ANALYSIS OF THE KAREZES AT THE GARDEZ FORWARD OPERATING BASE

by
Guy Fipps, P.E.[1]
July 19, 2006

Background

There are two karezes that run under portions the Gardez Forward Operating Base (FOB). Representatives from the downstream village have repetitively requested permission to clean out the karezs, but these requests have not been approved by the FOB commanders out of security concerns. Cleaning is needed to restore and maintain water flow in the karezes. The villagers have filed a human rights complaint against the FOB with the United Nations due to the continued refusal of access.

Recently, the villagers cleaned out a portion of one of the karezes before the point where it runs under the FOB. The cleaning restored the flow of water in the karez. However, additional cleaning of the karez, including the portion that runs under the base, will be needed in order to maintain and increase water flow.

The FOB has offered to construct wells and provide pumps for the village, but the villagers state that they are only subsistent farmers and have no income with which to purchase fuel for the diesel pumps and pay for maintenance. Hand pumps are not an option since they produce insufficient volumes of water for irrigation.

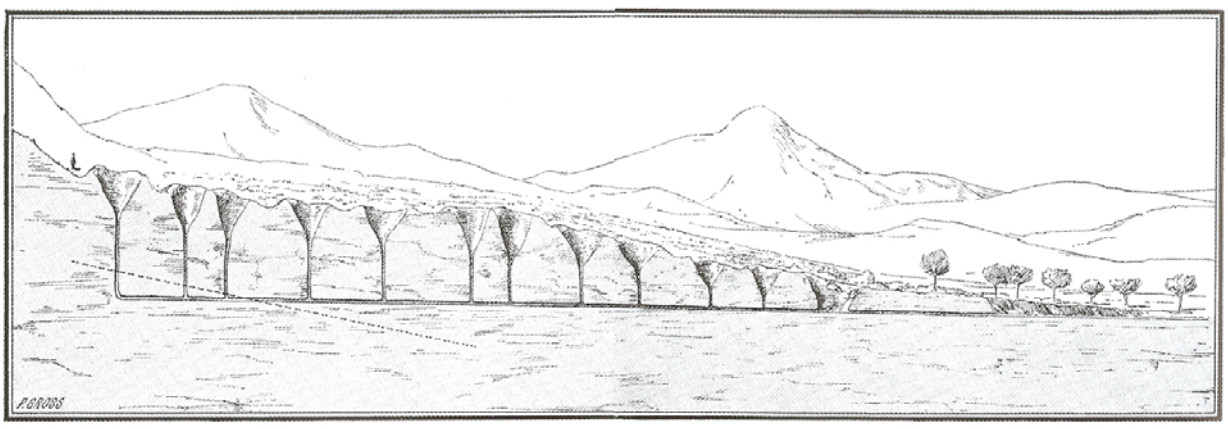


Figure 1. Diagram of a typical Afghan karez (source: Watershed Atlas of Afghanistan, UNFAO, 2004.)

[1] Senior Advisor for Water, Afghanistan Reconstruction Group, US Embassy, Kabul; Professor and Extension Agricultural Engineer, Texas A&M University, College Station.

At the invitation of the Gardez PRT, on July 9, 2006, I traveled to the FOB to analyze the problem. The PRT provided transportation and force protection for a mission to karezes and a downstream village which is located within a few kilometers of the FOB.

Karezes

Karezes are traditional water supply systems used in the Middle East and in a few other parts of the world with appropriate geology. In Afghanistan, people have depended upon karezs for drinking and irrigation water for centuries and perhaps thousands of years.

Figure 1 illustrates the type of karez commonly found in Afghanistan. Shown is a gently slopping channel or tunnel dug nearly horizontally into an alluvial fan which connects to a water bearing source, layer or other geological formation. Karezes very significantly in size and length, although the general shape of the tunnels is elliptical. Some karezes are lined and others are simply earthen channels.

Also shown in Figure 1 are access shafts which resemble hand dug wells. While the outlet of a karez is at ground surface, the point of origin is often deep below the surface due to the slope of the alluvial fan. The access shaft at the point of origin is referred to as the "mother well."

