PRELIMINARY: DESK STUDY - SHIRIN TAGAB STUDY SITE v1.1 July 2013

Location

The proposed study area is located in the valley of the Shirin Tagab river, towards the south of Shirin Tagab district, to the south of Faisabad.

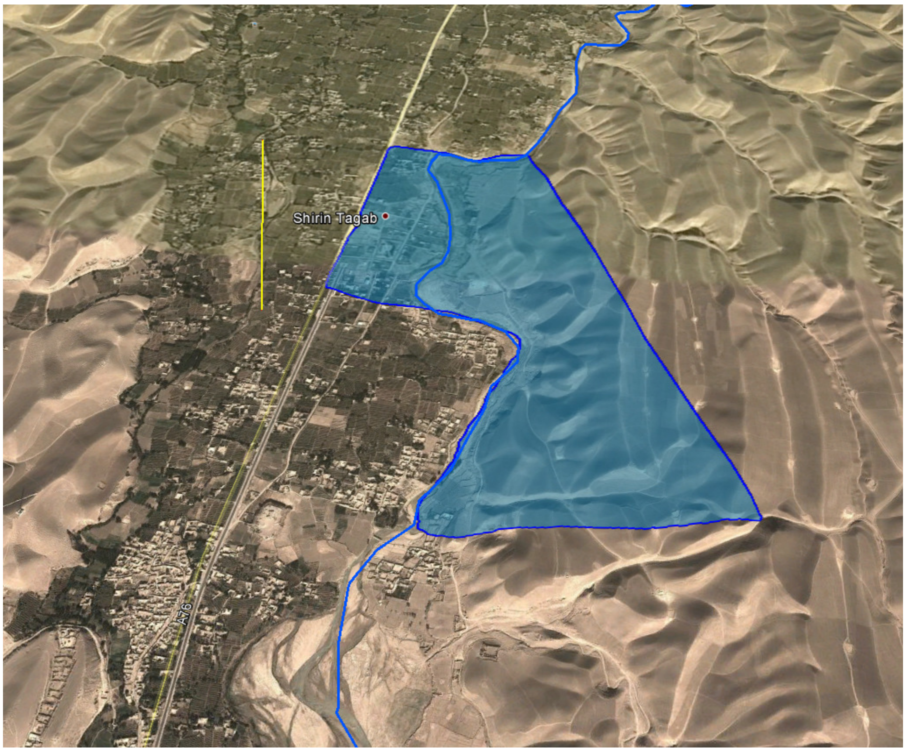

Figure 1. Location of Shirin Tagab study area (Google Earth). The blue line shows the Shirin Tagab River, flowing north. The yellow line is 1 km long.

The study area has been selected because:

- it straddles the boundary between the Quaternary (alluvial) aquifer system and the Neogene aquifer system.
- it allows us to evaluate the interaction between the River Shirin Tagab and the aquifer systems.

The study area straddles the valley bottom of the Shirin Tagab valley, at around 520 m asl. To the east of the study area, the terrain rises, as hills underlain by Neogene sedimentary rocks, to above 600 m asl.

The valley bottom contains habitation (the diffuse village of Islam Qala) and irrigated fields. The Neogene hilly terrain is largely uninhabited and appears uncultivated.

Geology

The published Afghan Geological Survey / USGS maps show that the valley floor is underlain by Quaternary alluvial deposits of the Shirin Tagab River. These are descried as:

Q_{34}a - Conglomerate and sandstone (Holocene and late Pleistocene) - Alluvium: shingly and detrital sediments, gravel, sand more abundant than silt and clay.

These alluvial deposits are underlain at presumed relatively shallow depth by Neogene sediments, which also outcrop as hilly terrain in the east of the study area. These are described as

N_{1l}csl - Clay and siltstone (early Miocene) - Red clay, siltstone more abundant than sandstone, conglomerate, limestone

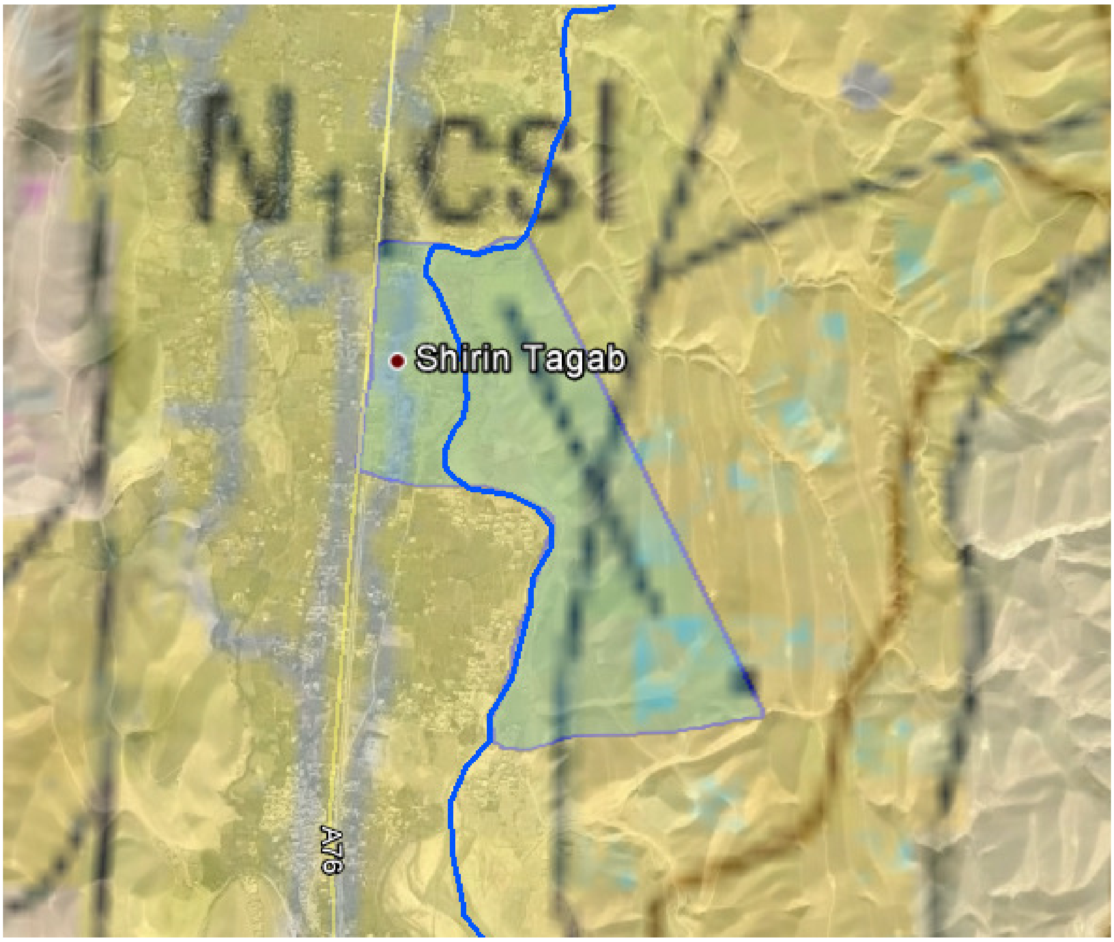

Figure 2. Geology of Shirin Tagab study area (Google Earth). AGS / USGS geological maps overlaid. See key below.

