4. *DAM SITE AND CATCHMENT AREA OF DAM*

4.1 Existing Dam

Dam and reservoir features and dam observations on damplanning, design, construction and O&M activities for selected existing dams are summarized in Table 4.1.1 and 4.1.2. The followings are detailed descriptions of the geo-hydrogeology, dam, its reservoir, conditions of socio-economy, agriculture, irrigation and environmental aspects, for the selected 10 existing dams.

(1) Khora Manda dam

Topography, geology and hydrogeology

The catchment area of Khora Manda dam is mostly composed of limestones of Jurassic age, of alluvial sands/gravels in the mountain side, and of silt tracing dense sands/gravels of Subrecent deposits around and just upstream of dam site. In the downstream, piedmont slope is extent widely. Just downstream side of the dam site is composed of considerable dense silt tracing sands/gravels strata of Subrecent deposits. Permeability at the dam site is relatively high. Due to good permeability and little siltation on the reservoir bed, water storaged in the reservoir infiltrates into the ground in a short duration. Fan deposits in the downstream of dam are very thick, and changes into valley floor mainly composed of silts/clay strata.

The radius of alluvial fan extent in the downstream of dam is between 2 and 3 km. Topographic gradient is more than 1 in 20 in the upstream side, and approximately 1 in 25 in the downstream side. Radial angle of alluvial fan is approximately 120 degrees assuming that the pivot is at the dam site.

Depth to bedrock has not been confirmed due to lack of data. Bostan Formation may lie from the depth around 150 m in the valley floor. Coefficient of permeability of alluvial fan is inferred to be the higher side in the order of 10^{-3} cm/sec, and gradually becomes lower as proceeding to the downstream. Transmissivity of the fan deposits is around 40 m^2/day estimating from the existing data. Specific yield is approximately 15 % around fan front, and a little more than 20 % at the uppermost-stream. Depth to groundwater surface is approximately 30 m as of 1988.

Dam and reservoir

The dam is located at fan head of the alluvial fan. The catchment area is situated in limestone area in the upstream of the catchment area, and Piedomont deposits in the middle and downstream of the catchment area. Vegetation cover is scarcely observed.

Proposed dam is situated in piedmont deposits. Sediment of 0.6 m thickness has been accumulated in the reservoir during 3 years after the dam completion. Recharge capacity through dam and reservoir foundation is expected less due to poor permeability of the foundation.

Dam Type	Dam Height	Crest Length	Catchment Area	Embankment Volume	Recharge Flow
Fill dam	10.4 m	238 m	12.2 km^2	45,700 m^3	through dam foundation

Socio-economical condition

The estimated number of households of the beneficial area is about 25, and population is about 200 souls. Brahvi speaking Syeds, and Achakzai and Kakar tribes of Pashtun ethnic group are the residents of these settlements. Out of 25 households, only 3 can be classified as agriculturalists, while the other 22 families are partly dependent on agriculture and partly on work as physical labours. Domestic water source is tubewells. Energy source is electricity and woods. There is one boys primary school. No health facilities exists. According to the residents they had suffered considerable flood damage on their agriculture lands due to the poor design of the dam.

Agriculture and irrigation

The land has very high potential for irrigated agriculture (irI). The crop suitability classification of the soil is well suited suggesting that all types of crops, vegetables and orchards can be grown in the area. The major source of irrigation water is tubewell, although vast of land remains unirrigated. Wheat and other upland crops are dominant.

Environment

The effectiveness of groundwater recharge by means of the DAD is comparatively low due to scarce volume of water infiltrated through the reservoir foundation. It implies that the DAD has not contributed to the sustainable use of natural resource. Therefore, the DAD creates no positive impacts to both physical and human environment. Flashing water through the spillway of the DAD caused flood damages to the arable land of left bank at the downstream. Those regarded as some negative impacts to the human environment related to agricultural and economic activities. In order to mitigate the concentration of flood to the left bank, a water course work has been implemented at the downstream of the spillway.

(2) Marium dam

Topography, geology and hydrogeology

The catchment area of Marium dam is composed of Conglomerates of Miocene age forming steep mountain slopes. The catchment area is too small to supply usable runoff. In the downstream of the dam, relatively thin talus-like alluvial deposits are extent widely forming relatively steep slopes. The thickness of alluviums may be 30 m at maximum in the valley bottom. Topographic gradient is steep showing approximately 1 in 10. Coefficient of permeability of alluvium is inferred to be in the order of 10^{-3} to 10^{-2} cm/sec.

Dam and reservoir

The dam is located at the small tributary of the Hanna river. Coucrops of conglomerate exists in whole of the catchment area. Vegetation is not observed over the catchment area. Talus deposits is observed at the dam site. These scheme is not viable because of small recharge capacity from the narrow catchment area. Few sediment has been accumulated in the reservoir during 2 years after the dam completion. Recharge capacity through dam and reservoir foundation is expected less due to poor permeability of the foundation. Impounding water is utilized for the domestic use in the vicinity area.

Dam Type	Dam Height	Crest Length	Catchment Area	Embankment Volume	Recharge Flow
Fill dam	14.5 m	122 m	0.5 km^2	42,300 m^3	through dam foundation

Socio-economic condition

The number of households of the beneficial area is about 60, and population is estimated about 800 souls. This area is located Urak valley near Quetta city. The residents belong to Kakar tribe of the Pashtun ethnic group. Although they live in the suburb of Quetta city, their social values and customs are very traditional. Out of 60 households only 10 households are dependent on agriculture, while 35 households are small traders or work as labours. Besides them 15 households are engaged in government service. Domestic water source is Wali Tangi Dam. Energy source is electricity and woods. There are one primary school and one middle school. One dispensary is set up. According to the residents, the dam is of no socio-economic benefit to them.

Agriculture and irrigation

The major soil in the area is man-made soil. The man-made soil material in the valley is mostly transported from out side. The land has high to moderate potential for irrigated cultivation (irI, irIIs and irIIIw). According to crop suitability classification, it is well to moderately well suited

soil to all types of crops, vegetables, and orchards. It also has good to moderate irrigation suitability. Major water source is spring. Orchard is dominant.

Environment

The effectiveness of groundwater recharge by means of the DAD is comparatively low due to small catchment. It implies that the DAD has not contributed to the sustainable use of natural resource. Therefore, the DAD has not created any positive and negative impacts to both physical and human environment.

(3) Bostan dam

Topography, geology and hydrogeology

The catchment area of Bostan dam is composed mainly of limestones interbedded with Marl, Sandstone, and Shale of Permo-Triassic to Jurassic age, and partly of Paleocene limestone. In the downstream, piedmont slope is extent widely. The thickness of alluvial fan deposits extending in the downstream of the dam is from 20 to 30 m, and reaches one hundred and tens of meters at maximum. The surface layers along Bostan Lora are silty to clayey valley floor deposits. Abutment of the dam body is emplaced on Chiltan limestone of Jurassic age. In the part of river bed, relatively thick river deposit or fan deposits distribute Bostan Formation forms hills extending in relief in the other bank side of Bostan Lora, and lies in the area of valley floor underlain by bedrock. Alluvial fan in the downstream forms typically with radius about 3 km, and topographic gradient approximately 1 in 20. Radial angle of alluvial fan is approximately 180 degrees assuming that the pivot is at the dam site.

Though depth to bedrock has not been confirmed due to lack of data, it is inferred to be more than 150 m in valley floor. Coefficient of permeability is 4 to 5×10^{-3} cm/sec in fan front area, and 7 to 8×10^{-3} cm/sec in the upstream area. Transmissivity is more than 500 m^2/day in the center of alluvial fan, and between around 100 and 300 m^2/day around fan front area. Specific yield of fan deposits is approximately 20 % or more. Depth to groundwater surface as of 1978 was more than 40 m, however it showed approximately 60 m as of 1988.

Dam and reservoir

The dam is located at the fan head of the alluvial fan. The construction was achieved with financial assistance of Kuwait (Small Irrigation Schemens in Balochistan) 6 years before. Most of the catchment area is composed of outcrops of limestone and vegetation cover is scarcely observed.

Dam site is situated in limestone at the right side abutment and piedmont deposits at the left side abutment. Recharging is effectively accelerated through well permeable foundation of the dam and reservoir.

Dam Type	Dam Height	Crest Length	Catchment Area	Embankment Volume	Recharge Flow
Fill dam	16.0 m	272 m	23.4 km^2	164,000 m^3	through dam foundation

Socio-economic condition

The estimated number of households of the beneficial area is about 300, and population is about 4,000 souls. The area is included the urban area of the Bostan. All residents belong to the Kakar tribe of Pashtun ethnic group. The socio-political structure is semi-tribal. Domestic water source depends on the facilities prepared by Public Health and Engineering Department (PHED) and energy source is electricity. There are two primary schools and one middle school, and three dispensaries in the area. According to the residents, the existing dam has given a positive impact on their lives.

Agriculture and irrigation

The area is moderately well drained and has moderately slow permeability. Major part of the cultivated area has very high potential (irl) for irrigated crops, vegetables, and orchards. It is well suited to all types of crops and orchard according to crop suitability classification. The area is mainly irrigated by tubewells. Orchard and wheat are major crops.

Environment

Although the effectiveness of groundwater recharge by means of the DAD is likely to high, it is difficult to identify its own recharging gain due to other dams effects. The DAD has contributed to the flood mitigation either, and some negative impacts to the human environment were recognized.

(4) Khushab dam

Topography, geology and hydrogeology

The catchment area of Khushab dam is composed of limestone and shale of Cretaceous age, and conglomerate of Miocene age, and partly Ophiolitic Intrusives.

In the downstream of the dam site, wide river bed extend. After passing the isthmus locating around 2 km downstream from the dam, piedmont slope is extent widely. The basement of isthmus part is Jurassic limestones. The dam body is emplaced on the foundation of

Cretaceous limestone and shale in the section of dam abutment, and river deposits of sands/gravels in the section of river bed. The thickness of river deposits is confirmed 12 m at 50 m downstream from dam axis by the result of test drilling. Coefficient of permeability is 1.42×10^{-3} cm/sec. However, siltation in the reservoir blocks storage water from infiltration into ground. Fan deposits in the downstream may be composed mainly of sands/gravels strata intercalated with silts/clay lenses. The thickness of the layer is inferred to be between 100 and 150 m. The bedrock of this area may be Ophiolitic Intrusives. The radius of alluvial fan extent in the downstream of dam is approximately 1 km. Topographic gradient is approximately 1 in 25. Radial angle of alluvial fan is approximately 180 degrees assuming that the pivot is at the dam site.

Depth to bedrock has not been confirmed due to lack of data. It may lie from the depth around 150 m in the valley floor. Coefficient of permeability of alluvial fan is inferred to be the higher side in the order of 10^{-3} cm/sec, and gradually becomes lower as proceeding to the downstream. Depth to groundwater surface is inferred to be in the range of 20 and 30 m.

Dam and reservoir

The dam is located intributary in the mountainous terrains. The catchment area is composed of limestone, shale and conglomerate. Vegetation cover is comparatively in good condition because of adequate soil moisture in the catchment area. Dam foundation comprising of shale exists 12.5m depth from the river surface. Recharge is accelerated through the dam foundation accumulated under the dam body, however recharge capacity is not so high due to fine materials such as sand silt in the aquifer.