Occasionally the tunnels and access shafts collapse, thereby blocking the flow of water. The villagers then enter the karez through the access shafts to clear out the blockage (i.e. "cleaning the karez").

The Karezes at the Gardez FOB

There are two karezes that run under portions of the Gardez FOB, referred to here as the Northwest (NW) Karez and the Helicopter Landing Zone (HLZ) Karez. The karezes are over 20 m below the land surface in the vicinity of the FOB. (Note: the old water well in the PRT Compound that is not a part of the karez system.)

NW Karez

Photograph 1 shows the outlet of the NW Karez a few hundred yards down slope from the FOB. From this point, a trench carries the water to a village and agricultural land below (Photograph 2). The NW Karez runs under the northwest corner of the outer wall of the FOB on a diagonal. The location of this diagonal is marked by the latrine on the road-side of the outer wall (Photograph 3). From the FOB, the karez continues under the road then turns south and continues to the base of the mountains, paralleling the road.

HLZ Karez

Within the last two years, the FOB constructed a helicopter landing zone (HLZ) and a half-mile jogging trail on top of a second karez. In Photograph 4, the outlet of this karez is located near the parked humvee, with the ridge running to the left making the path of the karez to the helicopter landing zone of the FOB. Inside the helicopter landing zone,

the path of the karez is clearly marked by an access shaft which is covered with a large metal sheet.

From discussions with villagers and examination of maps and aerial photographs, it appears that the mother well or point of origin of the HLZ Karez is in the general area of the FOB, either within or on the south side of the landing zone. However, it may be possible that the Karez runs another kilometer south of the FOB.

Issues

1. The NW and HLZ Karezes have existed here for generations, perhaps longer.

2. The karezes are vital to the villagers and provide irrigation water for the growing of crops.

3. The karezes occasionally collapse and require cleaning.

4. The karezes are very deep, over 20 meters below the surface in the vicinity of the FOB.

5. The villagers do not consider wells and diesel pumps as an acceptable alternative to the karezes as they have no cash income to pay for fuel and maintenance.

6. The northwest corner of the outer wall of the FOB was constructed on top of the NW Karez even though the path of the karez was clearly marked by a line of access shafts.

7. Within the last two years, the FOB was expanded and a helicopter landing zone was located on top of the HLZ Karez in spite of the presence of a large karez access shaft in the area.

8. The karezes are considered a security threat by the FOB.

Stabilizing and Securing the Karezes

Options

The two options for stabilizing and securing the karezes are to install:

1. pipelines or
2. concrete stabilization rings

For security, iron bars may be installed in the pipeline and the concrete rings to prevent access. Alternatively, manhole type covers can be installed in the top access shaft concrete ring.

Engineers in the EIRP (Emergency Irrigation Rehabilitation Program) at the Ministry of Energy and Water recommend using concrete stabilization rings, particularly for situations where portions of the karez are below a seasonal water table. The pipeline option, though can be made to work for these situations as well. Factors that affect the choice of materials are amount of funding, availability of materials and local labor.

Concrete Stabilization Rings

Two types of rings are used: (1) circular rings for the access shafts and (2) special elliptical-shaped rings for the tunnels. The diameter or size of the rings are based on the dimensions of the access shafts and tunnels. The molds will need to be fabricated locally.

Appendix A includes diagrams and costs from a karez stabilization project in Herat Province completed by the EIRP. These diagrams include schematics that show the rings and their placement within a karez for this particular project. EIRP engineers and managers are available at MEW to answer questions and to provide technical guidance.

Pipelines

Pipelines are also an option particularly in karezes which are above the shallow water table. However, for very deep karezes, thin-walled pipelines may collapse from the weight of the earth above.

Installation of pipe sections may be prohibitive difficult due to the access limitation through the shafts. Thus, in practice, their use is probably better suited for short karezes or the end portion of a karez, with installation through the outlet. Metal pipelines may provide additional security in high risk areas.

Determining the diameter of the pipe to use ranges from being obvious to difficult, depending on the size and shape of the karez. Pipelines are efficient at moving water, thus the entire cross-sectional area does not have to be enclosed to maintain the same flow.