Q_{34}a	Conglomerate and sandstone (Holocene and late Pleistocene)—Alluvium: shingly and detrital sediments, gravel, sand more abundant than silt and clay	
Q_2loe	Loess (middle Pleistocene)—Loess more abundant than sand, clay	Q_2loe
N_{1m}csl	Clay and siltstone (middle Miocene)—Brown clay, siltstone more abundant than sandstone, conglomerate, limestone	N_{1m}csl
N_{1l}csl	Clay and siltstone (early Miocene)— Red clay, siltstone more abundant than sandstone, conglomerate, limestone	N_{1l}csl

Registered Wells

<u>Dug Wells</u>

No dug wells are registered in the study area. Several are however registered just outside the study area in the valley of the Shirin Tagab River (Figure 3). Water levels in these range from 16 to 32 m bgl.

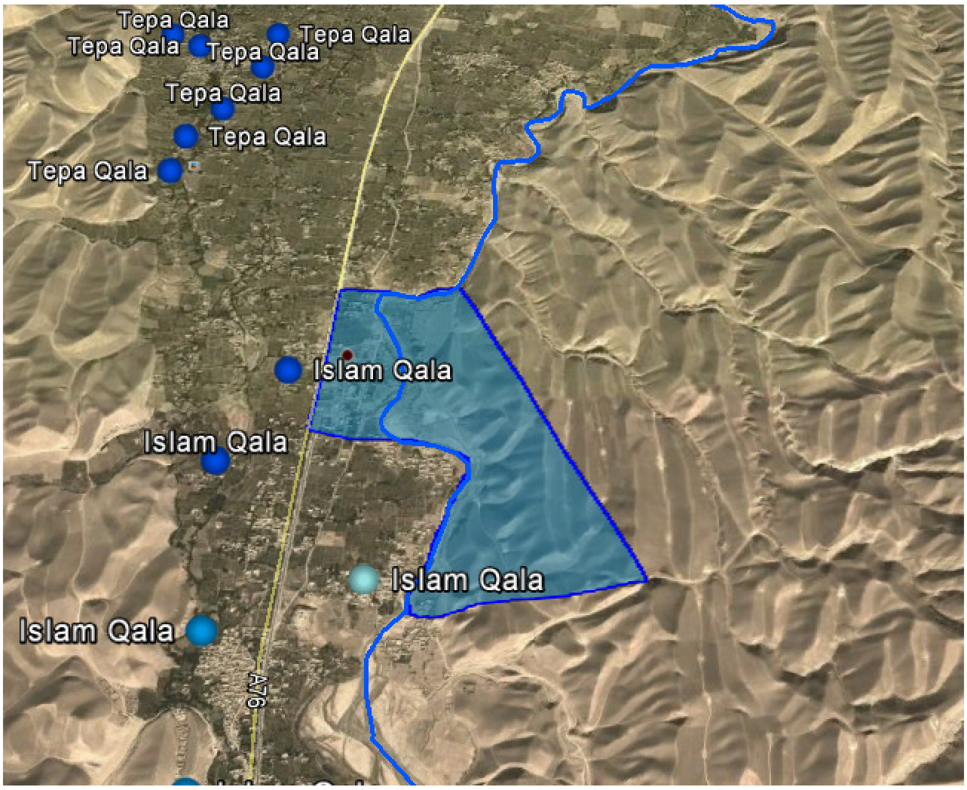

Figure 3. Registered dug wells in the Shirin Tagab study area (Google Earth). *Dark blue symbols indicate dug wells with water level between 25 and 35 m bgl.*

There are also a number of drilled boreholes registered in and around the study area.

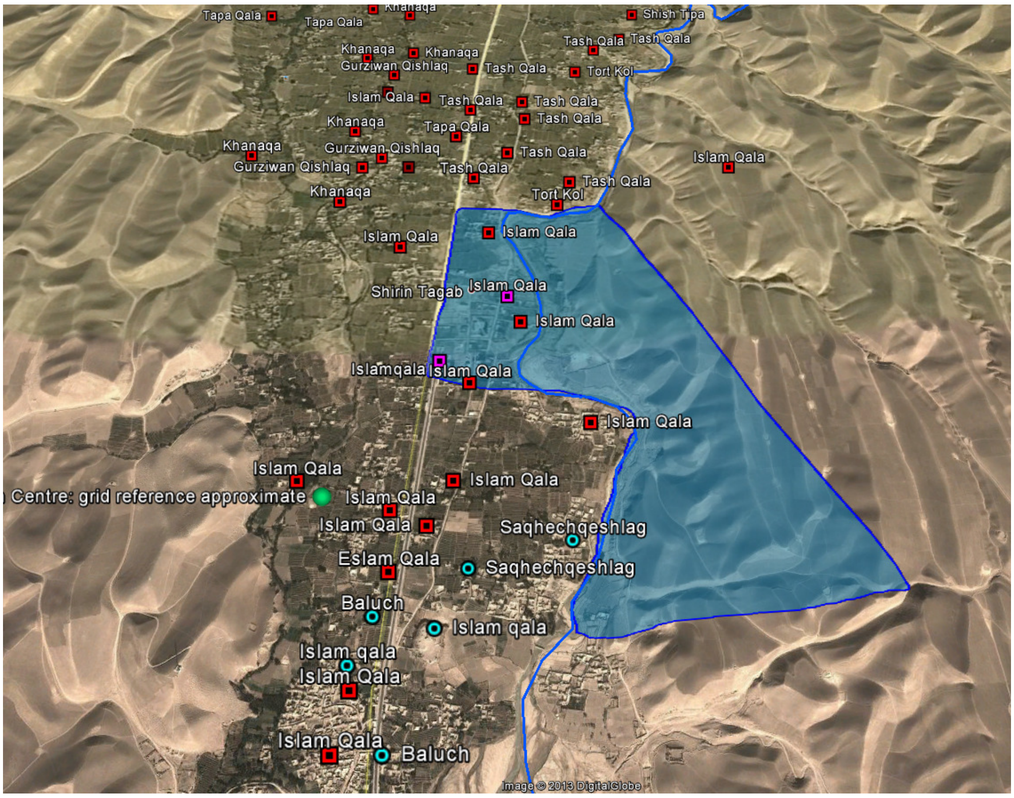

Figure 4. Registered drilled boreholes in the Shirin Tagab study area (Google Earth).

