APPENDIX H

TABLES

Table H4.1 Breakdown of Cost Estimate for Land Compensation

Description	Unit	Quantity	Unit Price (Rs.)	Amount (Rs.)	Amount (US$ equiv.)
1 Land acquisition (10 ha)	LS			20,000,000	400,000
2 Replace ment cost of privately owned				2,500,000	50,000
- Irrigation tubewells/ Pumps	LS			1,000,000	20,000
-	LS			1,000,000	20,000
- Cattle and goat shelter	LS			500,000	10,000
3 Compensation for farm produce				1,000,000	20,000
- Crops	LS			500,000	10,000
- Trees	LS			500,000	10,000
4 Relocation of community infrastructures				12,000,000	240,000
- Relocation of graves and mosque	LS			1,000,000	20,000
- Relocation of village roads	LS			1,000,000	20,000
- Relocation of bridges	LS			10,000,000	200,000
5 Cost of Resettlement Villages				50,000,000	1,000,000
- Development of resettlement village	LS			30,000,000	600,000
- Social infrastructure for resettlement village	LS			20,000,000	400,000
6 Contribution to integrated regional development programme	LS			5,000,000	100,000
7 Cost of studies				2,500,000	50,000
- Integrated regional development plan	LS			1,000,000	20,000
- Sewerage and treatment facilities for resettlement village	LS			1,000,000	20,000
- Town planning	LS			500,000	10,000
8 Monitoring cost				10,000,000	200,000
- Monitoring consultant	LS			5,000,000	100,000
- Visit of environmental review pannel	LS			5,000,000	100,000
9 WAPDA administration costs	LS			4,000,000	80,000
10 Contingencies	LS			16,000,000	320,000
Total				123,000,000	2,460,000

Table H4.2 Breakdown of Cost Estimate for Environmental Mitigation

Description	Unit	Quantity	Unit Price (Rs.)	Amount (Rs.)	Amount (US$ equiv.)
1 Fisheries				**20,250,000**	**405,000**
- Stocking / Restocking (During 7 Years of Construction)	year	7	750,000	5,250,000	105,000
- Research/Development/Demonstration	year	10	1,500,000	15,000,000	300,000
2 Archeology & Cultural Heritage				**51,150,000**	**1,023,000**
- Relocation of Cultural Property	nos.	1	150,000	150,000	3,000
- Savage operations in RB/LB	site	10	3,000,000	30,000,000	600,000
- Establish museum at F.C. post, dam site	LS			20,000,000	400,000
- Access road construction to F.C. post & shine	LS			1,000,000	20,000
3 Ecological Conditions				**92,900,000**	**1,858,000**
- Forestry & Scenic Value	trees	4,800,000	8	38,400,000	768,000
- Erosion control reservoir terracing	m^2	1,000,000	16	16,000,000	320,000
- Environmental Enhancement	LS			18,000,000	360,000
- Downstream Flow Variation - Mitigation by Restocking fish	LS			4,500,000	90,000
- Downstream river bank protection within re-regulating pond	LS			8,000,000	160,000
- Ramps for boating, 1 km u/s of dam and close to Panjkora on both banks	ramps	4	750,000	3,000,000	60,000
- Conservation of quarry site, borrow area and spoil bank after construction	LS			5,000,000	100,000
4 Agriculture/Water Usage				**9,000,000**	**180,000**
- L.B & R.B. main canals' environmental enhancement	LS			4,000,000	80,000
- Canal area terracing and vegetation	LS			5,000,000	100,000
5 Environmental management expense	LS			**40,000,000**	**800,000**
6 Monitoring Program expense	LS			**25,000,000**	**500,000**
7 Miscellaneous	%	5		**11,900,000**	**238,000**
Total				**250,200,000**	**5,004,000**

APPENDIX H

ATTACHMENT 1

FISHERIES AND AQUATIC BIODIVERSITY

MUNDA DAM MULTIPURPOSE PROJECT
ENVIRONMENTAL SURVEY

Attachment 1: Fisheries and Aquatic Biodiversity

Contents

Appendices

Exhibits

1. Introduction

1.1 Scope of Work of this Study

This study on fisheries and aquatic biodiversity was conducted for Japan International Cooperation Agency (JICA). It forms part of an environmental survey for JICA's environmental impact assessment of the Munda Dam Multipurpose Project.

This study covers all those areas where aquatic biodiversity or fisheries could be affected by the proposed project construction and operation. This includes areas affected by the dam and reservoir, and the riparian area downstream of the proposed dam. In the remainder of this report, the term "study area" refers to the dam and reservoir area and the river section downstream of the dam site.

This fisheries and aquatic biodiversity study included primary data collection in different parts of the project area. Data on fish, phytoplankton, and zooplankton was collected in the proposed dam and reservoir area, and the downstream river stretches. Data on fishing practices was collected from the reservoir area.

This fisheries and aquatic biodiversity study was conducted to produce a baseline inventory of the project area's fishing activities and aquatic biological resources. Possible impacts of the dam, both during and after construction, were also examined. Data was collected on fish, macro-invertebrates, phytoplankton, zooplankton and water quality. Primary information was collected on fishing practices, applicable legislation and illegal fishing within the project area.

The engineering interventions they will involve are likely to affect the aquatic biodiversity in the area for the following reasons:

- The physical and chemical conditions in the Swat River will change in the proposed reservoir and dam site area, upstream as well as downstream of the dam.
- The transition from a running stream to a reservoir will deeply affect aquatic biodiversity, especially the species of fish that form the apex of the aquatic biological pyramid.

This study was commissioned to evaluate the following aspects of the project and the area it would affect:

- Present Status
  - The existing physical and chemical conditions of water in the project area
  - Species of fish found in the area, their distribution and relative abundance
  - Presence of biological organisms that constitute fish food, such as phytoplankton, zooplankton, benthic fauna, and macro-invertebrates
  - Fish behavior, specifically, periodic or seasonal migration for spawning, breeding, or better foraging
  - Exploitation of aquatic resources for livelihood or recreational purposes
  - System for conservation, preservation, and propagation of fisheries, governing laws and regulations
- Analysis of project impacts
  - Positive and negative project impacts during construction
  - Positive and negative impacts after construction
- Mitigation measures
  - Measures to reduce or eliminate any negative effects, where possible
- Recommendations
  - Recommendations for a monitoring plan for sustainable future development

Identification of any data needs for which future studies are required.

1.2 Methodology

This study was conducted in three stages: a field survey, followed by data collection, and, finally, data analysis. These stages are outlined below.

1.2.1 Field Survey

The field survey was initiated in October 1998. It began with a visit by the environmental survey team to the proposed dam site. The second field trip was made to the proposed site of the reservoir at the confluence of the Pinjkora and Swat Rivers.

Local inhabitants were also interviewed for information regarding the project area.

Reconnaissance field observations were conducted along the Swat River, from Munda Barrage to the confluence of the Swat and Pinjkora Rivers. Based on accessibility, river morphology, and ecological features, the following sites were selected for field observations and sampling:

- Totakan
- Qosar (before and after the Pinjkora River – Swat River confluence)
- Dabar
- Salai Pati
- Marai Dab
- Munda Dam site
- Patai Banda
- Munda Barrage
- Khayali and Gindai tributaries.

The coordinates of the above sites are provided in Appendix A of this report.

It was not possible to survey the entire length of the river in the project area, as the river passes through a narrow, inaccessible gorge from Qosar to Marai Dab.

1.2.2 Collection of Data

The following data were collected and recorded from all the collection/observation sites on field survey sheets:

- Water and air temperature;
- Water quality (samples were collected);
- Fish and fisheries practices; and
- Macro-invertebrates and benthic fauna.

In addition, interviews were conducted with:

- Fishermen during field visits;
- Fish sellers from Chakdara;
- Fish sellers on the Sardayab River;
- Fisheries Directorate, NWFP;
- Assistant Director of Fisheries, Dir and Malakand at Chakdara; and
- Assistant Director of Fisheries, FATA and Charsadda in Peshawar.

Visits were also conducted to the:

- Mahseer Hatchery at Chakdara; and
- Tarbela Dam.

1.2.3 Data Analysis

Water samples were analyzed at the Hagler Bailly Pakistan laboratory in Islamabad.

Fish, macro-invertebrates and benthic fauna samples were analyzed and identified in the laboratories of the University of Peshawar.

