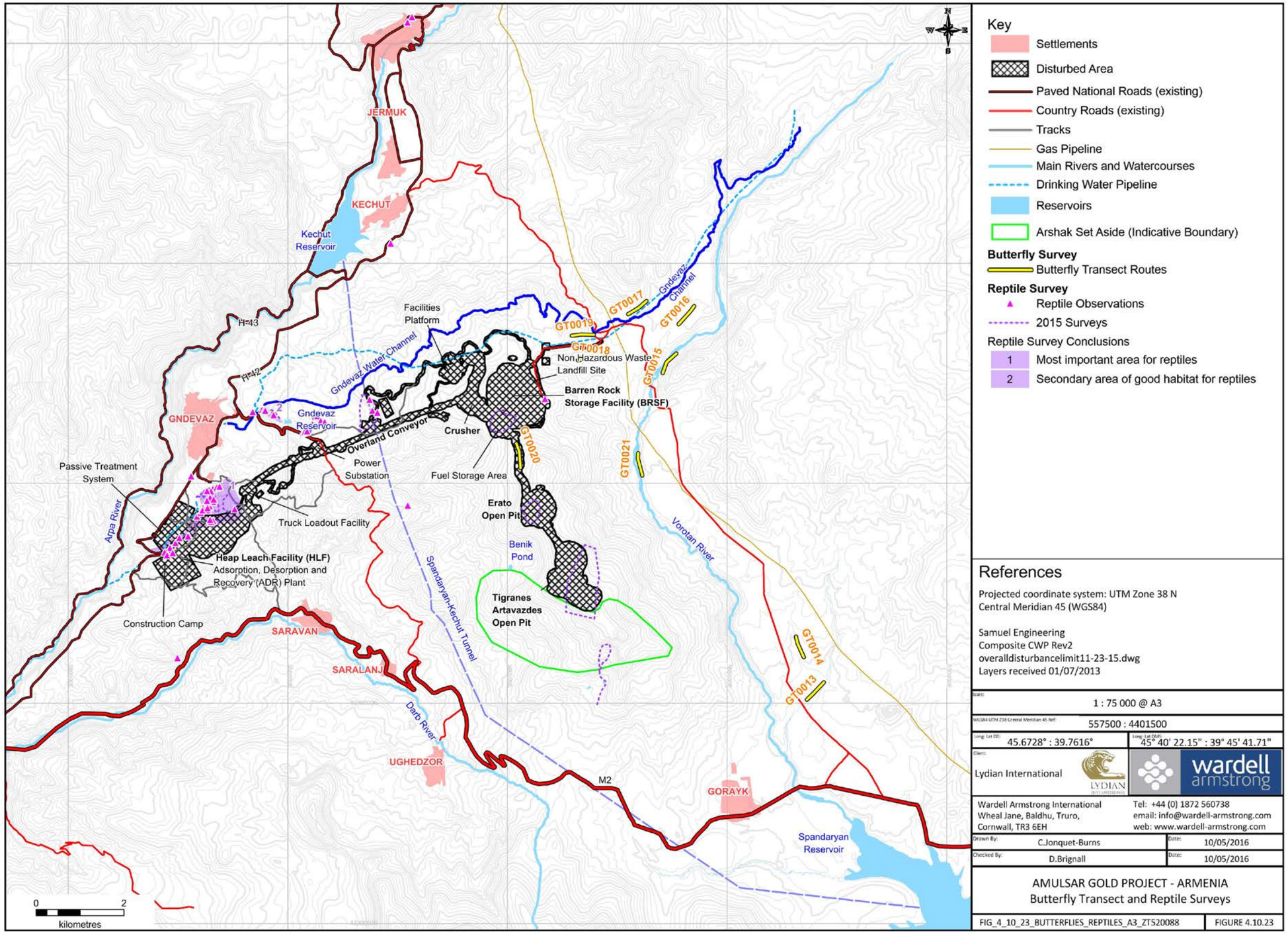


Figure 4.10.23: Butterfly Transect Routes

In 2013, the surveys focussed mainly on *Coleoptera* (beetle) spp. but also recorded butterfly species observed during the beetle surveys. These surveys were conducted in three locations:

- Near the village of Gorayk (Vorotan River basin) - N39.682095^0 E45.77747^0 (alt.2073 m) -> N39.722590^0 E45.756223^0 (alt.2328 m);
- Near Gndevaz village (Arpa River basin) - N39.75146^0 E45.65406^0 (alt.2140 m) N39.75011^0 E45.66174^0 (alt. 2225 m);
- Near Ughedzor village (Arpa River basin) - N39.70265^0 E45.688118^0 (alt. 2060 m) -> N39.69559^0 E45.68208^0 (alt. 2000 m).

Specimens of beetles were identified by comparing with the national archive collection. However, some hard-to-divide species were identified only to the genus level.

Results

Field surveys identified 60 species of butterfly within the study area, including *Parnassius apollo* (Apollo butterfly). This was the only species recorded which is listed in the IUCN Red List (as Vulnerable). Its preferred habitat was formerly affected by the BRSF location, but this has now been relocated.

Six species of *Odonata* (dragonflies and damselflies) were identified - three species of damselfly and three species of dragonfly along the surveyed transects: *Libellula depressa* (Broad bodied chaser), *Libellula quadrimaculata* (four spotted chaser), *Sympetrum flaveolum* (Yellow Winged darter), *Enallagma cyathigerum* (common blue damselfly), *Coenagrion lunulatum* (Irish damselfly) and *Lestes dryas* (emerald spreadwing).

One hundred and twenty-nine species of *Coleoptera* (beetle) species (including *Carabidae* and *Cerambicidae*) belonging to 21 families were collected during the surveys in 2013 (see Appendix 4.10.7). One species of beetle, *Dorcadion bistriatum Motsch*, listed in the RA Red Book, occurs in the area, and was recorded in the vicinity of Ughedzor (at N39.69907 E45.68325 (1986 m), N39.69547 E45.68183 (1969 m), and in the Gorayk area (at N39.68633 E45.77833 (2120 m), N39.717956 E45.76265 (2245 m)). This species was also recorded during the 2011 survey. Other recorded beetle species of significance included two Armenian endemics, six Trans-Caucasus endemics and six Caucasus Ecoregion endemics. Of these 14 species, *Dorcadion sisianum Lazar* and *Dorcadion scabricolle sevangense* (also recorded in 2011) are the most vulnerable endemics of Armenia and are a conservation priority.

Dorcadion sisianum Lazar is described from this area and has a strictly limited occurrence reaching eastwards towards the village of Sarnakunk. The second species is known from some locations on the southern slopes of the Vardenis Range. Both are known from the Gorayk area; the record points are as follows: *Dorcadion sisianum* (at N39.683740 E45.779255 (alt. 2075 m); N39.686373 E45.777553 (alt. 2115 m); N39.698805 E45.777773 (alt. 2148 m)) and *Dorcadion scabricolle sevangense* (at N39.684863 45.777996 (alt. 2091 m); N39.695689 E45.777311 (alt. 2140 m)). These species are apterygial (without wings) and spread over land: they are believed to live in the areas between the mentioned points, forming single populations. They have not been observed in the vicinity of proposed Project infrastructure.

Willow hawk moth occurs in the area, although not in as high density as usually found in other regions of Armenia (e.g. Aghababyan, Danchenko, Khanamiryan, unpublished data). This species has previously been listed on the IUCN Red List as Vulnerable (1994) but is listed as 'Data Deficient' in the latest version. It was not observed in the vicinity of proposed Project infrastructure.

The Project-affected area is important for Coleoptera - 129 species of beetle belonging to 21 families were collected during surveys in 2013, which is a very rich assemblage. One species of beetle, *Dorcadion bistriatum Motsch*, listed in the RA Red Book, occurs in the area, and was recorded in the vicinity of Ughedzor in 2011 and 2013 and in the Gorayk area. Other notable beetle species include two Armenian endemics, six Trans-Caucasus endemics and six Caucasus Ecoregion endemics. Of these 14 species, *Dorcadion sisianum Lazar* and *Dorcadion scabricolle sevangense* (also recorded in 2011) are the most vulnerable endemics of Armenia and are a conservation priority. These both occur in the Gorayk area, outside the Project Footprint.

A rich butterfly assemblage including Apollo butterfly *Parnassius Apollo* was recorded but not within the current proposed layout.

4.10.8 Freshwater invertebrates

Survey Methods

A survey of the Vorotan River and its tributaries was undertaken in 2009 to identify freshwater invertebrates, with further surveys in 2011 and 2013. In 2014, additional areas were included, giving an overall study area which is bounded broadly by the valley of the Vorotan River to the east, the Arpa River to the west and the Spandaryan reservoir to the south. Surveys focused in particular on the Vorotan, Arpa and Darb catchments both upstream and downstream of the potential Project-affected area. Relevant literature was reviewed and a

number of sampling stations were identified including 19 aquatic ecology stations and five fisheries stations within a variety of meso-habitats.

A common method for the assessment of water quality is the Biological Monitoring Working Party (BMWP) index. This gives a score to freshwater habitat based upon the number of families of macroinvertebrates found in a sample. It works on the basic principle that freshwater pollution levels affect macroinvertebrate families differently. Thus, certain families that are most susceptible to pollution score maximum points. These include many families belonging to the mayflies (Ephemeroptera), stoneflies (Plecoptera) and caddis (Trichoptera). Conversely, those families tolerant of polluted waters score the least points, and include families such as the leeches (Hirudinea), worms (Oligochaeta), chironomid midges (Diptera) and the freshwater hog-louse (Isopoda). Accordingly, high scoring watercourses are the cleanest with the highest water quality, whilst polluted watercourses score the lowest.

A standard methodology for obtaining BMWP scores was adopted. This involved one minute of hand searching (of rocks, leaf packs, and other submerged debris), followed by three minutes of kick sampling across each aquatic ecology (AE) Station. Kick sampling typically covers a distance of 10 to 20m of stream across each identified AE Station. The surveys were undertaken in general accordance with United Kingdom and European Union best practice guidelines for sampling (BS-EN 27828:1994). The net used for sampling conformed to European Union Water Framework Directive standards (1 mm mesh and 0.5 m deep). The sample was then placed into a sorting tray and all coarse debris was carefully checked and then removed prior to placing the remaining contents into a collection jar for identification by the NAS RA Institute of Zoology (IoZ) under laboratory conditions (see Figure 4.10.24).

The aquatic macro-invertebrate groups covered by the BMWP system were identified to species level where possible and all were identified to family level. The identification was undertaken by Evelina Ghukasyan, Director of the Armenian IoZ.

Total counts of all invertebrate taxa were made and abundance bandings applied for ease of interpretation. In addition, all macroinvertebrates were screened against the IUCN Red List and also the Armenian Red Book. Assessment as to the presence of any endemic species was also provided.

BMWP (original and revised) and Average Score Per Taxon (ASPT) were assigned to each AE

station to give an indication of water quality. The number of scoring taxa was also determined since this provides an indication of invertebrate (taxon) richness associated with each AE location. However, it is important to note that taxon richness is not necessarily indicative of water quality.



Figure 4.10.24: Sorting aquatic invertebrate samples on the bankside

Results

The survey of water macroinvertebrates revealed mainly representatives of *Plecoptera, Ephemeroptera, Trichoptera, Gammarus, Dugesia*, and at some points – *Dugesia* and *Chironomus* (see Appendix 4.10.8).

No aquatic invertebrate species listed on the IUCN Red List or the Armenian Red Book were collected within the samples analysed. Three species of aquatic invertebrate were assessed to have endemic characteristics at the Caucasus region level as defined by the Armenian IoZ. These species were *Habroleptoides caucasicus*, from the Mayfly family and *Drusus caucasicus* and *Hydropsyche pellucidula* from the caddis family. The abundance and quality of aquatic habitat within the Project-affected area and the broader region is likely to ensure that these

species are well distributed throughout the Caucasus region. None fulfil criteria for endemic or restricted range species as defined by the guidance notes to IFC PS6 (IFC, 2012).

Aquatic invertebrates provides a useful basis for monitoring impacts of the Project on water quality in the rivers potentially affected by abstraction or discharges. As defined by Golder in its 2013 study, the aquatic ecology baseline for the sampling stations ranged from 'Poor' to 'Clean' with the majority of the stations being classified as 'Fairly Clean' in accordance with the table below. Waterbodies that scored lowest were generally small ephemeral feeder streams or watercourses that were subject to high mineralisation rates from groundwater influence.

Indicative Water Quality Designation of BMWP Scores

Designation	Very Clean	Clean	Fairly Clean	Moderate	Poor
BWMP score	>150	100 to 150	50 to 99	26 to 49	<25
Number of samples (out of 15)	0	2	8	2	3

Revised BMWP scores ranged from 10.6 (Vorotan River tributary) to 101.5 (Vorotan main river). BMWP scores were generally supressed in small ephemeral feeder streams and elevated on main rivers. The fact that many of the feeder streams dry up for much of the year dictates that aquatic invertebrate life is likely to be inhibited by a lack of aquatic habitat on a seasonal basis. Low BMWP scores were, at times, aligned with high ASPT scores. This was the case for one sampling point on the Darb River, for example. This result indicates that species diversity is low, but the species that are present are 'high scorers' (e.g. pollution intolerant).

No freshwater invertebrate species listed in the RA Red Book or the IUCN Red List were found during hydrobiological research. Three regional endemic species were found, all of which are considered to be relatively widespread. BMWP scores are generally indicative of "fairly clean" water conditions.

4.10.9 Reptiles and Amphibians Surveys and Results

Survey Methods

A review of available literature revealed that no previous herpetological field studies have been undertaken to identify species of reptile and amphibian in Amulsar. Incidental sightings

were recorded during the course of other field surveys undertaken between 2008 and 2011, and again in 2013.

In 2015, an additional baseline survey was undertaken for reptiles and amphibians at Amulsar by TEC. The survey focused on the proposed Project footprint plus nearby areas considered potentially favourable for vipers (see Appendix 4.10.10).

Results

Two amphibian species were recorded as present: *Bufo viridis* (Green Toad) and *Rana macronemis* (Long Legged Wood Frog). Both are widespread in mainly wetlands. Neither are included in the RA Red Book.

Based on field activities and review of the literature, the following species of reptiles have either been observed or are considered likely to be present in the Project-affected area: *Hemorrhois (Coluber) ravergieri* (Ravergier's (multicolor) Whip Snake), *Coronella austriaca* (Smooth Snake), *Platyceps (Coluber) najadum* (Dahl's Whip Snake), *Natrix tessellata* (Dice Snake), *Elaphe sauromates/quatuorlineata* (Blotched Snake/Eastern Four-lined Rat Snake), *Dolichophis schmidti* (Schmidt's Whip Snake), *Eirenic modestus* (Ring-headed Dwarf Snake), *Eirenis punctatolineatus* (Dotted Dwarf Snake), *Telescopus fallax* (Cat Snake), *Pelias (Vipera) eriwanensis* (Armenian Mountain-steppe Viper), *Montivipera raddei* (Armenian Viper or Radde's Viper), *Macrovipera lebetina* (Levantine Viper), *Eryx jaculus* (Western Sand Boa), *Pseudopus apodus* (European Glass Lizard), *Lacerta vivipara* (Average Lizard), *Darevskia valentini* (Valentine's Rock Lizard), *Lacerta media* (Eastern Three-lined Lizard), and *Laudakia caucasia* (Causcasian Rock Agama).

Three reptile species (Armenian Mountain-steppe Viper, Radde's/Armenian Rock Viper, and Cat Snake) are listed in the RA Red Book as Vulnerable, and the two viper species are listed on the IUCN Red List as Vulnerable and Near Threatened, respectively.

The greatest diversity of reptiles associated with Amulsar Mountain is between 1600 and 1700 masl, where diverse habitats occur, including stony slopes with open bushy vegetation and rocky outcrops. 12 species were observed in this zone during the 2015 survey, including the three protected species.

Amphibians in the Project-affected area are generally widespread species, not included in the RA Red Book. However their biomass is high and they are an important food source for several raptor species.

The Project-affected area also provides good habitat for several species of reptile, particularly at lower elevations. Three species which are listed in the RA Red Book have been observed in the Project area: Armenian Mountain-steppe Viper, Radde's/Armenian Rock Viper, and Cat Snake. These species, however, also appear to have suitable habitat in the wider landscape.

4.10.10 Fish Survey and Results

Survey Methods

Incidental observations of fish were carried out in 2011 during the freshwater ecology survey. A survey of fish species present in watercourses was conducted in 2012 by the Sevan National Park and in 2013 by the NAS RA Institute of Zoology and Hydroecology with inputs from Golder. In the 2013 survey, fish were caught by hand net and fixed by 4% formaline solution. The surface of the net was 8.65m^2, with a mesh size of 1.5x1.5 cm^2 and pocket sections 1x1 cm^2. In 2014, further survey points were introduced.

Results

Eleven species of native fish were recorded during the 2012 – 2013 surveys in the Vorotan River and other surface waters of the catchment. These were *Salmo trutta* (Brown Trout), *Alburnoides bipunctatus* (Riffle minnow or Spiril), *Barbus lacerta* (Kura), *Pseudorasbora parva* (Topmouth gudgeon), *Capoeta capoeta, Barbus capito culd* (Barbel), *Barbus mursa guld* (Barbel), *Carassius gibelio gibelio* (Silver Prussian carp), *Varicorhinus capoeta* (Seven Khramulya), *Chondrostoma nasus* (Nase) and *Nemachilus brandti* (Kura loach). The non-native *Oncorhynchus mykiss* (Rainbow trout) was also recorded in 2012.

During the 2013 survey period, six species of fish were recorded: *Pseudorasbora parva* (Topmouth gudgeon), *Alburnoides bipunctatus* (Riffle minnow), *Salmo trutta* (Brown Trout), *Varicorhinus capoeta* (Seven Khramulya), *Carassius gibelio gibelio* (Silver Prussian carp) and *Capoeta capoeta*. The Kechut Reservoir was the richest in the species diversity of the fish assemblage. Relatively large individuals of riffle minnow were caught from Kechut Reservoir, and relatively small individuals from the Vorotan River. All the individuals of riffle minnows caught from the Kechut Reservoir were infected with *Ligula intenstinalis* parasites of *Ligula* family. In the Vorotan River, larvae of caddisflies and dayflies were the main component for the feed of trouts. During the survey period all the individuals of stone morocco and

khramulya caught from the near shore area were male due to the migrations to spawning areas during the reproduction period (during the reproduction period the male individuals are the first to make spawning migrations).

None of the species observed during surveys are listed within the Armenian Red Book or the IUCN Red List. *Nase Chondrostoma nasus* is listed under the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) Annex III – 'species that are in need of protection but may be hunted or otherwise exploited in exceptional instances'. This species is listed as of 'least concern' on the IUCN list.

During the survey period, Kechut Reservoir was the richest water body sampled in terms of fish species diversity. No species of fish were found at the waypoints at the Kechut dam, the Kechut aqueduct, Arpa waypoint, Gndevaz Lake, or the waypoint near the bridge of Vorotan River or at the waypoint on the River Darb. The main reasons were (i) impassable barriers on both the rivers Vorotan and Darb limit the movement of fish; (ii) unfavourable conditions in areas such as the Kechut aqueduct; (iii) flood conditions at the time of the surveys; and (iv) in the case of Gnedevaz Lake, the lake is fed by snowmelt and dries up completely in summer.

None of the fish species recorded during the desk and field studies are listed within the Armenian Red Book or the IUCN Red List. There are no endemic fish species present in the Project area and fish biomass and species diversity is relatively low. Non-native species encountered in surveys were Topmouth Gudgeon and Rainbow Trout.

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4.11 Social Political

4.11.1 Introduction

The socio-economic baseline is the basis of the social impact assessment. While not all information in the socio-economic baseline will be directly used in the impact analysis, the baseline section serves as a characterisation of the national, regional and local context prior to the development of the Project. Relevant information from the baseline will be referenced in the impact assessment (Chapter 6) and management plans (Chapter 8).

4.11.2 Socio-economic Setting

The socio-economic setting is defined at three levels. The national setting is the entire country. The regional setting includes the two Marzes (provinces) straddled by the proposed mine layout and footprint; Vayots Dzor and Syunik. The local setting is defined as the settlements in closest proximity to the Amulsar Project, and includes the three closest rural settlements (Gorayk, Gndevaz and Saravan (including Saralanj and Ughedzor)) and the town of Jermuk (including Kechut). The Social Study Area defined in Figure 4.1.5 is the same as the local socio-economic setting.

4.11.3 Socio-economic Baseline Methodology

Socio-economic baseline information and data for the Amuslar Project has been compiled for the period 2010 to 2015 using various methods. All studies have been informed by desktop study of existing and public information, including government websites, NGO reports and other online information. In addition, several topics included primary data collection, briefly described below.

Surveys and Focus Group Discussions

In 2010, MPG Consulting conducted quantitative and qualitative research in the three rural communities closest to the Project and in the town of Jermuk. In April 2010 household interviews were carried out, including 141 household interviews in Gndevaz (total number of households - 215[1]), 54 in Saravan (total number of households - 70[2]) and 79 in Gorayk (total number of households - 137[3]). In August of 2010, 540 household surveys were conducted in Jermuk (total number of households - 2050), as well as an additional 61 households in Kechut (total number of households – 350), which is part of the Jermuk

[1] Gndevaz Village Passport, 2009.
[2] Saravan Village Passport, 2010.
[3] Gorayk Village Passport, 2010.

administrative unit[4]. The percentage coverage within these surveys is higher for Gndevaz, Gorayk and Saravan than for Jermuk and Kechut. The surveys covered more than 50% of the households in these communities, while for Jermuk and Kechut, the coverage was 26% and 17% respectively.

Survey information was complemented through focus group discussions. Two focus groups were held in the rural communities, four in Jermuk and one in Kechut during 2010. Focus groups explored community needs and trends. In-depth interviews were also held throughout these communities.

Town and village level data has also been supplemented through the use of "Village Passport" data collected by the town and village administrators on an annual basis. "Village passport" data has been collected on an annual basis from 2009 to 2015.

Rapid Health Impact Assessment

Baseline information on community health was collected as part of a separate Rapid Health Impact Assessment conducted by SHAPE Consulting in 2012. The study included visits to Armenia and the Project area to conduct informant interviews with relevant health authorities and to make direct observations of the health facilities in nearby communities. In addition to informant interviews, the researchers conducted three focus group discussions with residents of Gorayk, Gndevaz and Saravan to collect additional qualitative information. The conclusions of this assessment have been updated in 2013, 2014 and 2015 to address project design changes.

Livelihoods

Baseline information on livelihoods was first collected in 2010 as part of the questionnaires conducted by MPG, as described above. This information has been updated based on additional data collected through the land acquisition process (to inform the livelihood restoration plan) in October 2014, and additional surveys conducted in November 2015. A livelihoods questionnaire was used to assess the livelihood impacts to all land owners and land users in areas where the project will require land. This equates to approximately 252 households being surveyed.

[4] Personal Communication with the Jermuk Municipality, 2013.

Skills Survey

In late 2011/early 2012, Lydian undertook a skills survey within the villages of Gorayk, Gndevaz and Saravan. 198 people were interviewed through this survey (77 in Gndevaz; 79 in Gorayk; and 41 in Saravan), of which 38% were women.

A follow-up survey was conducted by MPG consultancy in 2014, covering the same three villages and the town of Jermuk/Kechut. A total of 844 questionnaires were completed during this survey. More than 50% of the respondents in each village were female. The 2014 survey was conducted as a household survey and covered 25% of the population aged between 18 and 55 years of age within each of these communities. Both this survey and that conducted in 2011/2012 focussed on community members currently resident in these communities. No assessment of the skills held within diaspora community has been conducted.

Ecosystem Services

In December 2011, Lydian conducted an ethnobotany assessment within the villages of Gorayk, Gndevaz and Saravan to understand how local herbs and plants were collected and used by communities. The assessment used focus group discussions and informed the land use baseline and the ecosystem services impact assessment. The assessment was conducted using six focus group discussions (two in each of the three rural villages), with a balance of men and women participating, and approximately 15 people participating in each focus group discussion. In total approximately 90 people were involved in this assessment.

Further investigations into ecosystem services were conducted in 2014 and 2015 through a combination of approaches:

- In 2014, focus group discussions were held with residents of Gorayk, Gndevaz, Saravan and Jermuk/Kechut and with a group of seasonal herders. Focus group discussions were coordinated for each village, ensuring that discussion included people who currently use ecosystem services extensively, including the full range of activities known to occur within the area (bee-keeping, herb collection, mushroom collection, hay collecting etc.) as well as those who have lower usage patterns; and
- Questions related to ecosystem services were added to households surveys being undertaken as part of the livelihood questionnaires being completed to support the land acquisition work stream. The surveys covered all households whose land will be

acquired, and households who are known to use land which will need to be acquired.

- In June 2015 five ESIA follow-up focus groups were conducted, one with seasonal herders from Xhndoresk and four in project affected villages: Gorayk, Gndevaz, Saravan and Jermuk/Kechut. Each focus group had between 5 and 11 participants. Four semi-structured interviews were conducted with representatives of art, culture, policy and public engagement. The focus group and interview protocol was designed to elicit information about change, if any, in priority ecosystem services and issues associated with the proposed biodiversity set-aside at Arshak. To investigate use of the potential set-aside area in more detail, a further three interviews were conducted with herders who are seasonally resident in Ughedzor.

Cultural Heritage

Desktop studies and fieldwork were undertaken between 2010 and 2015 by local Armenian teams, including a "Cultural Heritage" NGO. Site visits were made by an ERM archaeologist between 2011 and 2013. Intangible cultural heritage and living heritage were addressed in the ecosystem services survey of 2014 described above.

Herder Census

In June and July of 2012, WAI undertook two research visits to the Project area to investigate seasonal herders that use the area on an annual basis. The herders were identified in scoping visits as a vulnerable group due to their primary reliance on herding, the periodic nature of their livelihood linked to the Project area and the challenge of engaging with the individuals.

In August 2012, Lydian conducted a survey of 70 herders in the Project area under the guidance of Frederic Giovannetti. The surveys covered all seasonal herders found in the project area and a sample of daily herders who reside in the local area of influence. Additional information on herders was collected through the ecosystem services focus group discussions, described above, which were completed in June 2014. An additional herder survey was conducted in September 2015 by the Geoteam social team to assess the impacts to herders linked to the revised project design. The 2015 survey covered both seasonal herders (predominantly located in proximity to the proposed BRSF) and daily herders (based in Gndevaz) potentially affected by the Project.

Tourism Study

In 2013, Lydian conducted a review of tourism in the Project area. The objectives of the study were to:

- Determine current trends of tourism development, particularly in Jermuk;
- Review and assess progress and changes since a comprehensive assessment of Jermuk tourism in 2008 that was prepared by USAID; and
- Explore priorities for improving the tourism sector either through mitigation measures or community development initiatives.

The study included a review of the USAID report from 2008 and primary research through informant interviews and focus group discussions. The primary research was conducted in February to March 2013 and targeted organisations linked to the tourism industry, such as hotel and spa staff, tour agencies, municipal authorities, universities and other services providers. Further baseline information on the hotels within Jermuk was collected by Geoteam in 2015 and an extensive assessment of accommodation options was conducted by InterSocial in early 2016, including occupancy estimates for individual facilities.

4.11.4 National Socio-economic Overview

In 2015, Armenia was considered part of the "high human development" group and ranked 85 out of 188 countries in the UN Human Development Index (HDI) [5]. The HDI is a composite indicator that measures human welfare using income, education and health statistics. Table 4.11.1 table below shows Armenia in comparison with neighbouring countries, the regional averages for Europe and Central Asia and average data for the high HDI countries.

[5] International Human development Indicators, UNDP 2012, http://hdrstats.undp.org/en/countries/profiles/ARM.html

Table 4.11.1: UN HDI Comparison with Neighbouring Countries[6]					
HDI Rank	**Country**	**HDI**	**Life Expectancy (yr)**	**Expected Years Schooling**	**GNI Per Capita*[1] (PPP USD)**
85	*Armenia*	*0.733*	*74.7*	*12.3*	*8,124*
76	Georgia	0.754	74.9	13.8	7,164
78	Azerbaijan	0.751	70.8	11.9	16,428
NA	Europe and Central Asia*	0.748	72.3	13.6	12,791
NA	High HDI	0.744	75.1	13.6	13,961
Notes: * Calculated from an average of 31 countries *[1] Gross National Income (GNI) figures are calculated at constant 2005 purchasing power parity.					

A review of Armenia's progress against HDI indicators since 1990 shows continued progress after an initial drop in the early transition years from 1990 to 1995 (see Table 4.11.2).

Table 4.11.2: UN HDI Trends[7]				
Year	**Life Expectancy (yr)**	**Mean Years Schooling**	**GNI Per Capita (2011 PPP $)**	**HDI**
1990	67.9	10.1	3,581	0.632
1995	68.8	10.4	2,170	0.605
2000	71.2	10.8	3,004	0.648
2005	73.2	10.8	5,533	0.695
2010	74.1	10.8	6,838	0.721
2011	74.2	10.8	7,054	0.723
2012	74.4	10.8	7,584	0.728
2013	74.6	10.9	7,891	0.731
2014	74.7	10.9	8,124	0.733

4.11.5 Administrative Structure

Armenia is divided into 11 administrative regions, comprising 10 *Marzes* (provinces) and the capital city of Yerevan, which is accorded regional status.

The *Marzes* are shown on Figure 4.11.1.

[6] UNDP. Human Development Report 2015, Work for human development. New York, USA. 2013.
[7] UNDP. Human Development Report 2015, Work for human development – briefing note for countries on the 2015 Human Development Report - Armenia. New York, USA. 2015.



Figure 4.11.1: Administrative Map of Armenia[8]

Marzes are further divided into rural and urban communities (*hamaynks*) and Yerevan into twelve Districts. *Marzes* vary greatly in terms of their territory, population, number of communities and level of economic development. The Project is located on the boundary between Vayots Dzor and Syunik *Marzes*[9]. The rural community of Gorayk is part of Syunik, while Gndevaz, Saravan rural communities and Jermuk and Kechut urban communities belong to Vayots Dzor.

Marzes are subdivisions of the central administration rather than a separate tier of the Government[i10]. The central government appoints and dismisses regional governors, who undertake a set of defined duties, with the assistance of regional administrations. These duties are administrative, with no budgetary responsibilities.

[8] Tumanyan, D (2005), Local Government in Armenia, Local Government in Europe, in the Caucasus and Central Asia, *www.etd.ceu.hu/2010/saroyan_zaruhi.pdf*

[9] It should be noted that different spellings exist for place names within Armenia. This is caused by the translation from Armenian (script and language) into English.

[10] The World Bank Infrastructure and Energy Services Department (2004). Rural Infrastructure in Armenia: Addressing Gaps in Service Delivery, viewed 13 May 2012. http://siteresources.worldbank.org/INTARMENIA/Resources/Armenia-rural-Infra-arm.doc

4.11.6 Local Government Structure

Armenian government has a two-tier structure, with most administrative power held by the Central Government Ministry of Territorial Administration. The second tier of government exists at the level of communities – both rural and urban. Each urban or rural community can consist of one or more settlements (for example, there are over a thousand settlements in Armenia, but only 915 communities[11]). Forty-nine of the communities are urban, with the remainder defined as rural communities. There is no legal distinction between a village and a city with the names deriving from location, infrastructure and tradition.

A process of "consolidation" of communities is planned for Armenia. Over 50% of rural communities have populations of less than 1000 people, resulting in many communities lacking the economic, financial and human resources, conditions and capacity to execute effective local self-government and to deliver high quality municipal services to the population. The consolidation process is expected to see some communities grouped together, affecting the administrative structure and roles held within rural areas in particular. Piloting of this process was launched in October 2013 by the President of the Republic, with a focus being placed on the voluntary nature of the pilot[12].

As part of this consolidation process, changes are expected to occur to the administrative structure of Gndevaz and Jermuk. The timing for the consolidation and its effects had not been defined at this time of writing of this ESIA.

Within the local government structure, two key roles are defined: the Council of Community Elders (Avagani) and the community head (often referred to as a Mayor). Together these two roles comprise the local decision making bodies, with the Council of Community Elders acting as the representative body, which meets at least once a quarter. Community heads and elders are chosen through general, equal and direct elections by secret ballot, each with a four-year term of office.

A vertical hierarchy of control exists within local government structures: local administrative staff and community institutions are accountable to the head of the community, who is in turn accountable to the council of elders[9]. The composition of local administrative staff

[11] Armstat (2015) General Characteristic of the Republic of Armenia, armstat.com (accessed December 2, 2015)
[12] http://www.sdc.admin.ch/en/Home/Projects/Project_Detail?projectdbID=226361

depends on the population size, but includes as a minimum a deputy head of community, secretary of staff and their divisions.

4.11.7 Service Provision Responsibilities

Local administration performs the following management functions:

- To provide for the rights of citizens and the interests of local self-government;
- To provide local development planning;
- To manage financial matters and community property;
- To implement projects and achieve strategic goals;
- To define, calculate and forecast citizen needs, formulate appropriate methods for their satisfaction and prepare the relevant draft resolutions;
- To assign resources for public service delivery, supplement existing resources and search out new resources; and
- To supervise implementation of the four-year development plans, making necessary adjustments. [9]

Responsibilities for service provision are summarised in Table 4.11.3. In this table it is evident that some services are the joint responsibility of municipalities and central government, e.g., primary health care, and local economic development.

Table 4.11.3: Specific Functions of Government Tiers in Armenia[9]

Functions	Municipalities	Central or Marz Administration
I. Education		
Pre-school	X	
Primary		X
Secondary		X
Technical		X
Higher		X
Specialised	X	
II. Social Welfare		
Nurseries	X	
Kindergartens	X	
Welfare Homes		X
Personal services for elderly and handicapped		X
Special services (for homeless, families in crisis, etc.)		X
Social Housing	X	
III. Health Services		
Primary health care	X	X
Health Protection		X

Table 4.11.3: Specific Functions of Government Tiers in Armenia[9]		
Functions	**Municipalities**	**Central or Marz Administration**
Hospitals		X
Public health	X	X
IV. Culture, Leisure, Sports		
Theatres	X	X
Museums	X	X
Libraries	X	X
Parks	X	
Sport, leisure	X	
Maintaining buildings for cultural events	X	
V. Economic Services		
Water Supply	X	
Sewage	X	
Electricity		X
Gas		X
District Heating	X	
VI. Environment, Public Sanitation		
Waste collection	X	
Waste disposal	X	
Street cleansing	X	
Cemeteries	X	X
Environmental protection	X	X
VII. Traffic, Transport		
Roads	X	X
Public lighting	X	X
Public transport	X	X
VIII. Urban Development		
Town Planning	X	
Regional / spatial planning		X
Local economic development	X	X
Tourism		X
IX. General Administration		
Authoritative functions (licenses, etc)	X	X
Other state administrative matters (electoral register etc)	X	X
Local police		X
Fire brigades		X
Civil defense	X	X
Consumer protection		X

Of relevance to the rural and urban communities in the Project area are the following responsibilities:

- **Kindergartens** – Local government is responsible for management and operation of kindergartens, with the cost of operating and maintaining these facilities covered

jointly by parents and the community budget.

- **Specialised education** – Specialised education includes institutions providing music, fine arts, athletics and technical skills for children. Local government is also responsible for providing these facilities and charges fees for attendance.
- **Primary and secondary schools** – Education is the responsibility of the state government which funds and administers institutions, employs teachers and administrators and determines curricula and performance standards.
- **Libraries and community buildings** – Maintenance of these facilities is the responsibility of the local government of a community.
- **Health care** – While health care is provided by the central government, some communities have primary health care clinics that are supported by user fees, contributions from community budgets and support from various international and local organizations.
- **Gas and electricity** – Gas and electricity supply systems are the provenance of central government; however, it is the responsibility of local governments to facilitate the installation of such services for residents and businesses.

4.11.8 Local Government Budgets

Local governments are heavily dependent on state budget transfers, which often comprise over fifty percent of local budget revenues. The main sources of community budget revenue are:

- Centrally established taxes and duties;
- Subsidies from the state budget;
- Local duties and fees;
- Land and property rent; and
- Revenue from the sale of community property.

While all taxes are collected by the State Taxation Agency, one hundred percent of the land and property taxes and rent collected at the community level are paid to the local government, and this often forms the primary income source for the local government. Remuneration of local government employees is regulated under the Law on Local Self Government, which stipulates that the Council of Elder's is not compensated for their work, and establishes the salary of the head of the community as a proportion of the salary of the regional governor's salary, based on population size.

4.11.9 Community Social Structure and Organisation

Kinship is an important element of social structure in the project area, as it is elsewhere in Armenia. Due to various economic and cultural reasons, many rural residents live in joint/multi-generational families.

Cooperation and informal social organisation is also seen in certain activities, for example some herders in the area share herding responsibilities for each other's animals, with four to five individuals working together in pre-agreed shifts. Where a family unit has no able bodied person to contribute to the herding (usually male), animals are entrusted to a friend or neighbour who is then paid for the service.

4.11.10 NGO's and Other Institutions

Key institutions influencing public opinion in Armenia include:

- Armenian Apostolic Church;
- Armenian Diaspora;
- European Union and World Bank Group institutions;
- International donors and NGOs;
- Mass media; and
- Armenian non-government organisations (NGOs) and civil society.

Armenia is one of the top exporters of people per capita, and twice as many Armenians live in the diaspora as in the country. Remittances from diaspora play an important role in the Armenian economy and diaspora provide an important connection to external markets and opportunities for resident Armenians. Between 2011 and 2015, personal remittances comprised 19.1% of national GDP, down slightly from 21% between 2006-10[13].

In Armenia, an NGO is defined as a non-government voluntary organisation formed to meet people's spiritual and other non-material needs or wants, and can be initiated by an individual or another NGO and founded by the decision of an assembly of no fewer than three individuals[9]. The limited requirements in order to form an NGO have led to a vast number of NGOs being registered in Armenia (over 3,300 registered in 2010[14], of which just under 1,000 are continuously operational). There are roughly 60 registered environmental NGOs in the country: it is believed that more than half of these NGOs have intermittent

[13] http://data.worldbank.org/indicator/BX.TRF.PWKR.DT.GD.ZS (accessed December 2nd, 2015)
[14] www.civilitasfoundation.org (accessed September 4th, 2012)

operations and activity levels depending on funding and available resources.

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4.12 Demographics

Armenia has a total *de jure* population of 3.02 million[1] (2011). The national census distinguishes between legally registered resident population (*de jure*) and actually resident (*de facto*) population. Due to the importance of migration for employment in Armenia, there are significant differences between these figures.

Population figures have been collected through a number of sources to inform this ESIA. Sources include the published 2011 national census results; village populations as recorded through household surveys conducted by MPG in 2010; and village populations as recorded by Village Mayors on an annual basis. There is significant variation within the figures recorded by each source and as such, national census figures have been cited as the definitive population figures, but where analysis of locally collected data is required, it has been assessed as a proportion of the population reported through that survey instrument to ensure consistency of assessment.

The national sex ratio at birth is 1.12 male births per female. Armenia has generally seen a population decline since the 1990s due to elevated levels of out-migration after the break-up of the Soviet Union. Armenia is also currently experiencing a significant aging of its population and a consequent decrease in the size of its working population[2]. In addition, the fertility rate in Armenia has fallen from about 4.5 children per woman in the 1950s to 1.74 children per woman at present, which is well under the fertility rate required for population replacement. As a result of these factors, Armenia's population is expected to decrease to 3 million by 2050[3].

4.12.1 Regional Population

A national census was conducted in 2011 and the preliminary data was made available in Armenian in 2014. This *de jure* population data is presented in Table 4.12.1.

[1] Armstat, (2014) www.armstat.am accessed 2 May 2014
[2] World Bank, (2011b), Armenia, Demographic Change and Implications for Social Policy and Poverty, South Caucasus Programmatic Poverty Assessment, Technical Note #5, World Bank, www.world.org (accessed 27th August 2012)
[3] https://openknowledge.worldbank.org/handle/10986/2803 accessed July 20, 2013

Table 4.12.1: Regional Population 2012[1]			
Name of Region (*Marzer)*	**Territory (km^2)**	**Population in 2011 (de jure)**	**Population Density (population/km^2)**
Yerevan	223	1,060,138	4,754
Aragatsotn	2,573	132,925	48
Ararat	2,086	260,367	125
Armavir	1,242	265,770	214
Gegarkunik	5,349	235,075	44
Lori	3,789	235,537	62
Kotayk	2,089	254,397	122
Shirak	2,681	251,941	94
Syunik	***4,506***	***141,771***	***32***
Vayots Dzor	***2,308***	***52,324***	***23***
Tavush	2,704	128,609	48
Total	**29,743**	**3,018,854**	**102**

As is clear in Table 4.12.1, Vayots Dzor *Marz* has the smallest population in the country, and together Syunik and Vayots Dzor *Marzer* have the lowest population densities in the country. It is important to note that between the 2001 and 2011, census results indicate Armenia's population reduced from 3.21 million to 3.02 million.

Vayots Dzor *Marz* comprises three districts: Jermuk, Yeghegnadzor and Vayk, with 2011 *de jure* populations of 4,346, 7,421 and 5,067 respectively. Syunik Marz comprises four districts: Kapan (34,713), Goris (17,881), Meghri (4,282) and Sisian (12,074). The Project is located in Jermuk, Vayk and Sisian districts.