Groundwater levels in the valley floor typically range from 20-30 m below ground level. It should be noted that this appears to be **below** the level of the Shirin Tagab River, suggesting:

1) There is a degree of discontinuity between River and aquifer
2) The River is likely to be infiltrating water into the ground.

There is only one groundwater monitoring well in the near vicinity of the study area, around 6.5 km north of the study area.

- GWM 140: Fiz Abad Shamsudin School, Shirin Tagab District is 51 m deep and has a typical water level of 16 m bgl.

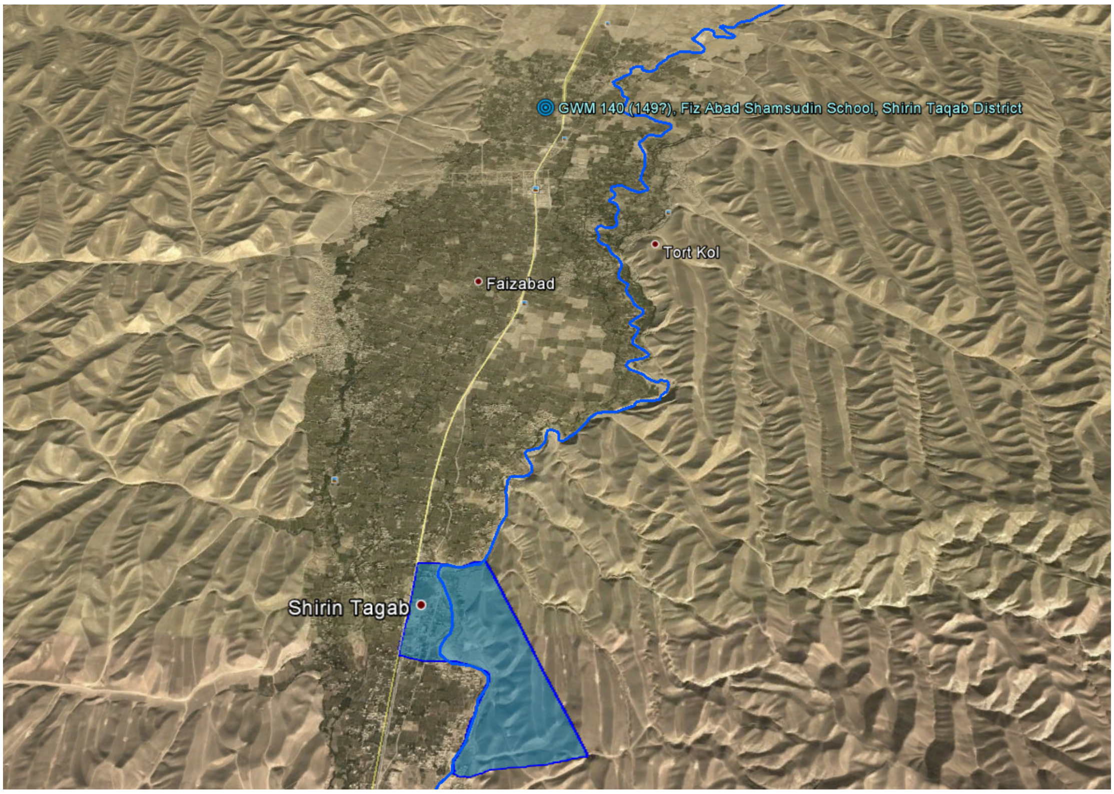

Figure 5. Registered groundwater monitoring boreholes near the Shirin Tagab study area (Google Earth).

Water quality

There is a considerable amount of data on groundwater electrical conductivity within the study area (Figure 6).

The groundwater appears to have a variable, but generally high, electrical conductivity, in the range 1800 - 4000 µS/cm.