In areas where the karez is below a seasonal water table, holes or slots should be drilled/cut in the pipeline to allow groundwater water to enter. In theory, the holes should be drilled into the top third of the pipe and surrounded with a gravel pack. In practice, a layer of gravel underneath and holes in the bottom third of the pipe should perform satisfactory.

Extent of Construction

The extent or length of construction depends primarily on available funding. Options include:

- Installation in the portions of the karezes that run under the FOB to the nearest access shaft in each direction
- Installation in the portion of the karezes that run under the FOB and extending to the karez outlets
- Installation in the total extent of the karezes.

Another concrete ring option is to install the tunnel rings in the portions of the karezes that run under the base as discussed above, and then install rings in all the access shafts and tunnel rings in the first few meters of the tunnel on either side of the shafts. This would reduce the costs while greatly improving the stability of the karezes.

Recommendations

NW Karez: Install concrete rings and/or a pipeline as discussed above. Manhole-type covers installed on the top ring can be used to secure the access shafts. If a pipeline is used, holes or slots should be drilled/cut in the metal pipe to allow groundwater water to enter.

HLZ Karez: Allow the villagers to clean out the karez on the FOB and determine the origin point of the karez. Install concrete rings and/or a pipeline as discussed above. If a pipeline is used, holes or slots should be drilled/cut in the metal pipe to allow groundwater water to enter the pipe.

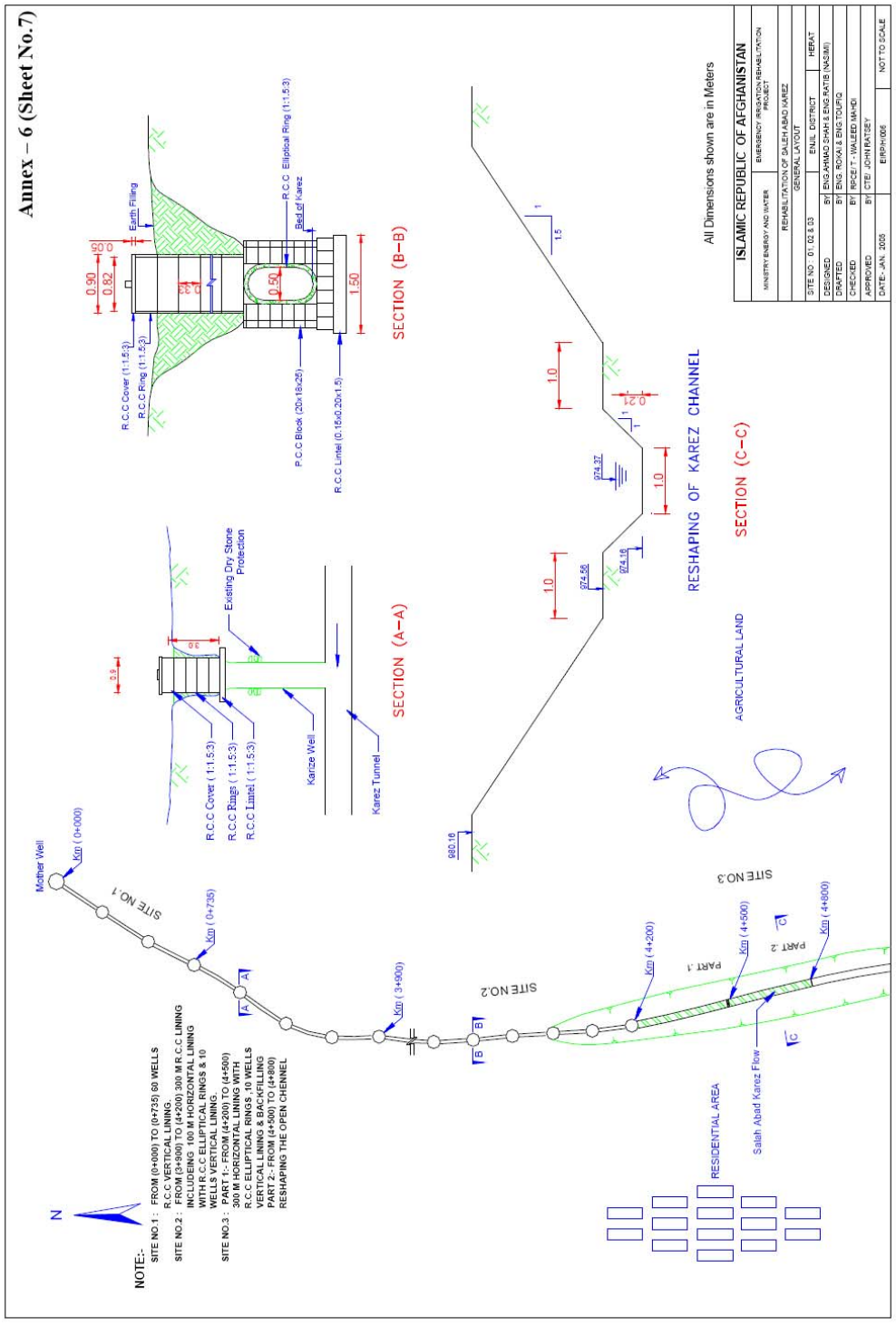
Photograph 1. Outlet of the NW Karez down slope from the Gardez FOB.

