Bakwa District Groundwater Study

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Farah Province, Afghanistan

BAKWA DISTRICT GROUNDWATER STUDY
FARAH PROVINCE, AFGHANISTAN

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Farah Province, Afghanistan

EXECUTIVE SUMMARY

This report summarizes work carried out in Farah Province, Bakwa District in October, November and December 2009 under the USAID ADP/SW project. The Study was focused on assessing groundwater resource development potential and constraints for irrigation use in the District. **Figure 1** is a shaded relief map for the District and **Table 1** provides a summary of the meetings that were held during the Study period.

The central and southern part of the District is characterized by productive loess soils that are farmed for wheat and other crops. The Study concluded that there is one principal aquifer unit (conglomerate and sandstone aquifer) in the central and southern parts of the District that is regional in extent, around 30 meters thick, and with considerable groundwater storage capacity. Well yields from less that 20 lps up to 70 lps have been documented. The aquifer system receives healthy recharge and comprises a renewable resource. Recharge is principally from the infiltration of seasonal surface-water runoff from a number of stream drainages and river systems that head in the mountainous areas to the north, northeast and east of the farmed areas. There are large alluvial fans (some > 100 km^2) that are prime groundwater recharge areas.

The conglomerate and sandstone aquifer contains very fresh water (low total dissolved solids or TDS content) in the plain areas in the north, northeast and east District areas and TDS levels show an increase in concentration from these groundwater recharge areas (alluvial fans) to the west-southwest.

The limited available current and historical water-level data/information indicate no significant mining of groundwater in the District. Having said that, groundwater is used in the District for irrigation and drinking water supply. A key unknown is the actual annual abstraction in the District and region and this should be addressed in future studies. A water-level monitoring program, initiated by DAIL with USAID assistance, focused on a subset of strategically located wells would be one way of getting a handle on recharge versus abstraction. At the end of the day, technical assistance with groundwater management would be a key and valuable input.

The Study has confirmed that there are opportunities for irrigation in the District as well as the need for the demonstration of new irrigation technologies and best practices. Technical input and guidance to improve irrigation application efficiency will reduce water usage, allow more hectares to be irrigated and reduce pumping costs. This can be accomplished through demonstration plots on existing farms, and/or new farm developments with improved irrigation techniques and other innovations. A number of recommendations are provided including:

1. Demonstration Plots on Existing Farms: Irrigation demonstration plots with new technologies that are highly visible and increase irrigation efficiency:

    - Land leveling with furrow irrigation.
    - Demonstration drip irrigation.

- Reclamation of salty soil.
- Introduction of high-value crops

2. New Demonstration Farms along the main road.

3. Water-level monitoring networks for any new farm development.

4. More detailed groundwater resource evaluation for the District and region with investigative, management and monitoring phases.

1.0 Background

Bakwa District (the District) is located in the south-southeast part of Farah Province **(Figure 1).** The district is about 2,500 square kilometers (km^2) in area with an approximate population of 30,000 to 50,000 residing in about 200 settlements & villages (pers. Communication with Bakwa Governor, November 2009). The northern part of the district is mountainous and the cultivated areas are located in the central and south-central parts of the district. The area under active cultivation has increased over the past 3+ decades.

The Farah River lies to the north of the District and the Khash River to the south. Surface water drainage in the District is from the north, northeast and east in a southwest direction to the Khowpas Rud which is tributary to the Khash River. The district is arid (Dasht-i-Bakwa) with precipitation less than 100 millimeters per year (mm/year) in the southern part of the district up to 200 mm/yr in the northern hilly-mountainous areas **(Figure 5)**. There are no perennial rivers or streams in the district and all surface water flow is seasonal and a direct result of snowmelt and seasonal rainfall.

Groundwater is the principal source of drinking and irrigation water supply in the District and is extracted via dug wells and tubewells (drilled wells) completed in the semi-consolidated conglomerate and sandstone unit (Q2a on **Figure 2)**. Historically, there were many hundreds of functioning karez systems in the District but reportedly none are flowing today. Hydrogeological investigations involving geophysical surveys, exploratory test well drilling, and pumping tests were conducted in Bakwa and the adjoining Khush Rod District in 1975 by the Government of Afghanistan (GOA) Water and Soil Survey Authority; Groundwater Branch.

2.0 Summary of Previous Studies and Reports

A 1959 Report by International Engineering Corporation (IEC) focused primarily on soil conditions in the lower elevation areas of Bakwa District for potential irrigation application. The 1959 report did recommend that a groundwater investigation be carried out to assess development feasibility. In the 1959 report timeframe, IEC reported that the measured discharge from karezes in the district was 9 to 10 cubic feet per second (250 to 285 liters per second [lps]).

Several 1959 report findings of interest are the following:

1. The lower part of the basin has highly saline soils (at least 35 to 40 km^2 area) in the southwest part of the District.
2. In 1957, the wadis/drainages were flowing full after some rainfall events during the winter/spring season.
3. 4284 acres (1734 hectares) were estimated to be under cultivation with winter wheat mostly.

The 1975 Hydrogeological Yearbook (Ministry of Water and Power) provides an overview of groundwater resource investigations carried out in various parts of Afghanistan by the GOA Groundwater Branch of the Water and Soil Authority. One of these investigations (1975) was carried out in the eastern part of Bakwa District and Khush Rod District in Nimroz Province which borders Bakwa District to the southeast. The study objectives were to assess groundwater development potential for irrigated agriculture, and hydrogeological/geophysical investigations, groundwater monitoring, and exploratory drilling were carried out.

Eight test wells were drilled to depths of 53 to 96 meters below ground surface (m, bgs). All of the wells were screened in the Q2a Conglomerate and Sandstone unit which underlies the Q34ac Fan Alluvium and Colluvium unit and Q3loe Loess deposits. Tested well yields were reportedly in the range from 30 to 70 liters per second (lps) which resulted in water-level drawdown from 12 to 18 meters. **Appendix A** contains maps and drilling logs for this work and a well location map superimposed on the Bakwa District map that was developed for this current 2009 Study. In the 1975 timeframe, groundwater level fluctuation was reported at 0.8 to 1.0 m with the lowest water levels measured in November/December and the highest levels in April/May.

3.0 Topography, Surface Water Drainage, and Groundwater Use

Topographic relief in the District ranges from over 2,000 meters above mean sea level (m, amsl) in the north-northeast to less than 600 m, amsl in the south-southwest. Surface drainage is from higher elevation areas in the north-northeast parts of Bakwa District and from adjoining areas of Gulistan District (located to the east-northeast) toward lower elevation areas in Bakwa District in the south-southwest. A review of the shaded relief map (**Figure 1**) and satellite imagery **(Figure 3)** shows surface drainage to the southwest in the direction of the Khowpas (Khuspas) Rud which is tributary to the Khash Rud. There are no perennial streams or rivers in the District and surface water flows occur after major rainfall events and from snow melt.

There is significant surface drainage input from the seasonal rivers/streams/drainages that head in the east-northeast and drain to the west-southwest. The Gulistan Rod is one of the larger rivers which heads in the mountainous parts of that district and dies in a large alluvial fan in the gently sloping plain area in the far eastern part of Bakwa District and southwest Gulistan District (**Figure 4**). This river has a fairly substantial 9,100 km^2 drainage area (Qureshi, 2002) that serves to provide recharge to the underlying aquifer system(s) in western Gulistan and central/southern Bakwa District. Other smaller rivers/drainages also die (infiltrate into) in the large alluvial fans (>100 km^2) that are evident on satellite imagery in the far eastern part of the District and southwest Gulistan

District. There are also smaller drainages that head in the northern part of the District with alluvial fan areas that are significant in aerial extent (**Figure 4 and Figures B-2 and B-3 in Appendix B).**

Hundreds of karezes were operative in the past. Now all are reportedly dry. Drilled wells fitted with line-shaft vertical turbine pumps are the main source of irrigation water supply. Personnel communication with the Bakwa Governor and Engineer Shah Mahoud from the Department of Rural Rehabilitation and Development (DRRD) indicates that the number of irrigation wells is in the hundreds up to a thousand, although no inventory is available from the GOA Department of Agriculture, Irrigation & Livestock (DAIL).

Drilled and hand dug wells fitted with hand pumps are the main source of drinking water supply. The Danish Committee for Aid to Afghan Refugees (DACAAR) indicated that they installed about 280 drinking water wells fitted with hand pumps in the District.

4.0 Field Inventory Summary

The field survey was carried out in November 2009 and over 60 wells were inventoried. At each well, GPS coordinates and elevation were recorded and a water sample was collected for a field analysis of electrical conductivity (EC) and pH. Five groundwater samples were collected over the study area for a more detailed laboratory analysis of major anions and cations and selected metals. The depth to static water level was also recorded at each inventoried well.

Due to security concerns and at the advice of the District Governor and Shura, some of the district areas were deemed inaccessible for our Afghan national staff. For these areas, local persons were trained by our field staff to conduct the well surveys.

Table 2 provides a summary of the collected field data from the well inventory. **Figure 6** shows the locations of the inventoried wells and **Figure 7** provides an overview of the EC levels in selected wells inventoried.

Water Quality: pH was in the range from 7.5 to 8.5 reflective of basic water. The field EC measurements were in the range from 470 to 1,349 micromhos per cm (umhos/cm) indicative of groundwater with a total dissolved solids (TDS) concentration in the range from 300 to 900 milligrams per liter (mg/l). TDS is a measure of the concentration of dissolved chemicals in a water sample and high TDS levels can result in salt deposits on the soil and reduced crop yields. In the Bakwa area, EC levels increase from around 500 umhos/cm (300 mg/l TDS) in the upgradient groundwater recharge areas (north, northeast, and east District areas) to levels greater than 1,349 umhos/cm (900 mg/l TDS) in the downgradient west-southwest areas.

The lowest EC/TDS concentrations were found in wells proximate to the alluvial fans in the southwest part of Gulistan district and eastern area of Bakwa District. These fans are prime groundwater recharge areas and the water quality in wells completed near these fans reflects the low TDS content of the recharge water (surface water runoff). The 1975 GOA work measured TDS levels from 310 to 460 mg/l in the 8 wells drilled in that timeframe and some existing wells (**Appendix A**). These relatively low TDS levels are reflective of groundwater proximate to recharge sources.

Groundwater Levels and Flow Direction: Groundwater levels ranged from 8 to 33 m, bgs. The deepest water levels were measured in wells located in upland or relatively higher elevation areas in the east-northeast part of the study area. Water levels were found to be shallower for wells in relatively lower elevation areas in the central-south-central part of the District. Groundwater flow is from northeast to southwest and under a relatively gentle hydraulic gradient (0.0022 m/m or about a 2-meter decline in water level [or head] over a 1-kilometer distance) on the basis of the groundwater level contour map developed in 1975 which is in **Appendix A**). A similar hydraulic gradient was observed on the basis of water-level measurements in the 2009 Study

Field Observations: The local villagers/farmers indicated that water levels had declined about 2 meters over the past several years. This may be due in part to increased pumpage as well as below average precipitation. Irrigation well depths are in the range of 50 meters and pumps are mainly line shaft turbine pumps powered by diesel engines. Pumpage may be constrained by an erratic diesel supply and price.

5.0 Geologic and Hydrogeologic Overview

Geologic maps for Bakwa District are shown on **Figures 2 and 8**. The District is underlain by Jurassic & Cretaceous Age limestone, sandstone and conglomerate rock units that outcrop in the higher elevation northern parts of the District. A Paleocene clay unit overlies these bedrock units in the lower elevation areas. These clays reportedly thicken from east to west (from 120 to 240 meters) as estimated on the basis of the geophysical surveys carried out in 1974-75 by the GOA. The Q2a Quaternary-Age conglomerate and sandstone unit (locally referred to as the Neogene) overlies the Paleocene clay unit. The conglomerate unit is overlain by Fan Alluvium and Colluvium (Q34ac) and Loess (Q3loe).

5.1 Principal Aquifer

The Quaternary-Age Conglomerate and Sandstone (Q2a) is the principal aquifer unit in the District and is fairly extensive as indicated on the geologic map for the District and area (**Figures 2 and 8**). This unit is overlain by the Fan Alluvium and Colluvium (Q34ac) and Loess (Q3loe) which on the basis of available geologic logs are thin (refer to **Appendix A**). The base of the Conglomerate-Sandstone Aquifer is underlain by a clay unit which contains carbonate salts according to the drilling logs from 1975. The geophysical work done in the central part of the district indicates that this clay unit may be up to 240 meters thick.

Based on this available data, there is a single aquifer unit in the District for all practical purposes. The thickness of the Conglomerate and Sandstone (Q2a) aquifer unit is on the order of 30 meters on the basis of the 1975 test wells and surface geophysical surveys. The conglomerate aquifer is regionally extensive (**Figure 8**) and for the purposes of Bakwa development, may be considered well over 1000 km^2 in extent (including areas to the east in Gulistan District and Nimroz Province).

5.2 Hydraulic Characteristics

The 1975 GOA drilling program involved pumping tests on the eight installed wells. Three wells reportedly yielded from 30 to 45 lps and the remaining five wells were pumped at rates from 60 to 70 lps. Water-level drawdown during these pumping tests ranged from 12 to 18 meters. To our knowledge, no other pumping test data are available.

On the basis of these available pump-tested yields (30 to 70 lps) and water-level drawdown during pumping (12 to 18 meters), a range in specific capacity (Q/s) - the pumping rate (Q) divided by water level drawdown (s) - was developed and an average specific capacity (Q/s) of 3.3 lps/meter is used in this report for planning purposes. This translates to an aquifer transmissivity of 400 m^2/day (32,000 gpd/ft or 4,300 ft^2/day).

5.3 Groundwater Level Overview – Present and Historical

The 1975 GOA investigations indicated natural groundwater fluctuations in the range of 1 meter/yr with the highest water levels in the spring season and the lowest levels in early winter months before the rain and snow season. In the 1975 timeframe, water levels ranged from approximately 10 m, bgs in the southwest part of the 1975 study area (see figure in **Appendix A**) to as much as 27 m, bgs in a well along the Ring Road in the northeast. A very approximate comparison was made between the water levels measured in the November 2009 field survey with the 1975 measurements by comparing water levels in wells situated at similar topographic elevations. This comparison, which was albeit somewhat limited, has indicated water level change/decline in this 3.5 decade period from 0 to 2 meters.

5.4 Estimates of Static Groundwater Reserves and Annual Recharge

Given the low annual precipitation in Bakwa District and environs (<100 to 200 millimeters/annum), recharge from direct infiltration of precipitation to the underlying aquifer system in the lower lying District areas is considered to be negligible. The principal recharge mechanisms include:

- Mountain-front recharge from the hilly/mountainous areas in Bakwa and Gulistan Districts in the north, northeast, and east, and

- Infiltration of runoff from rainfall events and snow melt into the large number of seasonal drainage pathways in both the upland and lowland areas. There are a number of alluvial fans, the most prominent being the Gulistan Rod fan, that are visible on aerial photography and satellite images. These fan areas are prime locations for groundwater recharge.

The static groundwater reserve is an estimate of total quantities of groundwater in storage in the aquifer. The static reserve provides an indication of the magnitude of the volume of groundwater in an aquifer system and how much of a drought buffer exists to enable pumpage during years of below average precipitation. It can be used to estimate the magnitude of water-level decline during drought periods under various pumping withdrawals.

Dynamic reserves reflect the magnitude of groundwater recharge in a year of normal precipitation. This is an important calculation for an aquifer system as it provides an estimate of how renewable the groundwater resource is on an annual basis. A brief overview is also provided of the principal groundwater recharge mechanisms.

Static Reserve: The static reserve is estimated based on a 30 m aquifer thickness and an aquifer porosity range from 5% to 10%. An aquifer porosity of 10% would provide for 3 million cubic meters storage per square kilometer (m^3/km^2) and an aquifer porosity of 5% porosity would provide for half this quantity of storage or 1.5 million m^3/km^2. Therefore, a 100 km^2 aquifer area would provide from 150 to 300 million cubic meters of groundwater in storage.

With a static reserve of this magnitude, a 1-meter depletion of a 500 km^2 aquifer area over a 1-year period would require a 790 to 1,580 lps continuous pumping withdrawal.

Dynamic Reserve: Groundwater recharge estimates were developed using two methodologies. The first method involves the application of Darcy's Law (Q = TIL) where groundwater flux/recharge (Q) to an area/region is taken as equal to the aquifer transmissivity (T) multiplied by the groundwater hydraulic gradient (I) and the length of groundwater recharge front (L).

This approach assumes that groundwater flux/recharge from upgradient areas (in this case the hilly and mountainous areas in Bakwa and Gulistan Districts to the north, northeast, and east) through an aquifer system is equivalent to annual or seasonal recharge. For the Bakwa area, groundwater flow direction is from north-northeast to southwest from the higher elevation areas in Bakwa and Gulistan Districts to the lower elevation areas in the central and southwest parts of Bakwa District.

The Darcy equation (Q = TIL) calculation is outlined below:

Transmissivity (**T**) was estimated from the pumping tests conducted in 1975 by the GOA on 8 test wells in the eastern part of Bakwa District. An average transmissivity of 400 m^2/d was calculated on the basis of average specific capacity. The hydraulic gradient (**I)** was calculated from the potentiometric surface map developed in 1975. The aquifer cross-sectional length **(L)** was estimated from the geologic map for the District and region.

The inputs to the equation Q = TIL were as follows:

T = Aquifer Transmissivity = 400 m^2/d.
I = Hydraulic Gradient = 20 meters/8,000 meters.
L = Aquifer Cross Sectional Length to the north, northeast and east = 50,000 to 70,000 meters (50 to 70 km).

Solving for Q:
Q = Groundwater Flux = 50,000 to 70,000 m^3/day
= 580 to 810 lps
= 13.3 to 18.6 MGD

The second method that was used to estimate groundwater recharge is based on the percentage of annual precipitation over the surface drainage area that actually infiltrates/recharges into the underlying aquifer system(s). In arid environments with low precipitation and high evapotranspiration rates, groundwater recharge is generally less than 10% of annual precipitation. In Bakwa District, annual precipitation ranges from less than 100 millimeters (mm) in the southern part of the district to 200 mm in the higher elevation northern parts of the district **(Figure 5)**.

An approximate estimate of the surface drainage area to the lower lying areas of the District north of the Delaram – Farah Road (a large portion of the irrigated areas lie south of this road) is in the range of 2,500 square kilometers (km^2). A large part of this drainage area is from Gulistan District to the east-northeast. If groundwater recharge is taken as 5% of annual precipitation, this translates to $18.75x10^6$ cubic meters per year (51,300 m^3/day or 600 lps). This is equivalent to 13.5 million gallons per day (MGD).

This recharge calculation does not take into account the total area of the contribution from the Gulistan Rod. Qureshi (2002), in an International Water Management Institute (IWMI) study, references the Gulistan Rod as having a 9,100 km^2 drainage area and a mean annual discharge of 40 million m^3. The large alluvial fans (>100 km^2) that are evident on satellite imagery in the far eastern part of the District and southwest Gulistan District receive the surface water discharge from this river system as well as other large drainages to the east-northeast and serve to recharge the groundwater system – Conglomerate and Sandstone Aquifer - that lies under the central and southern part of Bakwa District (**Figures 3 and 4)**. In summary, the recharge calculations provided are exceedingly conservative and the groundwater recharge contribution from the Gulistan Rod probably serves to increase the estimates by at least 50%.

5.5 Groundwater Flow Conditions

The 1975 water-level contour map (**Appendix A**) indicated a groundwater flow direction from the alluvial fan recharge areas in the north, northeast, and east to the south-southwest. The 2009 collected water-level data indicated a similar groundwater flow direction. There is also a groundwater flow component from the north to south in Bakwa District as evidenced by water quality (EC/TDS) conditions in the Sultani Bakwa area that show the lowest EC/TDS levels in the north (Chichi Village) and increasing EC/TDS levels to the south-southwest.