Dam Type	Dam Height	Crest Length	Catchment Area	Embankment Volume	Recharge Flow
Fill dam	15.4 m	164 m	15.2 km^2	52,200 m^3	through dam foundation

Socio-economic condition

The estimated number of households of the beneficial area is about 180, and population is about 2,000 souls. This area is a great the districe away to the direct center. Major residents is Kakar tribe of the Pashtun ethnic group. All of the households are engaged in agriculture. Domestic water source is karez and tubewells, and energy source is electricity and wood/coal. There are 2 primary schools and one middle school. No health facilities exist. The impact of the existing dam is not so remarkable.

Agriculture and irrigation

The land has very high potential for irrigated agriculture (irl). The crop suitability classification of the soil is well to moderately well suited to types of crops and orchard. Major source of

irrigation water is karez. Another new karez has been under construction to expand the cropped land in the area. Orchard is a major crop, followed by wheat.

Environment

The effectiveness of groundwater recharge by means of the DAD is not high due to scarce volume of water infiltrated through the reservoir foundation for the siltation in the reservoir. It implies that the DAD has not contributed on the sustainable use of natural resource. Therefore, the DAD creates no positive impacts to both field of physical and human environment. The DAD has contributed to the flood control.

(5) Tirkha dam

Topography, geology and hydrogeology

The catchment area of Tirkha dam is composed of clayey strata of Pleistocene Bostan Formation forming aquitard.

Up to some extent of the downstream from the dam site, Bostan Formation is exposed. Silt tracing sands/gravels strata of alluviums as aquifer is distributing along the stream channel. Groundwater flows as subsoil water in the river deposits. The thickness of river deposits was only 2 m at 50 m downstream of the dam as a result of test drilling.

After the way-out of hilly area, small alluvial fan followed by valley floor extends. Sandy strata forming relatively well aquifer lie over silty strata in the alluvial fan area. Topographic gradient along river bed is very gentle, and that of alluvial fan is between 1 in 80 and 100. Coefficient of permeability of river deposits and fan deposits is inferred to be in the order of 10^{-3} cm /sec.

Dam and reservoir

Because dam foundation is composed of low permeability comprising of fine materials of sandy clay, recharge of the impounding water is achieved at the downstream of the reservoir. Impounding water is diverted through an intake conduit installed in the dam foundation with valve control. Impounding water is periodically diverted to the downstream of the dam so as to minimize the evaporation loss. Fine materials of silt and sand have been accumulated in 1.5 m thick in the reservoir. Vegetation cover is scarcely observed in the catchment area due to heavy surface erosion.

Dam Type	Dam Height	Crest Length	Catchment Area	Embankment Volume	Recharge Flow
Fill dam	10.5 m	411 m	13.7 km^2	53,700 m^3	through river bed

Note) Outflow of impounding water is attained through conduit of Ø150mm diameter.

Socio-economic condition

The estimated number of households of the beneficial area is about 60, and population is 900 souls. The residents belong to the Kakar tribe of the Pashtun ethnic group. The socio-political structure is semi-tribal. Of the total number of 60 households, 10 are involved in agriculture, whereas the rest are employed in trading or government jobs. Domestic water source is tubewells, and energy source is electricity. There are two primary schools. None of health facilities exist. According to the residents, the existing dam has been successful in replenishing the groundwater table.

Agriculture and irrigation

The land has very high to high potential (irI to irIIs) under irrigation. It is well suited to all types of crops, vegetables, and orchards. However, some of the area is occupied by the soil which has poor to marginal potential under irrigated cultivation because of moderately coarse texture, moderately rapid permeability, and moderately low water holding capacity. The major source of irrigation is tubewell. Orchard and wheat are dominant crops in the area.

Environment

Infiltration through the reservoir bed is low due to geological condition of confining bed. In the end of rainy season, the surplus water discharged through the escape may contributes to groundwater recharge in the downstream. It implies that the DAD has contributed to the sustainable use of natural resource. Therefore, the DAD creates positive impacts to both fields of physical and human environment. In addition, the DAD has contributed to the flood control.

(6) Amach dam

Topography, geology and hydrogeology

The catchment area of Amach dam is composed mainly of limestones of Jurassic age, and partly of Miocene limestone. Valleys enclosed by these mountains are extent relatively in large scale buried by alluvial sand/gravels. The thickness of alluvial sands/gravels in river bed of dam site is inferred to reach to around 150 m. In the downstream, piedmont slope is extent widely. Sands/gravels strata found in the downstream of the dam get deeply under valley floor deposits, and forms deep confined aquifers. Valley floor deposits consist almost of silts/clay

strata in the upstream side, however in the section between Mastung Town and the Gap through Shirinab Sub-Basin, it consists mainly of sandy or sand-tracing silts overlain by about 10 to 15 m thickness of sands/gravels strata near ground surface. They may be supplied from mountains of western watershed of Mastung Sub-Basin.

Radius of alluvial fan exposed in the downstream of the dam is in the range of 2 to 3 km. Topographic gradient is in the range of 1 in 80 to 100. Radial angle of alluvial fan is approximately 180 degrees assuming that the pivot is at the dam site. Depth to bedrock has not been confirmed due to lack of data, however, it is inferred to be approximately 150 m around dam site, and 200 to 250 m in the downstream side. Coefficient of permeability of fan deposits is in the order of 10^{-3} cm/sec. Transmissivity may be around 150 m^2/day in alluvial fan, and less than 10 m^2/day in valley floor. Specific yield is approximately 20 % in alluvial fan, and less than 10 % in valley floor. Depth to water level during 1988 to 91 was in the range of 10 to 25 m.

Dam and reservoir

The catchment area is composed of outcrops of limestone. Piedmont deposits and talus deposits have been accumulated at the foots of limestone mountains with their thickness of more than 150 m at the dam site. Dam abutments of both river sides are composed of outcrops of limestone and alluvial deposits. Little sediment is observed in the reservoir during 8 years after the dam completion. Vegetation cover is well observed on the slope of piedmont and talus deposits. The total storage volume of 1,050,000 m^3 is comparatively large rather than those of other dams.

Dam Type	Dam Height	Crest Length	Catchment Area	Embankment Volume	Recharge Flow
Fill dam	15.2 m	762 m	25.7 km^2	136,000 m^3	through dam foundation

Socio-economic condition

The estimated number of households of the beneficial area is about 250, and population is about 2,000 souls. This area is situated near Mastung town. The majority of residents are Persian speaking Dehwars tribe with a small number of the Bangulzai tribe of the Brahvi ethnic group. The socio-political structure of the community is semi-tribal. Out of a total 250 households, only 50 are involved in agriculture while the rest depend on government jobs for their livelihood. Domestic water source is karez, and energy source was electricity and gas. There are 3 primary schools and one middle school. One dispensary was established. According to the residents, the dam has helped in replenishing the groundwater table.

Agriculture and irrigation

The land has very high to high potential under irrigated cultivation (irI to irII). It is well suited for all types of crops, vegetables, and orchards. However, irrigation requirements will be much rather than those of other crops. The higher terrace is presently being used for cultivation of dry-farmed crops such as wheat and watermelon. Irrigation is difficult due to landscape position. Part of the area is being used as grazing land which is subject to severe wind erosion. The lower terrace is under irrigated cultivation. Major source of irrigation water is karez. Orchard and wheat are major crops.

Environment

Groundwater recharge by means of the DAD has contributed to the sustainable use of natural resource. In addition, discharge of karez has been increased by the effectiveness of groundwater recharge, so that irrigation and domestic water supply tend to be stable. Furthermore the DAD has controlled the flush flood causing negative impacts to the human environment. Therefore, the DAD creates positive impacts to both fields of physical and human environment.

(7) Kad Kocha I dam

Topography, geology and hydrogeology

Kad Kocha I dam is located around 2.5 km upstream of proposed Kad Kocha II dam site. The site is situated in the wide valley enclosed by steep mountains composed of Jurassic and Miocene limestone, and emplaced on very thick alluviums in the river bed which continues to the downstream through the Kad Kocha II dam site.

The thickness of alluviums may be approximately 100 m in the valley bottom. Topographic gradient is approximately 1 in 30. Coefficient of permeability is inferred to be in the order of 10^{-3} cm/sec, and transmissivity is in the range of 50 to 100 m^2/day in the alluvium. Depth to water level may be around 50 m.

Dam and reservoir

The catchment area is composed of outcrops of limestone. Piedmont deposits and talus deposits have been accumulated at the foots of limestone mountains. Dam abutment of right side is composed of piedmont deposits, and left side is composed of outcrops of limestone. Because of high permeability of the dam foundation, recharge capacity of the dam is very high. Few sediment is observed in the reservoir during 12 years after the dam completion because

tributaries extend radically, accordingly floods flow down through small creeks distributed in the catchment area. Vegetation cover is well observed on the slope of piedmont and talus deposits.

Dam Type	Dam Height	Crest Length	Catchment Area	Embankment Volume	Recharge Flow
Fill dam	15.2 m	636 m	21.0 km^2	198,200 m^3	through dam foundation

Socio-economic condition

The estimated number of households of the beneficial area is about 270, and population is about 2,500 souls. This community belongs to Lango tribe of Baloch ethnic group. The social structure of the community is tribal. No marketing facilities exist in the area and the farmers usually market their agricultural products in Quetta and Sukkur. The farm input materials are usually bought from Quetta city. Domestic water source is open surface wells and tubewells. Energy source is electricity, kerosene, wood and coal. There are two boys' primary schools. No health facilities exist. The average household income is estimated better than the average of entire Balochistan Province. The technical capabilities of farmers are better than the average farmer in the province, but no agriculture training has been imparted to them. There is one agricultural cooperative in the village of Mall Khann.

Agriculture and irrigation

The soil is highly suitable for irrigation and good for growing of various crops. The main crops are apples, onion, Karif vegetables, wheat, Rabi vegetables, and forage crops. The main livestock is sheep and goats, out of which considerable heads are raising in herd size of 40 to 60. The farm size is relatively big resulted to high income level. As it is the best suitable region for groundwater use in viewpoint of hydrogeology, many number of shallow well and tubewell exist in the expected beneficial area of Kad Kocha II DAD. No karez is operated in these area. Flood irrigation is only available behind area irrigated by the tube-wells where extends far from 2 or 3 km downstream. Tubewells at 62 number are operational in the specified benefit area located upstream of the flood irrigation area.

Environment

Groundwater recharge by means of the DAD has contributed to the sustainable use of natural resource considerably. In addition, water level of existing tubewells located in adjacent areas has been stabilized by the effectiveness of groundwater recharge, so that irrigation and domestic water supply has been ensured. Furthermore the DAD has controlled the flush flood causing negative impacts to the human environment. Therefore, the DAD creates positive impacts to both fields of physical and human environment. However, those positive impacts

are fragile due to inappropriate installation of tubewells, it is necessary to execute appropriate groundwater use control in order to ensure the sustainable use of groundwater resource.

(8) Gorpad dam

Topography, geology and hydrogeology

The catchment area of Gorpad dam is composed of marly limestone, shale, and sandstones of Cretaceous age. The dam is situated on one of the branch stream of Kani Jhal locating around the foot of hills. Alluvial fan having topographic gradient approximately 1 in 30 is extent around there. The thickness of alluvial fan deposits may be 30 m at maximum in the valley bottom. The deposits in this area are in high saline. Though salinity of stored water in the reservoir is barely allowable for irrigation purpose, in the river bed of the downstream of dam, much salts have been remarkably solidified.

Dam and reservoir

Two dams of Gorpad I and II have been constructed in close distance. The catchment areas of both dams are composed of limestone and alternatives of shale and sandstone, and alluvial deposits have been accumulated in the river bed at the dam site. Groundwater recharge is accelerated through the dam and reservoir foundation, however, impounding water in the Gorpad I dam is contaminated with saline (EC=2,500 μS or more), so that the recharged water is not suitable for irrigation and also domestic use.