4.12.2 Social Study Area Population

The study area includes the rural communities of Gorayk, Gndevaz, Saravan and Jermuk (as indicated on Figure 4.1.5). Saravan rural community comprises three small villages (Saravan, Saranlanj and Ughedzor) and Jermuk includes both Jermuk city and its associated village of Kechut. The study area is predominantly rural, with Jermuk being the only urban centre.

While the area has been inhabited for centuries, as detailed in Section 4.19 (Cultural heritage), it has undergone significant change in the past century. The construction of the Spandaryan Reservoir in the 1980's required the resettlement of two villages, Gorayk and Tsghuk. The resettlement was undertaken by the Soviet State, and many residents of Gorayk retain some level of dissatisfaction with their new location. The second significant change in the region was related to the Azerbaijan – Armenia war, which prompted ethnic Armenians and Azeri's living in Azerbaijan and Armenia respectively to move to their ethnic homeland. Prior to the

war in 1991, the village of Ughedzor was an ethnically Azeri village, which was abandoned once the war broke out. The village of Ughedzor is now occupied by seasonal herders during the summer months, but remains unoccupied during the rest of the year. Seasonal herders also use other lands in the area, as seen in Figure 4.12.3.

Local demographic data is drawn from the 2011 National Census data. As illustrated in Table 4.12.2, the aggregated *de jure* study area population is approximately 6,700.

Table 4.12.2: Study Area Population	
Rural Community	**De jure (2011 census profile)**
Jermuk	4,346
Kechut	884
Gndevaz	791
Saravan (including Ughedzor (21))	256
Gorayk	401
Total	**6,678**

Additional detail on the study area population is provided in Table 4.12.3. This data has been collated through interviews with community Mayors, conducted in April 2014. While the figures in Table 4.12.3 vary from those reported in the national census (Table 4.12.2), this is a feature of the different sources of the data and the general trends within the communities are still evident.

Table 4.12.3: Study Area de Facto Population (2014)			
Locality	**De facto Population**	**Households**	**Number of Families in Social Welfare Programmes**
Gorayk	418 (51% women)	96	6
Saravan	282 (54% women)	80	7
Gndevaz	899 (52% women)	211	10
Ughedzor	20 herder families during summer	No data	N/A
Jermuk/Kechut Town	7542 (51% women)	2300	215
Seasonal Herders within the broader area	~ 58 herders during summer with approximately 20 herders within the Project License boundary	No data	N/A

The age profile (*de jure* population, 2011) for Syunik *Marz* in Figure 4.12.1 highlights an aging population, consistent with the trend across Armenia. Less than 20% of the population is aged

15 years or less. The proportion of youth in Vayots Dzor *marz* is even lower than that of Syunik (Figure 4.12.2).

In both Syunik and Vayots Dzor, there is an over-representation of women in working age groups. This is a direct result of the trend of male migration for work[4].

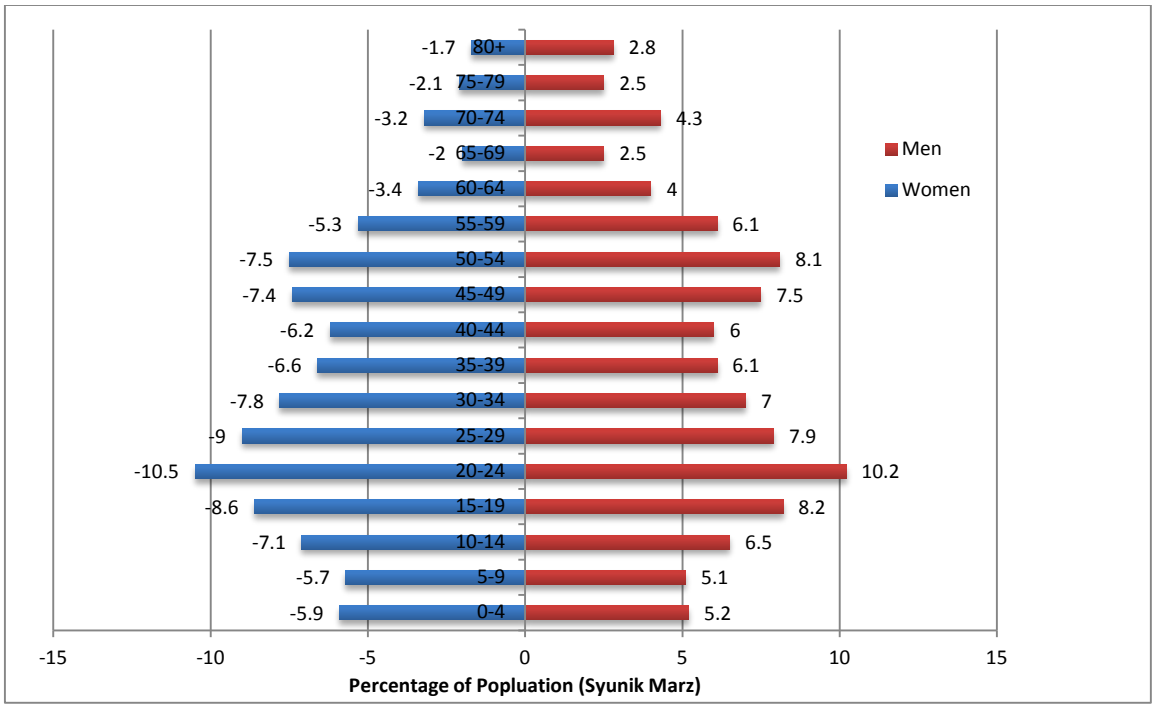


Figure 4.12.1: Population Pyramid for Syunik Marz[1]

[4] National Institute of Labour and Social Research (2010), Impact of the Global Financial Crisis on Households, Yerevan

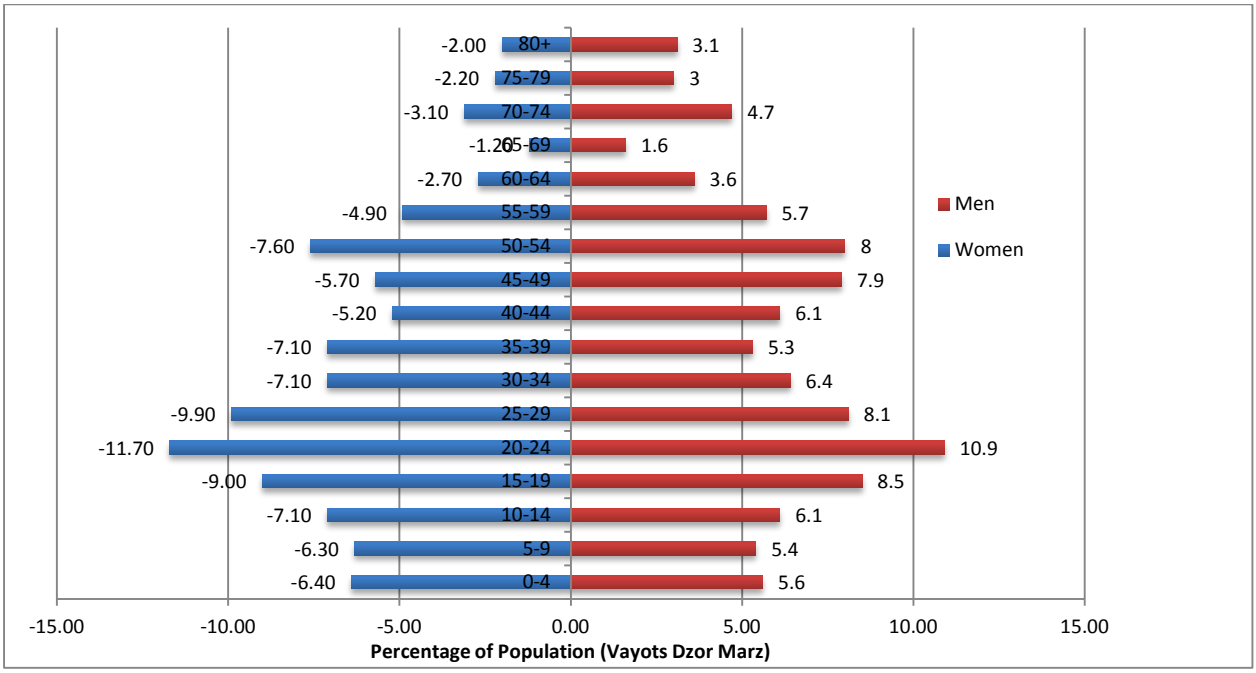


Figure 4.12.2: Population Pyramid for Vayots Dzor Marz[1]

Life expectancy in Armenia has increased somewhat since the 1970's to 67/75 years[5] for males/females respectively (as recorded in 2012), with women living longer than men. This rate of growth is considerably lower than that of neighbouring countries[2].

Within the working age group (19-64 years of age), a relatively balanced demographic is seen in the rural communities (Table 4.12.4).

Table 4.12.4: Ratio of Women in Working Age Group[6]

Town	De Facto Population Aged 19-64 Years	Number of Women Aged 19-64 Years	Proportion of Women (19-64 Years) in Rural Community
Gorayk (2010 data)	376	180	48%
Gndevaz (2009 data)	651	368	56%
Saravan (2009 data)	120	55	46%

4.12.3 Ethnic Groups

Armenia is largely ethnically homogenous with ethnic Armenians comprising 97.9% of the population. Yezidis make up 1.3%, Russian 0.5%, with other minorities including Asyrians,

[5] http://www.who.int/countries/arm/en/ accessed June 20th, 2014
[6] Sourced from the Village Passports

Ukrainians, Greeks, Kurds, Georgians and Belarusians. There are also smaller communities of Vlachs, Mordvins, Ossetians, Udis, and Tats. Minorities of Poles and Caucasus Germans also exist though they have become culturally more like Russians.

In both Syunik and Vayots Dzor *Marzer*, the homogeneity is even greater than the national average, with 99% of residents reported as ethnic Armenians. Baseline studies conducted in the study area in 2009 and 2010 confirmed this trend.

There are no ethnic groups in Armenia that would be considered "indigenous" as defined in IFC Performance Standard 7 and EBRD Performance Requirement 7.

4.12.4 Language

The Armenian language is a member of the Indo-European family of languages. With thirty-eight characters, and a distinct script, Armenian is spoken only by Armenians and their diaspora. Armenian is the language of education and business in Armenia, increasingly replacing the use of Russian which was dominant before independence.

Armenia has very high levels of literacy (reported to be 99.5% for adults over 15 years of age in 2011)[7].

4.12.5 Religion

The majority (94.7%) of the Armenian population follows the Armenian Apostolic church, while other Christian denominations make up 4%, and 1.3% are Yezidi (monotheist with elements of nature worship). This trend is also evident in the rural communities in the study area.

4.12.6 Housing and Household Size

Armenia is characterised by large households comprised of related family units, common in both rural and urban areas. The average household size in Armenia is 4.0 people[8], with rural households on average moderately larger than urban households (4.4 vs. 3.7 persons)[8].
In Gorayk, Gndevaz and Saravan, the average household sizes were reported to be between 5 and 7 members, usually as a result of two or more related families residing within a

[7] UNDP, (2011), Human Development Index, http://hdrstats.undp.org/en/countries/profiles/CIV.html
[8] Armstat, (2014) Preliminary Data for 2011 Population Census www.armstat.am (in Armenian) accessed May 2 2014

household, due to a combination of culture and tradition, and economies of scale in terms of housing affordability as well as availability of labour to carry out subsistence agriculture.

Approximately 75% of Jermuk town households have three or more members, with 35% having five to seven members[9]. This was linked to the lack of affordable housing choices for young people of marriageable age. Kechut showed greater tendency to larger households, with over 55% households having five to seven members.

4.12.7 Role of Women

Armenia was one of the first countries to give women the vote in the early twentieth century and while the Constitution states that men and women are equal, mechanisms to support this equality have not been well supported post-Soviet times[10]. In spite of this, over 10.7% of parliamentary seats were held by women in 2014 and 94% of adult women have reached at least a secondary level of education, compared to 95% of their male counterparts.[11]

Since 2010, as part of the UN Human Development Reports, countries were measured in a Gender Inequality Index (GII) which tries to capture the loss of achievement due to gender inequality in three dimensions: reproductive health, empowerment and labour market participation. The higher the GII value, the greater the discrimination. Based on 2014 data on 155 countries, Armenia was ranked 62 (see Table 4.12.5).

[9] MPG, (2010), Jermuk and Kechut Baseline Study
[10] Aslanyan, S, (2010) Women's Rights in Armenia, http://www.socialwatch.org/node/11600 (accessed 5 September 2012)
[11] UNDP. Human Development Report 2015, Work for human development – briefing note for countries on the 2015 Human Development Report 2015. New York, USA. 2015.

Table 4.12.5: UN GII Comparison with Neighbouring Countries[12]		
Country	**GII Rank**	**GII Value**
Armenia	62	0.318
Georgia	77	0.382
Azerbaijan	59	0.303
Europe and Central Asia[13]	NA	0.300
High HDI	-	0.310

Family life and family allegiance are the cornerstones of the local community. Often family units consist of different generations, with sons bringing their wives into the family home. Mother and daughter-in-law relationships are paramount, with the mother-in-law firmly managing the household assisted by daughters and daughters in law.

Although women have an important role in the household, men are regarded as the head of the family and community affairs are predominantly managed by men. High levels of migration by men searching for work have however led to a significant proportion of female-headed households (27% of Armenian households were headed by women in 2007)[14].

4.12.8 Migration Patterns

Migration has played and continues to play a significant role in the demographic structure and economy of Armenia. Two broad forms of external migration are identified: permanent external migration (with an intent to change the country of residence permanently), and seasonal external labour migration.

Permanent external migration peaked in the years following independence from the Soviet Union, with estimates of net out-migration of 760,000 to 780,000 people from 1991 to 1998[15]. This equated to out-migration of approximately 20% of the population during the time of independence, the vast majority of whom moved to Russia, with significant diaspora also based in the USA, France and Lebanon. Permanent external migration has declined significantly in subsequent years.

[12] UNDP. Human Development Report 2015, Work for human development – briefing note for countries on the 2015 Human Development Report 2015. New York, USA. 2015.

[13] Average of 31 countries: Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Georgia, Hungary, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Malta, Republic of Moldova, Montenegro, Poland, Romania, Russian Federation, Serbia, Slovakia, Slovenia, Tajikistan, the former Yugoslav Republic of Macedonia, Turkey, Turkmenistan, Ukraine, Uzbekistan

[14] International Fund for Agricultural Development (2007). Armenia Gender Profile, viewed 13 May 2012. http://www.ifad.org/english/gender/cen/profiles/arm.htm

[15] ILO, (2009) Migration and Development – Armenia Country Study

The practice of seasonal external labour migration emerged in Armenia in the 1960s as a spontaneous response to differential economic opportunities existing across the administrative areas of the Soviet Union. Beginning in the mountainous areas of Armenia, by the 1980s the practice had spread to urban centres of Armenia as well, with between 30,000 to 40,000 seasonal labourers migrating, predominantly to Russia, between spring and fall each year[16].

As of 2007, labour migrants constituted 94% of all migrants, with only 3% leaving Armenia with an intention to permanently reside abroad and 2% with an intention to study internationally[17]. The practice of seasonal labour migration remains common, with over 14% of households engaged in the activity in 2006, which equated to approximately 100,000 labour migrants per annum.

The overwhelming majority of Armenian labour migrants are married men between the ages of 21 and 50, with only 6.5% of the migration pool made up by women. The ILO estimated that this level of migration comprised 13% of the economically active men and just over 1% of economically active women in 2006[17].

The decision to migrate seasonally for labour is driven primarily by the absence of jobs in Armenia, and opportunities to improve salaries and job types abroad. Also supporting this decision is the tradition of *"khopan"*, where in some villages men have been continuously leaving to work abroad over a long period of time. Young men from these villages often leave to work abroad after completing their military service, without necessarily first seeking opportunities within Armenia.

The global financial crisis of 2009 has impacted migration patterns in Armenia, with a small reduction (approximately 2%) of seasonal labourers from both rural and urban areas[18].

Within the study area, migration is of less importance in the villages than it is at a national level. However, as indicated in Table 4.12.6 the seasonal migration pattern does appear to be dynamic, with an increase in seasonal migration seen in 2013/14 (anecdotally attributed

[16] UNDP, (2009), Migration and Human Development: Opportunities and Challenges, Armenia, 2009, www.undp.org (accessed 4th September 2012)
[17] ILO, (2009), Migration and Development – Armenia Country Study
[18] National Institute of Labour and Social Research, (2010), Impact of the Global Financial Crisis on Households

to delays in the development of the Amulsar Project) and a reduction in most villages in 2014/15.

Table 4.12.6: Individuals Participating in Seasonal Labour Migration in Study Area[19]			
	Number of individuals migrating away seasonally in 2009	**Number of individuals migrating away seasonally in 2014**	**Number of individuals migrating away seasonally in 2015**
Gorayk	7	12	15
Gndevaz	20	71	22
Saravan	20	15	7
Jermuk and Kechut	no data	560 (2013 data)	230

According to a core strategy for Jermuk town developed by USAID in 2008, many former Jermuk residents have moved abroad permanently, mainly to Russia, as migrant labourers. On the other hand, a large number of Jermuk residents with relatively high educational attainment are believed to have moved to Yerevan to pursue better work opportunities.

In addition, to the outwards migration patterns described above, the study area is also the recipient of inward migration during summer months associated with seasonal herding activities. Seasonal herders, who are predominantly residents of Vayk, Sisian, Xndzoresk and Yeghegnadzor, seasonally migrate to the study area to graze their animals (predominantly cattle, but also some sheep) on the pastures in the region, and grow hay. In 2012, 58 seasonal herders migrated to the Project study area to graze cattle and grow hay. Their approximate locations are shown in Figure 4.12.3.

[19] Due to the variation within the population data recorded from different sources, it is not possible to determine the percentage of households participating in seasonal labour migration in the study area.

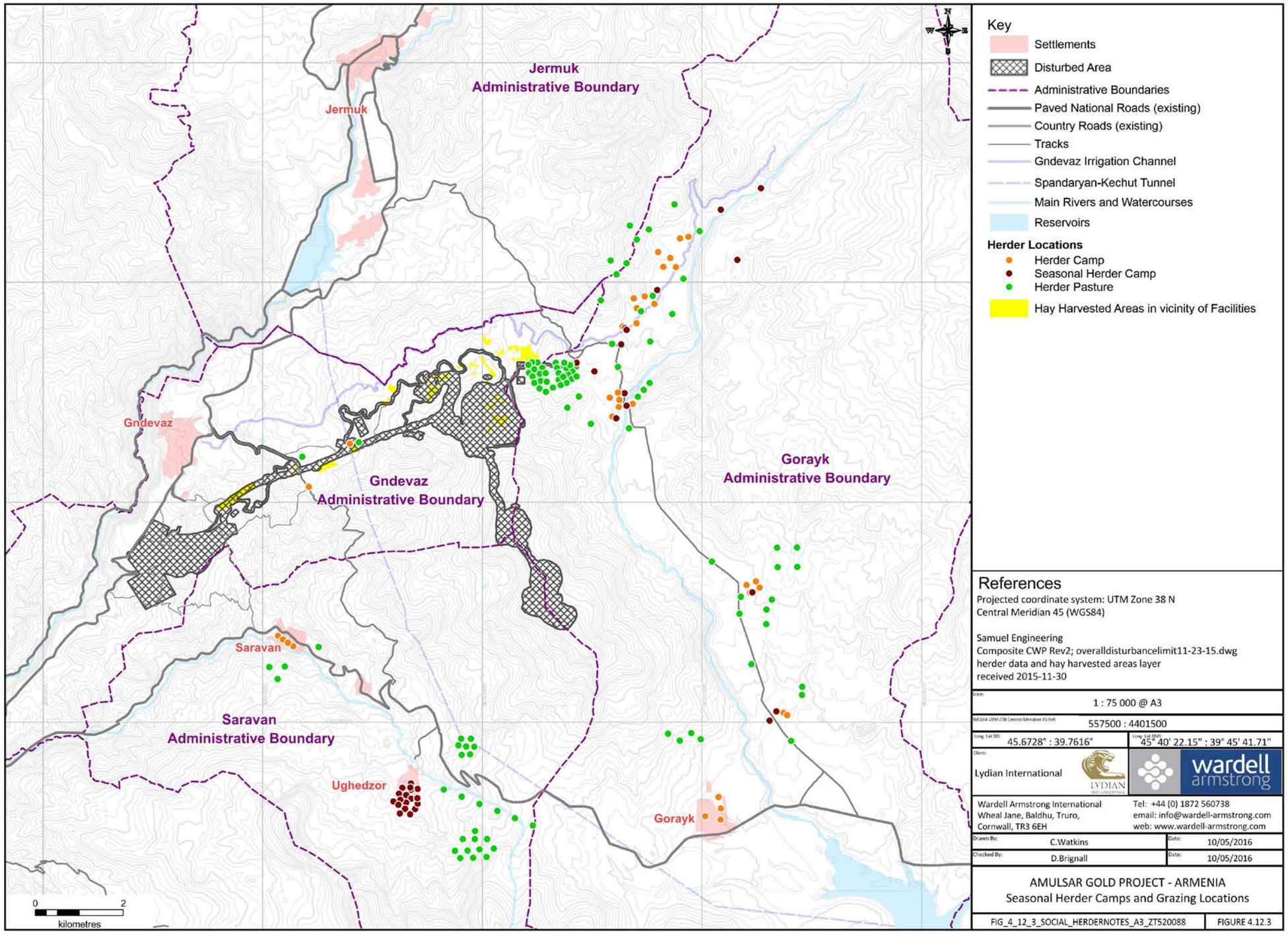


Figure 4.12.3: Seasonal Herder Camps and Grazing Locations

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4.13 Economic Situation

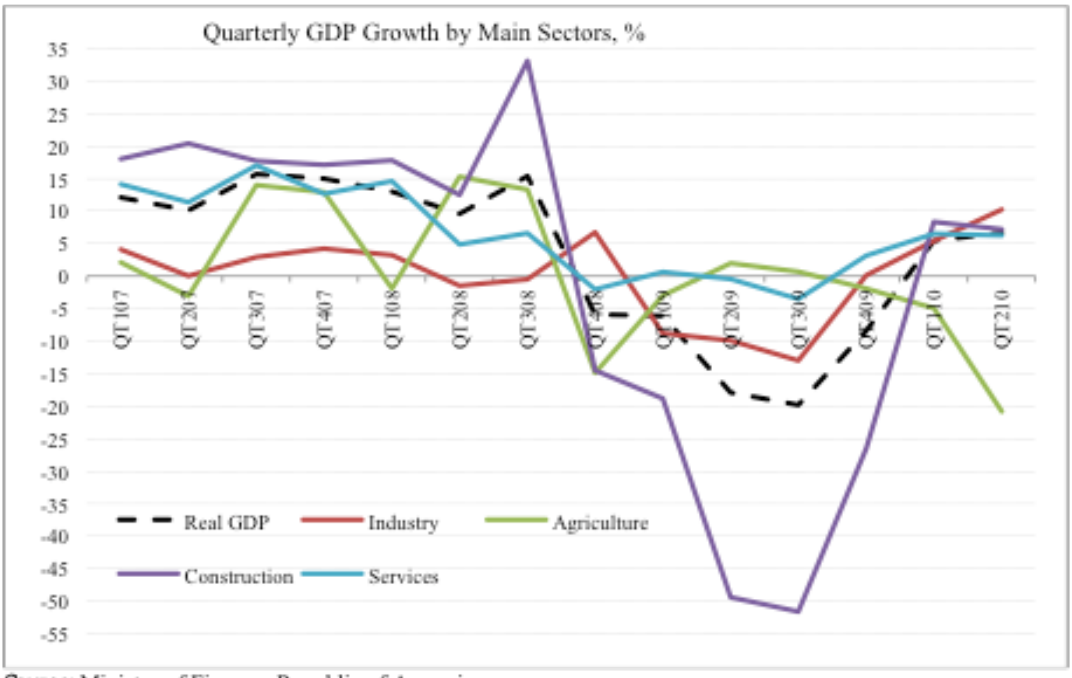
Armenia's economy has grown significantly since independence in 1991. It is considered a lower middle income country, with a GDP of USD 9.95 billion recorded in 2012[1]. Prior to the global financial crisis of 2009, Armenia recorded a growth rate of close to 13%. The global financial crisis had a major impact on Armenia, with growth only reaching 2.1% in 2010 and 4.6% in 2011[2]. The trend improved significantly in 2012, with recorded growth of 7.2%[3].

4.13.1 Macroeconomic Setting

Since independence, Armenia's economy has experienced extreme variations, including a GDP contraction of 42% in 1992 through to growth of 14% in 2007. Government has led a reform agenda focussing on price liberalisation, land privatization and titling, enterprise privatization and trade and investment liberalisation, resulting in strong economic growth between 2001 and 2007. During this time GDP per capita tripled and the poverty headcount fell from 56% to 28%[1].

The situation changed drastically when Armenia became one of the hardest hit countries in the East and Central Asian region from the global financial crisis. Figure 4.13.1 indicates the decline in growth during that period across all sections of the economy.

[1] http://data.worldbank.org/country/armenia accessed 2 May 2014
[2] World Bank, (2012), World Bank – Armenia Partnership: Country Program Snapshot, www.worldbank.org (accessed August 28th, 2012)
[3] http://search.worldbank.org/all?qterm=Armenia+growth+statistics&op= accessed 2 May 2014



Source: Ministry of Finance, Republic of Armenia.

Figure 4.13.1: Economic Growth before, during and after the Global Recession[4]

During this time, exports reduced by 33% and remittances (an important element of the Armenian economy) dropped by 35%[5]. The economic decline in this period was further influenced by the August 2008 conflict between Georgia and Russia, limiting Armenia's use of the transport route for goods through Georgia[6].

Positive growth was recorded in 2010-2011, with the expectation that Armenia should attain 4-5 % growth in the medium term[1], as shown in Figure 4.13.2.

[4] World Bank, (2011), Armenia, Poverty Update Using Revised Poverty Lines, Europe and Central Asia Unit, World Bank

[5] World Bank, (2012a), Fiscal Consolidation and Recovery in Armenia, Europe and Central Asia Knowledge Brief, February 2012, Volume, 45, www.worldbank.org (accessed 28th August 2012)

[6] ibid

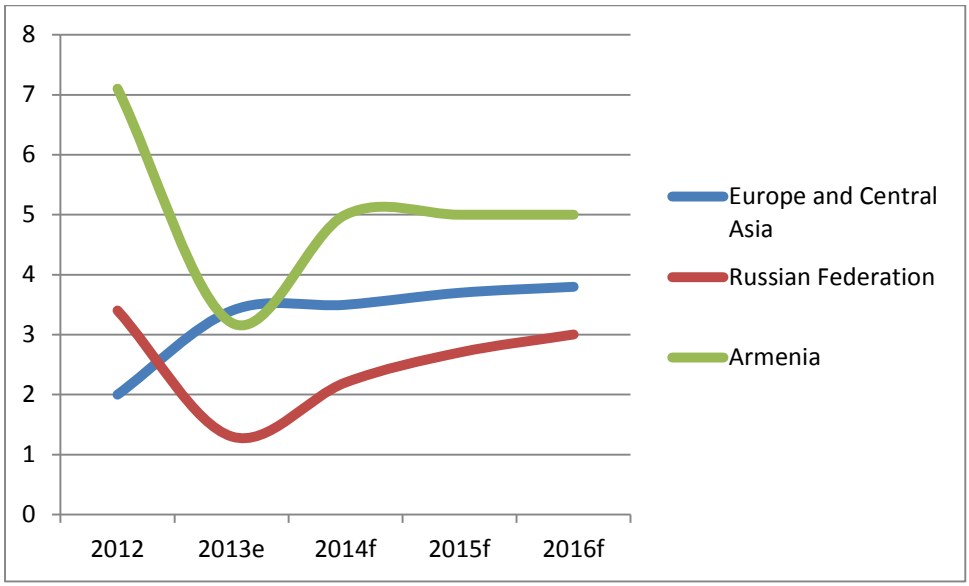


Figure 4.13.2 GDP Forecasts for Armenia and the Region (World Bank)

4.13.2 Inflation

In the post-independence period, Armenia has experienced both periods of modest inflation and periods of hyperinflation, as can been in Figure 4.13.3. Food prices have been the key driver behind inflationary pressure in recent years; however, their slow-down in 2011 has allowed inflation to decline to levels within the band (4% ± 1.5) targeted by the Armenian Central Bank[5]. Inflation of 2.6% was recorded for 2012[1].

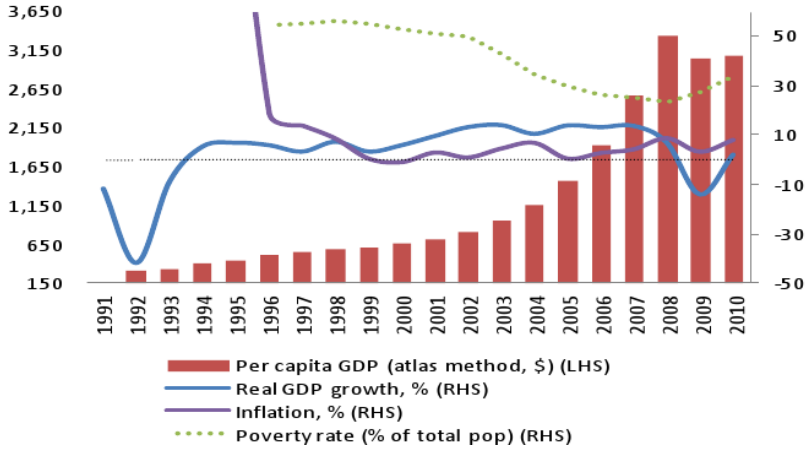


Figure 4.13.3: Armenian Inflation Trends (1991-2010)[6]

4.13.3 Sectoral Contributions

Armenia's economy is dominated by agri-business and increasingly by mining. Industry (combining both agri-business and mining) contributed more than half of the economic growth seen in 2011 and mining contributes over 60% of the export earnings (see Figure 4.13.4).

The World Bank Armenia has been working with the Government of Armenia to develop a new mining code over recent years. Since the development and implementation of the new mining code (in 2012), revenues received by the Government of Armenia from mining have more than doubled (from USD 17.9 million in 2011 to USD 45.3 million in 2013)[7].

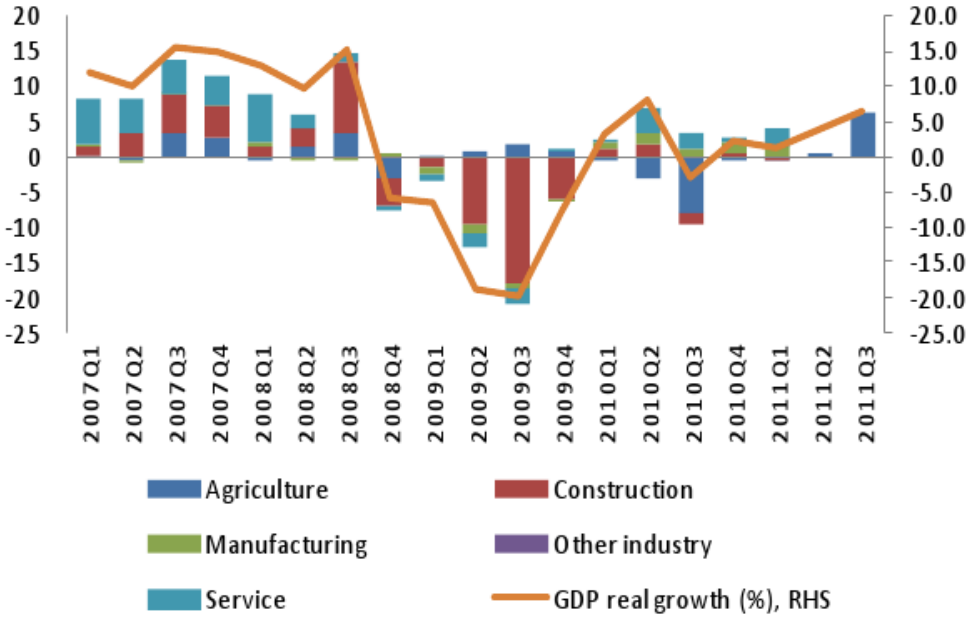


Figure 4.13.4: Economic Growth and Sectoral Contributions[5]

Syunik is the richest Marz in the country, due to the mineral production which is being undertaken in the Kapan District. The importance of this mineral production to the national economy is evident in Table 4.13.1. By comparison, the importance of Vayots Dzor to the national economy is limited at present, with the bulk of the "industry" contribution stemming from mineral water bottling plants in Jermuk.

[7] http://www.worldbank.org/en/news/feature/2014/04/15/infographic-resposible-mining-in-armenia

Table 4.13.1: Sectoral Contribution from Syunik and Vayots Dzor Marzer[8]	
Sector	**Contribution from *Marz* to Republic Economy**
Syunik	
Industry (mining and energy)	18.3%
Agriculture (crops and animal husbandry)	5.7%
Construction	7.2%
Retail Trade	0.9%
Services	1.1%
Vayots Dzor	
Industry	0.8%
Agriculture	2.2%
Construction	0.9%
Retail Trade	0.4%
Services	0.4%

4.13.4 Poverty Levels

Poverty levels reduced significantly between 1999 and 2007, with over a million Armenians lifted out of poverty during that time. This situation reversed, however, with the advent of the global recession, seeing approximately 30% of these people retreat back into poverty, and the poverty headcount rise to approximately 1.2 million Armenians in 2010[5]. Rural and urban areas experienced similar increases in poverty levels during this time, with an average increase in poverty headcount of 8%. This headcount is expected to decrease as GDP growth accelerates.

[8] Armstat, (2011), Marzes of the Republic of Armenia, www.armstat.am/en (accessed 4th September 2012)

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4.14 Education

Armenian state-funded educational institutions include:

- Pre-school education for children aged 3–6 years;
- General secondary education, comprising primary school (grades 1–3) and middle or basic school (grades 4–9);
- High school (grades 10–12);
- Specialist[1], vocational and higher education establishments; and
- Teacher training and in-service training institutions.

Middle school and high school graduates can continue their education in vocational or higher educational institutions.

There are also a number of non-State sector educational institutions, including schools, colleges and universities that provide their services on a fee-paying basis as per demand. Armenia has nearly 100% literacy.

There are no tertiary education facilities in the study area. The most popular tertiary education facilities include Vayk, Sisian, Kapan, Yeghnegdzor and Yerevan, with preferences varying considerably within individual communities.

4.14.1 Infrastructure

The study area is relatively well served with education facilities, as illustrated in Table 4.14.1 and Table 4.14.2, with over-capacity rather than under capacity being the dominant theme.

Table 4.14.1: Education Infrastructure in the Study Area

Community	Kindergarten	Primary and Secondary School	High School
Gorayk	1 (20-25 children)	1	1 (part of the Secondary school)
Gndevaz	1 (20 children)	1	1 (part of the secondary school)
Saravan	0	1	0
Jermuk	1 (30 children)	2	1
Kechut	1 (20 -25 children)	1	0
Total	**4**	**6**	**3**

[1] In this context, specialist schools refers to schools where students can gain specific tuition in a specialized field.

Table 4.14.2: School Capacities and Attendance (2015)				
School	**Maximum Capacity**	**Current Attendance (2015)**	**Capacity Ratio**	**Proportion of Female Students**
Gorayk - *Secondary and High School*	240	76	32%	43%
Saravan - *Secondary School*	100	26	26%	38%
Gndevaz - *Secondary and High School*	360	85	24%	47%
Jermuk N1 - *Secondary School*	300	295	98%	51%
Jermuk N2 – *High School*	1100	402	37%	51%
Kechut School - *Secondary School*	420	153 (2012 data)	36%	42%

Kindergarten

Gorayk has a Child Centre, located in the village school, which has received financial support from the NGO World Vision, as well as from Lydian. Almost all nursing age children in Gorayk attend the Centre (see Figure 4.14.1), which is not officially accredited yet and therefore does not receive State funding. Gndevaz has a refurbished kindergarten (Lydian undertook the refurbishment which was completed in 2011). Saravan has no pre-school facilities.



Figure 4.14.1: Gorayk Child Centre

The Jermuk kindergarten is in good condition and contains a satisfactory range of facilities including a playground, gym, music room and first aid centre, complete with toys and all other required equipment (see Figure 4.14.2). The kindergarten provides three meals a day and has a functioning toilet, as well as centralised heating which is switched on in winter.




Figure 4.14.2: Jermuk Kindergarten

Kechut kindergarten is in good condition and provides all required facilities apart from a music room, yard and gym.

Monthly fees are charged for kindergarten attendance in both Jermuk and Kechut (10,000 AMD (USD 24) and 7,000 AMD (USD 17) respectively in 2010). In both communities, concerns were raised over the affordability of these services.

Primary and Secondary School

Each of the three rural communities in the study area has one school. School levels range from secondary to high school. Jermuk has three schools, one of which is located in Kechut. The school facilities are summarised in **Table 4.14.3**.

Table 4.14.3: School Facilities

Village / Town	Facility	Status
Gorayk	One school covering secondary and high school	Gas operated central heating, operational toilets, a gym and a school library. Computer room with free internet provision, and local entrepreneur operating school canteen. 95% of students recorded as passing their final exams
Saravan	Secondary school only	Relatively poor condition. School has no indoor toilet, gym or science laboratories. 95% of students recorded as passing their final exams
Gndevaz	One school covering secondary and high school	Good condition with indoor toilets and gas central heating. No cafeteria and under-resourced computer room and library. 99% of students recorded as passing their final exams

Table 4.14.3: School Facilities		
Village / Town	**Facility**	**Status**
Jermuk	N1 School	Secondary school in good condition, central heating, sufficient classrooms, computer room with internet and a library. School buildings are subject to damage from high groundwater levels in spring.
Jermuk	N2 School	High school in excellent condition (repaired in 2008). Gas central heating, adequate toilets, computer room with internet well-stocked library.
Kechut	Secondary school	Graduates from this school commute to Jermuk for high school education.

Students from Gorayk tend to go on to higher education in Sisian or Kapan, rather than Yerevan.

Interview evidence suggests that the lack of an accessible high school in the Saravan area affects students' morale and reduces motivation levels. Only students with relatives in Vayk, Yeghegnadzor or elsewhere are sent to high school in those areas.

Approximately half of the graduating students from Gndevaz are reported to go on to higher education, either in Yerevan or Yeghegnadzor.

About half of Jermuk's school graduates continue onto university education, with Yerevan as the preferred destination. Some students also go to Yeghegnadzor, while others cannot afford any higher education.

Kechut currently has a secondary school, with graduates commuting to Jermuk for high school education. This is seen as an issue by most parents, who preferred the pre-2010 set-up where Kechut School covered both secondary and high school levels.

Specialist Schools

Jermuk also has two art schools, a sports school and a chess school. The art schools are state funded and cover music, dance and painting, as well as sculpture. They accept students from the age of six years upwards. Jermuk art students have had significant success at competitions.

The sports school, run by a local enthusiast, teaches boxing and wrestling. The sports school is reported to be underequipped and is not supported by the State.

The chess school is funded and supported by Jermuk community and is reported to be in good condition. It is free to attend. Students have won numerous local competitions and aim for more significant successes.

Gorayk School also supports extracurricular activities such as a chess club, sports facilities and music classes.

4.14.2 Enrolment

The level of education infrastructure is greater than the demand for most levels of education in the study area. The exception to this trend appears to be focussed on high school access, with a shortage of places for students at high school level in Jermuk and Kechut and the absence of a high school option for students from Saravan.

The children of seasonal herders are usually enrolled in school in their places of origin, missing some of the annual school curriculum due to the family's nomadic lifestyle (between April and October).

The lack of university and other higher education facilities in the local area can also be a barrier to educational achievement at high school level, in terms of motivation and career planning. Career opportunities in the area are limited and this affects the morale of school students.

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Appendix 4.15.1 Rapid Health Impact Assessment (June 2012)

4.15 Community Health

The Armenian health system is in a process of transition from the centralised Soviet model of health care, with a major focus on hospitalisation, to the development of a state operated network of economically independent enterprises.

Life expectancy at birth in Armenia is 67/75 years[1] for males/females respectively (as recorded in 2012), with women living longer than men. The country performs comparatively well in standard health indicators compared to other Central Asian countries and has made progress in achieving the Millennium Development Goals targets set for 2015. In 2010, the under-five mortality rate was reported at 16 per 1000 live births and infant mortality rate was 13 per 1000 births, compared to 1990 figures of 49 and 42 per 1000 live births respectively[2,3].

The major health concerns in Armenia are associated with non-communicable diseases (NCDs). Disability adjusted life years (DALYs) provide an indicator of the overall disease burden of a country, and the DALYs for Armenia (highlighted in Figure 4.15.1) portray the contribution of cardiovascular disease, cancer and chronic lung disease to the national health burden.

Estimates for 2008 showed that NCDs accounted for about 90% of all deaths in Armenia, 46% being from cardiovascular disease (CVD)[4]. In general, the burden of disease in the study area follows a similar pattern with CVD, cancers and diabetes listed as the most common health concerns.