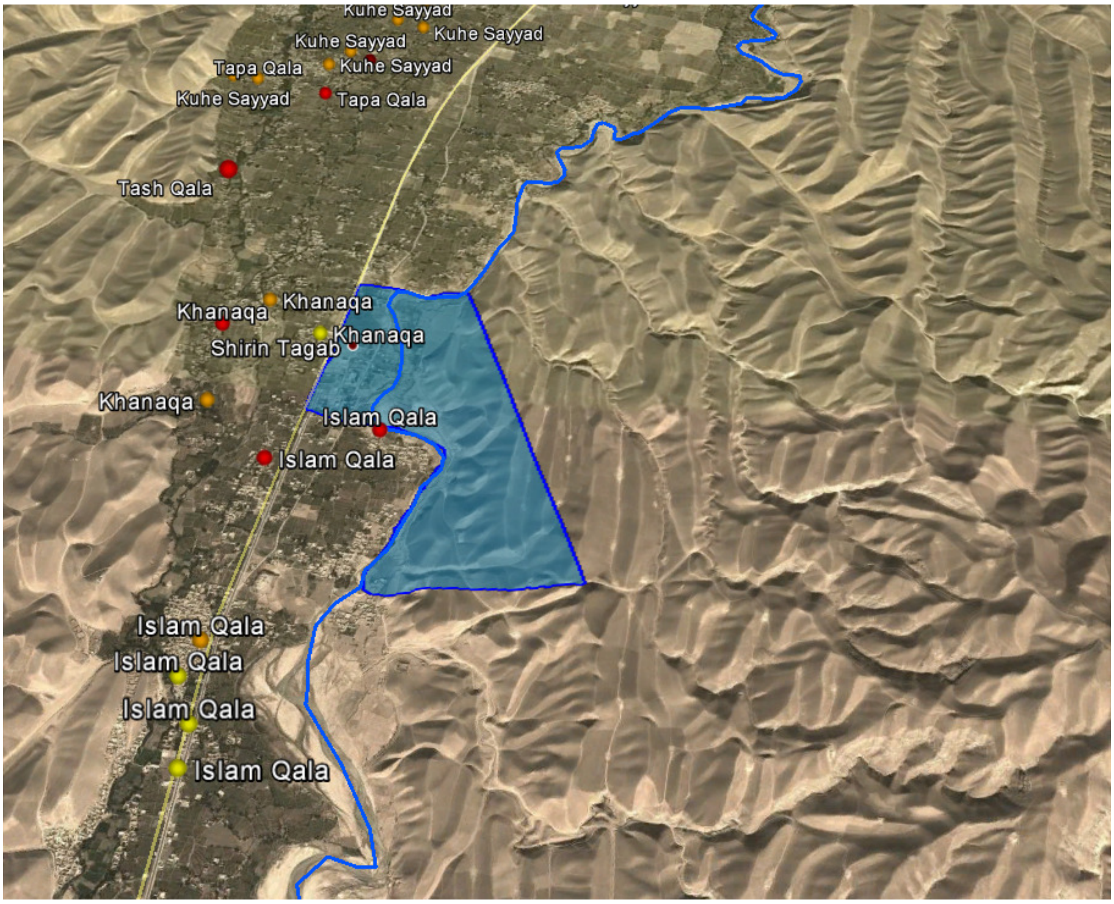

Figure 6. DACAAR groundwater electrical conductivity observations in the Shirin Tagab study area (Google Earth).

- Blue = <1203 µS/cm
- Green = 1203 - 1517 µS/cm
- Yellow = 1517 to 1996 µS/cm
- Orange = 1996 - 2950 µS/cm
- Red = 2950 - 5000 µS/cm

Meteorology

A considerable amount of data exists on the meteorology of Maimana. The World Meteorological Office data from 1961-83 result in graph in Figure 7.

The low precipitation and arid climate suggest that opportunities for direct recharge of groundwater systems are very limited. Some opportunities for small amounts of direct recharge may exist in the wettest, coolest months (January and February) or during snowmelt. Further north, at the Shirin Tagab study area, the opportunities for direct recharge will be even more limited.

The other potential source for groundwater recharge is infiltration from the Shirin Tagab River.

In addition, the GPCC Precipitation data set from NOAA provides mean precipitation data for the 0.5 x 0.5° grid square centred on 64.75°E 36.25°N, based on the period 1981-2010. This indicates that the mean annual precipitation near Shirin Tagab is 312 mm, distributed as shown in Figure 8a.

The GHCN Gridded V2 data provided by the NOAA provides mean air temperature data for the 0.5 x 0.5° grid square centred on 64.75°E 36.25°N, based on the period 1981-2010. This indicates that the mean annual air temperature near Shirin Tagab is 14.5°C, distributed as shown in Figure 8b.

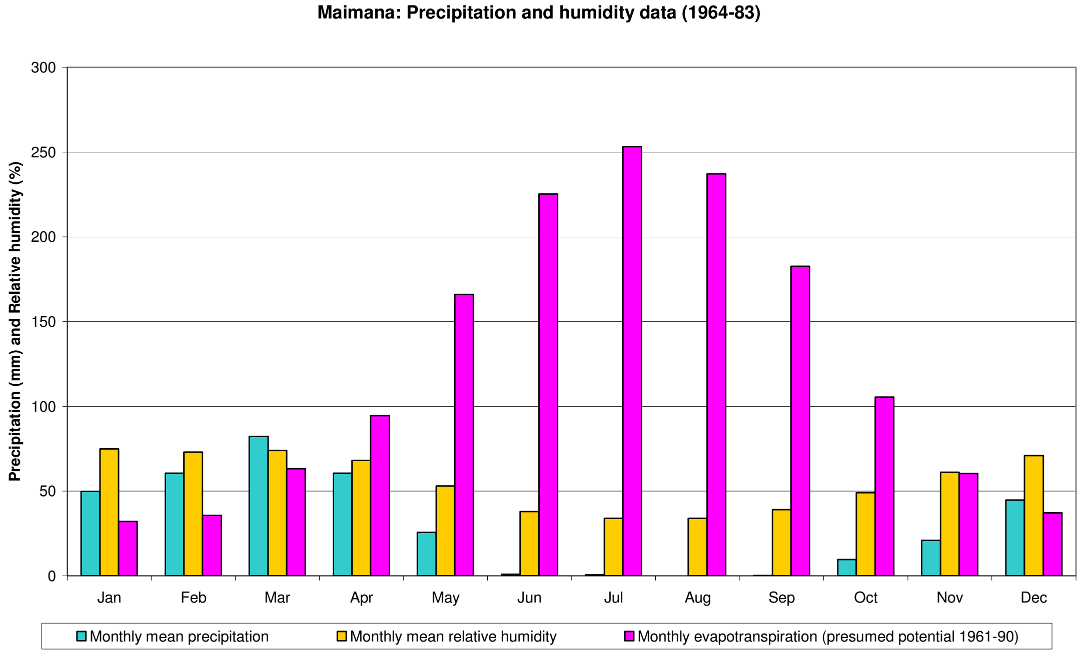

Figure 7. Monthly mean meteorological data 1964-1983 for WMO station 40922 Maimana.