Dame Name	Dam Type	Dam Height	Crest Length	Catchment Area	Embankment Volume	Recharge Flow
Gorpad I	Fill dam	9.8 m	244 m	0.9 km^2	38,800 m^3	through dam foundation
Gorpad II	Fill dam	6.7 m	160 m	0.5 km^2	23,200 m^3	through dam foundation

Socio-economic condition

The estimated number of households of the beneficial area is about 180, and population is about 1,500 souls. Brahui people live in the area. Near the dam site, nomadic people were observed. The area is located along the highway to the Karachi, and is relatively near the Kalat town. Domestic water source is spring and energy source is electricity and wood/coal. There is one primary school. No health facilities exist. The benefit of the existing dam is not remarkable.

Agriculture and irrigation

The soil is well drained and has moderate permeability and moderate water holding capacity. The land has a high potential under irrigated cultivation (irl). It is well suited to all types of crops, vegetables and orchards. Presently, it is under dry-farming for wheat only.

Environment

Groundwater recharge by means of the DAD has contributed to the rehabilitation of natural resource. However, high salinity of impounded water has caused deterioration of groundwater quality and soil fertility in the downstream. Due to no human and economic activities in the area, no negative impacts to the human environment has been caused.

(9) Laghmgir dam

Topography, geology and hydrogeology

The catchment area of Lagmgir dam is composed mainly of limestones of Permo-Triassic to Jurassic age and partly of alluviums. The dam is located at a little upstream from the way out of mountains so that the downstream section 700 to 800 m length from the dam is narrow river bed followed by widely extending piedmont slope. The thickness of alluvial fan deposits may be in the range of 100 to 150 m, and changes into valley floor deposits. Alluvial fan in the downstream forms typically with radius about 3 to 4 km, and topographic gradient in the range of 1 in 50 to 60 in average. Radial angle of alluvial fan is approximately 130 degrees.

Coefficient of permeability of fan deposits is in the order of 10^{-3} cm/sec. Transmissivity is in the range of 50 to 100 m^2/day in the center of alluvial fan, and specific yield of fan deposits is approximately 20 % or more. Depth to water level may be approximately 50 m.

Dam and reservoir

The catchment area is composed of alternatives of shale and sandstone, and limestone. Alluvial deposits have been thickly accumulated in the river bed at the dam site. Accordingly, recharge capacity through the dam and reservoir foundation is high. River run-off was assumed to be suitable to the reservoir capacity judging from the reservoir water level during floods. Vegetation is well observed on the slope of piedmont and talus deposits.

Dam Type	Dam Height	Crest Length	Catchment Area	Embankment Volume	Recharge Flow
Fill dam	12.2 m	135 m	29.2 km^2	77,400 m^3	through dam foundation

Socio-economic condition

The estimated number of the households of the beneficial area is about 180, and population of the area is about 2000 souls. The settlements are scattered with small size. The majority of the residents is the Lango tribe of the Baloch ethnic group. The socio-economic structure of the community is tribal, but the tribal ties have weakened due to the economical improvement.

Domestic water source is spring, and energy source is electricity. There are one primary school and one dispensary. According to the residents, the existing dam has caused improvement in agriculture.

Agriculture and irrigation

The land has a very high potential under irrigation (irl). It is well suited to all types of crops, vegetables and orchards. The area is mainly irrigated by tubewell and spring. Orchard, onion and wheat are major crops.

Environment

Groundwater recharge by means of the DAD has contributed to the sustainable use of natural resource considerably. In addition, water level of tubewells has been stabilized and discharge of karez has been increased by the dam's effect of groundwater recharge, so that irrigation and domestic water supply has been ensured. Furthermore the DAD has controlled the flush flood causing negative impacts to the human environment. Therefore, the DAD creates positive impacts to both fields of physical and human environment. However, as it is fear that these positive impacts are fragile due to inappropriate installation of tubewells, it is necessary to execute appropriate groundwater use control in order to ensure the sustainable use of groundwater resource. As a minor negative impact, changes in surface water hydrology by the DAD influences to water utilization by flood irrigation in the downstream.

(10) Sarbund dam

Topography, geology and hydrogeology

Sarbund dam is located around 4 km upstream of proposed Mangi dam site. The catchment is composed of Eocene and Jurassic limestones. Relatively wide alluviums forms the valley bottom occupying the large proportion of the catchment area. The dam is situated at the downstream end of this alluvium with their abutment founded on Cretaceous limestone. Just downstream of Sarbund dam expose bedrock in the surface.

Dam and reservoir

The catchment is composed of limestone. Piedmont deposits have been accumulated in the valley. Recharge capacity through the dam and reservoir foundation is high due to thickly accumulated river deposits at the dam site. The sediment in the reservoir area is less accumulated during 3 years after the dam completion because of the deposition of fine materials in the earth bunds constructed for the basin irrigation.

Dam Type	Dam Height	Crest Length	Catchment Area	Embankment Volume	Recharge Flow
Fill dam	12.8 m	412 m	34.8 km^2	60,700 m^3	through dam foundation

Socio-economic condition

The estimated number of households of the beneficial area is 440, and population is about 4,800 souls. The Sarparas tribes of Brahvi are true natives of the area. The social structure is tribal. The major part of the land is possessed by the a few land owners, and almost all of the land owners use to share their land with other villagers. No marketing facilities exist in the area. Farmers usually market their products and procure agricultural inputs from Quetta city located at a considerable distance. Domestic water source is the facilities provided by PHED and tubewells. Energy source is electricity, wood and coal. The area is located at 25 km away from main road, which is available when it is in good weather. There are two primary schools and one middle school, and two dispensaries in the area. There are no sanitations and drainage facilities in the area. The socio-economic condition of the residents is very poor.

Agriculture and irrigation

The soil has no physical or chemical constraints except for shallow depth which may be a problem for orchards. The land has high potential under irrigated agriculture. Most of the area is irrigated by tubewells. Onion cropping is dominant in the area. Wheat and cumin are also cultivated.

Environment

Groundwater recharge by means of the DAD has contributed to the sustainable use of natural resource. In addition, the DAD has controlled the flush flood causing damages to the human environment. Therefore, the DAD creates positive impacts to both fields of physical and human environment.

4.2 Proposed Dam

(1) Brewary dam

Topography, geology and hydrogeology

(Topo-interpretation)

The mountainous catchment of Brewary dam is composed of hard and massive limestones and highly watertight shale of Jurassic to Eocene age. To the northward of the mountain area, hilly

area composed of dense but unconsolidated gravely Subrecent deposits extends. In the downstream of proposed dam site, typically shaped alluvial fan is extends with radius approximately 3 km and reaches up to Sariab Lora.

(Main aquifers influenced by dam)

Alluvial fan with radius of about 3 km is formed and supplied gravels, cobbles and boulders from Karakhusa Nullah in the downstream of the proposed dam. Topographic gradient is approximately 1/50. Dam site situated around the pivot of this fan and the radiating angle of the fan is approximately 100 degrees. The area of this fan is approximately 8 km^2. At the dam site, the bedrock is Brewary limestone overlain by 12 m thickness cobble and boulder stratum, of which coefficient of permeability is $2.5x10^{-3}$ cm/sec. Depth to groundwater level at this point is less than 2 m. According to the data of existing wells identified as QA-ANK-1 and Animal Husbandry-1, the central part of alluvial fan is composed almost all of gravels, and the depth to bedrock is more than 125 m. The depth to groundwater level is 26 m as of February 1987 and the coefficient of permeability is 1.22 to $1.95x10^{-3}$ cm/sec at QA-ANK-1, and 1.84 $x10^{-3}$ cm/sec at Animal Husbandry-1.

Dam and reservoir

The catchment area of the propose dam is located at the Chiltan range, and situated in Brewary limestone, Dungan Formation, and Ghazing Formation composed of mudstone, sandstone and conglomerate. The catchment area forms mountainous hilly and undulated terrains. Karaksha nullah is located at the center of the catchment area which forms 14 km from south-west to north east, and 3 km from north-west to south-east. Perennial flow has not been observed at the middle and upstream areas of the catchment area, however observed upstream of the proposed dam site. The flow discharge has been reduced by 10 to 30 lit./sec in October and November.

Dam site is located at a very narrow gorge about 6.0 m width composed of limestone of Brewary limestone. Rock is exposed on the both abutments. Because the strike of the beds is almost perpendicular, limestone beds continue on the both abutments being correlated in the depth of 8 to 10 m from the river bed.

The right side ridge of the reservoir area is composed of Brewary limestone, and almost straight having dip slope face towards the reservoir. The left side ridge is composed of Ghazig shale having an irregular gentle escarpment face towards reservoir. Piedmont deposits and talus were thickly deposited at the mountain foot of the right side ridge.

Socio-economic condition

The estimated number of households the beneficial area is about 220, and population is about 2,400 souls. This area mainly belongs to the Baloch and Syed people. Being located in the suburbs of Quetta city, the farmers have access to the market and procuring facilities. The domestic water source is open well, and energy source is electricity, gas and wood/coal. Road was metalled for 1 km and unmetalled for 1.5 km. There are 2 middle boys' schools, and 1 dispensary. The sanitation facilities are also not satisfactory. The economic condition of the farmers is much better than the average household in rural area of entire Balochistan Province. There is one agricultural cooperative in Kirrani village.

Agriculture and irrigation

The beneficial area is located at a part of Quetta city. The soil of the area is highly suitable for irrigation farming, and also suitable for growing of various kind of crops. The orchard including grapes, apples and apricots occupy more than 80 % of the farm area, and wheat, vegetables, etc. are planted in Rabi season. In some part of the orchard, forage crops are intercropped under the fruits trees. Livestock is generally raised for self-sufficient, but some farmers raises poultry in large scale for commercial purpose. The situation of the area is favored for agricultural production, and income level of the beneficial farmers is considerably high. However, recently the irrigation water from karezes has decreased extremely due to the decline of groundwater, and instead of karezes, private tubewells have increased. Because of the location, the area has been sprawled with residential area.

Irrigated lands which are specified beneficial area of the proposed Brewary DAD extend in right bank of the Brewary river. Present water source is groundwater utilizing through 26 number of open wells and 2 barely operational karezes.

Environment

Typical environmental situation in the area includes the following issues:
flood damages to the agriculture land, groundwater depletion, State Forest controlled by Forest Department in the catchment area, rehabilitation of ecosystem, water right for karez, shift from exhausted karez to tubewells and substantial expense for shifting, insufficient water supply for irrigation and domestic in the dry season, surface water utilized as domestic water, and riverbed and/or riverside utilized as traffic route.

Environmental aspects changed by the construction of the dam include:
changes in surface water hydrology, changes in groundwater hydrology and apartness of traffic route by dam and related facilities.

Environmental impacts caused by the construction of the dam include:

Positive; mitigation of flood damages, reduction of ground water level decline, sustainable use of groundwater resource, and

Negative; deprivation of surface water use, and loss of traffic approach for social life and economic activities.

The results of IEE revealed that there were no residual negative impacts because the potential negative impacts of minor level could be mitigated by means of conservation and alternative measures in the development plans established in the Study. Therefore, EIA was not required.

(2) Ghutai Shela dam

Topography, geology and hydrogeology

(Topo-interpretation)

The catchment area of Ghutai Shela dam is composed of Permo-Triassic to Jurassic limestone and Subrecent deposits. Limestones form steep mountains. While Subrecent deposits are semi-consolidated, dense gravely strata are usually dissected hilly area forming complicated ups and downs in relief. In the downstream of the dam site, alluvial fan is extent with approximately 2 km wide.