1 http://www.who.int/countries/arm/en/ accessed June 20th, 2014
2 WHO, (2004), DALYs for Armenia, available from http://www.who.int/quantifying_ehimpacts/national/countryprofile/armenia.pdf
3 WHO, Non-communicable Diseases Country Profiles: Armenia. 2011.
4 ibid. 3, p 4.15.2

Environmental burden of disease (preliminary), per year
Estimates based on Comparative Risk Assessment, evidence synthesis and expert evaluation for regional exposure and WHO country health statistics 2004

DALYs/1000 cap	(World - lowest: 13, highest: 289)	**32**
Deaths		**7 500**
% of total burden		**17%**

Environmental burden by disease category [DALYs/1000 capita], per year

Disease group	World's lowest country rate	Country rate	World's highest country rate
Diarrhoea	0.2	**2.2**	107
Respiratory infections	0.1	**1.1**	71
Malaria	0.0	**0.0**	34
Other vector-borne diseases	0.0	**-**	4.9
Lung cancer	0.0	**1.4**	2.6
Other cancers	0.3	**3.1**	4.1
Neuropsychiatric disorders	1.4	**2.0**	3.0
Cardiovascular disease	1.4	**8.9**	14
COPD	0.0	**1.4**	4.6
Asthma	0.3	**0.8**	2.8
Musculoskeletal diseases	0.5	**0.9**	1.5
Road traffic injuries	0.3	**1.2**	15
Other unintentional injuries	0.6	**4.1**	30
Intentional injuries	0.0	**0.3**	7.5

Figure 4.15.1: Estimated DALYs ('000) by Cause, Estimated for 2004[1]

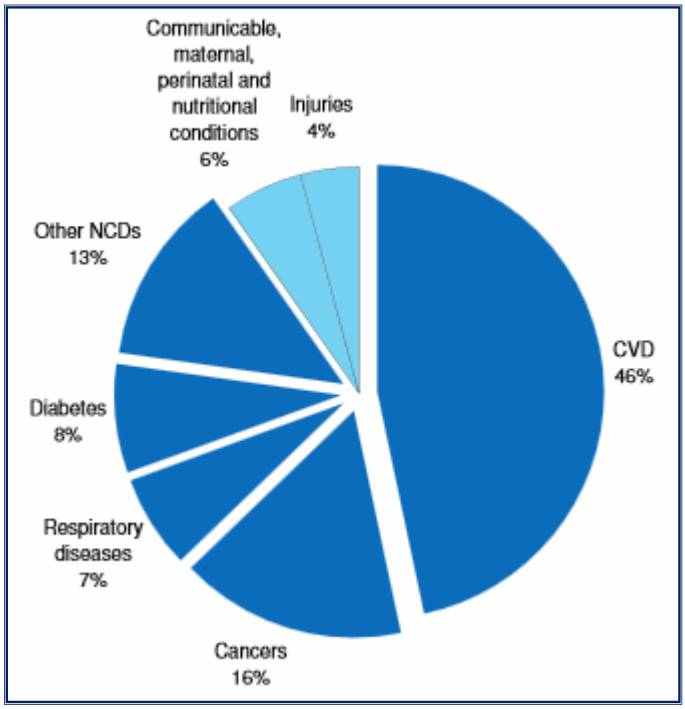


Figure 4.15.2: Proportional mortality (% of total deaths, all ages) by Cause, estimates for 2008

4.15.1 Health Infrastructure

The National Health Service and general health infrastructure faced numerous challenges after the collapse of the former Soviet Union. The health system was forced to reform from a centrally managed service that was free of charge with a strong focus on secondary care, to a

network of state controlled but economically independent entities. However, quality of health care remains a challenge with:

i) The management and allocation of health budgets;
ii) Limited health services and coverage in the rural areas; and
iii) Poor access to health care for the poor in society (often in rural areas).

Funding for health care and ability for poor or vulnerable groups to afford the current co-pay systems limits access to care in certain sectors of society. This is in spite of a public funded subsidy for vulnerable groups as part of the Basic Benefits Package, with the limitation on affordability of medications, especially those required for chronic diseases, which as mentioned contribute significantly to the overall national burden of disease. A 2011 World Health Organisation (WHO) report found that 50% of total health expenditure was privately funded, with 84% of that coming directly out of the consumer's pocket.

The current Armenian health system is divided into three levels:

- **Primary health care:** through services running out of polyclinics and health posts or so-called outpatient services located in small villages and supervised by a doctor and / or a nurse. Vulnerable groups are funded from the Basic Benefits Package subsidy which supports a list of services, but shortage of medications often require that users are forced to procure medications privately, with these often being unaffordable in the long term;
- **Secondary health care:** health posts and regional / municipal hospitals providing secondary care on a co-payment system (health expenses paid between the Government and the patient). Hospitals are generally large facilities with a vast number of beds, but poor bed occupancy rates limit the effective utilisation of many facilities. Thus, the number of beds per capita population has fallen dramatically in the last 20 years; and
- **Tertiary health care:** specialised hospitals that also operate on a co-payment system.

The study area is well resourced in terms of available health centres and hospitals and there is a functioning referral and ambulance system in place. Details of the existing facilities are provided in Table 4.15.1, which highlights the structural and operational challenges faced by a number of the facilities.

One of the key limitations to the functionality of health facilities in the study area is the limited availability of medications in the public health facilities, which is further compounded by the lack of local private pharmacies.

Table 4.15.1: Study Area Health Facility Characteristics

Location	Type of Facility	Catchment Area	Services / Facilities	In-patients Capacity	Staff	Challenges
Vayk	State-owned Regional Referral Hospital	Saravan, Gndevaz, Jermuk Vayk city	Ambulance service, surgery, outpatients, inpatients capacity, maternity, orthopaedics, emergency care, laboratory	180 beds	40 medical staff	• Limited financial resources with co-pay system (government subsidy, covering certain % for each medical condition) for socially vulnerable (disabled, special groups like veterans, pensioners, etc.) • Lack of modern and updated diagnostics in contrast with the scope of the facility in providing adequate secondary and referral care • Referral hospital for a large population (40,000 people)
Jermuk	State-owned General Hospital	Jermuk, Kechut	Ambulance service, surgery that is not functional for serious cases, outpatients, inpatients capacity, maternity, orthopaedics, emergency care, and laboratory. For serious cases the patients are taken to Vayk or Yerevan	25 beds	24 medical staff	• Lack of trained staff to operate modern equipment • Top-down approach in health policy implementation as directed by the Ministry of Health (MoH)
Gorayk	Health Centre	1 village	Basic health care, first aid, health education, monitoring of pregnancies and chronic diseases, family planning, vaccinations, home visits	0 beds	11 medical staff (2 nurses permanently at the health centre), one visiting medical doctor	• Structural issues (humidity damaged walls) and lack of heating and hot water in facility (currently under repair by Lydian) • Lack of basic diagnostic medical equipment • No inpatient capacity • A little equipment provided by Lydian (centrifuge, etc.)

Table 4.15.1: Study Area Health Facility Characteristics						
Location	**Type of Facility**	**Catchment Area**	**Services / Facilities**	**In-patients Capacity**	**Staff**	**Challenges**
Saravan	Health Post	1 village	Basic health care, first aid, health education, monitoring of pregnancies and chronic diseases, family planning, vaccinations, home visits	0 beds	1 nurse	• Irregular supply of medication and consumables • Lack of heating and running water • No sanitation facilities • Limited support of supply chain provided by the state
Gndevaz	Health Post	1 village	Basic health care, first aid, health education, monitoring of pregnancies and chronic diseases, family planning, vaccinations, home visits	0 beds	1 nurse	• Structural challenges with flooring • No sanitation facilities, no heating • Limited support of supply chain provided by the state

4.15.2 Health Profile

A detailed health baseline study was completed by SHAPE Consulting for the Amulsar Project and is included as Appendix 4.15.1. The health baseline was assessed in line with the IFC Introduction to Health Impact Assessments as good international industry practice, and addresses each of the twelve environmental health areas (EHAs) in turn as described in Table 4.15.2.

Table 4.15.2: Environmental Health Areas Baseline Health Description		
Environmental Health Area (EHA)	**National Level Findings**	**Study Area Findings**
EHA# 1 – Communicable Diseases linked to the living environment	Overcrowding: Average household size is 4 members. Overcrowding is not a national concern.	On average between five and seven people live in each household, although overcrowding does not appear to be an issue. However, it was recognised that many households do not have the means to live separately with a situation of children marrying and living with their parents, with a future potential risk for overcrowding. In Jermuk, 68% of households had more than one sub-family unit per household. Wood or dried manure was used for heating in some communities, which may increase the risk for acute respiratory infections, with children identified as an especially vulnerable group.
	Tuberculosis (TB): Central Asia and CIS are the second most important area globally for TB incidence or increasing trends of the disease. Armenia is not classified as a high burden TB country, with prevalence of 79/100,000 in 2012 (and incidence of 52/100,000 in the same year). This compares to a prevalence of 114/100,000 and an incidence of 79/100,000 in 2010, highlighting improved TB indicators. Armenia has high levels of multidrug resistant (MDR) TB. In 2012, 9.4% of new TB cases showed signs of MDR-TB[5,6]. This is the same rate as reported from a 2008 study, probably because of inadequate case detection. However, there were reports that trends were increasing.	Vayk Hospital had no cases of TB in 2011, however suspected cases are typically referred to Abovyan TB Centre (north of Yerevan) where diagnostic and treatment facilities are available. No TB cases have been reported in health posts and centres in the study area villages, with the exception of Jermuk Hospital that referred 20 cases in the period from 2010-11. All the case from Jermuk were suspected to be imported cases from other areas, originating in people that have recently returned from military service or were temporary labour migrants. These findings may reflect inadequate diagnostic services locally. Importantly, of the 20 cases detected locally, nine were reported with MDR-TB.

[5] WHO, *Global Tuberculosis Report 2013*. 2013.
[6] WHO. *Armenia Tuberculosis Profile*. 2012 [cited 2014/ 05/07]; Available from: https://extranet.who.int/sree/Reports?op=Replet&name=/WHO_HQ_Reports/G2/PROD/EXT/TBCountryProfile&ISO2=AM&outtype=html.

Table 4.15.2: Environmental Health Areas Baseline Health Description		
Environmental Health Area (EHA)	**National Level Findings**	**Study Area Findings**
	Acute Respiratory Infections (ARIs): In 2010, it was estimated that 11% of all deaths in children under five were due to pneumonia[7], with 5% of respondents in the 2010 Armenia demographic and health survey (ADHS) reporting signs of an ARI in the two weeks preceding the survey[8]. A 2008 report estimated that 17% of all deaths in children under 5 were due to pneumonia.	Only 1.2% of children under five years in Vayots Dzor *Marz* and none (0.0%) in Syunik *Marz* had signs of an ARI in the two weeks preceding the 2010 ADHS. These statistics are borne out from information received from key informants from the local health facilities that did not consider respiratory infections to be a serious health issue in the study area. Respiratory infections are recorded in the routine health management information system and between June and November 2011, ARIs accounted for approximately 15% of cases at Gorayk Health Centre, and 4.6% and 3% of patient diagnoses at Gndevaz and Saravan respectively. However, it was reported that the population tends to self-medicate or neglect ARIs as full treatment courses were rarely provided by the local health service. Case-loads were reported to increase in winter.
	Measles: Vaccination coverage for measles is good in Armenia, with 97% of children under one year of age immunised against measles in 2012[9]. In 2010, this figure was 94%, nationally. Three measles cases were reported nationally in 2013, but a measles epidemic is currently occurring throughout Eastern Europe including Ukraine, Georgia, Britain, and France and it is understood that cases have recently been notified in Armenia.	No cases of measles were reported locally.

[7] WHO. *Armenia Health Profile*. 2013 [cited 2014/ 05/08]; Available from: http://www.who.int/gho/countries/arm.pdf?ua=1.
[8] National Statistical Service [Republic of Armenia], Ministry of Health [Republic of Armenia], and ICF International, *Armenia Demographic and Health Survey 2010*. 2012.
[9] UNICEF. *Armenia: Statistics*. 2013 [cited 2014/ 05/07]; Available from: http://www.unicef.org/infobycountry/armenia_statistics.html.

Table 4.15.2: Environmental Health Areas Baseline Health Description		
Environmental Health Area (EHA)	**National Level Findings**	**Study Area Findings**
	Meningitis: Vaccination against meningitis is part of the national expanded programme of immunization (EPI). The country reported five cases of meningitis in 2010.	No cases were reported locally, recognising the local limitations in diagnostic services.
EHA# 2 – Vector related diseases	Malaria: Until the 1950's, malaria was endemic in Armenia. Malaria was eradicated by 1963, but re-emerged in the 1990's with Armenia only being granted malaria free status again in October 2011.	Malaria is currently not present in the study area, and the elevation and climate of the study area make it unlikely that it could be introduced.
	Tick-borne encephalitis: Unlikely to occur commonly in Armenia.	The elevation of the study area and lack of forested areas makes it unlikely that these diseases would exist in the study area.
	Borreliosis/ Lyme Disease: No data available.	No data on these conditions locally, however not expected to be significant due to the absence of forest in the study area.
EHA# 3 – Soil, water and waste related diseases	Potable water and sanitation situation: According to the 2010 ADHS, access to an improved water source in Armenia was at 95%, with 9 in 10 households having their drinking water piped directly into their dwelling, yard, or plot[10]. In 2011, coverage had improved to almost the entire population (100% in urban and 98% in rural areas)[11]. This was an improvement from 2005, where 93% of the population has access to improved water sources. Most households in Armenia use improved sanitation facilities that are not shared with another household.	All rural communities have good access to piped drinking water; however, the quality of piped water in Gorayk and Saravan does not meet international drinking water standards (Section 4.8). In the study area, ventilated improved pit (VIP) latrines are most commonly used. The waste water treatment plant in Jermuk was upgraded and opened in December 2014. With a design horizon of 2032, it has a capacity of 22,000 people, This far exceeds the current population of Jermuk. Sewerage systems in the rural villages are non-existent.

[10] ibid. 7
[11] WHO/UNICEF, *Progress on Sanitation and Drinking Water: 2013 Update*. 2013.

Table 4.15.2: Environmental Health Areas Baseline Health Description		
Environmental Health Area (EHA)	**National Level Findings**	**Study Area Findings**
	In 2010, 79% of the country's population (97% in urban and 49% in rural areas) used improved (not shared) sanitation facilities[12]. In 2011, access to improved sanitation was estimated at 90% (96% in urban and 81% in rural areas)[13]. This was an improved from 2005, where 47% of the population had access to improved sanitation facilities.	Prior to the project, domestic waste collection was limited. Lydian now provides a collection service to support the management of this environmental health risk. Damp is common in buildings due to poor construction and high levels of humidity and a high water table in the rural communities. Elevated radon levels exist in a number of houses within Gorayk but this is discussed in more detail in the radiation section as part of the naturally occurring radiation material present in the study area. The environmental hygiene situation in Jermuk is better than the rural communities, with 99% of the population reporting having access to an improved drinking water supply and domestic waste removal. However, the quality of drinking water was a community concern in Jermuk and Kechut (although in a lower proportion in the latter).
	Diarrhoeal diseases: Represents 2.2% of the Armenian DALYs. In 2010, 9% of children surveyed in the ADHS had experienced signs of diarrhoea in the two weeks preceding the survey[14].	About 7.5% of children under five years in Vayots Dzor and none (0.0%) in Syunik *Marzes* had signs of diarrhoeal disease in the two weeks preceding the 2010 ADHS[15]. Key informant interviews indicate that diarrhoeal or gastro-intestinal diseases are not a major challenge in the study area. However, cases are more common in summer and spring.

[12] ibid. 7
[13] ibid. 12
[14] ibid. 7
[15] ibid

Table 4.15.2: Environmental Health Areas Baseline Health Description		
Environmental Health Area (EHA)	**National Level Findings**	**Study Area Findings**
EHA# 3 – Soil, water and waste related diseases	Cholera: No epidemics have been recorded nationally since 1998.	
	Soil transmitted helminthiasis (STH): 4% of the Armenian population were reported to suffer from *ascaris* infections, 1% of *trichuria* and 26% from some form of *enterobacter* infections.	Cases of STH are rarely reported in the study area, and de-worming campaigns are routinely conducted twice per year, free of charge for children up to 12 years of age.
	Hepatitis A: Not included in the national EPI schedule. No statistics are available nationally.	No data available on this disease in the study area; however, it is expected that due to the prevailing sanitation situation, communities are likely to have been exposed in childhood and a portion of the community will now have antibodies and thus immunity to the condition.
EHA# 4 – Sexually-transmitted infections, including HIV/AIDS	HIV/AIDS: HIV prevalence remains low in Armenia (0.12% amongst adults aged 15-49 years), although the trend has been increasing in the past decade. In 2008, it was estimated that just over 2,200 people were HIV positive nationally. In 2010, the country registered 248 new cases of HIV infection. Men account for about two-thirds of the registered HIV cases and the age group most affected is 25-39 years[16]. Knowledge of HIV/AIDS is reported to be high, with 96% of the population (93% in rural and 98% in urban areas) reporting to have heard of HIV/AIDS, according to findings from the 2010 ADHS. However, HIV prevention knowledge has remained essentially unchanged since 2005. About 69% of women and 80% of men know that the risk of getting HIV can be reduced by using condoms and	In 2005, only 70% of men from Syunik Marz reported knowledge of HIV/AIDS, but this had increased to 91% by 2010. The level of knowledge of HIV/AIDS in Vayots Dzor Marz has decreased in recent years and in 2010 was found to be lower than the national average (86% for men and 88% for women). HIV screening is provided at the Vayk Hospital and screening is mandatory for all pregnant women. No cases have been reported in the past year. No HIV screening services are available in health centres in the study area, including Jermuk. There are five patients living with HIV being followed up at Jermuk hospital, all of whom were apparently infected while working as migrant labour in Russia.

[16] ibid. 14

Table 4.15.2: Environmental Health Areas Baseline Health Description		
Environmental Health Area (EHA)	**National Level Findings**	**Study Area Findings**
	limiting sex to one faithful, uninfected partner[17]. HIV related knowledge amongst groups at high risk (IV drug users, sex workers and men who have sex with men) remains limited, with only 54% of sex workers reported as having adequate knowledge related to HIV prevention methods. Many Armenians still have misconceptions about HIV/AIDS[18]. Stigma against HIV-positive people is reported to be high in the region. The proximity of Armenia to Russia and Ukraine poses an additional risk as these countries have the highest HIV prevalence in the sub-region. In the 2010 ADHS, 15% of men age 15-49 reported to have had two or more sexual partners in the 12 months preceding the survey. Almost three-quarters of these men reported use of a condom during their last sexual intercourse. Men reported an average of almost six sexual partners in their lifetime. The national coverage for voluntary HIV testing is generally low. In 2010, only 9% of women and 2% of men reported that they have ever been tested for HIV and received the results. For people seeking treatment, anti-retroviral therapy (ART) is only available in Yerevan.	HIV and sexual practices were discussed in women's focus group discussions (FGD) in the study area with the following key findings: • Local knowledge is good and women know how to protect themselves; • Stigma is low as the local community are well educated on this topic; • Cases do not originate locally and are generally limited to returning migrant workers; and • Commercial or forms of transactional sex work were described as being "very rare" in the study area (including Jermuk).

[17] ibid. 14
[18] ibid. 14

Table 4.15.2: Environmental Health Areas Baseline Health Description		
Environmental Health Area (EHA)	**National Level Findings**	**Study Area Findings**
	Sexually transmitted infections (STIs): In the 2010 ADHS, only 3.8% of women and 0.6% of men in rural areas reported signs or symptoms of STIs in the 12 months preceding the survey [1]. In the 2005 ADHS, only 0.5% of women in rural areas reported signs or symptoms of STIs. However, STIs are associated with high levels of stigma so it is anticipated that many people do not present to public health services with STI related conditions.	In Vayots Dzor Marz, 4.0% of the women (but none of the men) reported symptoms / signs of an STI in the 12 months preceding the 2010 ADHS. None of the men and women in Syunik Marz reported an STI symptom / sign in that period. Vayk Hospital rarely treats people with STIs. Health practitioners believe this is due to stigma and patients preferring private practitioners or self-medication. Gorayk health centre has had a few cases of suspected STIs, which have been referred to specialist hospitals. The other villages have not reported any cases, but acknowledged high levels of stigma locally.
	Hepatitis B: Vaccination against hepatitis B has been part of the Armenian EPI standard vaccination regime since 1999, with coverage (of 3rd dose) in under 1 year olds reported at approximately 95% in 2012[19].	Vaccination coverage for Hepatitis B is believed to be adequate in the study area. Any suspected cases are reported to specialist hospitals, as local diagnostic capabilities are limited. Suspected cases, however, were not common.
EHA# 5 – Food and Nutrition-related issues	Food security and Malnutrition: Malnutrition is reported in Armenia, with 7% of babies born between 2005 and 2009 having a low birth weight. Data from 2003-2009 indicated that 4% of children were moderately to severely underweight; 5% were wasted (low weight for height and a sign of acute malnutrition); and 18% were stunted (low height for age and a sign of chronic malnutrition).	Malnutrition indicators in Vayots Dzor Marz were broadly in line with national averages. By comparison, the level of stunting in Syunik Marz at 37% in 2010 was higher than the national average and much higher than the 2005 finding for the same indicator (7%)[21]. In the 2010 ADHS, 18% of children under five years in Vayots Dzor Marz and 22% in Syunik Marz were found to be overweight[22].

[19] National Statistical Service [Republic of Armenia], Ministry of Health [Republic of Armenia], and ICF International, *Armenia Demographic and Health Survey 2010*. 2012.
[21] ibid
[22] ibid

Table 4.15.2: Environmental Health Areas Baseline Health Description		
Environmental Health Area (EHA)	**National Level Findings**	**Study Area Findings**
	The 2010 ADHS found that 19% of children (under-five) had stunted growth (8% severely), 4% were wasted and 5% were underweight. At the same time 15% of children were reported as overweight[20]. Increasing food prices, particularly for staple food items such as potatoes, have added pressure to food affordability at a national level. Inflation of staple food products has risen sharply since 2010.	Gndevaz and Saravan health posts regularly weigh children under 12 years of age, and staff did not consider acute malnutrition to be a significant issue in the study area. In the women's FGD, this was confirmed as food security and malnutrition was not perceived as a major challenge, with a good variety of food to promote a balanced diet. Access to land to support agricultural or animal husbandry is a key element of local livelihoods. In general, the community has good access to municipal land to graze their cattle. Food production in the area is generally for subsistence means or for local sale. Produce sold outside of the immediate study area is usually sold to middle-men who visit the villages, as the local community does not have the means to take the produce to larger markets, such as those in big centres, like Yerevan.
	Anaemia: Anaemia is relatively uncommon in Armenia, which is a good indicator of the status of health in communities. In 2007, 0.5% of rural women (of reproductive age 15-49 years) and 0.6% of rural children were reported as having severe anaemia.	Severe anaemia levels in Vayots Dzor Marz are higher than the national average (2%), whereas Syunik is consistent with the national rural average (0.6%). Jermuk Hospital reports rarely seeing cases of anaemia.

[20] ibid. 7

Table 4.15.2: Environmental Health Areas Baseline Health Description		
Environmental Health Area (EHA)	**National Level Findings**	**Study Area Findings**
EHA# 6 – Non-communicable diseases (NCDs)	NCD overview: In 2008, it was estimated that 90% of all deaths nationally were associated with NCDs[23]. The leading causes of premature death, in order of magnitude include diseases of the circulatory system, cancer, diabetes, external injuries and poisoning. In 2008, it was estimated that 55% of the Armenian population was overweight, with 24% of the population classified as obese (higher for women than in men). Tobacco consumption by men and women is rising rapidly. About 69.4% of men between the ages of 24-65 years smoke. Alcohol consumption is not reported as a major problem currently, but is noted to be increasing especially in the youth.	

[23] ibid. 3

Table 4.15.2: Environmental Health Areas Baseline Health Description		
Environmental Health Area (EHA)	**National Level Findings**	**Study Area Findings**
	Cardiovascular disease (CVD): Nationally, CVDs account for 46% of all deaths in 2008 and are among the highest cause of DALYs[24]. This is up from 8.9% in 2002. Hypertension prevalence across Armenia in 2008 was estimated at 50.7% and this is believed to be an under-estimate due to general poor health seeking behaviour toward the public health sector and a preference for self-treatment.	16% of all patients treated between June and November 2011 at the Gorayk health centre were diagnosed with hypertension. These outpatient statistics include children and adolescents, thus the adult prevalence is much higher, outlining the burden of disease from this condition. In the same period, 15% and 24% of cases reported at Gndevaz/Gorayk and Saravan health centres respectively, were recorded as CVD. Based on a review of statistics provided by OXFAM who support a medication support programme, approximately 16.5% of the population in Saravan is receiving treatment for hypertension. In all key informant interviews, health centre staff confirmed that CVD was the major health challenge in the study area. In the FGD the challenge was acknowledged but with limited ability to reduce the occurrence and associated burden of disease.
	Diabetes mellitus: In 2008, deaths related to diabetes were 709 / 100,000 for men and 388/100,000 for women. There has been a gradually increasing trend of mean glucose levels.	No data was available on the burden of disease locally, however diabetes was mentioned by most health staff in the study area. Nineteen patients with diabetes are followed up at the Gorayk health centre. However, diabetes was not considered as a major challenge from the FGD held with local women. This may be due to lack of knowledge and education.

[24] ibid. 21

Table 4.15.2: Environmental Health Areas Baseline Health Description		
Environmental Health Area (EHA)	**National Level Findings**	**Study Area Findings**
	Cancer: Cancer causes approximately 20% of all deaths in Armenia, with the mortality rate for cancer having increased by over 70% in the past decade. Breast cancer and cervical cancer are among the biggest killers of women. There have also been increasing trends of cancer in adolescents and children. Public health policies and the primary healthcare system do not support early detection of cancer. Effective cancer screening programmes and poor health seeking behaviours in the community also limits early detection of cancer.	Data is only available from Gorayk health centre, where between June and November 2011 36 new cases of presumptively diagnosed cancer were recorded. Five deaths from cancer were reported in Gorayk in January 2011 for the preceding 12 months. Cancer was mentioned as a challenge by participants of the FGD with lung cancer more common in men and breast and cervix cancer occurring in women.
	Chronic Respiratory Disease: In 2008, chronic respiratory disease contributed to 7% of the total deaths nationally[25], up from 4% in 2002.	Chronic respiratory diseases and associated morbidity were not reported by health facilities in the study area.
EHA# 7 – Accidents / Injuries	Injuries: Injuries are the 5th leading cause of death in Armenia (4% of deaths). The leading causes of unintentional injury-related deaths include road traffic injuries (6.4%), poisoning, (1.4%), drowning (0.9%) and fires (0.8%). These levels are, however, lower than EU averages.	Road traffic accidents are reported to occur rarely in the study area. Domestic violence is also reported to be rare in the study area. The health centres have minimal capacity to manage trauma beyond immediate first aid with any mildly serious cases are referred to Sisian or Vayk hospitals for further treatment.
EHA# 8 – Veterinary and Zoonotic Diseases	Rabies: WHO confirmed the presence of rabies in Armenia in 2007.	No cases have been reported and the disease is not known in the study area.
	Crimean-Congo Haemorrhagic Fever (CCHF): The only case of CCHF ever reported in Armenia was in 1974, although other unconfirmed cases were also noted up until 2006.	No cases have been reported and the disease is not known in the study area.

[25] ibid. 21

Table 4.15.2: Environmental Health Areas Baseline Health Description		
Environmental Health Area (EHA)	**National Level Findings**	**Study Area Findings**
	Brucellosis: The national brucellosis control data shows a widespread and uneven distribution of brucellosis throughout the Republic of Armenia for both cattle and small ruminants[26]. There is a potential risk for human infection and active surveillance remains key in the control of the disease.	Brucellosis is known at a local and regional level, and control strategies have been implemented in the study area. Gorayk cattle are regularly tested and several contaminated animals were destroyed in 2011 to reduce the risk of human transmission.
EHA# 9 – Potentially hazardous materials, noises and mal-odours	Radiation related diseases: There is no reported data on this health condition at national or local level.	Elevated radon levels exist in the rural communities of the study area (in particular in Gorayk). These pre-existing levels are independent of any project activity. More detail on this and other related topics is in included in Chapter 6.
	Other environmental health determinants: The baseline description of air quality, noise, vibration and water quality are described in each specialist report relevant to the Project ESIA.	See Sections 4.4, 4.5, 4.8 and 4.9.
EHA# 10 – Social determinants of health	Mental Health: Mental health services in Armenia are currently described as very limited, with poor integration in the general health care system, very low standards of care or respect for human rights. Stigma on mental disease and poor confidentiality limits the willingness to seek care for mentally ill family members. Community based psychiatric care units are not available. Mental health is a serious concern in the youth with a 2004 study conducted nationally highlighting that 9% of boys and 10% of girls contemplated suicide in the previous year.	Mental illness was not mentioned as a major health concern in the study area interviews. This may be in part due to the stigma associated with mental health issues.

[26] Porphyre, T., et al., *Mapping brucellosis risk in communities in the Republic of Armenia.* Geospatial health, 2010. **5**(1): p. 103-118.

Table 4.15.2: Environmental Health Areas Baseline Health Description		
Environmental Health Area (EHA)	**National Level Findings**	**Study Area Findings**
	Life Style: Armenians are heavy smokers, with 60.7% of rural men using tobacco, with over 90% of this group smoking more than 10 cigarettes per day. Alcoholism has never been a widespread problem in Armenia, although the situation is slowly deteriorating, especially amongst the youth.	Alcohol consumption was not considered a major problem in the study area. However, most men and women smoke.
EHA# 11 – Cultural Health Practices and Health Seeking Behaviours	Health Seeking Behaviours: Under the Soviet Union, Armenians had access to free primary, secondary and tertiary health care (the Semashko model). With the transition to a different health care system, financing now relies upon payments by patients in more than 65% of cases for secondary and tertiary care. Primary health care is still provided free under the "basic benefits package". In a 2001 study, affordability was cited as the main reason (in 78% of cases) limiting care seeking behaviour towards public health care institutions, with 42% of respondents indicating that they did not seek health care even when displaying symptoms. In the 2005 ADHS, only half of women who reported they had a health condition actually consulted a health care practitioner in the preceding two weeks. This proportion increased to 58% in the 2010 ADHS[27].	Health staff and women in FGD in the study area reported concerns about the inability of the local community to afford health care services. This often led to delayed diagnosis as minor conditions escalate into conditions that are more complicated. At the Vayk hospital, it was reported that the fee structure was high and generally not affordable to the local community.

[27] ibid. 7

Table 4.15.2: Environmental Health Areas Baseline Health Description		
Environmental Health Area (EHA)	**National Level Findings**	**Study Area Findings**
	Traditional Medicine: Use of traditional medicine has strong roots in Armenia, with use of plants and herbs as medicinal products passed down through generations. This forms an essential part of current Armenian folk tradition and with practices widely used and culturally important.	The use of traditional medicine was not reported to be of great importance in the study area.
EHA 12 – Health System Issues	Health Infrastructure: Post independence, Armenia has seen a transition from large state hospitals to an increasing use of private health facilities (now representing 9.2% of all hospital beds). In 2005, the Armenian Government spent USD 29 per capita for health related expenses, and there were 44 hospital beds per 10,000 people, which is higher than the USA. In 2012, 8% of the total government expenditure was on health. The routine health information system is weak at a national level and is particularly limited in remote rural areas due to: • Poorly motivated staff; • Manual recording systems; • Limited diagnostics; • Centralised referral system not feeding results back to local level; and • Poor health seeking behaviours.	Due to the fees associated with health care provision, a number of health facilities in the study area are supported by NGOs, such as United Methodist Committee on Relief (UMCOR) and Oxfam. These interventions include the free or subsidised supply of medication, often requiring a subscription to a membership that allows access to health screening and medications. Lydian is supporting Oxfam in their health programmes in the study area as part of their community development plans. Only 40% of residents in Saravan were satisfied with the medical care they received compared to 77% in Gndevaz and 83% in Gorayk. Affordability was the key concern, with only 50%, 56% and 39% of Gndevaz, Gorayk and Saravan residents, respectively, reporting they could afford health care. Health seeking behaviour of the communities in the study area is poor, and therefore statistics for the local area are unlikely to fully represent the burden of disease in the area and portray an accurate health profile.

Table 4.15.2: Environmental Health Areas Baseline Health Description		
Environmental Health Area (EHA)	**National Level Findings**	**Study Area Findings**
	Reproductive Health: The total fertility rate in 2010 was reported at 1.7 children, which is less than the replacement fertility levels of just over two children. There has been a reported decline in rural fertility, with a drop from 2.1 in 2000, to 1.8 in 2010. Abortion is legal in Armenia and in 2000, it was reported that 46.8% of Armenian women have experienced at least one abortion, and in the 2010 ADHS it was reported that the abortion rate was 0.8 per women.	According to the 2010 ADHS, the total fertility rate in Vayots Dzor and Syunik Marzes was at 1.8 and 2.0, respectively[28]. In 2005, the ADHS reported that close to 51% of all pregnancies in Vayots Dzor were terminated through induced abortion in the three years preceding the survey. The percentage was lower in Syunik at 32.7%. However, this indicator had improved in 2010, with induced abortion rate at 30.8% and 15.7% for Vayots Dzor and Syunik, respectively. This improvement was supported by an increase in the use of contraceptives[29].
	Breastfeeding: The 2005 ADHS reported only 33% of mothers practiced exclusive breastfeeding in children under 6 months. In 2010, this increased marginally to 35%[30].	In the study area children are breastfed for a duration of time in line with the national mean.
	Maternal Health: Almost all (99%) pregnant women in Armenia receive antenatal care (ANC) from a skilled health provider and the majority (>90%) attend ANC at least 4 times during a pregnancy. Almost all child births occur at a health facility assisted by skilled health personnel[31]. The maternal mortality rate in Armenia was reported at 30 per 100,000 live births in 2011, which is a marked improvement from the rate in 2005 (67 per 100,000 live births).	According to the 2010 ADHS, all women in Vayots Dzor and Syunik Marzes attended ANC during their recent pregnancy, and almost all delivered their child at a health facility assisted by skilled health personnel[32]. No cases of maternal mortality have been recorded in the study area in recent years.

[28] ibid. 27
[29] ibid. 27
[30] ibid. 27
[31] ibid. 27
[32] ibid. 27

Table 4.15.2: Environmental Health Areas Baseline Health Description		
Environmental Health Area (EHA)	**National Level Findings**	**Study Area Findings**
	Child Health: Infant mortality in Armenia has continued to decline, compared to the 1990 baseline (under-five mortality rate of 49/1000 live births). In 2010, the under-five mortality rate per 1000 live births was recorded at 16 (average for both sexes) while the infant mortality rate was 13 per 1000 live births[33]. Two-thirds of the child deaths occur during the neonatal period.	No recent child deaths have been reported in the past years in Vayk hospital or in the study area.
	Immunisation: Immunisation coverage in Armenia is generally very high, with 92% of children aged between 18 and 29 months having received the full suite of WHO recommended vaccinations in 2010[34].	Statistics collected from the study area indicate that all children under five years of age have completed the vaccination schedule.

[33] ibid. 27
[34] ibid. 27

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APPENDICES

Appendix 4.16.1 Full Census of Seasonal Herders (2012)

4.16 Land Use and Tenure

The predominant land use within the Project area is permanent mountain pasture, or steppe grassland used for extensive summer grazing. The soils are generally shallow and nutrient poor, and the vegetation is subject to a relatively short growing season. These grasslands provide an important resource for summer grazing for cattle, horses, sheep and goats, leaving the hayfields at a lower elevation to produce fodder for winter feeding. Typically, hayfields will return to grazing in the later summer and autumn, once the hay crop has been removed.

4.16.1 Land Tenure

Four categories of land exist in Armenia:

- **Community land** – land owned and administered by the community, who hold full access rights over it and can rent it out at their discretion.
- **State land** – land owned by the State, which holds the administrative rights to rent the land out to the community. Applications for renting community land are decided by the community administration, with the decision-making process on renting State land following a strict hierarchical procedure outlined below in Figure 4.16.1.

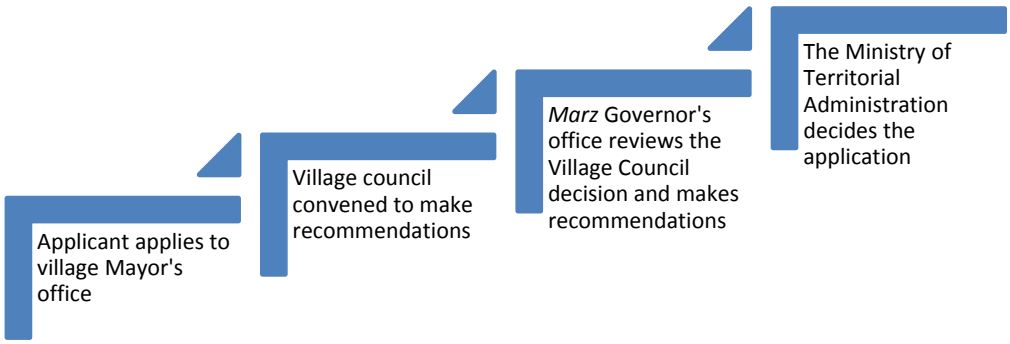


Figure 4.16.1: Decision Hierarchy for State Land

- **Legal ownership land** – land which may be owned and purchased by any individual or a legal entity.
- **Resident land** – land that can only be owned by an individual and not by a company or any other legal entity. The individual can use this land within the bounds of the land use and category that it was purchased under.

Prior to independence, most land was State owned. Privatisation of land began in 1991 when the Government redistributed some State land to households. Under this privatisation process, land ownership was awarded to households. Additional reform occurred in 2009 and 2010 when control over large tracts of State land was transferred to communities to promote economic development. Through this reform, communities gained the ability to rent out State land and retain rental payments within the community.

The majority of the land within the study area is defined as State land, although this is mainly due to the large State land holding in the community of Gorayk. Saravan and Gndevaz have less land and the land within their administrative boundaries is predominantly community land. Table 4.16.1 highlights the impact of the land privatisation process in the early 1990's where each household received 2 ha of land.

Table 4.16.1: Land Status

Land status	**Gorayk**	**%**	**Saravan**	**%**	**Gndevaz**	**%**	**Jermuk**	**%**
Community land	5,089.8	23.2	5,546.5	71.2	3,548.4	57.6	3,389.0	24.6
State land	14,927.2	67.9	1,776.4	22.8	2,028.8	32.9	9,422.1	68.5
Legal ownership land	10.9	< 1	0.1	< 1	-	-	-	-
Resident land	1,951	8.9	465.4	6.0	583.4	9.5	948.4	6.9
Total	21,978.9	100	7,788.4	100	6,160.5	100	13,760	100

Most users of the land in the study area rent access to the land on an annual basis. Rental agreements for pasture and hayfields appear to have little connection to geographical areas, with the renter gaining access to a broader area for the grazing season. Land rentals for pastures are normally for more extended time periods (3, 5, 10 or 25 years). The following groups of rural land users have been defined for the study area:

- Private land owners – a number of private land parcels exist within the study area.
- Community renters – local residents rent land from their community for agricultural purposes. This includes land rented close to their homes in the villages as well as grazing land distant from the village. These land agreements are monitored by both the community administrators and *Marz* officers.
- Community non-rent payers – includes local residents who use common land but do not pay for its use. While not officially endorsed, this practice is ongoing with the

administrators' knowledge. Reserve land is available in some areas for use by vulnerable groups, and residents of Saravan are understood to have access to land in this category.

- Temporary renters – residents of other urban and rural communities who rent land parcels in the study area. This includes some seasonal herders who may or may not have formal rent agreements; i.e. some herders make one-off payments, confirmed by receipts.
- Temporary non-rent payers – residents of other urban and rural communities who use land parcels in the study area but who do not pay rent. This group is known locally as the "illegal herders". These herders are considered to have customary rights to the land.

4.16.2 National Land Categorisation

The Armenian land cadastre categorises all land according to its permitted use. Categories of land use include:

- Settlement;
- Agricultural;
- Industrial;
- For sub-soil use (minerals) and production;
- Energy;
- Transport;
- Communications;
- Public infrastructure;
- Specially protected areas;
- Special importance;
- Forestry;
- Water; and
- Reserved land.

Within the administrative boundaries of the rural communities in the study area, the majority of land is categorised as agricultural (Table 4.16.2). As an urban community, Jermuk has a different land categorisation profile from that of the rural communities.

Table 4.16.2 : Land Category								
Land category	**Gorayk**		**Gndevaz**		**Saravan**		**Jermuk**	
	ha	%	ha	%	ha	%	ha	%
Agricultural land	19521.99	88.82	5,727.0	92.96	6,402.3	82.2	4,734.7	34.4
Energy, Communications Transportation & Communal Infrastructure & other land	25.95	0.12	23.4	0.38	25.9	0.3	162.0	1.2
Forest land	-	-	29.2	0.47	274.8	3.5	4,072.9	29.6
Land for Industrial, Mining Industry and Other Industrial Objects	1659.64	7.55	336.2	5.46	1,012.3	13.0	112.3	0.8
Lands for Water and Hydro-technical Objects	750.90	3.42	21.5	0.35	43.1	0.6	181.7	1.3
Settlement Lands	12.26	0.06	16.6	0.27	17.0	0.2	148.9	1.1
Specially Protected Lands	8.10	0.04	6.5	0.11	13.1	0.2	4,347.0	31.6
Grand Total (ha)	21,978.9	100	6,160.5	100	7,788.4	100.0	13,759.5	100.0

The Armenian cadastre further sub-divides agricultural land categories into arable land, hayfields, other agricultural lands and pasture. The study area is predominantly categorised as pasture land (Table 4.16.3).