1.3 Organization of this Report

Section 2 of this report describes the existing aquatic ecology of the project area, including fish fauna, macro-invertebrates, zooplankton and mosquito fauna, phytoplankton, predators and parasites of fish, and existing water quality and use in the project area. Section 3 describes current fishing practices. Section 4 describes the expected project impacts on aquatic ecology, during construction and operation. Section 5 suggests mitigation measures to be adopted during construction and operation, and presents a monitoring plan to ensure that mitigation measures are implemented properly.

2. Water Resources and Aquatic Life in the Project Area

This section describes the existing aquatic ecology of the project area, including fish fauna, macro-invertebrates, zooplankton and mosquito fauna, phytoplankton, predators and parasites of fish, and existing water quality and use in the project area.

2.1 Fish

Using various methods of sampling, sixteen species of fish were identified in the proposed project area and the area around the Swat River. Details of these fish are provided in Exhibit 2.1. The manner in which fish samples were collected, and the survey findings are discussed below.

2.1.1 Fish Collection Methodology

Fish samples were collected for this study using:

- Gill nets: 2-inch mesh;
- Cast nets: 1-inch mesh; and
- Mosquito/hand nets for small fry in pools.

Two fishermen were engaged to collect the fish using gill and cast nets. Both were inhabitants of Patai Bandi Village in the Mohmand Agency. Fish samples were also obtained from fishermen at fishing points.

Gill Netting Operation

Gill nets were fixed at appropriate sites in the river (for sampling sites, see Exhibit 1.3 and 1.4). The gill nets were set in the afternoon and the fish collected early the next morning.

Cast Net Fishing Operation

Cast net fishing was performed at accessible and appropriate sites in the river. The number of netting

efforts and the catch (number of fish collected) were recorded.

Collection of Fish at Fishing Points

Local fishermen's fishing points were visited. The catch they brought in was examined for fish composition and numbers. The fishermen were questioned regarding fishing sites and gear.

Collection of Small Fish from Pools

Small fish and fry were collected from the few pools and backwaters found downstream of Munda Barrage from the Khayali tributaries. The fish were preserved in 10-percent formalin and a field data label attached to the sample container. The fish collected were identified with the help of taxonomic literature, using morphometric characters.

2.1.2 Salient Features of Fish

The salient features of fish, their distribution, and relative abundance, that emerged from the survey are shown in Exhibits 2.2, 2.3, and 2.4. The information collected can be summarized as follows:

- There are sixteen species of fish in the project and adjoining areas.
- The Swat River is located in Pakistan's northern mountainous region. Fish in the area are predominantly High Asian (Central Asian) species and mainly consist of the snow trout (*Schizothoracinae*), loaches (*Noemacheilus*) and the catfish genus, *Glyptosternum*. Some Asian forms belonging to the genera *Labeo, Tor, Puntius, Garra, Ompok, Botia* and *Glypothrorax* have also been reported.
- Of these, the *Tor putitora* (Mahseer), *Schizothorax plagiostonus* (Swati) and *Clupisoma naziri* (Sher Mahi) are the major food fish and of significant economic value. Also important are the *Racoma labiata* (Chun Mahi) and other species of *Schizothoracinae* that stray downstream from the upper reaches of the Swat River.
- *Labeo dero* (Pehari Rahu), *Labeo dyocheilus* (Torki) and *Glyptothorax cavia* (Sulemani) are also food fish and make up minor portions of the catch.
- *Baralius vagra* (Chilwa), *Baralius bendelisis* (Pehari Chilwa), *Puntius ticto* (Ticto popra), *P. sophore* (Sophore), *Gara gotyla* (Pather chat) are forage fish and *Carassius auratus* (Goldfish) and *Channa punctatus* (Daula) are fish that are only occasionally found in the project area.
- The data on fish food, breeding seasons, status as food/forage fish, and distribution in Pakistan and other countries have been collected from secondary sources and are presented in Appendix B. Fish distribution in the project area is also indicated there.
- Fish found in and around Swat are interesting from a zoological point of view, in that they show a transition from the Oriental fish forms (found in southern Pakistan) to Central Asiatic forms (found in northern Pakistan). Only a few of these forms seem to be endemic to the Swat River (Mirza, 1976).

  The Sher Mahi, Swati, along with other members of *Schizothoracinae*, and the Mahseer constitute the flagship, popular or charismatic species, and need to be conserved.[1] Though widely distributed in the Swat River at present, their population and size is reported to be dwindling due to exploitation, loss of breeding grounds, and anthropogenic pollution.

  Mahseer, Ticto popra (*Puntius ticto*), Asala Mahi (*Schizopyge esocinus*) and Glypotothrorax cavia (Sulemani) may qualify as indicator or keystone species as they are reported to feed on forage fish.

  The above classifications are of a conjectural nature, and need to be backed by ecological field studies supported with laboratory observation.
- All forage fish found in the survey may be considered umbrella species since they are a source of food for piscivorous fish and also keep the population of macro-invertebrates and phytoplankton in balance. Again, this is a postulate based on biological rationale that has to be verified in future studies.
- Four species of the genus *Nemacheilus* are endemic to the area but were not found in the present survey as they exist only in the upper reaches of the Swat River, outside the project area.

2.2 Macro-invertebrates of the Project Area

A macro-invertebrate is any invertebrate that can be retained by the US No. 30 standard sieve, which has 0.059-cm openings.

Macro-invertebrates are an essential part of any aquatic habitat inventory. They are:

[1] "Flagship, popular, or charismatic species" are those that serve as symbols and rallying points for major conservation initiatives.

- An essential part of the diet of fish;
- An indicator of environmental conditions;
- An essential intermediate link in the food web of an aquatic ecosystem;
- A bio-indicator of pollution/health of an aquatic body; and
- An indicator of food sources for fish.

2.2.1 Methodology

Selection of Sampling Sites

Macro-invertebrates were collected from the same sites as the fish for the project survey. Pools, run habitats and riffles were surveyed. At the time of the survey, there were very few pool formations and run habitats were not easily accessible, so riffles were the main source of samples.

Sampling Techniques

A Surber square foot sampler was used at first. However, the samples it collected consisted mostly of dead parts of organisms, decaying vegetation material and sediment. Hand picking with a drawing brush or fine forceps was found to be more effective.

It was also observed that most of the macro-invertebrates cling to the undersurface of the small and large cobbles forming the substratum.

At each site, a square meter area was delineated, all large or small cobbles that could be detached were overturned and the organisms underneath were collected. Moving the brush gently over the undersurface agitated the organisms and made them move, facilitating collection.

The macro-invertebrates collected were counted and preserved in small vials filled with 5-percent formalin and labeled with all relevant data.

The macro-invertebrates were identified to the lowest possible taxa in a laboratory by using relevant literature. The findings are presented in Exhibits 2.5 to 2.19. Data on relative abundance and distribution ranking are presented in Exhibit 2.20.

2.3 Zooplankton and Mosquitoes

Information about mosquitoes and zooplankton (crustaceans) was collected from secondary sources, concerning habitats on the River Swat that are similar to the project area.

Based on adult and larva surveys conducted in Swat between 1991 and 1993, the mosquito species include:[1]

- *Anopheles annularis*
- *A. gluviatilis*
- *A. maculatus*
- *A. splendidus*
- *A. stephensi*
- *A. subpictus*
- *Aedes caspius*
- *A. pseudotaeniatus*
- *A. shortti* (found in river bed rock pools near Kalam)
- *Culista longiareolata*
- *Culex bitaeniorhynchus*
- *C. mimeticus*
- *C. quinquefasciatus*
- *C. theileri*
- *C. tritaeniorhynchus*
- *C. vishnui.*

The zooplankton species include:[2]

- *Eocyzicus swatiensis*
- *Cyprinotus fretens*
- *Anisogammarus madyensis*
- *Potaimon (Potamon) simulum.*

Exhibit 2.20 shows that the bulk of macro-invertebrates is composed of midges, mayfly nymphs and flatworms, followed by dragonflies, caddis flies, and stone flies. These organisms are important food for fish in the study area, as can be seen in Exhibit B.1.

Macro-invertebrates have been used as biological indicators of the health of aquatic bodies. The abundance of midges (dipteran larvae) at Totakan, Marai Dab, and downstream of Munda Headworks, compared to other places in the study area, indicates that these sections of the river are more polluted (Exhibits 2.5 to 2.20). Midges are more resistant to pollution than other macro-invertebrates and are able to inhabit polluted areas, where they face little competition from other species.