(Main aquifers influenced by dam)

Alluvial fan with approximately 2 km wide is extent in the downstream of the dam site, and change into silts/clay strata in the down reaches of valley floor. Topographic gradient is approximately 1 in 40. At the dam site, river deposits exist up to the depth approximately 4 m underlain by Subrecent deposits which consist of mainly sands in the upper layers and mainly silts in the lower layers. River deposits are mainly composed of sands/gravels. Coefficient of permeability of which is approximately 9×10^{-3} cm/sec. According to the existing data QA-ANK-2, sands/gravels up to the depth 54 m lies over Subrecent clay deposits. Depth to water level was approximately 20 m as of October 1987. Coefficient of permeability was 6.7×10^{-3} cm/sec, and transmissivity and specific yield are 45 m^2/day and 23 %, respectively.

Dam and reservoir

The catchment area is situated in consolidated and unconsolidated Piedmont deposits (Fanglomerate), Subrecent deposits, and limestone. Gravel and cobble stone are deposited in the river bed. Piedmont deposits have been eroded by precipitation and form undulated terrains. The upstream area bounds with the catchment area of the proposed Brewary dam and

composed of Ghazig Shale. Vegetation is scarce in entire catchment area due to heavy erosion and also over grazing.

Proposed dam site is located at consolidated Subrecent deposits. Gravel and sand deposits with its thickness of 28 m have been accumulated in the river bed. Base rock foundation composed of consolidated Subrecent deposits is observed under the river deposits. Both side of dam abutments are also composed of consolidated Subrecent deposits comprising of gravel and fine materials. Subrecent deposits are accumulated in the reservoir area.

Socio-economic condition

The estimated number of households of the beneficial area is about 410, and population is about 4,000 souls. The area is located in the suburbs of Quetta city. This area was originally Brahui speaking people, however, considerable Afghan refugees came to the area during the Afghan war. Majority of the households are involved in small trading or work as labors. Domestic water source is facilities provided by PHED. Energy source is electricity. There are a primary school, but no health facility exists.

Agriculture and irrigation

The beneficial area is located in the suburb of the Quetta city. The soil suitability is high for irrigation and also for growing of various crops. Most of farmers in this area have only small farm land, and generally they have sidejobs for getting supplemental income. Main crops are fruits trees like apples and grapes, and wheat in Rabi season. Irrigation sources are tubewells. However, recently farm lands has been affected by the sprawl of urban area, resulting into the gradual shifting of irrigation water use to domestic water use.

Environment

Typical environmental situation in the area includes the following issues:
flood damages to the residential quarters and infrastructures, impermeable stratum in the catchment area, immigration of Afghan refuges, and riverbed and/or riverside utilized as traffic route.

Environmental aspects changed by the construction of the dam include:
changes in surface water hydrology, changes in groundwater hydrology and apartness of traffic route by dam and related facilities.

Environmental impacts caused by the construction of the dam include:
Positive; mitigation of flood damages, and while
Negative ; loss of traffic approach for social life and economic activities.

The results of IEE revealed that there were no residual negative impacts because the potential negative impacts of minor level could be mitigated by means of conservation and alternative measures in the development plans established in the Study. Therefore, EIA was not required.

(3) Wali Dad dam

Topography, geology and hydrogeology

(Topo-interpretation)

The catchment area of Wali Dad dam is composed of Jurassic limestone and Cretaceous limestone, sandstones, and shale. Dam is situated on Jurassic limestone. Alluvial fan is extent in the downstream with 3 to 4 km wide, though the isthmus was formed by small isolated hills at approximately 1 km downstream, reaching up to Sariab Lora. Though the shape of alluvial fan is not typical, its radial angle is approximately 120 degrees, with topographic gradient of 1 in 25 in average.

(Main aquifers influenced by dam)

Geological section in the downstream of the dam is inferred as shown in attached figure. The thickness of alluvial fan deposits is in the range of fifty to one hundred and tens of meters at maximum and changes into valley floor deposits from around Sariab Lora. A sandy strata exists between sands/gravels of fan deposits and silts/clay of valley floor deposits. Depth to bedrock is approximately 150 m around Sariab Lora which was confirmed by existing data. Coefficient of permeability of fan deposits is 2 to $3x10^{-3}$ cm/sec. Transmissivity is 50 to 60 m^2/day in mid-fan, and 20 m^2/day around the border of alluvial fan and valley floor. Specific yield is 20 % or more in alluvial fan, and 15 % in valley floor. Depth to water level is approximately 20 m around Sariab Lora as of 1988, and becomes deeper gradually to the upstream side.

Dam and reservoir

The catchment area of the proposed dam is wholly situated at Brewary limestone, and partly alternatives of sandstone and shale. Mostly uniform river bed with 20 to 30 m width continues from the proposed dam site to 2 km upstream of the dam site. The river forms narrow gorge with 3 to 4 m width composed of limestone 2 km upstream from the dam site. Gravel and cobble stone have been deposited in the river bed, however, fine material is not observed.

Proposed dam site forms narrow gorge of around 12 m width composed of Chiltan limestone at the both abutments. Limestone is exposed on the both abutments, and limestone beds continue

on the both abutments being correlated at the depth of 5 to 6 m from the river bed. Limestone in abutments is moderately hard to hard, moderately fractured and jointed without infilling. Gravel and cobble stone have been accumulated in the river bed at the dam site. Reservoir area is also situated in limestone area. Few vegetation cover is observed in the catchment area. Relatively large gravel and cobble stone are deposited in the narrow gorge caused by a mountainside collapse.

Socio-economic condition

The estimated number of households of the beneficial area is about 230, and population is about 3,000 souls. The residents are Brahui tribe. Though social customs are tribal, urban life style being in the vicinity of the Quetta city has considerably influenced the area. Domestic water source is the facilities provided by PHED. Energy source is electricity. There are one middle school and one primary school, and one dispensary.

Agriculture and irrigation

The beneficial area is located in the suburb of the Quetta city. The soil suitability is high for irrigation and also for growing of various crops. As the area is favored with both of the conditions, crop production and marketing, fruits, vegetables and wheat production is prevailing and producing relatively high income. However, recently farm lands has been affected by the sprawl of urban area, resulted to the gradual shifting of irrigation water use to domestic water use.

Environment

Typical environmental situation in the area includes the following issues:
groundwater depletion, substantial expense entailed by utilization of tubewells and riverbed and/or riverside utilized as traffic route.

Environmental aspects changed by the construction of the dam include:
changes in surface water hydrology, changes in groundwater hydrology and apartness of traffic route by dam and related facilities.

Environmental impacts caused by the construction of the dam include:
Positive; reduction of ground water level decline, sustainable use of groundwater resource and
Negative ; loss of traffic approach for social life and economic activities.

The results of IEE revealed that there were no residual negative impacts because the potential negative impacts of minor level could be mitigated by means of conservation and alternative measures in the development plans established in the Study. Therefore, EIA was not required.

(4) Dara dam

Topography, geology and hydrogeology

(Topo-interpretation)

The central part of mountain area is composed mainly of hard and massive limestones of Jurassic age, and the periphery is highly watertight shale of Eocene age and partly conglomerates of Miocene age. These are seemed to be impervious bedrock. In the downstream of the proposed dam site, after passing through relatively narrow stream channel, typically shaped alluvial fan is extending with radius approximately 2 to 3 km and reaches up to Gnundak Rud - Loe Manda.

(Main aquifers influenced by dam)

In the downstream of the proposed dam site, alluvial fan with approximately 2 to 3 km radius is formed and supplied gravels, cobble and boulders from the catchment area. Topographic gradient is approximately 1/20 in the upstream side and 1/30 to 1/40 in the downstream side. The radiating angle of the fan is approximately 60 degrees. The area of this fan is approximately 5 to 6 km^2 and reaches up to Loe Manda. Area beyond Loe Manda is a part of valley floor mainly composed of silts and clay.

At dam site, relatively thick silts/clay strata is lying from the depth around 20 m to 35 m. The bedrock and groundwater was not observed by drilling with 40 m depth conducted by the Study Team. Coefficient of permeability of the unsaturated gravels layers is 1.5×10^{-3} cm/sec. The central part of alluvial fan is considered to be composed of very thick sands/gravels strata.

Dam and reservoir

The catchment is broadly divided by the tributaries of Kazha Shela nullah, Nauda Takai nullah. The catchment area is mostly composed of limestone, and mudstone and conglomerate layers exists at the upstream of the dam site. Nullah being located upstream of the dam site is with around 100 m width, in which sand, gravel and cobble stone are deposited. Water course has been changes by floods. Nauda Takai nullah has its river width of 50 to 100 m from the dam site to 2.5 km upstream, and upper stream reduces its width to around 10 to 20 m. Steep limestone walls of the both sides produces narrowest valley of its width of 3 m and that is preferable to detention bund construction. Piedmont deposit is observed at foothills of the limestone. Several narrow gorges with their width of 5 to 10 m were developed in the middle and upstream in the catchment area. Some slumping of the weathered limestone were also

occurred at the fold and fault portions. Ghazig shale is mostly observed along the Kazha Shela nullah located to the north of the dam site.

Proposed dam site is located at the fan head of the alluvial fan. Right side abutment is composed of interbedded shale, and Hanna Urak conglomerate is exposed. These forms hilly undulation terrains. Left side abutment is composed of Chiltan limestone, which are naudulated. River deposits or alluvial fan with thin silt layers were developed with their depth of around 20 m from the river bed at the dam site. Silt and clay layers with depth of between 20 to 30 m exist below the river deposits. The layer contains a few limestone concretions.

Upstream area of the Kazha Shela nullah is composed of outcrop of the limestone, and sandstone, mudstone layers are observed in the middle stream. Sparse vegetation covers the catchment area. Talus deposits of these layers are accumulated in the river bed, however the outflow of soil seems not so high. Proposed dam site is located at the confluence of these nullahs. Because of its steep river bed slope of 1 in 30 at the site, the thickly deposited river materials is susceptible to flowing down into the reservoir area by floods. In this connection, river bed consolidation works, which is effective to settle and storage sediment, are available to prevent from movement of the river materials.

Socio-economic condition

The estimated number of households of the beneficial area is about 120, and population is about 1,700 souls. The area is located at a distance of about 12 km north of Quetta city. The majority of the residents are Kakar belonging to Pashtun ethnic group. The area is in the vicinity of Quetta city and as such the product finds ready market. Agricultural inputs are also obtained from the market in the city. Domestic water source of the area is the facilities constructed by the PHED, open wells and tubewells. Energy source is electricity, gas and wood/coal. The road length in the area is about 2 km that is partly metalled and partly unmetalled. There are a boys' primary school and a girls' primary school. There are no health facilities. The economic condition of the area is much better than the average of the rural households in Balochistan.

Agriculture and irrigation

The beneficial area is a production center in agriculture located at the plain in a suburb of the Quetta city, with high suitability of soil for irrigation. The soil suitability is also good for various crops. The marketing situation is advantageous. The main crops are apples, grapes, Karif and Rabi vegetables and wheat. One of the irrigation water source is the canal water from a spring near the proposed dam, and another is the groundwater pumped up with tubewells. Both irrigation areas are mixed each other. There is considerable grassland in surrounding area, and the farmers raising sheep is often observed.

