H4.2.1 Construction Phase

The proposed Munda Dam construction activity will entail:

i) Procurement of construction material;
ii) Laying down and excavating the foundation, blasting, and building the structure;
iii) Use of construction machinery and other equipment;
iv) Manpower and its activity;
v) Rock material for construction will be taken from the quarry site Sappare downs stream or Todobo Banda falling in the reservoir area. It will have no impact on the flora or fauna of the river in the project area; and
vi) Excavated earth to amount to 10 m high in an area of 1 km^2.

The dam filter material and concrete aggregate would not be obtained from river deposits of sand and gravel downstream of the Munda Dam site. The source for the filter material or concrete would be quarry rock. Obtaining this material from the riverbed would have a negative impact on the aquatic biology of the river. The river deposits of sand and gravel are breeding and foraging grounds for many fish. Bacteria and fungi decompose in this zone, thus releasing organic nutrients for the first trophic level of organisms. Past instances of borrowing for sand and gravel for construction purposes in upstream areas of the Swat River has already shown a decline of Mahseer and Swati fish populations in the river.

Since, the earth material for the dam core zone will be procured from quarries a few kilometers downstream of the dam site or one located in the reservoir area. This will have no impact on aquatic biology if the construction is at a distance from the riverbank and care is taken to transport and unload the material at the construction site in a way that minimizes impacts.

The solid and liquid waste produced as a result of construction activity and the presence of a workforce would effect the water quality if not disposed of in a sanitary manner. Of special interest will be the air-bound dust particles produced during blasting and unloading gravel and sand at the construction site. Dust from excavation activities and dumping in water bodies will lead to a turbidity of water.

Although the volume estimates are not yet available, it is certain that construction activity will produce construction waste. The easiest and most economical way to dispose of the waste would be to dump it in the river but this will adversely effect the water quality. A safe method of disposal away from the riverbank must be found.

Oil, lubricants and other chemicals used during the construction process may enter the river as waste. This will be minimized if not totally eliminated by the judicious use and disposal of chemicals and proper machinery maintenance to prevent leakage.

The workforce will be tempted to catch fish during their tenure at the construction site. If fishing is limited to angling with proper permission and due regard for fisheries rules it may be permitted. The most serious violation leading to a loss of fish would be if explosives or chemicals were used to procure fish. This is a strong possibility as explosives, and chemicals will be easily available during the construction period. This possibility must be avoided by educating the construction workers and other staff about the importance of preserving aquatic biology.

The areas of concern are:

1) The excavation of gravel and sand from the riverbed will lead to a loss of breeding and foraging ground for many fish.
2) Solid and liquid waste produced during the construction or worker's activities and then dumped in the river will adversely effect the water quality.
3) Construction waste, if dumped in the river, will have serious negative impacts on the water quality.
4) Workers using explosives or chemicals to fish will lead to loss of fish, particularly young fish, in the river.

H4.2.2 Post-Construction or Operative Phase

(1) Negative Impacts

Due to the construction of the dam, a 56 km long reservoir, with an inundated surface area of 24 km^2 will be created. The post-construction or operative phase will foresee the following changes:

a) Fragmentation of Population

The natural downstream flow of the water from the dam will change. This will be due to a release pattern conditioned by the power generation at powerhouse and for the new irrigation canals, existing lower Swat and Doaba canals and water release required for the new irrigation canals.

The first major impact in the area will be the creation of a reservoir in a lacustrine (lake) form habitat for flora and fauna. Lake fauna and flora have their own characteristics. Fish migrate upstream and downstream to spawn, to find better or alternative foraging grounds and to avoid seasonal rigors of climate. The dam will halt the upward and downward migration of fish. This will lead to fragmentation of populations into two and over a longer period of time the adapted species may display genetic changes.

b) Migration for Spawning

Though there are no documented observations on the spawning behavior of most of the foraging fish in the project area, literature shows that in similar

habitats elsewhere most of the breeds search for spawning areas in shallow water close to their foraging grounds. The Sher Mahi breeds in the gorges of the Swat River in Mohmand Agency. The fisheries officials of FATA have also observed breeding close to the Munda Headworks. Young hatchlings, presumably of Sher Mahi, were also observed during the field survey. The Sher Mahi could be considered a flagship or charismatic/popular species that will suffer no negative effects by spawning upstream in the Panjkora River or in the Swat River where suitable spawning grounds will also be available.

The Swati (Schizothorax plagostomus) and other members of the Schizothoracinae family, are also plentiful and could be considered as flagship species. There have never been scientific studies or data on spawning grounds, spawning behavior or breeding season. The breeding season is from June to August for all members of Schizothoracinae found in the field survey. The observation made by fishermen and substantiated by fisheries officials is that the eggs are laid in shallow water in a gelatinous mass numbering in the thousands. Fries become visible to the naked eye in subsequent months after the absorption of the yolk sac. The young fish caught from Qosar downstream up to Munda Headworks support the view that spawning ground may be available all along the river.

In the operative phase, the Swati and other related species will find new suitable spawning and breeding grounds after bearing the initial trauma of a changed habitat. Downstream from the proposed dam site the Swati may face the problem of changed water flow.

The Labeo dero (Pehari Rohu) and L. dyocheilus (Torki), like other carp species, breed in July and August. They generally lay their eggs where rooted vegetation is present in the inundated water during the rainy season. Carps in general are prolific egg layers, laying millions of eggs but no site-specific data of their breeding biology have been available in the project area.

Of all the species of fish found in the study area, the Mahseer (Tor putitora) has attracted the attention of Pakistani, Indian, and Nepalese scientists. Their spawning behavior, grounds and seasons are better known and are summarized hereafter.

It is reported that the Mahseer breeds 2 - 3 times in a year. Its breeding season extends from the arrival of the rains in summer until September. The rain, combined with higher temperatures, trigger the fish to move upstream to seek suitable spawning grounds. The spawning grounds are shallow water, preferably springs or small tributaries. The males mature first, followed by females. Gravel beds are preferred, where the water flows slow and steady, are the preferred breeding spots. The number of eggs varies from 600 – 63,000, averaging 4,208 eggs per kg of female fish body weight.

The spawning grounds and breeding behavior of the golden Mahseer of Malakand have been studied by Khan[2] in the area where the Swat River drains into the Malakand Agency. In the past, the Swat River at Mingora was an ideal place for Mahseer breeding. The breeding grounds were lost due to many anthropogenic interventions, i.e., water diversion, extraction of gravel from riverbeds and pollution. The Mahseer start their upstream migration to the streams and rivers of the Malakand division in March and remain there until September. The breeding season extends from April to September in the Swat and Panjkora Rivers. Three spawning periods during early June, late July and late August were observed. The survey team had observed fish fries one to two months old in the Khiali River (a tributary of the Swat River downstream of Munda Headworks).

According to Butt in his unpublished 'Some Observations on the Fishes of NWFP', the Mahseer seems to be resident in the Mohmand Agency where it breeds throughout the year. The fisheries officials of FATA have observed Mahseer spawning grounds near Munda Headwork, a fact that is mentioned in their Annual Report.

The Study Team's findings confirm these observations as they collected young fries (4 – 5 cm) from the river downstream of the Munda Barrage and at Frontier Constabulary (FC) Post, Tangi.