Table 4.16.3: State Defined Agricultural Land Categorisation in Administrative Lands								
Land uses	**Gndevaz**		**Gorayk**		**Saravan**		**Jermuk**	
	ha	%	ha	%	ha	%	ha	%
Arable Lands	461.2	8.4	1727.8	8.9	381.8	6.0	624.4	9.3
Hayfields	115.6	2.1	858.4	4.4	402.6	6.3	535.1	7.9
Perennial plantings	-	-	-	-	-	-	-	-
Other agricultural lands	421.9	7.7	3324.8	17.1	1249.3	19.7	1249.3	18.6
Pastures	4501.1	81.8	13477.8	69.5	4323.2	68.0	4323.2	64.2
Agricultural land total	5499.7	100.0	19388.8	100.0	6356.9	100.0	6732.0	100.0

Changing land category requires central Government approval, including from the Ministry of Territorial Administration and Ministry of Nature Protection. Approval is not required to change the sub-category of land (e.g. from hayfields to pasture).

In June of 2013, Lydian completed a verification survey of the land categorisation in the administrative land within the permit area. This survey aimed to confirm that the land use categories identified by cadastre records were consistent with actual land use.

The survey confirmed that the large majority of land categorisation was accurate. Land categorisation, per the cadastre, is illustrated in Figure 4.16.2, integrating minor changes observed in the Lydian verification survey. In Gorayk and Jermuk, consultation with local authorities confirmed all cadastre classifications as correct. In Saravan there were a small number of plots that had a different actual use than the cadastre.

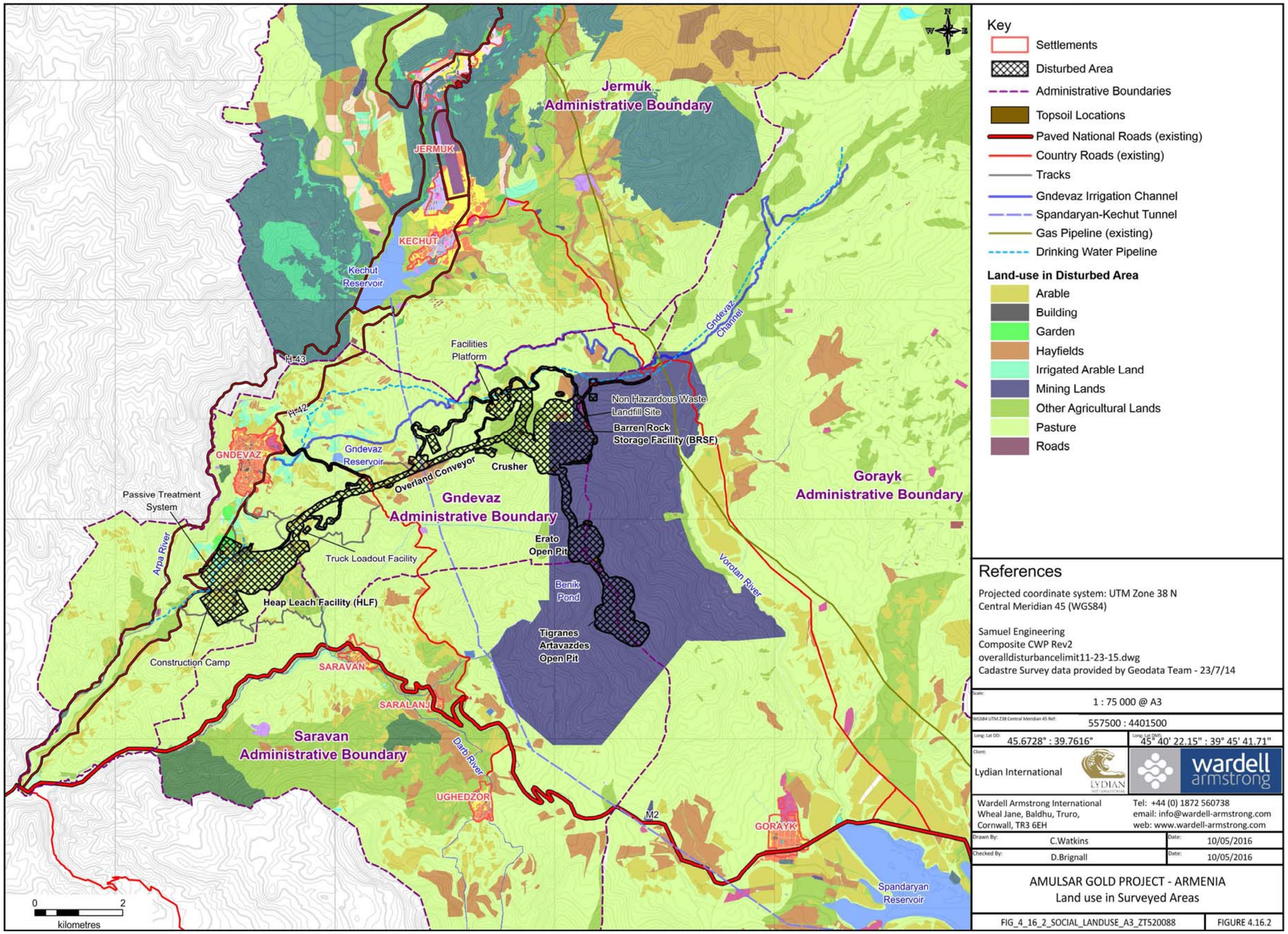


Figure 4.16.2: Land Use in Surveyed Area

4.16.3 Rural Land Use

Land use in the study area is dominated by cattle grazing activities. Because of the mobile nature of this activity and the disconnect between rental agreements and geographic constraints, it is difficult to define land use in the rural areas. Using remote sensing imagery, a visual assessment of land use in the study area estimated that 68% of the study area comprised grassland, with 9% classified as agricultural land (see Table 4.7.7). Visually it is difficult to recognise the difference between grassland and pasture, so it is likely that a significant proportion of the land use identified as grassland is used for pasture as well. There is also a degree of fluidity between pasture and hayfields, with local weather conditions dictating when grass dries out and is ready for hay making.

Animal grazing is the most visible activity in the rural lands in the study area during the summer months. Herding is undertaken by local herders as well as seasonal herders who originate from other areas in Armenia. Local herders typically return to their homes in the rural communities at the end of each day, while seasonal herders establish temporary residence in derelict buildings, caravans, tents or buses in the rural landscape. The locations of herders and the pastures they use (recorded through two separate surveys in 2012 as described in Section 4.11) are illustrated in 4.16.7. In addition to the temporary pastoral camps, a group of seasonal herders also use the seasonal village of Ughedzor for the summer months and graze their animals in close proximity to the village.

Based on a census conducted in September 2012, the total number of seasonal herders in the study area is 58 (see Appendix 4.16.1). The total number of herders within the Project licence area is considerably lower (approximately 20 herders, most of whom originate from the town of Xndzoresk). The length of time seasonal herders spend in the study area varies year upon year, controlled by the time of snow fall on the pasture. Most seasonal herders are present in the study area between June and September; Ughedzor-based herders continue working in the area until late October or early November.

The Mayors of the rural communities believe that pasture land in the area is currently under-utilised, with scope for increased density of animals. According to the findings of the Herder's field survey undertaken in 2012 by WAI, the best pasture land in the Gorayk administrative lands is located between 2,200 and 2,350 m above sea level, with land above 2,500 m only supporting sheep grazing (see Appendix 4.16.1).

Animal grazing and hay making are dominant summertime land-uses. In Gndevaz apricot cultivation is particularly important. People in all three villages engage in a variety of land-based activities to meet their livelihood needs.

The ethnobotany survey conducted in December 2011 identified a number of other land-based activities. Focus Group Discussions carried out for the Ecosystem Services Review in 2014 and 2015 also addressed these activities (see Chapter 6.20 for analysis of impacts on ecosystem services). They include:

- Foraging for mushrooms, rosehips, berries and a wide diversity of herbs in accessible hayfields, pastures and forested areas throughout the study area.
- Collecting dry wood from forested areas, particularly in Saravan, as a replacement or supplement for gas and electric central heating, as well as for household fuel use;
- Making honey for own use or for sale;
- Hunting and fishing are traditional recreational activities, practiced in the forested areas and the rivers and tributaries in the study area; and
- Walking trails in the forested parts of the study area are popular with tourists and visitors.

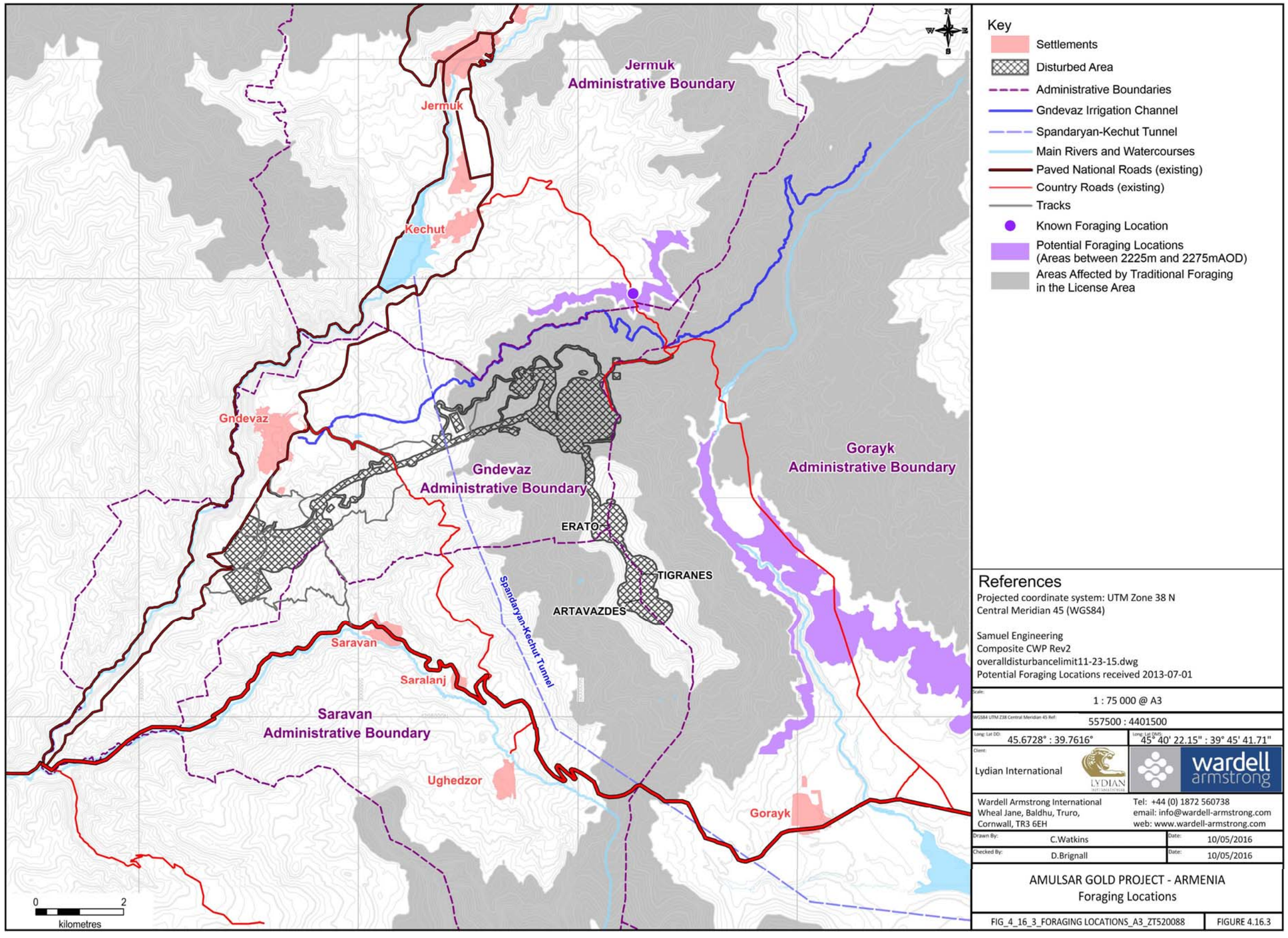


Figure 4.16.3: Foraging Locations

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4.17 Livelihood Activities and Employment Opportunities

The focus of the United Nations Human Development Report for 2015 is on the role of work in development. To support this focus, indicators related to work in Armenia have been reported in the country briefing note for Armenia[1], and are summarised in Table 4.17. The data demonstrates the importance of agriculture within Armenian employment, and also highlights a high level of youth unemployment comparative to other countries.

Table 4.17.1 Indicators related to work for Armenia

Work Indicators	Armenia	High HDI	Europe and Central Asia
Labour force participation rate (% ages 15 yrs and older)	63.4	67.1	57.2
Female	*54.2*	*57*	*45.6*
Male	*72.6*	*77.2*	*70.0*
Share of employment in agriculture (% total employment)	38.9	28.8	24.5
Share of employment in services (% total employment)	44.4	43.8	52.5
Labour force with tertiary education (%)	22.9	-	-
Total unemployment (% of labour force)	18.4	4.7	9.9
Long term unemployment (% of labour force)	9.7	-	-
Youth unemployment (% of of youth labour force)	36.0	16.7	19.5
Working poor, PPP $2 per day (% of total employment)	12.2	14.7	3.8

An Integrated Living Conditions Survey (ILCS)[2] was conducted across all *marzer*, across a 12 month period, in 2009. The results of this survey inform the following summary of livelihood activities in Armenia.

The *de facto* labour resource population (aged 15-75 years of age) of Armenia was 2.4 million in 2009, which comprised approximately 77% of the total population. Of this group, men comprised 45% and women 55%, with 66% resident in urban areas and 34% resident in the rural landscape. Within this labour resource, a labour participation rate of 59% was recorded (69% for men, and 51% for women). Unemployment was recorded at 18.7% in 2009, with no significant bias by gender, and this rate had only reduced slightly (to 18.4%)

[1] UNDP. Human Development Report 2015, Work for human development – briefing note for countries on the 2015 Human Development Report - Armenia. New York, USA. 2015

[2] ILCS data is reported within ADB (2011) The Informal Sector and Informal Sector Employment in Armenia, Country Report 2010, ADB

in 2014.

The vast majority of Armenians (approximately 97%) have only one job, with a significant proportion of these roles being considered "informal" (52.1%). Most agricultural activity in Armenia is considered informal under the International Labour Organisation's classifications. Therefore, it is unsurprising to find that the majority of informal employment (82%) is located in rural areas.

In addition to employment opportunities, remittances play an important role in household incomes, with remittances averaging 16 % of GDP between 2004 and 2009 with up to 20% of households receiving remittances of some form[3].

4.17.1 National Structure of Employment and Labour

In Armenia, the highest share of employment is recorded in the agricultural sector followed by industry, education and wholesale and retail trade (as indicated in Figure 4.17.1 and Figure 4.17.2).



Figure 4.17.1: Employment by Industry[4]

[3] International Monetary Fund (2012), *www.imf.org/external/country/arm/rr/2012/062012.pdf*
[4] ADB, (2011) The Informal Sector and Informal Sector Employment in Armenia, Country Report 2010, ADB

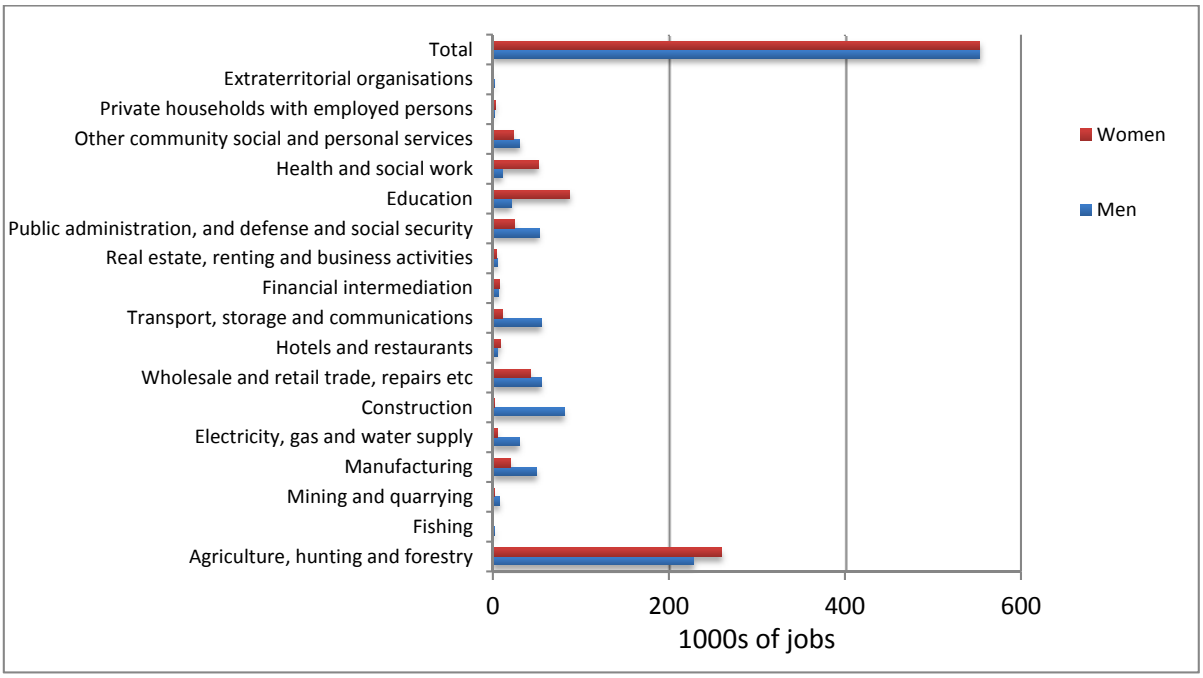


Figure 4.17.2: Employment by Sector[5]

Figure 4.17.2 highlights a bias towards roles which are traditionally considered feminine by women in Armenia (agriculture, education, health, and retail). A more detailed breakdown of employment by industry, location and sex is shown in Table 4.17.2.

Table 4.17.2: Employment by Industry and Sex (%)[6]

Sector	Industry	Nature of Employment						Total Employment (1,000 jobs)		
		Formal			Informal					
		Men	Women	Total	Men	Women	Total	Men	Women	Total
A	Agriculture, hunting, and forestry	4.2	2.7	6.9	223.7	257.2	480.8	227.8	259.9	487.7
B	Fishing	0.1	0.0	0.2	0.1	0.0	0.1	0.2	0.0	0.2
C	Mining and Quarrying	7.4	2.1	9.5	0.1	0.0	0.1	7.5	2.1	9.7
D	Manufacturing	41.5	13.2	45.6	8.5	7.3	15.8	50.0	20.4	70.4
E	Electricity, gas, and water supply	29.5	4.7	34.2	0.4	0.3	0.7	29.8	5.0	34.9
F	Construction	33.6	1.2	34.8	47.6	0.5	48.1	81.2	1.7	82.9
G	Wholesale and retail trade, repairs, etc.	33.3	26.7	60.0	21.4	16.5	37.9	54.7	43.1	97.8

[5] ibid
[6] Ibid. 1

Table 4.17.2: Employment by Industry and Sex (%)[6]										
Sector	**Industry**	**Nature of Employment**						**Total Employment (1,000 jobs)**		
		Formal			**Informal**					
		Men	**Women**	**Total**	**Men**	**Women**	**Total**	**Men**	**Women**	**Total**
H	Hotels and restaurants	3.3	4.7	8.0	1.5	3.6	5.0	4.8	8.2	13.1
I	Transport, storage, and communication	41.5	9.8	51.3	13.5	0.6	14.1	55.0	10.5	65.4
J	Financial intermediation	6.2	6.9	13.1	...	...	...	6.2	6.9	13.1
K	Real estate, renting, and business activities	4.4	3.7	8.1	0.6	0.2	0.8	5.0	3.9	8.9
L	Public administration and defense, social security	52.5	25.0	77.5	...	...	...	52.5	25.0	77.5
M	Education	20.7	86.5	107.2	0.2	1.1	1.3	20.9	87.6	108.5
N	Health and social work	10.4	51.2	61.6	0.1	0.2	0.2	10.5	51.4	61.8
O	Other community social, and personal services	23.0	17.8	40.8	7.8	5.0	12.9	30.8	22.9	53.7
P	Private households with employed persons	0.3	0.4	0.6	1.1	2.8	3.8	1.3	3.2	4.4
Q	Extraterritorial organisations	1.3	1.0	2.3	-	-	-	1.3	1.0	2.3
	Total	313.1	257.5	570.7	236.4	295.3	621.7	639.5	552.8	1,192.3
Notes: ... = no observation/no data available, - = not applicable										

Agriculture, hunting and forestry account for 76% of employment in rural areas. In the study area, the importance of agriculture is even more pronounced, with 96% of all employment in Vayots Dzor *Marz* derived from agriculture. Agriculture is less important (43% of employment) in Syunik *Marz* as a whole, due to the influence of mining activities in the south.

Table 4.17.3: Employment by Marz[7]						
Marz	Nature of Employment					
	Thousand			%		
	Formal	Informal	Total	Formal	Informal	Agriculture
Yerevan	273.8	65.5	339.2	80.7	19.3	2.0
Aragatsotn	17.0	49.0	66.0	25.7	74.3	65.4
Ararat	34.7	92.3	127.0	27.3	72.7	62.7
Armavir	28.3	85.6	113.9	24.8	75.2	64.1
Gegharkunik	27.2	66.1	93.3	29.1	70.9	65.4
Lori	42.9	64.2	107.1	40.1	59.9	51.3
Kotayk	46.8	53.2	100.0	46.8	53.2	39.9
Shirak	37.5	48.9	86.5	43.4	56.6	53.0
Syunik	33.9	33.7	67.6	50.1	49.9	42.9
Vayots Dzor	9.8	14.7	24.5	40.1	59.9	95.9
Tavush	18.9	48.4	67.2	28.1	71.9	59.5
Total	**570.7**	**621.7**	**1,192.3**	**47.9**	**52.1**	**40.9%**

The average monthly earnings in Armenia were estimated at AMD 66,511 in 2009 (USD 161), with significant variation seen between male and female salaries (men earned on average 53% more than women). There was also a distinct variation between salaries paid in Yerevan and urban areas more generally and those salaries received in rural areas, with average rural salaries only reaching approximately 60% of the average Yerevan salary, as indicated in Table 4.17.4.

Table 4.17.4: Average Earnings[8]			
Employment Status	Average Earnings (AMD)		
	Yerevan	Urban	Rural
Employee	81, 653	67,653	64,736
Employer	240,661	205,011	91,909
Own-account worker	93,421	43,681	41,345
Average Earnings	**84,434**	**65,007**	**50,167**

Salaries also vary widely across employment sectors, with mining and quarrying recording one of the higher average salaries as illustrated in Figure 4.17.3.

[7] ibid. 1
[8] ibid. 1

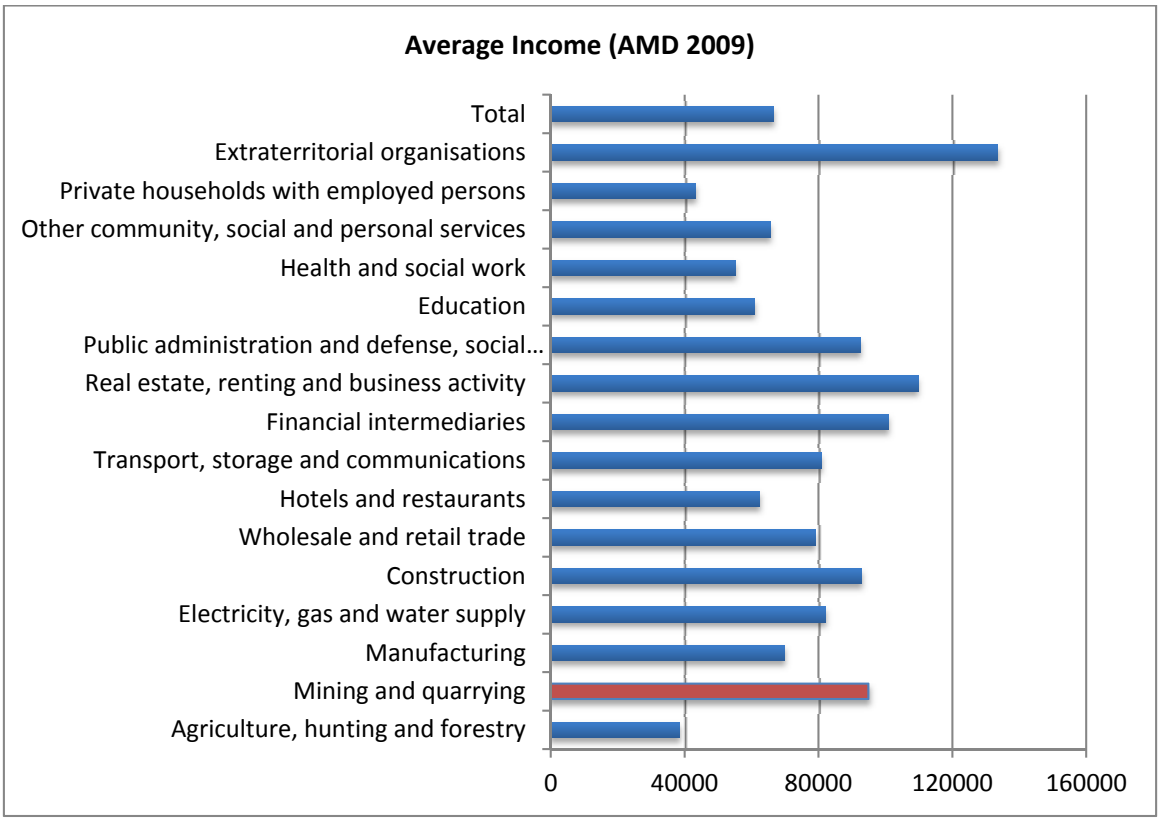


Figure 4.17.3: Average Earnings by Sector (AMD 2009) [9]

4.17.2 Livelihoods in the Study Area

Most households in Armenia derive income from a number of sources. Figure 4.17.4 summarises the findings of a national survey to identify income sources across each *Marz.* Vayots Dzor *Marz* and Syunik *Marz* both stand out for the absence of loans and debt as a source of income, and remittances also play a less important role in these *Marzes* compared to other areas. The public sector salaries are of significant importance in these *Marzes*, and even though agriculture is the dominant employer in the region, its contribution as a source of income is lower than would be expected.

[9] ibid. 1

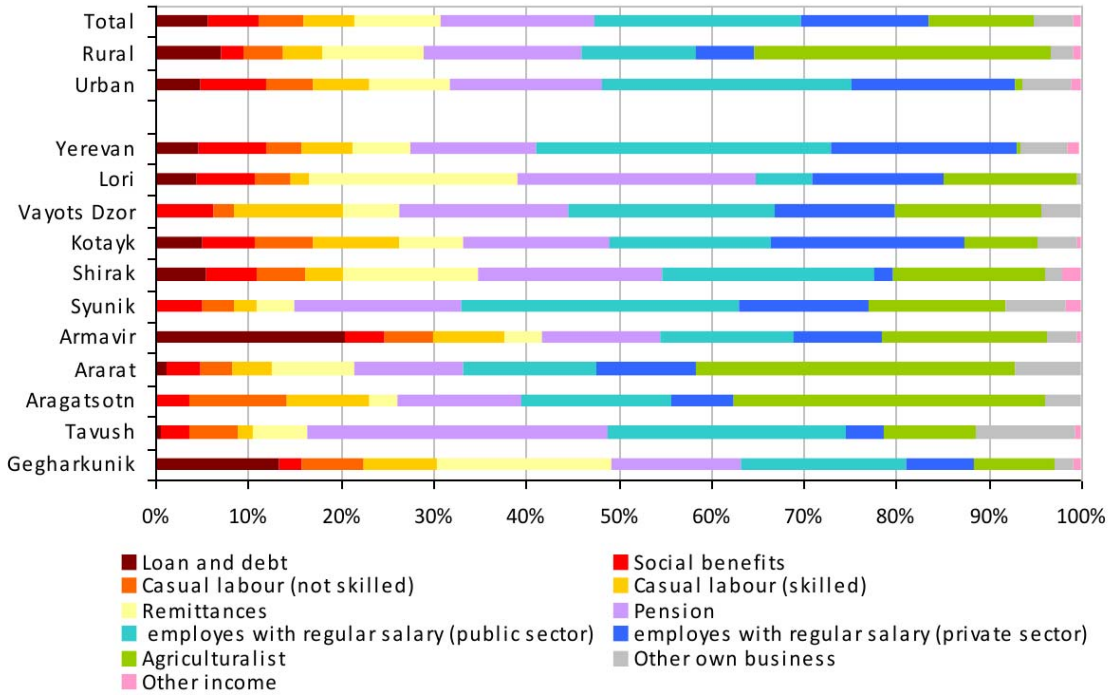


Figure 4.17.4: Livelihood by Marz[10]

Household surveys were completed by Armenian consultancy MPG in Gorayk, Gndevaz, Saravan, Kechut and Jermuk in 2010, and these surveys provide the source of much of the data presented in this chapter. In addition to these surveys, each village prepares a "Village Passport" annually which captures basic statistics about the village. This data is collected from the village Mayors by Lydian and used where relevant and when the data is considered robust.

Livelihoods in the rural communities of Gndevaz, Gorayk and Saravan[11] are dominated by agriculture, as can be seen in Figure 4.17.5. Many people reported receiving income from a number of the highlighted sources, rather than being dependent on a single income stream. In Jermuk and Kechut, the importance of full-time employment is evident in Figure 4.17.6.

While remittances are important at a national level, their role in the economy of the study area appears limited.

[10] National Institute of Labour and Social Research, (2010), Impact of the Global Financial Crisis on Households, Yerevan
[11] MPG, (2010), Gorayk, Gndevaz and Saravan Baseline Study

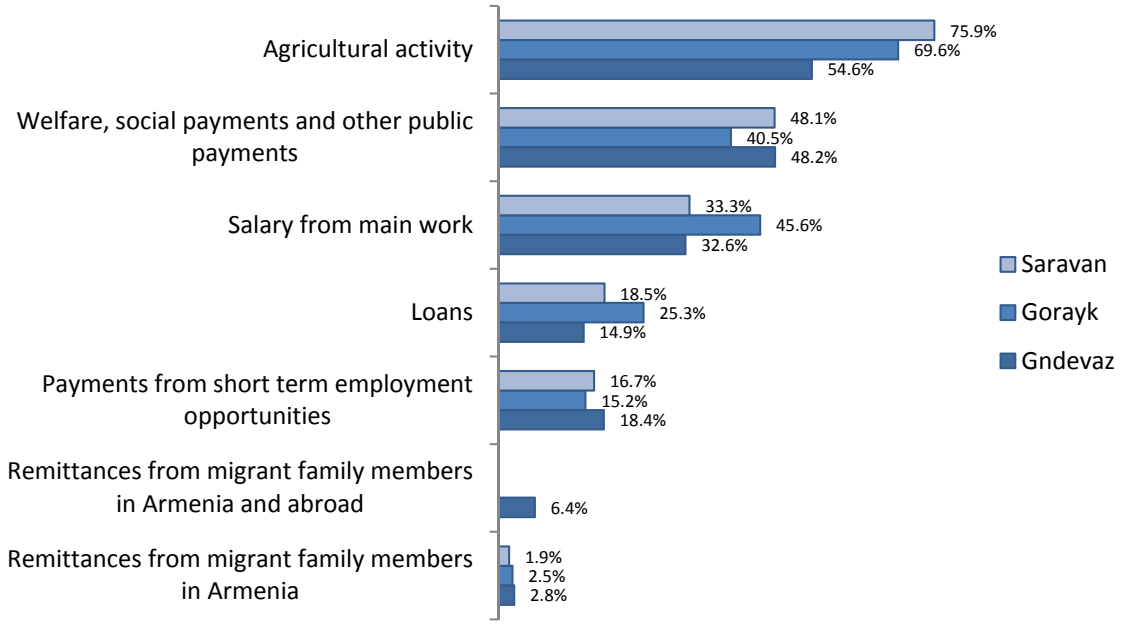


Figure 4.17.5: Sources of Livelihood in the Rural Communities (2010)[12]

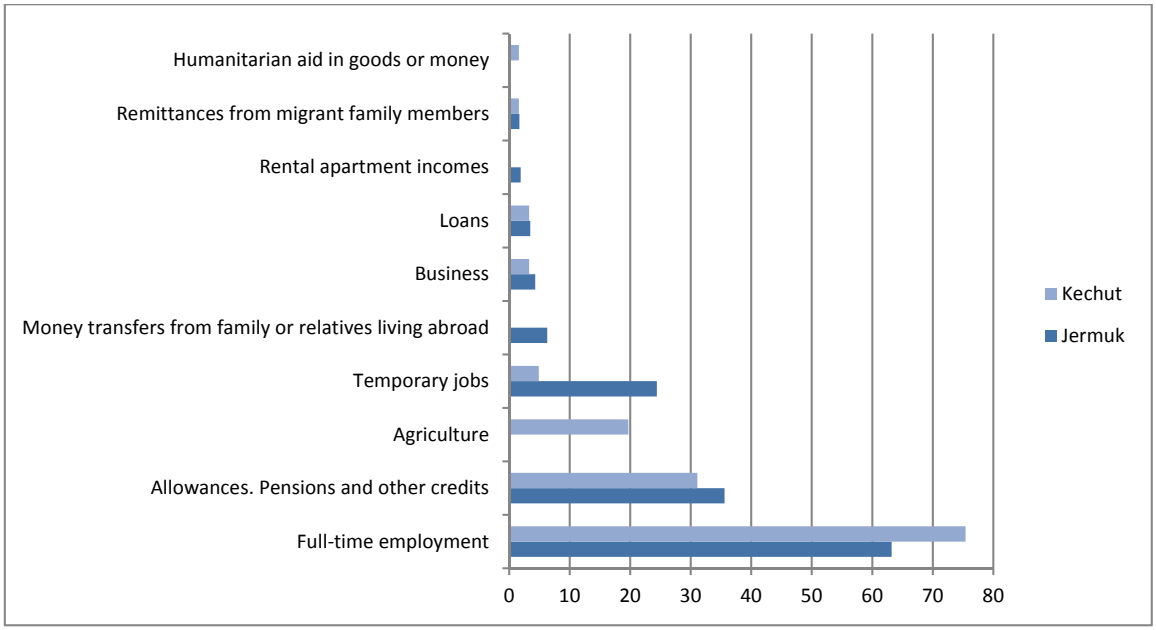


Figure 4.17.6: Sources of Livelihood in Jermuk and Kechut (2010)[13]

Key informant interviews conducted with the Mayors of each of the villages in 2014 again highlighted the importance of agriculture within each of these communities (as seen in Figure 4.17.7), with the villages having a far greater reliance upon agriculture than Jermuk.

[12] ibid. 10, p 4.17.7
[13] MPG, (2010), Jermuk and Kechut Baseline Study

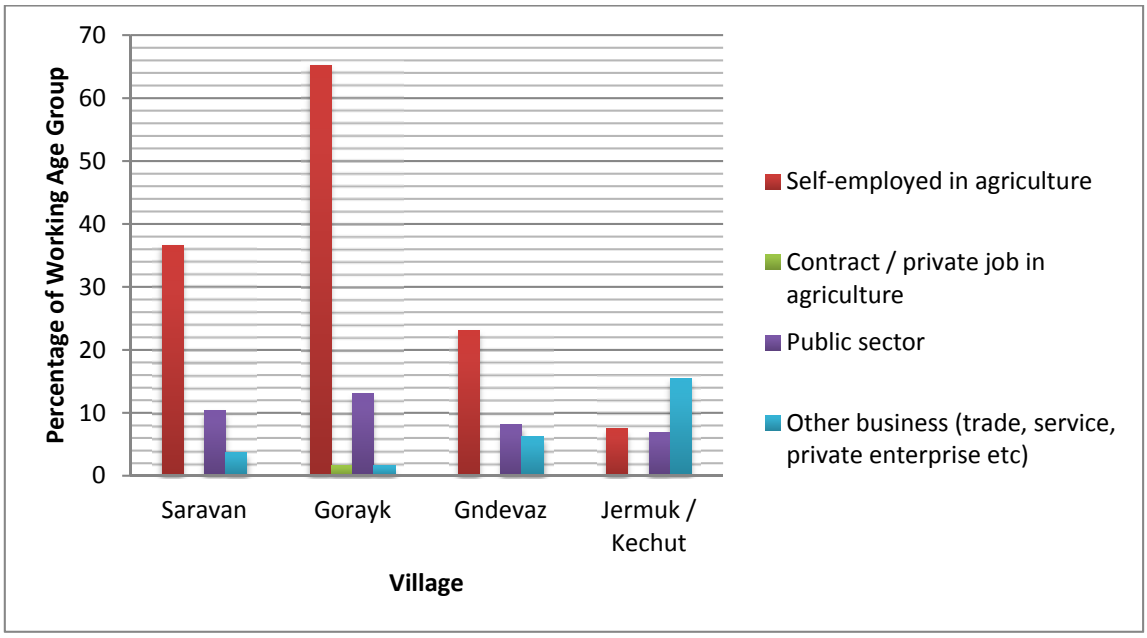


Figure 4.17.7 Employment breakdown reported by village Mayors (2014)[14]

4.17.3 Mining Industry

Southern Syunik *Marz* is the centre of mining activity in Armenia at present. Despite its relative proximity to the study area (about 80-100 km) there were no reports of workers from the study area seeking employment in the mines bordering Iran. As at November 2014, within Armenia, Lydian employed 33 people as direct employees (23 men, and 10 women), with another 59 contractors (37 men and 22 women) from the local area working for the project. Lydian International had a total workforce of 99 at that time: 92 in Armenia (as described) and 7 (6 men and 1 woman) based internationally. Based on these figures, exactly one third of the Lydian workforce was female at the end of 2014.

4.17.4 Private Sector (non-mining)

Between 30 and 45% of income in the rural communities of Gndevaz, Gorayk and Saravan was attributed to salaried employment in 2010. This includes public and private sector employment, taking account of employment by Lydian (which would have been in the order of 50 people at the time of the survey). In contrast, full-time employment is the dominant source of livelihood in Jermuk and Kechut[15] (comprising approximately 70% of income).

[14] Key informant interviews conducted with village mayors in 2014.
[15] ibid. 12

There are relatively few private sector opportunities available in the area, with the largest employers being:

- Jermuk Mineral Water Bottling Factory (employee figures vary seasonally, but are officially recorded as between 30 and 100);
- Mayr Gortsaran Bottling Factory (similarly, figures vary seasonally between 15 and 50);
- Gndevaz livestock farm (employs approximately 10 people);
- Ashtarak Kat Milk Company (Gorayk – employs nine people);
- Gas Station in Gorayk employing an estimated 6-12 people; and
- Jermuk Tourism – During summer, Jermuk population increases with increased levels of tourism, and approximately 450 summer jobs exist to support this tourist industry[16]. During winter a smaller number of jobs are also generated to support the small ski industry. Most of these jobs are taken up by the residents of Jermuk, Kechut and Gndevaz.

Historically, Kechut was the housing base for workers developing the Kechut reservoir.

4.17.5 Public Sector

As evidenced in Figure 4.17.5, public sector salaries are an important part of livelihoods at the Marz level. Data is not available to confirm this trend in the study area; however, it can be assumed that public sector salaries significantly contribute to the full-time employment statistics for all rural and urban communities in the study area. This employment would include administrative staff of the rural community, teachers, health employees and service providers (e.g. water and sanitation staff).

4.17.6 Agriculture

Agriculture is the cornerstone of rural livelihoods in Armenia and the study area is no different from the national norm. Agriculture is practiced by both family units and by individuals, working on either common or private land. Agriculture is the largest source of income for the rural communities of Gorayk, Gndevaz and Saravan (as shown in Figure 4.17.5). Agricultural incomes are broadly split between cultivation and animal husbandry.

[16] USAID (2008) Comprehensive Development Plan: Jermuk as a Destination Spa & Winter Tourism Center

4.17.7 Cultivation

Typically, family units cultivate a garden or piece of land they either own or rent within the rural community lands. Staple crops such as wheat, spelt and barely are commonly grown, as are potatoes (see Figure 4.17.8). Cultivation is undertaken primarily as a subsistence activity, with very little surplus sold for income. The exception to this is in Gndevaz, where apricots are grown commercially and approximately 18% of households participate in this activity.