Specified beneficial area of the proposed Dara DAD overlaps the irrigated area of the Sra Gurgi Irrigation Scheme for which irrigation water has been released from the Kach river. Orchard is majority extending in the beneficial area where irrigated by one spring and 26 number of tubewells. Over-irrigation was inspected in the area, of which some area irrigated at the rate of more than 16 mm/day that is around 150 % of adequate irrigation rate.

Environment

Typical environmental situation in the area is the following issues:
flood damages to the agriculture land, groundwater depletion, water right for karez, shift from exhausted karez to tubewells and substantial expense for shifting, insufficient water supply for irrigation in the dry season and riverbed and/or riverside utilized as traffic route.

Environmental aspects changed by the construction of the dam include:
changes in surface water hydrology, changes in groundwater hydrology and apartness of traffic route by dam and related facilities.

Environmental impacts caused by the construction of the dam include:
Positive; mitigation of flood damages, reduction of groundwater level decline, sustainable use of groundwater resource and
Negative ; loss of traffic approach for social life and economic activities.

The results of IEE revealed that there were no residual negative impacts because the potential negative impacts of minor level could be mitigated by means of conservation and alternative measures in the development plans established in the Study. Therefore, EIA was not required.

(5) Murgi Kotal dam

Topography, geology and hydrogeology

(Topo-interpretation)

The mountainous catchment of the proposed dam is composed of hard and massive limestones of Jurassic age (partly of Paleocene age). This mountain extends straightway toward south from the dam site, and dividing the area into 2 parts in Kuchlagh Sub-Basin and in Quetta Sub-Basin. Alluvial fans extend in both Sub-Basins. Piedmont slope distributes with 1 to 2 km width including these alluvial fans along the foot of mountains, and the downward forms valley floor. Along Baleli River - Khwaja Lora, a lot of gully erosion develops remarkably shaping so many creeks, and forms badlands.

(Main aquifers influenced by dam)

Murgi Kotal Nullah which forms the catchment area of the proposed dam supplies sands, gravels, cobble and boulder, etc. to both alluvial fans. The fan in the side of Kuchlagh is with radius of 1.5 to 2 km, and has the radial angle of approximately 100 degrees assuming that pivot is at the dam site. Quetta side of the fan is, however, with radius approximately 3 km of about 60 degrees radial angle as the pivot of 1 km upstream of proposed dam. Murgi Kotal Nullah flows toward the dam site scooping out the foot of the rivet of the latter. Topographic gradient and the former area are approximately 1/25 and approximately 2 km^2, while the latter area are approximately 1/25 and approximately 6 km^2, respectively.

Test drilling was carried out at the proposed dam site during Phase I Study. The bedrock and groundwater was not be found by the drilling with 40 m depth. Alluvial fans consist mainly of gravels, cobble and boulder, and coefficient of permeability may be in the order of 10^{-3} cm/sec.

Dam and reservoir

The upstream area bounds with the catchment areas of the dams of Bostan and Dara. Murgi Kotal nullah flows down toward south-west with its length of around 9 km, and the catchment area has its width of 2 km in average. The catchment area is wholly situated in Chiltan limestone formation at the left side and limestone of Alozai Gr. at the right side, and partly in Ghazig shale. Thin bedded limestone which was thinly bedded and closely fractured with thin marly bands forms mountainous hilly and rolling terrains. River deposits comprising of mixture of gravel, cobble stone and sand with some silt occupied the river bed.

Proposed dam site is located in a gorge with about 80 m width, and composed of Chiltan limestone. Limestone is exposed on the both abutments. Limestone exposed at the right side abutment is almost straight having dip slope face towards river bed. Limestone at the left side abutment was naudulated. Limestone beds continue on both the abutments, however, river deposits accumulated in the river bed is with more than 40 m thick. River deposits comprising of gravel and boulder were thickly deposited.

River deposits comprising of fine materials of 10 m thick were accumulated in the reservoir due to the dam construction. Piedmont deposit and talus deposits were developed surrounding the reservoir area. These materials are susceptible to erosion during floods, and some slumping of the deposit is likely to occur by inundation of the reservoir area.

Socio-economic condition

The estimated number of the households of the beneficial area is about 330, and population is about 4,600 souls. The residents are mainly tribe of Kanci and Kakar of Pashtun and the social

structure of the community can be classified as semi tribal. Besides agriculture, many of villagers are involved in government, business and labour, etc. Domestic water sources are the facilities provided by the PHED, open wells and tubewells. Energy source is electricity, kerosene oil, gas cylinders, wood/coal, etc. The main Quetta-Chamman road passes through the area. There are 2 boys' primary schools and 2 girls' primary schools and one girls' secondary school. There is one each agricultural cooperative in the village of Chasma Achozai, Kateer and Samli.

Agriculture and irrigation

The beneficial area is a production center located at the plain in a suburb of the Quetta city. The soil suitability is high for irrigation and good for growing of various crops, except some stony areas. The marketing situation is advantageous. The area is divided into two blocks out of which one is prevailing with fruits trees, and the other is including lots of rainfed area. In former area, the main crops are apples and apricots, while in later livestock husbandry is popular among the farmers whose raising size is usually 5 to 10 heads. Many nomad people immigrate in the surrounding areas in every summer season.

There is only a few hectares irrigated area in the downstream of the proposed Murgi Kotal DAD besides rainfed agricultural land. Otherwise orchard area extends in alluvial fan located left side of the dam reservoir belonging to the village of Chasme Achozai, in which apples have been prominently cultivated by 30 number of tube-wells.

Environment

Typical environmental situation in the area is the following issues:
reduction of groundwater level decline by the existing dam, insufficient water supply for irrigation and domestic in the dry season and riverbed and/or riverside utilized as traffic route.

Environmental aspects changed by the construction of the dam include:
changes in surface water hydrology, changes in groundwater hydrology and apartness of traffic route by dam and related facilities.

Environmental impacts caused by the construction of the dam include:
Positive; reduction of ground water level decline, sustainable use of groundwater resource and
Negative ; loss of traffic approach for social life and economic activities.

The results of IEE revealed that there were no residual negative impacts because the potential negative impacts of minor level could be mitigated by means of conservation and alternative measures in the development plans established in the Study. Therefore, EIA was not required.

(6) Kach dam

Topography, geology and hydrogeology

(Topo-interpretation)

The mountain area is composed of hard and massive limestones of Jurassic age, shale and limestone of Eocene age and partly conglomerate of Miocene age. Jurassic limestone and Eocene shale are impervious, though Eocene limestone and Miocene conglomerate are porous and cavernous forming partly aquifer and may supply water to Gnundak Rud. In the right bank, hilly area composed of dense but unconsolidated gravely Subrecent deposits extend from 2 to 6 km downstream of the existing dam. In the 4 km downstream of proposed dam site, alluvial fan extends with radius approximately 5 km and radial angle approximately 30 degrees. The southward of this alluvial fan, also the other adjacent alluvial fans extend widely being supplied gravels from the other catchment areas.

(Main aquifers influenced by dam)

Alluvial fan with approximately radius 5 km is formed and supplied the gravels, cobble and boulder from the Gnundak Rud from the 4 km downstream of the existing dam. Topographic gradient is approximately 1/40 to 1/50 in the upstream side, the radial angle of the fan is approximately 30 degrees. The area of this fan is approximately 4 to 5 km^2. The riverbed of Gnundak Rud is composed of shale of Eocene age covered by very thin river deposits with 1 or 2 m thickness in the upstream of this alluvial fan. However, sands/gravels strata may be rapidly thick from around the way out of hill to the alluvial fan. There is an existing well identified as QA-22 drilled up to the depth 154 m around the southern edge of this alluvial fan, in which bedrock was not confirmed. The lithology at this point was almost all sands/gravels. In the area of another alluvial fan apart about 2 km from the above existing well, one existing well identified as UN-QA-29 drilled up to 183 m, in which bedrock was also not confirmed. The lithology is mainly sands/gravels. Groundwater level as of 1969 - 1971 was approximately 100 m.

Dam and reservoir

Chundak Rud flows down at the center of the catchment area, and catchment area is broadly divided into the catchment areas of Kuchnai Mangala nullah, Mari Chak nullah, Inzar, Shpol nullah. The catchment area is composed of shales and limestone, and the upstream of the area is in Urak formation comprised of sand and gravel. The reservoir area had been fully silted up with in four years immediately after the completion of the existing dam due to excessively high

soil production of shales around the reservoir. Specific sediment volume was estimated at around 2,100 $m^3/km^2/year$. Surface of shales have drying shrinkage of 50 cm depth or more and it incurs high erosion. Accordingly, vegetation cover is scarcely observed at and around the reservoir area due to frequent erosion and land slide of shales. River bed is with 30 to 40 m width at the middle portion of the catchment area, and partly reduces its width. Slope failures with 30 m height are observed along the river, however the tulas composed Urak formation have broadly gentle slope in the catchment area. Vegetation cover is relatively in good condition.

The catchment area of Mari Chak nullah is located in limestone zone, and its tributary has steep slope. The catchment area is composed of outcrop of the limestone, that little soil production is expected. The catchment area of Kuchnai Mangala nullah is composed of limestone wall of more than 50 m height at the right side and steep slope of Urak formation comprising of gravel and sand at the left side. Hundreds of small creek are developed on the gentle slope toward the nullah, however, heavy erosion is not observed, thus soil productivity is small. Most upstream of the catchment area is composed of denuded limestone at the right side and talus deposits at the left side. Rivers or creeks has not been developed. Vegetation cover is in good condition in the area.

Dam and reservoir area is occupied by exposed shales of Ghazij formation. The shale beds from an anticlinal bend across the stream, and form semirounded hills of low relief.

Most of the hill slopes over the shale deposits are talus, indicating high erosive nature of the shale in the right side abutment. Surface run-off from these slopes brings heavy silt load into the reservoir in addition to the transported sediments brought by the flood from the catchment area.

Socio-economic condition

The estimated number of households of the beneficial area is about 330, and population is about 3,000 persons. The community is composed of Bazai, Kakar tribe of Pashtun ethnic group. In addition to the Pashtun tribal traditions, modern urban values have also penetrated and influenced the social structure of the community. Due to the proximity of the area with Quetta city, the products can be marketed and the inputs procured from the city market quite easily. Domestic water source of the area is spring and the facilities provided by the provincial PHED. Energy source is electricity and gas. Road is partly metalled and partly unmetalled. There are 1 boys' primary school and 1 girls' primary school, and 1 dispensary. The small farmers in this area are well off in economic condition, compared to the average small farmers in the entire province.

Agriculture and irrigation

The beneficial area is a production center located at the plain in a suburb of the Quetta city. The soil suitability is high for irrigation and good for growing of various crops, except some stony areas. The marketing situation is advantageous. The main crops are apples, grapes, Karif and Rabi vegetables and wheat. One of the irrigation water source is the canal water from a spring near the proposed dam, and another is the groundwater pumped up with tubewells. Both irrigation areas are mixed each other. There is considerable grassland in surrounding area. Main livestock is sheep and poultry. The beneficial area is in Umer, Ghulgi and Sra Gurgi, which overlaps with the beneficial area of Dara DAD more or less.

Environment

Typical environmental situation in the area is the following issues:
groundwater depletion, water right for spring and karez, shift from exhausted karez to tubewells and riverbed and/or riverside utilized as traffic route.

Environmental aspects changed by the construction of the dam include:
changes in surface water hydrology, changes in groundwater hydrology, and silting in the reservoir and apartness of traffic route by dam and related facilities.

Environmental impacts caused by the construction of the dam include:
Positive; reduction of groundwater level decline, sustainable use of groundwater resource, and
Negative ; loss of traffic approach for social life and economic activities.