Photograph 2. Trench that carries the water from the NW Karez down slope to the village.

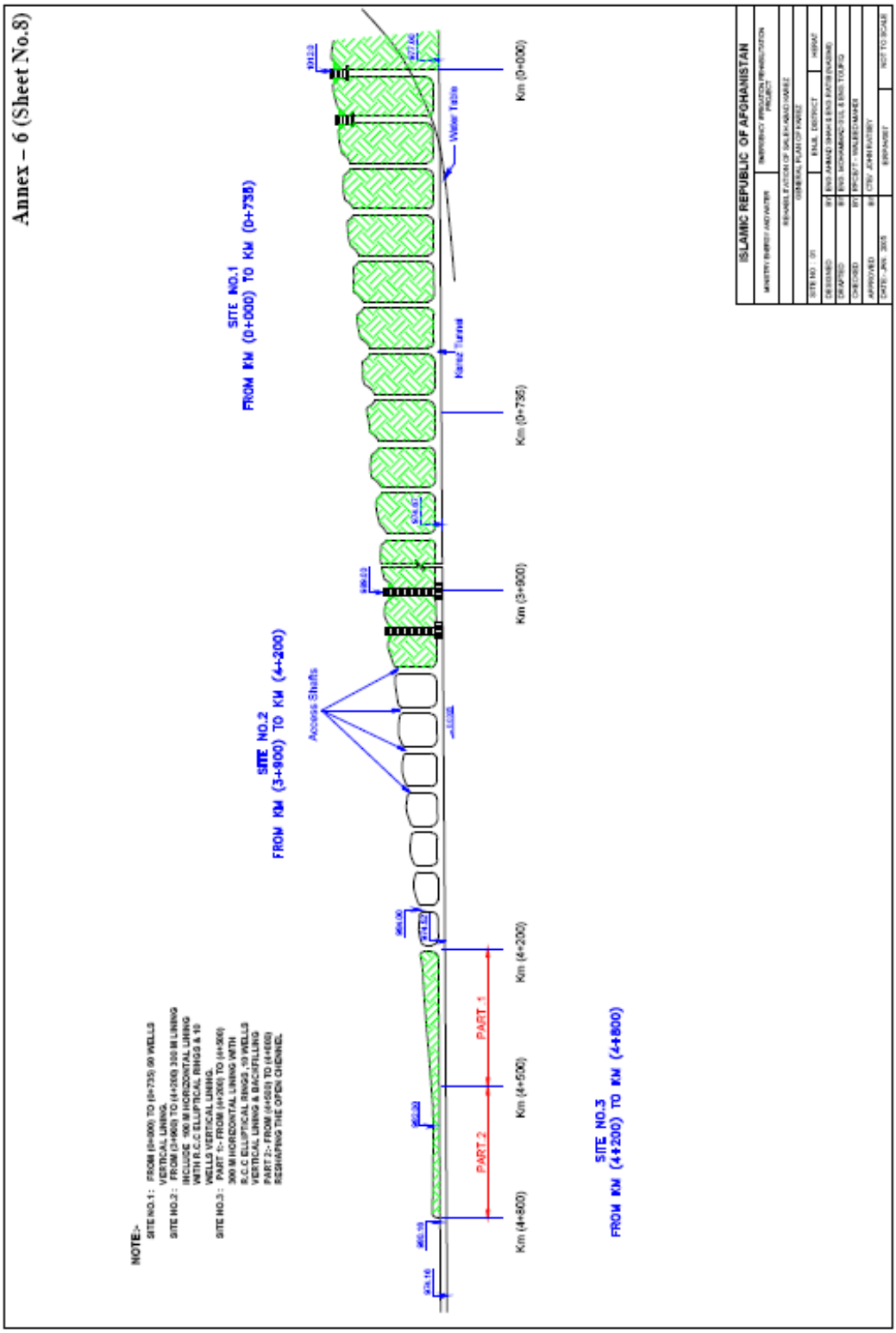
Photograph 3. Approximate direction (line from filled-in hole through latrine) of the karez which passes under the northwest corner of the Gardez FOB on a diagonal.