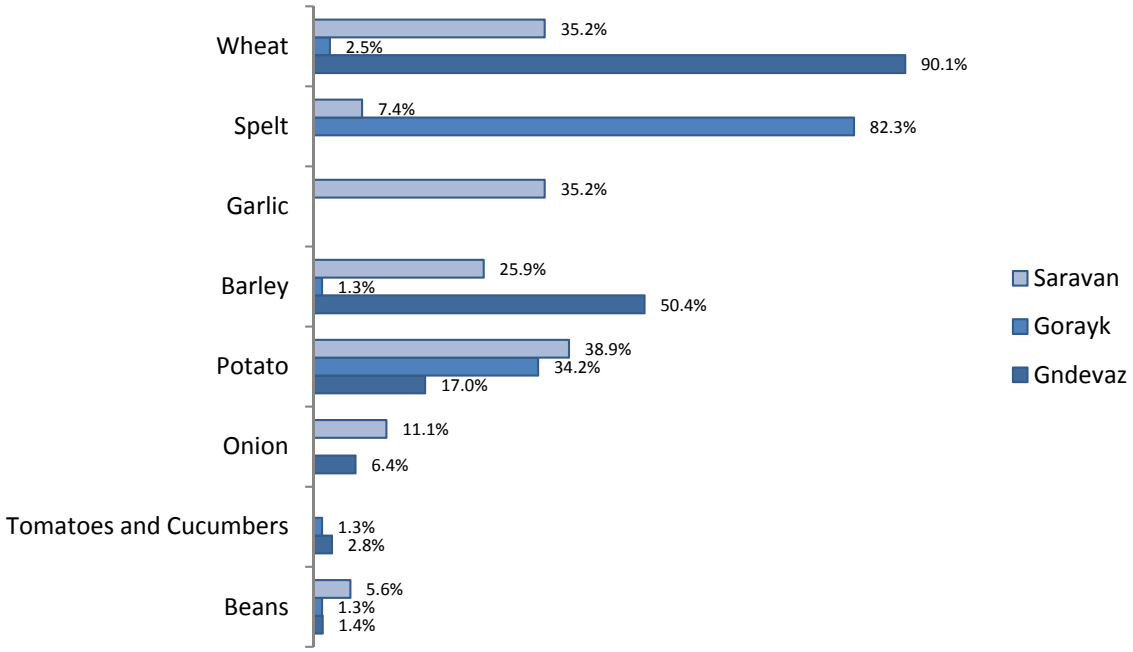


Figure 4.17.8: Crops Grown in the Rural Communities[17]

Residents in the rural communities in the study area typically maintain vegetable gardens close to their property where potatoes, tomatoes, cucumbers, beans, carrots onions and garlic are grown. Agriculture is important in Kechut also, although to a lesser extent. The dominant crop in Kechut is potato. Jermuk did not report agriculture as a source of income (see Figure 4.17.6).

Limited agricultural equipment is available to the rural communities to support their cultivation activities. Lydian International has been supporting an agricultural improvement project in the rural community of Gorayk, working with HDP, an NGO partner, since 2012.

[17] ibid. 10

In addition to cultivation, bee-keeping is also undertaken in the study area for household honey consumption.

Surveys conducted with community members as part of the 2010 households surveys (MPG)[18] revealed the high cost of fertilisers, seeds and fuel was seen as the main reason for the poor profitability of fixed agriculture in the area, with the lack of a well-developed market for agricultural products as a close second. As the MPG household survey did not include specific questions on market access, quantitative figures on perceived market access are unavailable.

4.17.8 Animal Husbandry

The majority of households in the rural communities in the study area reported a high degree of reliance on animal husbandry as an income stream, with livestock ownership summarised in Table 4.17.5. With over three times as much agricultural land compared to the other rural communities, it is unsurprising that Gorayk has a much larger livestock quota. Animal husbandry is also practiced by residents of Kechut, but the village is less reliant upon it as a source of income.

Table 4.17.5: Livestock Owned in the Study Area (2014)[19]

Animals	Gorayk	Saravan	Gndevaz	Jermuk
Cows	653	180	507	630
Sheep and Goats	1048	350	1206	420
Donkeys	2	0	13	1
Horses	28	8	11	26
Poultry	1222	453	20000	760
Hares and rabbits	0	0	114	65
Bee hives	377	511	309	350
Pigs	22	31	290	110

Animal husbandry activities are typically undertaken by family units, with family members dividing essential tasks such as washing, feeding, milking, hay collection and grazing. Washing and milking are typically the domain of women, with men supervising grazing and other field activities. In some cases herders from the rural communities are hired by

[18] ibid
[19] ibid. 10 & 12

wealthier families in the same area to undertake their herding activities for them.
Cattle in the study area are primarily raised for diary production, with milk being sold to the Ashtarak Kat milk factory in Gorayk. Ashtarak Kat organises collection from Gorayk and Saravan and the surrounding area. The lack of a formal milk collection point is seen as a key limitation for residents of Kechut and Gndevaz. Additionally, the climate and topography of Gndevaz and Kechut are less favourable for animal husbandry.

A low volume of agricultural trade exists in the rural communities, with approximately 50% of survey respondents indicating they had either bought or sold agricultural products in the past year in 2009. Cows, poultry and sheep were traded in Gorayk, Saravan and Gndevaz, while Saravan respondents reported buying and selling pigs.

Table 4.17.6: Agricultural Trade (2010)*[20]

Rural Communities	Sold	Exchanged	Consumed
Saravan	68.5%	3.7%	57.4%
Gorayk	69.6%	36.7%	16.5%
Gndevaz	31.9%	3.5%	75.2%
Kechut	8.2%	11.5%	80.3%

* Note: these percentages indicate the proportion of positive responses to a question, with some respondents answering affirmatively for a number of options in response to a single question. As such, they should not be interpreted as relative proportions of an activity occurring.

Table 4.17.6 indicates the proportion of survey respondents who have traded agricultural items, for the period 2009 to 2010. The remoteness of all the settlements in the study area places local residents in a poor trading position, as merchants compensate for high transportation costs by driving the purchase point prices very low, resulting in low returns for producers in the area.
Barter is carried out unofficially between residents of the same village as well as between villages, for access to a greater variety of products; e.g. Gorayk and Gndevaz residents often exchange apricots for cheese.

Gorayk residents have access to two formal milk market routes – a local branch of Ashtarak Kat, a private milk collection and a distribution company active throughout Armenia, as well as a Sisian based enterprise, which operates a collection van in the area. Gorayk farmers produce cheese and yogurt mainly for local consumption.

[20] ibid. 10 & 12

The majority of surplus agricultural produce in Saravan is purchased by merchants from Vayk, Yeghegnadzor and sometimes from Yerevan. Milk is rarely sold, but is processed further to make cheese and yogurt, which obtain better prices. Meat is also a popular sale item. The section of highway connecting the settlements of Saravan, Saralanj and Ughedzor is an important physical location for trade and exchange. Residents of Saravan rural community therefore have good access to these trading sites.

While Gndevaz is an agriculture-based community, apricots are its dominant commodity. Gndevaz residents identify the absence of a storage hub and a unit for producing fruit jams and fruit juice, as a key barrier to the economic development of their community. Most of the farmers in Gndevaz sell their products to merchants from Yerevan, Georgia, Russia or Ararat.

In addition to the agricultural and animal husbandry activities of the residents of the rural communities, seasonal herding also occurs. A total of 58 seasonal herders have been identified who travel from other regions of Armenia to graze their cattle, and grow hay on the pasture land, during the summer months each year. Seasonal herders vary significantly, with the following typologies identified[21]:

- **Ughedzor families:** Family units from other parts of Armenia (mostly Vayk and Malishka village) come to Ughedzor in the summer and occupy the buildings comprising this abandoned village. The same families tend to occupy the same buildings every year. The family cultivates the garden associated with the house as well as one or more pieces of land in or just outside the village. Men take livestock to graze on pasture land under Saravan administration and also collect hay. Men from different households form groups of five to six and operate a shift system for supervising grazing animals, so that only one man per group needs to travel up to the pastures each day. Family units which lack an able male member can pay a neighbour or friend AMD 4000 (USD 9.70) per animal for the whole season's grazing.
- **Individual herding families:** Family units from other parts of Armenia travel to lands under Gorayk and Saravan administration in summer. Each family lives in a caravan, vehicle or bus and / or occupies ruined buildings in the area and / or puts up tents,

[21] Typology developed based upon results of field survey conducted by WAI in 2012 as described in Section 4.11

or uses a combination of all these to meet its domestic and cattle needs. Women and children rarely stay for the whole summer, and tend to travel back and forth, visiting family members on a weekly or fortnightly basis. A number of family units tend to cluster together in nearby camps.

- **Groups of men:** Herding units made up of related men bring their combined stock to lands in Gorayk and Gndevaz and follow similar residential and herding patterns to individual herding families, as above.
- **Hired herders:** A herding unit made up of five to six hired herders bring other people's stock to land in Gorayk and Gndevaz. They follow similar residential and herding patterns to individual herding families, as above. Some hired herders also maintain their own livestock.

Land availability is not generally seen as a limitation or constraint to the agricultural potential of the region; however some concern has been raised in Gorayk over the number of seasonal herders who are using the land in this region.

4.17.9 Tourism Sector

Jermuk was established to be a tourist centre. The mineral waters natural to the area were known long before the establishment of the modern town in 1940, when it was set up as a destination for internal tourism within the Soviet Union. In size and importance, the town reached its height in the late 1980s with a population of 10,000. This number greatly diminished after the breakup of the Soviet Union with the 2001 census recording around 6,300 residents.

As a tourism spa town, Jermuk has both hotels and apartment accommodation available for rent. Hotels are considered the high-end tourist option, with apartment rental providing a lower-cost option. Tourism in Jermuk is highly seasonal, with hotels reporting full or near-full capacity during the summer months of July – September and also over a one-week period over New Year, as seen in Figure 4.17.9.

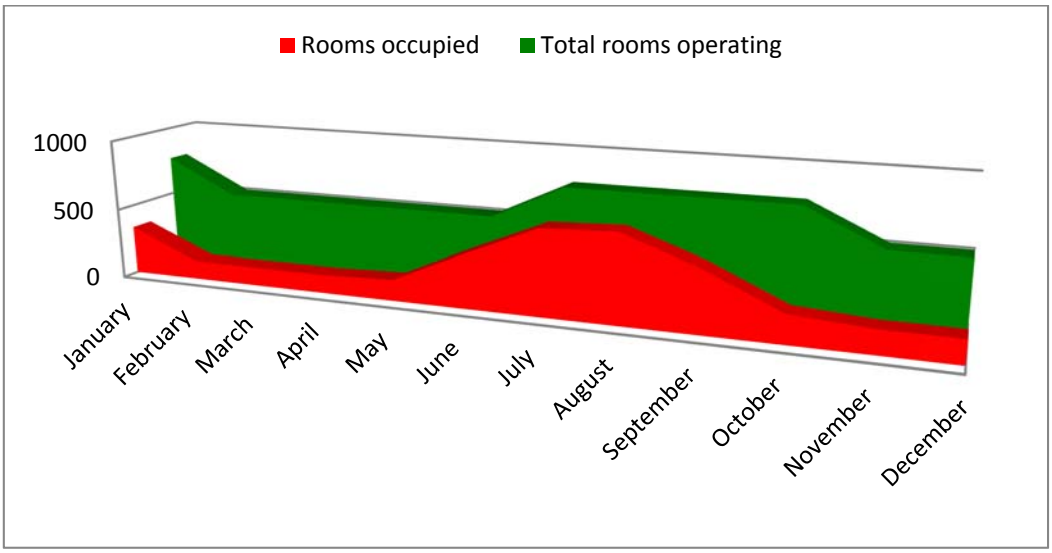


Figure 4.17.9 : Room Availability in Jermuk Accross Calendar Year

Hotels are located across the length of Jermuk town, as demonstrated in Figure 4.17.10. An assessment of potential accommodation options across the local area identified 27 lodging facilities, with 2,410 beds in total (including some facilities which are currently under construction). Further details on the accommodation units available within the local area can be found in Chapter 6.21 and Appendix 8.24.

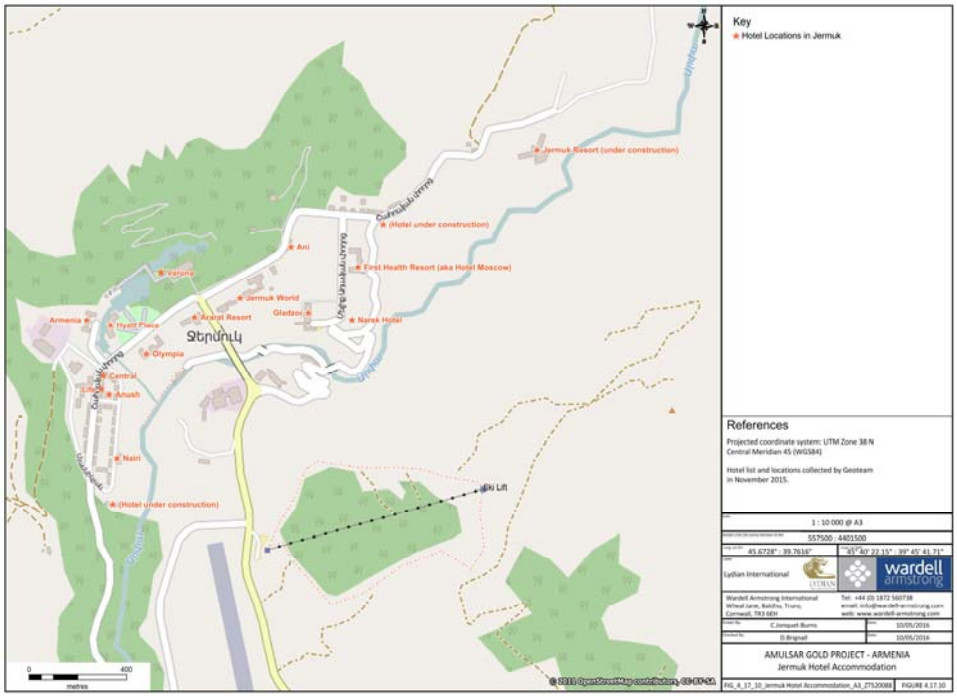


Figure 4.17.10 Jermuk Hotel Accommodation Locations

In 2008, Armenia adopted a tourism development concept paper aimed at increasing the gross national income through development of tourism countrywide. As part of this endeavour, the Ministry of Economy directed USAID to conduct an assessment in Jermuk outlined in Government Decree No. 1064[22] to designate Jermuk as a "Tourism Centre" and outline a vision for the following outcomes:

- Turn Jermuk into a year-round spa resort that meets international standards through the development of:
  - Spa and winter tourism facilities and services as an alternative to European destinations;
  - An international chess championship centre;
  - A pan-Armenian and international youth camp destination; and
  - A cultural tourism destination.
- Ensure 100,000 annual visitors;
- Increase tourism-generated incomes to USD$100 million; and
- Create 4,000 additional jobs.

Based on visitor surveys from 2006 and 2007, USAID researchers estimated the total income from visitors to be USD $15 million per annum. Tourism was also estimated to generate 450 seasonal jobs within Jermuk. This analysis was conducted prior to the implementation of the Armenian "Social Packages" programme[23], which provides affordable holiday accommodation for Armenian public servants in a number of areas across Armenia, including Jermuk. During the tourism fieldwork conducted in November 2015, most hotels reported participating in the Social Packages programme, which has increased their occupancy rates.

The USAID analysis in 2008 indicated that the tourism targets defined above were achievable, but would take a number of years to achieve. The USAID analysis, using data available, estimated that the target for visitors would be almost a 200% increase in four years. The target of an industry generating USD $100 million was considered to be

[22] The September 2008 decree, designated the town as a 'Tourism Center' in accordance with article 2 and clause 4 of article 6 of the Law on Tourism and Tourist Activities of the GOA of the Republic of Armenia.

[23] Social packages for public sector employees were implemented by the Government of Armenia in 2012 designed to improve the attractiveness of work at state bodies and organisations. The Social Packages includes healthcare, support for mortgage payments, tuition support for children and "recreational services" for employees and their family members.

approximately 50% more than what is achievable. While the analysis thought these goals were achievable, such targets for a four-year period were not considered feasible and have not been reached.

Lydian conducted key informant interviews in 2013 to understand the level of progress, which had been achieved against these targets. The primary research involved interviews with 11 hotels, five representatives from the Jermuk health services, six Yerevan based tourism operators, and two representatives from the Yerevan based Department of Tourism within the European Academy. Two focus groups meetings were also conducted with small groups of residents in Jermuk. While the research does not cover all targets from the 2008 report, it seeks to characterise areas of progress, as well as topics and elements of the strategy that have not progressed as expected. This detailed assessment was conducted in 2013, and progress which is known to have occurred in the intervening period has been incorporated into the results.

Table 4.17.7: Review of 2008 Comprehensive Development Plan

Targets 2008	Status as assessed by Lydian in 2013[24]
Objective 1: Upgrade and improve the quality of spa, hotel, guesthouse and services to orient them toward foreign and domestic consumers (including introduction of international standards).	
• All spas refurbished per development control guidelines; • Develop building maintenance codes; • Laws requiring disabled access enforced; All hotels/spas with >30 rooms include internet; • At least four hotels providing a business center; five channels (each Russian and English) via satellite TV in major spas; and • Three restaurants/spas offer vegetarian food; five offer international food; 50% have printed menus.	• Control guidelines not widely understood; most hotels visited were renovated or under repair for expansion or interior design (with Armenian building codes); • Most hotels/spas remain inaccessible to wheelchair users; • Progress is made in Internet: all hotels/spas visited have Wi-Fi; • There are only two or three public restaurants in Jermuk (two open in winter) with printed menus, with traditional Armenian food; and • Most hotels/spas provide buffet food service (not public): vegetarian food is available upon request.
Objective 2: Improve and upgrade the range of medical treatment facilities and services at spas to orient toward more foreign and domestic consumers.	
• Research on health benefits of mineral waters to be collated by 2009; external study	• Since 2008 no research (internal or external) has been conducted;

[24] Information on progress and the remaining challenges and limitations was collected by Lydian through primary research conducted in February 2013. The results of this assessment have not been validated with Jermuk stakeholders, however stakeholders were interviewed to conduct the assessment.

Table 4.17.7: Review of 2008 Comprehensive Development Plan	
Targets 2008	**Status as assessed by Lydian in 2013[24]**
completed by 2012; • Wellness services in 50% of spas; and • Three spas introducing new treatment packages for specific target markets.	• Limited treatment diversification; and • Traditional mineral water and other treatment (mud treatment, stomach, intestines, etc.) is provided in big hotels/sanatoriums only; whereas the small hotels serve as an accommodation. • A new spa hotel (Hyatt) has been developed and commenced operation in mid 2015.
Objective 3: Develop the winter skiing and other winter sports facilities in Jermuk	
• At least one ski school established by 2010 and two by 2012; • Bus or other transport service established and functional by 2009; • Ski pass scheme in effect by 2010; • Feasibility study completed prior to any new development; and • At least two events/annually developed.	• There is no ski school; • No transportation service is available from hotels to ski lift; • Authorities were not aware of any feasibility studies; • Ski lift is not reported to seem to be busy; and • Special events ("Farewell to winter") are held from time to time (a few years ago it was done annually).
Objective 4: Enhance Jermuk reputation as an international center for chess competitions through provision of appropriate facilities and promotion	
• Venue constructed to host up to 1,000 tournament participants at one time; • One major international tournament held in Jermuk annually; and • Prize funds comparable to those of other international tournaments.	• Jermuk is hosting two or three international chess tournaments annually; participation of international chess players estimated at 10-15 persons; • No new building has been constructed as a chess venue; and • Prize fund is limited making it difficult to attract many international chess players.
Objective 5: Develop Jermuk capacity and reputation to host high quality pan-Armenian and international youth camps.	
• Public workshops held or surveys conducted to determine community needs and interests; • New sports facilities developed in keeping with community interests; and • Purpose built sports facility constructed by 2012: two trainers for each sport available trained to international standards.	• There are no public sports, indoor clubs or recreational facilities in Jermuk for local residents or tourists; • There are two sport schools for boxing and chess; • Large hotels furnish their facilities upgrade their equipment; and • There has been no public workshop held to determine needs or collect feedback.
Objective 6: Improve the quality and diversity of tourism industries – attractions, restaurants, shops and leisure activities – to provide tourists with more activities, increase daily expenditure per tourist and increase longer stays.	
• At least three existing attractions renovated with signs and interpretation boards; • At least two evening entertainment venues	• No attractions have been renovated lately; no signage or interpretation boards, but sites are in acceptable condition through annual

Table 4.17.7: Review of 2008 Comprehensive Development Plan	
Targets 2008	**Status as assessed by Lydian in 2013[24]**
developed by 2012; • At least two new trails developed and signed by 2012; • One mountain biking/horse trail developed; • Investor attracted to develop bike rental facility or horse-riding center; • At least three retail shops catering to tourist needs developed by 2012; and • At least one internet cafe established on the right bank by 2010.	maintenance; • There is good potential for marketing of hiking or trekking trails, however, not used frequently; • Bicycle rental businesses have developed, however, only a total of 6 bicycles available; • No outlets for tourists or internet cafes; and • Currency exchange only located within banks; two ATM's in the city.
Objective 7: Improve tourism management and staff capabilities: local tourism training programs, internships, apprenticeships and vocational training.	
• All 450 staff to have received basic training by 2012; • All staff dealing directly with clients to have received some basic language training; • Tourist office established by 2012; and • All tourism enterprise managers and senior staff to have received some form of management training by 2012	• In the past two to three years, the Union of Hotels in Yerevan has had approximately 15 people enrolled in basic training and some technical courses (e.g., accounting, marketing) but not languages; • No tourist office in Jermuk at this point; and • The European Academy in Yerevan has had a tourism department for 10 years; however, there are no linkages between the academic institutions and Jermuk.
Objective 8: Develop a unique "brand" for Jermuk aligned with its current and potential competitive advantages.	
• Target customer profile prepared by municipality; • Branding and promotion strategy developed by 2011; • Promotional materials created and printed by 2009 and distributed to Jermuk tourist facilities, tour operators, tour guide; and • Web portal re-designed in at least 5 languages and included on other websites as a link.	• Municipality representatives were not aware of any branding or promotion strategy; • Promotional materials (maps, brochures) are available in the Municipality that are given away to interested tourists upon request; and • Web-portals on Jermuk provide basic information on treatment, history, mostly in three languages.
Objective 9: Upgrade information on tourism services to encourage tourists to visit, more easily orient themselves and to increase awareness on activities in Jermuk.	
• All hotels/spas with more than 30 rooms provide online booking options; • Website for the ski lift operation established by 2010; • Visitor Information Center established and functional by 2010; and • Ten tourist information panels installed throughout the town.	• Booking.com is widely used by hotels for online bookings; • Ski lift website has few images only; • No visitor information center, but interested tourists can get information at the municipality building; and • No tourism information panels.
Objective 10: Enhance the character of Jermuk as a tourism destination, typified by the architecture, green space, quality of the environment, cleanliness and hospitality of the people.	

Table 4.17.7: Review of 2008 Comprehensive Development Plan	
Targets 2008	**Status as assessed by Lydian in 2013[24]**
• Implementation of guidance on sound planning and urban design – 50% by 2010, 100% by 2012.	• Municipality representatives referred to the Armenian building or maintenance guides.
Objective 11: Improve and expand transport infrastructure and transportation services to and from Jermuk.	
• Road surface renovated by 2010; • Decision made on establishment of airport or heliport; • Growth Management Strategy completed by 2010; and • Signs provided at each major intersection in the road between Yerevan and Jermuk.	• Roads or sections are periodically renovated; however, road signage on Jermuk is poor and limited; and • The Municipality representatives were not aware of Growth Management Strategy.
Objective 12: Upgrade modern communication links to Jermuk.	
• WiMax available in Jermuk by 2010; • 100% cellular phone coverage by 2010; and • 75% of accommodation establishments and restaurants accept credit cards by 2010.	• All hotels/spas interviewed reported to have Wi-Fi in the rooms (all sizes); • The cellular phone coverage is 100%; • Credit card payment is not widely practiced; however, hotels can work through transfer.
Objective 13: Expand medical and health facilities (refer to Community Health, Section 4.15).	
• Polyclinic upgraded to provide accident and emergency facilities, x-ray facilities and basic surgery by 2012; • One fully functional dental clinic by 2010; and • Ambulance and paramedics trained and available by 2010.	• The Jermuk hospital has not been upgraded in the past few years; • An X-ray room is now a storage area; the surgery room is not operational due to lack of medical doctors; • There are three small private dental offices (2 chairs each); • No optician; and • No paramedics trained or available and two nurses trained in first aid to provide services in ambulance.
Objective 14: Determine number of additional jobs likely to be created and assure adequate and affordable housing.	
• Growth Management Strategy completed by 2010; • 100% of owners identified, with mailing addresses; • At least 75% apartments or units available for monthly rental by 2010; and • At least 50% of units filled during off-peak season.	• Owners of housing units currently empty are not identified; • Many apartments/units are being rented out (residents move to sub-standard places during the season, to accommodate visitors and tourists); • Focus group participants estimate that 80% of residents rent their places out during season; and • During off-season people also rent their places (e.g., during chess tournaments).

Table 4.17.7: Review of 2008 Comprehensive Development Plan	
Targets 2008	**Status as assessed by Lydian in 2013[24]**
Objective 15: Improve the existing infrastructure: improve the quality of signage and develop a modern, pleasing appearance for city streets, pavements and the park.	
• At least 10 km of pedestrian areas improved per development control guidelines by 2012; • All relevant streets provided with street lighting; and • All road intersections in the town and all major tourist areas provided with signage.	• Central sections of street roads are in poor condition; • Street lights are on during holidays; • No tourist-centered signage in the town; and • Private sector key informants interviews suggested that they removed signage of their hotel due to high fares and payments.
Objective 16: Develop solid and sewage waste treatment and disposal methods.	
• Town has renovated sewage system by 2012; • Landfill certified to no longer create groundwater pollution; and • Jermuk covered by functional waste and recyclable materials collection system.	• Phase 1 of a new sewerage system has been installed (mechanical separation). Funded by KfW. Unknown when Phase 2 will be implemented; • The landfill is not removed and a large area is covered by functional waste.
Objective 17: Seek to align local agricultural production toward the needs of tourism accommodations, restaurants, and retail outlets; focusing on high quality organic production and local tradition.	
• Study undertaken by 2009 on market requirements for meat, dairy and vegetables; and • Agricultural producers improved productivity by 25%.	*No information collected on this objective.*
Objective 18: Provide community facilities and services to improve the living standards and social environment of local people.	
• At least five play areas developed by 2010; • At least one community center developed; • At least 50% of unemployed people seeking jobs in tourism completing short courses by 2012; and • At least 50% of these individuals obtaining jobs in tourism within four months.	• There is a small playground in the center; • Jermuk does not have a community center; • The Municipality representatives said that there is no organized training or education for job seekers in tourism; and • Key informants cite outmigration as being high in recent years.
Objective 19: Promote the religious and cultural heritage of Vayats Dzor and Jermuk for the economic and social benefit of the local community and visiting tourists.	
• Establishment of tourism marketplace by 2012; • At least one to two exhibitions or events held during peak and off-peak season annually; • Renovation of the 'Kings bathing area' in mineral water spring building and Gndevank Monastery; • Signage established at four cultural monuments; and • At least four events held annually.	• Jermuk has a scattered handicraft and herb sale place in central location, poorly organized, with no toilet or covered stalls; • Art gallery rarely changes its exhibits; and • There used to be an annual winter event, but now takes place every few years.

Table 4.17.7: Review of 2008 Comprehensive Development Plan	
Targets 2008	**Status as assessed by Lydian in 2013[24]**
Objective 20: Maintain and enhance the rural environment in and around Jermuk.	
• Gorge cleaned and industrial buildings removed; • Marked trails developed; • National Park to be designated by 2012; and • Agreement reached between stakeholders on zoning.	• The Municipality representatives confirmed that the gorge and surrounding area is being cleaned regularly; • No network of marked trails; and • Jermuk is not designated as a National park.
Objective 21: Give authority for the development of Jermuk to the town itself, engage community by participation and feedback, to enhance the sustainability of Jermuk's development.	
• At least three courses held per year for the next three years for local government employees and officials; • Planning department established and operational by 2010; official hired by the planning department by 2009; and • At least four events held annually for local residents to celebrate culture and lifestyle.	• Municipality does not have a planning department or a paid official for tourism; • Focus group participants indicate that there are few formal mechanisms or practical events for their participation and feedback.
Objective 22: Enhance the business environment to increase the chances of attracting private sector actors to invest in Jermuk.	
• At least 20 businesses opened each year; • At least 50% of businesses utilizing incentive programs; and • Determine by 2010 if it is appropriate to develop economic zones based on market analysis.	• Jermuk is not an assigned economic zone; • While there was no specific information on new business, residents and key informants point to decreasing population as indication that economy is in decline.

There are no accurate and up to date visitor numbers for Jermuk. During the summer, hotels reported having full occupancy, which fell to 20 % in the low season. Some hotels close over winter due to an absence of heating (e.g. Gladzor Hotel) and demand (e.g. Moscow Hotel). The condition of hotel and guesthouses at this time was variable, with two of the spa hotels having been renovated between 2005 and 2008. The same study referred to a previous estimate provided by the Jermuk Municipality that the total number of annual tourists had fallen to 5,000 visitors from a peak of over 25,000 during Soviet times[25]. Further research presented in this report, however, referred to a 2007 study, which estimated that the actual numbers of visitors was approximately 22,500 foreign leisure and health visitors, including people visiting for just an hour and those having much lengthier stays. Annually, it was estimated that domestic over-night stays in Jermuk amounted to 47,300 nights in 2008[9]. Further facilities for tourists, such as restaurants, were in a variable state of repair and had

[25] USAID (2008) Comprehensive Development Plan: Jermuk as a Destination Spa & Winter Tourism Center

operated a limited service in winter. Other attractions included visiting the mineral water springs, the outdoor environment, Gndevank monastery, three monuments in Jermuk and the ski complex located just outside of Jermuk offering limited runs.

Since 2008 progress has been limited and most targets outlined in the Comprehensive Development Plan have not been met. Developments have been made in the provision of upgraded internet connection across the range of hotels, renovation of some hotels and spas, a small number of annual chess tournaments have been held and there is anecdotal evidence of a small increase in domestic tourism. Progress has been limited, however, relating to the lack of planning for tourism in Jermuk, the lack of investment in tourist facilities and from a limited expansion in general tourist infrastructure which would facilitate further growth.

4.17.10 Natural Resource Use

The collection of plants for both consumption and medicinal purposes is undertaken by each of the rural communities (see Appendix 4.17.1). Residents of both Gorayk and Kechut barter herbs and mushrooms collected from open fields for agricultural products unavailable in their own areas (e.g. fruit and nuts).

4.17.11 Fishing

Recreational fishing is undertaken in the Vorotan River and in Spandaryan Reservoir. No instances of fishing for subsistence purposes have been identified. Two fish farms are located downstream of the hydropower power plant west of Gndevaz (also downstream of Kechut Reservoir) as described in Section 4.9.

4.17.12 Other Economic Activities

Small artisans operate in each of the rural communities providing carpentry, mechanical, plumbing and building services.

Remittances and pensions also contribute to the local economy in the study area. The contribution to livelihoods made by remittance payments varies between the rural and urban communities, with average remittances in Gorayk and Saravan being less than AMD 30,000 per month (USD 72). Remittances in Gndevaz and Jermuk were reported to be modestly higher, although this has not been validated.

All persons aged 63 and above are eligible for a state pension, while all those who have worked for 25 years (and in some cases less than this), are eligible for a long service labour pension. There are also a number of other types of benefits such as health pensions, military pensions and special pensions; an individual entitled to more than one type of pension can choose the most suitable one for themselves.

	Table 4.17.8: Pensioners in Study Area[26]				
Population	Gorayk	Saravan	Gndevaz	Jermuk and Kechut	Armenia
Pensioners	54	30	145	1015	509,312
De jure population	418	282	899	7542	3.274 mln
%	12.9%	10.6%	16.1%	13.5%	15.7%

The actual percentage of pensioners in Gorayk, Gndevaz and Saravan is lower than the national average (see Table 4.17.8); however surveys and interviews in the study area revealed a high degree of dependence on pensions as well as other state benefits.

The average pension in Armenia was AMD 24,520 per month in 2009 and AMD 27,062 in 2011. A World Bank study[27] put Armenia's revised upper poverty line at AMD 30,920 (USD 74) per adult equivalent per month[28]. Kinship networks generally look after older people whose next of kin migrate seasonally for work.

4.17.13 Income from Livelihood Activities

Average monthly income in the study area is summarised in Figure 4.17.11, with Jermuk and Kechut having the highest proportion of higher income earning population. Within the rural communities, qualitative and quantitative data indicates that subsistence agriculture is the dominant economic activity.

[26] Data sourced from "Village Passports" collected and prepared by Village mayors, collected in 2015.
[27] World Bank, (2011) Armenia poverty update using revised poverty lines, Europe and Central Asia Unit.
[28] Old basket (2004) poverty line was AMD 25,877

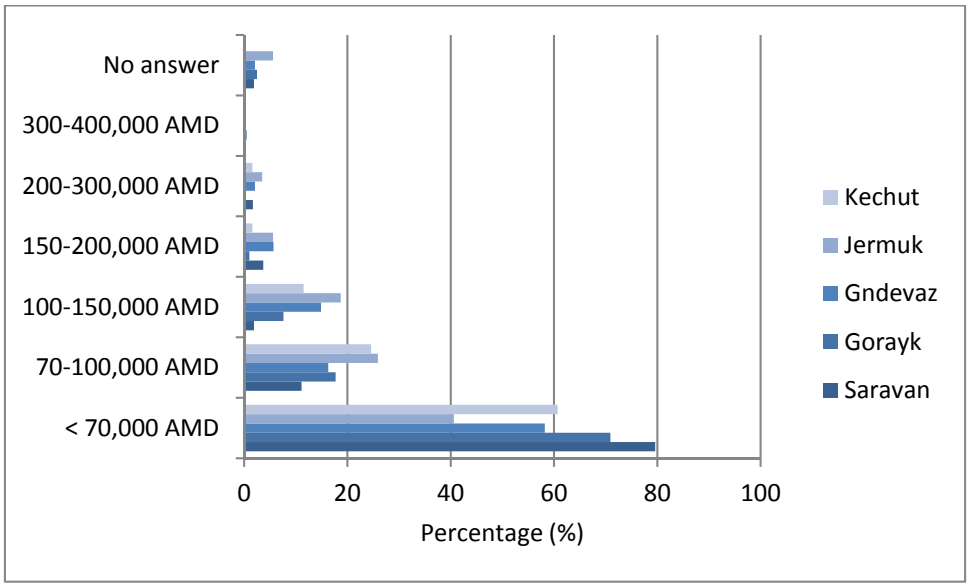


Figure 4.17.11: Average Monthly Incomes from Rural Communities (2010)[29]

Given the informal nature of most income generating activities in the study area, income assessments have been derived from estimates and self-reported income bands. As one of the only commercial cultivation activities which is practiced in the rural areas, income from apricot production in Gndevaz was assessed. Approximately 60% of the surveyed Gndevaz population reported a monthly income of less than AMD 100,000 during the harvest season from apricot cultivation.

Figure 4.17.12 indicates the self-reported annual incomes generated from animal husbandry activities in the rural communities. Given the seasonal nature of these activities, this income is likely to be concentrated in summer months. Anecdotal data from the ecosystem services focus group discussions with seasonal herders suggest that herder incomes are low and that more cattle are required to sustain a livelihood[30] than was the case in the past. Herders indicated that they received approximately 1700 drams (~USD 4.20) per kilo when they sell the meat from their cattle, compared to market prices of approximately 2500-3000 drams (~USD 6.15-7.40)/kilo.

[29] ibid. 10 & 12

[30] Herders interviewed commented that owning 20 cattle used to provide for a good living whereas now closer to 30 or 40 cattle were required to achieve a similar standard of living.

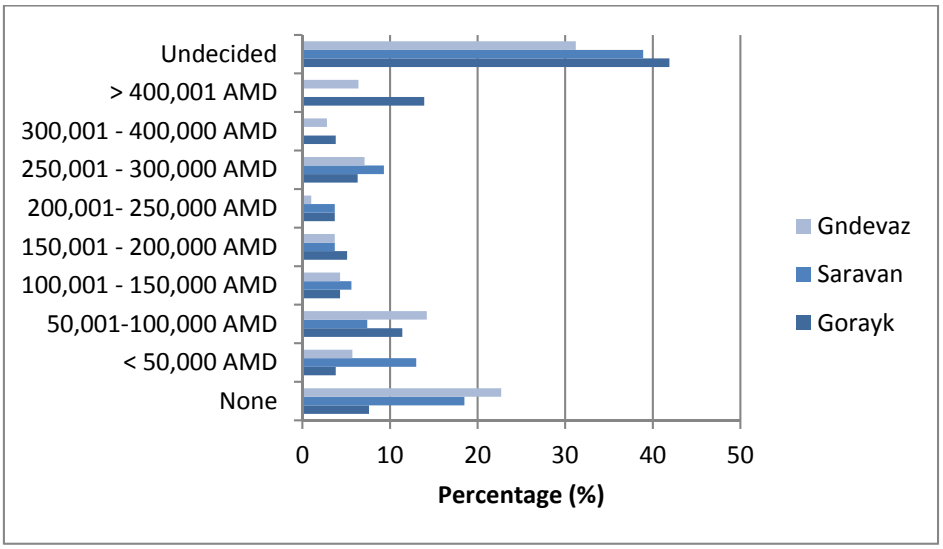


Figure 4.17.12: Annual Income Generated from Animal Husbandry in Study Area[31]

Survey responses indicate that the local study area is predominantly a low income area, with Figure 4.17.13 indicating the self-assessed perception of financial capacity within the communities. This assessment does not include perceptions of financial capacity amongst seasonal herders; however, through interviews it is understood that this group feels economically vulnerable.

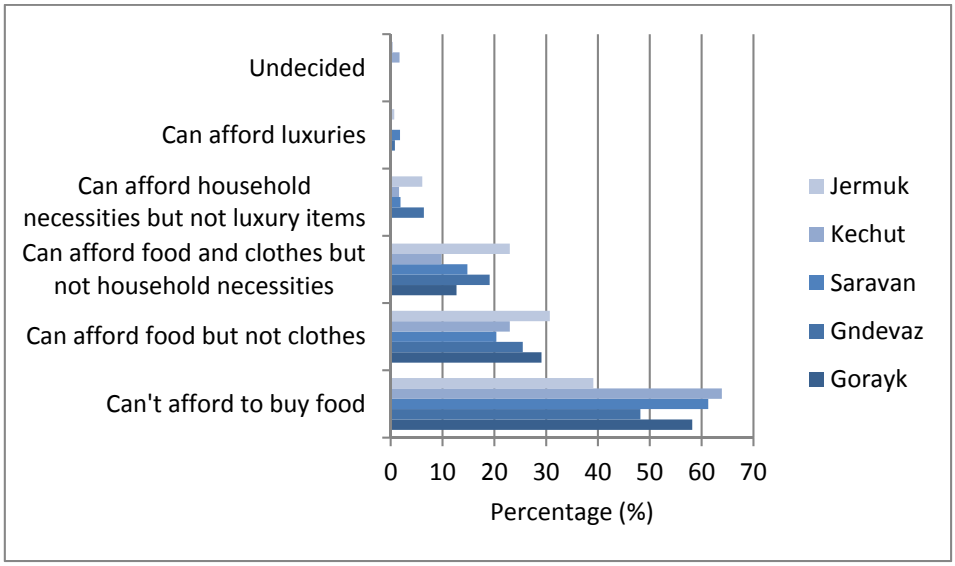


Figure 4.17.13: Perceptions of Financial Status[32]

[31] ibid. 10
[32] ibid. 10 & 12

4.17.14 Skills Profile

A skills audit was conducted by Lydian in the study area in 2011 and was repeated again in 2014 (conducted by Armenian consultancy, MPG).

Table 4.17.9 summarises the self-reported skills held in the rural communities, in 2011, in the study area that may be relevant to the Amulsar Project. Unsurprisingly, more men hold skills of immediate relevance to the project than women in these communities.

Table 4.17.9: Self-reported Skills in Study Area (2011)[33]

Generic Skill	Gorayk (%)		Saravan (%)		Gndevaz (%)	
	Men	Women	Men	Women	Men	Women
General Mechanical	93.8 %	-	52.2%	-	81.1%	4%
Crane operator	12.5%	-	34.8%	-	-	-
Excavator	31.3%	-	13.0%	-	11.3%	-
Bulldozer operator	33.3%	-	17.4%	-	13.2%	-
Front end loader	29.2%	-	21.7%	-	18.9%	-
Truck driver	66.7%	-	21.7%	-	18.9%	-
Welder	45.8%	-	60.9%	-	58.5%	-
Saw operator	-	19.4%	-	15.8%	-	24%
Other operator	37.5%	-	-	-	9.4%	-
Construction worker	79.2%	-	87%	15.8%	79.2%	-
Electrician	75.0%	-	91.3%	42.1%	-	-
Carpentry and masonry worker	37.5%	-	52.2%	10.5%	43.4%	-
Engineer	6.3%	3.2%	-	26.3%	35.8%	-
Nurse	-	6.5%	-	26.3%	-	12%
Accountant	-	9.7%	-	15.8%	-	16%
Cook	-	19.4%	-	15.8%	-	12%
Other	-	38.7%	17.4%	26.3%	-	28%
Notes:						

In the course of the skills audit, skills comparable to those that would be required for various roles at Amulsar mine were discussed. Many respondents reported having more than one skill; the table above should be read as a profile of skills present in the community that relate to proposed work at the mine, rather than as proportions of people in the community practicing them.