6.0 Groundwater Quality Overview

6.1 Field Measurements

The levels of Total Dissolved Solids (TDS) and Electrical Conductivity (EC) show an increase from principal areas of groundwater recharge (alluvial fans to north, northeast, and east) to areas in the District in the west-southwest. The lowest measured TDS/EC levels are in the 300 mg/l (500 umhos/cm) range and increase to greater than 900 mg/l (1,350 umhos/cm) in the west, southwest District areas.

IEC (1959) noted that areas in the southwest part of the District contained saline soils and this can be noted on the infrared satellite images (**Figure 3**) which indicate limited agricultural irrigation (refer to **Map C3 in Appendix B**). A general area of salty soils is also outlined on **Figure 7**.

The 1975 GOA work measured TDS levels from 310 to 460 mg/l in the 8 wells drilled in that timeframe and some existing wells (Appendix A). These relatively low TDS levels are reflective of groundwater proximate to recharge sources. The 2009 field inventory documented similar TDS levels in surveyed wells in the east-northeast parts of the District near the alluvial fans.

6.2 Salinity and Sodium Hazard Analysis

Five (5) water samples were submitted to the DACAAR laboratory in Kabul for a physical and chemical analysis. The measured electrical conductivity (EC) and calculated “Sodium-Adsorption-Ratio” (SAR) were evaluated using the United States Salinity Laboratory (USSL) methodology (**Figure 9**) to assess the suitability of the groundwater for irrigation purposes. The USSL analysis (1954) allows for an evaluation of Salinity and Sodium Hazards. The Salinity Hazard has four (4) categories C1 – C4 as does the Sodium Hazard S1 – S4 which are explained below.

Electrical Conductivity – Salinity Hazard:

C1 – represents “Low-Salinity Water” (100 to 250 umhos/cm) which can be used for irrigation with most crops and on most soils.

C2 – represents “Medium-Salinity Water” (250 to 750 umhos/cm) which can be used if a moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown in most cases.

C3 – represents “High Salinity Water” (750 – 2250 umhos/cm) which is not recommended on soils with restricted drainage. Even with adequate drainage, leaching is required and plants with good salt tolerance should be selected.

C4 – represents “Very High-Salinity Water” (>2,350 umhos/cm) which may be used under special circumstances. The soils must be permeable, drainage adequate, irrigation water applied in excess to provide leaching, and very salt-tolerant crops selected.

SAR - Sodium Hazard:

The classification of waters with respect to the “Sodium-Adsorption-Ratio” is principally focused on the impact of exchangeable sodium on the physical condition of the soil.

“High sodium concentrations become a problem when the infiltration rate is reduced to such a rate that the crop does not have enough water available or when the hydraulic conductivity of the soil profile is too low to provide adequate drainage. Other problems to the crop caused by an excess of Na is the formation of crusting seed beds, temporary saturation of the surface soil, high pH and the increased potential for diseases, weeds, soil erosion, lack of oxygen and inadequate nutrient availability.” (lenntech url).

S1 – “Low-Sodium Water” (SAR from 0 to 10) can be used for irrigation on most soils.

S2 – “Medium-Sodium Water” (SAR from 10 to 18) presents a Sodium Hazard in fine-textured soils under low-leaching conditions.

S3 – “High-Sodium Water” (SAR from 18 to 26) may produce harmful levels of exchangeable sodium in most soils and will require management (good drainage, leaching, and soil amendments).

S4 – “Very High-Sodium Water” (SAR > 26) is generally unsuitable for irrigation purposes.

Figure 9 is a plot of “Electrical Conductivity” (Salinity Hazard) vs. “Sodium-Adsorption-Ratio” (Sodium Hazard) for the five water samples that were analyzed by DACAAR. Two samples for wells located in the Sultani Bakwa area indicated a relatively high salinity hazard (in the lower part of the C3 range) and a medium sodium hazard (S2). Three samples for wells located in the east-northeast District areas indicated a medium salinity hazard (C2) and low sodium hazard (S1). These three wells are located close to groundwater recharge areas (alluvial fans).

7.0 Physical Model for the District – Summary Overview

The Study area is underlain by a regionally extensive aquifer system with considerable groundwater storage capacity which receives healthy recharge and comprises a renewable resource. The Study has confirmed that there are opportunities for irrigation in the District as well as the need for the demonstration of new irrigation technologies and best practices.

- The principal aquifer that is tapped for drinking and irrigation water supply is the Conglomerate and Sandstone Unit (Q2a). It is estimated to be 30 meters thick and is regionally extensive.

- Groundwater flow is from east-northeast to west-southwest from areas of groundwater recharge which are principally located on the alluvial fans to the north, northeast and east of the lower elevation farming areas (areas with loess soils - Q3loe).

- There are limited data for well yields and aquifer hydraulic properties: well yields in the range of 30 to 70 lps have been reported in the hydrogeologic investigation work that was conducted by the GOA in 1975.

- Groundwater recharge to the Bakwa area has been estimated to be in the range from 600 to > 800 lps on the basis of a 2,500 km^2 contribution area. These recharge calculations are exceedingly conservative and do not reflect the totality of the groundwater recharge contribution from the Gulistan Rod.

- The Gulistan Rod is one of the larger rivers/drainages contributing to groundwater recharge in Gulistan and Bakwa Districts. The River heads in the mountainous parts of that district and dies (infiltrates into) in large fans in the gently sloping plain area just east of Bakwa District (**Figure 4**). Other smaller rivers/drainages also die in the large alluvial fans (>100 km^2) that are evident on satellite imagery in the eastern part of the District and southwest Gulistan District. The groundwater recharge contribution from the Gulistan Rod probably serves to increase the recharge estimates by at least 50%.

- Groundwater Storage for a 100 km^2 aquifer area is in the range of 150 to 300 million cubic meters and a significant groundwater storage buffer exists in the Conglomerate and Sandstone Aquifer System.

- Overview of groundwater availability with regard to current use:

    - The limited current and historical water-level data/information indicates that there has been no significant mining of groundwater in the District.
    - Having said that, groundwater use for irrigation is extensive, seasonal and somewhat limited by diesel availability and cost.
    - A key unknown is the actual annual abstraction for the District and region, and in all likelihood this will remain an unknown for some years to come.
    - A water-level monitoring program, initiated by DAIL, and focused on a subset of strategically located wells would be one way of getting a handle on recharge versus abstraction.

- The levels of Total Dissolved Solids (TDS) and Electrical Conductivity (EC) show an increase from principal areas of groundwater recharge (alluvial fans to north, northeast and east) to the west-southwest. The lowest measured TDS/EC levels are in the 300 mg/l/500 umhos/cm range and increase to over 900 mg/l/1,350 umhos/cm.

- Groundwater in the north, northeast, and eastern areas that are subject to cultivation appears suitable for irrigation on the basis of the Salinity and Sodium Hazard analysis. Two samples for wells located in the Sultani Bakwa area indicated a relatively high salinity hazard (in the lower part of the C3 range) and a medium sodium hazard (S2). Three samples for wells located in the east-northeast District areas indicated a medium salinity hazard (C2) and low sodium hazard (S1). These three wells are located close to groundwater recharge areas (alluvial fans).

- Potential pumping impacts: The siting of a new farm will need to take the following into consideration and evaluate:
    - Proximity to nearby wells and associated water-level drawdown impacts.
    - Expected groundwater quality and well yields.
    - Soil conditions – quality, composition and permeability.
    - Assessment of impacts from a wellfield for different size farms (25, 50, and 100 hectares). A 25- hectare farm, if irrigated efficiently with some drip irrigation mixed in, would require 15 to 30 lps.

- A preliminary assessment of water-level drawdown impacts using the Theis Non-Equilibrium Analytical Model from a hypothetical well system continuously pumped for 90 days at 15 lps indicated that drawdown at 500 meters from a pumping well would be around 1 m, and at 1,000 meters around 0.25 m. The model inputs were a Transmissivity of $400m^2$/day and an aquifer Storativity of 0.01.

- The radius of influence of a wellfield pumping at a 15 lps rate for a 90-day withdrawal period would be about 2,800 m using the same model inputs as above.

8.0 Recommendations

Technical input and guidance to improve irrigation application efficiency will reduce water usage, allow more hectares to be irrigated and reduce pumping costs.
This can be accomplished through demonstration plots on existing farms, and/or new farm development with improved irrigation techniques and other innovations.

The following steps are recommended:

1. Demonstration Plots on Existing Farms: Irrigation demonstration fields with new technologies that are highly visible and increase irrigation efficiency:

    - Land leveling with furrow irrigation.
    - Demonstration drip irrigation.
    - Reclamation of salty soil.
    - Growing of high value crops.

2. New Demonstration Farms along the main Farah to Delaram Road.

3. Water-level monitoring networks for any new farm development.

4. More detailed groundwater resource evaluation for the District and region with investigative, management and monitoring phases.

Demonstration Plots to improve irrigation practices and application efficiencies on existing farms: Optimal locations will be along the main Delaram to Farah Road for maximum visibility. Irrigation practices could include land leveling for furrow irrigation and drip irrigation where TDS levels are acceptable. Irrigation applications to reclaim land impacted by salt concentrations is also a consideration in parts of the District.

New Demonstration Farm Development: Optimal locations from a groundwater quality perspective as depicted on **Figure 10** include: 1. The general area east of Sultani Bakwa to the eastern District boundary, and 2. The general area north of Sultani Bakwa between the 2 drainages that trend north to south**.** Both of these areas are characterized by low EC/TDS levels.

Consideration should be given to two or more farms with a smaller footprint (25 to 50 hectares) to minimize impacts to other well owners. Some considerations for new farm development include:

- Land leveling to optimize irrigation applications.
- Demonstration drip irrigation.

- Improved irrigation technologies – furrow.
- Alternate energy source(s).
- Located at safe distances from existing wells.

In summary, there is an excellent opportunity to engage locally for demonstration of both **(a)** best practices for Irrigation on existing or new farms and **(b)** Groundwater Management, in a region where the resource is clearly renewable. Technical input and guidance to improve irrigation application efficiency will reduce water usage, allow more hectares to be irrigated and reduce pumping costs.

Provided below is a cost overview for the well installation component for New Demonstration Farm development which includes: 1. The well installation and pumping equipment component, and 2. Technical oversight for the work.

Demonstration Farm Development – either one 100 Hectare Farm or 2 to 4 Smaller Farms

1. Capital Costs – Wells and Pumps

Basis:

- 0.6 to 0.75 lps/hectare – for an efficient irrigation system.
- Plan on 30 - 50 lps for 50 hectares.
- Plan on 25 lps/well – which translates to 2 wells per 50 hectares. Design with 3 wells per 50 hectares.

- Well costs including casing, screen, filter pack, grout and a 24 hour pumping test: $12,000/well.
- Pumping plant – line shaft turbine, diesel engine and installation and set up: $3,000/well.

Estimate:

- $150,000 for a 100 hectare farm (or two 50-hectare or four 25-hectare farms) with 8 wells (2 back-up), pumping tests and pumping plants.

2. Oversight Consulting

Basis:

- Prepare drilling specifications for bid documents including details for efficient well designs including requirements for well casing, screen type, and cement grout.
- Assist in contractor evaluation and selection.
- Design well field layout for the Demonstration Farm including spacing considerations made on the basis of available aquifer hydraulic information which will be refined after the first well has been installed and pump tested.

- Oversight of well drilling, installation, and pump testing - plan on 2 to 4 rigs working concurrently.

- Analysis of individual well pumping test data to determine safe sustained pumping rates, pumping plant sizing, and aquifer hydraulic characteristics.
- Oversight of pumping plant installation and start up.

- Water quality sample collection and analysis, coordination and interpretation.
- Project Report to include as-built well diagrams, geologic logs, pumping test data and analysis, water quality analysis, pump sizing/selection input, monitoring, and management recommendations.

Estimate:

- Consulting Fees: +/- $95,000.

Timeline – 3 months

9.0 References

Doebrich, J. L. and Ronald R. Wahl. 2006. Geologic and Mineral Resource Map of Afghanistan, United States Geological Survey (USGS) and Afghan Geological Survey (AGS).

Government of Afghanistan, 1975. Hydrogeological Yearbook (Ministry of Water and Power, Water & Soil Survey Authority).

International Engineering Corporation, 1959. Report on Soil and Water Resources of Southern Afghanistan. Prepared for the Royal Government of Afghanistan.

Organization for Surveying and Cartography. 1984. National Atlas of the Democratic Republic of Afghanistan. Geokart Poland. 1984.

Qureshi, Asad S. 2002. Water Resources Management in Afghanistan, The Issues and Options. International Water Management Institute. Working Paper 49.

URL: http://www.lenntech.com/applications/irrigation/sar/sar-hazard-of-irrigation-water.htm#ixzz0ZUIQSSUo.

U. S. Salinity Laboratory Staff, 1954. Diagnosis and Improvement of Saline and Alkali Soils: U. S. Department of Agricultural Handbook 60, 160p.

TABLES

Table 1. Meetings Summary - ADP/SW - Bakwa Groundwater Study

Date	Place	Venue	Persons From:	Purpose	Persons Attending:
22-Oct-09	Kabul	DACAAR		Coordinate water quality testing and request data for wells in Bakwa District.	V. Uhl, Q. Tahiri
25-Oct-09	Kabul	USACOE	K. Carpenter	Update Kathryn on the project; Kathryn provided update on assessments being done by USACOE and contact point with Red Horse Drilling Team for FOB wells.	V. Uhl
27-Oct-09	Farah	PRT	Trevor Hublin - USAID Darren Richardson - USDA Major Wayne A. Bodine - USMC	Overview of our Bakwa program and discuss potential project in Kharmeleq.	V. Uhl, Q. Tahiri, Vance Purvis, Ed Brooks
28-Oct-09	Farah	ADP/SW	Bakwa Gov - Haji Labujan Eng. Shah Mahmod - DRRD	Review options for field survey; Governor to set up Shura meeting in next day or so; Eng. Mahmod provided brief on DRRD work in District.	V. Uhl, Q. Tahiri, Tim Michael, ADP/SW Engineers
29-Oct-09	Farah	DACAAR Office	Ahmad Shah Safa Manager DACAAR Farah	Obtain update on DACAAR activities in Bakwa District; They have been inactive in the District since 2003 because of security concerns. Eng. Safa explained the DACAAR database and that they have installed 248 wells in the District.	V. Uhl, Q. Tahiri
31-Oct-09	Farah	ADP/SW	Bakwa Gov - Haji Labujan Three Shura Members	Review Field Program objectives and coordinate with Bakwa Governor and Shura	V. Uhl, Q. Tahiri, Tim Michael, ADP/SW Engineers
11/7/2009	Farah	PRT	Trevor Hublin - USAID Darren Richardson - USDA Major Wayne A. Bodine - USMC.	Update on progress in Bakwa; Outline of expected outputs.	V. Uhl, Q. Tahiri, Vance Purvis

Table 1. Meetings Summary - ADP/SW - Bakwa Groundwater Study

Date	Place	Venue	Persons From:	Purpose	Persons Attending:
11/14/2009	Farah	PRT	Trevor Hublin - USAID Darren Richardson - USDA Major Wayne A. Bodine - USMC.	Update on progress; review of report outline; Farah River Basin Summary Overview.	V. Uhl, Q. Tahiri, Ed Brooks, Tim Michael
11/21/2009	Farah	PRT	Trevor Hublin - USAID Darren Richardson - USDA Major Wayne A. Bodine - USMC Marine Commanders from Bakwa and Gulistan Districts	PowerPoint presentation of Principal Findings and Recommendations for moving forward.	V. Uhl, Q. Tahiri, Andy Curtin, Tim Michael
12/3/2009	Kabul	USAID	Joseph Goodwin, USAID/OAG Darren Richardson - USDA	PowerPoint presentation of Principal Findings and Recommendations for moving forward	V. Uhl, Q. Tahiri

TABLE 2. SUMMARY OF INVENTORIED WELLS: BAKWA DISTRICT

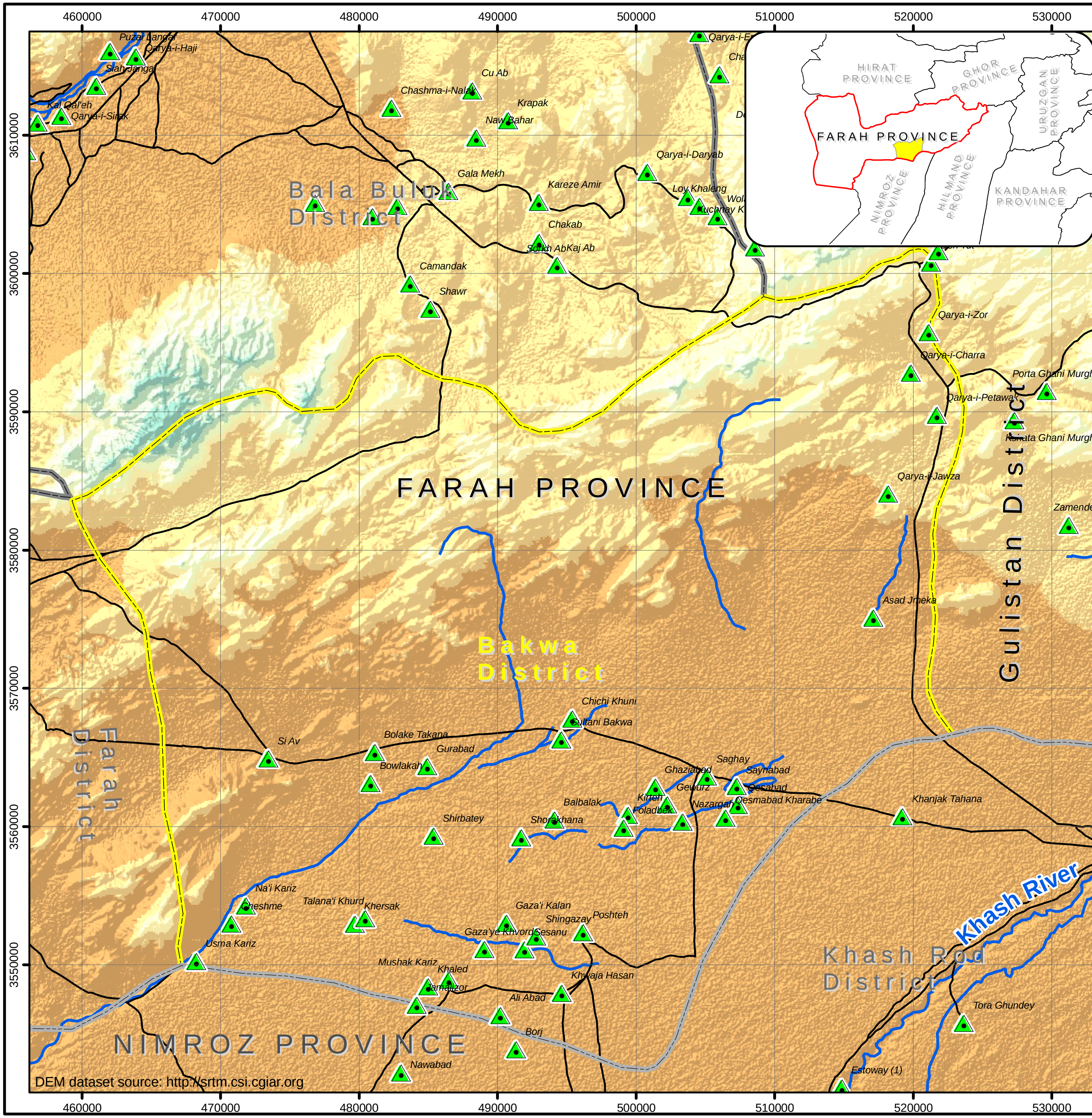
Well No.	*Well Location*	*pH*	*Conductivity (umhos/cm)*	*UTM Coordinates*		*Elevation (m, amsl)*	*Static Water Level (m, bgs)*	*Remarks*
				Northing	*Easting*			
1	Sultani Bakwa	8.2	1050	3567266	495232	708	10	
2	Sultani Bakwa	8.5	1052	3566986	495017	721	8	
3	Sultani Bakwa	8.5	1127	3566739	494693	726	8	
4	Dewalak	8	813	3569940	490399	741	10	
5	Dewalak	8	814	3567115	490901	720	9	
6	Shoraka	8	1285	3566831	491675	727	12	
7	Shoraka	8.5	1226	3566850	496417	733	11	
8	Barghana	8	1182	3564336	496268	698	11	
9	Chichi	8.5	731	3570022	495743	727	10	
10	Chichi	8	742	3569100	495654	733	10	
11	Balak	8.5	753	3567387	481079	715	13	
12	Balak	8	744	3567714	477027	721	12	
13	Koragaz	8.2	1349	3566418	485046	710	11	
14	Koragaz	8.4	1213	3567678	487964	711	11	
15	Koragaz	8.2	1343	3562472	492892	712	11	
16	Azizabad	8	1155	3566491	489691	718	11	
17	Azizabad	8.5	1213	3563317	486610	712	10	
18	Bolak	8	1223	3564111	494596	721	12	
19	Bolak	8.5	1155	3562735	491459	728	12	
20	Bolak	8	1050	3566495	492020	724	12	
21	Ashkeen	8	591	3562725	512554	792	23	
22	Ashkeen	8	591	3570213	512935	789	23	
23	Ashkeen	8	591	3565080	509321	789	23	
24	Charbak	8	493	3573603	531081	765	25	Plots off Map
25	Charbak	8	493	3543454	510771	757	25	Plots off Map
26	Mehdadi	8	490	3569859	512464	803	26	
27	Mehdadi	8	490	3574220	507285	801	26	
28	Mehdadi	8	490	3580844	510943	804	26	
29	Sharbati	8.2	495	3574703	507346	735	14	
30	Sharbati	8.2	495	3576652	512845	738	14	
31	Sharbati	8.2	495	3575138	507345	733	14	
32	Aliabad	7.8	489	3544741	528512	690	12	Plots off Map
33	Aliabad	7.8	497	3556054	501947	698	12	
34	Aliabad	7.8	497	3561441	513069	699	12	