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[1] Suleman, M, Unpublished data, Department of Zoology, University of Peshawar

[2] Chaudhri, M A, *et al.*, "Aquatic Fauna of Swat Valley, Pakistan, Part III: Crustacea," *Biologia*, 24 (2): 177-198

The species of mosquitoes that may be potential vectors of malaria are the *Anopheles stephensi* (urban areas), and the *A. gluviatilis*, which is suspected to be a vector in the highland regions of Swat.

2.4 Phytoplankton

Phytoplankton forms the first trophic level in the ecological pyramid of an aquatic system.

No research has been conducted on phytoplankton in the area, mainly due to the area's inaccessibility and general lack of interest. Therefore, for information on these organisms in the project area, this study relies on secondary data collected in the upper reaches of Swat River.

Green Algae

Chlorophyceae, the green algae found in different localities of the Swat River include forty-five genera with ninety-seven species and six varieties. The genera belong to the following orders:

- *Volvocales*
- *Tetrasporales*
- *Ulotrichales*
- *Microsporales*
- *Chaetophorales*
- *Cylindrocapsales*
- *Cladophorales*
- *Oedogoniales*
- *Siphonales*
- *Zygnematales*
- *Chlorococcales*

The genus *Sprirogyra* was most commonly found in the area with other algae groups of *Cosmarium*, *Ulothrix*.[1]

The following species of algae have been reported from the Kalam – Utror area:[2]

- *Eudorina elegans*
- *Pleodorina illinoisensis*
- *Asterococcus superbus*
- *Characium lemnetium*
- *Dispora crucigenioides*
- *Coelastrum proboscideum*
- *Legerheimia citriformes*
- *Kirchneriella elongata*
- *Scenedesmus armatus*
- *Crucigenia retangularis*
- *Vaucheria pachyderma*
- *Zygnema chalalybeospermum*

The presence of a wide variety of phytoplankton in the Swat River system indicates that phytoplankton is probably a readily available source of food. This is supported by the documented feeding habits of fish in the project area (Exhibit B.1), which show that 12 out of the 16 fish species consume phytoplankton.

2.5 Predators and Parasites of Fish

Predators

The mammalian predator, the common otter (*Lutra lutra*), has been reported in the River Swat. It principally preys on fish. However, the otter has not been sighted in recent years due to overhunting. No otter burrows were found during the field survey as they are generally constructed below the water level and are therefore difficult to locate.

Kingfishers and a few other fish-eating birds were identified in the field and reported in the vicinity.

Parasites

Field observations indicated that the fish were healthy without any external symptoms caused by bacteria or fungi or secondary infections due to injury.

Implementing a study of external gill parasites and internal parasites (protozoan and helminthes) was beyond the scope of this study. However, extensive literature research on fish parasites in NWFP, including the River Swat, showed that the parasitic load of helminthic parasite includes a few flukes, tapeworms, and nematodes, that pose no serious problem to the health of the fish.

However, introducing intensive aquaculture of fish may lead to parasite problems. These have already been reported in the upper reaches of the Swat, where trout aquaculture is an increasing trend in the public and private sector.

2.6 Water Quality and Water Use

There are very few settlements along the river between the dam site and the Pinjkora – Swat River confluence. Upstream from Mahodhand (by the Kalam River) to Totakan village, there are a large number of settlements, bank-side shops, restaurants and water diversions created for agriculture purposes. Downstream of the Munda Barrage, the two

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[1] Department of Zoology, University of Peshawar

[2] Sarim, F.M., *et al.* 1990. "Some Algae from Kalam – Utror, District Swat," *Sarhad Journal of Agriculture* 6(1) 81-83

tributaries, Khayali and Gindai, are also bordered by settlements and agriculture fields.

2.6.1 Water Use

The following use of water was observed in the project area:

- Drinking;
- Washing and bathing;
- Irrigation;
- Fishing;
- Transportation (using boats or rafts made of truck tires to fish or cross the river);
- Collecting wood.

No water mills are located in the project area.

Presently, there appears to be little pollution in the proposed project area from Qosar downstream to the dam site.

Water samples were collected for analysis from Qosar downstream to the Khayali River near Tangi. The analysis results are presented in Exhibit 2.21. The collection sites correspond to the areas from where the fish and fauna samples were collected. The results indicate that the water quality is well within acceptable limits for fish life. Water quality parameters suitable for fish are presented in Exhibit 2.22. Since the data are site-specific and cover only limited parameters, water quality data covering a larger number of parameters and a wider range of the River Swat were collected from literature sources. This information is presented in Appendix C.

3. Fisheries and Fishing Practices

This section describes current fishing practices in the study area. It includes discussions on fishing methods, fishing seasons, reasons for fishing, and a description of legislation dealing with commercial and recreational fishing in the area.

3.1 Fishing in the Project Area

Since there is no documented record of the number of fishermen in the project area, this information has been gathered through the field survey. Interviews were conducted with fishermen, fish sellers and fish contractors. Fisheries officials were also consulted about the number of fishing licenses issued, where applicable.

Five fishermen were observed using gill nets in the proposed project reservoir area at Qosar and at Patai Banda near Munda Barrage. Interviews with them revealed that their livelihood depended on fishing with gill nets. Their catch varied seasonally from 10 to 15 kg a day, and comprised of *Clupisoma naziri* (Sher Mahi), the *Schizothorax* species, *Racoma labiata* (Chun Mahi) and, occasionally, other species like *Labeo dyocheilus* (Torki).

The catch quantity determines its utilization. If the catch is less than 2 kg, the fishermen and their families consume the fish. If the quantity is more than 2 kg, it is sold to the fish contractor at Totakan. The contractor's landing site is at Qosar, where he makes cash purchases from the fishermen in the morning. Fishermen who fish in the gorge area of the river sell their catch to a contractor at Shabqadar.

This type of fishing activity was found in the upper part of the proposed reservoir area, downstream of the confluence of the Swat and Pinjkora rivers. The fishermen were generally Swatis, Bajauries and Afghan refugees.

The numbers of fishermen engaged in fisheries in areas where licenses are issued, e.g., in the Malakand Agency, are presented in Exhibit 3.1.

A fish market was surveyed on the Charsadda Road at the bank of the Sardiab River, a tributary of the Kabul River. This is one of the biggest fish markets in the area. There are about 60 shops between the main road and the bank of the Sardiab River. It was found that fishermen from the project area contributed negligibly to the amount of fish at the market. Peshawar appears to be its main source. Fish is also brought to the market from distant places like Chashma Barrage in the Mianwali District, and the Tarbela and Mangla Dams.

3.1.1 Fisheries Survey

The scope of this study included a survey of fishing practices in the project area. Therefore, information was not collected upstream of Totakan, or from Pinjkora River beyond the limit of the proposed reservoir.

During this survey, 18 fishermen were observed netting fish; 14 of them did not have valid fishing licenses.

3.1.2 Fisheries in Mohmand Agency

There is no formal record of fishing activities in the Mohmand Agency, as no licenses are issued. According to the Assistant Director, Fisheries, Federally Administered Tribal Areas (FATA) in Peshawar, there are two makeshift fish nurseries in Mohmand Agency, one in Harat Village, and the other at Navai Killai.

The Swat River and its tributaries are stocked with fish fry as shown in Exhibit 3.2. Three privately owned fish farms have been established in the area,

the relevant data for which is presented in Exhibit 3.3.

3.1.3 Fishing and Fishing Practices in Khayali and Gindai Tributaries

The stretch of Swat River downstream of Munda Headworks, known also as the Khaylai River, drains into the settled district of Charsadda and is therefore under the administrative control of the Assistant Director of Fisheries, Peshawar.

During the field survey, no fishermen were seen between the Munda Headworks and the Tangi Village. Some boys were observed collecting *Gara gotyla* (Pather Chat) and small *Glyptothrorax* (Sulemani) fish from the river, just downstream of the Munda Barrage. However, this appeared to be an informal, recreational fishing expedition, rather than routine fishing for any economic purpose.

From 1990 to 1997, the Assistant Director of Fisheries issued the following licenses in Charsadda:

- 597 general fishing licenses;
- 6 seasonal licenses for rod and line fishing;
- 16 special rod and line licenses; and
- 11 daily licenses for rod and line.

The licenses issued specifically for the Khayali and Gindai Rivers cannot be ascertained as the records for the district are combined.

3.2 Recreational Fisheries

The stretch of the Swat River from Maho Dhand Lake to the town on Mingora (well outside the project area) is an angler's paradise, where trout fishing contributes considerably to local income.