[33] Data sourced from Geoteam Skills Survey (2011), included as Appendix 4.17.2

Of the 844 questionnaires which were completed in the June 2014 skills survey, only 2 respondents indicated that their highest level of education was primary school. By far the majority (approximately 39%) indicated they had completed secondary school, with nearly a fifth (19%) indicating they have completed higher education (a four year university degree or greater). Importantly, a significant level of higher education completion was seen consistently across all villages (Gndevaz 14%; Gorayk 19%; Jermuk 21%; Kechut 12%; and Saravan 24%), highlighting the importance placed on education in all communities in Armenia. This is highlighted in Figure 4.17.14.

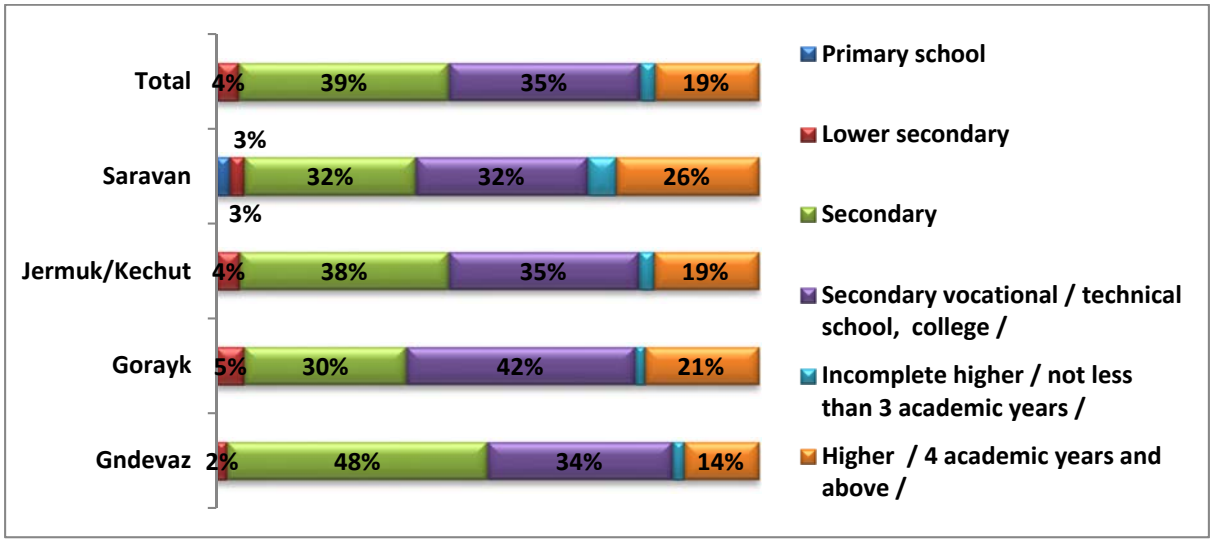


Figure 4.17.14: Educational level of respondents within communities[34]

This educational attainment will provide a good basis upon which to train people as needed for new roles.

As the working language of the Amulsar Project will be English, it is relevant to note that approximately 10% of all survey respondents indicated that they have good or professional (2 top categories) levels of written, spoken and reading skills in English. Speaking English is not a requirement for the majority of roles on the Project, but will be an asset for an individual seeking employment.

Within the skills survey, respondents were asked to indicate whether they had specific skills of relevance to the mining industry and to provide an indication of their skill level. The

[34] Data sourced from MPG (2014) Skills Survey Initial Analysis

figures below represent the proportion of respondents who reported having good or professional skills levels in specific fields:

- 7% plumbers
- 6.5% electricians
- 6.5% carpentry and masonry skills
- 6.5% welders
- 11% experience in scaffolding and construction
- 15 responded that they are engineers (1.8%)
- 12.5% accountants
- 8% professional cleaning experience
- 10% professional catering experience
- 3% crane operators
- 3% backhoe operators
- 3% excavator operators
- 4.5% bulldozer operators
- 4% front end loader operators
- 7.5% truck drivers

The survey also identified the number of people with different classes of drivers licence, as illustrated in Figure 4.17.15.

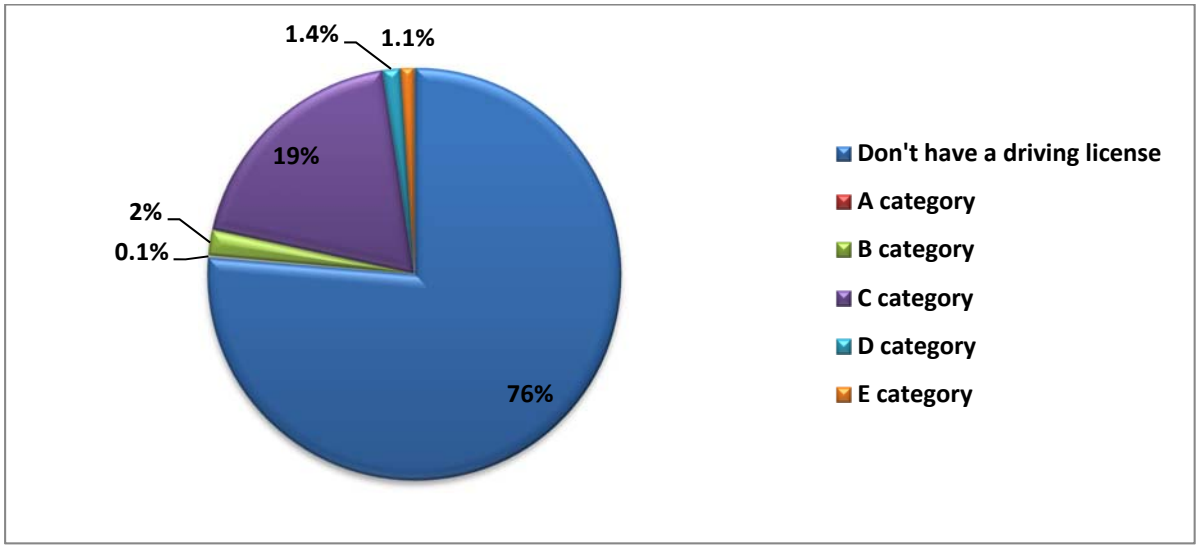


Figure 4.17.15 Ownership and Class of Drivers Licence[35]

[35] ibid. 31

Approximately 38% of respondents indicated that they currently have salaried jobs, with an additional 5% reporting to be self-employed. The majority of respondents (48%) indicated they are currently unemployed. Importantly, over 75% of all respondents indicated they have worked at some time in the past. Within the context of the development of the Project, the high education levels and diversity of skills held within the community at present should provide opportunities for a significant number of local community residents to successfully gain employment on the Project. Table 4.17.10 provides an indication of the employment status within the local communities, highlighting the high levels of unemployment experienced in the area at present.

Table 4.17.10: Skills survey initial results - Employment status[36]

	Salaried employment	Self-employed	Looking after dependents	Seasonal job	Other	Subsistence or basic farming	Currently unemployed
Gndevaz	40%	4%	3%	2%	1%	12%	37%
Gorayk	44%	2%	0	12%	3%	7%	32%
Jermuk	38%	6%	2%	<1%	1%	<1%	53%
Kechut	29%	5%	8%	5%	0	5%	48%
Saravan	45%	0	0	13%	0	5%	37%

[36] ibid. 31

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APPENDICES

Appendix 4.18.1 Baseline Traffic Surveys (2012 – 2014)

4.18 Transport Assessment

4.18.1 Introduction

The Traffic Impact Assessment (TIA) covers a desk-based assessment of the transport impacts associated with the construction, operation and closure phases of Amulsar mine. This chapter considers the baseline conditions and sets the context of the assessment from a national, regional and local perspective. Baseline conditions have been obtained from sources, including the Ministry of Transportation and Communications (MoTC) and the Armenian Roads Directorate (ARD). Other, secondary data sources have been referenced including World Bank Reports on transport infrastructure in Armenia. Primary data included traffic counts obtained from road junctions over a number of 24 hour periods during 2013 following initial snap-shot surveys undertaken in 2012. A further baseline survey was undertaken in June 2014.

4.18.2 Methodology

The TIA develops an analysis of present traffic conditions to establish the capacity of supporting infrastructure, current levels of service, existing traffic related conditions on the highway network and predicted future baseline growth in travel demand.

TIA methodology conforms to current good practice and in the absence of standards relating to transport assessment for the RA, traffic impacts have been considered and analysed in line with the following published international and UK guidance:

- IFC Performance Standards;
- EBRD Performance Requirements;
- Institute of Environmental Assessment (IEA) (UK) Guidelines for the Environmental Assessment of Road Traffic (1991);
- Institution of Highways and Transportation (UK) Guidelines for Traffic Impact Assessment (1994); and
- Department for Transport (UK) Guidance on Transport Assessments (2007).

Baseline conditions have been established using a combination of sources including detailed site mapping, field-based observations, site photographs and data sources supplied by Geoteam during 2011/2012. The data obtained in 2013/14 followed a scope of work, prepared by iPRT Transport Planning, which will be used as the basis for ongoing monitoring during the life of the Project (see Appendix 8.10). An important element to establish the

baseline conditions is the identification of the geographic boundaries of the assessment. These were established during initial fieldwork undertaken by WAI and Geoteam during 2011. Further fieldwork and site observations were undertaken by WAI staff during a 3 day site visit in February 2013. Over this period, data was collected on the transportation aspects of the Amulsar Project as well as field observation at road junctions that would be used for the Project.

Four 24 hour traffic counts were undertaken in March / April 2013 by Geoteam staff to provide an understanding of the nature of the traffic conditions at identified highway links within the assessment boundary. These surveys were undertaken between 00:00 and 23:59 and timed to coincide with the busy Easter weekend which attracts visitors, hence, higher volumes of traffic to the Jermuk area. This methodology has been adopted because it presents the potential worst case conditions on the highway network when it is at its busiest, augmented by holiday traffic. During the survey periods the weather was fine and the driving conditions were good (refer to Appendix 4.18.1). A further survey was undertaken during 2014 on the M-2 Highway to Gorayk, using the same methodology as the previous year (refer to Appendix 4.18.1). The highway network within which the surveys were undertaken (Appendix 4.18.1) are shown on Figure 4.18.3.

Following a review of the baseline data and survey data obtained at highway links relevant to the Project (the M-2 and H-42 highways), this data was used to determine the level of 'available' capacity on these links. The use of highway link capacity assessments conforms to advice within the IEA Guidelines for the environmental assessment of road traffic and is a standard tool for assessing traffic impacts within Environmental Impact Assessments of development projects. A link capacity assessment is used in this instance as the marginal changes in traffic on the perceptible environment are less sensitive than changes in traffic flows at junctions in the surrounding network. This allows for a more direct assessment of changes in traffic levels which might be deemed significant in environmental or social terms.

For each highway link, a baseline case in terms of link capacity was established which accords with the standards set out within the Armenia: Transport Sector Development Strategy (ADB, November 2008) and the UK's Design Manual for Roads and Bridges Volume 5, Section 1, Part 3, TA 46/97. One hour baseline traffic flows, extrapolated from the traffic counts, have then been developed to provide an indication of the volume of traffic using highway links influenced by the Project. Using this data, the baseline ratio of flow to capacity has been

calculated to determine the level of 'available' capacity on the main highway links within the assessment area.

Junction turning movement has been extrapolated from the survey information provided by Geoteam for the surveyed junctions within the study area, the M-2/H-42 Highways. As a result, the traffic survey data has been used to establish the baseline conditions at both existing and new junctions, which would be required to access the Project from the highway. The surveys provide a robust baseline of existing traffic movement to assess the impacts of the construction, operational and closure phases of the Project.

4.18.3 National road network

Introduction

This section outlines the existing road and transportation infrastructure in the context of Armenia and with particular reference to the local area within which the Amulsar Project is situated.

The sections of the road network included within this assessment have been determined on the basis of the potential effect of increased traffic associated with the Project on the junctions and road links within which baseline have been defined (see Appendix 4.18.1).

Strategic context

Figure 4.18.1 illustrates the location of the Amulsar site in relation to the international transport network for RA, which is a land-locked country with closed borders to Turkey and Azerbaijan. As a result border access is concentrated on access to and from Georgia to the north and to a lesser extent Iran from the south.

RA has a continental climate, located in the Caucasus Mountains, with the potential for very low temperatures and heavy snowfall in the winter (see Section 4.2). This has the potential, at times, to limit access to parts of the country and affect economic and trading potential.

The country is approximately 29,800 square kilometres in area, with a population of more than 3 million people. The demographics of RA have been identified in Table 4.12.1.



Figure 4.18.1: International transport context for the Amulsar Gold Mine

Cross-border and international links

Prior to independence Armenia had unrestricted access to other countries within the Caucasus Region of the former Soviet Union, although routes to Turkey and Iran were less well developed. Border issues have lead to the closure of all routes to Turkey and Azerbaijan. This includes the main railway link through Azerbaijan, the main highway from Yerevan to Tbilisi and Russia through Azerbaijan, as well as the rail connection with Turkey, linking Ghumri and Kars, and the road connection to Turkey from Yerevan to Karakala.

Currently there are rail and road connections only with Georgia via Yerevan-Gyumri-Akhalkalak-Batumi and the Yerevan-Vanadzor-Tbilisi-Poti routes to the Black Sea ports of Batumi and Poti respectively. The southern road route to Iranian ports is a greater distance, passing through difficult mountainous terrain. Yerevan is approximately 650 km travel distance to the Black Sea ports and approximately 2,000 km from the Iranian ports. The Georgia-Russian Federation Border was closed in 2006, but in April 2007 a ferry service started operation between Poti and Russia.

Armenia's rail network plays a key role in providing mobility for people and freight in the northern part of the country. Armenian Railways was established in 1991 and prior to independence was part of the Trans-Caucasus Railway with headquarters in Tbilisi, Georgia. However, there is no rail infrastructure within the vicinity of the Project. Armenia has three main airports: Zvartnots, Shirak and Erebuni. Of these, Zvartnots International Airport (serving Yerevan) is the principal gateway into the country.

National highway network

The national transport context is shown in Figure 4.18.2. The Interstate Network of 1,561 kilometres (km) connects all Marzes and provides international links. A further 1,832 km of republican roads connect district centres and 4,122 km of local roads provide access for the rural population.

About 1,000 km of local road is under the responsibility of local communities, the remainder being under state and Marz responsibility. Daily traffic volumes on interstate roads range from 1,000 to 25,000 vehicles. M-roads (Magisterial) leading to Georgia in the north and Iran in the south are part of international corridors.

Most of the M-roads converge on the capital Yerevan. However, Yerevan has no bypass

and through traffic has to transit through the centre of the city.

The primary road network is well developed and consists of:

- M-roads – magisterial roads, and
- H-roads – republic roads.

The M-road network is fully paved and approximately 90% of republican roads are paved. The Armenia Roads Directorate estimates magisterial/republican surface conditions to be 15% good, 75% fair and 10% poor.



Figure 4.18.2: National transport context

Note: National roads are M-roads, other roads are H-roads

4.18.4 Road network, study area

Amulsar Mountain is located on the main M-2 highway network, some 170 km from the capital city of Yerevan. The Project will be accessed from the H-42 that connects the city of Jermuk with the M-2 approximately 7km east of Vayk. The M-2 continues south past Gorayk, to the border city of Agarak, approximately 104km to the south east of the Project.

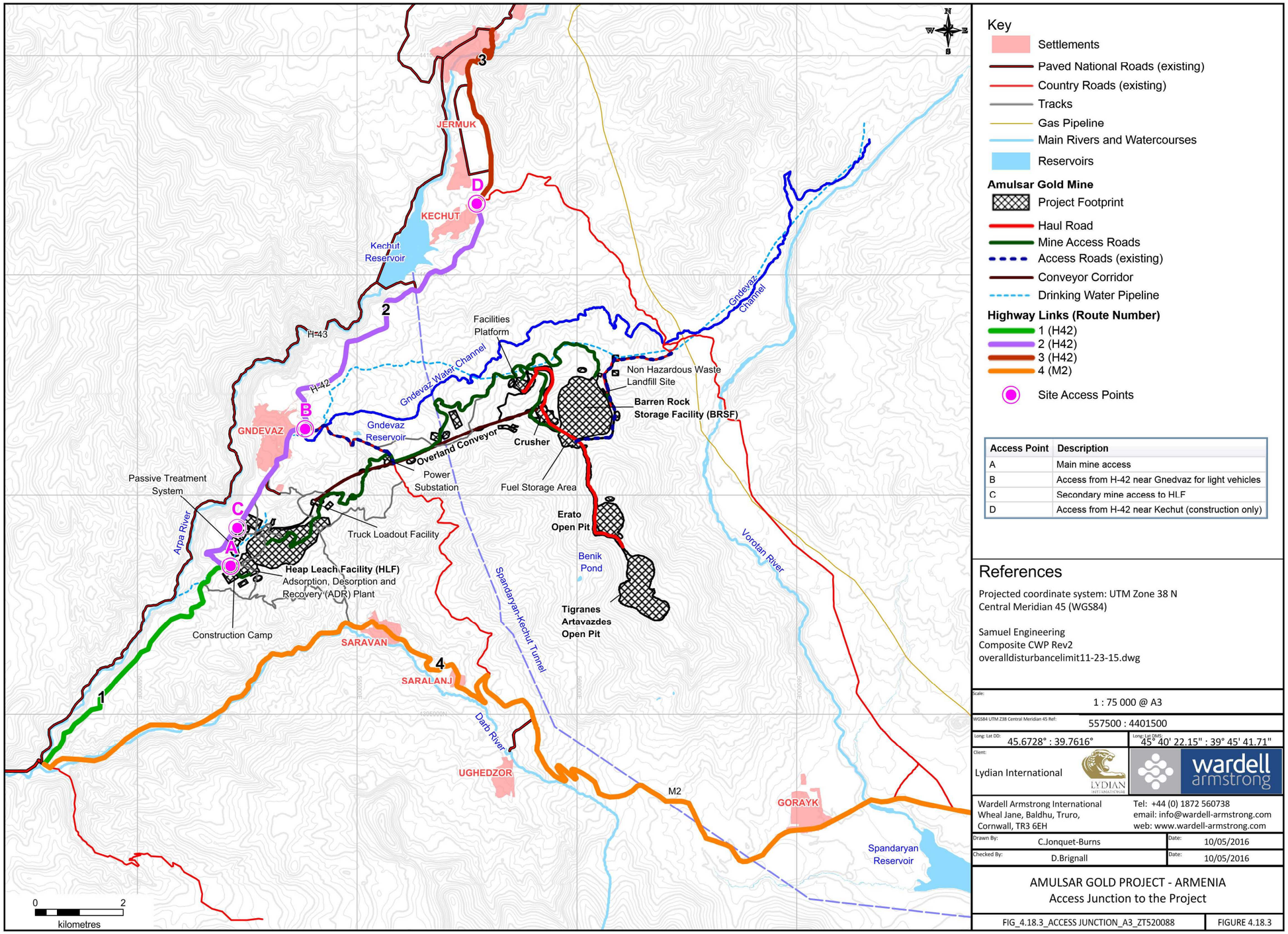


Figure 4.18.3: Highways Links, Local Settlements and the Amulsar Project Site

M-2 Highway

This route forms part of the North-South Route Corridor and Asian Highway Network (AHN), routes AH81/82, which obliges partners to adopt AHN road classifications and design standards. The M-2 (see Figure 4.18.3) is also part of north-south European route E-117 from the Russia/Georgia border via Tbilisi, Dzoramut and Vanadzor.

The M-2 is a key strategic route connecting Yerevan with Meghri / Agarak on the Iranian border. It is single carriageway (2-lane) throughout with the exception of the section between Yerevan and Ararat, which is dual 2-lane. The M-2 is also the main route for tourist traffic between Yerevan, Jermuk and Tatev. The M-2 highway provides the only land connection with Iran.

The M-2 highway provides a direct road route from Yerevan to the Project (see Figure 4.18.2which illustrates the Project in relation to the strategic and local road network).

M-2 Highway Road Surface Conditions

The surface condition of the interstate network is generally fair, with an average international roughness index (IRI) of 4.9. A sample survey of republican roads (report by Armenia Roads Directorate) illustrates worse road conditions, with an average IRI of 8.6 in 2008. Table 4.18.1 identifies the road surface conditions for the M-2 Highway. Notably, the sections of the M-2 closest to Jermuk are indicated, by the Armenia Roads Directorate, to have poorer road surface conditions than elsewhere.

Table 4.18.1: M-2 Highway International Roughness Index 2008[1]

M-2 Section	IRI 2008	Length Km
M-2/M-15 (km15) – Yeraskh (km65)	4.10	50
Yeraskh (km65) – M-2/M-10 (km 120)	5.45	55
M-2/M-10 (km120) – M-2/Jermuk (km 147)	6.07	27
M-2/Jermuk (km147) – Goris (km 238)	5.51	91
Goris (km 238) – Kapan (km 300)	4.95	62
Kapan (km 300) – Iran border (km 383)	4.6	83

[1] Asian Development Bank TA7208-ARM, Ministry of Transport and Communication Republic of Armenia (2010) Preparing the North-South Road Corridor Development Project, PADECO co Ltd

Local context

The Project is located within two separate Marzes (administrative areas) – Vayots Dzor and Synik Marz. The Project is located to the north of the M-2 Highway in a section of the highway that passes the villages of Saravan, Saralanj and Gorayk (see Figure 4.18.3 that illustrates the Project in relation to the local road network). The majority of the route is single carriageway following along the north bank of the Arpa River through hilly terrain with short sections of hairpin bends over the Vorotan Pass. Sections of the M-2 are in poor condition, however some of these sections have recently been improved under a $50M World Bank project. Improvement consisted of overlays and limited rehabilitation, which was completed on the M-2 road south of Yerevan in 2011 where the pavement was in critical condition, thus improving the IRI on the M-2 within the sections that have been subject to these works.

Jermuk, which is located to the north west of the Project, is 24 km north of the M-2 Highway along the single carriageway H-42 Highway (see Figure 4.18.3). The M-2 Highway/ H-42 Highway junction is a standard 'give way' priority T-junction. The Project is located to the north east of this junction. Jermuk is a tourist resort with a resident population of 4,346 (see Table 4.12.2); the city is located on a lava plateau at a height of 2,070 m. With visitor attractions that include spas with warm springs, a 60m waterfall and access to winter sports facilities, tourism contributes to the volume of traffic on both the H-42 and M-2. Outside of tourism, Jermuk's main industry is bottled mineral water, which is widely distributed across Armenia by road. The main road into Jermuk is via a roundabout junction on the H-42, which is the main tourist route to the centre of the city, with its hotels and visitor attractions. A second access to the west of the H-42 and approximately 0.5km to the south of the roundabout junction provides the access to Jermuk airstrip and then onto the residential area of the City. A third, small junction, approximately 2.5km south of the roundabout junction provides direct access to the residential area of Jermuk. Kechut is a residential village to the south of Jermuk, with a main road access off the H42, approximately 1km south of the southern Jermuk junction (see Figure 4.18.3,

Main access to mine

Approximately 1.3 km to the south of the Gndevaz junction on the H-42, the main junction into the Project would give access to internal roads within the HLF and associated operational area (see Figure 4.18.3**Figure 4.18.6**). From the HLF, this internal road network would also link with to the conveyor load out. A separate light vehicle access to the HLF would also be constructed to the north of Access A (see Figure 4.18.3).



Figure 4.18.4: Access (A) Main Site Access (south of Gndevaz)

Figure 4.18.3 identifies the highway links in relation to the Project and local settlements.

Secondary mine access

Midway between the junction of the M-2 / H-42 and Jermuk is the village of Gndevaz, which is accessed by traffic via a junction off the H-42 to the south of the village.

An existing gravel access road to the east of the village of Gndevaz will provide at Access (B) to the conveyor and via access roads to the mine (see Figure 4.18.5). This access will be used to deliver lime to the truck loadout station, where the overland conveyor terminates. Access via this junction will be required during the construction and operational period of the Project but not as a main site access (see Figure 4.18.4).



Figure 4.18.5: Access (B) to conveyor infrastructure and mine access roads north of Gndevaz

Secondary access to mine during the construction phase

The existing gravel track to the north of the village of Kechut, which has been the main access to the exploration camp for the Project's exploration activities will continue to be a primary access during the construction phases of the Project (Access D, on Figure 4.18.6). This gravel road is used by residents of Jermuk to gain access to the informal landfill site, approximately 2 km from the junction to the H-42.



Figure 4.18.6: Access (D), the current access to the exploration camp, north of Kechut

Link description

The primary junctions that would provide access to the Project as identified in are:

- Main site access, to south of Gndevaz (Access A);
- Access to mine, north of Gndevaz (Access B);
- Light vehicle access to mine site, to the north of HLF (Access C); and
- Existing exploration camp access and junction to be used during construction, north of Kechut (Access D).

The sections of the Highway leading to these junctions are (also Figure 4.18.3):

- Link 1 M-2 / H-42 junction northwards to Junction A;
- Link 2 Junction A northwards on the H-42 to the Junction D, north of Kechut;
- Link 3 north of Junction D on the H-42 to Jermuk; and
- Link 4 south east of the M-2 / H-42 junction, on the M-2 past Saravan, Saralanj and Gorayk (which has been included in the baseline traffic surveys).

Links 1 - 3 are the sections of the H-42 north of the junction with the M-2 Highway. This section of the H-42 is a single carriageway local road paved to reasonable standard. North of the junction with the M-2 Highway the road climbs rapidly. The initial sections of the route have sharp hairpin bends. The road levels off as it reaches higher altitude and is generally straight, with the exception of a hairpin bend 3km to the south of Gndevaz and a further steep section of road approximately 1km to the north of Gndevaz. The village of Gndevaz is located at a midway point to Jermuk and is set back to the west of the carriageway.

The H-43 forms a T Junction with the H-42 to the north of Gndevaz (midway along Link 2, see Figure 4.18.3) and approximately 1.5km south of Kechut.

The M-2 highway from the H-42 junction to east of Gorayk, also has been surveyed for traffic counts (Link 4), which had the highest base flow (including the contribution of Heavy Goods Vehicles HGVs to the baseline conditions).

Baseline traffic flows

Baseline traffic flows have been derived from 24hr traffic counts undertaken in March / April 2013 and June 2014. These traffic counts provide an understanding of the nature of the traffic conditions along the key highway links within the assessment boundaries. The 2013 surveys were undertaken simultaneously between 00:00 and 23:59 in good driving conditions during the busy Easter holidays where the vehicular movements along the H-42 were considered to represent peak volumes of traffic. The 2014 surveys were undertaken over the same time period in June 2014, on the M-2 highway.

Four survey locations were included:

- The H-42 at the junction of the M-2 Highway and H-42 Highway;
- From M-2 on H-42 to Gndevaz (Link 1 and 2)
- From Gndevaz to Jermuk on the H-42 (Link 2 and 3); and
- M-2 to Vorotan Road, east of Gorayk (Link 4).

All surveys were undertaken during 2013, with the exception of the M-2 to Vorotan Road survey that was completed in June 2014.

The traffic conditions along the M-2 Highway are fairly constant through the day as this route acts as the main route between Yerevan and the Iranian border at the border city of Agarak / Meghri. Observations during the site visit confirmed that a high percentage of traffic along this route relates to truck movements. These conditions were further confirmed through discussion with local residents.

Temporal/ seasonal variations

The March / April surveys in 2013 on the H-42 represent a peak in Jermuk due to the importance of the Easter holiday for tourism combined with a weekend break. However, to be robust and to present a worst case for baseline traffic flow, a seasonality factor was applied to all baseline flows to determine appropriate traffic volumes for summer months. The Armenian Road Directorate have indicated that traffic flows outside of summer months are 18% lower than those in summer months. Therefore, a seasonality factor of 1.18 has been applied to all baseline traffic volumes for future year assessments of highway link and junction capacity to account for growth in background traffic in particular during summer months.

The development programme for the Project (see Chapter 3.1) identifies that construction would commence in 2016. Construction of the Project will occur over two years (2016 – 2017). The mine is expected to commence full production in 2018 and has been assigned as the appropriate base year against which to assess construction traffic impacts. Operational traffic impacts have been assessed against a 2017/18 opening year for operations. It is therefore necessary to apply a growth factor to surveyed traffic flows to generate baseline traffic conditions for 2013 and 2014. Discussions with Geoteam have identified that there are no other major committed developments relevant to the study

area. Therefore, baseline flows need to take account of temporal and seasonal variations for future assessment years but no other large-scale developments that generate traffic.

The Asia Development Bank (ADB) Transport Sector Development Strategy for Armenia includes three future growth scenarios: low, medium and high traffic growth (5.5%, 7.2% and 8.3% respectively). For the purpose of a robust assessment, the 8.3% high traffic growth scenario has been used when calculating the compound (i.e. 8.3% year on year) annual growth in background traffic levels for all future year assessment scenarios.

Link capacity assessment

Reference to the baseline traffic flows illustrates that the links on the H-42 will experience very low volumes of traffic. Where existing traffic flows are very low, any increase in traffic flow would result in a predicted increase in traffic levels which would be high when compared to the baseline condition. Where this situation is identified, it is necessary to consider any increase both in terms of the relative increase in respect of existing traffic flows, as well as the overall total flow in respect of the available capacity of the section of road being considered. For example, a relatively small numerical increase in traffic could be seen as an increase of major magnitude when considered against very low background flow, but when considered against link capacity, the capability of the junction to accept a major increase in traffic flow is also high, i.e. there is little or no deterioration in the operating capacity of the junction itself. Therefore, such an increase would be unlikely to cause a major environmental effects given the road's overall capacity.

A highway capacity analysis for the highway links has been undertaken using the UK Design Manual for Roads and Bridges (DMRB) Volume 5, Section 1, Part 3, TA 46/97. This section defines the current baseline capacity on the M-2 highway using this methodology. Chapter 6.18 considers the effects on highway capacity of the construction and operational phases of the Project. The DMRB capacity information was published in February 1997. While this information is fourteen years old, TA 46/97 is still a current document and is used as best practice by the UK Highways Agency. The calculation of link capacity using this method is generalised for Principal roads; this is considered appropriate for the H-42 highway. The H-42 has a standard carriageway width for most of its length; however there are a number of hair-pin bends on some sections as indicated previously.

The UK Design Manual for Roads and Bridges (DMRB) calculates traffic capacity for rural

roads using the method of Congestion Reference Flows (as indicated in DMRB TA 46/97). Link capacity in this instance defined as the 'maximum sustainable hourly lane throughput'. The Congestion Reference Flow (CRF) of a link is an estimate of the traffic flow at which the carriageway is likely to be congested in the peak periods on an average day. For the purposes of calculating the CRF, 'congestion' is defined as the situation when the hourly traffic demand exceeds the maximum sustainable hourly throughput of the link. At this point the effect on traffic will be one of the following:

- Flow breaks down with speeds varying considerably;
- Average speeds drop significantly; or
- Sustainable throughput is reduced and queues are likely to form.

In reality capacity varies day to day due to the prevailing conditions (for example, day/night, wet/dry, percentage of heavy vehicles, regular/holiday traffic) and as a result the values used must be an average. DMRB TA 46/97 identifies that capacity for existing links not currently experiencing congestion can be estimated from the following relationship:

CAPACITY	[A - B * Pk%H]
Where:	A = 1380 (for single lane carriageway)
	B = 15 (for single lane carriageway)
	Pk%H is the percentage of heavy vehicles in the hour

Capacities for the links 1 to 4 have been calculated using this methodology. Both the M-2 and H-42 local roads are considered to equate to rural road classification. Site observations have suggested that the M-2 and H-42 have a higher capacity than the existing traffic flows that have been surveyed on the highway. The proportion of HGVs on the M-2 is, however, greater than that on the H-42 which is currently generally light traffic (compare Link 4 to Links 1 to 3 in Table 4.18.2).

Table 4.18.2 summarises the seasonally adjusted baseline traffic flows and the baseline at 2016 together with the baseline ratio of flow to capacity for each link; the flow to capacity being the recorded flow as a percentage of the theoretical capacity of the link.

Table 4.18.2: Baseline Link Capacity Assessment

Link Description	Season Factor	Direction	Seasonally adjusted Baseline (2014)[1,3] (PCU/hr)	% HGV	Link Capacity	Baseline 2016[2] (PCU/hr)	RFC %	Baseline 2017[3] (PCU/hr)	RFC %
Link 1 M-2 / H-42 junction to Junction A	1.18	NB	14	0	1380	16	1.2	18	1.3
		SB	40	3.3	1330	46	3.5	50	3.6
Links 2 & 3: Junction A – to Jermuk		NB	55	4.9	1307	64	4.9	70	5.1
		SB	60	0	1380	70	5.1	76	5.5
Link 4: M-2/H-42 junction to east of Gorayk		EB	137	23.7	1025	178	17.0	188	18.4
		WB	95	35.0	855	121	14.1	131	15.3

Notes:

[1] In line with best practice the highways link capacity assessment has been undertaken in Passenger Car Units (PCUs) to reflect the greater environmental impact of heavy vehicles on public highways than a private car. A private car has a PCU value of 1, while a heavy vehicle has a value of 2.

[2] 8.3% compound growth has been applied to the baseline traffic flows to reflect increases in background traffic.

[3] The hourly baseline flow was taken as the highest number of vehicles counted during the four periods. This scenario is exaggerated as, based on the data available, (a) all the peak hours do not coincide (b) predominantly the peaks were exhibited during the busy Easter break rather than a neutral day. However, by assuming all peak hours coincide and selecting the busiest period, this would produce a robust assessment.

See Figure 4.18.3 to identify the links in relation to the footprint of the Project.

Table 4.18.2 confirms that the baseline local traffic flows on the H-42 are very low. In the survey years of 2013, 2014 and predicted baseline at 2017/8 the Ratio of Flow to Capacity (RFC) on each link is at or below 10% of their overall capacity.

The hourly traffic flows on Link 4 (the M-2) are the highest surveyed. In the westbound direction, these are just below 20% of link capacity (RFC) in both 2016 and 2017.

4.18.5 Summary

The baseline has considered traffic flows on two roads which Project-related traffic would use:

- M-2, which is a magisterial road that connects to Yerevan in the north and the Iranian border to the south; and

- H-42, a republic road that connects Jermuk to the M-2 and on which the primary junctions to the Project would be located.

The baseline surveys that have been completed in 2013 (H-42) and 2014 (M-2) have identified that the ratio of flow to capacity (RFC) for construction and at the initial years for operation on each road would be at or below 20% on the M-2 and 10% on the H-2. Therefore, both the M-2 and H-2 are lightly trafficked.

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APPENDICES

Appendix 4.19.1 Maps of Known Cultural Heritage Sites
Appendix 4.19.2 Excavations in 2012 at Zugy Aghbyur

4.19 Archaeology and Cultural Heritage

The archaeological and cultural heritage baseline has been collected through a combination of desktop research and fieldwork conducted by a team of Armenian and international archaeologists.

4.19.1 Desktop Survey

Desktop research included a literature review of published sources on Armenian history, prehistory and archaeology and systematic satellite imagery analysis of proposed Project component locations.

Desktop Survey: Literature Review

During the literature review, particular attention was paid to the mountainous region in southern Armenia where the Project is located. Additional research also focused on understanding the history of archaeological research in Armenia, providing a historical context for appreciating local archaeological research methodologies. Results from the desktop research contributed to the historic and cultural context presented below and have assisted the interpretation of field finds (see Appendix 4.19.1 and 4.19.2).

Desktop Survey: Satellite Imagery Analysis

The satellite imagery analysis involved a systematic review of aerial images of the Project area and a multispectral analysis of specific Project component locations to identify potential cultural heritage sites, referred to as cultural heritage anomalies. Cultural heritage anomalies were defined as potential archaeological or built heritage sites detectable through the analysis of both visible and non-visible wavelengths of light in satellite imagery. The multispectral analysis was conducted through the analysis of satellite images of Project component areas with four wavelength bands: Red, Green, Blue and Near-Infrared.

Anomalies identified during the satellite imagery analysis were targeted for further analysis in the field during field reconnaissance surveys. A number of landscape features are of a similar size and shape to archaeological resources making it difficult to confirm if an anomaly is in fact a cultural heritage resource. For example, kurgans and large stone piles created during agricultural field clearance can be of similar shape and size. During field reconnaissance survey Armenian archaeologists or ERM cultural heritage specialists visited anomalies to assess the likelihood that they represented archaeological sites.

4.19.2 Cultural Context

The Project area is located in southern Armenia, a mountainous area in the South Caucasus region, situated between Western Asia and Eastern Europe. Armenia's archaeological and historical wealth is evident in this region from vestiges of local prehistoric cultures as well as of later foreign influences. Armenia's long history includes periods of independence interspersed with periods of control by external forces. Its strategic location between two continents has made Armenia prone to invasion, the country having suffered occupations by the Assyrians, Greeks, Romans, Byzantines, Arabs, Mongols, Persians, Ottoman Turks and Russians.

Table 4.19.1 presents a brief timeline of Armenian history and prehistory, with a focus on southern Armenia. The information presented in the timeline was developed from standard published sources. The timeline provides a wider context for understanding and evaluating cultural heritage sites identified by the survey.

Table 4.19.1 : General Timeline of Relevant Armenian History and Prehistory

Period	Date[1]	Characteristics and Major Events
Paleolithic Period	2.5 million years ago – 10,000 BC	Movement of humans out of African continent; the earliest evidence of human occupation found outside of Africa north of the Project area, in the neighboring country of Georgia, dating as far back as 1.8 million years; development of basic stone tools; small groups relying on hunting and gathering.
Mesolithic Period	10,000 – 6,000 BC	Nomadic foraging economy exploiting favorable post-Pleistocene resources; movement of people into the areas formerly occupied by ice sheets; development of micro-lithic stone tool assemblages; bow and arrow used in hunting; beginning of plant domestication.
Neolithic Period	6,000 – 3,000 BC	Emergence of village life dependent on domestication of plants and animals; first traces of human settlement in the Project area; manufacture and use of obsidian tools; pottery; mud-brick and stone architecture; anthropomorphic female figurines.
Bronze Age	3,400 – 1,500 BC	Kura-Araxes culture (3500-2400 BC), economic stability based on cattle and sheep raising; Trialeti culture (2200 – 1500 BC); local warlords emerge as men of wealth and power; burial mounds; bronze weapons.
Iron Age	1,500– 600 BC	Development of iron metallurgy, Nairi (1200 – 800 BC), Urartian culture (1000 – 600 BC), advanced agricultural practices.
Antiquity/Antique Period	590 BC – AD 646	Kingdom of Armenia, expansion under the rule of Tigranes the Great, Hellenism, Armenia becomes Roman province (AD 114-118); Christianity becomes the state religion (AD 301); foreign incursions from Roman, Byzantine, and Parthian Persian empires.

Table 4.19.1 : General Timeline of Relevant Armenian History and Prehistory		
Period	**Date[1]**	**Characteristics and Major Events**
Middle Ages	AD 646 – 1375	End of Byzantine and Parthian partition of Armenia. Autonomous Emirate of Arminiya under Umayyad Caliphate; Independent Kingdom of Armenia (858-1045); Turkish control (1071-early 12th century); invasions by Mongols and other Central Asian tribes.
Period of Foreign Control	AD 1376 – 1918	Continued invasions from Central Asian groups; parts of Armenia controlled by Ottomans & Persians, then Ottomans & Russians after the Russo-Persian War (1826-1828); WWI; Armenian Genocide; Democratic Republic of Armenia declared independent in 1918.
Modern Period	1919 – Present	Territorial wars with Georgia, Azerbaijan and Turkey; communism introduced; Armenian Soviet Socialist Republic joins the Soviet Union; WWII; Soviet Union dissolves and Armenia regains independence (1991); formation of modern Armenian national identity.
Note: [1] Dates are approximate		

Palaeolithic Period

Evidence of human occupation has been recorded in Armenia as early as the Paleolithic Period, a time when small groups of hunter-gathers made their way out of the African continent and slowly began to populate Europe and Asia. The Republic of Georgia, which borders Armenia to the North, is home to the earliest evidence of human occupation found outside of the African continent at the site of Dmanisi, a site dating to 1.8 million years ago. Such remains may be present in Armenia as well. The use of rudimentary stone tools is the most significant technological development during this period. One of the oldest archaeological sites in Armenia is the Lower Palaeolithic site of Satani-Dar, where hand-axes, thick flakes, and rough chopping tools of obsidian and dacite have been found[1]. An archaeological survey conducted in 2009 documented Paleolithic, Neolithic/Chalcolithic and Bronze Age artefacts in the Debed river valley in north-eastern Armenia[2]. Other Palaeolithic sites containing Acheulean Period and Mousterian Period tools have been recorded, but they are found primarily in northern Armenia[3].

[1] A. Mongait. 1961. Arkhaeologiya v SSSR. Moscow, 1955, English Translation by M. W. Thompson, London.

[2] Egeland, Charles P., Boris Gasparian, Dmitri Arakelyan, Ryan M. Byerly, Christopher M. Nicholson & Diana Zardaryan. Sept 2011. "Multiperiod archaeological reconnaissance in the Debed river valley, north-eastern Armenia". *Antiquity*. Vol. 085, Issue 329.