TABLE 2. SUMMARY OF INVENTORIED WELLS: BAKWA DISTRICT

Well No.	Well Location	pH	Conductivity (umhos/cm)	UTM Coordinates		Elevation (m, amsl)	Static Water Level (m, bgs)	Remarks
				Northing	Easting			
35	Borj	8	536	3556427	502601	748	15	
36	Borj	8	536	3550746	502522	744	15	
37	Borj	8	538	3543175	508940	741	15	
38	Nazaghah	8	532	3557995	506341	738	12	
39	Nazaghah	8	532	3570701	507914	736	12	
40	Nazaghah	8	555	3563509	514558	733	12	
41	Khaja Hasan	8	494	3562546	518754	794	17	
42	Khaja Hasan	8	497	3556120	518779	728	17	
43	Khaja Hasan	8	494	3556259	520306	730	17	
44	Sagay	8	539	3575001	509184	770	22	
45	Sagay	8	539	3562221	503042	778	22	
46	Poshta	8	540	3562299	509033	770	19	
47	Poshta	8	545	3576933	511391	772	19	
48	Poshta	8	540	3562253	514644	775	19	
49	Sogaz	8	474	3569947	502883	788	17	
50	Sogaz	8	478	3576987	531831	785	17	Plots off map
51	Joisafrid	8.5	494	3565473	507926	753	16	
52	Joisafrid	8.5	494	3565795	507172	752	16	
53	Joisafrid	8.5	490	3565826	507441	753	16	
54	Jamalzor	8	470	3570403	511833	792	17	
55	Jamalzor	8	474	3571783	512454	794	17	
56	Jamalzor	8	471	3569686	511810	774	17	
57	Gaziabad	8.2	544	3556355	511365	745	15	
58	Gaziabad	8	544	3574827	502231	743	15	
59	Gaziabad	8	555	3571287	509472	741	15	
60	Asad	8	480	3571807	516100	792	27	
61	Asad	8.2	485	3571757	517819	800	27	
62	Asad	8	480	3571582	518897	810	27	
63	Daman	8	517	3572900	503316	743	33	
64	Daman	8	514	3574866	508059	743	33	
65	Syaqala	8.5	567	3565786	512901	751	16	
66	Syaqala	8.5	567	3567807	517821	749	16	
67	Syaqala	8	567	3558366	515794	749	16	

m, amsl - meters above mean sea level.
m, bgs - meters below ground surface.

FIGURES



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Coordinate System: UTM Zone 41 N; Datum: WGS 84

N W E S

Miles
5 2.5 0 5

10 5 0 10
Kilometers

Legend

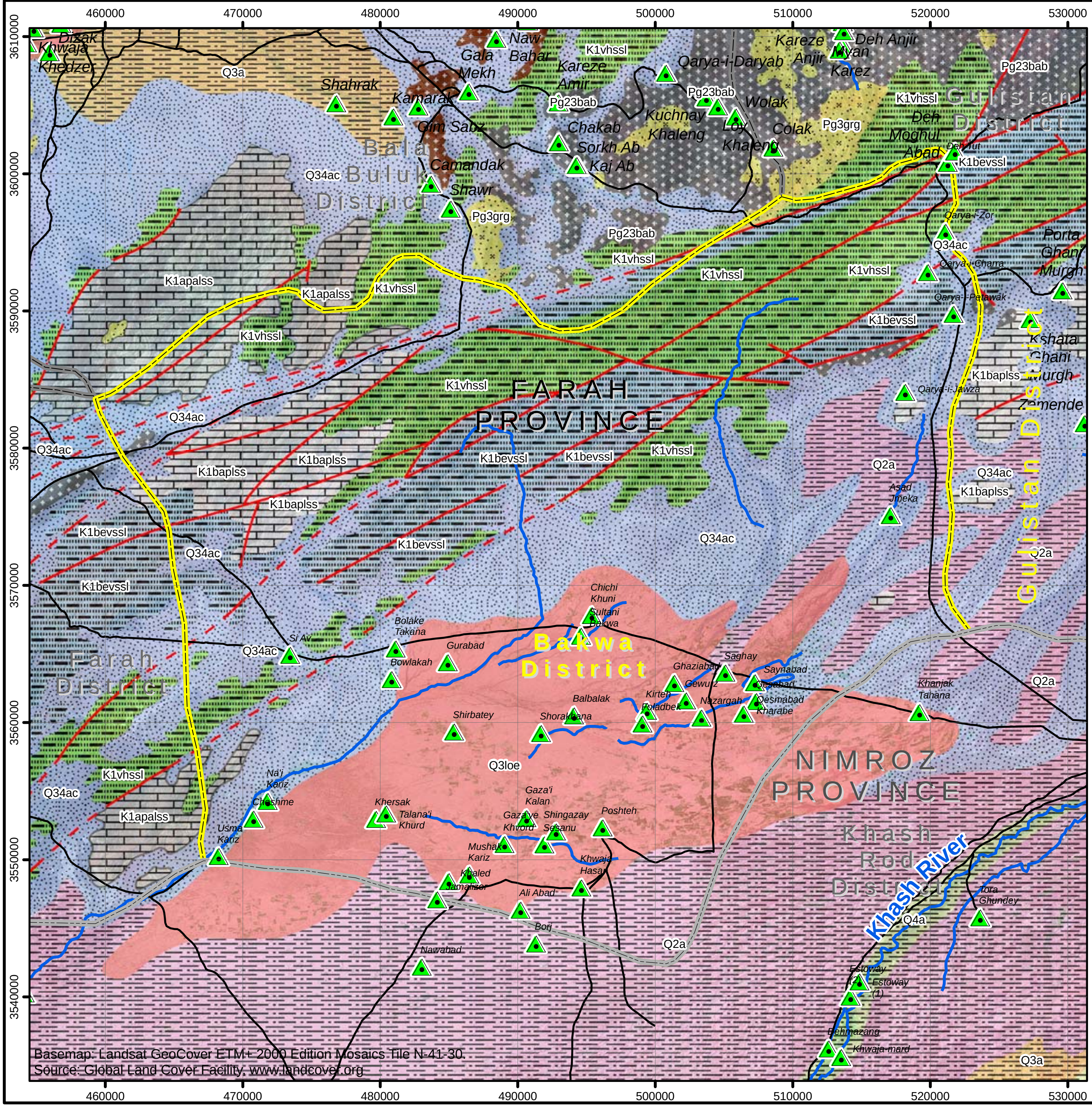
- Village/Settlement
- Drainage
- Roads
- Selected District Boundary
- District Boundary
- Province Boundary

Elevation in Meters Above Mean Sea Level

- <450 amsl
- 450 - 600
- 600 - 900
- 900 - 1200
- 1200 - 1500
- 1500 - 1800
- 1800 - 2100
- 2100 - 2500
- 2500 - 3000
- 3000 <

FIGURE 1

Shaded Relief Map, Bakwa District



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Miles
5 2.5 0 5
10 5 0 10
Kilometers

N E S W

Legend

- Village/Settlement
- Drainage
- Roads
- Selected District Boundary
- District Boundary
- Province Boundary
- Normal Fault - Concealed
- Normal Fault - Confirmed

Bedrock Geology*

Unit - Lithology

- Q4a - Conglomerate and Sandstone (Youngest)
- Q34ac - Fan Alluvium and Colluvium
- Q3a - Conglomerate and Sandstone
- Q3loe - Loess
- Q2a - Conglomerate and Sandstone
- Pg3grg - Granite and Granodiorite
- Pg23bab - Basaltic Andesite and Basalt
- K1apalss - Limestone and Sandstone
- K1baplss - Limestone and Sandstone
- K1vhssl - Sandstone and Siltstone
- K1bevssl - Basalt
- K1bevssl - Sandstone and Siltstone (Oldest)

*Geology Data Source: USGS (2006)

FIGURE 2

Geologic Map of Bakwa District

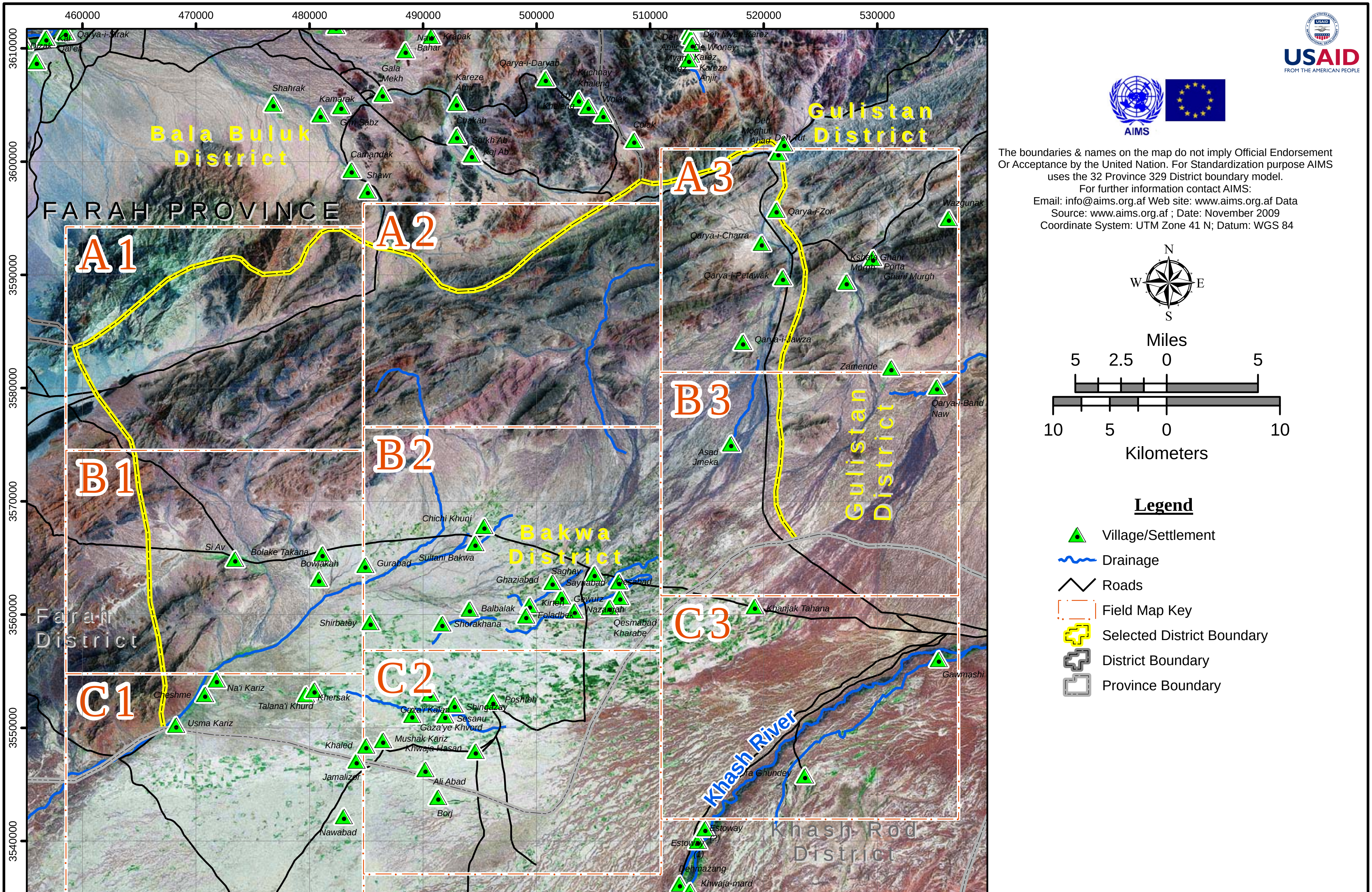
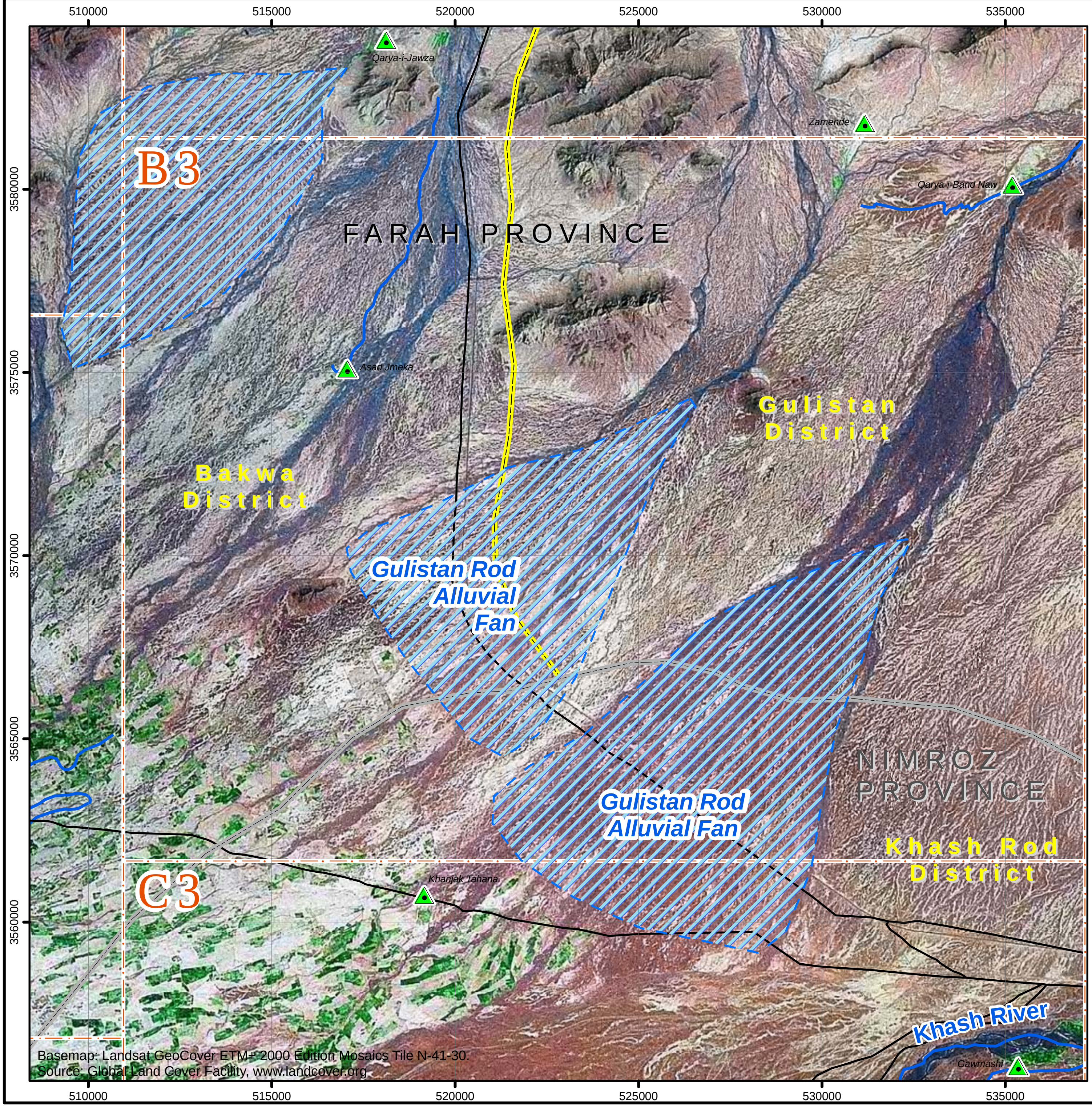


FIGURE 3

Satellite Image Base Map, Bakwa District



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Coordinate System: UTM Zone 41 N; Datum: WGS 84

N
W E
S

Miles
2 1 0 2
3 1.5 0 3
Kilometers

Legend

- Village/Settlement
- Drainage
- Roads
- Field Map Key
- Approximate Extent of Alluvial Fan
- Selected District Boundary
- District Boundary
- Province Boundary

FIGURE 4

Satellite Image Depicting Alluvial Fans from Gulistan Rod and Other Drainages from the East-Northeast