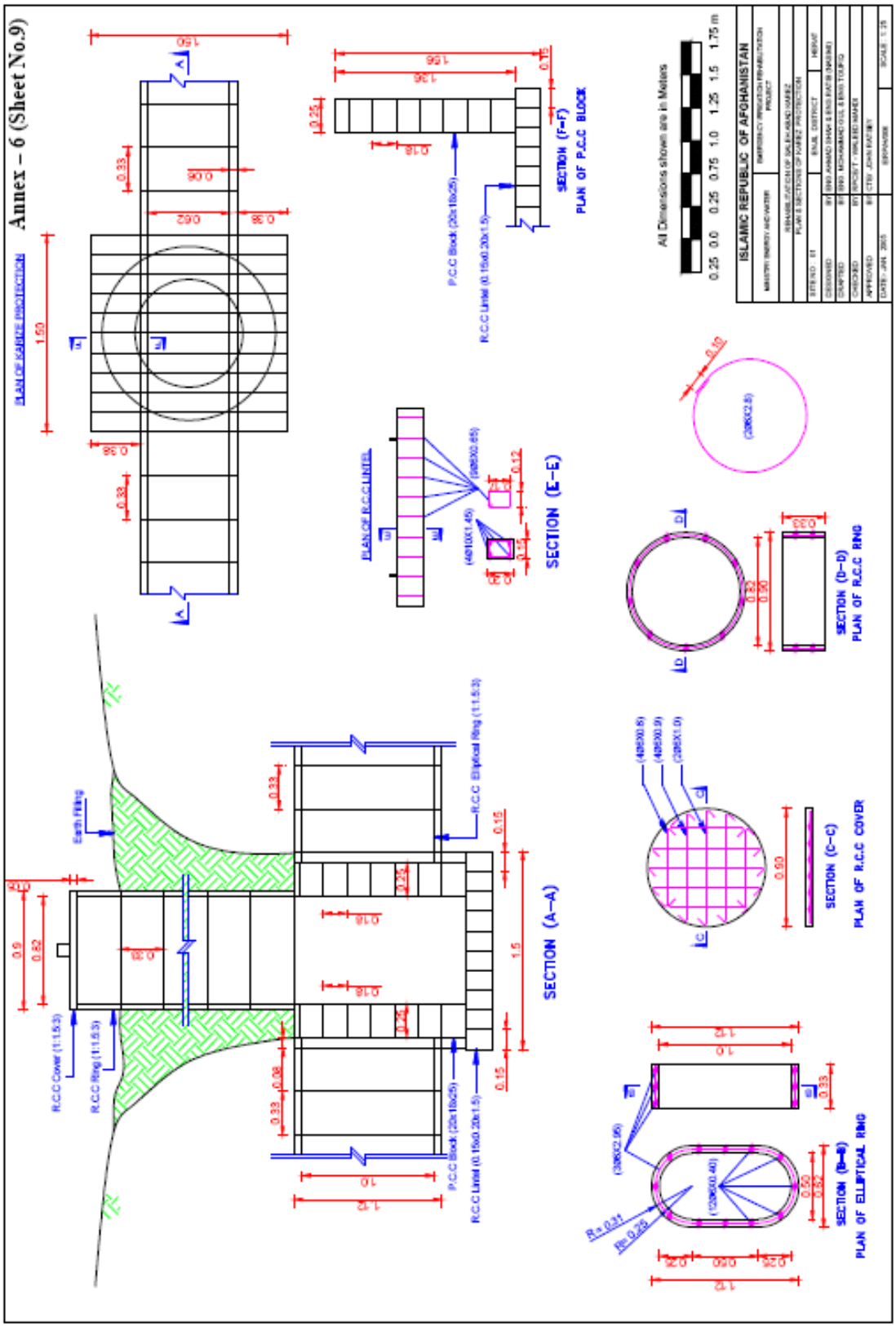
Photo. 4. The trench of the NW Karez. In the distance, (beyond the UN vehicle) the humvee is parked near the outlet for the HLZ Karez. To the left of the humvee is the line of access shafts marking the path of the HLZ Karez leading to the helicopter landing zone of the Gardez FOB.