The results of IEE revealed that there were no residual negative impacts because the potential negative impacts of minor level could be mitigated by means of conservation and alternative measures in the development plans established in the Study. Therefore, EIA was not required.

(7) Jigda dam

Topography, geology and hydrogeology

(Topo-interpretation)

The mountain area is composed of mainly shale of Oligocene age and forming impervious bedrock. The proposed dam site is located in this mountain area where the relief of the upstream side from the dam site is relatively ups and down, but of the downstream side show very low relief. Jigda Nullah flows to westward in this mountain and flows rapidly and widely

into the extending alluvial fans situating from around Killi Jigda. These alluvial fans are mixed each other forming the width 5 to 6 km piedmont slope along the western foot of the mountain area. In the downward of this piedmont slope, very flat valley floor spreads.

(Main aquifers influenced by dam)

Along the western side of the mountain area, the piedmont slope which is derived from 3 hill torrents with approximately 5 to 6 km width extends. Main aquifers exists in this piedmont forming some groundwater layers. Topographic gradient of this alluvial fan is 1/45, and the area of this fan is approximately 12 to 13 km^2.

River deposits along Jigda Nullah in the mountain area are also relatively thick. According to the test drilling carried out during Phase I Study (June 1996), the thickness of river deposits at proposed dam site is observed at 9.5 m, depth to groundwater level is 6.2 m, and coefficient of permeability is $1.5x10^{-3}$ cm/sec. Two existing wells are located around this area. One is in the piedmont slope about 2 km away from the foot of mountain around the northward of Timrak Nullah identified as PN-KMT-3 which was drilled at June 1987, another is about 3 km southwest of the beneficiary area identified as Tore Shah which was drilled in May 1988. At the point of PN-KMT-3, depth up to 72 m gravels layer, between 72 and 110 m alternation of clay and sands/gravels strata, and deeper than 110 m gravels bearing thick clay strata up to at least 131 m. Bedrock was not confirmed. According to the result of pumping test, the depth to groundwater level is 32.2 m, coefficient of permeability; 6.2 to $6.6x10^{-3}$ cm/sec, transmissivity; 160 to 170 m^2/d, specific yield; 23 %, and specific storage; $1 x10^{-5}$ 1/m. At the Tore Shah located in the valley floor, the uppermost strata with thickness approximately 55 m is sands/gravels, and deeper than this depth partly gravels intercalating clay strata. The pumping test result as of May 1988 shows depth to groundwater level 46.3 m, coefficient of permeability; $4.59 x10^{-3}$ cm/sec, transmissivity; 51 m^2/d, specific yield; 22 %, and specific storage; $2 x10^{-5}$ 1/m.

Dam and reservoir

Jigda nullah flows in the center of the catchment area. Several tributaries are located 4 km upstream of the proposed dam site. The catchment area is composed of Murgha Faquirzai Shale, and Subrecent deposits is accumulated in the river bed. The catchment area forms of hilly and rolling terrains. Surface of shale is weathered, and vegetation cover is scarce. River bed slope is gentle at the middle of the catchment area and weathered shale of 5 to 50 mm grain are accumulated in the river bed. Both sides of the river have gentle slope. Numerous fine shale materials are deposited in the two major steep tributaries 1.5 to 2.0 km upstream of the dam site. These deposits are susceptible to flowing down toward downstream by floods because of steep slope of these tributaries. The middle and upstream catchment area also forms

of hilly and rolling terrains. Vegetation cover is sparse due to thin topsoil on the shales. Weathered shales of their sieve size of 5 to 10 mm are deposited in the river bed. Fine materials such as silt, sand deposited in the river bed are gradually reduced at the upstream of the catchment area.

The dam site is situated in Murgha Faqirzai shale. Shaighalu sand is also thinly inbedded. Since the shale was severely weathered or eroded by water, the surface was cracked, and vertically dipping. Gravel, sand and boulder stone originated from the shale fully occupied the river bed with their depth of around 10 m at the dam site. Weak foundation composed of silt and clay river deposits exists 5 to 8 m below the river bed according to the drilling survey. Reservoir is bounded by hills predominantly formed of thin Piedmont deposit at the left side, and weathered shale at the right side.

Socio-economic condition

The estimated number of households of the beneficial area is about 100, and population is about 1,500 souls. The communities belong to the Kakar and Syed Chishti. The socio-political organization is semi-tribal. No marketing facilities exist in the area. Domestic water source is karez and open surface wells. Energy source is electricity, kerosene, wood and coal. Road is all shingle. There are two primary schools and no health facilities. The agricultural income of small farmers is so insufficient that considerable numbers of them are involved in other additional income sources.

Agriculture and irrigation

The beneficial area is located on the fan, relatively near the center of the Pishin District. The soil suitability is high for irrigation and good for growing of various crops. The Karif and Rabi vegetables, wheat and apples are main crops of this area. However, marketing condition is not so good because of the poor farm to market roads. The large rainfed area stretches out around this beneficial area. Some sheep and goats are raised for self-sufficient.

The beneficial area of the Jigda DAD extends in both sides of the Jigda river. Single karez in each river side is only water sources for irrigation and drinking purpose having certain water users organization being well operational. Pumping irrigation for orchard and vegetable production has been done by 20 number of tube-wells in agricultural lands in Kamarzai village located around 10 kilometers downstream.

Environment

Typical environmental situation in the area is the following issues:
groundwater depletion, decreasing discharge of karez, water right for karez, insufficient water supply for irrigation and domestic in the dry season and riverbed and/or riverside utilized as traffic route.

Environmental aspects changed by the construction of the dam include:
changes in surface water hydrology, changes in groundwater hydrology and apartness of traffic route by dam and related facilities.

Environmental impacts caused by the construction of the dam include:
Positive; reduction of groundwater level decline, sustainable use of groundwater resource, and
Negative ; loss of traffic approach for social life and economic activities.

The results of IEE revealed that there were no residual negative impacts because the potential negative impacts of minor level could be mitigated by means of conservation and alternative measures in the development plans established in the Study. Therefore, EIA was not required.

(8) Sanzali dam

Topography, geology and hydrogeology

(Topo-interpretation)

The mountain area is composed of Bostan Formation of Pleistocene age covered with relatively thick Subrecent deposits. There may be geological tectonic line along the western edge line of mountain, and the eastern part had probably been upheaved such new Subrecent deposits forms mountain and hill. Hillock area is mainly composed of Bostan Formation covered with very thin surface gravely layers. Bostan Formation is usually composed of impervious clay, but in this area interceded partly with sandstone and conglomerate strata with thickness of few to ten and few meters, inclining gently to west-south-west ward. These strata may have good permeability, and may recharge into deep aquifers lying in the western area.

Bostan Formation holds low sharing strength in the wet situation, so that a lot of landslide develops along the channel.

(Main aquifers influenced by dam)

The colluvial deposits formed by landsliding is loose and mixed with a lot of sands and gravels derived from upstream mountain area or washed out the fine material to the downstream

resulting good permeability. These deposits distribute along the channel relatively widely, and forms the small scale of aquifers. According to the test drilling result carried out during Phase I Study (June 1996), the thickness of the river deposits at proposed dam site is observed at 2.5 m. Groundwater flows down into this surface layer.

These groundwater flows into valley floor around Pishin Town. In the central part of valley floor, the maximum depth to Bostan Formation which forms the impervious bed is 140 to 150 m overlain by gravels bearing sandy silts having relatively good permeability. According to information on the existing well PLV-19 located around 1 km north from the way out of Sanzali Nullah to valley floor, the lithology is the fine alternation of gravels and clay layers showing groundwater at the depth of 85 m. Deeper than this, Bostan Clay is underlying. Coefficient of permeability may be around 1 $x10^{-3}$ cm/sec.

Dam and reservoir

Upstream of the catchment area is composed of subrecent-recent deposition comprising of rounded gravel, sand and clay. Rest of the catchment area is composed of Bostan formation. Subrecent-recent deposition forms mountainous hilly and rolling terrains, and was heavily eroded by precipitation. Slope failures of the Bostan formation are observed along the river, and it causes huge sedimentation in the reservoir associated with the dam construction. Because of the susceptibility to erosion of the Bostan formation, little vegetation cover was observed especially in the upstream of the catchment area.

River deposits composed of gravel, sand, silt and clay were originated from the Subrecent-recent deposition. Fine particles of Bostan clay caused by erosion was not accumulated in the river bed, and transferred towards downstream as a suspended solid. Gravel and clay river deposits were accumulated in the river bed with their thickness of 2 to 3 m. It is anticipated that the fine materials originated from Bostan Formation is accumulated in the reservoir by flood.

Proposed dam site is situated in Bostan formation composed of silt, sand and radish clay. Since Bostan clay is susceptible to erosion, the configuration around the dam site forms rolling and hilly terrains. Gravel and clay river deposits were accumulated in the river bed with 2 to 3 m thickness. The base foundation of Bostan Formation has depth of more than 40 m at the dam site, and thin sandstone layer with 2 m thickness is inbedded at the depth of 13 to 15 m from the river bed. Groundwater was observed on the clay foundation, 1.5 m below from the river bed. Both abutments were deeply eroded, 0.5 to 1.0 m from the surface by precipitation, however clayey foundation was well consolidated. Thus bearing capacity of the foundation is enough to construct the dam embankment.

Socio-economic condition

The estimated number of households of the beneficial area is about 30, and population is about 500 souls. The community belongs to the Kakar tribe of Pashtun ethnic group. No marketing/procurement of inputs facilities exist in the area. The approach roads are sometimes difficult to transport the products of the farm to the market due to bad weather. Domestic water source is open surface wells and the facilities constructed by PHED. Energy source is electricity, wood and coal. There is a boys' primary school. No health facilities exist in the area. Due to uncontrolled grazing and cutting of the trees, the area has been in devoid of vegetative cover resulting in soil erosion.

Agriculture and irrigation

The beneficial area is located at the somewhat undulating and hilly area, relatively near the center of the Pishin District. The coarse soil is predominant that is not so suitable for irrigation. The main crops are vegetables and tobacco in Karif season and wheat in Rabi season. The marketing condition is unfavorable due to poor farm to market roads. As considerable grassland stretches around the beneficial area, sheep and goats, that are the main livestock, are raised by most of farmers out of which some farmers keep a herd from 50 to 100 heads of sheep and goats.

The specified beneficial area of the Sanzali DAD being irrigated at present has been dependence with 5 karezes. The karezes are still operational in spite of needed adequate operation and maintenance such as timely cleaning. Pumping irrigation has been done by 12 number of tube-wells, some of them are in-operational due to lowering groundwater level, in agricultural lands in Killi Haji Abdula village located around 9 km downstream.

Environment

Typical environmental situation in the area is the following issues:
flood damages to the agriculture land, groundwater depletion, decreasing discharge of karez, considerable soil erosion and loss, water right for karez, shift from exhausted karez to tubewells, insufficient water supply for irrigation and domestic in the dry season and riverbed and/or riverside utilized as traffic route.

Environmental aspects changed by the construction of the dam include:
changes in surface water hydrology, changes in groundwater hydrology and apartness of traffic route by dam and related facilities.

Environmental impacts caused by the construction of the dam include:

Positive; mitigation of flood damages, reduction of ground water level decline, sustainable use of groundwater resource, and

Negative ; loss of traffic approach for social life and economic activities.

The results of IEE revealed that there were no residual negative impacts because the potential negative impacts of minor level could be mitigated by means of conservation and alternative measures in the development plans established in the Study. Therefore, EIA was not required.