The provincial government has declared the stretch of Swat River from Thana to Amandara a reserved fishing area. This is the best area for Mahseer angling in the entire Swat River. Here, fishing is restricted to special permit holders and only a limited number of fishing licenses are issued for rod and line angling during the year. These are issued by permission of the Governor or Chief Minister of the province. The fish catch quota is limited to five fish per person.

The survey team encountered a party of four students from Charsadda close to the dam site, who were going upstream for night camping and fishing. In general, however, the area is not a known recreational fishing site. Outside anglers might consider the area unsafe because it is tribal territory.

Only 33 licenses have been issued in the Charsadda district in 1999, including the Khayali and Gindai Rivers. This figure, and all other documented figures mentioned above, do not reflect the full extent of recreational fishing in the area. Most people fish illegally due to the lack of monitoring by fisheries officials. This observation is substantiated by a survey conducted by WWF from Landaki to Barikot, a stretch of 15 km, during which 200 anglers were observed fishing in the area. The number of unlicensed fishermen, however, was not documented in the WWF report.

3.3 Fish Production

The data for fish production in the Swat River and its tributaries (Khayali and Gindai) have been collected from the relevant fisheries officials.

Fish production in the Malakand and Dir districts is presented in Exhibit 3.4. Data on fish production in Mohmand Agency were not available. Fish production from the Khayali and Gindai rivers is included in the statistics for Charsadda, which are presented in Exhibit 3.5.

3.4 Fisheries Administration, Laws, and Illegal Fishing

3.4.1 Fisheries Administration in the Project Area

Fisheries are provincial subjects under the Constitution of the Islamic Republic of Pakistan. An Assistant Director of Fisheries supervises each district and the overall administrative head of the fisheries is the Provincial Director. The NWFP Provincial Director is based in Peshawar.

Although the proposed reservoir, dam and the command area of the right bank canal are located in the Mohmand Agency, the fisheries in the area are controlled by different administrative agencies:

- The area located upstream of the confluence of the Swat and Pinjkora Rivers is under the administration of the Assistant Director Fisheries, Malakand and Dir (headquarters at Chakdara);
- The extent of the river from Qosar to Munda Barrage is under the control of the Assistant Director of Fisheries, FATA; and
- The Khayali and Gindai tributaries are under the control of the Assistant Director of Fisheries based at Peshawar.

The Assistant Director of Fisheries, FATA manages the Fisheries in FATA along with an Assistant Warden, a Fisheries Supervisor, and nine Fisheries Watchers. Like other laws in Pakistan, the fisheries laws and regulations are not applicable in FATA.

The functions of the provincial department of fisheries, which does not play any role in FATA, are:

- To conserve and manage the fisheries in the province by implementing fisheries laws and regulations;
- To replenish fish in natural water bodies from fish hatcheries and to stock both natural and manmade reservoirs;
- To introduce appropriate exotic species which are fast growing and can breed in impounded waters;
- To encourage tourism based on cold water trout fishing in the province;
- To provide extension services to private fish farmers in the province;
- To train fisheries officials and private farmers in fish production and management;
- To conduct surveys of water bodies for the introduction of fish; and
- To advise the provincial government on matters related to fisheries.

Fisheries associated with dams are a major exception in this setup. All such fisheries in the country fall under the administrative control of the Water and Power Development Authority (WAPDA), Directorate of Fisheries, Lahore.

3.4.2 Fisheries Laws, Ordinances, and Rules

Laws related to fisheries are outlined in the West Pakistan Fisheries Ordinance, 1961 (West Pakistan Ordinance XXV of 1961), which is also applicable to NWFP. In 1973, entries were made in Schedule I of the 1961 Ordinance prohibiting the catching of undersized fish during the "Closed" season. In 1976, the comprehensive North West Frontier Province Rules, 1976 were compiled, which supported the Fisheries Ordinance. The 1976 Rules were further amended in 1982 by an ordinance issued by the Governor of NWFP (NWFP Ordinance No. II of 1980).

The provincial legislative assembly of NWFP passed an amendment bill in 1991 (PA/NWFP/Legis/91/5115) entitled the *North West Frontier Province Fisheries (Amendment) Act, 1991* (NWFP Act No I of 1991).

The above rules and ordinances deal mainly with the issuance of fishing licenses, leasing of fishing rights, fishing seasons, size and number of catch allowed, and type of gear to be used. They also specify the authorities for the management and monitoring of these issues and for addressing their violations at fisheries.

The Fisheries Act, 1991 and other regulations do not apply to the FATA region.

3.4.3 Illegal Fishing

Illegal fishing includes fishing during the closed season, fishing using prohibited gear (particularly small-mesh nets), fishing without a license, and fishing in prohibited areas. The most devastating aspect of illegal fishing is the use of explosives, electrocution, pesticides, and other poisons.

During the field survey, two instances of fishing with explosives were noted. The culprits selected the large fish in the catch and left the small fish. Of the fish left behind, the survey team found eight specimens of the Swati breed, measuring 15-20 cm.

From interviews with local people, fishermen and fisheries officials, it was found that the use of pesticides and herbicides is prevalent in areas where there are shallow pools. Explosives are easily available due to local quarrying activities, and are used in comparatively calm sections of the river, particularly during the winter months.

Such offences are generally committed by influential people in the area who have access to poisonous materials and explosives. In addition, local fishermen indulge in fishing with drag nets, cast nets, or gill nets of prohibited mesh.

Another illegal fishing method is to electrocute fish by passing electric currents in shallow waters, particularly during the winter months. The sources of electricity are either generators or direct live transmission lines diverted by a hook, popularly known as a "*kunda*." The use of the *kunda* is more prevalent where transmission lines run parallel or close to the river shallows.

Site-specific data on the use of poisons, explosives and electrocution were not available, so this discussion relies on field observations and interviews. However, the magnitude of the problem in Swat in general may be judged from a study conducted by the WWF, Peshawar (*Project Report on Pilot Studies to Determine Feasibility of Freshwater Network in the Malakand Division*. 1998). For the study, 22 villages in Swat were surveyed through interviews with fishermen and local people. The use of explosives for fishing was found to occur in varying degree in 68 percent, i.e., 15 of the 22 villages. It was estimated that a total of 542 dynamiting cases occurred in 15 out of 22 villages in 1998. Similarly, electrocution was reported in 10 villages (45 percent of the total). The total number of such cases was estimated to be 78 and it was found that they mostly occur during the winter months at points where the transmission line runs close to the upper Swat River in Fatehpur, Shin, Nawey Kaley and Asala. In this area, electrocution accounts for 50 percent of the total fish catch. The study also reported the use of poison in 5 villages (22.5 percent). It was estimated that 95 cases of poisoning occurred every month.

3.5 Community Participation in Fish Conservation

During the study just mentioned, WWF concluded that the current methods of monitoring fishing practices and ensuring that fisheries laws are observed were inadequate for various reasons. WWF therefore embarked on a project to elicit community participation in the monitoring process. Fish Conservation Committees (FCC) were formed in the Malakand Division including Swat, Dir and the Malakand Agency. In 1998, 44 FCCs were formed (30 in Swat District, 6 in the Malakand Agency, 6 in Dir and 3 in the Buner District). Each committee comprises a patron, president, vice president, general secretary and 10-15 executive members. The patron and other office bearers are all educated and influential people from the area who have been involved in social welfare work in their areas. At the time the FCCs were initiated, the members were briefed about the importance of conserving fish fauna. The performance of the FCCs is yet to be evaluated. This is the first effort at involving the community in fish conservation in NWFP, perhaps even in Pakistan.

There are no FCCs in the proposed project area. The nearest is in Totakan and comprises of the following members:

- Patron: Subedar Amin Khan
- President: Mr. Khan Mohammad
- Vice President: Mr. Amir Azam Khan
- General Secretary: Mr. Abdullah Khan
- 7 executive members.

3.6 Economic Benefits of Fisheries in the Project Area

The data collected during this study were not sufficient to offer an insight into the direct or indirect economic benefits of fisheries to the inhabitants of the project area. Some general observations are outlined below.

Presently, 15 to 20 people make their living by fishing in the project area. Approximately the same number are involved in fishing-based occupations, such as contractors (middlemen) and fried fish sellers.