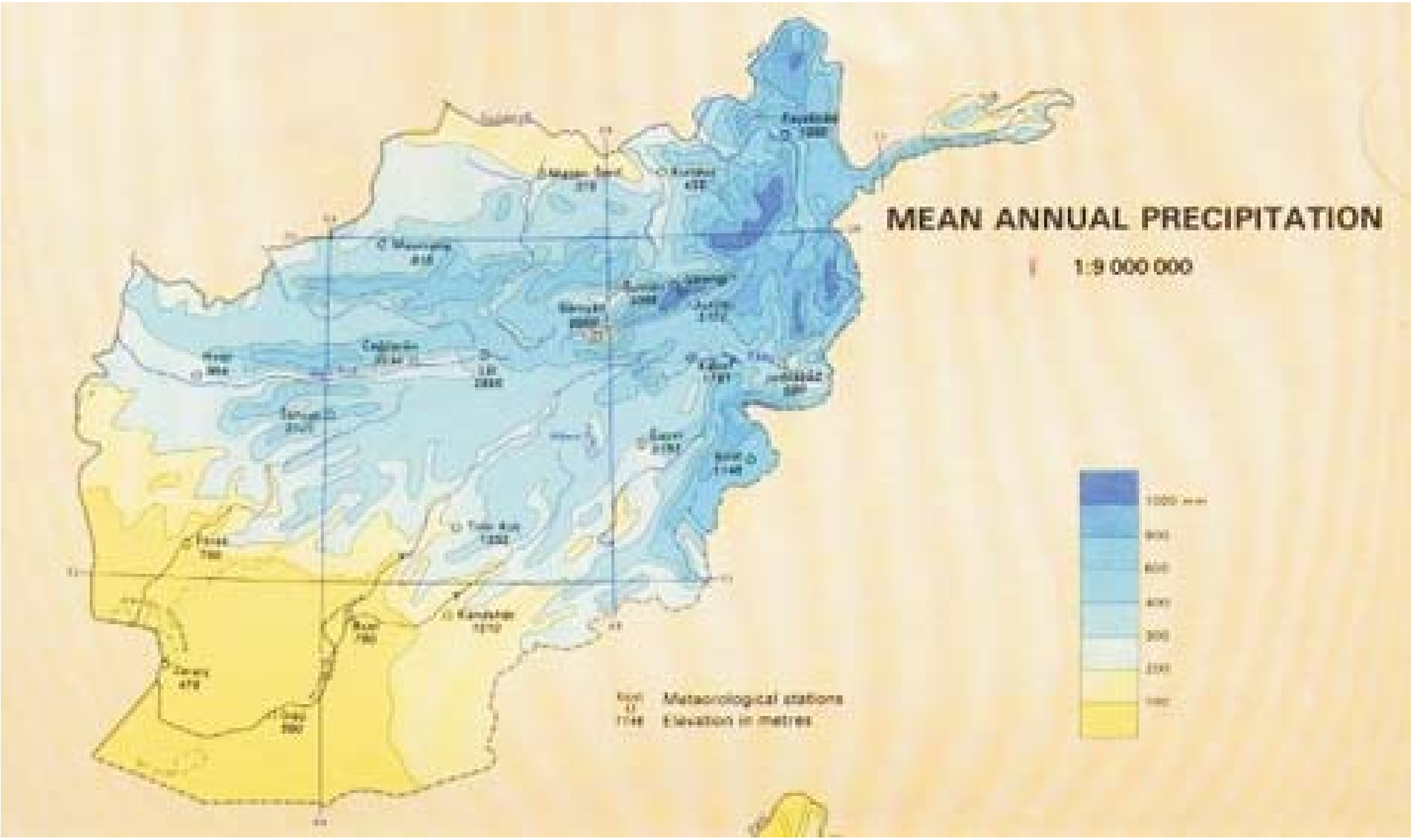
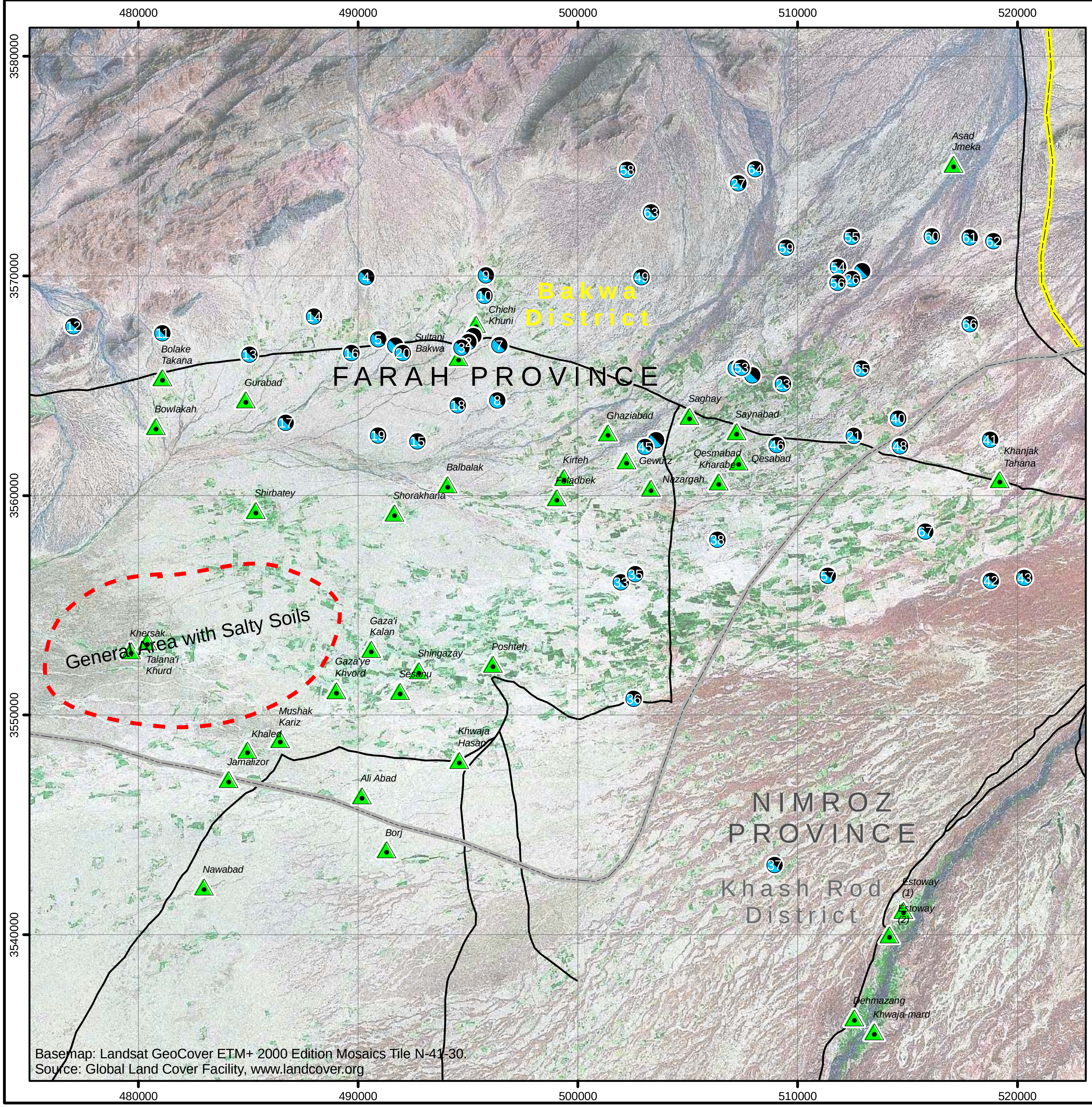


FIGURE 5

Mean Annual Precipitation Distribution
(Geokart 1984)



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Coordinate System: UTM Zone 41 N; Datum: WGS 84

N S W E

Miles
3 1.5 0 3

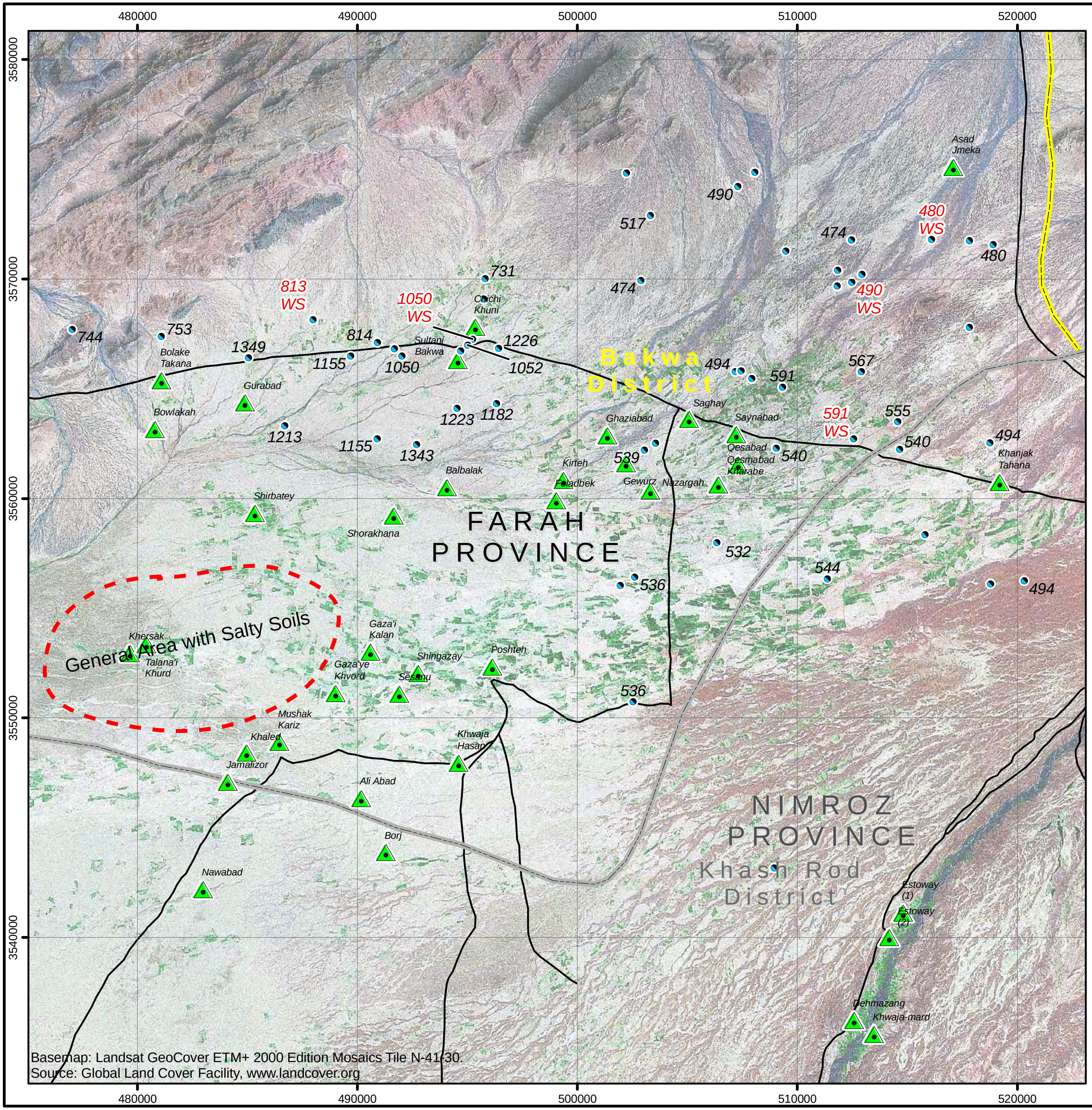
6 3 0 6
Kilometers

Legend

- Village/Settlement
- 12: Well ID No.
- Roads
- Selected District Boundary
- District Boundary
- Province Boundary

FIGURE 6

Map Showing Inventoried Well Locations



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Coordinate System: UTM Zone 41 N; Datum: WGS 84

N
W E
S

Miles
3 1.5 0 3
6 3 0 6
Kilometers

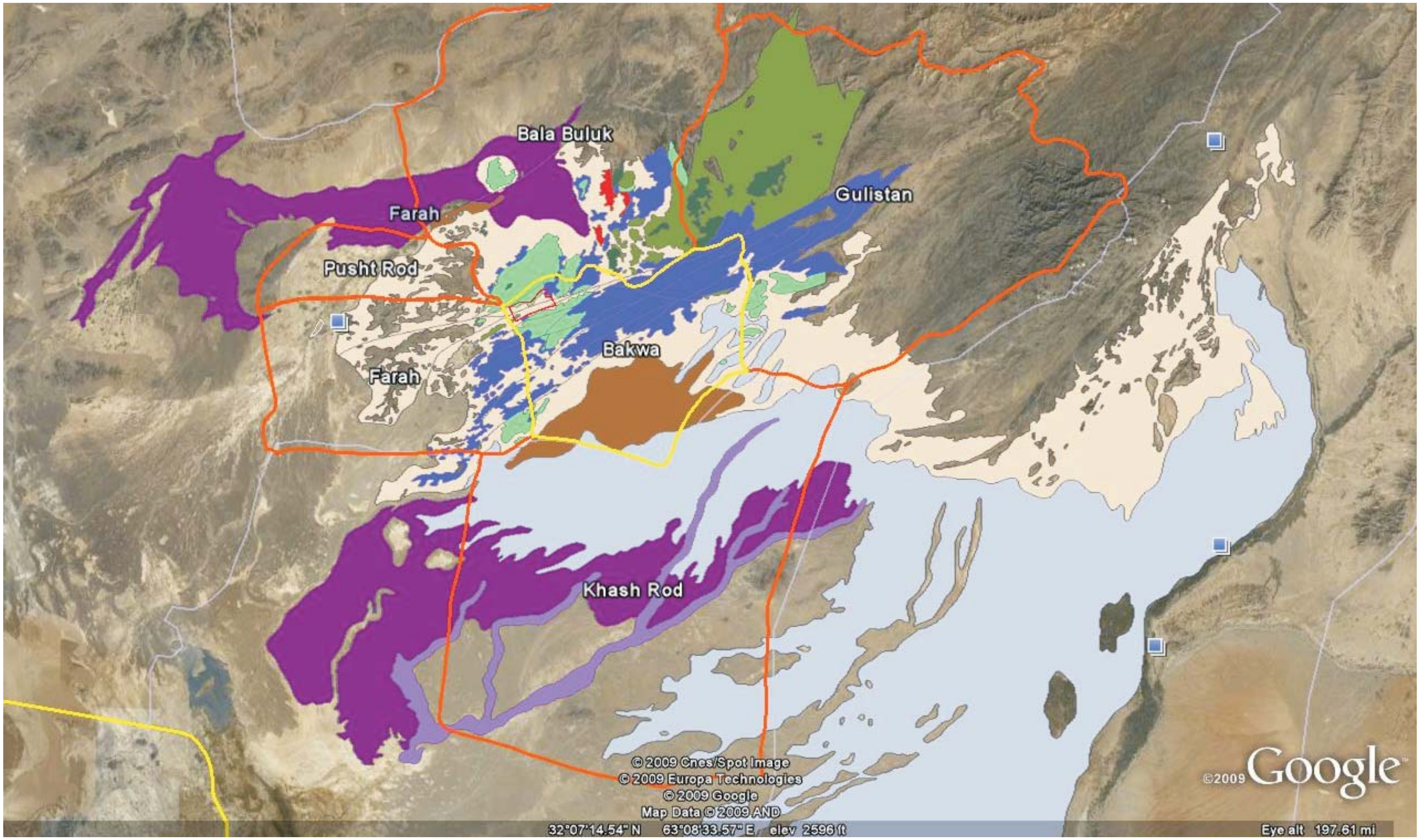
Legend

- Village/Settlement
- Roads
- Selected District Boundary
- District Boundary
- Province Boundary
- Well Location

1127: Electrical Conductivity (umhos/cm)
WS: Water Sample Sent to DACAAR for Analysis

FIGURE 7

Electrical Conductivity Levels in Inventoried Wells



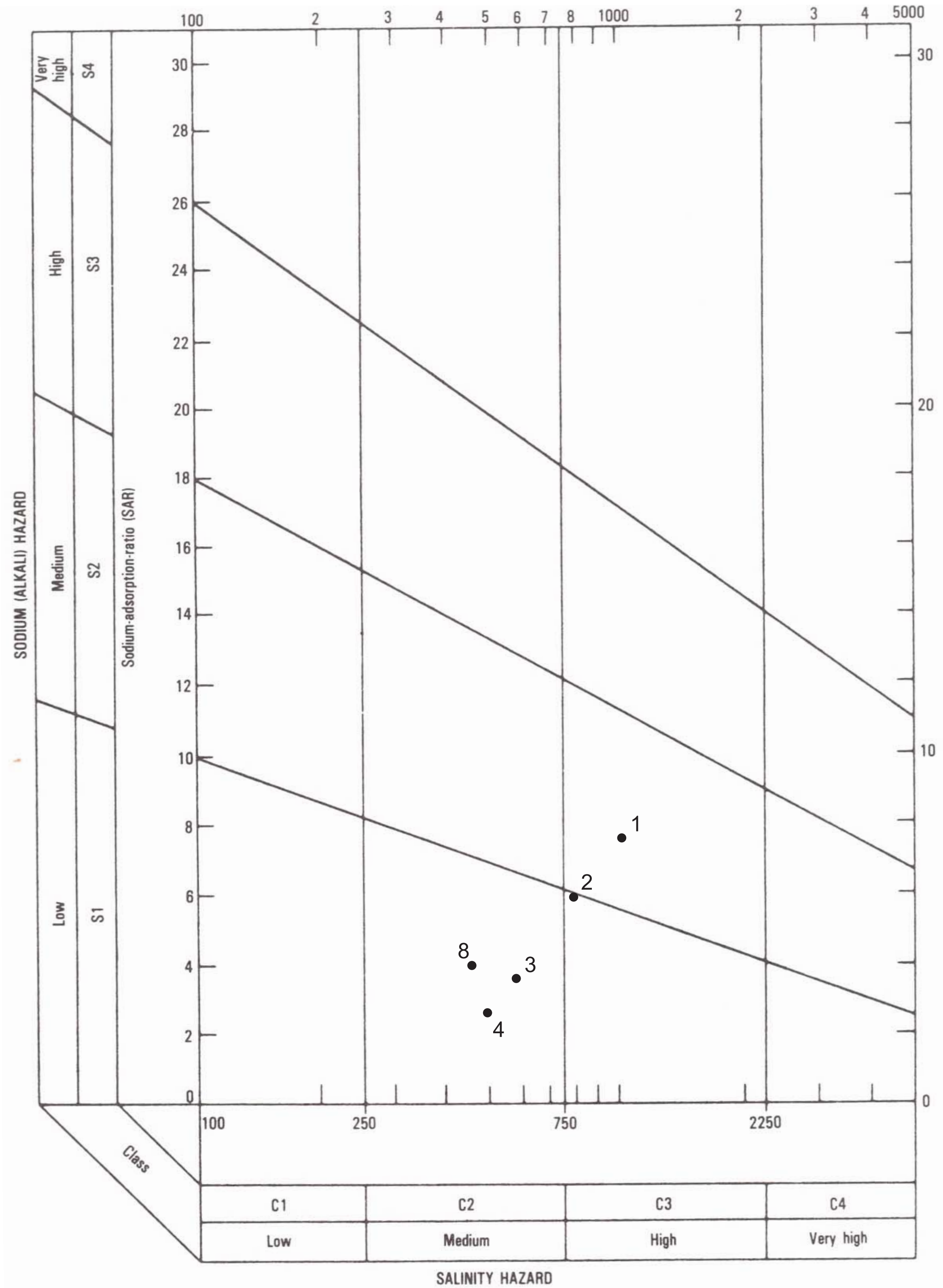
Legend

Conglomerate and Sandstone	Granite and Granodiorite
Fan Alluvium and Colluvium	Basaltic Andesite
Conglomerate and Sandstone	Limestone and Sandstone
Loess	Basalt
Conglomerate and Sandstone (Principal Aquifer)	Sandstone and Siltstone