In summation, spawning and breeding of the Mahseer in the Swat River occurs from Chakdara, Totakan, Sallai Patti (all in the Mohmand Agency) down to the Khiali River.

Although the Mahseer has extensive spawning and breeding areas, many of these areas will be lost due to inundation in the reservoir area related to the construction of the proposed dam. Areas like Salai Patti (in the reservoir area) and parts of the Swat River draining through Mohmand Agency (up to the dam site) and beyond will be affected due to fluctuations in the water levels. This is a serious negative impact that requires mitigation measures. These could include constructing channels and weirs for the passage of fish moving upstream.

c) Loss of Foraging Ground

The formation of a reservoir and related altered flow regimes in the project area and downstream will result in physico-chemical changes and will also have negative effects on the fish foraging grounds. Fishes forage in the early hours of morning and late hours of evening in shallow water. The fish found in the Project area range from strict herbivores (feeding on algae) to fish feeding on macro-invertebrates to fish-eaters (piscivorous) and a number of species are omnivores (plant and animal diet). The Sher Mahi also depends on terrestrial adult insects.

The initial loss of foraging grounds and food due to the sudden and serious change in habitat and water flow will lead to a loss of food, and feeding or foraging grounds. However, freshwater biota (both plants and animals, including fish) are known to re-colonize rapidly after a change in the water flow or a loss of suitable foraging grounds. This occurs due to:

1) The recruitment of new members from the vicinity.
2) The drifting of juveniles or spores or young larvae and fries.
3) The aerial flight of insects to lay eggs and breed in new, suitable areas.

Similarly, algae and other phytoplankton will rapidly re-colonize in changed circumstances. Pools and puddles created on the embankment of the reservoir and downstream from the dam site may also create new sites for zooplankton.

d) Sedimentation

Sedimentation or silting is another important consequence of damming and changed water flow. The accumulation of sediments in the reservoir and its method of disposal (if any) downstream from the dam may have a negative effect on aquatic biology. During the early phases of reservoir maturity, the sediments may have a positive impact, as the river drainage in the Project area is oligotrophic, meaning that there is enough organic material to sustain aquatic biota. This may be due to the rocky nature of the riverbed. The sediments will provide a base for food production for organisms and eventually for fish.

However, there are two areas of concern regarding the accumulation of sediments. The first is flooding due to natural or operative mechanisms. The second is the release of sediments downstream, which will lead to turbidity. Turbidity directly effects the efficiency of respiration in fish and may have many indirect effects on the growth of fish.

Fish and other biota have efficient mechanisms to adapt to a changed physical and chemical environment and other parameters. Rain, erosion and flooding increase sedimentation load annually and add to turbidity until solid particles settle down. However, fish do adapt to these occurrences.

At times erratic release of water from the dam downstream for power generation or irrigation and water released from the spillway will effect fish and other biota. It may also lead to stressful conditions for them.

e) Water Flow Regime

The current natural flow of the water will be changed due to the construction of the dam and storing water in the reservoir. Intermittent mechanisms of water release will have serious negative impacts on river ecology,

particularly downstream from the dam. This will be mitigated to some extent by the re-regulation dam.

The availability of water in summer months (from April to September) does not seem to pose a problem as water from the dam can be released downstream. However, water shortages from October to March are an area of concern. A provision of 2.8 m^3/s biological maintenance flow has been estimated in the Main Report, based on the currently drawn volume and the future requirements. In addition, the reservoir study has concluded that enough water downstream will be available because of continuous power generation. The negative impact will be only during initial impounding.

f) Changes in Physico-Chemical Parameters and Water Quality

The data on current water quality has been provided from site-specific areas and from secondary sources on different sections of the Swat River.

The dam will introduce changes in thermal levels, the amount of dissolved oxygen in the water, pH value and mineral and salt levels. The most critical change will be the amount of dissolved oxygen in the water as well as thermal changes and stratification (particularly in the reservoir). They could be positive or negative and major or minor.

A discussion on each parameter or on the cumulative impacts of most parameters is beyond the scope of this study. The only solution that can be presented in this study is a safety level and monitoring plan.

The water quality in an impoundment can often be better than that of the original stream due to the precipitation of solids; exposure of water to light and air for longer periods; thermal stratification resulting in a reduced heat budget for the system; and trapping of nutrients.

The dam will introduce changes in ambient temperature, the amount of dissolved oxygen in the water, pH value and mineral and salt levels. The most critical change will be the amount of dissolved oxygen in the water as well as temperature changes and stratification (particularly in the reservoir).

According to Lone, "the water quality in an impoundment can often be better than that of the original stream due to the precipitation of solids; exposure of water to light and air for longer periods; thermal stratification resulting in a reduced heat budget for the system; and trapping of nutrients". (Ref.)

However, the quality of water may deteriorate due to turbidity and the depletion of oxygen because of pollution. Pollution has increased in the areas from Kalam to Totakan. There are no close settlements up to Patti Banda in the proposed Project area and it is therefore almost free from anthropogenic pollutants.

Pollution problems may arise due to the establishment of post-construction new settlements and the decreased flow of water from the reservoir downstream. The gushing water released from turbines can cause a super saturation of gases in the water. This super saturation leads to gas bubble disease in fish, their symptoms include the blocking of capillaries in the gill filaments by gas emboli.

g) Rooted Vegetation

There are no rooted trees on the bank up to the maximum water level of the river. It is generally recommended in similar projects to remove all decaying trees which otherwise will lead to the production of methane gas (a greenhouse gas) and snags for fishermen's lines.

In the reservoir, currently, there is not much possibility of humus in the river stretch due to a lack of prominent decomposition. The decomposing vegetation, if left submerged after the inundation, will provide organic material useful to aquatic biology.

The typical vegetation in the project area is scrub forest in the foothills. The plants are will decompose easily and provide a rich base for food production in the reservoir for various organisms.

(2) Positive Impacts

a) Enhanced Fish Production

The creation of a 56 km long reservoir with an inundated surface area of 24 km^2 and 1,594 million cubic meters capacity will create a new resource for capture and recreational fisheries. The amount of fish production will depend upon the type of stock and how it adapts to the new physical conditions and which new species of fish are introduced.

The Tarbela and Mangla reservoirs, both with approximately the same climatic conditions, produce 150 and 1,000 metric tons of fish per annum. The revenue from these reservoirs amounts to Rs.0.48 and Rs.4.1 million and the hatchling and fry production at the facilities are 0.25 and 0.5 million, respectively. Fishermen number 400 and 1,500 at Tarbela and Mangla Dams respectively. The two reservoirs provide recreational fishing facilities to 1,500 – 2,000 anglers/line fishing per annum.

b) Creation of Jobs

Another positive impact of the proposed dam would be the creation of professional jobs in fisheries as exemplified by the Mangla and Tarbela reservoirs. Currently there are 42 and 30 employees respectively in the dam fisheries for these reservoirs.

c) Canal Fisheries

Pakistan has the most extensive irrigation canal system in the world, with more than 40,000 km of primary and 160,000 km of secondary canals.