The average price of raw fish is Rs.70 per kg for all fish except Sher Mahi, which is sold at Rs. 90 per kg at Totakan and Rs.140 per kg at Shabqadar. Assuming that an average fisherman's catch is 3 kg per day during the open season, his income may be considered Rs. 270 per fishing day. This compares favorably with daily-wage workers in the area. The Government of NWFP commissioned a benchmark survey of fishermen in NWFP in 1991. According to the survey, there were 900 people engaged in fishing in District Swat and 880 in District Charsadda. This includes both full- and part-time fishermen but not the tribal areas. The total income of 22 respondents in the Government's study in 1991 from fishing was Rs.335, 264.

4. Project Impacts

This section discusses the expected effects of the proposed project on the aquatic resources and related activities in the area. It is divided into two parts: the first describes effects associated with the project construction, while the second examines impacts after the dam and associated project facilities become operational.

4.1 Impacts during Construction

The following major structures are to be built during the construction phase of the project:

- Dam: concrete face, rock-filled, 217 m high
- Spillway: service-spillway with radial gates, and non-gate portion
- Diversion tunnels, located on the left abutment of the dam
- Power intake tunnels and powerhouse
- Outlet control structure for operational use of the tunnel with gates
- Irrigation canals: Left and right bank canals with command areas of 4, 539 ha and 2,314 ha respectively, and a total length of 27 km.

The construction activities will include:

- Procurement of construction material;
- Excavation, blasting, laying of foundations, and structure building;
- Use of construction machinery and other equipment; and
- Workers' activities.

Rock material for construction will be obtained from the established quarry site(s) outside the project area and not from the riverbed. Therefore, its procurement will have no impact on the flora or fauna of the river in the project area.

Dam filler material and concrete might be obtained from river deposits of sand and gravel. However, this will harm the aquatic biology of the river because the deposits are breeding and foraging grounds for many fish species. Bacteria and fungi decompose in this zone, releasing organic nutrients for the first trophic level of organisms. Sand and gravel quarrying has been undertaken in areas upstream of the Swat River in the past; already, the Mahseer and Swati fish populations in the river have declined as a result.

The earth material for the dam will be procured from a terrace deposit a few kilometers downstream of the dam site. This will have no impact on aquatic biology if construction work is undertaken at a distance from the riverbank and care is taken in transporting and unloading the material at the construction site.

The solid and liquid waste produced as a result of construction activity and the presence of a workforce will adversely affect water quality unless safe disposal methods are adopted.

Excavation, blasting, and unloading gravel and sand at the construction site will generate dust emissions. The emissions and the dumping of earth material in water bodies will lead to water turbidity, which will adversely affect the aquatic flora and fauna.

Although the exact volume cannot be estimated at this stage, it is certain that construction activity will produce a sizeable quantity of waste. The easiest and most economical way to dispose of the waste would be to dump it in the river but this will deteriorate the water quality. A safe method of disposal, away from the riverbank, must be found.

While cofferdams and a water passage in the tunnels are being built, the riverbed will be dried completely between the two cofferdams. This will mean a short-term loss of fish and other aquatic biota in this area. The exact extent of the stretch between the two cofferdams is not known yet, but the loss is likely to be minor and temporary.

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

The workforce may be tempted to catch fish while at the construction site. If this fishing is limited to angling with proper permission and due regard for fisheries rules, there should not be any environmental damage. Serious problems could arise, however, if the workers use explosives or chemicals to fish. This is not entirely impossible, as explosives and chemicals will be easily available during construction. To avoid this, strict discipline will have to be maintained among construction workers and other project staff, and they will need to be educated about the importance of preserving aquatic biology.

To sum up, the concerns in the construction phase are:

- Excavation of gravel and sand from the riverbed would lead to a loss of breeding and foraging ground for many fish
- If the solid and liquid waste produced during construction is dumped in the river, water quality will be deteriorated
- If workers fish illegally in the area (especially, if they use explosives or chemicals), fish fauna, particularly young fish, will suffer.

4.2 Impacts during Operation

The proposed reservoir will be 56 km long. It will stretch from Qosar, downstream through a gorge to the Munda dam. The project impacts that will be perceived once the dam becomes operational will include desirable as well as some undesirable effects. These are discussed separately below.

4.2.1 Negative Impacts

Fragmentation of Fish Populations

The construction of the dam will change the natural downstream flow of the water. Water will be released from the dam depending on when it is required for electricity generation, and for the irrigation canals.

The first major impact in the area will be the creation of a reservoir. Riverine fish migrate upstream and downstream to spawn, to find better or alternative foraging grounds, and to avoid unfavorable climate conditions. The dam will put an end to this upward and downward migration. This will divide the fish population into two segments. In the long run, the fish species may adapt to this change, and genetic changes might take place.

Migration for Spawning

Although the spawning behavior of most of the foraging fish has not been documented in the project area, research for other areas shows that, in similar habitats elsewhere, most of the spawning areas lie in shallow water close to foraging grounds. The Sher Mahi (*Clupisoma naziri)* breeds in the gorges of the Swat River in the Mohmand Agency. According to FATA fisheries officials, there are spawning areas close to the Munda barrage, where fish have been observed breeding. Young hatchlings, probably the Sher Mahi, were also observed near Munda Barrage during the present survey. Thus, the Sher Mahi populations will not suffer significantly due to dam construction.

No scientific study has been conducted in the area on the spawning grounds, spawning behavior, or breeding seasons of the Swati and other members of the *Schizothoracinae* family. It was found during this survey that all members of the *Schizothoracinae* family breed from June to August. Fishermen and fisheries officials have stated that the eggs are laid in thousands in shallow water in a gelatinous mass. Fry become visible to the naked eye in the months after the absorption of the yolk sac. The fact that young fish were caught between Qosar and Munda Barrage

leads us to believe that spawning grounds will be available along the river even after the dam is constructed.

Though the Swati and other related species may not adjust well to their new habitat initially, they will be able to find new suitable spawning and breeding grounds in the operative phase. Downstream from the proposed dam site, the changed water flow may be a problem for the Swati.

The Pehari Rohu (*Labeo dero*) and Torki (*Labeo dyocheilus*), like other carp species, breed in July and August. They generally lay their eggs during the rainy season in inundated areas where there is rooted vegetation. Carps generally lay millions of eggs but no site-specific data of their breeding biology are available. The creation of a reservoir will affect carp spawning areas, by changing the water level and physical and chemical properties, and, possibly, affecting the rooted vegetation in the reservoir.

Of all the species of fish found in the study area, the Mahseer has attracted the most attention among Pakistani, Indian and Nepalese researchers. More is known about their spawning behavior, grounds and seasons than any other fish. The facts are summed up below:

The Mahseer breeds two to three times a year. Its breeding season extends from the start of the rains in summer until September. The rain, combined with higher temperatures, forces the fish to move upstream to seek suitable spawning grounds. The spawning grounds are shallow water areas, usually springs or small tributaries. The males mature earlier. Gravel beds, where the water flow is slow and steady, are the preferred breeding spots. The number of eggs spawned varies from 600 to 63,000, averaging 4,208 eggs per kilogram of female fish weight.

The spawning grounds and breeding behavior of the Golden Mahseer of Malakand have been studied in the area where the Swat River flows into the Malakand Agency. In the past, Mingora was an ideal breeding location for the fish. These breeding grounds disappeared, however, because of certain anthropogenic interventions, such as water diversion, extraction of gravel from riverbeds, and pollution. In March, the Mahseer migrates upstream from Mingora to the streams and rivers of the Malakand division. It remains there until September. The breeding season extends from April to September in the Swat and the Pinjkora Rivers. Three spawning periods have been observed: early June, late July, and late August. The survey team spotted one- to two-month-old fish fry in the Khayali River.

An annual report of FATA fisheries officials mentions spawning grounds of the Mahseer near the Munda Barrage. This fact was confirmed when the survey team found young Mahseer hatchlings (4 to 5 cm long) downstream of the Munda Barrage at the Frontier Constabulary Post, Tangi.

The Mahseer's spawning and breeding grounds in the Swat River extend from Chakdara, Totakan and Sallai Patti (all in the Mohmand Agency) to Khayali River.

There are currently many spawning and breeding grounds of the Mahseer in the project area, many of which will disappear due to inundation associated with the dam. Areas like Salai Patti (in the reservoir area) and parts of the Mohmand Agency drained by the Swat River (up to the dam site and beyond) will be affected by fluctuations in water levels. This is a serious negative impact that should be mitigated.