FIGURE 8

Geologic Map of Bakwa District and Region

Electrical Conductivity, in Micromhos Per Cm
at 25 Degrees Centigrade



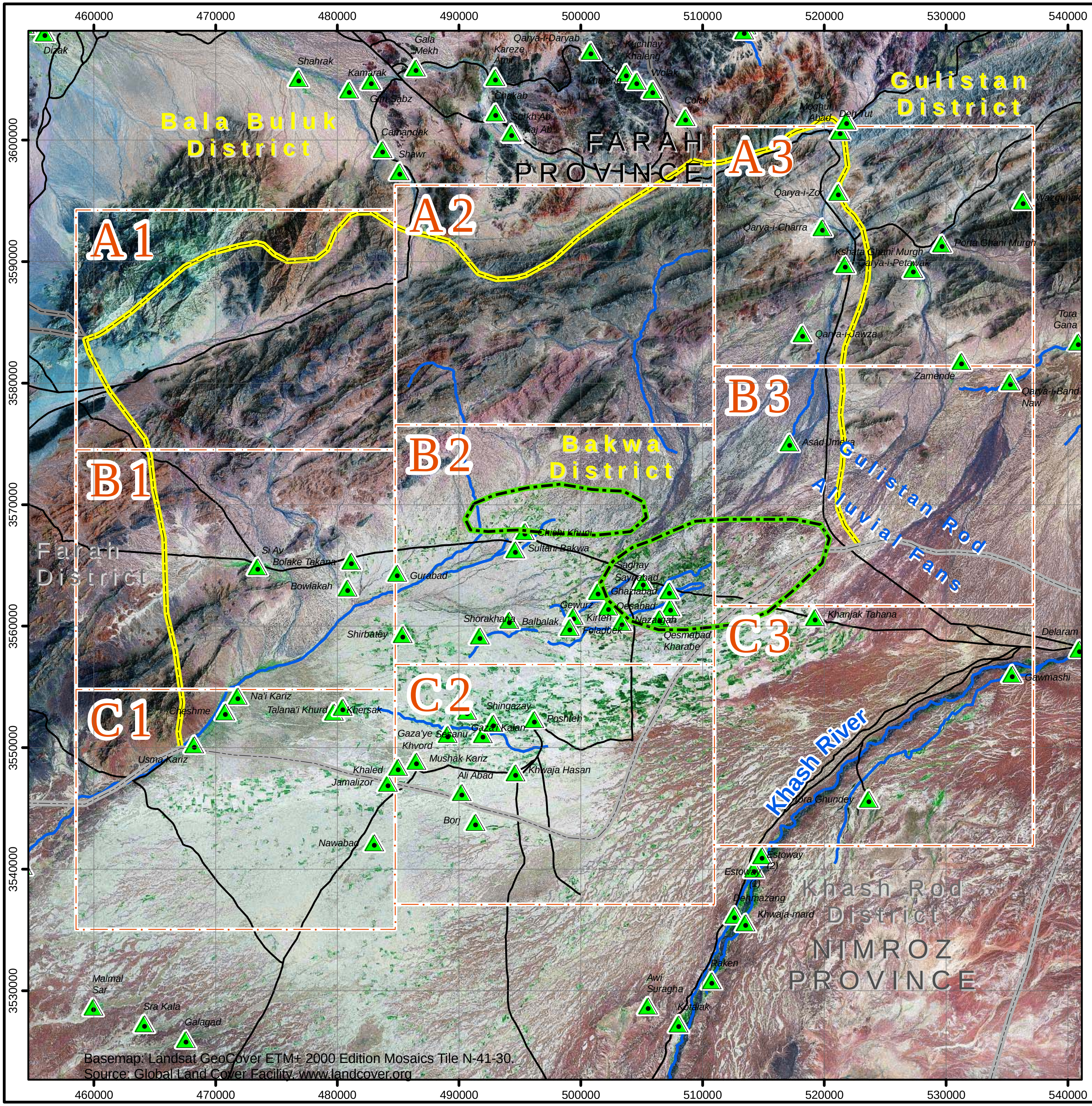
Adapted from U.S. Salinity Laboratory staff (1954)

Legend

● 2 - Water Sample No.

FIGURE 9

Plot of Sodium Adsorption Ratio vs. Electrical Conductivity for Water Samples in Bakwa District



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Email: info@aims.org.af Web site: www.aims.org.af Data Source: www.aims.org.af ; Date: November 2009
Coordinate System: UTM Zone 41 N; Datum: WGS 84

Miles: 5 2.5 0 5
Kilometers: 10 5 0 10

Legend

- Village/Settlement
- Drainage
- Roads
- Recommended Area
- Field Map Key
- Selected District Boundary
- District Boundary
- Province Boundary

FIGURE 10

Outline of Recommended Areas for New Demonstration Farms

APPENDIX A

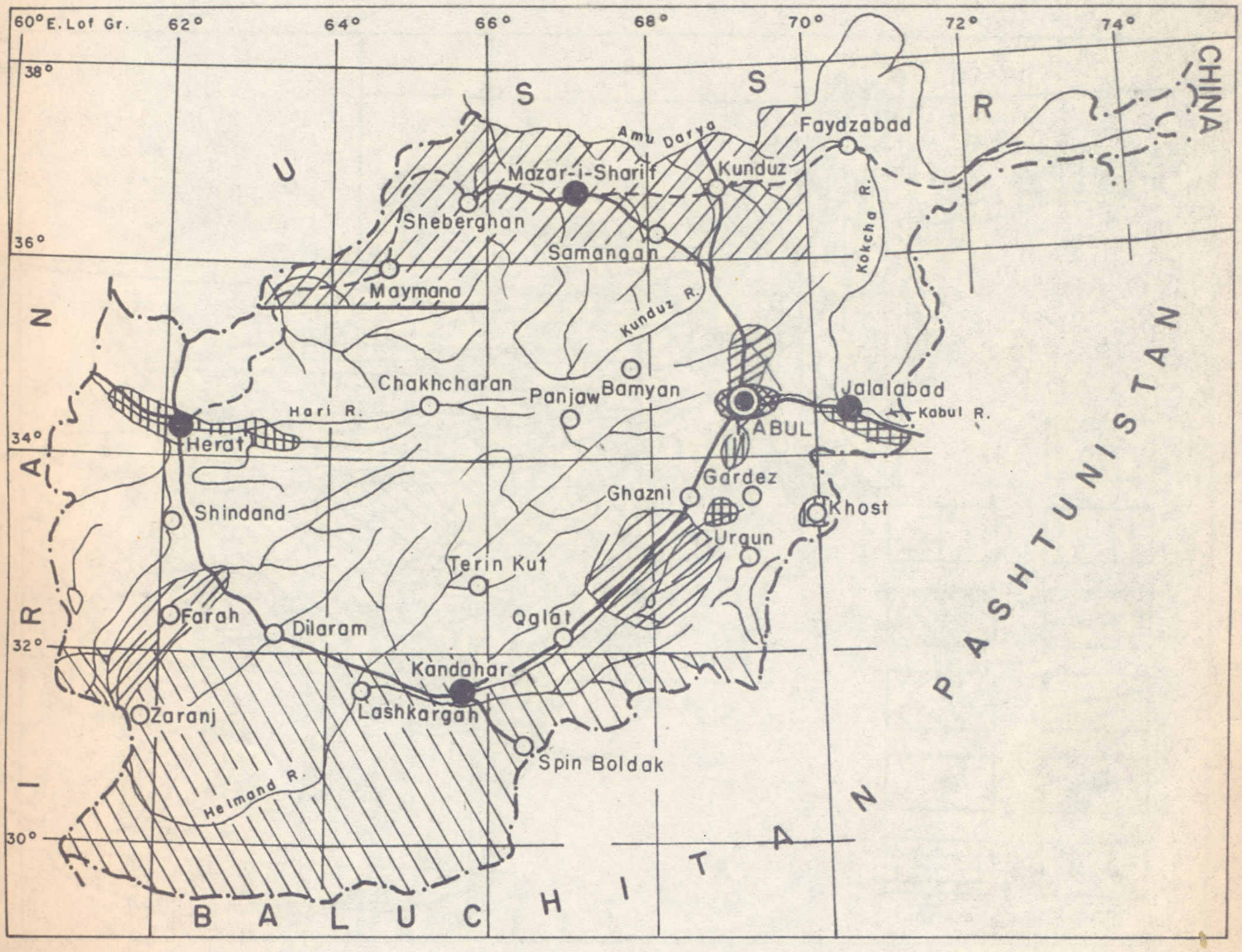
Well Logs and Maps from 1975 GOA Work and Test Well Location Map Superimposed on 2009 Study Base Map.

HYDROGEOLOGICAL INVESTIGATION

IN AFGHANISTAN

Scale 1:8,000000

1975



LEGEND

Hydrogeological survey conducted in scale of 1:25000

Hydrogeological survey conducted in scale of 1:50,000

Hydrogeological survey conducted in scale of 1:100 000

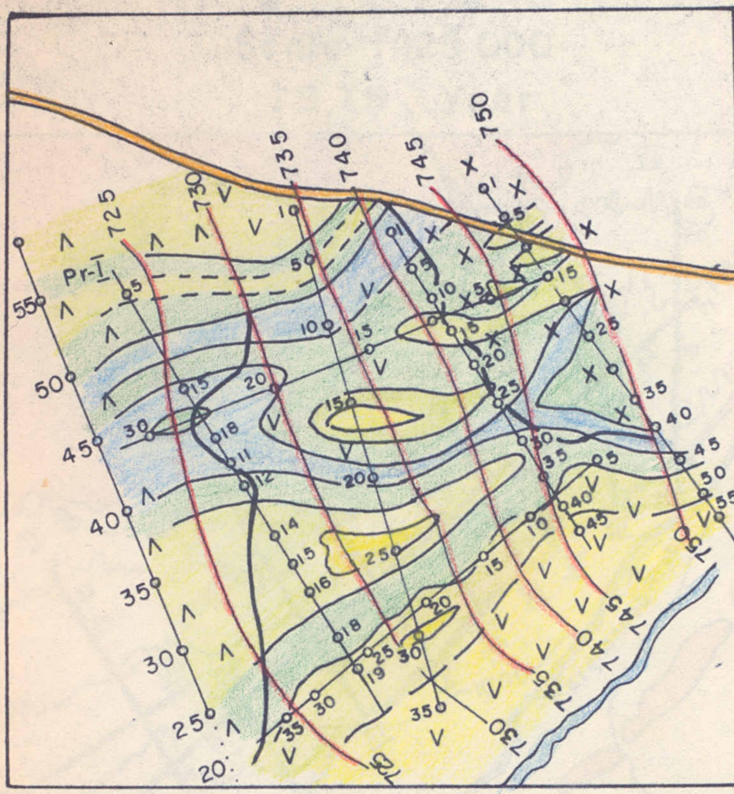
Hydrogeological survey conducted in scale of 1:250,000

Hydrogeological survey conducted

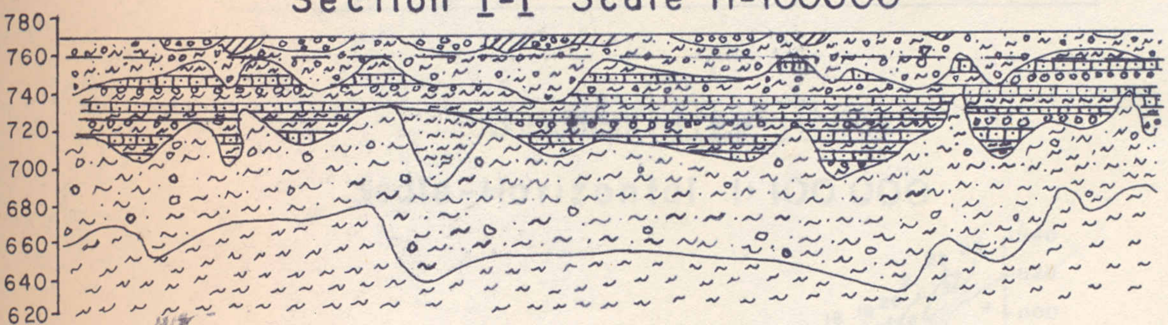
HYDROGEOLOGICAL MAP OF BAKWA PROJECT AREA

Scale 1:250,000

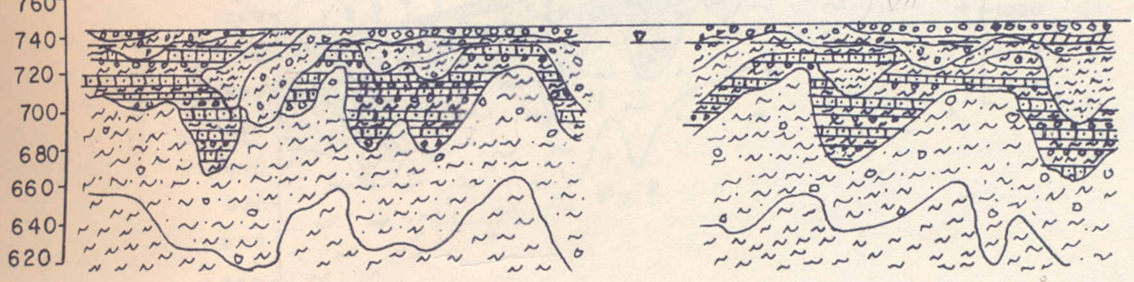
1975



Section I-I Scale H-100000



Section II-II Scale H-125000



Pr I o-o-o-o-I Geophysical profile and VES points

750 Hydroisohypse

1. Depth to groundwater level

Up to 10m

2. Thickness of water-bearing deposits

Up to 30m

From 30 to 50m

3. Lithological Legend.

Loam

Clay

Clay occasionally interlayered by thin layers, of gravel & sand

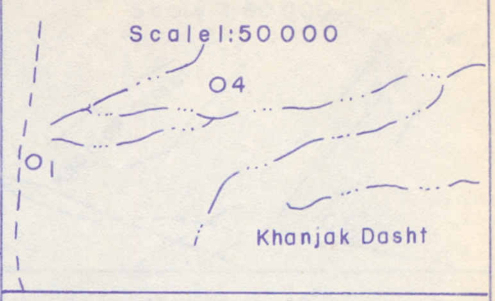
Interlayer of-clay sand and gravel

MINISTRY OF WATER AND POWER

Appendix No 21

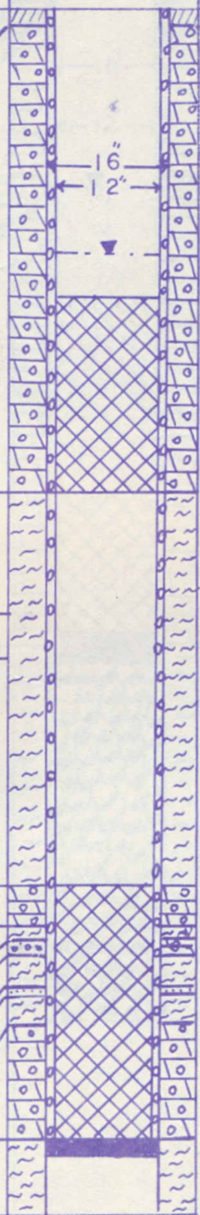
WATER AND SIOL SURVEY AUTHORITY:GROUND WATER BRANCH

Drilled well register No Regional code No 4	Coordinates Loti 63°–11′–16″ Longi 32°–7′–00″	Location scheme of Borehole Scale1:50000
Location Dasht-i-Bakwa; Farah Province	Well type Production Drilling method: Percussion	
Elevation of ground surface 770 m Elevation of well mouth 770 50m	Drilling date Depth: 80 m	Drilling diameter 16″ Filter diamete 12″



Type of filter slotted(mild stell)pipe filter interval 19-32 and 58-75 m — Slots opening 2.5 mm (17 %)

Geologic index	Depth (m)	Thickness (m)	Lithological Description	Geological and Construction section Scale 1:	Water level	Remarks
Q	1.2	1.2	Loam, light, gray.			
	32	30.8	Conglomerates, weak and compact calcareous-clayey size of grains is 0.6-6cm; from the depth of 19.2 m water bearing.		16.4	
	40	8	Clay, greyish, yellow with fine gravels			
	43	3	Clay with compact with fine gravels.			
	58	15	Clay, compact whitish-grey.			
	61	3	Conglo. hard on carbona cement size of grain is 0.4-2.0m.			
	62	1	Clay, very compacted greysh white.			
	63	1	Conglom. hard on corbonate cement.			
	65	2	Clay compacted greyish-white.			
	66	1	Sandstone fine grained weak.			
	69	3	Clay compacted whitish-grey.			
	75	6	Conglomerate hard on corbonate cement size of graine 0.4-3.4 cm water bearing			
	80	>5	Clay compacted yellowish brown crumbed.			

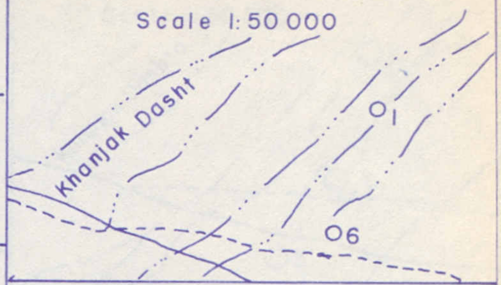


MINISTRY OF WATER AND POWER

Appendix No 22

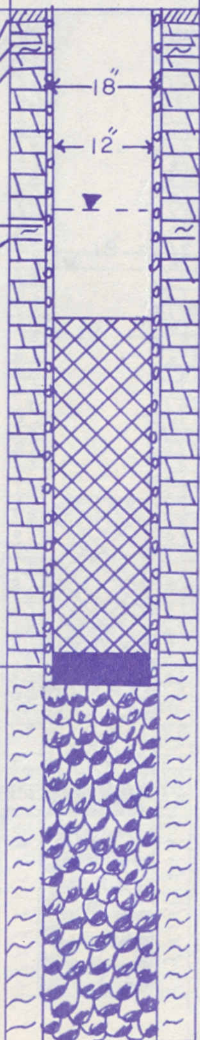
WATER AND SOIL SURVEY AUTHORITY:GROUND WATER BRANCH

Drilled well register No Regional code No 6	Coordinates Lati 63° − 11′ − 37″ Longi 32° − 10′ − 24″	Location scheme of Borehole Scale 1:50 000
Location Dasht-i-Bakwa, Farah Province	Well type Production Drilling method Percussion	
Elevation of ground surface: 780m Elevation of well mouth: 780 50m	Drilling date Depth: 96m	Drilling diameter 18″ Filter diameter 12″



Type of filter OBO, filter interval 29 − 60 m   Slot opening 15 − 17 %

Geologic index	Depth (m)	Thickness (m)	Lithological Description	Geological and Construction section Scale 1:	Water level	Remarks
	0.5	0.5	Sandy loam, light, grey, with gravels.			
	3	2.5	Conglomerate, weak.			
	4	1	Clay compact, brownish-grey.			
	20	16	Conglomerate, weak chalky clayey.		18.5 25.V.74	
	21	1	Clay compact, yellowish-grey.			
	61	40	Conglomerate weak chalky clayey water bearing.			
NEOGEN	96	35	Clay, compact, white, with carbonate salts.			



Scale: 7, 14, 21, 28, 35, 42, 49, 56, 63, 70, 77, 84, 91, 98, 105, 112, 119

MINISTRY OF WATER AND POWER

Appendix No = 23

WATER AND SOIL SURVEY AUTHORITY: GROUND WATER BRANCH

Drilled well register No

Regional code No 3

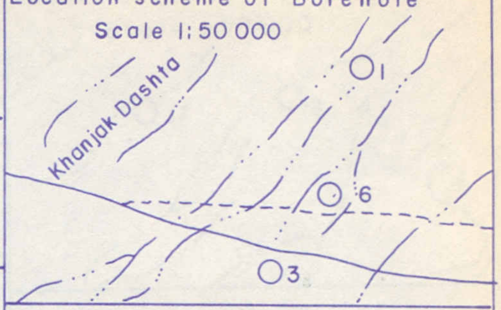
Coordinates.