Unfortunately, such a vast, potential source of fisheries has not been exploited due to various constraints. The two new irrigation canals proposed in this project along with the existing canals of Doaba and Swat should be developed as an additional source of fisheries. The Department of Fisheries, Provincial Irrigation and Drainage Authority (PIDA) and WAPDA may undertake a joint study to utilize this valuable water resource for further augmentation in fish production.

d) Improvement in Quality of Life

All the projected changes related to the proposed dam, including the construction of roads, supply of more consistent electricity, incoming tourists, recreational fishing, and better harvest of capture fisheries will bring positive impacts on the socioeconomic conditions of the area's inhabitants. The fishermen and people involved in the secondary phase of fishing (fish sellers, fried fish sellers, tourist guides and renters of line fishing equipment, etc.) will particularly benefit.

e) Navigation and Boating

These activities are positive impacts and recreational boating in the reservoir will be evaluated in this phase.

H4.2.3 Salient Features of Major Impacts in the Operational Phase

a) The construction of the dam will lead to a fragmentation of habitat and fish population into lacustrine and lotic communities.
b) Fish migration (particularly of indigenous species) for spawning upstream from the dam will be hampered.
c) In the initial phases there will be a loss of fish, as well as, their feeding, spawning and shelter grounds.
d) This loss will be minimal as fish and other organisms have efficient mechanisms to relocate and re-colonize new, suitable areas.
e) The Swati and Sher Mahi, two expensive in the market fish have widely distributed spawning areas. Forage fish and carp (Torki) breed close to their foraging grounds in shallow waters. There will be some loss of fish, which may be compensated later when conditions stabilize.
f) Spawning grounds for Mahseer have been reported from the Panjkora and Swat Rivers in upstream areas and they have also been reported downstream

as far as the Khiali tributary. Still the loss of fish due to construction may be significant and must be mitigated.

g) Sedimentation will lead to turbidity and also deteriorate water quality. Sedimentation in the reservoir in its early maturing phase may have a positive impact, as it will lead to food production for fishes.

h) Downstream from the dam the sedimentation load will have a negative impact.

i) The low water flow regime in from October to March and its maximum utilization for power generation will adversely effect the river ecology downstream, especially below the Munda Headworks. Pollution problems, which are a bare minimum now, may reach serious proportions. This will be mitigated by 2.8 m^3/s compensation release. The in stream flow regimes for fish, wild life recreation and other related environmental resources is presented in table below.

In Stream Flow Regimes for Fish Wildlife Recreation and Related Environmental Resources

Narrative Description of Flows	Recommended Base Flow Regimes	
	October- March	April – September
Flushing or Maximum	200% of the average flow	
Optimum range	60% of the average flow	
Outstanding	40%	
Excellent	30%	
Good	20%	
Fair or degrading	10%	
Poor of minimum	10%	
Severe degradation	10% of average flow to Zero flow	

Source: Tennant, D.L.

j) Reduced Swat River flow's impact will be: (i) loss of fish habitat, (ii) loss of visual amenity and (iii) lower water quality.

k) The positive impacts include the potential enhancement in fish production, recreational fisheries, and increase in fishermen and their income.

l) In the post-dam construction phase, initiating canal fisheries can further enhance fish production.

Fishing related work employs about 40 people in the area. These include roughly 20 fishermen, who use gill or cast nets. The rest are fish contractors and sellers of fried fish. Illegal fishing is reported over extensive areas of the Swat River. This is conducted in a highly destructive manner—i.e., using explosives, electrocution, and poison—and needs to be monitored and curbed through strict law enforcement. Current laws and regulations pertaining to fisheries are governed by the North West Frontier Province Fisheries (Amendment) Act. Recreational fishing is uncommon in the study area.

H4.3 Archeological and Cultural Heritage

H4.3.1 Introduction

The study area falls within the Gandhara region, which includes areas around Charsadda, Mardan, Khyber, Mohmand, Swat, Dir, Malakand, and Bajaur. The entire Gandhara region lies on the right bank of the Indus River.

The Gandhara region was conquered repeatedly by different nations and dynasties; from the Achaemenians, Greeks, Mauryans, Bactrian Greeks, Scythians, Parthians and Kushanas to more recent rulers such as the Mughals, Sikhs and the British. The region is believed to have flourished from about the sixth century BC, to the fifth century AD.

Two archeological sites were already known to exist in the study area before field surveys were conducted. These are Zarif Koruna, which is an ancient Aryan cemetery belonging to the proto-historic period, and the other is Kanro Qala, a stone fort that has been uncovered by illegal diggings. Both sites are situated away from the project area, and will not to be affected by the project.

During field surveys for this study, ten archeological sites were discovered to the east of the dam site, four of which fall within the left bank command area. A number of sites had already been excavated illegally, and some artifacts had been removed. Three of the sites within the command area will not be affected by the project, as they are located on hilltops. The only site that may be affected by the project is Sulai Khat, a high mound littered with artifacts.

Only two archeological sites were discovered to the west of the dam site. Both are located outside the right bank command area, and are not expected to be affected by the project.

The study area also contains four shrines. Jud Baba's shrine is located in the right bank command area, whereas the shrines of Shahji Baba, Chalgazai Baba, and Zarif Shah Baba lie in the left bank command area. The shrine of Jud Baba will most likely not to be affected by the project.

The sites of concern described above are either threatened directly, i.e., by project construction, or indirectly, i.e., from land clearing that farmers may undertake when the proposed new irrigation canals make more cultivable land available.

Once the alignment of the proposed canals is finalized, salvage and development work for the endangered sites should begin. Sites such as Khazana Ghund, Kanro Qala and Zarif Koruna could be developed for tourism. All artifacts salvaged could be displayed at a museum that could be established close to the dam site.

H4.3.2 Munda Dam Area

The shrine of Jud Baba, 3 km downstream from the proposed dam site on the left bank of the Swat River, is the most significant ancient Muslim religious structure

in the Project area. It will not be threatened by the proposed Munda Dam Project. During the investigations, no reliable or authentic information was available regarding the antiquity of the shrine, its ancestry or identity although the local people revere Jud Baba. This area will be very close to the access road and maximum care will be taken to ensure the safety and integrity of this shrine during the construction period, and later during the operation period.

On the right side there is also a grave/shrine where there has been an enclosure under construction and local people place colored scarves. This is in the area where the access road will have to be constructed. Shrines are normally sensitive and delicate issues and would be dealt in a careful and cautious manner. The Political Agent of the Mohmand Agency will be asked to mediate with the relocation of this grave with help of local area's priest (maulvi).

A few km downstream of the dam on the right bank, on top of a hill, where currently, the Frontier Constabulary (FC) picket is located, is a site locally known as Khazana Ghund. This site will not be affected by the Project at all. However, looking from this site one gets a most spectacular view of the dam and the river. It should be developed as a tourist attraction, consisting perhaps, of a museum where the Project area related antiquities could be displayed and provide for a recreational attraction close to the Munda Dam.

H4.3.3 Reservoir Area

The survey found that the reservoir area has no significant archeological sites or remains of cultural heritage.

H4.3.4 The Command Area Canals

(1) Left Bank

There are 15 known archeological sites in the command areas of the proposed left bank canal. Of these, thirteen sites were new excavations. In the command area of the proposed left bank canal there are 11 archeological sites of great cultural importance.