Loss of Foraging Ground

The formation of a reservoir will alter the flow regime of the river in the project area and in areas downstream of the dam site. This will cause some changes in the physical and chemical properties of the water that will adversely affect fish foraging grounds.

Fish forage early in the morning and late in the evening, in shallow water. The fish found in the project area include strict herbivores (feeding on algae), fish that feed on macro-invertebrates, piscivores (fish-eaters), and a number of omnivores (plant and animal diet). The Sher Mahi also feeds on terrestrial adult insects.

The sudden 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 recolonize rapidly after a change in the water flow or a loss of suitable foraging grounds. This occurs because:

- New species move in from surrounding areas
- The juveniles, spores, or young larvae and fry drift in from surrounding areas
- Insects (upon which fish feed) will lay eggs and breed in this new habitat

Similarly, algae and other phytoplankton will rapidly recolonize 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.

Sedimentation

The construction of the dam and the change in the water flow will lead to an accumulation of sediments (silt) in the reservoir. This sedimentation, and the release of silt downstream (if planned), will affect aquatic biology.

The average annual sediment inflow into the Munda reservoir has been estimated at 373 ton/km^2. It is

estimated that, after 100 years, 373 million m^3 of sediment will have accumulated in the reservoir. The method of sediment disposal is not known at this stage.

During the initial years, sedimentation may have a positive impact, as the river drainage in the project area is oligotrophic, i.e., there is not enough organic material to sustain aquatic biota in the river. 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, sedimentation will also lead to problems. It will increase the incidence of flooding due to natural or operative mechanisms, and if the sediments are released downstream, they will cause turbidity. This will adversely affect the respiration and growth of fish in the project area.

Fish and other biota can often adapt to small perturbations in the physical and chemical characteristics of their habitat. Rain, flooding, and land erosion increase sedimentation every year and add to the water's turbidity, and fish are able to adapt to these conditions.

However, changes caused by the construction of the dam will be much more severe, and will significantly affect fish and other biota.

Water Flow Regime

Currently, no water is released beyond Munda Barrage from October to March. The only water available downstream comes from seepage through the barrage gates and from natural recharge, which is enough to sustain the river ecology. The field survey found that fish and other organisms are present in the stretch of the river downstream of Munda Barrage. This proves that the minimum level of water required to sustain aquatic life is available round the year in this area.

Construction of the dam and water storage in the reservoir will change the natural flow of the water. Water will be released from the dam depending on electricity and irrigation water requirements, and may not be enough to sustain plants and animals downstream of the dam.

Since the Swat River will be in full flow during summer months (April to September), water will have to be released through the dam, and there will be sufficient water in the downstream reach. However, due to reduced winter flows, less water will be released from the dam from October to March, which may negatively affect aquatic life downstream of the dam. A plan to ensure that the minimum water level required to sustain aquatic life is given in Section 5.

Changes in Physical and Chemical Parameters and Water Quality

The dam will cause changes in thermal levels, the amount of dissolved oxygen in the water, pH, and mineral and salt levels. The most critical change will be related to dissolved oxygen, and thermal properties and stratification (particularly in the reservoir).

According to Lone, 1983, the water quality can be better in an impoundment than in the original stream due to the precipitation of solids, exposure to light and air for longer periods, thermal stratification (resulting in a reduced heat budget for the system), and trapping of nutrients.

However, it is also possible for the water quality to deteriorate because of turbidity and oxygen depletion from pollution.

Pollution due to anthropogenic sources is a concern in the areas between Kalam and Totakan. In the project area, there are no settlements up to Patti Banda so it is almost free of anthropogenic pollution. Pollution problems may arise after dam construction, when the flow of water from the reservoir downstream will decrease, and settlements in the project area may increase. Thus, the volume of pollutants entering the river will increase, but there will be less water to dilute them. Provisions need to be made to mitigate this potential impact.

Another potential problem that needs to be addressed is the gas bubble disease in fish, caused by gas supersaturation in the river that arises when whitewater is released from turbines. The gas bubbles block the capillaries in the fish's gill filaments.

Rooted Vegetation

Vegetation on the river banks, when submerged, will start decaying and produce methane gas (a greenhouse gas), and would create snags for fishing lines. In dam projects, the removal of trees from river banks before inundation is generally recommended.

However, another view is that because of lack of humus in the river, decomposing vegetation, if left submerged after the inundation, will provide useful organic material for aquatic organisms.

Vegetation in the project area consists mainly of scrub forests. The plants are generally herbaceous, and will decompose easily, providing a rich food base in the reservoir for various organisms.

4.2.2 Positive Impacts

Enhanced Fish Production

The construction of a 56 km long reservoir with a 1,694 million m^3 capacity will create a new resource for fisheries in the project area. The increase in fish production will depend on how existing fish species adapt to the formation of the reservoir, and which new species of fish are introduced or stocked.

The Tarbela and Mangla reservoirs, both of which experience roughly the same climate, produce 150 and 1,000 metric tons of fish per annum respectively. The revenue from fish is Rs. 0.48 and Rs. 4.1 million, and the revenue from fry production is 0.25 and 0.5 million, respectively. Tarbela Dam employs 400 fishermen, while Mangla employs 1,500. The two reservoirs provide angling facilities to 1,500-2,000 people.

Similar fisheries could be developed in Munda reservoir, increasing income and employment opportunities for local people.

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 (Stockwell, 1995). Unfortunately, this 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, can be developed as additional sources of fisheries. The Department of Fisheries, the Irrigation Department, and WAPDA should undertake a joint study to utilize this valuable water resource for further augmentation in fish production.

Improvement in Quality of Life

The construction of Munda dam is expected to lead to road construction, a more consistent supply of electricity, increased tourism and recreational angling in the area, and a better commercial fish harvest. This will improve the socioeconomic conditions of the area's inhabitants. In particular, the fishermen and people engaged in fishing-related activities (fish sellers, fried fish sellers, tourist guides, and renters of angling equipment, etc.) will benefit greatly from these changes.

5. Mitigation Measures

This section discusses the measures that could be taken to reduce or eliminate the adverse environmental effects of the proposed project. The mitigation measures for the project construction phase and operation phase are discussed separately.

5.1 Mitigation for Construction Phase

The negative impacts during construction will be short-term and, if mitigated or prevented, will not be significant or long-term.

5.1.1 Filler Material Acquisition

If the dam filler material and concrete aggregates are acquired from the riverbed, the breeding and foraging grounds of many fish could be destroyed, which would constitute significant and long-term environmental damage. The alternative, which is also suggested in the project inception report, is to procure material from a quarry, even though this will be more costly.

5.1.2 Disposal of Solid Waste

Construction activity will result in the generation of solid waste. Dumping the waste in the river may be inexpensive and easy but it will lead to turbidity and change the quality of the water, which will hamper the breeding of indigenous species. Therefore, appropriate alternative waste disposal sites should be selected.

5.1.3 Disposal of Liquid Waste

Liquid and solid waste and oil spills should be treated and disposed of safely. Solid waste should be dumped away from the riverbank, leveled, and covered with topsoil. This will provide precious fertile land for agriculture, afforestation, or a park for tourists and local inhabitants.

The liquid waste should be adequately treated before its disposal; e.g., septic tanks and soaking pits should be used for sanitary waste.

5.1.4 Illegal Fishing

Significant and long-term environmental harm could also accrue from the project if the construction workers use explosives or poison to catch fish. This will kill many organisms, particularly young fish and macro-invertebrates. The problem can only be avoided and mitigated by enforcing strict discipline and monitoring by supervisory staff.

5.2 Mitigation for Operation Phase

5.2.1 Fragmented Fish Populations

The fragmentation of fish populations will be an unavoidable and a lasting consequence of the project. It is believed that it will not be possible to mitigate

this impact, even with the construction of a fish ladder. Fish ladders are not always successful, and a lot of research on fish biology and behavior is required before a suitable fish ladder can be designed. Very little research has been done on fish in the project area.

5.2.2 Loss of Foraging and Spawning Grounds

The loss of the fish population in the river will be compensated with increased finsh in the reservoir. The new fish will include both resident animals, and stock added after project completion. The phytoplankton, zooplankton, and macro-invertebrates too will recolonize the reservoir and the area downstream of the dam after a temporary decline.