Lati $63^{\circ} - 11' - 15''$

Longi $32^{\circ} - 10' - 9''$

Location scheme of Borehole

Scale 1:50 000



Location: Dasht-i-Bakwa Farah, Province

Well type: Production

Drilling method Percussion

Elevation of ground surface 765m

Elevation of well mouth 765.50m

Drilling date

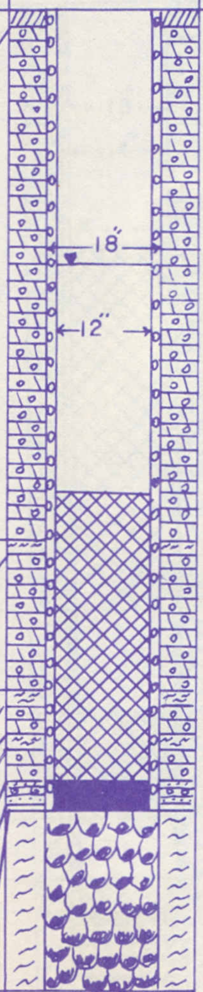
Depth 65m

Drilling diameter 18"

Filter diameter 12"

Type of filter OBO, filter interval 32-51 m   Slots opening 17 %

Geological and Construction section Scale



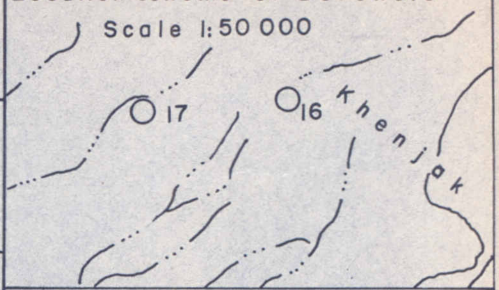
Geologic index	Depth (m)	Thickness (m)	Lithological Description	Water level	Remarks
	1	1	Sand loam, light, light-grey		
	35	34	Intercalation of hard compact and weak conglomerates, chalky clayey cement. From the depth of 20 m-water bearing.	16.5m	
	36	1	Clay, compact, grey.		
	45	9	Interchange of weak and compacted conglomerates on chalky-clayey cement, water bearing.		
	46	1	Clay compact, grey.		
	48	2	Conglo. compact on carbonate cement.		
	49	1	Clay, compact, grey.		
	51	2	Conglo. compact carbonate cement.		
	52	1	Sandstone, fine-grained, grey.		
	53	1	Conglo weak on clayey cement.		
	65	12	Clay, compact yellowish grey.		

MINISTRY OF WATER AND POWER

Appendix No 24

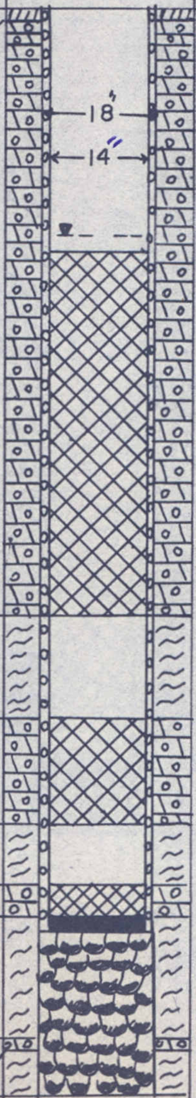
WATER AND SIOL SURVEY AUTHORITY: GROUND WATER BRANCH

Drilled well register No Regional code No 17	Coordinates Lati 63°–10′ – 2″ Longi 32°–6′ – 35″	Location scheme of Borehole Scale 1:50 000
Location Dasht-i-Bakwa; steppe, Farah Province	Well type Production Drilling method: Percussion	
Elevation of ground surface 760m Elevation of well mouth 760.50m	Drilling date From / to Depth 71mm	Drilling diameter 18″ Fillter diameter 14″



Type of filter shulter type filter interval 16-40, 49-54 and 58-60m. Slot opening 25 %′ (14″ (mm) 350mm)

Geologic index	Depth (m)	Thickness (m)	Lithological Description	Geological and Construction section Scale 1:	Water level	Remarks
Q	0.6	0.6	Sandy loam light, grey			
NEOGENE	40	39.40	Intercalation of conglomerates from saft to hard of light grey colour with clayey cementation.		15.0m	
	47	7	Clay, light-grey, compacted crumbed.			
	54	7	Conglomerate, hard carbonate water bearing.			
	58	4	Clay, compacted crumbed – greyish-brown.			
	60	2	Conglome compacted water.bearing.			
	68	8	Clay, compacted crumbe, greyish brown.			
	69	1	Conglome. saft, water-bearing.			
	71	>2	Clay, compacted, crumbed.			



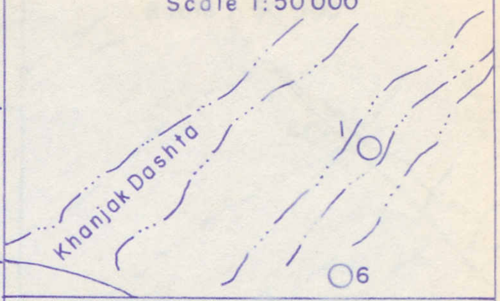
Depth scale: 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85

MINISTRY OF WATER AND POWER

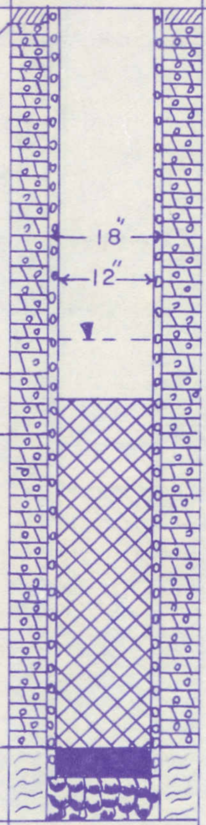
Appendix No 25

WATER AND SOIL SURVEY AUTHORITY: GROUND WATER BRANCH

Drilled well register No Regional code No I	Coordinates Lati 63°-0-0 Longi 32°-10′-50″	Location scheme of Borehole Scale 1:50000
Location Dasht-i-Bakwa, Farah Provinc	Well type: Production Drilling method	
Elevation of ground surface 790 m Elevation of well mouth 790.50 m	Drilling date From / to Depth: 54 m	Drilling diameter 18″ Filter diameter 12″



Type of filter OBO, filter interval 26 - 49 m; Slot opening 2.5 mm (17 %)



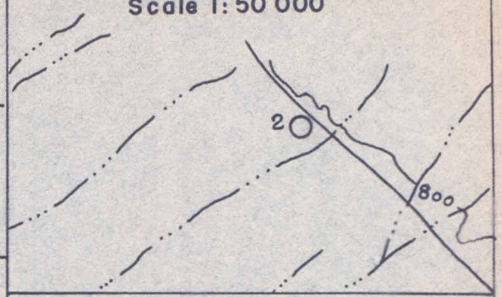
Geologic index	Depth (m)	Thickness (m)	Lithological Description	Geological and Construction Section Scale1:	Water level	Remarks
	0.8	0.8	Sandy loam light			
	24	23.2	Conglomerate weak on clayey cement, size of porholes ronglo from 1-2 cm to 8-9 cm		22.10 m	
	28	4	Gravelite, weak on clayey cement			
	41	13	Conglomerate, hard, on carbonate cement water bearing.			
	49	8	Conglomerate solt - fine gravel water bearing.			
	53	4	Clay, compact yellowish grey			

MINISTRY OF WATER AND POWER

WATER AND SOIL AUTHORITY: GROUND WATER BRANCH

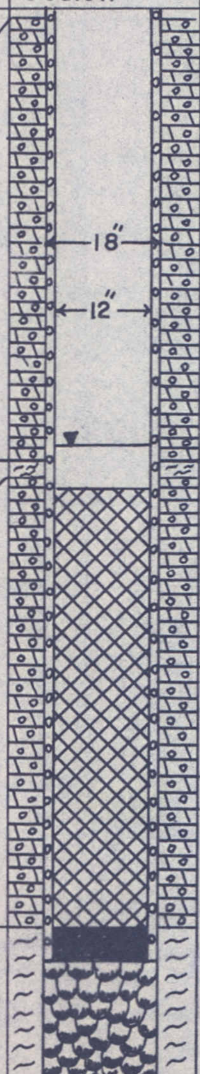
Appendix No 26

Drilled well register No Regional code No 2	Coordinates Lati 63°–11′–25″ Longi 32°–1′–43″	Location scheme of Borehole Scale 1: 50 000
Location: Dasht-i-Bakwa, Farah Province	Well type: Production Drilling method: percusion	
Elevation of ground surface: 800 m Elevation of well mouth: 800.5 m	Drilling date Depth 71 m	Drilling diameter 18″ Filter diameter 12″



Type of filter OBO, filter interval 32–62 m   Slot opening 17 % (2.5 mm

Geologic index	Depth (m)	Thickness (m)	Lithological Description	Geological and construction section Scale:	Water level	Remarks
Q	0.4	0.4	Sandy loam, heavy lightgrey.			
	30	29.6	Conglomerates; poorly compacted hard on chalky clayey cement, size of grains from 0.3-4-6 cm water bearing.		28.7 m	
	31	1	Clay - compact.			
	61	30	Conglomerates, weak compacted and hard on Carbonate and clayey – cement.			
	71	>10	Clay, white, with carbonate salts.			

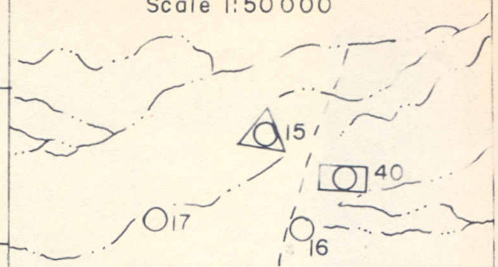


MINISTRY OF WATER AND POWER

Appendix No 27

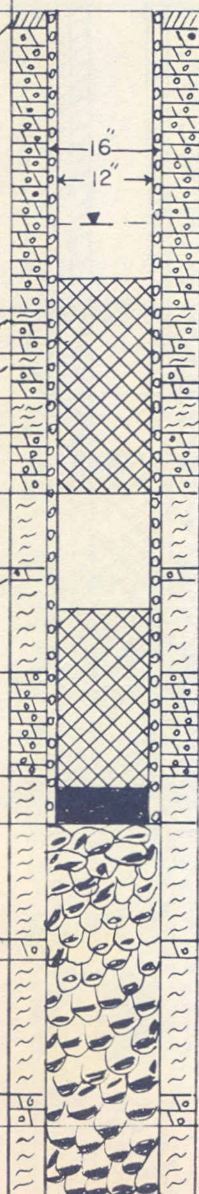
WATER AND SOIL SURVEY AUTHORITY: GROUND WATER BRANCH

Drilled well register No Regional code No 15	Coordinates Lati 69° — 10′ — 33″ Longi 32 — 5′ — 16″	Location scheme of Borehole Scale 1:50 000
Location Dosht-e-Bokwa, Farah Province	Well type: Production Drilling method: Percussion	
Elevation of ground surface: 765 m Elevation of well mouth: 765.50 m	Drilling date Depth 79 m	Drilling diameter 18″ Filter Diameter 12″



Type of filter OBO, filter interval 18-32, 40-51.5. Slots opening 17 % (2.5 mm)

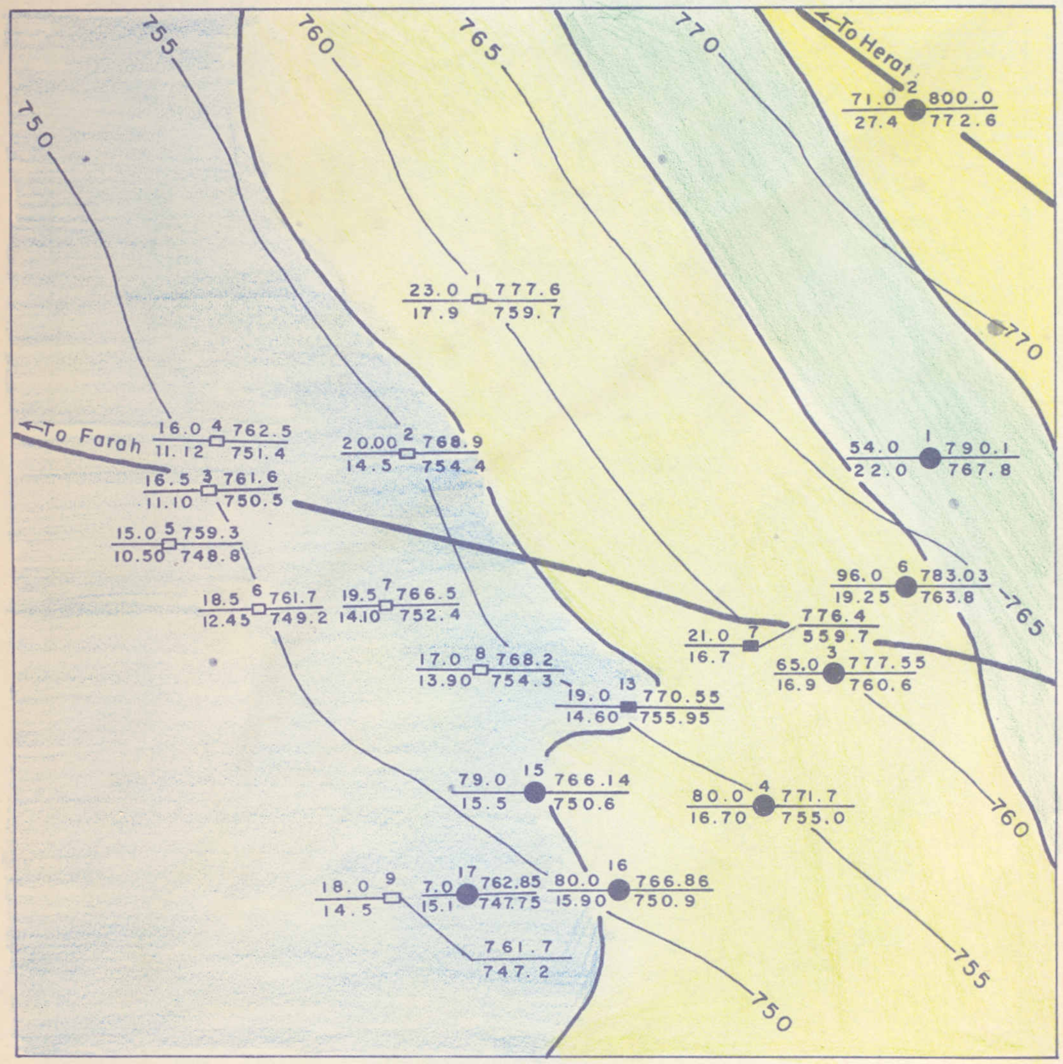
Geologic index	Depth (m)	Thickness (m)	Lithological Description	Geological and construcion Section Scale 1:	Water level	Remarks
	1.3	1.3	Sandy loam, medium grey dry			
NEOGEN	20	18.7	Conglomerate, hard, on calcareous cement. Occasional interlayers of weak conglomerate from the depth of 18.0 m; the rock is water bearing.		14.5 m	
	21	1.0	Clay yellowish-grey.			
	23	2.0	Conglomerate weak on clayey cement.			
	24	1.0	Clay grey.			
	26	2.0	Conglomerate weak.			
	28	2.0	Clay, conglomerated greyish yellow.			
	32	4.0	Conglomerate, hard on calcareous cement.			
	37	5.0	Clay, compacted, white, with sockets of carbonate salts.			
	38	1.0	Conglomerate weak on clayey cement			
	44	6.0	Clay of whitish colour compacted with sockets of carbonate salts.			
	51	7.0	Conglomerate, hard, on carbonate cement.			
	54	3.0	Clay, yellowish compacted, with carbonate salts.			
	62	8.0	Clay, white compacted crumbed.			
	63	1.0	Conglomerate, weak.			
	72	9.0	Clay, greyish_white.			
	74	2.0	Conglomerate weak.			
	79	>5	Clay, brownish grey.			



Groundwater Contours and depth to ground Water level in North East Dasht-e-Bakwa Area (Farah province)

Scale 1:100 000

Year 1975



LEGEND

Bore-hole No

54.6 1 790.1 / 22.3 767.8 — Well depth / WL — Ground surface elevation / Ground WL elevation

Project dug well No

21.0 7 776.4 / 15.7 759.7 — Well depth / WL — Ground surface elevation / Ground WL elevation

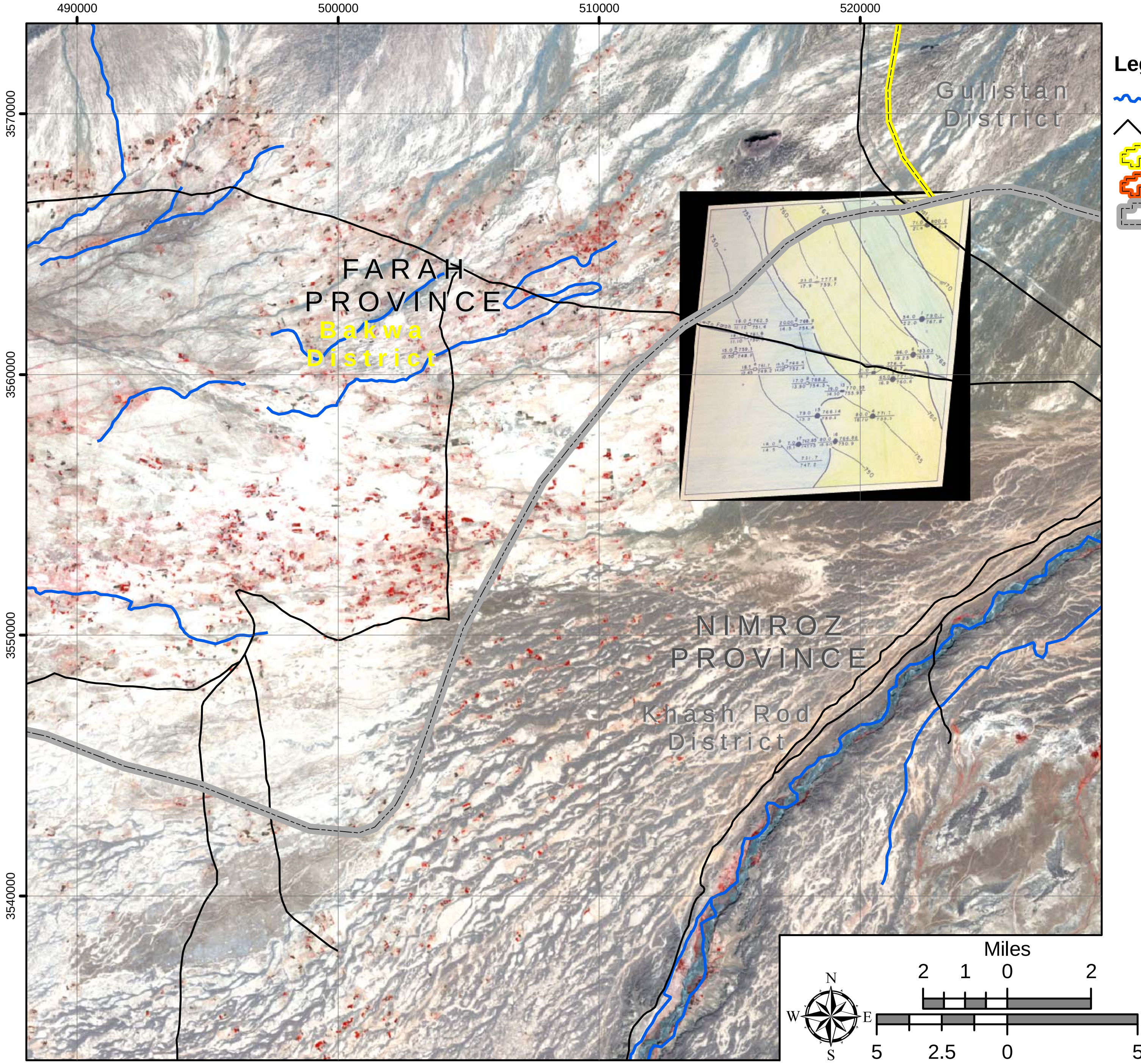
Private dug well No.