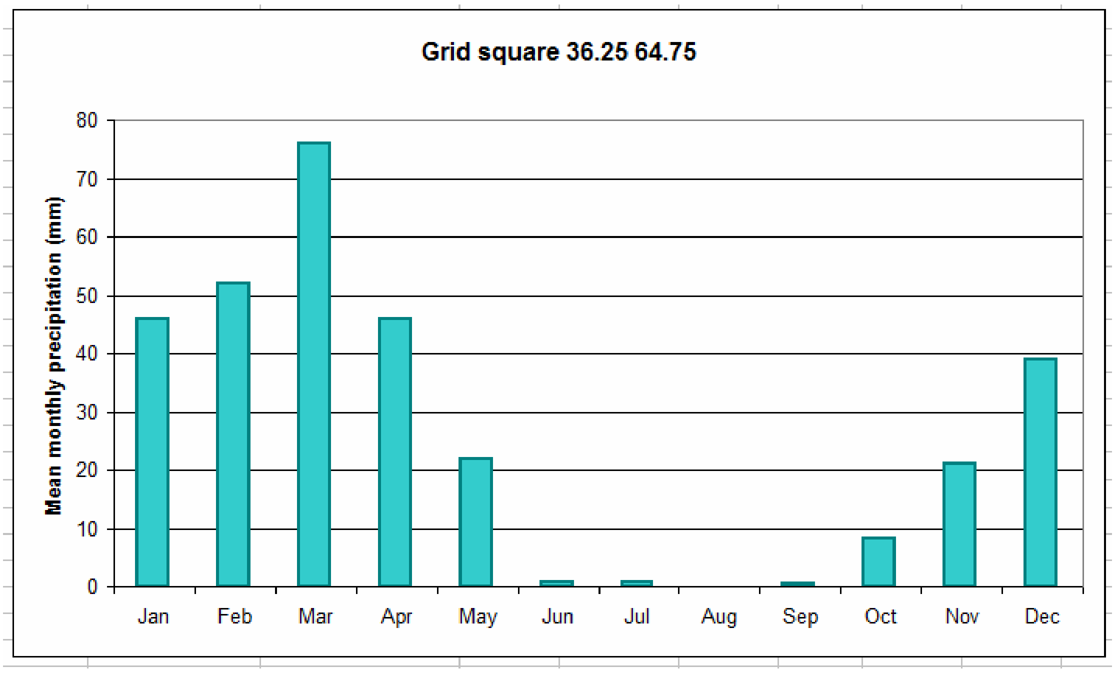

Figure 8a. Monthly mean precipitation data 1981-2010 for 0.5 x 0.5° grid square centred on 64.75°E 36.25°N, derived from the GPCC Precipitation data set from NOAA. *Data derived from GPCC Precipitation data provided by the NOAA/OAR/ESRL PSD, Boulder, Colorado, USA, from their Web site at http://www.esrl.noaa.gov/psd/. Reference: Schneider, Udo; Becker, Andreas; Finger, Peter; Meyer-Christoffer, Anja; Rudolf, Bruno; Ziese, Markus (2011): GPCC Full Data Reanalysis Version 6.0 at 0.5°: Monthly Land-Surface Precipitation from Rain-Gauges built on GTS-based and Historic Data. DOI: 10.5676/DWD_GPCC/FD_M_V6_050*

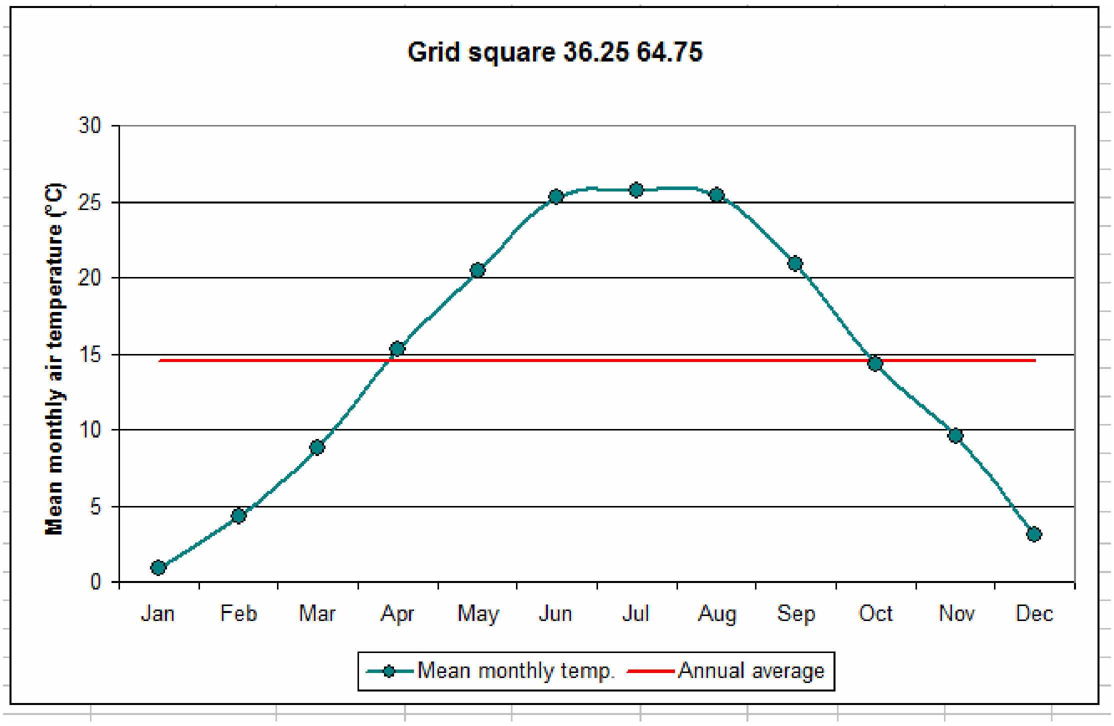

Figure 8b. Monthly mean air temperature data 1981-2010 for 0.5 x 0.5° grid square centred on 64.75°E 36.25°N, derived from the GHCN Gridded V2 data provided by the NOAA. *Data derived from GHCN Gridded V2 data provided by the NOAA/OAR/ESRL PSD, Boulder, Colorado, USA, from their Web site at http://www.esrl.noaa.gov/psd/. Reference: Fan, Y., and H. van den Dool (2008), A global monthly land surface air temperature analysis for 1948-present, J. Geophys. Res., 113, D01103, doi:10.1029/2007JD008470.*

Cross sections

Two geological cross-sections have been constructed as follows:

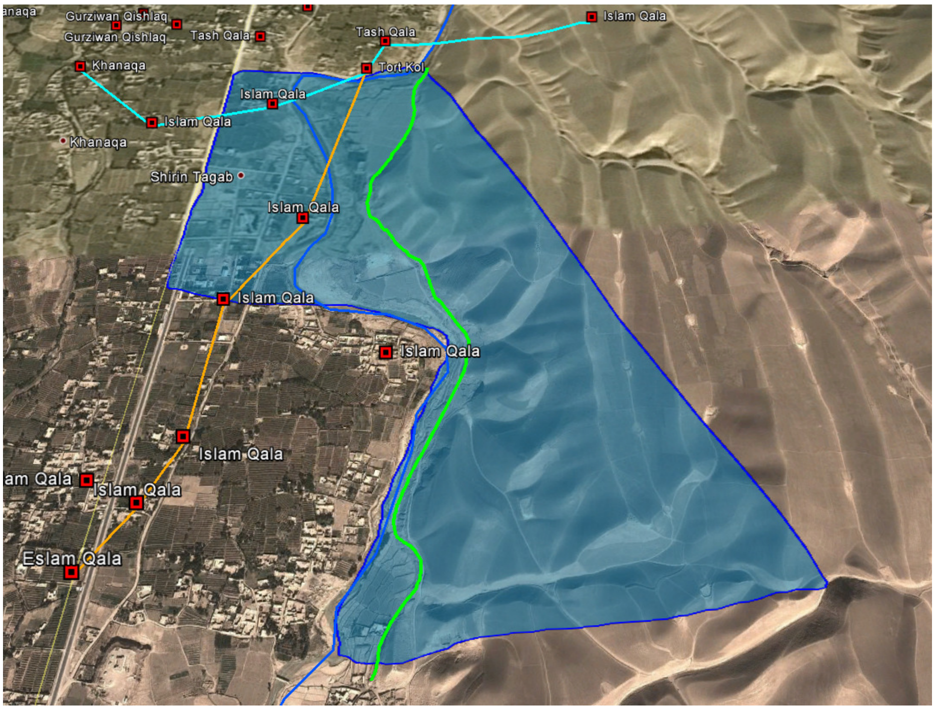

Figure 9. Locations of cross-sections 1-2 in study area Shirin Tagab. *Pale blue line = cross-section 1; orange line = cross-section 2; green line = approximate edge of Neogene outcrop. Deeper blue line = River Shirin Tagab.*

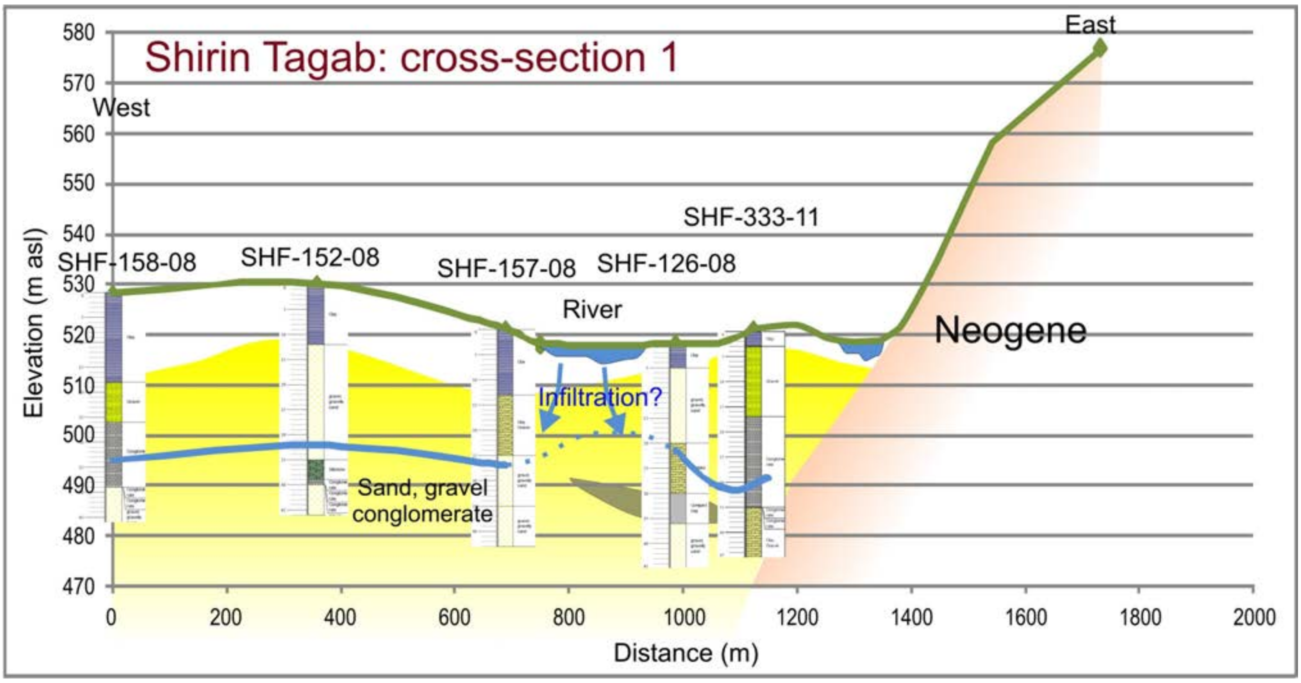

Figure 10. Cross section 1 of study area Shirin Tagab. *Elevation in m asl, horizontal distance in m.*

Cross section 1, approximately west-east, suggests that, below the study area there is an initial clayey layer of thickness 3-18 m, underlain by a substantial sandy-gravel / conglomerate aquifer unit, whose base has not been proved but which appears to be at least 30-40 m thick (saturated and unsaturated total thickness).

In no borehole has the top of the Neogene been unequivocally identified, despite its presumed outcrop in the east of the study area.

The groundwater level is around 20-30 m below ground level, at an elevation of 490-500 m asl. It thus appears to be at least 20 m below the elevation of the Shirin Tagab River, suggesting:

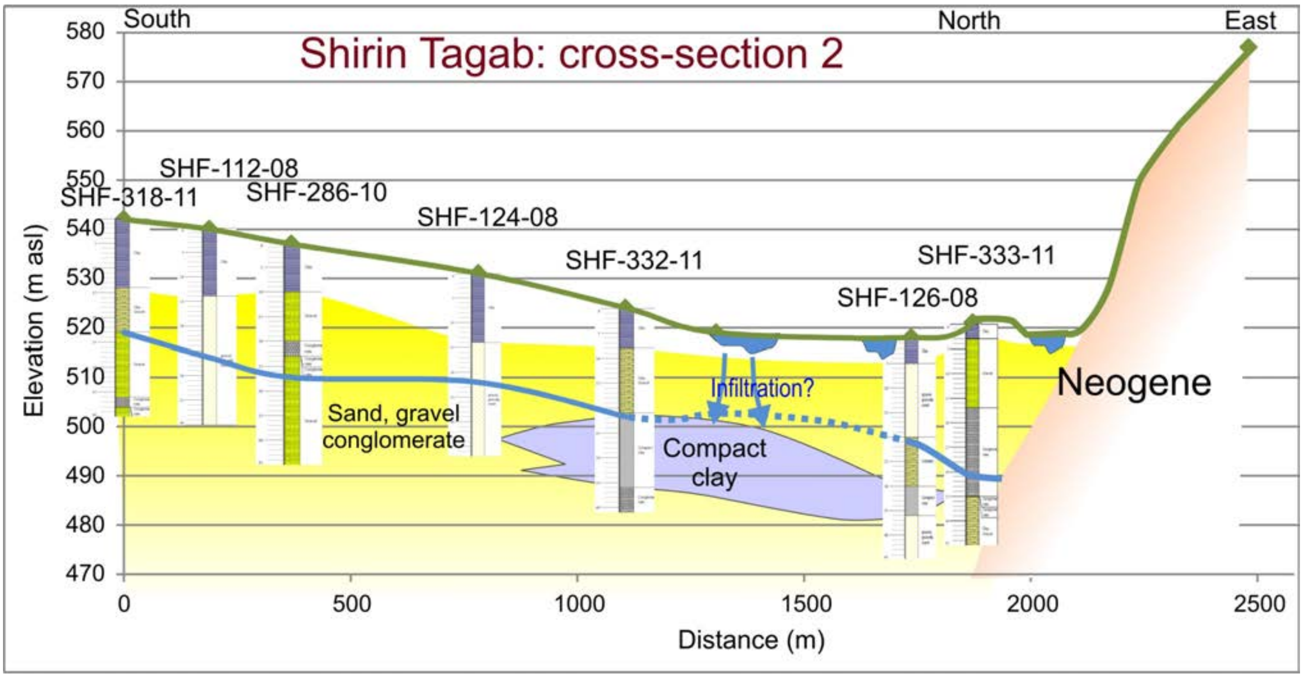

Figure 11. Cross section 2 of study area Shirin Tagab. *Elevation in m asl, horizontal distance in m.*

1) There is a degree of discontinuity between River and aquifer
2) The River is likely to be infiltrating water into the ground.

However, the sediments in the vicinity of the river are generally clayey in their upper portion, so the degree of river infiltration to the aquifer may possibly be limited.

The second, south-north cross-section, cross-section 2 (Figure 11) broadly supports the findings of cross-section 1. It confirms, however, that there is a groundwater hydraulic gradient along the course of the Shirin Tagab valley from south to north, with heads falling from +520 m asl to less than +500 m asl.

Two old pumped abstraction wells have formerly been drilled in the Shirin Tagab area:

- Shirin Tagab Health Centre: Aquifer = 33 m thick. Drilled to 50 m but only completed to 42 m. Rest water level = 21.5 m below well top. Test pumped at 1.4 L/s with 3.8 m drawdown after 20 hrs. Optimum yield judged to be 2.6 L/s with 6.9 m drawdown. EC = 850 µS/cm. Constructed by cable tool methods 10/6/1978 to 21/6/1978. No exact grid reference given. Information from old Dari handwritten table from MRRD
- Shirin Tagab Markaz (Centre): UNICEF/WHO Assisted Rural Water Supply Project, Kabul, October 1978. German PVC screen 2.0 mm slots. Aquifer = 16.9 m of sand, gravel, cobbles. Drilled to 43 m but only completed to 41 m. Rest water level = 22.2 m below well top; EC = 1650 µS/cm. Tested at 5 L/s for 5 hrs with 1.32 m drawdown. Optimal yield calculated as 11.8 L/s with 5.3 m drawdown. Constructed by cable tool method in Feb 1975. No exact grid reference given. An older handwritten Dari summary suggests that the rest water level on completion was 22.9 m bgl, not 22.2 m bgl. *Information from Radojicic, S. (1978): Summary report on deep tube wells constructed by Water and Soil Survey Dept., Ministry of Water and Power, 1973-78.*

It thus appears that yields in the range 2 to 12 L/s can be expected from this aquifer, with drawdowns of 5-7 m.

Conclusions

There appears to exist a substantial aquifer storage of brackish groundwater below the study area in a Quaternary alluvial sand/gravel/conglomerate unit of thickness at least 30-40 m, of which we know that at least 10-20 m are saturated.

The aquifer is overlain by clayey sediments ranging in thickness from a few metres to around 18m.

The aquifer is believed to be underlain by Neogene lower permeability materials at unknown depth. None of the boreholes in the area have unequivocally encountered Neogene and nothing is conclusively known about their hydraulic properties.

The aquifer is generally unconfined with groundwater levels typically 20- 30 m bgl in shallow boreholes. In an east-west orientation (perpendicular to the River) there is no clear hydraulic gradient on the water table. There is, however, a clear north-south hydraulic gradient down the River valley, indicating the groundwater flow in the Quaternary alluvial aquifer is generally northwards.

The aquifer systems seems to be characterised by downward vertical head gradients, with the Shirin Tagab River seemingly disconnected from regional groundwater heads and presumably with a tendency to infiltrate river water into the ground.

It appears that yields in the range 2 to 12 L/s can be expected from this aquifer, with drawdowns of 5-7 m. BUT the source of recharge to the aquifer is not clear.

- The climate (and the clayey overburden) means that opportunities for direct recharge are very limited.
- The clayey surface layer may hinder infiltration from the Shirin Tagab river to the aquifer.

Thus, a large question mark must be placed over the ultimately sustainability of a major groundwater abstraction from this aquifer.

Proposed Investigatory Programme

Summer 2013

Send a field hydrogeological and geophysical team to the Shirin Tagab area to

1) Carry out Water Features Survey (1 km radius around study focus area) and to locate any springs or karezes within 2 km of study focus area. Electrical conductivity to be determined at all visited springs, karezes, wells or boreholes.
2) Field team to collect chemical and isotopic samples from up to 10 boreholes and wells in and around study area. Electrical conductivity to be determined at all visited boreholes/wells. Samples to be sent to BGS England for analysis.
3) Identification of geophysical lines within study focus area (proposed geophysical lines shown in Figure 12). Obtain permissions and consent for geophysical survey.