(9) Ghazlona and Samaki dam (Arambi)

Topography, geology and hydrogeology

Ghazlona

(Topo-interpretation)

The mountain area is composed mainly of shale of Eocene age which forms impervious bedrock. The downstream from around proposed dam is generally low relief hilly area with gradually the width of riverbed widening little by little ranging from some tens of meters to hundred and some tens of meters. Ghazlona Nullah finally joins to Arambi Manda. Arambi Manda has generally wide riverbed. The left bank in the upstream side of Arambi Manda from joining point is composed mainly of gully eroded talus. In the downstream of Arambi Manda after joining with Halkai Arambi Nullah, very wide riverbed with width reaches 2 km extends.

(Main aquifers influenced by dam)

Aquifers to be recharged by the proposed dam is an alluvium of the riverbed. It is generally composed of cobble and gravels having high permeability. Groundwater flows within the surface alluvial layers because bedrock is impervious shale. The topographic gradient of the river bed is 1/50 to 1/60. The width of the river is 40 m at the narrowest and approximately 200 m at the widest. The groundwater flowing surface layers of Ghazlona Nullah river deposits flows into the large scale of alluvium of Arambi Manda.

Samaki

(Topo-interpretation)

The catchment area of Samaki DAD is composed of Miocene Sandstone intercalated with Shale which form hydrogeological bed in this area. North-western mountainside shows remarkable lineation and continue to valley forming Arambi Manda. Talus-like very gentle hills are situated

linealy with width few kilo-meter between Arambi Manda and mountains. Streams derived from these mountains cut these hills and pour to river-bed of Arambi Manda.

(Main aquifers influenced by DAD)

Aquifer to be recharged by the proposed dam is talus-like deposits, alluvial cone deposits distributing along streams, and river deposits of Arambi Manda. Talus-like deposits include relatively much silt at some places resulting low permeability.

Dam and reservoir

Ghazlona

The whole catchment area is composed of Murgha Faquirzai Shale, and forms rolling terrains at the proposed dam site. Bostan formation overlain the shale is observed at the most upstream of the catchment area. Some steep slumping were occurred on the shale, on contrary to this, widely surface erosion were developed on the Bostan formation. Upstream of the catchment area forms mountainous hilly and most upstream is located at Arambi Range at where severe erosion has developed. Ghazlona nullah flows in the center of the catchment area. Rolling terrains composed of shale is located at the downstream of the catchment area. Vegetation cover is sparse. Gravel, sand deposits produced from the surface erosion of the shales and cobble stone of rectangular plate or bar shapes originated by slope failures are accumulated in the river bed. River bed has 60 to 70 m width.

The river is distributed in several tributaries at the middle of the catchment area. River reduces its width around 20 to 30 m at around the dam site. Vegetation cover is scarce, however soil production is not so high because surface soil is thin on the slope. River deposits has 1 to 2 m depth and shale foundation is partly exposed on the river bed. River width is around 15 m at the upstream of the catchment area. The gorge forms deep valley due to severe land failure and erosion.

Proposed dam site is situated in Ghazig shale formation, which dominantly consists of cracky and vertically dipping direction. Surface of the shale was severely weathered or eroded by water. Both of abutments form hilly configuration, and deeply eroded gullies were developed, especially at the right side slopes. Gravel, sand and boulder originated from the shale occupy the river bed with their depth of 3 to 4 m at the dam site.

Samaki

The catchment area of the proposed dam is broadly composed of Shaigalu Formation composed of shale and partly inbedded sandstone. Shale and sandstone strata have the prevalence of folded structures. Talus deposits were accumulated on the mountain foots along the river.

Dam site is located at the confluence of the two tributaries. River gradient is relatively steep at 1:10. River deposits have thickly accumulated in the river bed.

Proposed dam site is also located at Shaigalu Formation composed of shale and sandstone. A thin layer of shale is well jointed and severely weathered on their surface. Both site of dam abutment has undulated terrains. River deposits comprising of gravel and stone of shale and sandstone have been accumulated at the depth of 17 m in the river bed.

Socio-economic condition

The estimated number of households of the beneficial area is about 460, and population is about 5,600 souls. The community belongs to the Kakozai tribe of the Pashtun. Socio-political structure of the community is semi-tribal. The area is well known for the production of good varieties of apples and vegetables. However due to no marketing facilities exist in the area the farmers have to go to Pishin, located at more than 40 km far from the area, for marketing products and procuring farm inputs. Domestic water source is karez and open surface wells. Energy source is electricity, kerosene, wood and coal. All road concerned is all shingle. There are one boys' and one girls' primary school, and one dispensary.

Agriculture and irrigation

The beneficial area is located at the somewhat undulating and hilly area, far from the center of the district. The soil is highly suitable for irrigation and for growing of various crops. However, the marketing condition is unfavorable due to poor farm-to-market roads. The main crops are apples, apricots, grapes, Karif vegetables, wheat, etc. The water source for irrigation is karezes and tubewells. Main livestock is sheep and goats that are raised by almost all farmers only in small raising size.

The beneficial area extends partly along the Ghazlona River in Mullayan village, and adjacent of the confluence of the Ghazlona River and Major stream in Silad village. Beneficial area in Mullayan village faces scarce of water, having an in-operational karez and 10 shallow wells with very low availability of water. Beneficial area in Silad village is mainly orchard harvesting by 10 tubewells.

Environment

Typical environmental situation in the area is the following issues:
flood damages to the agriculture land, groundwater depletion, decreasing discharge of karez, water right for karez, insufficient water supply for irrigation and domestic in the dry season, surface water utilized as domestic water and riverbed and/or riverside utilized as traffic route.

Environmental aspects changed by the construction of the dam include:
changes in surface water hydrology, changes in groundwater hydrology and apartness of traffic route by dam and related facilities.

Environmental impacts caused by the construction of the dam include:
Positive; mitigation of flood damages, reduction of ground water level decline, sustainable use of groundwater resource, and
Negative ; loss of traffic approach for social life and economic activities.

The results of IEE revealed that there were no residual negative impacts because the potential negative impacts of minor level could be mitigated by means of conservation and alternative measures in the development plans established in the Study. Therefore, EIA was not required.

(10) Sakhol dam

Topography, geology and hydrogeology

(Topo-interpretation)

The mountain area is composed mainly of hard and massive limestones of Jurassic age forming valley with steep slope. This valley is buried by thick talus and alluvial deposits, and form relatively wide valley through the gap at the proposed dam site and continuing to the piedmont slope to the downstream. The downstream side of the proposed dam is gradually depressed gently from both directions of north and south due to probably erosion surpassing sedimentation. This area has different features to some extent from the other piedmont where usually forming alluvial fan. Therefore, it is inferred that this area may be composed mainly of impervious fine grained soil such as silts/clay rather than the permeable material. Sand-dune deposits composed of fine sands whirled up and transported by strong western wind in winter season through the Gap between Mastung and Shirinab Sub-Basin covers the piedmont of this area, though the foot of mountain with width few hundred meters consist mainly of sands and gravels derived from the upstream area. The downstream side of sand-dune is valley floor, which is composed of very thick silts/clay strata reaching its thickness around 300 m and covered with thin eolian deposits.

(Main aquifers influenced by dam)

Sands/gravels strata along the foot of mountain with width few hundred meters may be, like as UN-MST-4A, underlain by silts/clay strata. Then, the recharged groundwater into these sands/gravels strata may be once stored in these aquifers. This is assured by the facts that

relatively many karezes exist in this area, and the karez system is difficult to take groundwater because aquifers and groundwater table are so deep.

Sand dune deposit may be relatively permeable due to composed of loose sands and silts. As this deposits may be underlain by impervious silts/clay, groundwater may flow to the downstream within sand-dune deposits. The influenced area by the recharged groundwater flowing from the proposed dam is limited due to topographic condition. Topographic gradient is approximately average 1/100.

Dam and reservoir

The catchment area is composed of Chiltan limestone, Shirinab formation, Spin Tangi limestone and Bostan formation. The catchment area forms mountainous hilly and the materials for sedimentation was derived from surrounding out-crops of older rocks. Piedmont deposits were accumulated at the foot of limestone mountains. Talus deposit and river deposit are observed in the wider valley. Sand dune was developed at the lower part of the proposed dam site.

Two of large tributaries located at the left and right side of the catchment area have confluence at the proposed dam site. Both tributaries are located at limestone area (Chiltan limestone), and have alluvium in the river beds. Talus deposits are accumulated on the alluvium. Vegetation cover is observed on the talus deposits and alluvium. Earth bunds have been constructed by inhabitants for the basin irrigation at the proposed reservoir area and also upstream of the catchment area. Series of earth bunds in small creeks are effective for silt trap during floods.

Proposed dam site is located at the fan head of the alluvial fan and the depth of the river deposits is more than 100 m. Proposed dam would be constructed acrossing the wider valley of its width of around 1,000 m. Both abutments are composed of out-crops of the limestone. Dam foundation is composed of semi-permeable materials due to fine material contents.

Socio-economic condition

The estimated number of households of the beneficial area is about 180, and population is about 2,000 souls. Bangulazai tribe of the Brahui is the main ethnic group. The social structure of the residents was relatively democratic. Domestic water source is open surface well, karez and tubewell. Energy source is electricity, kerosene oil and wood. All roads are unpaved roads available only in good weather. There is a primary school for boys and girls. No health facilities exist. The discharges of karezes were very low due to improper maintenance. The average household income is estimated very low. One agricultural cooperative is established in the village of Fizabad.

Agriculture and irrigation

The beneficial area is in the flat area along the highway, near the center of the Mastung District. The soil is highly suitable for irrigation and for growing of various crops, but it has a little high penetration rate due to its sandy characteristics. The soil condition does not so properly for fruits trees that onion and wheat are mainly planted. Main livestock is sheep and goats, but rearing size is small. Generally, the farm size is small and the household income is low.

In expected beneficial area of the Sakhol DAD, potentiality for groundwater exploitation is limited due to hydrogeological conditions as described in the section of Hydrogeology. The agricultural areas extending downstream of the dam could clearly categorized areas in karez use, tubewell use and flood irrigation, from the upstream. Half number of existing 6 karezes are in-operational at all , and remaining half have decreased availability due to effect of exploitation of groundwater by tubewells. The proposed dam could give an effect for groundwater use by existing 20 tubewells.

Environment

Typical environmental situation in the area is the following issues:
groundwater depletion, decreasing discharge of karez, water level decline of tubewells in the dry season, surface water utilized as flood irrigation, water right for karez, insufficient water supply for domestic in the dry season and riverbed and/or riverside utilized as traffic route.

Environmental aspects changed by the construction of the dam include:
changes in surface water hydrology, changes in groundwater hydrology and apartness of traffic route by dam and related facilities.

Environmental impacts caused by the construction of the dam include:

Positive; reduction of ground water level decline, sustainable use of groundwater resource, and

Negative ; deprivation of surface water use for flood irrigation and loss of traffic approach for social life and economic activities.

The results of IEE revealed that there were no residual negative impacts because the potential negative impacts of minor level could be mitigated by means of conservation and alternative measures in the development plans established in the Study. Therefore, EIA was not required.

(11) Mangi dam

Topography, geology and hydrogeology

(Topo-interpretation)

The mountain area is composed mainly of hard and massive Jurassic limestones and Eocene limestone. There are two types of Eocene limestone, one is relatively hard and massive, another is porous and cavernous so that partly aquifers may develop. Inside of this mountain area, relatively wide valley buried by talus and alluvial exists and forms a part of the catchment area of existing Sarbund dam. Piedmont slope extends widely with width few kilometers along the western foot of mountain area. Further downstream side up to Shora Rud is valley floor covered with silts/clay, but the riverbed of Shora Rud is composed of sands/gravels.