18.5 6 761.7 / 12.45 749.2 — Well depth / WL — Ground surface elevation / Ground WL elevation

750 Hydroisohypse

Depth to ground water level.

- Up to 15m.
- From 15 to 20m.
- From 20 to 25m.



Source: USGS: http://glovis.usgs.gov/

Legend

- River/Stream
- Roads
- Selected District Boundary
- District Boundary
- Province Boundary

The boundaries & names on the map do not imply Official Endorsement Or Acceptance by the United Nation.
For Standardization purpose AIMS uses the 32 Province 329 District boundary model.
For further information contact AIMS:
Email: info@aims.org.af Web site: www.aims.org.af
Data Source: www.aims.org.af ; Date: November 2009
Coordinate System: UTM Zone 41 N; Datum: WGS 84

1975 GOA Work and Test Well Location Map Superimposed on 2009 Study Base Map

Farah Province, Afghanistan

Uhl, Baron, Rana & Associates, Inc.
Lambertville, New Jersey

APPENDIX

A

APPENDIX B

Satellite Image Field Maps.
(Not Included in the Electronic Version)

APPENDIX C

Draft Drilling Specifications and Bill of Quantities (BOQ) for Production Well Drilling Program.

SPECIFICATIONS FOR DRILLING SERVICES
PRODUCTION WELL DRILLING PROGRAM FOR IRRIGATION WELLS
FARAH PROVINCE

1.0 GENERAL

1.1 Work covered by these contract documents consists of providing all work required by the Specifications complete, necessary for the drilling/installation of Irrigation Production Wells in _____ District, Farah Province, Afghanistan. The production wells must be drilled by, or under the supervision of an experienced well driller.

1.2 The production well program described herein is part of a program to increase irrigation water supply for agricultural production. ADP/SW is the CLIENT.

1.3 The drilling program will involve the following components:

1.3.1 The installation of __ production wells, 8-inch (200mm) diameter completion.

1.3.2 The development of the completed production wells and the running of step drawdown (4 steps) and 24-hour constant rate pumping tests on the completed wells.

1.3.3 The collection of water samples for analysis by the DACAAR Laboratory in Kabul.

1.4 QUALIFICATIONS OF DRILLERS

1.4.1 Equipment in first-class working order must be provided. The DRILLER shall use his own drilling equipment, having the minimum capabilities necessary to do the described work. No unnecessary delays or work stoppages will be tolerated because of equipment failure. These will not be considered as valid reasons for extending the length of the contract. The DRILLER shall be held responsible and payment may be withheld for damages to the well(s) through any cause of negligence, faulty operation, or equipment failure.

1.4.2 The DRILLER shall employ only competent workmen, expert in the performance of the type of work required by these Specifications. The crew shall be under the direct supervision of an experienced driller. The DRILLER shall provide the services of a drilling foreman, who shall be available to the job at all times. The crew and foreman shall be in the employ of the DRILLER.

1.5 CODES AND STANDARDS

1.5.1 The DRILLER shall at his own expense obtain all permits, certifications, and licenses required of him by law for the execution of the work.

1.5.2 The DRILLER shall comply with all national and provincial laws, ordinances, or rules and regulations relating to the performance of the work.

1.5.3 Where the provisions of the pertinent codes, standards, or regulations conflict with this Specification, the more stringent provisions shall govern.

1.6 MISCELLANEOUS

1.6.1 Throughout the drilling and well installation process, the well heads shall be protected from tampering with at all times when the drilling crew is not present at the site.

1.6.2 In the event that a well cannot be used for its intended purpose, the DRILLER will abandon the well, as directed by the CLIENT, by removing the well casing materials and grouting the borehole with a cement-bentonite slurry. The cement-bentonite slurry will be pressure grouted from the bottom of the borehole to the top using a tremie pipe.

1.6.3 Protection of Site: The DRILLER shall protect all structures, trees, etc. during the progress of the work and shall remove from the site all unused materials and debris and shall restore the site to its original condition. During the conduct of the work, the site will be kept tidy and in a workmanlike condition and free of rubbish and waste material.

1.7 DRILLING SITES

The drilling and installation of the production wells will be carried out at sites selected in advance by ADP/SW.

1.8 LOCAL GEOLOGY

1.8.1 The area to be drilled is underlain by several meters of unconsolidated materials which are underlain by a conglomerate and sandstone unit which is the aquifer system in which the wells will be completed.

1.8.2 Information regarding subsurface conditions is intended to assist the DRILLER in preparing its bid. The CLIENT does not guarantee its accuracy or that it is necessarily indicative of conditions to be encountered in the drilling of the well under this program. The DRILLER shall satisfy himself regarding all local conditions affecting the work by personal investigation and neither the information on local geology nor that derived from maps or drawings or the CLIENT or his agents or employees shall act to relieve the DRILLER of any responsibility hereunder or from fulfilling all of the terms and requirements of this contract and this Specification.

2.0 PRODUCTS

2.1 GROUT

Grout materials shall comply with internationally recognized requirements for sealing the annular space of wells. Grout materials shall consist of Portland Neat Cement in accordance with density ranges and water/cement ratios (a mix of Portland Cement and high-grade Bentonite using 5 pounds of bentonite per 94 pounds of Portland Cement (Type I and II only)).

2.2 CASINGS AND WELL SCREEN

2.2.1 Casing Details: The well casing shall be 8-inch diameter Class D PVC. A sample of the well casing to be used in the work must be provided to the CLIENT prior to the start of the work.

2.2.2 The DRILLER shall assume responsibility for casing failure and shall correct, subject to approval of the CLIENT, any casing failure at no cost to the CLIENT. In the event that the DRILLER cannot correct a casing failure to the satisfaction of the CLIENT, the DRILLER shall replace the casing with material complying with the Specifications at no extra cost to the CLIENT.

2.2.3 The well screen shall be of 8-inch (200 mm) diameter and approximately 20 meters long. The slot size will be 2.5mm. A sample of the well screen to be used in the work must be provided to the CLIENT prior to the start of the work.

2.2.4 Temporary Casing: The DRILLER shall provide such temporary casing as may be necessary to prevent the collapse of the formation during the drilling operations.

2.3 CENTRALIZERS

Centralizers shall be of the half moon steel strap type and shall be located at 0, 90, 180, and 270 degrees around the casing for every 10 linear meters of casing. A centralizer shall also be placed at the bottom of the well screen assembly.

2.4 FILTER PACK MATERIAL

The filter pack shall be a washed, graded material of a size distribution to be selected by the CLIENT. The filter pack shall consist of well rounded water washed silica grains. The material must contain 95 percent siliceous material and must be cleaned and washed prior to placement in the screen annulus. A sample as well as sieve analysis results must be presented to the CLIENT prior to the use of filter pack materials.

3.0 EXECUTION

3.1 PRODUCTION WELL DRILLING AND INSTALLATION

3.1.1 The Production Wells will be drilled by the Percussion (Cable Tool) Method. Initially a 14-inch (350mm) diameter borehole will be drilled by driving casing to final depth (+/- 50 meters). This will be followed by the installation of the casing and screen assembly inside of the 14-inch diameter casing.

3.1.2 The Production Well will be constructed using an approximate 20 meter length of 8- inch diameter PVC well screen and an approximate 30 meter length of 8-inch diameter PVC casing. The screen and casing string shall be equipped with centralizers and hung plumb in the borehole.

3.1.3 After installation of the 8-inch diameter well screen and casing, a properly sized filter pack will be added in the annular space via a tremie pipe to at least 5 meters above the top of the well screen. The filter pack will be added as the 14-inch diameter casing is removed from the borehole. A well construction schematic is provided in **Figure 1.**

3.1.4 A gravel fill pipe will be installed in the annular space between the 8-inch diameter casing and the 14-inch diameter borehole for the adding of additional filter pack after the well has been operational for some time.

3.1.5 Grouting of annular space: after the filter pack as been installed to the required depth, the annular space between the 8-inch diameter casing and the 14-inch diameter borehole will be grouted with a cement-bentonite mixture.

3.1.6 Any drilling fluid(s) or additives must be approved by the CLIENT prior to use.

3.2 WELL DEVELOPMENT

3.2.1 The Production Wells will be developed to maximize yield, minimize turbidity, and remove any remaining drill cuttings and fluids.

3.2.2 The well screen will be developed using an air-lift pumping system. Surging with a double-surge block and simultaneous pumping might also be required. Well development will be conducted until the maximum yield per meter of drawdown is achieved and the well produces clear, sediment free water.

3.2.3 During the well development process, the DRILLER shall run short term (15 - 30 minute) specific capacity tests for at least every 6 hours of rig development to provide a real-time quantification of the well development progress.

3.3 PLUMBNESS AND ALIGNMENT

3.3.1 The completed well shall be tested for plumbness and alignment as per Section 8 of the American Water Works Association (AWWA) Standard for Water Wells (ANSI/AWWA A100-84). The completed well shall meet the requirements of this AWWA referenced standard.

3.3.2 Should the DRILLER fail to correct such faulty plumbness or alignment, the CLIENT may refuse to accept the Well without charge to the CLIENT.

3.3.3 The DRILLER is encouraged to test the wells for plumbness and alignment during the drilling process. Since line shaft vertical turbine pumps are to be installed in the wells, this specification will be strictly adhered to and any well that does not meet the required standard will not be accepted by the CLIENT and no payment will be made for that well.

3.4 DRILLER RECORDS

3.4.1 The DRILLER shall maintain a detailed log of operations during all drilling operations. The log shall give a complete description of all formations encountered, yield, size of the hole drilled, depth, sizes of all casings installed, a description of cementing operations, and other such pertinent data as may be requested by the CLIENT.

3.5 DRILLING SITES

3.5.1 The drill sites shall be kept free of trash and in a well maintained condition throughout the drilling and pumping test program. At the conclusion of drilling and testing activities, the sites shall be left in a clean condition and no equipment or materials shall be left to remain on the site.

4.0 PUMPING TESTS

4.1 After completion of the production well installation and well development, step drawdown and constant rate pumping tests will be performed on the well.

4.2 The step drawdown pumping test will be conducted at 4 different pumping rates which will be sequentially increased as per the instruction of the CLIENT. The duration of each step will be 1-hour.

4.3 Following the step drawdown pumping test, a 24-hour constant rate pumping test will be performed to determine aquifer hydraulic characteristics and the well's sustained yield. The selected pumping rate for the 24-hour pumping test will be specified by the CLIENT.

4.4 The DRILLER shall be responsible for providing the pump, prime movers, pipelines, meters, water-level access pipes, orifices, gages, temporary utilities, and all equipment necessary for testing. Access for collection of water samples will be provided at the wellhead.

4.5 The test pump shall be a submersible pump or a line-shaft turbine pump powered by a portable generator or diesel engine. The DRILLER shall have flexibility to provide a pump with a capacity ranging from 20 to 70 liters per second against 30 meters of total dynamic head. The pumped water will be discharged to at least 100 meters from the wellhead.

4.6 The test pump and prime mover shall be capable of not less than 40 hours of continuous operation. If accidental shutdown occurs and invalidates the test data in the opinion of the CLIENT, the DRILLER shall make any necessary repairs and restart the test. No payment will be made for pumping time prior to any accidental shutdown if the test results are invalid.

4.7 The DRILLER will insure that the pumping rate is kept constant and does not fluctuate by more than 5 percent throughout the 24-hour pumping test. Excessive fluctuation in the pumping rate may necessitate cessation of the pumping test at the CLIENT'S discretion. In the event of such a cessation, the DRILLER will make necessary repairs and adjustments to the pumping equipment and repeat the constant rate test at his own expense.

4.8 Recovery data will be collected for the same duration as the pumping period.

4.9 DRILLER shall provide on the discharge pipe measuring devices capable of accurately measuring up to 70 lps continuously during the test. An in-line orifice plate and manometer is required as well as an in-line totalizing flow meter.

4.10 DRILLER shall provide and install a 1-inch diameter access pipe of 20 - 30 meters length for water level measurements.

4.11 The DRILLER shall have a competent operator on hand at all times during the tests to insure that the equipment is running smoothly without interruption.

4.12 At the completion of the pumping tests, the DRILLER shall secure the well with a secure cap.

PROPOSAL – BILL OF QUANTITIES

To: The ADP/SW Project in compliance with your invitation for bids dated _____, 20__, the undersigned hereby declares that he proposes to furnish all labor, equipment, and material to complete all work promptly and as specified and delineated in the Specific Requirements in the price per unit of measure for each schedule item of work in the "Schedule of Prices" following:

ITEM DESCRIPTION	ESTIMATED QUANTITY	COMPUTED TOTALS
1. Production Well Mobilization/demobilization: For moving all drilling equipment, personnel, supplies, etc. to/from site the price of ________________Dollars.	1	$_______
($____________)		
2. Drilling Production Well: For drilling 6 number 14-inch nominal diameter borehole to 50 m, bgs. the unit price of ___________Dollars and _________Cents per foot.		
($____________/Linear meter)	300m	$_______
3. For providing and installing 8-inch diameter (Schedule D) casing to 30m, bgs, the unit price of ___________Dollars and ___________Cents per meter		
($___________/Linear meter)	180 m	$_______
4. For supply and installation of 8-inch diameter, 20-meter length PVC 2.5mm slot well screen, the unit price of ________________Dollars and ___________________Cents per meter		
($___________/Linear meter)	120m	$_______

ITEM	DESCRIPTION	ESTIMATED QUANTITY	COMPUTED TOTALS
5.	Filter Pack: For furnishing and installing filter pack, the unit price of_______________ Dollars and __________________Cents per cubic meter ($____________/per cubic meter)	18 m^3	$_____
6.	Grouting of annular space: For grouting of the annular space between 14-inch diameter borehole and the 8-inch diameter casing, the unit price of _________Dollars and __________cents per well ($______/well)	6 nos.	$______
7.	Well Development: For developing the well screen using a cable-tool rig or equivalent with double-surge blocks, and air-lift pumping system, the unit price of ______________Dollars and ____________________Cents per hour ($__________/Hour)	80 hours	$______
8.	Pumping Test: For furnishing all pumping test equipment, labor, and supplies for and conducting pumping tests the unit price of _________________Dollars. and _________________________Cents per hour ($________/hour)	240 hours	$_______

(TYPE OR PRINT)

Company__________________________
Street_____________________________
City_______________________________
Province_______________________

TOTAL BID PRICE $__________________

(Please Print)____Dollars

It is understood and agreed that the total price stated by the undersigned in the Proposal is based on estimated quantities. It is further understood that the quantities stated in the Proposal are estimates only and may be increased or decreased as provided in the specifications.

(an individual)
The undersigned is (a corporation) under the laws of the ____ Province
(a partnership)

______________________ having offices at______________________

Signed____________________

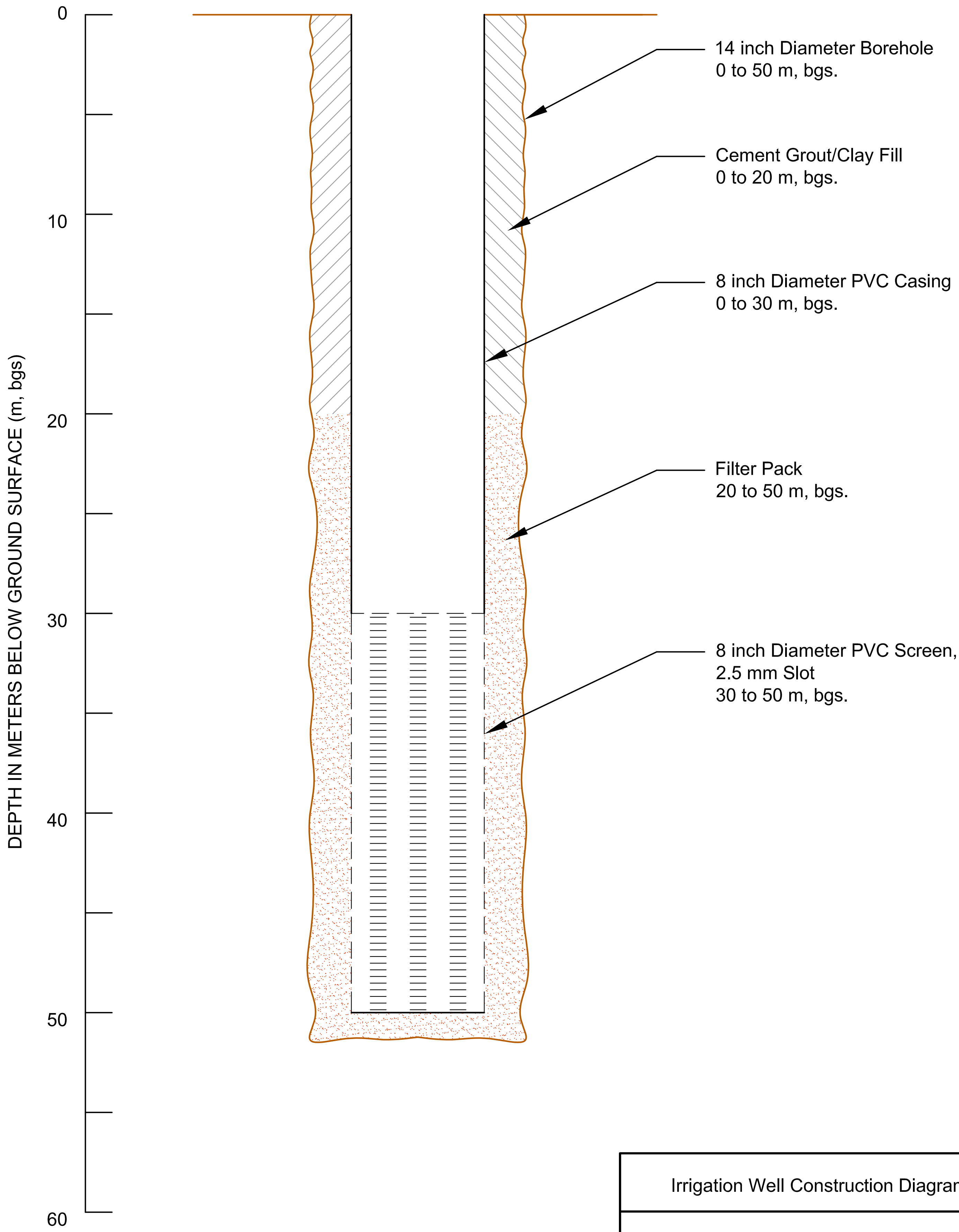
(Type or Print) Name_____________________

Title______________________

Company__________________

Phone_____________________

Email______________________



Irrigation Well Construction Diagram

ADP/SW - Farah Province

Uhl, Baron, Rana & Associates, Inc.
Lambertville, New Jersey

FIGURE
C-1

APPENDIX D

Water Quality Test Reports from DACAAR Laboratory.