[3] Dolukhanov, Pavel, Stephen Aslanian, Evgeny Kolpakov & Elena Belyaeva. September 2004. "Prehistoric Sites in Northern Armenia". *Antiquity*. Vol. 078, Issue 301.

Mesolithic Period

The Mesolithic period in the Caucasus coincides with the milder climate associated with the onset of the Holocene. Humans continued to hunt but also developed wider-ranging foraging economies to exploit the more abundant resources that resulted from the milder environmental conditions of the time. Humans continued to maintain a nomadic lifestyle and gradually migrated into areas formerly covered by glaciers. More refined micro-lithic stone tool kits, the bow and arrow, and the beginnings of plant domestication developed in this period. As in the Paleolithic period, evidence of human occupation in the Mesolithic period has been recorded primarily in northern Armenia. For example, an archaeological survey conducted in the southern Armeno-Javakhet volcanic plateau in north-western Armenia identified both Paleolithic and Mesolithic artefact assemblages[4].

Neolithic Period

The Neolithic period was characterised by the emergence of fully sedentary lifestyles associated with the domestication of plants and animals. In Armenia, the earliest indications of human habitation have been uncovered in a cave, Areni-1, in southern Armenia. Areni-1 has yielded Chalcolithic and Early Bronze Age remains including urn burials, a leather skirt, the oldest known leather shoe, and the oldest winery recorded in the world[5]. The earliest systematically excavated agricultural settlements appear to belong to the Shulaveri-Shomu tepe culture of the Late Neolithic[6]. Between 6000 and 4200 BC, the Shulaveri-Shomu and other Neolithic/Chalcolithic cultures of the Southern Caucasus were using local obsidian for tools, raising animals such as cattle and pigs, and growing crops. Characteristic traits of the Shulaverian material culture include circular mud-brick architecture, pottery, anthropomorphic female figurines, and an obsidian industry with an emphasis on production of long prismatic blades.

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[4] Eugen M. Kolpakov. 2009. “The Late Acheulian Site of Dashtadem-3 in Armenia“. PaleoAnthropology. http://www.paleoanthro.org/journal/content/PA20090003.pdf

[5] BBC. January 11, 2011. "Oldest known wine-making facility' found in Armenia". http://www.bbc.co.uk/news/world-europe- 12158341
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[6] Wilkinson, Keith N., Boris Gasparian, Ron Pinhasi, Pavel Avetisyan, Roman Hovsepyan, Diana Zardaryan, Gregory E. Areshian, Guy Bar-Oz & Alexia Smith. 2012. “Areni-1 Cave, Armenia: A Chalcolithic–Early Bronze Age settlement and ritual site in the southern Caucasus”. Journal of Field Archaeology. Vol. 37, No. 1.

Bronze Age

A wide range of Bronze Age Kura-Araxes culture (4000 – 2200 BC) settlement site types have been investigated in southern Armenia. Site types include densely populated tepes (settlement mounds) located on the plains of river valleys (e.g., Mokhra Blur, Kyul Tepe 1, Khizanaant Gora, Kvatskhelebi, Yanik Tepe and Norsuntepe), as well as large low-density settlements with stone architecture found in high-elevation mountainous areas (e.g., Gora-Amiranis, Gegharot). Another regional Bronze Age culture, the Trialeti culture (2200 – 1500 BC) is characterized by its burial mounds, sometimes called kurgans or cromlechs. Also during the late Bronze Age, between 1500 and 1200 BC, the western part of the Armenian Highland was occupied by the Hayasa-Azzi culture which was frequently in conflict with the Anatolian-based Hittite Empire.

Iron Age

During the Iron Age, most of the Armenian Highland was united, first under a confederation of kingdoms, known as the Nairi (1200 – 800 BC) based in Anatolia. In the 10th century BC, the Nairi joined the Kingdom of Urartu (1000–600 BC), which became a powerful rival of the Assyrian empire in the first half of the 8th century BC. The Urartu had well-developed agricultural practices including irrigation, cultivating wheat, barley, sesame, millet and emmer. They also practiced horticulture and viticulture.

Antiquity

Around 600 BC, the Orontid Dynasty established the Kingdom of Armenia, which reached the peak of its power and integration with Hellenistic culture between 95 and 66 BC under Tigranes the Great. Following the rule of Tigranes the Great, Armenia was ruled by a series of foreign powers. During this time, after 20 BC, Armenia became a buffer zone and area of contention between the Parthian and the Roman empires. The Roman influence in Armenia resulted in it becoming a Roman province, although the period of Roman control was short-lived (AD 114–118). In AD 301, Armenia declared Christianity as its official state religion. Later in the fourth century, the Parthians attempted to wrest control of Armenia from the Byzantine Empire, resulting in a split of Armenia into East and West in AD 387. Western Armenia remained a province of the Byzantine Empire until AD 536 while Eastern Armenia remained a kingdom within Parthian Empire until AD 646.

Middle Ages

The collapse of Byzantine and Persian control of Armenia in the late 7th century led to the

rise of the Emirate of Armenia, also known as the Ostikanate of Arminiya or the Principality Armenia. The spread of Islam resulted in the collapse of both Byzantine and Parthian Persian control across the Near East and South Caucasus. During this period, Armenia emerged as an autonomous principality in the Umayyad Caliphate and was ruled by local princes from 637-885. During the subsequent collapse of the Umayyad Caliphate and rise of the Abbasid Caliphate in the late 9th century, Armenia gained full independence. The Kingdom of Armenia under the rule of King Ashot I of the Bagratuni Dynasty of Armenia was formally recognized by both the Byzantine Emperor and Abbasid Caliph in AD 884. The Kingdom of Armenia remained an independent kingdom until it was conquered by the Seljuk Turks in AD 1071. The Seljuk Turks controlled Armenia until the early 12th century. Armenia suffered invasions from the Mongols in the 1230's, followed by invasions by other Central Asian groups from the 13th to 15th centuries.

Period of Foreign Control

By the 16th century, Armenia was weakened from centuries of invasion. Between 1513 and 1737, the Ottoman Empire and Persia fought over and divided Armenia. After the Russo-Persian War (1826-1828), the parts of Armenia controlled by Persia, primarily in the East, were incorporated into Russia, while Western Armenia was held by the Ottoman Empire. In the early 20th century, during World War I, the Turkish government carried out a series of massacres which are now known as the Armenian Genocide, in which up to 1.5 million Armenians were systematically killed.

Modern Period

After World War I and the collapse of the Ottoman and Russian empires, Armenia finally regained independence as the Democratic Republic of Armenia in 1918. The newly independent Democratic Republic of Armenia was engaged in territorial wars with its neighbours Georgia (1918), Azerbaijan (1919-1920) and Turkey (1920). By 1922, the influence of communism had spread to Armenia and the newly-proclaimed Armenian Soviet Socialist Republic became part of the Soviet Union. Armenia remained part of the Soviet Union until the early 1990's, when it declared independence as the Soviet Union ceased to exist.

4.19.3 Field Investigations

Cultural Heritage field investigations employed surface reconnaissance and excavation. Field reconnaissance in the Project area was undertaken in stages beginning in 2010 and is

continuing at present. Information in this baseline chapter is based on the following field efforts:

- Pedestrian field reconnaissance and test excavations conducted by an Armenian archaeological team for nine days from July 21 to 28, 2010;
- Pedestrian field reconnaissance and test excavations conducted by the Armenian team for five days from October 16 to 20, 2011;
- Pedestrian field reconnaissance by an Environmental Resource Management (ERM) archaeologist for 5 days from July 25 to 29, 2012. This included visits to known sites identified by the Armenian team and field reconnaissance of areas not previously covered by the Armenian team;
- Pedestrian field reconnaissance by an ERM archaeologist for 9 days from September 8 to 16, 2012; and
- Pedestrian field reconnaissance by an ERM archaeologist for 5 days from November 30 to December 4, 2012.
- Pedestrian field reconnaissance by an Armenian archaeological team for 10 days from October 4 to 14, 2013.
- Pedestrian field reconnaissance by an Armenian archaeological team in June 2014.
- Pedestrian field reconnaissance of a proposed water line realignment by an Armenian archaeological team in November 2015.

The above mentioned surveys included general reconnaissance, but also focused on specific Project components, some of which have been moved due to Project redesign.

Fieldwork Techniques: Surface Reconnaissance

Archaeologists conducted surface reconnaissance surveys of specific Project component areas looking for indications of archaeological remains. Surface reconnaissance is an efficient and frequently used archaeological technique for identifying sites that have substantial associated earthworks or the remains of ruined stone structures. As a part of this technique, the ground surface is scanned visually for artefacts especially in areas where the subsurface is exposed through erosion or other processes. Surface reconnaissance may not identify smaller sites with limited surface evidence such as campsites, activity areas and human burials which often have no above-ground indicators.

Potential site indicators documented within the Project area include suspicious rock piles; apparent artificial mounding of earth; gravestones; surface artefact scatters; and ruined

architectural features such as walls or building foundations. Surface artefacts and sites with limited surface indicators were difficult to detect in most survey areas, as thick grass cover limited ground surface visibility.

Sites and potential site locations identified by surface reconnaissance were described briefly in field notebooks, photographed, and their locations recorded with hand-held GPS (geographic positioning system). In some instances, it was difficult to confirm whether certain features indicated the presence of an archaeological site; a modern agricultural structure, installation, or feature; or a natural feature. In these cases, different levels of "site potential" were assigned. Three levels of site potential are used: High Potential, Medium Potential Site, and Low Potential Site.

At present, the following current and former Project component footprints have been investigated by surface reconnaissance:

- Former Heap Leach Facility (HLF), Phase I Area (Site 14);
- Former Waste Dump Area (Site 13);
- Former HLF location (Site 6);
- Former access road through the Vorotan River Valley;
- Former proposed infrastructure areas 11, 12, and 19;
- Current HLF (Site 28) and associated facilities;
- Erato and Tigranes /Artavazdes mine pits;
- Barren Rock Storage Facility (BRSF) (Site 27) and associated facilities;
- ADR plant;
- Crusher platform;
- Conveyor corridor;
- Main access road; and
- A 3.5 km water pipeline alignment south of the HLF (Site 28).

The remaining Project component footprints, including access roads, laydown areas and construction camp, if required will be subject to future surface reconnaissance under commitments outlined in the Project's Cultural Heritage Management Plan (Chapter 8).

Initially, the focus of the surface reconnaissance surveys was within the proposed footprints of Project components in the Vorotan River valley, specifically the initial location of the HLF, Site 6, and the originally planned construction access road from Gorayk. Due to the large

number of cultural heritage sites identified in these areas as well as other environmental concerns, these proposed Project components were relocated out of the Vorotan Valley.

Fieldwork Techniques: Excavation

A sample of sites identified by surface reconnaissance was selectively excavated by the team of Armenian archaeologists. Excavation involved controlled removal and recording of soil, artefacts and structural remains from the sites. The specific excavation approach taken at each site depended on the size, depth and complexity of the site, but in general involved slow and careful, layered excavation with hand tools.

Typically, excavations were conducted in rectangular units several metres on a side (e.g. 2.5m x 3m.) and excavation layers were based on observed soil conditions at each site. Final excavation depth was no more than 1m. Excavations were recorded through field notes, sketches and scaled maps, and photography. Artefacts were retained for later study and potential public display. Excavated soil was manually culled for artefacts. In some cases, excavation revealed few or no artefacts, structures or other cultural information.

As with the surface reconnaissance, excavations that have informed the baseline environment also include the previous location for the Project's HLF, (known as Site 6), the initial route of the construction access road from Gorayk, and other proposed Project components that would have been located in the Vorotan River valley. Although, these areas are now no longer going to be disturbed, the data recovery contributes to mitigation of impacts, as these excavations have provided more insight into general archaeological patterns in the Project area, indicating preservation patterns. Excavations have allowed the Armenian archaeological team to assess subsurface conditions and resources more accurately than is possible based on surface indications alone. For example, after test excavation, some sites that had the appearance of Bronze Age burials from the surface proved not to be burials. Typical conditions at these "apparent" burials have been noted in order to avoid unnecessary efforts in the future.

4.19.4 Project Area Archaeological Finds

Fieldwork in the Amulsar Project area has identified a total of 487 potential cultural heritage sites. The 487 potential sites are possible archaeological sites, confirmed archaeological sites, or living heritage sites. Some of the confirmed archaeological sites include ruined structures visible and partially preserved on the surface. Summary information is provided

on each of the archaeological sites in Table 4.19.2, which includes ERM's judgement of the importance of each site, based on present evidence. The sites include:

- Earth and stone mounds of various sizes that may represent tombs from various periods, some potentially dating to the Bronze Age (3,400-1,500 BC);
- Cemeteries denoted by stone markers, some of them worked and/or inscribed, and mounded earth dated to the Middle Ages;
- Potential settlement sites dated to the Late Middle Ages indicated by ruined architecture on the surface;
- Prehistoric campsites and activity areas of pre-Bronze Age peoples, indicated by chipped and ground stone tools; and
- Living heritage sites including 20th century seasonal shepherd's camps with possible burials/cemeteries. The Armenian archaeological team identified some of these sites as belonging to ethnic Azeris.

A summary of the types of potential cultural heritage sites identified during surveys of proposed Project components is provided below. In most instances the site types assigned to each potential cultural heritage site have not been confirmed through any type of intrusive investigation and assigned site types remain provisional.

The Armenian archaeological team identified nine potential cultural heritage sites within the proposed Erato and Tigranes-Artavazdes mine pits. These sites have been provisionally identified as tomb hills, stone circles, and obsidian stone scatters. In addition to these nine potential sites, five potential sites were identified in the stockpile area to the northeast of the mine pits. Potential site types located within the stockpile footprints include stone circles/foundations and tombs.

A reconnaissance survey of the proposed HLF (Site 28) location was executed by the Armenian archaeological team over the course of 10 days from October 4 to 14, 2013 and as part of a waterline realignment survey conducted in November 2015. The survey area included the proposed new footprint of the HLF as well as the surrounding landscape. The survey team identified a total of 99 potential cultural heritage sites within the surveyed area. Fifty of these potential sites are located within or adjacent to the footprint of the HLF and nearby facilities, and a further 45 potential sites within the disturbance footprint of the proposed facilities and an additional five potential sites within 50m. Provisional site types identified by the Armenian archaeological team include tombs, crypts, grave mounds or

kurgans, wall fragments and stone structure foundations. Two additional potential sites were identified within the HLF footprint during the satellite imagery study of this area. These two sites were provisionally identified as potential tombs or burial mounds by the satellite imagery analyst.

Cultural heritage site CH-335 was identified by an ERM archaeologist during a November 2012 field reconnaissance survey of the former HLF location. Due to subsequent Project component realignments, the proposed conveyor corridor and main access road no longer pass through the surveyed area. CH-355 is a scatter of potsherds, obsidian flakes and obsidian tool fragments. The scatter of artefacts covers an area of approximately 3.1 hectares. A large number of stone piles created during agricultural field clearing were found within the artefact. These piles may represent the remains of prehistoric dry-laid-stone features associated with an archaeological site. Based on the recovery of potsherds, the site is dated to the Neolithic Period or later.

In January of 2014, ERM cultural heritage specialists conducted a satellite imagery analysis of the proposed locations of the BRSF, conveyor corridor, and main access road. This analysis identified 35 cultural heritage anomalies within and immediately adjacent to proposed Project component areas. Later, in June of 2014, the Armenian archaeological team conducted a pedestrian reconnaissance survey of these Project component areas. This survey was conducted to "ground truth" the cultural heritage anomalies identified by ERM as well as to survey for any additional potential sites not identified by the satellite imagery analysis. The alignment of the conveyor together with the footprint of mine infrastructure, including infrastructure close to the BRSF has been determined following a technical review of the Project. Therefore, in-field reconnaissance surveys have not been completed in all Project component areas. This has been identified in the Cultural Heritage Management Plan (Appendix 8.17).

A total of forty-two potential sites were identified by the Armenian archaeological team during a survey of the BRSF, conveyor corridor, and main access road areas, including 25 potential sites that were initially identified by the satellite imagery analysis. The remaining 17 cultural heritage anomalies were determined to represent the remains of 20th century farmsteads and animal corrals, or stone piles created by field clearing activities.

Potential archaeological site types identified by the Armenian team during these surveys included:

- A 19th-20th century structure and associated grave;
- An Eneolithic Period artefact scatter;
- Potential Bronze Age tombs and ritual sites;
- Structural ruins from seasonal, 20th century Azeri shepherd's camps including potential burials;
- A petroglyph image of a fish associated with the remains of a possible temple.

A total of 17 potential sites were determined to be within the disturbed area of BRSF, conveyor corridor, and main access roads, with an additional five potential sites located within 50m of the disturbed area.

4.19.5 Assessment of Archaeological Finds

A number of sites identified during the 2010 and 2011 reconnaissance surveys were re-visited to assess their potential cultural heritage sensitivity. Evaluation criteria for determining a site's sensitivity are presented in Chapter 6.16 and Table 6.16.2 of this document. In total, 138 of the 487 potential archaeological sites were assessed, resulting in the identification of:

- 4 very high importance sites;
- 27 high importance sites;
- 32 medium importance sites;
- 22 low importance sites; and
- 53 negligible importance sites.

Site locations and assessed sensitivities are shown in relation to planned Project components in Figure 4.19.1. The majority of the re-visited sites are located in the Vorotan River valley. Due to subsequent realignments to the Amulsar mine layout these sites are currently located outside the proposed development area. The site assessments conducted at the 138 re-visited sites did not identify any critical cultural heritage sites within the current Amulsar Project footprint[7] and disturbed area[8]. The scientific importance level of

[7] The Project footprint is defined as areas physically occupied by Project infrastructure, including roads and mine pits.

the remaining 349 sites will be assessed only if they are found to be located within the footprint of the Project components or within 50 m of proposed Project components. These assessments will be conducted during planned pre-construction phase reconnaissance surveys and archaeological evaluations.

In addition to the known and possible sites identified to date, there is a high likelihood for additional undiscovered archaeological resources in the Project area. Such newly discovered sites would most likely include the same types of sites already identified. Other types of archaeological sites may be present as suggested in the cultural context (Table 4.19.1). Other unknown sites are most likely to be situated in level, well-drained areas near permanent and semi-permanent water sources (rivers, streams, springs, etc.). Intact archaeological sites, of course, are more likely to be encountered in areas subject to stable depositional conditions or to soil accretion.

Figure 4.19.2 and Figure 4.19.3 include photographs of representative conditions in the Project area.

[8] For the purposes of the cultural heritage baseline, the Project disturbed area is defined as any area in which significant ground disturbance will take place. This includes the Project footprint as well as adjacent areas disturbed as part of construction activities.

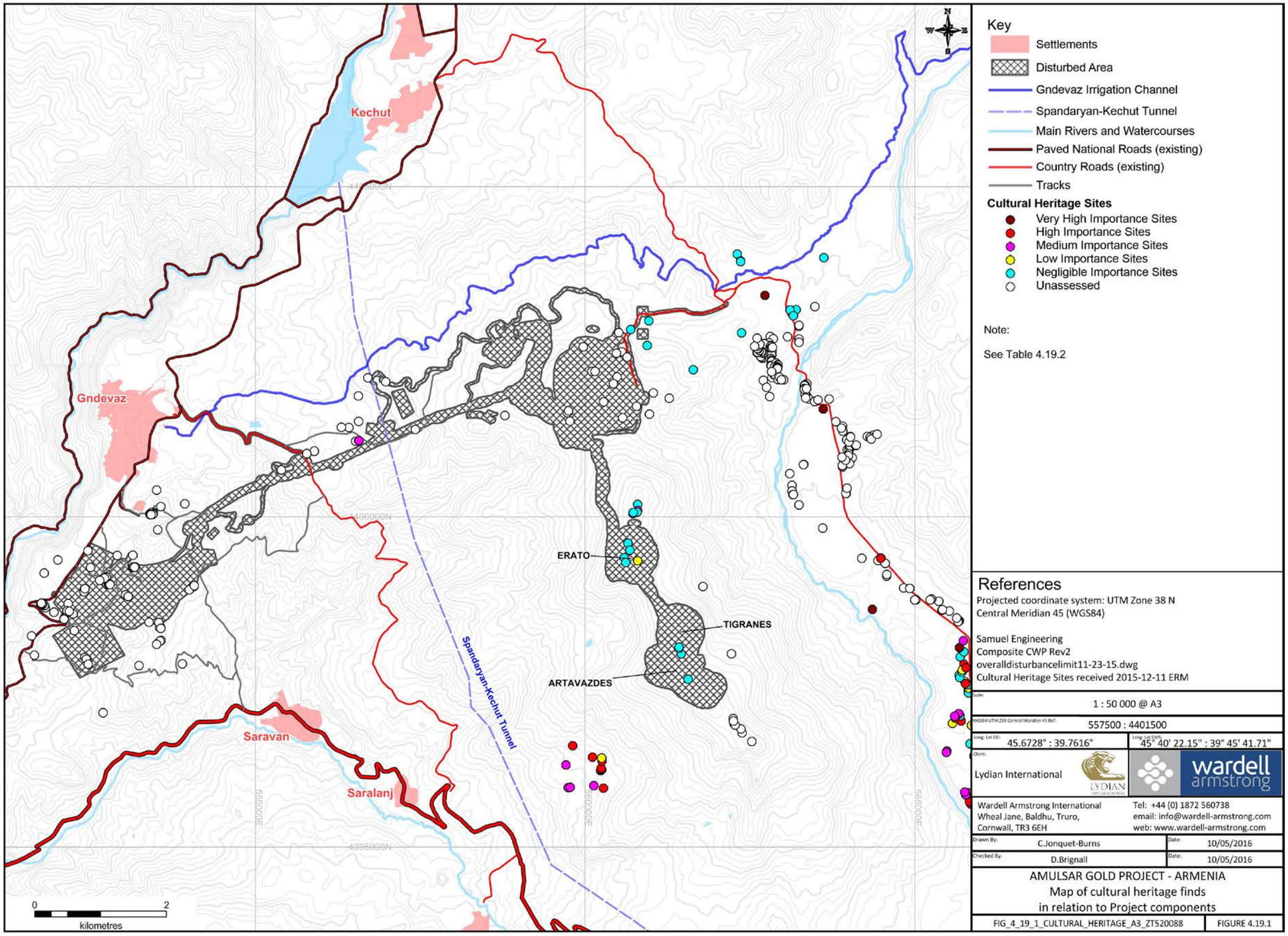


Figure 4.19.1: Map of cultural heritage finds in relation to Project components



Figure 4.19.2: Photographs of Archaeological Resources in the Project area

a. Possible Bronze Age Tomb (top), b. Stone Remains of Ancient Architecture (bottom)



Figure 4.19.3: Photographs of Project area Terrain

a. Rolling Topography on Valley Bottom, View to South (top), b. Mountain Topography, View to North (bottom)

4.19.6 Additional Post-Assessment Fieldwork

The ERM field effort referenced above was accomplished in coordination with the Armenian teams during the 2010-2014 archaeological field seasons. Additional fieldwork including more intensive reconnaissance, archaeological evaluation of potential sites, and archaeological data recovery excavations will be conducted by the Armenian archaeological team in coordination with ERM. The results of these efforts will be reported on more fully in subsequent Project documents. Additional reconnaissance and excavation is planned in the Project area, focusing on areas of planned ground disturbance (see Chapter 6 and 6.16).

Table 4.19.2 is colour coded to correspond with the site sensitivity colour labels presented in Figure 4.19.1. The following colours have been assigned to the various site sensitivity levels:

- Very High Sensitivity Sites: Purple;
- High Sensitivity Sites: Red;
- Medium Sensitivity Sites: Orange;
- Low Sensitivity Sites: Yellow;
- Negligible Sensitivity Sites: Blue; and
- Unassessed Sensitivity Sites: White.

Table 4.19.2: Listing of Archaeological Finds

ESIA Site ID	Armenian NGO Site ID	Project Location	ERM Judgement of Importance	Armenian Archaeologist's Description	ERM Description
Site-1	82.4; 82.5	Solution Pond	Low	Goshabulag ancient rural settlement	Recent historic yet largely abandoned building. Late 19th-Early 20th century. The site is known as Goshabulag.
Site-2	84	HLF 6	Negligible	Tomb	Neither obvious, nor ambiguous site identifiers visible on surface.
Site-3	84.1	HLF 6	Negligible	The ruins of a wall	Neither obvious, nor ambiguous site identifiers visible on surface.
Site-4	84.2	HLF 6	Negligible	The ruins of a wall	Neither obvious, nor ambiguous site identifiers visible on surface.
Site-5	100.4	HLF 6	Negligible	Tomb	Neither obvious, nor ambiguous site identifiers visible on surface.
Site-6	100.3	HLF 6	Negligible	Tomb	Neither obvious, nor ambiguous site identifiers visible on surface.

Table 4.19.2: Listing of Archaeological Finds					
ESIA Site ID	**Armenian NGO Site ID**	**Project Location**	**ERM Judgement of Importance**	**Armenian Archaeologist's Description**	**ERM Description**
Site-7	98	HLF 6	Negligible	Tomb Hill	Neither obvious, nor ambiguous site identifiers visible on surface.
Site-8	100.2	HLF 6	Negligible	Tomb	Neither obvious, nor ambiguous site identifiers visible on surface.
Site-9	100.1	HLF 6	Negligible	Tomb	Low potential for being a cultural site. Neither obvious, nor ambiguous site identifiers visible on surface.
Site-10	100	HLF 6	Negligible	Tomb	Low potential for being a cultural site. Neither obvious, nor ambiguous site identifiers visible on surface.
Site-11	99	HLF 6	Medium	Tomb	A potential small burial mound, possible Kurgan, marked by a clustering of field stones.
Site-12	82.3	HLF 6	Negligible	The ruins of walls	Neither obvious, nor ambiguous site identifiers visible on surface.
Site-13	85	300m East HLF 6	Negligible	Tomb	Neither obvious, nor ambiguous site identifiers visible on surface.
Site-14	84.3	35m East HLF 6	Negligible	Rock	Neither obvious, nor ambiguous site identifiers visible on surface.
Site-15	85.1; 85.2	400m East HLF 6	Uncertain, Not Visited	Muslim Graves/The Ruins of Walls	-
Site-16	82.2	HLF 6	Negligible	Observation tower	Neither obvious, nor ambiguous site identifiers visible on surface
Site-17	NA	HLF 6	Medium	-	Potential burial mound, possible Kurgan, atop natural rise 200 m NW of guard station. Dense concentration of small field stones acting as seal-stones.
Site-18	81.1; 82; 82.1	HLF 6	Low	Tomb	Surface identifiers are ambiguous. Could either be natural concentration of small field stones or perhaps a small grave site.

Table 4.19.2: Listing of Archaeological Finds					
ESIA Site ID	**Armenian NGO Site ID**	**Project Location**	**ERM Judgement of Importance**	**Armenian Archaeologist's Description**	**ERM Description**
Site-19	NA	HLF 6	High	-	Potential burial mound, possible Kurgan. Small, less than 10 m across and 75 cm high.
Site-20	NA	HLF 6	High	-	Large graveyard with 2 Early Christian/Islamic carved grave stones.
Site-21	81	HLF 6	Low	Tomb	Medium Potential for being a cultural site. Surface identifiers are ambiguous. Just seems to be a natural low concentration of small field stones
Site-22	85.3	900m East HLF 6	Uncertain, Not Visited	Stone Piles	-
Site-23	86; 86.1	850m East HLF 6	Uncertain, Not Visited	Tomb/The Ruins of Walls	-
Site-24	97.1	HLF 6	Low	Tomb	Surface identifiers are ambiguous. Could either be natural low concentration of small field stones or perhaps a small prehistoric grave site.
Site-25	80.1	HLF 6	Negligible	Stone Piles	Neither obvious, nor ambiguous site identifiers visible on surface
Site-26	86.2	950m East HLF 6	Uncertain, Not Visited	Tomb	-
Site-27	87	750m East HLF 6	Uncertain, Not Visited	Tomb	-
Site-28	87.1	700m East HLF 6	Uncertain, Not Visited	Pile of Stones	-
Site-29	79.1; 80	HLF 6	Low	Tomb and the Ruins of Walls	Surface identifiers are ambiguous. Likely modern stone gathering from agricultural activity and/or modern field wall.
Site-30	78.2; 79	HLF 6	Low	Tomb and Stone Piles	Surface identifiers are ambiguous.
Site-31	75.1; 76	HLF 6	High	Tomb	Potential stone lined/filled grave.
Site-32	87.2	700m East HLF 6	Uncertain, Not Visited	Stone Piles	-
Site-33	75	HLF 6	Negligible	Tomb	Low potential for being a cultural site. Neither obvious, nor ambiguous site identifiers visible on surface

Table 4.19.2: Listing of Archaeological Finds					
ESIA Site ID	**Armenian NGO Site ID**	**Project Location**	**ERM Judgement of Importance**	**Armenian Archaeologist's Description**	**ERM Description**
Site-34	74	HLF 6	Medium	Tomb Hill	Large potential burial mound, possible Kurgan. A large and deep trench has been dug into the middle of it.
Site-35	78; 78.1	HLF 6	Low	Tomb and Stone Piles	Surface identifiers are ambiguous.
Site-36	77	HLF 6	Negligible	Tomb	Neither obvious, nor ambiguous site identifiers visible on surface.
Site-37	71; 72; 72.1; 73	HLF 6	Negligible	Tomb and Stone Piles	Neither obvious, nor ambiguous site identifiers visible on surface.
Site-38	70	HLF 6	Low	Tomb	Medium Potential for being a cultural site. Surface identifiers are ambiguous. It is likely it is just a modern field wall.
Site-39	69	HLF 6	Low	Tomb	Medium Potential for being a cultural site. Surface identifiers are ambiguous. It is likely a modern pile of field stones.
Site-40	68	HLF 6	Negligible	Tomb	Low potential for being a cultural site. Neither obvious, nor ambiguous site identifiers visible on surface.
Site-41	-	HLF 6 Ext	High	-	Stone lined/filled grave. Old Lichen growth on stones. Possibly prehistoric.
Site-42	89	HLF 6 Ext	High	Tomb Hill	Stone circle, possibly associated with an adjacent potential burial mound, possible Kurgan, and potentially part of a larger site.
Site-43	-	HLF 6 Ext	High	-	Potential burial mound, possible Kurgan. Possibly part of a larger site.
Site-44	67.5	HLF 6 Ext	Low	Stone Piles	Surface identifiers are ambiguous. It is likely just a pile of modern field stones.
Site-45	87.3; 88	5m East HLF 6 Ext	High	Tomb	Foundations of a stone building, potentially historic or ancient. Possibly part of a larger site.
Site-46	67.4	HLF 6 Ext	Negligible	Stone Piles	Neither obvious, nor ambiguous site identifiers visible on surface.

Table 4.19.2: Listing of Archaeological Finds					
ESIA Site ID	**Armenian NGO Site ID**	**Project Location**	**ERM Judgement of Importance**	**Armenian Archaeologist's Description**	**ERM Description**
Site-47	67.3	HLF 6 Ext	Negligible	Tomb	Neither obvious, nor ambiguous site identifiers visible on surface.
Site-48	90	HLF 6 Ext	Medium	Tomb	Surface identifiers are ambiguous. Could either be natural concentration of small field stones, modern agricultural stone pile, or a potential small grave site.
Site-49	67.2	HLF 6 Ext	Negligible	Tomb	Neither obvious, nor ambiguous site identifiers visible on surface
Site-50	91	5m East HLF 6 Ext	High	Tomb Hill	Potential burial mound, possible Kurgan. Possibly part of a larger site.
Site-51	67; 67.1	HLF 6 Ext	Low	Tomb	Medium Potential for being a cultural site. Surface identifiers are ambiguous. It is likely just a pile of modern field stones.
Site-52	92	50m East HLF 6 Ext	Uncertain, Not Visited	Tomb Hill	-
Site-53	-	HLF 6 Ext	High	-	Possible stone lined/filled grave.
Site-54	93	150m East HLF 6 Ext	Uncertain, Not Visited	Tomb Hill	-
Site-55	96; 97	HLF 6 Ext	Medium	Tomb	Surface identifiers are ambiguous. Could either be natural low concentration of small field stones or perhaps a small grave site.
Site-56	95	HLF 6 Ext	Medium	Tomb	Surface identifiers are ambiguous. Could either be natural low concentration of small field stones or perhaps a small grave site.
Site-57	66; 66.1	HLF 6 Ext	High	Tomb	Potential stone lined/filled grave.
Site-58	93.1	150m East HLF 6 Ext	Uncertain, Not Visited	The Ruins of Walls	-
Site-59	94	150m East HLF 6 Ext	Uncertain, Not Visited	Tomb	-

Table 4.19.2: Listing of Archaeological Finds					
ESIA Site ID	**Armenian NGO Site ID**	**Project Location**	**ERM Judgement of Importance**	**Armenian Archaeologist's Description**	**ERM Description**
Site-60	65.2	HLF 6 Ext	Negligible	Obsidian Tools	Low potential for being a cultural site. Neither obvious, nor ambiguous site identifiers visible on surface. Did not find any obsidian.
Site-61	65.1	HLF 6 Ext	Negligible	Tomb	Low potential for being a cultural site. Neither obvious, nor ambiguous site identifiers visible on surface.
Site-62	62	5m north of HLF 6 Ext	Very High	Kurgan	Kurgan that is currently being excavated. Was thought to lie within previous Project Area of Disturbance (HLF site 6), but in fact does not.
Site-63	-	Just East HLF 6 Ext	Low	-	A clustering of historical rural structures. Probably early 20th Century
Site-64	63; 63.2; 63.1; 64	35m north of HLF 6 Ext	Medium	Tomb and Tomb hill	Settlement with possible grave dated to the Middle Ages. Currently being excavated.
Site-65	-	200m North of Former Conveyor Belt	Very High	-	Very large potential settlement defined by a series of large wall complexes on multiple levels and possible domestic structures. Possible occupations dating from the Neolithic through Antique periods.
Site-66	41; 41.2; 42; 42.1; 44; 45; 45.1; 46; 47; 48; 48.1; 49	Construction Access Road	Very High	Tomb and Tomb Hill and stone piles	Cultural mound, not a tomb, with rectilinear architecture. Located north of potential ancient settlement upon the river. Architectural remains visible atop of mound used bedrock as its southern wall. Circular/apsidal foundation identified. Undetermined age but likely ancient

Table 4.19.2: Listing of Archaeological Finds					
ESIA Site ID	**Armenian NGO Site ID**	**Project Location**	**ERM Judgement of Importance**	**Armenian Archaeologist's Description**	**ERM Description**
Site-67	36; 37; 38; 39; 40; 41; 42; 43; 44; 45; 45.1; 46; 47; 48; 49; 50; 51; 52; 53; 56; 73; 74; 75	Construction Access Road	Very High	Tomb and Tomb Hill	A potential very large necropolis containing a burial mound (possible Kurgan) and early Christian and Muslim graves. A dense Kurganfield of multiple potential burial mounds located on the southern edge of the site appear to have been heavily disturbed by an existing pipeline.
Site-68	58	South of Site 11	Negligible	Lodging	Neither obvious, nor ambiguous site identifiers visible on surface.
Site-69	60	South of Site 11	Negligible	Circular masonry made of massive stones?	Neither obvious, nor ambiguous site identifiers visible on surface.
Site-70	59	South of Site 11	Negligible	Ruins of walls	Neither obvious, nor ambiguous site identifiers visible on surface.
Site-71	69	Located within Site11	Negligible	Exposure 13	Pile of field stones removed from agricultural fields. Not an archaeological site. Confirmed by local herder consulted near this location.
Site-72	51.1; 52.1; 52.2; 52.3	Located just to the east of Site11	Negligible	Tomb	Bed rock, not a cultural feature.
Site-73	49.2; 49.3	Located just to the east of Site11	Low	Tomb	Possible stone lined/filled grave.
Site-74	49.1	Located just to the west of Site11	Negligible	Tomb	Bed rock, not a cultural feature.
Site-75	65; 66	Located 50m to the east of Site13	Negligible	Tomb	Bed rock, not a cultural feature.
Site-76	55	Within Site 13	Negligible	Circular Situated Rocks	Bed rock, not a cultural feature.
Site-77	1.1; 1.4; 1.5	Within Site 13	Negligible	Tomb, Stone Piles, Dwelling	Bed rock, not a cultural feature.
Site-78	1.3	Within Site 13	Negligible	Tomb	Bed rock, not a cultural feature.