In the command area of the proposed left bank only three sites (Maizero Dand, Ghatta Bakkara, Kotagai) will not be endangered or affected by the construction of the canal.

During the survey it was observed that all 11 of these archeological sites were subjected to illegal diggings and some of them have been badly vandalized. The sites are under threat from the local people who use stone blocks from them for construction purposes. The following are the major sites, some of which would be negatively impacted by the Project:

a) Sulai Khat is in the command area and will be negatively impacted by the Project.
b) Selay has been vandalized and will not be negatively impacted by the Project.
c) Kajigal (Kandar) - Illegal excavations have been carried out here for the last 3 years. This site will be negatively impacted by the construction of the left bank canal.
d) Digir Raj - this site has had extensive illegal excavations and will also be negatively impacted
e) Salgaro site has a Gandhara period stupa and statues and relieves have been excavated by the farmer leasing this land. This site will be negatively impacted by the proposed left bank canal.
f) Kandarai, at this site the owner is removing stones from the exposed wall. The proposed canal will pass through and the site will be negatively impacted.

(2) Right Bank

In the right bank canal area there are four archeological sites, of which two are new excavations. The site, Kanro Qala will also not be negatively impacted by the canal. However, illegal diggings have damaged this site substantially.

The sites Shin Ghundai and Zarif Koruna, will be negatively impacted by the Munda Dam Project. The Zarif Koruna site is also endangered because the tenant farmer working there, has determined to excavate all the Aryan era, 2nd century B.C., graves and remove the gravestones to make a passage, to obtain a better supply of water from an irrigation canal. Kanro Qila, and Zarif Koruna are both located in the Mohmand Agency.

Some of the archeological sites in the command areas of the proposed right and left bank irrigation canals are likely to be negatively impacted during construction and operation. The prospect of the availability of irrigated land is also a potential danger for the archeological sites. The increasing land reclamation for agriculture will ultimately lead to the leveling of archeological mounds.

Once the final alignment of the proposed canals and its command areas is determined, salvage or rescue excavations of the endangered sites would be essential.

H4.4 Terrestrial Ecology

It is anticipated that the duck and waterfowl population will increase in the reservoir. The reservoir area due to the scrub vegetation is also very suitable habitat for Seesee, Black, Grey and Chakaur Partridges. The measures need to mitigate the adverse existing ecological impacts include wildlife conservation, erosion control, social forestry, range management, sustainable use of medicinal

plants, and development of ecotourism in the area. Most plant species found were common to areas degraded by heavy grazing and timber cutting.

According to published literature, the study area contains 7 bird species, 2 mammal species, 12 reptile species and 2 amphibian species that are classified as rare, and 2 mammal species that are classified as threatened. However, no rare or threatened animals were seen during field surveys. According to locals, very few animal species are now found in the area since, over the years, they have suffered from habitat degradation and uncontrolled hunting.

Soils of the study area were found to be of mixed mineralogical composition and of varying texture. There was a strong correlation between soil types and vegetation communities.

The study area's arable land was categorized into 'land capability classes' using the US Bureau of Reclamation System. This system categorizes land into four classes according to its suitability for agriculture: suitability decreases from Class I to IV. It was found that 29 percent of the study area falls in Class I, 11.6 percent in Class II, 23.9 percent in Class III, and 27 percent in Class IV.

Water quality analyses has showed that the values of all safety parameters were well within limits. Nitrate and phosphate contents were found to be low, indicating that only limited agriculture is practiced in the upstream areas, and the use of fertilizers is limited. Low nutrient levels, combined with climatic and hydrological factors, suggest that eutrophication in the reservoir is unlikely.

Results of the ecological survey have showed that the study area's flora and fauna have been significantly affected by human activities. Vegetation communities have undergone significant degradation because of activities such as clearing, fodder collection, livestock grazing, and timber extraction, and wildlife communities have suffered as a result of habitat degradation and uncontrolled hunting.

No rare or endangered plant or animal species were observed or reported in or around the study area. It is believed that the construction and operation of Munda Dam would not lead to a significant loss of plant or animal biodiversity, provided appropriate mitigation, restoration and rehabilitation measures are taken during the construction period and afterwards. The area has already undergone significant environmental degradation, and the plant and animal communities that will be affected are not of great ecological value. Similar communities are found in areas around the study area.

In the study area, the most detrimental activity now is overgrazing, deforestation, and hunting. 15 habitat types were determined in the study area together with the wildlife species. The floristic composition of all the habitat types were investigated at the Munda Dam site, reservoir area and command area. The dam

and reservoir area mainly possesses scrub vegetation type with some trees and wild palms.

The forest will provide valuable watershed protection in the study area. Community based social forestry project similar to the one in Malakand Agency will be immediately beneficial in the reservoir area. In addition, it is anticipated that the duck and waterfowl population will increase in the reservoir. The reservoir area due to the scrub vegetation is also very suitable habitat for Seesee, Black, Grey and Chakaur Partridges. The reservoir area for these considerations should be declared a game sanctuary.

The negative impacts on the area's ecology are few, as shown in the following checklist table:

Potential Environmental Impacts (Ecological Conditions) of Munda Dam Project

(Based on WAPDA Environment Cell (WEC) "Checklist for Potential Issues of Water Resources Projects")

Component	Environment Issue	Overall Impact (Upstream / Downstream)
Physical		
Water	Siltation of reservoir	- (in the long-term)
	Swat river water quality	-
	Swat river discharge	+
	Irrigation water quality	+
	Irrigation water quality (Project area)	+
	Groundwater quality	0
	Groundwater levels (waterlogging)	-
	Flooding	+
Land	Soil salinity	-
	Soil alkalinity	-
	Soil erosion	-
	Land availability	+
	Land capability	+
Atmosphere	Dust	Construction,-ve
	Odor	-
	Noise	Construction,-ve
Climate	Climate change	0
	Micro-climate change	-
Biological	Bird communities/habitats	+
	Mammal communities/habitats	+
Fauna	Reptile communities/habitats	-
	Fish communities/habitats	+
	Aquatic micro-fauna	+
Flora	Forests/trees	+
	Scrub vegetation in the gorge	+
	Aquatic vegetation	+

Component	Environment Issue	Overall Impact (Upstream / Downstream)
Socioeconomic	Settlement/composition	+
	Population (human carrying capacity)	+
Social	Demography	+
	Land ownership/security	+
	Social cohesion	+
	Social attitudes	+
	Gender	+
	Health	+
	Safety	0
Economic	Incomes	+
	Employment	+
	Land value	+
	Credit availability	+
Institutional	Institutional set-up/effectiveness	+
Human Activity	Cultivation	+
	Livestock	+
	Fishery activity	+
	Afforestation	+
	Agro-industrial activities	+
	Transport/communications	+
	Domestic/industrial water supply	+
	Energy supply/utilization	+
	Recreation	+
Cultural	Life style (quality of life)	+
	Historic (archeological sites)	0
	Aesthetics (natural and scenic beauty)	+

Note: + = positive, - = negative, 0 = no change

The Project overall is considered ecologically acceptable and it will also result in general uplift of the area and provide sizeable economic benefits to the people.