(Main aquifers influenced by dam)

The piedmont slope with a few kilometers width extend widely in the western side of mountain area. Average topographic gradient of the alluvial fan is approximately 1/100, and the area is around 14 to 15 km^2. According to the result of test drilling during Phase I Study, the thickness of the sands/gravels at proposed dam site is 27 m, and bedrock is shale of Oligocene age. Groundwater was not observed at that time. Upstream side may be sands/gravels rich, and downstream side silts/clay rich from existing 4 wells data of UN-PS-3 to 5 and KB-BKB-1 along Shora Rud. Bedrock is generally shale and/or sandstone of Eocene to Miocene age.

Dam and reservoir

The catchment area is composed of Shirinab Formation at the left side and Nimargh limestone at the right side, and alluvium are deposited in the river bed. Shirinab Formation is composed of limestone and interlogged shales. The catchment area of the Sarbund dam is composed of Nimargh limestone and alluvium is thickly accumulated in the widely spread valley of the catchment area. Vegetation cover is in good condition in the catchment area of the Sarbund dam, and several bunds constructed in the valley for the basin irrigation contribute to trap silt and turbid water in them during floods. Siltation volume is slightly observed in the reservoir of the Sarbund dam even after 3 years from completion.

Plain river bed with 500 to 700 m width is formed in the downstream area of the Mangi dam catchment area. Vegetation cover is sparse on the alluvium and talus deposits. Several bunds with their length of more than 200 m are constructed for the basin irrigation in the river and it contributes for silt trap during floods. River forms gorge configuration in the middle of the catchment area. Gorge width ranges from 15 to 20 m. Outcrop of limestone is observed at the both sides of the river. Vegetation cover is sparse. Perennial flow (groundwater) is observed

at the mountain foot located at the left side of the river. Upstream of the catchment area forms wide basin with sparse vegetation cover. Groundwater flow is observed at the shallow depth throughout the year. Vegetation cover is in good condition on the alluvium located at the left side of the area. Basin irrigation is adopted along the river. Several rows of earth bunds contributes to capture fine silt, clay eroded by precipitation inside of the bunds.

Proposed dam is located at the fan head of the alluvial fan with around 700 m width. Right side abutment is composed of out-crops of naudulated limestone. Left side abutment is composed of Piedmont deposit originated from Shirinab formation. River deposits composed of boulder, gravel, sand and clay is thickly accumulated at the dam site. Base rock of shale (Shirinab formation) is observed at the depth of 17 m from the river bed.

Socio-economic condition

The estimated number of households of the beneficial area is about 440, and population is about 4,800 souls. The Sarparas tribes of Brahvi are true natives of the area. The social structure is tribal. The major part of the land is possessed by the a few land owners, and there are considerable share croppers in the area. No marketing facilities exist in the area. Farmers usually market their products and procure agricultural inputs from Quetta city located at a considerable distance. Domestic water source is the facilities provided by PHED and tubewells. Energy source is electricity, wood and coal. The area is located at 25 km from main road, and available when it is in good weather. There are two primary schools and one middle school and two dispensaries in the area. There are no sanitation and drainage facilities in the area. The socio-economic condition of the residents is very poor. One agricultural cooperative was established in the village of Shapchi.

Agriculture and irrigation

The beneficial area is in the flat area located at the boundary of Mastung and Kalat Districts. The physical and chemical characteristics of soil textures are moderate and soil suitability for irrigation is high, but the area is not suitable for orchard due to the shallow subsoil layer. Main crops are onion, wheat, and cumin, especially onion is grown by most of all farmers. Main livestock is sheep, goats and poultry, and most of farmers are raising sheep and goats. There are considerable sharecroppers whose income level is low. Karez use has been rapidly shifted to tubewell operation in the beneficial area of the Mangi DAD. Only 2 karezes are scarcely operational at present among existing 12 karezes.

Environment

Typical environmental situation in the area is the following issues:
groundwater depletion, decreasing discharge of karez, water level decline of tubewells in the dry season, water right for karez, shift from exhausted karez to tubewells, seasonal migration of transhumant pastoralist and riverbed and/or riverside utilized as traffic route.

Environmental aspects changed by the construction of the dam include:
changes in surface water hydrology, changes in groundwater hydrology and apartness of traffic route by dam and related facilities.

Environmental impacts caused by the construction of the dam include:
Positive; reduction of ground water level decline, sustainable use of groundwater resource, and
Negative ; loss of traffic approach for social life and economic activities.

The results of IEE revealed that there were no residual negative impacts because the potential negative impacts of minor level could be mitigated by means of conservation and alternative measures in the development plans established in the Study. Therefore, EIA was not required.

(12) Kad Kocha II dam

Topography, geology and hydrogeology

(Topo-interpretation)

The mountain area is composed mainly of hard and massive Jurassic limestones and porous and cavernous Eocene limestone. Jurassic limestone forms steep slopes. In the catchment area of the proposed dam, relatively wide valley buried by talus and alluviums are formed and supplied sands and gravels from the mountain slope. Likewise, the middle scale of alluvial fan extends through the Gap of near downstream of proposed dam. The other alluvial fans from the other catchment areas contact to this alluvial fan. The downward of this alluvial fan is valley floor reaching up to Rud Sariab.

(Main aquifers influenced by dam)

Based on the topography, the influenced area by the recharged groundwater from the proposed dam may be limited in the aquifers of the alluvial fan and of the valley floor continuing from this alluvial fan. Topographic gradient of the alluvial fan is 1/30 to 1/40, the area is 3 to 4 km^2. Sands/gravels strata of the alluvial fan continues to the silts/clay strata of the valley floor

resulting semi-confined or confined aquifers in the part of valley floor. According to the existing well data of MST-11 drilled in 1974 located in the valley floor, these semi-confined or confined aquifers have their hydrogeologic characteristics as follows:

Depth to groundwater level was approximately 30 m as of the date drilled, coefficient of permeability approximately; $1x10^{-3}$ cm/sec, transmissivity approximately; 90 m^2/d, specific yield; 15 %, and specific storage; $8x10^{-5}$ 1/m. Unconfined aquifers in the alluvial fan seem to be higher permeability than the above. Some number of tubewells exist in this alluvial fan. All of them are located along the southern end of the alluvial fan where is convenient to pump up groundwater.

Dam and reservoir

The catchment area is composed of Chiltan limestone, Shirinab formation, Spin Tangi limestone and Bostan formation, and alluvial deposits comprised of gravel, sand and cobble stone have been thickly accumulated on the mountainfoot. Vegetation cover is observed on the alluvium deposits and talus deposits. River deposits are thickly accumulated, however accumulation of siltation in the reservoir area is less expected because tributaries extend radically, accordingly floods flow down through small creeks distributed in the catchment area. Less inflow of sediment is expected by the existing delay action dam of the Kad Kocha I.

Proposed dam site is located at the fan head of the alluvial fan and the depth of the river deposits is more than 100 m. Proposed dam is constructed acrossing the wider valley of its width of around 400 m. Both abutments are composed of out-crops of the limestone. River deposits are composed of boulder stone, gravel, sand and silt. Boulder size is relatively large, 20 to 40 cm. The water impounded in the dam reservoir will seep into reservoir bed and ultimately drain into the area downstream of the dam site.

Socio-economic condition

The estimated number of households of the beneficial area is about 270, and population is about 2,500 souls. This community belongs to Lango tribe of Baloch ethnic group. The social structure of the community is tribal. No marketing facilities exist in the area and the farmers usually market their agricultural products in Quetta and Sukkur. The farm input materials are usually bought from Quetta city. Domestic water source is open surface wells and tubewells. Energy source is electricity, kerosene and wood and coal. There are two boys' primary schools. No health facilities exist. The average household income is estimated better than the average of entire Balochistan Province. The technical capabilities of farmers are better than the average farmer in the province, but no agriculture training has been imparted to them. There is one agricultural cooperative in the village of Mall Kharm.

Agriculture and irrigation

The beneficial area is located at a flat area along the highway. The soil is highly suitable for irrigation and good for growing of various crops. The main crops are apples, onion, Karif vegetables, wheat, Rabi vegetables, and forage crops. The main livestock is sheep and goats, out of which considerable heads are raising in herd size of 40 to 60. The farm size is relatively big resulting into high income level.

As it is the best suitable region for groundwater use in viewpoint of hydrogeology, many number of shallow well and tube-well exist in the expected beneficial area of the Kad Kocha II DAD. No karez is operated in this area. Flood irrigation is available in a area behind irrigated area by the tubewells, where extends 2 or 3 km downstream from the dam site. 62 tubewells are operational in the specified benefit area located upstream of the flood irrigation area.

Environment

Typical environmental situation in the area is the following issues:
flood damages to the facilities for flood irrigation and substantial expense for its rehabilitation, groundwater depletion, water level decline of tubewells in the dry season, surface water utilized as flood irrigation and riverbed and/or riverside utilized as traffic route.

Environmental aspects changed by the construction of the dam include:
changes in surface water hydrology, changes in groundwater hydrology and apartness of traffic route by dam and related facilities.

Environmental impacts caused by the construction of the dam include:

Positive; mitigation of flood damages, reduction of ground water level decline, sustainable use of groundwater resource, and

Negative ; difficulty of surface water use for flood irrigation at a part of the area and loss of traffic approach for social life and economic activities.

The results of IEE revealed that there were no residual negative impacts because the potential negative impacts of minor level could be mitigated by means of conservation and alternative measures in the development plans established in the Study. Therefore, EIA was not required.

(13) Iskalkoo dam

Topography, geology and hydrogeology

(Topo-interpretation)

The catchment area of Iskalkoo dam is composed of Miocene limestone. This limestone is porous and cavernous in many localities and easily eroded by water forming hilly topography. The dam site is located at the mid-area in the hills in which western side is dissected, and covered by relatively thin alluviums.

(Main aquifers influenced by dam)

The proposed dam site consists of white to pinkish limestone in general, though very thin river deposits lies along river bed. From about 1 km downstream of the dam site, alluvial fan composed generally of sands/gravels develops. According to the information of the test drilling, the thickness of alluviums at the way-out from hills is 6.5 m, and depth to water level is 2.6 m. It is inferred that the thickness of alluvium may be around 30 m at maximum. They are underlain by shale in general. Miocene limestone in the area lies over the shale.

Dam and reservoir

Proposed dam site is situated in Kirthar Formation compose of limestone and Nari Formation composed of shale and mudstone. Several layer of shale and sandstone are well jointed, and talus deposits were thickly accumulated on the hillfoot along the river. Vegetation is in good condition on the thickly deposited talus deposits.

Proposed dam site is located at Nari Formation composed of shale and sandstone. Shale is well jointed and its surface has loosened solid rocks. Dam abutments form mountainous hill and terrains. Consolidated clayey layer is observed on the right side and lower part of the river bed. River deposits composed of gravel and cobble stone of shale and sandstone were accumulated with their thickness of 6.5 to 30 m from the river bed surface. Kirthar limestone is observed under the river deposits.

Socio-economic condition

The estimated number of households of the beneficial area is about 85, and population is about 1,500 souls. All the residents of the area belong to Brahui ethnic group. The area is located 3 km far from Kalat urban center. Domestic water source is spring. Energy source is electricity and oil. There are one high school and one primary school, and one dispensary in the area.