The Mahseer, Swati, and Sher Mahi are the most important fish in the area. As mentioned earlier, the Swati and Sher Mahi will not be affected adversely by the project, because they will be able to find alternative spawning grounds throughout the project area. From the reservoir, they may move upstream to suitable sites in the Pinjkora and Swat Rivers. The project will affect the Mahseer, however: it is a well-documented fact that the Mahseer migrates upstream for spawning with the advent of the summer and the rainy season. Earlier studies and data collected by FATA fisheries reveal that the Mahseer also spawns and breeds downstream in the Swat River, where the river enters the Mohmand Agency and in the Khayali tributary.

To maintain the Mahseer population, Mahseer fry could be restocked annually or periodically in the reservoir once the reservoir water has stabilized. The fry could be obtained from Chakdara Mahseer Hatchery. The size of the stock will depend on the stocking of other fish—the ratio of Mahseer with other carps should be 1:2. The fish may also be stocked downstream from the dam site, along the stretch till the confluence of the Swat and Kabul Rivers.

The provincial department of fisheries has established another hatchery for the breeding of Mahseer and to produce Mahseer fish spawn for stocking rivers, lakes, *dhands* and manmade reservoirs. This project, implemented for the rehabilitation of the Mahseer, has been completed but has not initiated production due to some technical problems. Studies have recommended (biological and physical measures) to make the project operative and enable the hatchery to produce 100,000 Mahseer seed annually.

Two additional methods are recommended for mitigating the loss of fish. The first is to increase the stocking rates and frequency in the river in the project area. The second is habitat improvement. The field survey indicated that there are almost no natural pools or puddles—which are considered ideal for foraging and shelter—along the river. These could be created artificially. Fisheries biologists recommend many methods to improve habitat. The best option for this project would be to construct small spurs about 1.5 to 2 meters high above the riverbed at suitable places.

5.2.3 Changed Water Flow Regime

The Munda dam project will lower the water flow downstream of Munda Barrage. At this stage, it is difficult to ascertain the required mitigation measures because specific information is not available on the current annual, monthly or daily average water flow downstream from the dam.

It will have to be ensured that there is sufficient compensation water to sustain water ecology in the Lower Swat and Doaba Canals. In the absence of specific data, the amount of compensation water required can only be estimated using the "Montana Method." This method, evolved in Tennant (1976), determines the inflow stream regime for fish, wildlife recreation and related environment resources. It is based on a 17-year study of hundreds of streams in the USA, north of the Mason-Dixon line, between the Atlantic Ocean and the Rocky Mountains. According to Tennant, this method produces a factual, conclusive stream flow for any stream using the average annual flow of the stream (width, depth and velocity). It has been field tested in 11 streams covering 196 stream miles in three states (1964-1974). There is significant hydrological and biological evidence that the Montana Method is applicable to both cold and warm water streams and may be applied in other parts of the world, including tropical waters.

Studies showed that 10 percent of the average flow covered 60 percent of the substrate depth (which averaged one foot) and velocity averaged 0.75 ft/sec. Studies also showed that these are critical points (minimal levels) as far as the well-being of many aquatic organisms, particularly fish, is concerned. This substantiates the conclusion that a 10 percent flow is necessary for the short-term survival of aquatic organisms. A 30 percent flow would ensure good conditions for aquatic organisms.

Therefore, to mitigate the negative impacts of the reduced water flow downstream from the dam site down beyond Munda Barrage, at least 10 percent of the annual average flow, i.e., the average daily flow, must be released at all times from the reservoir. This is the level required for subsistence; if possible, at least a 30 percent level should be maintained to ensure the health of the fish and other aquatic biota.

The in-stream flow regimes for fish, wild life recreation and other related environmental resources are presented in Exhibit 5.1.

5.2.4 Sedimentation, Physical/Chemical Changes, and Turbidity

As mentioned in Section 4, the accumulation of sediment in the initial maturing phase of the reservoir may have a positive impact. However, the negative effects of the sediment load beyond the dam site have to be mitigated. This can only be achieved through the release of compensation water flow to improve the quality of water.

As discussed in Section 4, the changes in the physical and chemical properties of water properties in the reservoir may actually improve the water quality.

However, turbidity and pollution may adversely effect the area downstream from the dam. Again, this effect will be mitigated if sufficient compensation water is released downstream.

5.2.5 Gas Bubble Disease

The possibility of the gas bubble disease in fish can be avoided through careful design at the engineering stage to ensure that the water slows down as it enters the area likely to be affected.

5.3 Monitoring Plan

As fish are at the top of the trophic level of the aquatic ecological pyramid, their biology and relationship with environmental factors is highly complex. Perturbations in any intermediate link, whether biological, physical or chemical, may lead to serious consequences.

Continuous monitoring and evaluation by aquatic biologists is, therefore, necessary to facilitate healthy and sustainable aquatic production. Such monitoring and evaluation becomes all the more important where human intervention for water diversion or impoundment is proposed for electricity generation, irrigation and flood control.

It has been recognized fairly recently that an institutionalized, efficient and sustained monitoring component should be part of any hydroelectric power and irrigation development project. Therefore, a monitoring plan for fisheries and aquatic biology is being proposed as a part of the Munda Dam Multipurpose Project.

The mitigation measures discussed in Section 5.1 and 5.2 will address most of the adverse impacts predicted at this stage. The monitoring plan will not only help implement these mitigation measures, but will also provide in-depth, site-specific information on aquatic biodiversity, and identify the need for any further remedial measures.

5.3.1 Organizational Setup

For the monitoring of aquatic biological resources of the project area, it is recommended that a monitoring team be established by the project proponent. This team will be responsible for monitoring fisheries, wildlife, and other aquatic biology. It will include a monitoring coordinator for river ecology, who will be a mid-level professional with a postgraduate degree in environment planning, fisheries or zoology; one biologist; one chemist; two field staff; and two support staff for laboratory work.

A laboratory may be established for the analysis of physical and chemical parameters and biological studies. The Provincial Department of Fisheries, or the Department of Zoology or Environment Planning and Management, University of Peshawar can be considered for this purpose. Collaboration with these institutions will be more cost-effective as basic infrastructure and expertise will be available.

The monitoring should commence before the project installation phase and should continue throughout the project.

In order to include more refined and authentic data, many components of the monitoring plan may be given as MPhil or PhD research projects to students of zoology, botany, chemistry and environmental planning and management. This will not only be cost-effective but will also train manpower for future employment in such projects.

5.3.2 Responsibilities of Monitoring Team

During Construction Phase

The monitoring team will:

- Ensure that the mitigation measures discussed in Section 5.1 above are adequately implemented;
- Assist the local authorities in enforcing the Fisheries Act in the project area through the monitoring of all fishing in the area;
- Periodically monitor and record the water quality of the Swat River at various locations within the project area, with especial emphasis on the relevant parameters included in Exhibit 2.22;
- Periodically monitor and record data on fish catch within the project area;
- Periodically identify, record and monitor key spawning areas for various fish species within the project area;
- Periodically identify, record and monitor key foraging grounds for various fish species within the project area; and

- Conduct specific studies on key fish and macro-invertebrate species of the project areas.

During Operative Phase

The monitoring team will:

- Ensure that the mitigation measures discussed in Section **5.2** above are adequately implemented;
- Monitor and record the water flow from the reservoir on a periodical basis;
- Assist the local authorities in enforcing the Fisheries Act in the project area;
- Monitor and record water quality of the Swat River at various locations within the project area, with especial emphasis on the relevant parameters included in **Exhibit 2.22** on a periodical basis;
- Monitor and record data on fish catch within the project area on a periodical basis;
- Establish the project's impacts on the population of various fish species;
- Periodically identify, record and monitor key spawning areas for various fish species within the project area;
- Periodically identify changes in the spawning areas since the dam construction;
- Periodically identify, record and monitor key foraging grounds for various fish species within the project area;
- Periodically identify changes in the foraging areas since the dam construction;
- Establish the need for and then recommend and monitor the restocking of various fish species from local hatcheries; and
- Conduct specific studies on key fish and macro-invertebrate species of the project areas and determine additional mitigation measures required to preserve the river ecology.

5.3.3 Parameters to Monitor

Under the Second Pakistan Aquaculture Development Project, the Provincial Department of Fisheries, NWFP has prepared five documents that provide a methodology for assessing fisheries prospects and problems. These may be followed and modified, where required, for the monitoring of aquatic biota in the project area.[1]

[1] The documents were prepared under the supervision of Mr. Alan Stockwell, a Consultant with Agrodev, Canada.