APPENDIX A: DIAGRAMS AND COSTS FROM THE EIRP KAREZ PROJECT IN HEART PROVINCE



Annex – 6 (Sheet No.8)




Annex – 6 (Sheet No.9)
PLAN OF KARIZE PROTECTION
SECTION (A–A)
SECTION (E–E)
SECTION (F–F)
PLAN OF P.C.C BLOCK
SECTION (D–D)
PLAN OF R.C.C RING
SECTION (C–C)
PLAN OF R.C.C COVER
SECTION (B–B)
PLAN OF ELLIPTICAL RING
All Dimensions shown are in Meters
ISLAMIC REPUBLIC OF AFGHANISTAN

BILL NO. 2

Wells and tunnel protection from Km (3+900) to Km (4+200)

S/No	Work Description	Unit	Quantity	Unit Cost (USD)	Total Cost (USD)
1	**Excavation:** To be done in ordinary soils of the karize wells	m^3	90	3	270
2	**Back filling:** Compacted earth fill with excavated or new material to the required dimensions, and grades around the structures as shown in relevant drawings and strictly in accordance with Technical Specifications and/or as directed by the Engineer.	m^3	230	2	460
3	**Reinforcement Cement Concrete (RCC) of Lintels:** Providing and laying RCC (1:1.5:3) for lintels with installation in 10 wells of 9m average depth as shown in relevant Drawings and strictly in accordance with Technical Specification and/or as directed by the engineer	m^3	5	145	725
4	**Reinforcement Cement concrete (RCC) Circular Rings:** Providing and laying RCC (1:1.5:3) rings for 3m vertical lining with installation in 10 wells of 9m average depth, as shown in relevant Drawings and strictly in accordance with Technical Specification and/or as directed by the engineer	m^3	10.5	150	1,575
5	**Reinforcement Cement concrete (RCC) Top covers:** Providing and laying RCC (1:1.5:3) circular covers for 10 wells, as shown in relevant Drawings and strictly in accordance with Technical Specification and/or as directed by the engineer	m^3	0.5	140	70
6	**Reinforcement Cement concrete (RCC) Elliptical rings:** Providing and laying RCC (1:1.5:3) Elliptical rings for a total of 100m horizontal tunnel lining, as shown in relevant Drawings and strictly in accordance with Technical Specification and/or as directed by the engineer	m^3	12	150	1,800
7	**Plain Cement Concrete (PCC) Block:** Providing and laying RCC (1:2:4) Blocks for a total for structures as shown in relevant Drawings and strictly in accordance with Technical Specification and/or as directed by the engineer	m^3	10	40	400
Total					**5,300**

- Farmers' contribution in earthworks equivalent to $1,500 for removing the collapsed earth material in the Karez