H4.5 Floods and Their Impacts

Downstream of the Munda Headworks, the Swat River is a braided stream, divided into Khiali River with creeks and channels with islands in between, and the lower Swat canal. Over the years, population in the area has increased and settlements along the river have grown denser. To irrigate the agricultural lands on the river banks, small stone weirs are constructed on the river and channels dug to link them with the fields. The irrigation channels are communally constructed and maintained. According to the Irrigation Department, there are 11 major channels in the area, serving 30,951 acres of land. Floods often damage or wash away the diversion weirs and irrigation channels.

The Swat River's flooding regime is the same as that of all snow-fed streams of Pakistan and Northern India. Summer discharges are generally 10 to 12 times greater than winter discharges. Floods vary in duration from a few hours to three or four days. Records show that river discharge during floods is generally twice as high as it is normally in that season, the significant peaks reaching up to five or six times the normal high flow. However, such floods are very infrequent.

At the Munda Headworks, the Swat River floods can reach peaks of 21,000 to 24,000 cubic feet per second (cfs). The normal high flows vary from 12,000 to 16,000 cfs.

The effects of floods in the area mainly consist of dislocation of temporary diversion weirs and irrigation channels, and, occasionally, erosion of the river banks. Sometimes, cultivated lands and villages are also affected. Almost 75% of villages in the area have dikes built along the river banks to protect land and houses. However, these are not always effective and, very often, do not last for more than one season. The total damage caused by floods to infrastructure had amounted to Rs. 4.78 million in 1989-1990, and to Rs. 3.25 million for 1998-1999. These figures do not include losses resulting from lower crop yields because of damaged irrigation systems.

H4.6 Socioeconomic Environment

(1) General

a) Socioeconomically the people in the area of the Dam and reservoir are backward and traditional. The main means of their livelihood are agriculture, mostly subsistence, and as day labor, mostly unskilled.

b) The social organization in the study area is tribal and ethnically Pushtoon, with the joint household being the primary unit. The settlements, villages and towns are collections of households of people belonging to the same ethnic group or sub-group. The people of this region reportedly aspire upward mobility and not averse to movement and change for socioeconomic betterment. Because of the lack of economic opportunity, considerable out-migration has been occurring, and continues.

c) By and large the area's population is skeptical about the government projects, the Munda Dam Project has been on the books for over thirty years now. The respondents of the field survey had heard about the project but were concerned about its actual, construction, as it had not been implemented for a long time.

d) The overwhelming response about the project was positive, considering that it would provide irrigation water, which will significantly improve the largely agricultural economy of the nearby area

e) The negative environmental impacts of the proposed project would be negligible. There will be 118 people involved in resettlement, with 5,500 goats and 1,300 cows approximately in the reservoir area, most of these are seasonal, from October to April. Goat and cow herding is the main activity of these people. The WAPDA Compensation Survey Team has estimated 118 people who will be compensated at the dam site and reservoir area.

(2) Short Term Positive Impacts

a) It is self-evident that the construction work will result in additional demand for local resources and provide employment opportunities.

b) Those who provide local materials and resources will be receiving cash compensation. This is likely to affect the consumption patterns of the beneficiaries, which in turn will have a positive spill-over effect on the demand of goods and services of daily life.

c) The construction activities will provide a big employment opportunity to the locals. The level of positive impact of employment will be a function of the scale and duration of civil works. The provision of employment locally will have a positive impact in two ways: One through the increased consumption capacities of the workers, which will raise the demand for local goods and services. And second through the reduction in out-migration, which is a considerable existing problem.

d) The building of access road on both sides of the Swat River downstream of the Munda Dam and to the quarry (8.5 km) for the movement of construction machinery and dump trucks, etc. will facilitate the development of the local infrastructure.

(3) Long Term Positive Impacts

a) The most important positive impact will be a boost in the agricultural productivity of the command area through the provision of irrigation water. The people of the area are traditionally inclined to farming and agricultural activities. Even now wherever water is available for cropping, people have developed thriving farms and orchards. In many cases rugged land have been leveled and made cultivable. The major hurdle in the agricultural development of the area is lack of regular supply of water. Once water becomes available, there are indications that the people of the area will be capable of taking advantage of that in order to better their socioeconomic condition. The human resource will be there for a major improvement in agricultural productivity. The availability of water will provide the necessary natural resource.

b) The electricity generated in Munda Dam would give a significant boost to the local mining, and affiliated small industries, which are struggling at present.

c) There have been some reported (1929,1995) floods in the Swat River that have caused some destruction. However, those have been very few and far between. The construction of the dam will mitigate and will considerably, minimize, the chances of flooding in the future.

d) The provision of irrigation water and electricity will contribute significantly in the overall economic development of the people and the area. This economic uplift will factor into social development and a

qualitative positive shift in the availability of essential services like education, and health.

(4) Short Term Negative Impacts

a) There is a small human habitation close to the proposed dam site and in the reservoir area, it consists of 102 hutments. There will be a small need for relocation of the people living in the reservoir area. Out of 102, there will be 11 hutments at the proposed dam axis that will have to be relocated after the dam has been completed and the spillway comes into operation.

b) There is also a grave/shrine on the right side, and the shrine of Jud Baba 3.2 km from the dam, on the left side down stream of the dam. Arrangements will have to be made for their protection during the construction period and after.

c) The construction activities will necessarily mean the concentration of workers around the building site. This could have a negative impact on the nearby local communities. The closest villages to the dam site are quite small and the infusion of even a small number of outsiders is likely to have a big impact.

d) The use of roads for the movements of construction equipment would have a negative effect on the already stressed communications infrastructure.

e) The use of dynamite for blasting, for construction purposes will introduce negative elements into the local ecology. To a degree this is unavoidable but care should be exercised regarding the storage and use of such materials, and the timing of blasting activities.

f) The excavated earth from the Project will amount to 1 km^2 and 10 m high, which can become a problem. Plans for the appropriate utilization and safe disposal of such materials should be undertaken.

(5) Long Term Negative Impacts

a) The key and complex problem will be of the rights over the use of irrigation waters, and the ownership and use of land. The provision of irrigation water will inevitably raise the value of the land and the possibility of land related disputes.

b) Currently in the command area about 50% of the locals are landless, and the land-owners also have small holdings. With the increase in the productive value of the land the traditional landlords, many from the proximal settled areas, are likely to acquire the land.

c) Electricity production, up to 800 MW installed capacity, will be the other major output of the dam. This will impact on the dynamics of socioeconomic relations. The Mohmand tribes have already made a claim to royalties from the Warsak dam, which falls in Mohmand Agency.

Again the possibility of a conflict of interests (between the locals and the government) emerging around the Munda Dam electricity would be very high.

d) The generation and greater availability of electricity will make the setting up of mining and associated industries a profitable business. However, there is a strong likelihood that the already rich would derive most of the accrued benefits.

e) The Munda Dam construction will bring to the front the problem of governance. The building of the dam is likely to result in the importation of the governance mechanisms operative in the settled areas, and all the problems associated with that. Currently there are two parallel systems of administration and justice in operation. One, the government controlled tribal administration system under the Political Agent. Two, there is the traditional 'Jirga'* system which is more community based and egalitarian. The entry of line departments will bring in a third structure and complicate matters even further. The coming into operation of the new systems will result in upsetting what currently prevails and the possibilities of conflicts would be high.