Table 4.19.2: Listing of Archaeological Finds					
ESIA Site ID	**Armenian NGO Site ID**	**Project Location**	**ERM Judgement of Importance**	**Armenian Archaeologist's Description**	**ERM Description**
Site-79	1; 1.2	Within Site 13	Negligible	Tomb Hill	Bed rock, not a cultural feature.
Site-80	13; 14	N Erato	Negligible	Tomb and Tomb Hill	Bed rock, not a cultural feature.
Site-81	12	N Erato	Medium	Tomb Hill	Potential collapsed burial mound, possible Kurgan.
Site-82	11	N Erato	Negligible	Tomb Hill	Bed rock, not a cultural feature.
Site-83a	10	N Erato	Negligible	Tomb Hill	Bed rock, not a cultural feature.
Site-83b	9	N Erato	Negligible	Tomb Hill	Bed rock, not a cultural feature.
Site-84	8	Erato	Negligible	Tomb Hill	Bed rock, not a cultural feature.
Site-85	4; 5; 6; 7	Erato	Negligible	Tomb Hill	Said to be a tomb. It is a concentration of rocks in what looks like to be a pit. In fact this type of bolder-in-pit is wide-spread across this side of Erado. Interpreted as a natural landscape feature.
Site-86	3	Erato	Negligible	Tomb Hill	Bed rock, not a cultural feature.
Site-87	1	Erato	Low	Stone Circle	Said to be a stone circle. Is actually a triangular feature made out of small field stones. Unclear if cultural or not. If cultural it likely represents a temporary structure. No associated artefacts found.
Site-88	2	Erato	Negligible	Tomb Hill	Bed rock, not a cultural feature.
Site-89	76	Artavazd	Negligible	Obsidian Fragments	Bed rock, not a cultural feature.
Site-90	77	Artavazd	Negligible	Stone Circle 1	Site of previous excavation, but looks like only bed rock was uncovered. Not a site.
Site-92	78	Artavazd	Negligible	Stone Circle 2	Bed rock, not a cultural feature
Site-93	79	Artavazd	Negligible	Stone Circle 3	Not a cultural feature.
Site-94	15	Topsoil Stockpiles	Uncertain, Not Visited	Tomb	-
Site-95	16	Topsoil Stockpiles	Uncertain, Not Visited	Tomb	-

Table 4.19.2: Listing of Archaeological Finds					
ESIA Site ID	**Armenian NGO Site ID**	**Project Location**	**ERM Judgement of Importance**	**Armenian Archaeologist's Description**	**ERM Description**
Site-96	17	Topsoil Stockpiles	Uncertain, Not Visited	Tomb	-
Site-97	18	Topsoil Stockpiles	Uncertain, Not Visited	Tomb	-
Site-98	19	Topsoil Stockpiles	Uncertain, Not Visited	Tomb	-
Site-99	20	Topsoil Stockpiles	Uncertain, Not Visited	Tomb	-
Site-100	21	Topsoil Stockpiles	Uncertain, Not Visited	Tomb	-
Site-101	22	Topsoil Stockpiles	Uncertain, Not Visited	Tomb	-
Site-102	23	Topsoil Stockpiles	Uncertain, Not Visited	Tomb	-
Site-103	24	Topsoil Stockpiles	Uncertain, Not Visited	Tomb	-
Site-104	25	Topsoil Stockpiles	Uncertain, Not Visited	Tomb	-
Site-105	26	Topsoil Stockpiles	Uncertain, Not Visited	Tomb	-
Site-106	27	Topsoil Stockpiles	Uncertain, Not Visited	Tomb	-
Site-107	28	Topsoil Stockpiles	Uncertain, Not Visited	Tomb hill	-
Site-108	29	Topsoil Stockpiles	Uncertain, Not Visited	Tomb hill	-
Site-109	30	Topsoil Stockpiles	Uncertain, Not Visited	Mound	-
Site-110	31	Topsoil Stockpiles	Uncertain, Not Visited	Tomb hill	-
Site-111	32	Topsoil Stockpiles	Uncertain, Not Visited	Tomb	-
Site-112	33	Topsoil Stockpiles	Uncertain, Not Visited	Tomb	-
Site-113	34	Topsoil Stockpiles	Uncertain, Not Visited	Tomb hill	-
Site-114	35	Topsoil Stockpiles	Uncertain, Not Visited	Tomb	-
Site-115	54	HLF 13	Uncertain, Not Visited	Tertaedral rock ledder	-
Site-116	57	HLF 11	Uncertain, Not Visited	Late middle ages cemetery	-
Site-117	61	HLF 11	Uncertain, Not Visited	Tomb 9	-

Table 4.19.2: Listing of Archaeological Finds					
ESIA Site ID	**Armenian NGO Site ID**	**Project Location**	**ERM Judgement of Importance**	**Armenian Archaeologist's Description**	**ERM Description**
Site-118	62	HLF 11	Uncertain, Not Visited	Footprints of massive and small stone masonry?	-
Site-119	63	HLF 11	Uncertain, Not Visited	Tombs	-
Site-120	64	HLF 11	Uncertain, Not Visited	Stone gatherings?	-
Site-121	67	HLF 11	Uncertain, Not Visited	Tomb 1	-
Site-122	68	Topsoil Stockpiles	Uncertain, Not Visited	Exposure 12	-
Site-123	70	Topsoil Stockpiles	Uncertain, Not Visited	Tomb hill	-
Site-124	71	HLF 11	Uncertain, Not Visited	Tomb	-
Site-125	72	HLF 11	Uncertain, Not Visited	Southern border of the necropolis	-
Site-126	80	Parandzem	Uncertain, Not Visited	Roofing slabs?	-
Site-127	81	Parandzem	Uncertain, Not Visited	Tomb - stone box	-
Site-128	82	Parandzem	Uncertain, Not Visited	Tomb hill with stone circle	-
Site-129	83	Arshak	Uncertain, Not Visited	Stone circle?	-
Site-130	84	Arshak	Uncertain, Not Visited	Stone circle with a roofing slab in the center	-
Site-131	85	Arshak	Uncertain, Not Visited	Tomb hill with stone circle	-
Site-132	86	Arshak	Uncertain, Not Visited	Tomb hill with stone circle (?)	-
Site-133	87	Arshak	Uncertain, Not Visited	Tomb hill	-
Site-134	88	Tigranes	Uncertain, Not Visited	Obsidian tool - spear edge	-
Site-135	1.6	HLF 12	Uncertain, Not Visited	Ceramic finding	-
Site-136	2	HLF 12	Uncertain, Not Visited	Tomb hill	-
Site-137	2.1	HLF 12	Uncertain, Not Visited	Rock	-

Table 4.19.2: Listing of Archaeological Finds					
ESIA Site ID	**Armenian NGO Site ID**	**Project Location**	**ERM Judgement of Importance**	**Armenian Archaeologist's Description**	**ERM Description**
Site-138	3	HLF 12	Uncertain, Not Visited	Tomb hill	-
Site-139	4	HLF 12	Uncertain, Not Visited	Tomb hill	-
Site-140	5	HLF 12	Uncertain, Not Visited	Stone basket	-
Site-141	6	HLF 12	Uncertain, Not Visited	Tomb	-
Site-142	6.1	HLF 12	Uncertain, Not Visited	Stone piles	-
Site-143	7	HLF 12	Uncertain, Not Visited	Tomb hill	-
Site-144	8	HLF 12	Uncertain, Not Visited	Tomb	-
Site-145	9	HLF 12	Uncertain, Not Visited	Tomb hill	-
Site-146	10	HLF 12	Uncertain, Not Visited	Tomb	-
Site-147	10.1	HLF 12	Uncertain, Not Visited	Tomb	-
Site-148	10.2	HLF 12	Uncertain, Not Visited	Tomb	-
Site-149	11	HLF 12	Uncertain, Not Visited	Tomb hill	-
Site-150	11.1	HLF 12	Uncertain, Not Visited	Tomb	-
Site-151	12	HLF 12	Uncertain, Not Visited	Tomb	-
Site-152	13	HLF 12	Uncertain, Not Visited	Tomb	-
Site-153	14	HLF 12	Uncertain, Not Visited	Tomb hill	-
Site-154	15	HLF 12	Uncertain, Not Visited	Tomb	-
Site-155	16	HLF 12	Uncertain, Not Visited	Tomb hill	-
Site-156	17	HLF 12	Uncertain, Not Visited	Tomb	-
Site-157	18	HLF 12	Uncertain, Not Visited	Dwelling	-
Site-158	18.1	HLF 12	Uncertain, Not Visited	Tomb	-
Site-159	18.2	HLF 12	Uncertain, Not Visited	The ruins of a wall	-

Table 4.19.2: Listing of Archaeological Finds					
ESIA Site ID	**Armenian NGO Site ID**	**Project Location**	**ERM Judgement of Importance**	**Armenian Archaeologist's Description**	**ERM Description**
Site-160	18.3	HLF 12	Uncertain, Not Visited	Obsidian tools	-
Site-161	18.4	HLF 12	Uncertain, Not Visited	Tomb	-
Site-162	19	HLF 12	Uncertain, Not Visited	Tomb	-
Site-163	20	HLF 12	Uncertain, Not Visited	Tomb	-
Site-164	21	HLF 12	Uncertain, Not Visited	Tomb	-
Site-165	22	HLF 12	Uncertain, Not Visited	Tomb	-
Site-166	23	HLF 12	Uncertain, Not Visited	Tomb hill	-
Site-167	23.1	HLF 12	Uncertain, Not Visited	Stone piles	-
Site-168	23.2	HLF 12	Uncertain, Not Visited	Stone piles	-
Site-169	24	HLF 12	Uncertain, Not Visited	Tomb hill	-
Site-170	25	HLF 12	Uncertain, Not Visited	Tomb	-
Site-171	26	HLF 12	Uncertain, Not Visited	Tomb	-
Site-172	27	HLF 12	Uncertain, Not Visited	Tomb	-
Site-173	28	HLF 12	Uncertain, Not Visited	Tomb	-
Site-174	28.1	HLF 12	Uncertain, Not Visited	Dwelling	-
Site-175	29	HLF 12	Uncertain, Not Visited	Tomb hill	-
Site-176	30	HLF 12	Uncertain, Not Visited	Tomb	-
Site-177	31	HLF 12	Uncertain, Not Visited	Tomb	-
Site-178	32	HLF 12	Uncertain, Not Visited	Tomb	-
Site-179	33	HLF 12	Uncertain, Not Visited	Tomb	-
Site-180	34	HLF 12	Uncertain, Not Visited	Tomb	-
Site-181	35	HLF 12	Uncertain, Not Visited	Tomb	-

Table 4.19.2: Listing of Archaeological Finds					
ESIA Site ID	**Armenian NGO Site ID**	**Project Location**	**ERM Judgement of Importance**	**Armenian Archaeologist's Description**	**ERM Description**
Site-182	35.1	HLF 12	Uncertain, Not Visited	Tomb	-
Site-183	36	HLF 12	Uncertain, Not Visited	Tomb	-
Site-184	36.1	HLF 12	Uncertain, Not Visited	Tomb	-
Site-185	36.2	HLF 12	Uncertain, Not Visited	Tomb	-
Site-186	37	HLF 12	Uncertain, Not Visited	Tomb hill	-
Site-187	38	HLF 12	Uncertain, Not Visited	Tomb	-
Site-188	39	HLF 12	Uncertain, Not Visited	Tomb	-
Site-189	40	HLF 12	Uncertain, Not Visited	Tomb hill	-
Site-190	40.1	HLF 12	Uncertain, Not Visited	Tomb	-
Site-191	41	HLF 12	Uncertain, Not Visited	Tomb hill	-
Site-192	41	HLF 12	Uncertain, Not Visited	Tomb hill	-
Site-193	41.1	HLF 12	Uncertain, Not Visited	Tomb	-
Site-194	41.2	HLF 12	Uncertain, Not Visited	Tomb	-
Site-195	42	HLF 12	Uncertain, Not Visited	Tomb	-
Site-196	42.1	HLF 12	Uncertain, Not Visited	Tomb	-
Site-197	43	HLF 12	Uncertain, Not Visited	Tomb	-
Site-198	50	HLF 12	Uncertain, Not Visited	Tomb	-
Site-199	50.1	HLF 12	Uncertain, Not Visited	Tomb	-
Site-200	50.2	HLF 12	Uncertain, Not Visited	Stone piles	-
Site-201	50.3	HLF 12	Uncertain, Not Visited	Stone piles	-
Site-202	51	HLF 12	Uncertain, Not Visited	Tomb	-
Site-203	52	HLF 12	Uncertain, Not Visited	Tomb	-

Table 4.19.2: Listing of Archaeological Finds					
ESIA Site ID	**Armenian NGO Site ID**	**Project Location**	**ERM Judgement of Importance**	**Armenian Archaeologist's Description**	**ERM Description**
Site-204	52.1	HLF 12	Uncertain, Not Visited	Stone piles	-
Site-205	52.2	HLF 12	Uncertain, Not Visited	Stone piles	-
Site-206	53	HLF 12	Uncertain, Not Visited	Tomb	-
Site-207	54	HLF 12	Uncertain, Not Visited	Tomb	-
Site-208	54.1	HLF 12	Uncertain, Not Visited	Stone piles	-
Site-209	54.2	HLF 12	Uncertain, Not Visited	Tomb	-
Site-210	54.3	HLF 12	Uncertain, Not Visited	Tomb	-
Site-211	54.4	HLF 12	Uncertain, Not Visited	Muslim tomb stone	-
Site-212	55	HLF 12	Uncertain, Not Visited	Tomb	-
Site-213	56	HLF 12	Uncertain, Not Visited	Tomb	-
Site-214	57	HLF 12	Uncertain, Not Visited	Tomb	-
Site-215	57.1	HLF 12	Uncertain, Not Visited	Muslim graves	-
Site-216	57.2	HLF 12	Uncertain, Not Visited	Tomb hill	-
Site-217	58	HLF 12	Uncertain, Not Visited	Tomb	-
Site-218	59	HLF 12	Uncertain, Not Visited	Tomb	-
Site-219	59.1	HLF 12	Uncertain, Not Visited	Tomb	-
Site-220	59.2	HLF 12	Uncertain, Not Visited	Tomb	-
Site-221	59.3	HLF 12	Uncertain, Not Visited	Stone piles	-
Site-222	59.4	HLF 12	Uncertain, Not Visited	Obsidian tools	-
Site-223	60	HLF 12	Uncertain, Not Visited	Tomb	-
Site-224	60.1	HLF 12	Uncertain, Not Visited	Stone piles	-
Site-225	61	HLF 12	Uncertain, Not Visited	Tomb	-

Table 4.19.2: Listing of Archaeological Finds					
ESIA Site ID	**Armenian NGO Site ID**	**Project Location**	**ERM Judgement of Importance**	**Armenian Archaeologist's Description**	**ERM Description**
Site-226	61.1	HLF 12	Uncertain, Not Visited	The ruins of a walls	-
Site-227	61.2	HLF 12	Uncertain, Not Visited	Tomb	-
Site-228	61.3	HLF 12	Uncertain, Not Visited	Tomb	-
Site-229	61.4	HLF 12	Uncertain, Not Visited	Tomb	-
Site-230	83	HLF 6	Uncertain, Not Visited	Tomb	-
Site-231	101	HLF 12	Uncertain, Not Visited	Tomb	-
Site-232	102	HLF 12	Uncertain, Not Visited	Tomb	-
Site-233	103	HLF 12	Uncertain, Not Visited	Tomb	-
Site-234	104	HLF 12	Uncertain, Not Visited	Tomb	-
Site-235	104.1	HLF 12	Uncertain, Not Visited	Ceramic finding	-
Site-236	105	HLF 12	Uncertain, Not Visited	Tomb	-
Site-237	105.1	HLF 12	Uncertain, Not Visited	The ruins of a wall	-
Site-238	105.2	HLF 12	Uncertain, Not Visited	Dwelling	-
Site-239	106	HLF 12	Uncertain, Not Visited	Tomb	-
Site-240	106.1	HLF 12	Uncertain, Not Visited	Tomb	-
Site-241	106.2	HLF 12	Uncertain, Not Visited	Ceramic finding	-
Site-242	107	HLF 12	Uncertain, Not Visited	Tomb	-
Site-243	108	HLF 12	Uncertain, Not Visited	Tomb	-
Site-244	109	HLF 12	Uncertain, Not Visited	Tomb	-
Site-245	110	HLF 12	Uncertain, Not Visited	Tomb	-
Site-246	111	HLF 12	Uncertain, Not Visited	Tomb	-
Site-247	112	HLF 12	Uncertain, Not Visited	Tomb	-

Table 4.19.2: Listing of Archaeological Finds					
ESIA Site ID	**Armenian NGO Site ID**	**Project Location**	**ERM Judgement of Importance**	**Armenian Archaeologist's Description**	**ERM Description**
Site-248	113	HLF 12	Uncertain, Not Visited	Tomb	-
Site-249	113.1	HLF 12	Uncertain, Not Visited	Tomb	-
Site-250	114	HLF 12	Uncertain, Not Visited	Tomb	-
Site-251	114.1	HLF 12	Uncertain, Not Visited	Tomb	-
Site-252	114.2	HLF 12	Uncertain, Not Visited	Tomb	-
Site-253	115	HLF 12	Uncertain, Not Visited	Tomb hill	-
Site-254	115.1	HLF 12	Uncertain, Not Visited	Tomb	-
Site-255	116	HLF 12	Uncertain, Not Visited	Tomb	-
Site-256	117	HLF 12	Uncertain, Not Visited	Tomb hill	-
Site-257	118	HLF 12	Uncertain, Not Visited	Tomb hill	-
Site-258	119	HLF 12	Uncertain, Not Visited	Tomb	-
Site-259	120	HLF 12	Uncertain, Not Visited	Tomb	-
Site-260	120.1	HLF 12	Uncertain, Not Visited	Tomb	-
Site-261	120.2	HLF 12	Uncertain, Not Visited	Tomb	-
Site-262	120.3	HLF 12	Uncertain, Not Visited	Tomb	-
Site-263	120.4	HLF 12	Uncertain, Not Visited	Tomb	-
Site-264	120.5	HLF 12	Uncertain, Not Visited	Ceramic finding	-
Site-265	121	HLF 12	Uncertain, Not Visited	Tomb hill	-
Site-266	122	HLF 12	Uncertain, Not Visited	Tomb hill	-
Site-267	123	HLF 12	Uncertain, Not Visited	Tomb	-
Site-268	123.1	HLF 12	Uncertain, Not Visited	Tomb	-
Site-269	123.2	HLF 12	Uncertain, Not Visited	Tomb	-

Table 4.19.2: Listing of Archaeological Finds					
ESIA Site ID	**Armenian NGO Site ID**	**Project Location**	**ERM Judgement of Importance**	**Armenian Archaeologist's Description**	**ERM Description**
Site-270	123.3	HLF 12	Uncertain, Not Visited	Rock	-
Site-271	124	HLF 12	Uncertain, Not Visited	Tomb	-
Site-272	125	HLF 12	Uncertain, Not Visited	Tomb hill	-
Site-273	125.1	HLF 12	Uncertain, Not Visited	Tomb	-
Site-274	125.2	HLF 12	Uncertain, Not Visited	Tomb	-
Site-275	125.3	HLF 12	Uncertain, Not Visited	Tomb	-
Site-276	125.3	HLF 12	Uncertain, Not Visited	Tomb	-
Site-277	125.4	HLF 12	Uncertain, Not Visited	Tomb	-
Site-278	Not Defined	HLF 6	Negligible	Possible Tomb	Excavated but nothing found.
Site-279	Not Defined	HLF 6	Negligible	Possible Tomb	Not a site.
Site-280	Not Defined	HLF 6	Negligible	Ancient Rock Art	A few stones with markings. Inconclusive.
Site-281	Not Defined	HLF 6	Medium	Tomb	Possible tomb or cromlech
Site-282	Not Defined	HLF 6	High	Tomb	Potential large burial mound, possible kurgan with 5 associated smaller mounds or cromlechs. Many obsidian stone tools and early bronze age black burnished ceramics
Site-283	Not Defined	HLF 6	Low	Tomb	Looted grave. Found some carnelian, faience and bone beads. Could have surrounding cromlechs
Site-284	Not Defined	HLF 6	Low	Tomb	Possible tomb.
Site-285	Not Defined	Solution Pond	High	Tomb	Possible large round cromlech. Well preserved. Two series of concentric circles. Exists next to a large wall with two courses.
Site-286	Not Defined	Solution Pond	Medium	Tomb	Obsidian tools and bronze tools, unclear if a grave
Site-287	Not Defined	HLF 6	High	Acheulian Tools	Location of acheulian tool.
Site-288	Not Defined	HLF 6	Low	Stone Tools	Large wall where about 50 obsidian tools were found.
Site-289	Not Defined	HLF 6	High	Acheulian Tools	Location of three Acheulian handaxes.

Table 4.19.2: Listing of Archaeological Finds					
ESIA Site ID	**Armenian NGO Site ID**	**Project Location**	**ERM Judgement of Importance**	**Armenian Archaeologist's Description**	**ERM Description**
Site-290	Not Defined	HLF 6	Negligible	Acheulian Tools	A trench that was dug to look for obsidian and Acheulian tools (ERM is unsure if this is a site).
Site-291	Not Defined	HLF 6	Negligible	Stone Tools	Site turned up very few natural obsidian chunks.
Site-292	Not Defined	HLF 6	Negligible	-	Just testing nothing found
Site-293	Not Defined	HLF 6	Negligible	Stone Tools	A few pieces of obsidian shatter. When obsidian pieces encountered during in-field assessment appeared to be natural shatter.
Site-294	Not Defined	HLF 6	Low	Possible Tomb	Found a few medieval ceramics and obsidian fragments.
Site-295	Not Defined	50m East of previous storm water pond location.	Medium	Tomb	Potential grave
Site-296	Not Defined	50m East of Stormwater Pond	Medium	Tomb	Possible grave
Site-297	Not Defined	50m East of Stormwater Pond	Medium	Tomb	Possible grave
Site-298	Not Defined	50m East of Stormwater Pond	Medium	Tomb	Possible grave or cromlech
Site-299	Not Defined	50m East of Stormwater Pond	Medium	Tomb	Possible cromlech
Site-300	Not Defined	50m East of Stormwater Pond	Medium	Tomb	Possible cromlech
Site-301	Not Defined	Stormwater Pond	Medium	Tomb	Possible triangular cromlech
Site-302	Not Defined	ARD Plant	Medium	Tomb	Possible cromlech
Site-303	Not Defined	ARD Plant	Medium	Tomb	Possible cromlech
Site-304	Not Defined	HLF 6	Medium	Tomb	Possible tomb currently under excavation. Bronze Age and Iron Age ceramics, obsidian tool, cow/horse bones (2).

Table 4.19.2: Listing of Archaeological Finds					
ESIA Site ID	**Armenian NGO Site ID**	**Project Location**	**ERM Judgement of Importance**	**Armenian Archaeologist's Description**	**ERM Description**
Site-305	Not Defined	HLF 6	High	Tomb	Cromlech, currently under excavation.
Site-306	Not Defined	HLF 6	Low	Tomb	Potential grave, but very low potential. There is bed rock here. The only indication is a circular berry bush growing on top of this. But probably best left for chance finds.
Site-307	Not Defined	HLF 6	Low	Tomb	Possible 2 cromlechs, but not very convincing. Maybe part of the site just to the east
Site-308	Not Defined	Former Conveyor Belt	High	Tomb	Large potential burial mound, possible kurgan, located outside of impact area.
Site-309	Not Defined	Former Conveyor Belt	High	Tomb	Possible large cromlech. Should be avoided
Site-310	Not Defined	Former Conveyor Belt	Medium	-	Possible small grave
Site-311	Not Defined	Former Conveyor Belt	Medium	-	Possible small grave just to west of conveyor belt
Site-312	Not Defined	Former Conveyor Belt	Medium	-	Possible small grave to west of conveyor belt
Site-313	Not Defined	Former Conveyor Belt	Medium	-	Possible small grave to west of conveyor belt
Site-314	Not Defined	Former Conveyor Belt	Medium	-	Possible kurgan/cromlech.
Site-315	Not Defined	Former Conveyor Belt	Medium	-	Possible smaller cromlech
Site-316	Not Defined	HLF 6	Low	-	Possible small grave.
Site-317	Not Defined	HLF 6	High	-	Possible large stone tomb/cromlech
Site-318	Not Defined	HLF 6	Medium	-	Potential small tomb
Site-319	Not Defined	100 meters east of Site 12	High	-	Muslim cemetery
Site-322	Not Defined	Site-19	Medium	-	Possible cromlech
Site-323	Not Defined	Site-19	Medium	-	Possible cromlech

Table 4.19.2: Listing of Archaeological Finds					
ESIA Site ID	**Armenian NGO Site ID**	**Project Location**	**ERM Judgement of Importance**	**Armenian Archaeologist's Description**	**ERM Description**
Site-324	Not Defined	Site-19	Medium	-	Possible cromlech
Site-325	Not Defined	Site-19	High	-	Potential large burial mound, possible kurgan situated above a settlement site.
Site-326	Not Defined	Site-19	High	-	Stone structure, possible house.
Site-327	Not Defined	Site-19	High	-	Stone circle
Site-328	Not Defined	Site-19	High	-	Stone structure
Site-329	Not Defined	Site-19	High	-	Stone circle
Site-330	Not Defined	Site-19	High	-	Stone structure, possible wall/building ruin.
Site-331	Not Defined	Site-19	Low	-	Modern herder's pen.
Site-332	Not Defined	Site-19	High	-	Obsidian scatter. Debitage. Maybe washed down from above. A sample was collected.
Site-333	Not Defined	Site-19	High	-	Stone circle with obsidian tools inside.
Site-334	Not Defined	Site-19	Medium	-	Possible small stone grave
Site-335	Not Defined	Site 14	Medium	-	A wide scatter of artefacts including obsidian tools and ceramics sherds.
Site-336	Not Defined	Site 28	Uncertain, Not Visited	-	Possible cluster of domestic structures identified during satellite imagery analysis.
Site-337	Not Defined	Site 28	Uncertain, Not Visited	-	Possible cluster of domestic structures identified during satellite imagery analysis.
Site-338	Not Defined	Site 28	Uncertain, Not Visited	-	Possible cluster of domestic structures identified during satellite imagery analysis.
Site-339	Not Defined	Site 28	Uncertain, Not Visited	-	Possible kurgan identified during satellite imagery analysis.
Site-340	Not Defined	Site 28	Uncertain, Not Visited	-	Possible kurgan identified during satellite imagery analysis.
Site-341	Not Defined	Site 28	Uncertain, Not Visited	-	Possible kurgan identified during satellite imagery analysis.

Table 4.19.2: Listing of Archaeological Finds					
ESIA Site ID	**Armenian NGO Site ID**	**Project Location**	**ERM Judgement of Importance**	**Armenian Archaeologist's Description**	**ERM Description**
Site-342	Not Defined	Site 28	Uncertain, Not Visited	-	Possible kurgan identified during satellite imagery analysis.
Site-343	Not Defined	Site 28	Uncertain, Not Visited	-	Possible kurgan identified during satellite imagery analysis.
Site-344	Not Defined	Site 28	Uncertain, Not Visited	-	Possible kurgan identified during satellite imagery analysis.
Site-345	Not Defined	Site 28	Uncertain, Not Visited	-	Possible kurgan identified during satellite imagery analysis.
Site-346	Not Defined	Site 28	Uncertain, Not Visited	-	Possible kurgan identified during satellite imagery analysis.
Site-347	Not Defined	Site 28	Uncertain, Not Visited	Grave Mound	-
Site-348	Not Defined	Site 28	Uncertain, Not Visited	Grave Mound	-
Site-349	Not Defined	Site 28	Uncertain, Not Visited	Grave Mound	-
Site-350	Not Defined	Site 28	Uncertain, Not Visited	Tomb	-
Site-351	Not Defined	Site 28	Uncertain, Not Visited	Crypt	-
Site-352	Not Defined	Site 28	Uncertain, Not Visited	Crypt	-
Site-353	Not Defined	Site 28	Uncertain, Not Visited	Crypt	-
Site-354	Not Defined	Site 28	Uncertain, Not Visited	Cavern	-

Table 4.19.2: Listing of Archaeological Finds					
ESIA Site ID	**Armenian NGO Site ID**	**Project Location**	**ERM Judgement of Importance**	**Armenian Archaeologist's Description**	**ERM Description**
Site-355	Not Defined	Site 28	Uncertain, Not Visited	Cavern	-
Site-356	Not Defined	Site 28	Uncertain, Not Visited	Cavern	-
Site-357	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-358	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-359	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-360	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-361	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-362	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-363	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-364	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-365	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-366	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-367	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-

Table 4.19.2: Listing of Archaeological Finds					
ESIA Site ID	**Armenian NGO Site ID**	**Project Location**	**ERM Judgement of Importance**	**Armenian Archaeologist's Description**	**ERM Description**
Site-368	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-369	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-370	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-371	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-372	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-373	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-374	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-375	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-376	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-377	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-378	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-379	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-380	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-

Table 4.19.2: Listing of Archaeological Finds					
ESIA Site ID	**Armenian NGO Site ID**	**Project Location**	**ERM Judgement of Importance**	**Armenian Archaeologist's Description**	**ERM Description**
Site-381	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-382	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-383	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-384	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-385	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-386	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-387	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-388	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-389	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-390	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-391	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-392	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-393	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-

Table 4.19.2: Listing of Archaeological Finds					
ESIA Site ID	**Armenian NGO Site ID**	**Project Location**	**ERM Judgement of Importance**	**Armenian Archaeologist's Description**	**ERM Description**
Site-394	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-395	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-396	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-397	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-398	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-399	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-400	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-401	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-402	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-403	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-404	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-405	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-406	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-

Table 4.19.2: Listing of Archaeological Finds					
ESIA Site ID	**Armenian NGO Site ID**	**Project Location**	**ERM Judgement of Importance**	**Armenian Archaeologist's Description**	**ERM Description**
Site-407	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-408	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-409	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-410	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-411	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-412	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-413	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-414	Not Defined	Site 28	Uncertain, Not Visited	Tomb mound	-
Site-415	Not Defined	Site 28	Uncertain, Not Visited	Circular stone wall foundations	-
Site-416	Not Defined	Site 28	Uncertain, Not Visited	Circular stone wall foundations	-
Site-417	Not Defined	Site 28	Uncertain, Not Visited	Circular stone wall foundations	-
Site-418	Not Defined	Site 28	Uncertain, Not Visited	Circular stone wall foundations	-
Site-419	Not Defined	Site 28	Uncertain, Not Visited	Circular stone wall foundations	-

Table 4.19.2: Listing of Archaeological Finds					
ESIA Site ID	**Armenian NGO Site ID**	**Project Location**	**ERM Judgement of Importance**	**Armenian Archaeologist's Description**	**ERM Description**
Site-420	Not Defined	Site 28	Uncertain, Not Visited	Circular stone wall foundations	-
Site-421	Not Defined	Site 28	Uncertain, Not Visited	Circular stone wall foundations	-
Site-422	Not Defined	Site 28	Uncertain, Not Visited	Circular stone wall foundations	-
Site-423	Not Defined	Site 28	Uncertain, Not Visited	Tomb	-
Site-424	Not Defined	Site 28	Uncertain, Not Visited	Tomb	-
Site-425	Not Defined	Site 28	Uncertain, Not Visited	Tomb	-
Site-426	Not Defined	Site 28	Uncertain, Not Visited	Tomb	-
Site-427	Not Defined	Site 28	Uncertain, Not Visited	Tomb	-
Site-428	Not Defined	Site 28	Uncertain, Not Visited	Tomb	-
Site-429	Not Defined	Site 28	Uncertain, Not Visited	Tomb	-
Site-430	Not Defined	Site 28	Uncertain, Not Visited	Tomb	-
Site-431	Not Defined	Site 28	Uncertain, Not Visited	Tomb	-
Site-432	Not Defined	Site 28	Uncertain, Not Visited	Tomb	-

Table 4.19.2: Listing of Archaeological Finds					
ESIA Site ID	**Armenian NGO Site ID**	**Project Location**	**ERM Judgement of Importance**	**Armenian Archaeologist's Description**	**ERM Description**
Site-433	Not Defined	Site 28	Uncertain, Not Visited	Tomb	-
Site-434	Not Defined	Site 28	Uncertain, Not Visited	Tomb	-
Site-435	Not Defined	Site 28	Uncertain, Not Visited	Tomb	-
Site-436	Not Defined	Site 28	Uncertain, Not Visited	Walls	-
Site-437	Not Defined	Site 28	Uncertain, Not Visited	Walls	-
Site-438	Not Defined	Site 27	Uncertain, Not Visited	Phallic monolith	-
Site-439	Not Defined	Site 27	Uncertain, Not Visited	Isolated small structure	-
Site-440	Not Defined	Site 27	Uncertain, Not Visited	Isolated small structure	-
Site-441	Not Defined	Site 27	Uncertain, Not Visited	19th-20th century structure and grave	-
Site-442	Not Defined	Site 27	Uncertain, Not Visited	Tomb	-
Site-443	Not Defined	Site 27	Uncertain, Not Visited	Eneolithic artefact scatter	-
Site-444	Not Defined	Site 27	Uncertain, Not Visited	Wall ruin	-
Site-445	Not Defined	Site 27	Uncertain, Not Visited	Petroglyph	-

Table 4.19.2: Listing of Archaeological Finds					
ESIA Site ID	**Armenian NGO Site ID**	**Project Location**	**ERM Judgement of Importance**	**Armenian Archaeologist's Description**	**ERM Description**
Site-446	Not Defined	Site 27	Uncertain, Not Visited	Kteis	-
Site-447	Not Defined	Site 27	Uncertain, Not Visited	Cluster of structures	-
Site-448	Not Defined	Site 27	Uncertain, Not Visited	Large structure	-
Site-449	Not Defined	Site 27	Uncertain, Not Visited	Tumulus	-
Site-450	Not Defined	Site 27	Uncertain, Not Visited	Animal corral	-
Site-451	Not Defined	Site 27	Uncertain, Not Visited	Petroglyph and temple	-
Site-452	Not Defined	Site 27	Uncertain, Not Visited	Cluster of structures	-
Site-453	Not Defined	Site 27	Uncertain, Not Visited	Isolated small structure	-
Site-454	Not Defined	Site 27	Uncertain, Not Visited	Structure	-
Site-455	Not Defined	Site 27	Uncertain, Not Visited	Tower	-
Site-456	Not Defined	Site 27	Uncertain, Not Visited	Road	-
Site-457	Not Defined	Site 27	Uncertain, Not Visited	Tower	-
Site-458	Not Defined	Conveyor Corridor/ Main Access Road	Uncertain, Not Visited	Terrace wall	-

Table 4.19.2: Listing of Archaeological Finds					
ESIA Site ID	**Armenian NGO Site ID**	**Project Location**	**ERM Judgement of Importance**	**Armenian Archaeologist's Description**	**ERM Description**
Site-459	Not Defined	Conveyor Corridor/ Main Access Road	Uncertain, Not Visited	Obsidian tool	-
Site-460	Not Defined	Conveyor Corridor/ Main Access Road	Uncertain, Not Visited	Tumuli	-
Site-461	Not Defined	Conveyor Corridor/ Main Access Road	Uncertain, Not Visited	Tower	-
Site-462	Not Defined	Conveyor Corridor/ Main Access Road	Uncertain, Not Visited	Tower	-
Site-463	Not Defined	Conveyor Corridor/ Main Access Road	Uncertain, Not Visited	Tower	-
Site-464	Not Defined	Conveyor Corridor/ Main Access Road	Uncertain, Not Visited	Stone pile with tower in centre	-
Site-465	Not Defined	Conveyor Corridor/ Main Access Road	Uncertain, Not Visited	Tumulus	-
Site-466	Not Defined	Conveyor Corridor/ Main Access Road	Uncertain, Not Visited	Tumuli	-
Site-467	Not Defined	Conveyor Corridor/ Main Access Road	Uncertain, Not Visited	Fort and tumuli	-
Site-468	Not Defined	Conveyor Corridor/ Main Access Road	Uncertain, Not Visited	Terrace	-
Site-469	Not Defined	Conveyor Corridor/ Main Access Road	Uncertain, Not Visited	Fort	-

Table 4.19.2: Listing of Archaeological Finds					
ESIA Site ID	**Armenian NGO Site ID**	**Project Location**	**ERM Judgement of Importance**	**Armenian Archaeologist's Description**	**ERM Description**
Site-470	Not Defined	Conveyor Corridor/ Main Access Road	Uncertain, Not Visited	Tower-shaped stone mounds	-
Site-471	Not Defined	Conveyor Corridor/ Main Access Road	Uncertain, Not Visited	Stone tower	-
Site-472	Not Defined	Conveyor Corridor/ Main Access Road	Uncertain, Not Visited	Wall	-
Site-473	Not Defined	Conveyor Corridor/ Main Access Road	Uncertain, Not Visited	Stone tower	-
Site-474	Not Defined	Conveyor Corridor/ Main Access Road	Uncertain, Not Visited	Stone tower	-
Site-475	Not Defined	Site 27	Uncertain, Not Visited	Obsidian artefacts	-
Site-476	Not Defined	Site 27	Uncertain, Not Visited	Tombs	-
Site-477	Not Defined	Site 27	Uncertain, Not Visited	Fortress wall	-
Site-478	Not Defined	Site 27	Uncertain, Not Visited	Sanctuary	-
Site-479	Not Defined	Site 27	Uncertain, Not Visited	20th century, Azeri herder's summer camp and possible child burial	-
Site -480	Not Defined	Site 28	Uncertain, Not Visited	Tomb	-
Site-481	Not Defined	Site 28	Uncertain, Not Visited	Crypt	-

Table 4.19.2: Listing of Archaeological Finds					
ESIA Site ID	**Armenian NGO Site ID**	**Project Location**	**ERM Judgement of Importance**	**Armenian Archaeologist's Description**	**ERM Description**
Site-482	Not Defined	Site 28	Uncertain, Not Visited	Obsidian Artefact Scatter	-
Site-483	Not Defined	Site 28	Uncertain, Not Visited	Obsidian Artefact Scatter	-
Site-484	Not Defined	Site 28	Uncertain, Not Visited	Crypt	-
Site-485	Not Defined	Site 28	Uncertain, Not Visited	Crypt	-
Site-486	Not Defined	Site 28	Uncertain, Not Visited	Crypt	-
Site-487	Not Defined	Site 28	Uncertain, Not Visited	Potential Kurgan	Possible kurgan burial mound identified during ERM remote sensing survey
Notes	**ERM Judgement of Importance**				
	Negligible				
	Low				
	Medium				
	High				
	Very High				
	Uncertain				

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4.20 Stakeholder Engagement

Stakeholder engagement for the Amulsar Project was initiated in 2006 and has gradually become more formalised as the Project developed.

Full details of the stakeholder engagement approaches taken by the Project are defined in the Stakeholder Engagement Plans (SEP) in Appendix 8.6. This plan is a living document and is updated regularly (at least annually and most recently in May 2016).

The first SEP was developed in 2011 and subsequently disclosed in October 2011. Revisions of the SEP with immediate disclosure took place in September 2012, May 2013, June 2014 and January 2015. The latest version of this document is dated January 2016, available in English and Armenian, disclosed at the Amulsar Information Centre (AIC) in Gndevaz, the Geoteam office in Yerevan and on Lydian and Geoteam websites.

During the exploration, pre-feasibility and feasibility phases, the main aim of stakeholder engagement was to establish two-way communication between Geoteam and stakeholders at national, regional and local levels, to ensure stakeholder views were incorporated into the ESIA, the EIA and the Project design as it developed through feasibility studies, culminating with the November 2015 "Technical Report - Amulsar Value Engineering and Optimization" - which presents a final mine plan and layout. The SEP will now be continued to support the construction activities to be undertaken on site starting Q2/Q3 2016.

The SEP outlines how stakeholders have been and will be informed and consulted on the Project development activities and the impact assessment process, and the upcoming stages of construction. During the construction and operation phases, stakeholder engagement activities will focus on keeping stakeholders informed and receiving feedback about the Project activities, and engaging with them in terms of disseminating and discussing information on impacts, mitigation measures, monitoring and environmental management. Feedback on stakeholder concerns is received through a variety of mechanisms, including the AIC in Gndevaz, the community grievance mechanism, and ongoing engagement with communities through formal and informal consultation events and meetings.

All concerns raised are registered and tracked via the Geoteam Environmental and Social Management System (ESMS) using a stakeholder engagement database and the grievance mechanism (cf. chapter 10 of SEP) managed by the social development team. All questions, claims and grievances are considered by the Company management and/or respective

team/office and addressed through follow-up meetings and additional consultation events.

4.20.1 Information Disclosed

Geoteam has sought to provide stakeholders with information on a regular basis prior to engagement activities. The full list of meetings held until end of December 2015 is provided in the SEP (cf. Chapter 7 of SEP).

The EIA dated July 2014 prepared in Armenian language for the Mining Right application was publicly disclosed in August 2014. A new version of the EIA prepared in and disclosed in 2016 is available on the Geoteam website (http://www.geoteam.am/amulsar-project/environmental-impact-assessment.html).

The v9f ESIA documentation was published on Geoteam's website on 27 May 2015, with a link from the Lydian website also. The documents provided were:

- In English, the full ESIA comprising the Non-Technical Summary (NTS), the main text, the individual management plans that comprise the Environmental and Social Management Plan (ESMP), and the technical appendices; and
- In Armenian, the Non-Technical Summary (NTS), the main text, the SEP, the Land Access and Livelihood Restoration Plan (LALRP), and the Public Commitments Register (PCR).

A full set of ESIA documents in English was made available for viewing in printed form at Geoteam's Yerevan office. A set of documents excluding the technical appendices was made available at the AIC in Gndevaz. In both the Yerevan office and at AIC, printed versions of the NTS, main text, SEP and LALRP in Armenian were also provided.

The "Technical Report - Amulsar Value Engineering and Optimization" was disclosed in November 2015 on the Lydian website as well as on the Canadian Securities Administrators System for Electronic Document Analysis and Retrieval (SEDAR) website (http://www.sedar.com) as required for companies listed on the Toronto Stock Exchange (TSX).

This current ESIA v10 will be disclosed on the Lydian and Geoteam websites and through local disclosure events in Armenia (May 2016), with disclosure by the IFC and the EBRD on their websites as required by the relevant internal procedures.

Key disclosure events have included the following formal meetings during the iterative process of preparing EIA and ESIA reports:

- Public Hearing on Amulsar detailed EIA Report (Tigranes Open Pit), November 2009;
- Amulsar Open Pit Gold Project Scoping Report – Armenia, February 2011;
- Public Hearing of the conceptual EIA on the exploration license "Khachakar", April 2011;
- Presentation of the Scoping Study results & the concept of the ESIA, baseline conditions and mine plan, May 2011 in each community (four in total);
- Presentation of the ESIA; summary of the results of the baseline studies completed; information available from the feasibility study, such as mine design, operating specifics and timelines, November 2011 in Gorayk and Jermuk;
- Public Hearing on the EIA of ore processing operations conceptual design (crushing, conveying, HLF and ADR), November 2011;
- Four Public Hearings of the detailed EIA on Artavazdes and Tigranes Open Pit and Waste Rock Dump, March to July 2012;
- Public Hearing of conceptual EIA on Heap Leach Facility, July 2013;
- Presentation of the ESIA; summary of the results of the baseline studies completed; information available from the feasibility study, such as mine design, operating specifics and timelines, July 2013 in Jermuk;
- Series of Working Group meetings held to discuss potential heap leach facility locations, July-September 2013 in Yerevan;
- Information meetings and focus groups with local residents in 2014 and 2015 to explain the land acquisition process in Gndevaz, the herders surveys and the biodiversity studies;
- For the EIA approval process as part of the Mining Permit application submitted to the Government in July 2014, two Public Hearings took place, the first in Gndevaz on August 25th and the second on September 27th in Gorayk. Geoteam received the final positive opinion from MNP on October 17, 2014;
- ESIA v9f pre-disclosure meeting in Yerevan on October 30th, 2014 with a good representation of civil society organizations (CSOs);
- ESIA v9f disclosure meetings in Jermuk, Gndevaz, Saravan, Goryak and Yerevan in June and July 2015; and
- A combined EIA Public Hearing and ESIA information meeting in Gndevaz on December 17th, 2015 to inform all local stakeholders about the restart of the EIA and

ESIA preparation.

The public disclosure of the ESIA v10 is scheduled at the end of May and early June 2016.

The most recent documents related to Geoteam's environmental and social management, feasibility-value engineering work and ESIA preparation are located on the Geoteam website (http://www.geoteam.am/en/reports/technical.html).

All stakeholders should note that potential impacts and mitigation measures have changed over time as the Project design and impact assessment have developed and evolved and in response to feedback from stakeholders.

4.20.2 Stakeholder Issues

The SEP (see Appendix 8.6) provides a summary of common stakeholder issues raised during recent consultation events during the disclosure on ESIA v9f in mid-2015, and during regular engagement, respectively. During the consultation events the issues, concerns and questions presented are collated from various consultation events, letters received from stakeholders and regular monitoring of public opinion about the Project. Responses raised during the consultation events have also been recorded and these can be reviewed in the SEP.

4.20.3 ESIA Disclosure and Engagement Planning

In the first and second quarter of 2016 there will be public consultation events in the four local communities and in Yerevan with NGOs, CSOs and respective government authorities:

- First information meetings in Gndevaz, Saravan, Goryak and Jermuk for ESIA disclosure availability;
- Post-disclosure ESIA Roundtable in Yerevan organized with NGOs;
- Information meeting on ESIA in Yerevan with local representatives of IFIs, Embassies, International Organizations and business partners;
- Focus-group discussions in the Project area and in Yerevan on specific issues as deemed necessary;
- Post-ESIA Disclosure Consultation Meeting in Gndevaz, Saravan, Goryak and Jermuk; and
- Additional ESIA disclosure and information meetings as required by stakeholders.