DACAAR Danish Committee for Aid to Afghan Refugee

WATER QUALITY ANALYSIS REPORT

Project	ADP/SW	Source	Water No 1	Analysis n.	442-2009
Province	Farah	District	Bakwa	Village	Sultani
Latitude		Longitude		Sample date& time	03/11/09

Physical parameters

Parameter	Value	Unit		WHO recc	WSG recc	
EC	1126	µS/cm		1500	3000	
TDS *	775	mg/l	0.688	1000	2000	* From Conductivity
ORP	185	mV				
Turbidity	6.18	NTU		5	5	< 1 for chlorination
pH	7.98			6.5 - 8	6.5 - 8	< 8 for chlorination
°T	14.3	°C		-	-	

Chemical determination

Spectrophotometer Palintest 8000

Anions		mg/l	conv	me/l	WHO recc	EU recc	Comments
Total Alkalinity	(as $CaCO_3$)	410			-	-	
Alkalinity P	(as $CaCO_3$)	40			-	-	
Alkalinity M	(as $CaCO_3$)	515			-	-	
Bicarbonate	HCO^{3-}	435	0.01639	7.130	-	-	
Carbonate	CO_3^{2-}	80	0.03333	2.667	-	-	
Hydroxide	OH^-	0	0.05880	0.000	-	-	
Chloride	Cl^-	18.5	0.02820	0.522	250	-	Taste
Sulphate	SO_4^{2-}	190	0.02082	3.956	250	-	Taste
Sulphite (sulphatest)	SO_3^{2-}	2	0.02498	0.050	-	-	
Sulphide		0		0.000	-	-	
Fluoride	F^-	1.4	0.05263	0.074	1.5	0.5	Fluorosis
Nitrate	NO_3^-	4.22	0.01613	0.068	50	50	Blue baby syndrom
Nitrite (nitricol)	NO_2^-	0.005	0.02174	0.000	0.2 - 3	0.1	long - short term exposure
Phosphate	PO_4^{3-}	0.08	0.03159	0.003	-	-	
Boron	BO_2^-		0.02335		0.5	-	Testicular lesions
Bromine	Br^-	0.35	0.01251	0.004	-	-	

Cations		mg/l	conv	me/l	WHO recc	EU recc	Comments
Total Hardness	(as $CaCO_3$)	190			300	-	Taste and incrostation
Calcium Hardness	(as $CaCO_3$)	91			-	-	
Sodium	Na^+	243	0.04348	10.585	200	-	Taste
Potssium	K^+	3.3	0.02558	0.084	-	-	
Calcium	Ca^{2+}	36	0.0499	1.816	-	-	
Chromium	Cr^{6+}	0.02	0.05768	0.001	0.05	0.05	Canceragenic
Magnesium	Mg^{2+}	24	0.08224	1.974	-	-	
Ammonia	NH_4^+	0.01	0.05543	0.001	1.5 - 35	0.5	Odour - taste treshold
Manganese	Mn^{2+}	0.001	0.03641	0.000	0.4	0.05	> 0.1 affects taste and stains laundary
Copper	Cu^{2+}	0.2	0.03148	0.006	5	-	Taste
Alluminium	Al^{3+}	0.02	0.1112	0.002	-	-	
Total iron	Fe^{2+} and Fe^{3+}	0.07	0.03581	0.003	0.3	5	Taste and odour
Arsenic	As^{3+} and As^{5+}	0			0.01	0.05	

Other components		mg/l	WHO recc	EU recc	
Silica	SiO_2	0.96	-	-	
Hydrogen Sulphurate	H_2S	0	0.100	-	Taste and odour
Cyanidric acid			0.07	0.05	

Bacteriological Determination

	Y/N	WHO recc	SPHERA recc	
H_2S determination		N	-	
Total Coliforms	Col/100 ml	0	-	(Incubation time: 24 hrs @ 36°)
Fecal coliforms (e-Coli)	0 Col/100 ml	0	0	(Incubation time: 24 hrs @ 42°)

Comments & recommendations

SAR 7.7

Bacteriological analysis is negative.

According to WHO recommendation Turbidity and Sodium are slightly high.

DACAAR Danish Committee for Aid to Afghan Refugee

WATER QUALITY ANALYSIS REPORT

Project	ADP/SW	Source	Water No 2	Analysis n.	443-2009
Province	Farah	District	Bakwa	Village	Dewalak
Latitude		Longitude		Sample date& time	03/11/09

Physical parameters				WHO recc	WSG recc	
EC	809	µS/cm		1500	3000	
TDS *	557	mg/l	0.688	1000	2000	* From Conductivity
ORP	184	mV				
Turbidity	2.38	NTU		5	5	< 1 for chlorination
pH	8			6.5 - 8	6.5 - 8	< 8 for chlorination
°T	14.5	°C		-	-	

Chemical determination — Spectrophotometer Palintest 8000

Anions		mg/l	conv	me/l	WHO recc	EU recc	Comments
Total Alkalinity	(as $CaCO_3$)	270			-	-	
Alkalinity P	(as $CaCO_3$)	85			-	-	
Alkalinity M	(as $CaCO_3$)	305			-	-	
Bicarbonate	HCO^{3-}	135	0.01639	2.213	-	-	
Carbonate	CO_3^{2-}	170	0.03333	5.667	-	-	
Hydroxide	OH^-	0	0.05880	0.000	-	-	
Chloride	Cl^-	14	0.02820	0.395	250	-	Taste
Sulphate	SO_4^{2-}	170	0.02082	3.539	250	-	Taste
Sulphite (sulphatest)	SO_3^{2-}	5	0.02498	0.125	-	-	
Sulphide		0.01		0.000	-	-	
Fluoride	F^-	1.26	0.05263	0.066	1.5	0.5	Fluorosis
Nitrate	NO_3^-	8.02	0.01613	0.129	50	50	Blue baby syndrom
Nitrite (nitricol)	NO_2^-	0.008	0.02174	0.000	0.2 - 3	0.1	long - short term exposure
Phosphate	PO_4^{3-}	0.98	0.03159	0.031	-	-	
Boron	BO_2^-		0.02335		0.5	-	Testicular lesions
Bromine	Br^-	0.18	0.01251	0.002	-	-	

Cations		mg/l	conv	me/l	WHO recc	EU recc	
Total Hardness	(as $CaCO_3$)	125			300	-	Taste and incrostation
Calcium Hardness	(as $CaCO_3$)	73			-	-	
Sodium	Na^+	192	0.04348	8.350	200	-	Taste
Potssium	K^+	2	0.02558	0.051	-	-	
Calcium	Ca^{2+}	29	0.0499	1.457	-	-	
Chromium	Cr^{6+}	0.03	0.05768	0.002	0.05	0.05	Cancerogenic
Magnesium	Mg^{2+}	28	0.08224	2.303	-	-	
Ammonia	NH_4^+	0	0.05543	0.000	1.5 - 35	0.5	Odour - taste treshold
Manganese	Mn^{2+}	0.001	0.03641	0.000	0.4	0.05	> 0.1 affects taste and stains laundary
Copper	Cu^{2+}	0.04	0.03148	0.001	5	-	Taste
Alluminiium	Al^{3+}	0.02	0.1112	0.002	-	-	
Total iron	Fe^{2+} and Fe^{3+}	0.04	0.03581	0.001	0.3	5	Taste and odour
Arsenic	As^{3-} and As^{5-}	0			0.01	0.05	

Other components		mg/l	WHO recc	EU recc	
Silica	SiO_2	0.74	-	-	
Hydrogen Sulphurate	H_2S	0.0106	0.100	-	Taste and odour
Cyanidric acid			0.07	0.05	

Bacteriological Determination

		WHO recc	SPHERA recc	
H_2S determination	Y/N	N	-	
Total Coliforms	Col/100 ml	0	-	(incubation time: 24 hrs @ 35°)
Fecal coliforms (e-Coli)	0 Col/100 ml	0	0	(incubation time: 24 hrs @ 42°)

Comments & recommendations — SAR 6.1

Bacteriological analysis is negative.
According to WHO recommendation the water is acceptable.

WATER QUALITY DACAAR CONTROL

Signature ________ Date 23.11.2009

DACAAR Danish Committee for Aid to Afghan Refugee

WATER QUALITY ANALYSIS REPORT

Project	ADP/SW	Source	Water No 3	Analysis n.	439-2009
Province	Farah	District	Bakwa	Village	Ashkeen
Latitude		Longitude		Sample date& time	06/11/09

Physical parameters				WHO recc	WSG recc	
EC	590	μS/cm		1500	3000	
TDS *	406	mg/l	0.688	1000	2000	* From Conductivity
ORP	165	mV				
Turbidity	6.39	NTU		5	5	< 1 for chlorination
pH	8			6.5 - 8	6.5 - 8	< 8 for chlorination
°T	15.5	°C		-	-	

Chemical determination — *Spectrophotometer Palintest 8000*

Anions		mg/l	conv	me/l	WHO recc	EU recc	Comments
Total Alkalinity	(as $CaCO_3$)	205			-	-	
Alkalinity P	(as $CaCO_3$)	40			-	-	
Alkalinity M	(as $CaCO_3$)	295			-	-	
Bicarbonate	HCO^{3-}	215	0.01639	3.524	-	-	
Carbonate	CO_3^{2-}	80	0.03333	2.667	-	-	
Hydroxide	OH^-	0	0.05880	0.000	-	-	
Chloride	Cl^-	15.5	0.02820	0.437	250	-	Taste
Sulphate	SO_4^{2-}	79	0.02082	1.645	250	-	Taste
Sulphite (sulphatest)	SO_3^{2-}	4	0.02498	0.100	-	-	
Sulphide		0.01		0.000	-	-	
Fluoride	F^-	0.41	0.05263	0.022	1.5	0.5	Fluorosis
Nitrate	NO_3^-	6	0.01613	0.097	50	50	Blue baby syndrom
Nitrite (nitricol)	NO_2^-	0.004	0.02174	0.000	0.2 - 3	0.1	long - short term exposure
Phosphate	PO_4^{3-}	0.08	0.03159	0.003	-	-	
Boron	BO_2^-		0.02335		0.5	-	Testicular lesions
Bromine	Br^-	0.02	0.01251	0.000	-	-	

Cations		mg/l	conv	me/l	WHO recc	EU recc	Comments
Total Hardness	(as $CaCO_3$)	125			300	-	Taste and incrostation
Calcium Hardness	(as $CaCO_3$)	86			-	-	
Sodium	Na^+	117	0.04348	5.093	200	-	Taste
Potssium	K^+	1.9	0.02558	0.049	-	-	
Calcium	Ca^{2+}	34	0.0499	1.697	-	-	
Chromium	Cr^{6+}	0.02	0.05768	0.001	0.05	0.05	Cancerogenic
Magnesium	Mg^{2+}	20	0.08224	1.645	-	-	
Ammonia	NH_4^+	0.04	0.05543	0.002	1.5 - 35	0.5	Odour - taste treshold
Manganese	Mn^{2+}	0.04	0.03641	0.001	0.4	0.05	> 0.1 affects taste and stains laundary
Copper	Cu^{2+}	0.08	0.03148	0.003	5	-	Taste
Alluminium	Al^{3+}	0.02	0.1112	0.002	-	-	
Total iron	Fe^{2+} and Fe^{3+}	0.02	0.03581	0.001	0.3	5	Taste and odour
Arsenic	As^{3+} and As^{5+}	0			0.01	0.05	

Other components		mg/l	WHO recc	EU recc	Comments
Silica	SIO_2	0.72	-	-	
Hydrogen Sulphurate	H_2S	0.0106	0.100	-	Taste and odour
Cyanidric acid			0.07	0.05	

Bacteriological Determination

		WHO recc	SPHERA recc	
H_2S determination	Y/N	N	-	
Total Coliforms	Col/100 ml	0	-	(Incubation time: 24 hrs @ 36°)
Fecal coliforms (e-Coli)	0 Col/100 ml	0	0	(Incubation time: 24 hrs @ 42°)

Comments & recommendations — SAR 3.9

Bacteriological analysis is nigative.
According to WHO recommendation Turbidity is slightly high.

WATER QUALITY DACAAR MONITORING

Signature

Date 23,11,2009

DACAAR Danish Committee for Aid to Afghan Refugee

WATER QUALITY ANALYSIS REPORT

Project	ADP/SW	Source	Water No 4	Analysis n.	440-2009
Province	Farah	District	Bakwa	Village	Meh Dadi
Latitude		Longitude		Sample date& time	06/11/09

Physical parameters

				WHO recc	WSG recc	
EC	499	µS/cm		1500	3000	
TDS *	343	mg/l	0.688	1000	2000	* From Conductivity
ORP	179	mV				
Turbidity	1.52	NTU		5	5	< 1 for chlorination
pH	8			6.5 - 8	6.5 - 8	< 8 for chlorination
°T	15	°C		-	-	

Chemical determination

Spectrophotometer Palintest 8000

Anions		mg/l	conv	me/l	WHO recc	EU recc	Comments
Total Alkalinity	(as $CaCO_3$)	170			-	-	
Alkalinity P	(as $CaCO_3$)	55			-	-	
Alkalinity M	(as $CaCO_3$)	220			-	-	
Bicarbonate	HCO^{3-}	110	0.01639	1.803	-	-	
Carbonate	CO_3^{2-}	110	0.03333	3.667	-	-	
Hydroxide	OH^-	0	0.05880	0.000	-	-	
Chloride	Cl^-	10	0.02820	0.282	250	-	Taste
Sulphate	SO_4^{2-}	71	0.02082	1.478	250	-	Taste
Sulphite (sulphatest)	SO_3^{2-}	1	0.02498	0.025	-	-	
Sulphide		0.01		0.000	-	-	
Fluoride	F^-	0.42	0.05263	0.022	1.5	0.5	Fluorosis
Nitrate	NO_3^-	7	0.01613	0.113	50	50	Blue baby syndrom
Nitrite (nitricol)	NO_2^-	0.001	0.02174	0.000	0.2 - 3	0.1	long - short term exposture
Phosphate	PO_4^{3-}	0.03	0.03159	0.001	-	-	
Boron	BO_3^-		0.02335		0.5	-	Testicular lesions
Bromine	Br^-	0.06	0.01251	0.001	-	-	

Cations		mg/l	conv	me/l	WHO recc	EU recc	
Total Hardness	(as $CaCO_3$)	135			300	-	Taste and incrustation
Calcium Hardness	(as $CaCO_3$)	83			-	-	
Sodium	Na^+	91	0.04348	3.950	200	-	Taste
Potssium	K^+	2.6	0.02558	0.067	-	-	
Calcium	Ca^{2+}	33	0.0499	1.647	-	-	
Chromium	Cr^{6+}	0.02	0.05768	0.001	0.05	0.05	Cancerogenic
Magnesium	Mg^{2+}	21	0.08224	1.727	-	-	
Ammonia	NH_4^+	0	0.05543	0.000	1.5 - 35	0.5	Odour - taste treshold
Manganese	Mn^{2+}	0.001	0.03641	0.000	0.4	0.05	> 0.1 affects taste and stains laundary
Copper	Cu^{2+}	0	0.03148	0.000	5	-	Taste
Alluminium	Al^{3+}	0	0.1112	0.000	-	-	
Total iron	Fe^{2+} and Fe^{3+}	0.01	0.03581	0.000	0.3	5	Taste and odour
Arsenic	As^{3+} and As^{5+}	0			0.01	0.05	

Other components		mg/l	WHO recc	EU recc	
Silica	SiO_2	1.6	-	-	
Hydrogen Sulphurate	H_2S	0.0106	0.100	-	Taste and odour
Cyanidric acid			0.07	0.05	

WATER QUALITY CONTROL DACAAR

Bacteriological Determination

		WHO recc	SPHERA recc	
H_2S determination	Y/N	N	-	
Total Coliforms	Col/100 ml	0	-	(incubation time: 24 hrs @ 36°)
Fecal coliforms (e-Coli)	0 Col/100 ml	0	0	(incubation time: 24 hrs @ 42°)

Comments & recommendations

SAR 3.0

Bacteriological analysis is nigative.

According to WHO recommendation the water is acceptable

Signature ____________

Date 23,11,2009

WATER QUALITY ANALYSIS REPORT

Project	ADP/SW	Source	Water No 8	Analysis n.	444-2009
Province	Farah	District	Bakwa	Village	Asad
Latitude		Longitude		Sample date& time	10/11/09

Physical parameters

Parameter	Value	Unit		WHO recc	WSG recc	
EC	489	µS/cm		*1500*	*3000*	
TDS *	336	mg/l	*0.688*	*1000*	*2000*	** From Conductivity*
ORP	179	mV				
Turbidity	1.34	NTU		5	5	*< 1 for chlorination*
pH	8.08			*6.5 - 8*	*6.5 - 8*	*< 8 for chlorination*
°T	14.5	°C		-	-	

Chemical determination

Spectrophotometer Palintest 8000

Anions		mg/l	*conv*	*me/l*	WHO recc	EU recc	Comments
Total Alkalinity	(as $CaCO_3$)	155			-	-	
Alkalinity P	(as $CaCO_3$)	70			-	-	
Alkalinity M	(as $CaCO_3$)	240			-	-	
Bicarbonate	HCO^{3-}	100	*0.01639*	*1.639*	-	-	
Carbonate	CO_3^{2-}	140	*0.03333*	*4.667*	-	-	
Hydroxide	OH^-	0	*0.05880*	*0.000*	-	-	
Chloride	Cl^-	13	*0.02820*	*0.367*	*250*	-	*Taste*
Sulphate	SO_4^{2-}	69	*0.02082*	*1.437*	*250*	-	*Taste*
Sulphite (sulphatest)	SO_3^{2-}	13	*0.02498*	*0.326*	-	-	
Sulphide		0		*0.000*	-	-	
Fluoride	F^-	0.76	*0.05263*	*0.040*	1.5	0.5	Fluorosis
Nitrate	NO_3^-	3.06	*0.01613*	*0.049*	50	50	Blue baby syndrom
Nitrite (nitricol)	NO_2^-	0.009	*0.02174*	*0.000*	0.2 - 3	0.1	long - short term expositure
Phosphate	PO_4^{3-}	0.64	*0.03159*	*0.020*	-	-	
Boron	BO_2^-		*0.02335*		0.5	-	Testicular lesions
Bromine	Br^-	0.17	*0.01251*	*0.002*	-	-	

Cations		mg/l	*conv*	*me/l*	WHO recc	EU recc	
Total Hardness	(as $CaCO_3$)	125			*300*	-	*Taste and incrostation*
Calcium Hardness	(as $CaCO_3$)	72			-	-	
Sodium	Na^+	123	*0.04348*	*5.361*	*200*	-	*Taste*
Potssium	K^+	0.04	*0.02558*	*0.001*	-	-	
Calcium	Ca^{2+}	29	*0.0499*	*1.447*	-	-	
Chromium	Cr^{6+}	0.02	*0.05768*	*0.001*	0.05	0.05	Cancerogenic
Magnesium	Mg^{2+}	21	*0.08224*	*1.727*	-	-	
Ammonia	NH_4^+	0.07	*0.05543*	*0.004*	*1.5 - 35*	0.5	*Odour - taste treshold*
Manganese	Mn^{2+}	0.001	*0.03641*	*0.000*	0.4	0.05	*> 0.1 affects taste and stains laundary*
Copper	Cu^{2+}	0.04	*0.03148*	*0.001*	*5*	-	*Taste*
Alluminium	Al^{3+}	0.01	*0.1112*	*0.001*	-	-	
Total iron	Fe^{2+} and Fe^{3+}	0.04	*0.03581*	*0.001*	*0.3*	5	*Taste and odour*
Arsenic	As^{3+} and As^{5+}	0			0.01	0.05	

Other components		mg/l	WHO recc	EU recc	
Silica	SiO_2	0.7	-	-	
Hydrogen Sulphurate	H_2S	0	*0.100*	-	*Taste and odour*
Cyanidric acid			0.07	0.05	

Bacteriological Determination

		WHO recc	SPHERA recc	
H_2S determination	Y/N	N	-	
Total Coliforms	Col/100 ml	0	-	*(Incubation time: 24 hrs @ 36°)*
Fecal coliforms (e-Coli)	0 Col/100 ml	0	0	*(Incubation time: 24 hrs @ 42°)*

Comments & recommendations

SAR 4,3

Bacteriological analysis is negative.

According to WHO recommendation the water is acceptable.

Signature

Date 23.11.09