(*The Jirga system is based on the assembly of local elders, who base community decisions on a consensus of all present. It is the traditional form of resolving conflicts, it has its problems but is more familiar and acceptable to the locals.)

H4.7 Overall Mitigation Strategies, and Mitigation Plan

H4.7.1 Mitigation Measures for Fisheries

The proposed Project will have certain impacts on aquatic life in the area, most of which can be mitigated. The effects and recommended mitigation actions are outlined below.

1) Filler material for dam construction should be acquired from a quarry. Under no circumstances should the riverbed be excavated for this purpose, or the fish will be deprived of valuable breeding and foraging grounds.

2) Dam construction waste should not be dumped in the river, as it will deteriorate water quality and harm aquatic life. A disposal site may be selected away from the riverbank, and later developed for afforestation by terracing and addition of topsoil. Unsafe disposal of liquid waste into the river should also be avoided.

3) Once constructed, the dam will act as a barrier in the natural upstream and downstream migration of fish, and lead to fragmentation of various fish populations in the reservoir and downstream reach. Although it may be possible to construct a fish ladder to enable fish to migrate, such ladders have not been used successfully over high dams (i.e., over 50 m). If a fish ladder

were considered, considerable research on the target fish species and their habits would be required before a suitable ladder could be designed. This problem has the most serious implications for the Mahseer, which needs to migrate upstream for spawning.

As an alternative to the ladder, the reservoir and different stretches of the river should be stocked with Mahseer seed from the Chakdara Mahseer Hatchery, which is due to open soon.

4) Inundation in the reservoir area and decreased water flow downstream from the dam will diminish fish foraging and spawning grounds and food availability (phytoplankton, zooplankton, macro-invertebrates). However, freshwater fish communities adapt efficiently to changed habitat conditions under stress conditions. Moreover, suitable spawning and foraging grounds will be available for the displaced Swati and Sher Mahi fish, as the species are widely distributed in the area.
5) The aquatic life in the Project area will also be affected by sedimentation of the reservoir and the spread of sediment load beyond the dam site. In the initial 'maturing' stage of the reservoir, sedimentation may actually prove beneficial, as it will provide a base for food production for the fish. However, a minimum discharge of water (which has not yet been determined) will need to be released from the dam to offset the negative impacts of turbidity in the downstream reach.
6) In order to assess the volume of water to be released to mitigate the impacts of reduced downstream flows, use of the "Montana Method" devised by Tennant (1976) is recommended. This will ensure that the minimum water required to sustain aquatic organisms, particularly fish downstream from the dam, is maintained. Data on average annual flow or daily average flow of the river after dam construction are not available yet.
7) Regular monitoring of the physical and chemical characteristics of water in the reservoir and in the downstream reach is recommended to ensure adherence to standard safety levels.

Although the Project will negatively affect the area's natural aquatic ecosystem, it will have some positive socioeconomic impacts. These are as follows:

8) The dam will ensure a better catch for fishermen, and create more employment in fishing and related business in the area. It will also create a number of professional jobs in dam fisheries, and thus initiate positive socioeconomic changes.
9) It may be possible to initiate fishing in the proposed canals, which would increase fish production.
10) Recreational fishing, which is almost non-existent at present, should be developed on a large scale for residents and tourists. This would provide additional jobs and business opportunities for local inhabitants.

H4.7.2 Mitigation Measures for Archeological & Cultural Heritage

(1) Rescue and Retrieval of Archeological Sites and Artifacts

Appropriate arrangements would be made for the protection of the archeological sites identified in section above. These could comprise *in situ* protection or the salvage of artifacts for display in museums. Construction work for the proposed dam must be according to the requirements of the following:

1) The Antiquity Act, 1975 and Archeological Excavation And Exploration Rules, 1978; and
2) UNESCO Legal Instrument, 1968.

(2) Establishment of Dam Site Museum

The antiquities and the cultural material recovered from the rescue excavations of the endangered sites will provide a strong basis for establishing a museum near the dam site. Therefore, it is recommended that a site museum be established as a part of the Munda Dam Multipurpose Project. The land and the building for this museum should be provided by the Project proponents. All antiquities retrieved during salvage or rescue operations should be placed in this museum.

Since these artifacts will be the property of the Department of Archeology and Museums, Government of Pakistan, formal permission will have to be obtained for salvage work, and for setting up the museum. In case, permission is not granted by the Department, a good photographic exhibition of the ancient sites and antiquities can be arranged. The site museum may also include flora and fauna samples to depict the area's natural history and make the museum more attractive.

(3) Promotion of Tourism

In order to promote tourism in the area, three archeological sites in the command area of the proposed right bank canal—Khazana Ghund, Kanro Qala and Zarif Koruna—can be developed as tourist attractions. The three sites are easily accessible and safe enough to visit without escort. In addition to providing recreation in the area, this will help instill in the local people a desire to protect the archeological sites.

H4.7.3 Mitigation Measures for Terrestrial Ecology

The terrestrial ecology mitigation will involve extensive repair and development efforts. Programs for forestry, and environmental enhancement will be initiated. Erosion control will be implemented by terracing the reservoir area. Downstream river bank protection within the reregulating pond will be taken up. Mitigation will involve constructing ramps for boats on locations 1 km up stream of the dam

and close to Panjkora River's confluence. Large conservation work including the quarry site, borrow area and spoil banks after construction will also be undertaken.

H4.7.4 Mitigation Measures for Floods and Their Impact

The Munda Dam is expected to effectively reduce the harm inflicted by flooding in the study area. Floods may continue to occur downstream of the dam when the reservoir is full, but their intensity will be significantly lower than what it is at present.

H4.7.5 Mitigation of Socioeconomic Impacts

(1) General

The following section provides elaboration on and mitigation about the socio-economic impacts in the dam, reservoir and command areas of the Project:

a) Socioeconomically the people in the Dam, Reservoir and Command Areas (CA) are backward and traditional. The main means of their livelihood are agriculture, mostly subsistence, and as day labor, mostly unskilled.

b) The social organization in the project area is tribal and ethnically Pushtoon, with the joint household being the primary unit. The settlements, villages and towns are collections of households of people belonging to the same ethnic group or sub-group. The people of this region reportedly aspire upward mobility and not averse to movement and change for socioeconomic betterment. Because of the lack of economic opportunity in CA, considerable out-migration has been occurring, and continues.

c) By and large the area's population is skeptical about the government projects, the Munda Dam Project has been on the books for over thirty years now. The respondents of the field survey had heard about the project but were concerned about its actual construction, as it had not been implemented for a long time.

d) The overwhelming response about the project was positive, considering that it would provide irrigation water, which will significantly improve the largely agriculture base economy of CA.

e) The negative environmental impacts of the proposed project in CA would be negligible. There will be 118 people living, with 5,500 goats and 1,300 cows approximately at the dam site and reservoir area, most of these are seasonal, from October to April.