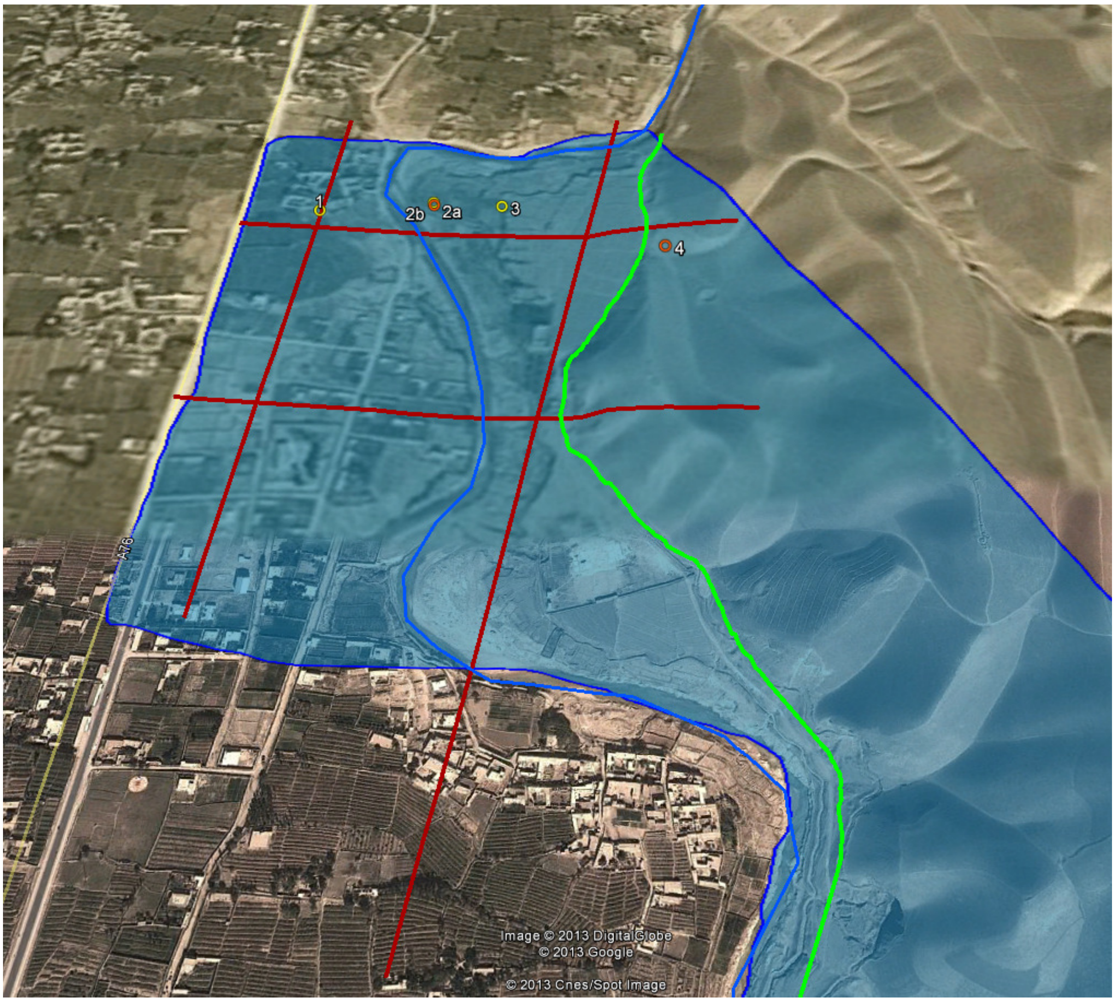

Figure 12. Shirin Tagab study area showing possible proposed geophysical lines (red), edge of Neogene outcrop (green) and proposed new boreholes.

4) Identification of possible drilling sites for

- 1 x production well (2a) to c. 60 m depth at 200 mm final diameter
- 1 x Neogene borehole (2b) to c. 100 m depth at 150 mm final diameter.

- 2 x Quaternary observation wells (1 and 3) to c. 60 m depth at 150 mm final diameter.
- 1 x Neogene observation well (4) to c. 60 m depth at 150 mm final diameter.

Obtain permissions and consent for drilling

5) **August-September 2013.** Geophysical survey[1] of study area using identified geophysical lines (Step 3). **Eng. Jalil (MRRD), possibly assisted by DACAAR.**

Spring/Summer 2014

Drilling and test pumping program to commence

6) **April 2014.** Drilling of boreholes at study area. Tentatively:

- 1 x production well (2a) to c. 60 m depth at 200 mm final diameter
- 1 x Neogene borehole (2b) to c. 100 m depth at 150 mm final diameter.
- 2 x Quaternary observation wells (1 and 3) to c. 60 m depth at 150 mm final diameter.
- 1 x Neogene observation well (4) to c. 60 m depth at 150 mm final diameter.

Sampling and geophysical logging of all boreholes.

Installation of 5 water level divers in boreholes

Installation of 1 barometric diver

Installation of river level gauging post in Shirin Tagab River

Possible installation of 1 water level diver in Shirin Tagab river (within constructed, protected unit).

Accurate surveying (levelling) of all well-heads and Shirin Tagab gauging post.

7) **July 2014**. Test pumping and water sampling of all wells.

Clearance pumping.

Short term (6 hour) test of all 4 observation wells, with drawdown response being monitored.

Regular monitoring of electrical conductivity during test pumping.

Water sample from all 4 wells after 1 hour pumping and after 6 hour pumping.

Sampling of Shirin Tagab River.

Chemical and stable isotope analysis of all samples.

8) **August 2014.** Test pumping of exploration well

Step testing of production well at 4 different rates

Constant rate testing of production well for at least 7 days (and possibly longer), with regular water sampling.

Recovery test of production well.

9) **August-September 2014.** Securement of all well heads and conversion to permanent monitoring facilities.

Necessary purchases

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[1] At present, it is envisaged that the geophysical survey will comprise a systematic series of VES soundings along pre-agreed lines. Following the recommendations of Eng. Jalil and Dr de Jong, these may be upgraded to full 2-D resistivity profiles.

- Surveying equipment (presumably already available from MRRD??) with 1 cm accuracy.
- Geophysical equipment and teams from MRRD or DACAAR
- Drilling rigs from MRRD (percussion rigs preferred) capable of constructing 8" completed diameter holes to 70 m and 6" completed diameter holes to over 100 m.
- Geophysical logging equipment
- 5-6 SWS water level divers with appropriate ranges.
- Flow meter gauging kit
- River gauging post
- Water sampling bailer / Waterra type hand sampling pump.
- Appropriate pumps (possibly two different types required, depending on well yield characteristics)
- Generator.

AFTER THE STUDIES

It will be problematic to prevent the wells being utilised following the study. This would be especially difficult if private farmers take them into use for motorised irrigation. While the short term capacity of the aquifer may be high, we know nothing about the long-term capacity or sustainability. NORPLAN needs to develop a strategy to limit the unauthorised use of the wells following the study (e.g. restricting the diameter at the headworks and installing monitoring equipment).