(2) Short Term Positive Impacts

a) The construction activities will provide a big employment opportunity to the locals. The level of positive impact of employment will be a function

of the scale and duration of civil works. The provision of employment locally will have a positive impact in two ways: One through the increased consumption capacities of the workers, which will raise the demand for local goods and services. And second through the reduction in out-migration, which is a considerable existing problem.

b) Those who provide local materials and resources will be receiving cash compensation. This is likely to affect the consumption patterns of the beneficiaries, which in turn will have a positive spill-over effect on the demand of goods and services of daily life.

c) The building of access road on both sides of the Swat River downstream of the Munda Dam and to the borrow pit (8.5 km) for the movement of construction machinery and dump trucks etc. will facilitate the development of the local infrastructure.

(3) Long Term Positive Impacts

a) The most important positive impact will be a boost in the agricultural productivity of the command area through the provision of irrigation water. The people of the area are traditionally inclined to farming and agricultural activities. Even now wherever water is available for cropping, people have developed thriving farms and orchards. In many cases rugged land have been leveled and made cultivable. The major hurdle in the agricultural development of the area is lack of regular supply of water. Once water becomes available, there are indications that the people of the area will be capable of taking advantage of that in order to better their socioeconomic condition. The human resource will be there for a major improvement in agricultural productivity. The availability of water will provide the necessary natural resource.

b) The electricity generated in Munda Dam would give a significant boost to the local mining, and affiliated small industries, which are struggling at present.

c) There have been some reported (1929, 1995) floods in the Swat River which have caused some destruction. However, those have been very few and far between. The construction of the dam will mitigate and will considerably eliminate chances of flooding in the future.

d) The provision of irrigation water and electricity will contribute significantly in the overall economic development of the people and the area. This economic uplift will factor into social development and a qualitative positive shift in the availability of essential services like education, and health.

(4) Short Term Negative Impacts

a) There is a small human habitation close to the proposed dam site and in the reservoir area, it consists of 102 hutments. There will be a small need

for relocation of the people living in the reservoir area. Out of 102, there will be 11 hutments at the proposed dam axis that will have to be relocated after the dam has been completed and the spillway comes into operation.

b) The construction activities will necessarily mean the concentration of workers around the building site. This could have a negative impact on the nearby local communities. The closest villages to the dam site are quite small and the infusion of even a small number of outsiders is likely to have a big impact.

c) The use of roads for the movements of construction equipment would have a negative effect on the already stressed communications infrastructure.

d) The use of dynamite for blasting, for construction purposes will introduce negative elements into the local ecology. To a degree this is unavoidable but care should be exercised regarding the storage and use of such materials, and the timing of blasting activities.

e) The excavated earth from the project will amount to 10 million m^3, which can become a problem. Plans for the appropriate utilization and safe disposal of such materials should be undertaken.

(5) Long Term Negative Impacts

a) The key and complex problem will be of the rights over the use of irrigation waters, and the ownership and use of land. The provision of irrigation water will inevitably raise the value of the land and the possibility of land related disputes.

b) Currently in the command area about 50% of the locals are landless, and the land-owners also have small holdings. With the increase in the productive value of the land the traditional landlords, many from the proximal settled areas, are likely to acquire the land.

H4.7.6 Affected People's Participation

WAPDA's Compensation Survey & Resettlement Action Plan has covered this issue.

H4.7.7 Compensation Issues

WAPDA's Compensation Survey & Resettlement Action Plan has covered this issue.

H4.8 Costs of Environmental Impact Mitigation

The cost for resettlement compensation and land acquisition was estimated by WAPDA compensation survey team. Major items surveyed comprise land

acquisition, compensation and replacement/relocation cost of privately owned houses and structures, farm products and community infrastructures, cost of resettlement villages, contribution to integrated regional development program, cost of studies and others. Breakdown of the cost estimate is summarized as follows:

Cost for Resettlement Compensation and Land Acquisition

	Amount (Rs.1,000)	Amount (US$ 1,000Equiv.)
Land acquisition:	20,000	400
Compensation and replacement/relocation cost of privately owned houses and structures,	2,500	50
Cost of resettlement villages	50,000	1,000
Contribution to integrated regional development program	5,000	100
Relocation of Community Infrastructure	12,000	240
Compensation for farm product & trees	1,000	20
Cost of studies	2,500	50
Others	30,000	600
Total	123,000	2,460

All the details are also provided in the Main Report. The costs derived here could change during the negotiations for the purchase of the land, which may be protracted.

The cost for environmental mitigation is for minimizing or offsetting the adverse impact due to construction and operation and mitigating the costs of biological, socioeconomic and physical impacts of the project on the affected area. The total mitigation cost was assessed to be US$ 5 million (Rs. 250 million) as summarized below:

Cost for Environmental Mitigation

	Amount (Rs.1,000)	Amount (US$ 1,000Equiv.)
Fisheries	20,250	405
Archeology & Cultural Heritage	51,150	1,023
Ecological Conditions	92,900	1,858
Agricultural/Water Usage	9,000	180
Environmental Management and Monitoring Cost	76,700	1,534
Total	250,000	5,000

Table H4.2 provides the line item details of mitigation costs for minimizing or offsetting the adverse impact due to construction and operation and mitigating the costs of biological, socioeconomic and physical impacts of the project on the affected area. The total mitigation cost is assessed to be US$ 5 million (Rs. 250 million). The breakdown of costs for fisheries is assessed to be $0.405 million, archeology and cultural heritage is assessed to be $ 1.023 million, and ecological conditions is assessed to be $ 1.858 million. The costs for environmental management plan and monitoring program are assessed to be $ 1.534 million.

The cost for resettlement compensation and land acquisition is the major portion of the costs. WAPDA's Resettlement Action Plan has assessed $ 2.46 million (Rs. 123 million), details are provided in the Compensation Survey Report. The costs derived here could change during the negotiations for the purchase of the land, which may be protracted.

H5 Environmental Management & Monitoring

H5.1 Introduction

A comprehensive and effective environmental management program will be required that establishes the environmental protection and rehabilitation during construction and operation phases of Munda dam. This program will incorporate an environmental monitoring program that will provide control and information of changes anticipated during the project implementation. It is assumed that many of these changes have correctly been, predicted by the EIA & Resettlement Action Plan. However, flexibility will be provided to deal with some impacts that may have different outcomes and their corresponding mitigation.

H5.2 Environmental Management Plan

The Environmental Management Plan (EMP), will be the main and comprehensive environmental protection plan to carry all the required environmental issues into the detailed design, construction, and operation phases.

The EMP will be implemented by a senior professional from WAPDA's Environmental Cell, who will have the overall control for all aspects of the program.

The EMP will be developed as part of the requirements for detailed design of the Munda Dam. The EMP will build on the EIA report and will plan for the many different environmental conditions and requirements that will exist during the detailed design, construction and operation phases. Overall, the EMP will have two important components.

(1) An overall strategy together with a time based schedule for carrying out the EMP, and a detailed budget and areas of responsibilities for WAPDA and the people's participation.

(2) A Project Site Protection and Rehabilitation Program which will be prepared for the reinstatement of disturbed areas. This program will propose how disturbed construction sites are to be rehabilitated together with site stabilization and replantation of lost vegetation. Mitigation requirements for site clean up and stabilization of major waste disposal areas after construction is completed will be included.

In addition, a comprehensive watershed management program will be considered to initiate tree planting and afforestation during the detailed design stage of the project.

H5.3 Environmental Monitoring Plan

Monitoring will involve the measurement and recording of environmental, social and economic variables associated with the Munda Dam Multipurpose Project. This plan should provide information on the characteristics and functioning of variables in time and space, and in particular on the occurrence and magnitude of the impact. Monitoring can improve environmental management of the Project. It can also be used as an early warning system to identify harmful trends at the dam site and the entire project area before it is too late to take remedial measures. It will help in identifying unanticipated impacts. Monitoring will also provide an acceptable database, which will be used in mediation between interested parties. Monitoring is one of the most effective guarantees by WAPDA of its commitment to environmental quality. Monitoring of key activities will be required during detailed design, construction and operation. The following areas will be included in the monitoring plan.

H5.3.1 Water Quality Monitoring

Water quality monitoring will be required to (i) establish base line environmental conditions and (ii) evaluate effects of the Swat River's diversion during the construction period.

Water quality measurements will be needed from the Swat River before Panjkora River's confluence for basic parameters including nitrates and phosphates, and at 1 km before the existing Munda Headworks for human use parameters that will include biological oxygen demand (BOD), chemical oxygen demand COD and bacteriological contamination.

Additional water quality measurements will need to be made to evaluate the effect of the Swat River's diversion. The samples would be taken regularly over two years on a two months basis.

H5.3.2 Fishery and Aquatic Biodiversity Monitoring

The EIA has assessed that the fish species composition is unlikely to be affected by the diversion, though productivity will most likely decline. The monitoring will be carried out to confirm the validity of this assessment. A monitoring program will recommend that the samples be collected for fish and plankton every two months at four places of the Swat River, before the Panjkora River's confluence, reservoir area, near Pattai Banda, and the road bridge near Munda Headworks near canal inlet.

H5.3.3 Resettlement and Compensation Monitoring

The community acceptance of large dam projects is now being judged by the fairness of the resettlement and compensation procedures. Similarly, in the Munda dam's case it will not only be the amount that the affected people will receive but also whether this handled by WAPDA in a speedy and acceptable manner to the people linked to the land around the reservoir and the dam site. Like in Ghazi Barotha an NGO group would be able to act impartially with respect to mediation between WAPDA and locals. In addition a community awareness program will be beneficial to advise and reassure the local community.

H6 Conclusions & Recommendations for the EIA

H6.1 Conclusions of the EIA for the Feasibility Study

The conclusions drawn from the Environmental Impact Assessment for the Feasibility Study and the recommendations for their mitigation measures are summarized below. The objective of these recommendations is to maximize the benefits and to minimize the undesirable impacts of the Munda Dam Multipurpose Project on the environment and the surrounding local community.

1) There will be no significant loss of any rare or precious flora caused by the construction of the Munda Dam. This will be an opportunity to organize the grazing land in a scientific manner where areas are periodically rotated for replenishment.
2) There will be great opportunities for enhanced fish production in a reservoir which 56 km long and up to 190 m of water depth.
3) The sediment load will be 90% less passing the dam site.
4) The reservoir is unlikely to exacerbate any landslides or falling rocks within the Munda Dam Project area.
5) The only serious loss to any infrastructure will be the newly constructed bridge on the Swat River right after it meets Panjkora River to connect Malakand with Bajaur Agency, and five wire and rope bridges.
6) A 2.8 m^3/s compensation discharge will maintain the biological minimum flow.
7) Excavation (underground & surface) will yield large amounts (1 km^2 and 10 m high) of earth and dirt materials. These will be utilized and disposed off in an environmentally acceptable way.
8) Apart from one small grave/shrine d/s of the dam on the right side no other cultural sites will be adversely affected by Munda dam and reservoir.
9) The Project will displace in total 118 people. All of these people would be easily resettled as discussed in the WAPDA's Compensation Survey & Resettlement Action Plan in nearby areas in the Mohmand agency.
10) During construction the Contractor should give preference to hiring labor

from within the above people so as to maintain good working relations between the Munda Dam Multipurpose Project and the local people who are economically not much above poverty level.

11) The cost of environmental mitigation has been estimated at Rs. 250 million (US$ 5 million).
12) The cost for resettlement compensation and land acquisition has been assessed by WAPDA to be Rs. 123 million (US$ 2.46 million). The compensation costs derived at here could change during the negotiations for the purchase of the land, which may be protracted.

H6.2 Future Work Program During the Detailed Design

The following issues will need detailed analysis to be carried for the next phase of Environmental Assessment.

1) An EIA for the route of the transmission lines planned for the Munda Dam Multipurpose project will need to be carried out.
2) Detailed studies of fish for fragmented populations and other aquatic life will be carried out. Community participation and evaluation of the economic benefits will also be carried out.
3) Detailed plans for rescue and retrieval of archeological sites, establishment of a museum, and a plan for the promotion of tourism.
4) A master plan will be developed for wildlife conservation, range management, social forestry, medicinal plants and erosion control.

References:

1. Imperial Gazaetteer of India (1905), Provincial Series, North-West Frontier Province, Reprinted, Lahore 1991.
2. Dijk, Albert Van and Hussain M.H. Environmental Profile of N.W.F.P, Pakistan Enterprise & Developing Consulting, Islamabad, 1994.
3. Butt, J.A., Some Observations on Fishes of N.W.F.P, Pakistan, Unpublished, Peshawar, 1998.
4. Khan, S. A., Golden Mahseer of Malakand, Directorate of Fisheries N.W. F. P., Peshawar, 1998.
5. Lohani, B. N., et. al. Environmental Impact Assessment for Developing Countries in Asia, Volume 2, Selected Case Studies, Asian Development Bank, 1997
6. Lone, K. P., Inland Fisheries and Aquaculture in Pakistan: A Review, Pakistan Agricultural Research Council, Islamabad 1983.
7. Qureshi, M. R., Common Freshwater Fishes of Pakistan, Food and Agriculture Council of Pakistan, 1965.

8. Stockwell, A, Fisheries and Aquatic Habitat Resource Assessment Manual Volume II, Fish and Fish Habitat Sampling Methods of Water-bodies in N.W.F.P, Second Aquaculture Development Project, Directorate of Fisheries N.W. F.P, Peshawar, September, 1995.
9. SHYDO, GoNWFP, Matiltan Hydropower Project Feasibility Study, Final Report, Volume 3: Environmental Assessment, Sir William Halcrow and Partners, 1996.
10. Tennant, D.L., Instream Flow Regimes for Fish, Wildlife Recreation and Related Environmental Resources., Fisheries 1 (4) 1976
11. WAPDA, Neelum-Jhelum Hydroelectric Project, Feasibility Study Report, Volume 3: Environmental Impact Assessment, Norconsult and Norplan, A. S., 1996.
12. World Bank, Environmental Assessment Sourcebook, Volume II Sectoral Guidelines, Environment Department, Technical Paper No. 154, 1991.
13. World Bank, Staff Appraisal Report 14587-PAK, Ghazi Barotha Hydropower Project, South Asia Region, Country Department I, 1995
14. WAPDA, Compensation Survey and Resettlement Action Plan for Munda Dam Multipurpose Project, December 1999.