Exhibit 2.1: Fish Collected during the Field Survey

Scientific Name and Classification	*Common Name*
Family: Cyprinidae	
Sub-family: Rasborinae	
1. Baralius vagra *(Hamilton)*	Chilwa
2. Baralius bendelisis *(Hamilton)*	Patha chilwa
Sub-family: Barbinae	
1. Labeo dero	Pehari Rohu
2. Labeo dyocheilus pakistanicus *(Mirza and Awan)*	Torki
3. Tor putitora *(Hamilton)*	Mahseer
4. Puntius ticto *(Hamilton)*	Ticto popra
5. Puntius Sophore *(Hamilton)*	Sophore popra
Sub-family: Garrinae	
6. Gara gotyla *(Gray)*	Pather chat
Sub-family: Schizothoracinae	
7. Schizothorax plagiostomus *(Heckel)*	Swati
8. Ptychobarbus conirostris *(Steindachner)*	Ladakhi snow carp
9. Racoma labiata *(McLelland)*	Chun mahi
10. Schizopyge esocinus *(Heckel)*	Asala mahi
Sub-family: Cyprininae	
11. Carassius auratus *(Linnaeus)*	Goldfish
Family: Sisoridae	
12. Glyptothorax cavia *(Hamilton)*	Sulemani, Kan Kapr (Pushto)
Family: Schilbeidae	
13. Clupisoma naziri *(Mirza and Awan)*	Sher Mahi
***Family:* Chandidae**	
14. Channa punctata	Daula

Exhibit 2.2: Gill Net Fishing Efforts during Field Survey

Place/Coordinates	*Fish Caught*	*Quantity*	*Gill Net Efforts*
Dabar	*Tor putitora*	4 + 4 + 1+ 0	4
	Racoma labiata	4 + 0 + 0 + 0	
	Schizothorax plagiostomus	2 + 0 + 0 + 0	
	Clupisoma naziri	2 + 0 + 0 + 0	
Salai Patti	*Schizothorax plagiostomus*	2 + 0 + 0 + 0	4
	Clupisoma naziri	1 + 0 + 0 + 0	
Garm Chasma	*Nil*	Nil	5
Maria Dab to Dam Site	*Nil*	Nil	5
Camp Site Near Peeko	*Tor putitora*	1 + 0 + 0	3
	Schizothorax plagiostomus	4 + 2 + 0	
	Clupisoma Naziri	1 + 6 + 1	
Munda Barrage Area, Upstream of Canal Inlet	*Tor putitora*	6 + 0 + 0	3
	Clupisoma naziri	3 + 1 + 0	
	Carassius auratus	1 + 0 + 0	

Note: Rafts made out of truck tires were used to set gill nets at appropriate and accessible places in the afternoon. The nets were harvested the next morning. The approximate time the gill nets remained in place was 14 to 16 hours.

Exhibit 2.3: Cast Net Fishing Efforts during Field Survey

Site	*Fish found*	*Fish per Effort*	*Number of Cast Net Efforts*
Totakan	*Puntius ticto: 1* *P. sophore: 1* *Gara gotyla: 6*	1+1+6+0+0+0	6
Sershai Tangi	*Puntius ticto: 1* *Baralius bendelisis: 8*	2 + 7	2
Mestosar Bridge	*Garra gotyla: 6*	1+0+2+1+0+2	6
Pinjkora River	*Schizothorax plagiostomus: 1*	0+1+0	3
Reservoir Area	*Schizothorax plagiostomus: 1*	1+0+0	3
Maria Dab	*Nil*	Nil	12
Maria Dab (using garlic and corn flour bait spread from Garm Chashma to Maria Dab)	*Schizothorax plagiostomus: 1* *Tor putitora: 1*	0+0+0+1+0+1	6
Peeko	*Nil*	0+0+0+0	4
Patai Banda	*Nil*	0+0+0+0+0	5 (3 efforts with bait of corn flour and garlic)
Munda Barrage Downstream	*Tor putitora: 4 (Fingerlings)* *Glyptothorax cavia: 1* *Garra gotyla: 1*	4+1+1	3
Abazai near Frontier Constabulary Post	*Tor putitora: 3* *Glyptothorax cavia: 8* *Barilius vagra: 2* *Gara gotyla: 2*	6+2+5+2	4
Khayali Tangi	*Barilius bendelisis: 1*	0+0+1+0	4 (Fishing effort was done with rowing boat)
Salai Patti	*Gara gotyla: 1*	1+0+0	3
Dabar	*Nil*	0+0+0	3

Exhibit 2.4: Fish Observed and Collected from Landing and Fishing Sites

Landing/Fishing Sites	*Name of Fisherman/ Contractor (Middleman)*	*Type of Fish*	*Quantity*
Totakan (Catch brought to the shop by fishermen)	Tahir Khan	*Tor putitora*	4
		Ptychobarbus conirostris	1
		Channa punctatus	1
		Racoma labiata	7
		Clupisoma naziri	14
		Schizothorax esocinus	1
		Glyptothrorax cavia	1
Qosar	Tahir Khan	*Schizothorax plagiostomus*	4
		Clupisoma naziri	3
Qosar	Zafar Khan	*Clupisoma naziri*	5
		Schizothorax plagiostomus	3
Sherbatai Village (Bajaur Agency)	Ajab Khan	*Clupisoma naziri*	8
		Schizothorax plagiostomus	12
		Racoma labiata	4
Marai Dab (Gill netting in the gorge upstream of Garm Chashma, at a place called Mizer)	Afzal Khan	*Clupisoma naziri*	43
Marai Dab (Fishing five miles upstream of the proposed dam site)	Jan Mohammad	*Tor putitora*	4
		Schizothorax plagiostomus	8
		Clupisoma naziri	4

Exhibit 2.5: Macro-Invertebrates Collected from Totakan

Classification	*Macro-Invertebrates*	*Collected from One Square Meter*
Diptera *(Midge)*	*Midges*	17
Ephemorptera *(Mayfly)*	*Pre-adult Mayfly nymphs*	5
Trichoptera *(Caddis-fly)*	*Caddis-fly nymphs*	1
Hemiptera *(Insects)*	*Nepidae (Water scorpion)*	1
Platyhelmenthes	*Dugesia*	7
Detritus containing parts	*Parts and cast of insects*	0

Exhibit 2.6: Macro-Invertebrates Collected from Mastosar Bridge

Classification	*Macro-Invertebrates*	*Collected from One Square Meter*
Diptera *(Midge)*	*Midges Dendipedidae*	9
Ephemorptera *(Mayfly)*	*Mayfly nymphs of many species*	7
Odonata *(Dragonfly)*	*Dragonfly nymph*	1
Trichoptera *(Caddis-fly)*	*Caddis-fly*	1
Platyhelmenthes	Dugesia	3

Exhibit 2.7: Macro-Invertebrates Collected from Pinjkora River

Classification	*Macro-Invertebrates*	*Collected from One Square Meter*
Diptera *(Midge)*	*Midges Dendipedidae*	6
Ephemorptera *(Mayfly)*	Heptageniidae	8
	Stenonema *(young and pre-adult)*	3
Trichoptera *(Caddis-fly)*	*Caddis-fly nymphs*	2
Odonata *(Dragonfly)*	*Dragonfly nymphs*	2
Hemiptera *(Insects)*	Notonectidae *Back Swimmer*	1
Hydracrina	*Water mite*	1
Platyhelmenthes	Dugesia	2
Protozoa	Vorticella *(Colonial Protozoa)*	1
Detritus containing parts	*Parts and cast of different insects, mostly mayfly nymphs*	

Exhibit 2.8: Macro-Invertebrates Collected from Reservoir Area(Upstream of Bridge)

Classification	*Macro-Invertebrates*	*Collected from One Square Meter*
Diptera *(Midge)*	*Midges*	3
Ephemorptera (Mayfly)	*Mayfly nymphs, mixed species & age groups*	17
Trichoptera (Caddis-fly)	*Caddis-fly nymphs*	5
Plecoptera (Stonefly)	*Stonefly nymph*	1
Platyhelmenthes	Turbellerian *flat worm and different forms of* Dugesia	11

Exhibit 2.9: Macro-Invertebrates Collected from Reservoir Area (Downstream of Bridge)

Classification	*Macro-Invertebrates*	*Collected from One Square Meter*
Diptera *(Midge)*	*Midges*	7
Ephemorptera *(Mayfly)*	Stenonema, *Mayfly nymphs, different age groups*	8
Trichoptera *(Caddis-fly)*	*Caddis-fly nymphs*	2
Odonata	*Dragonfly nymphs*	1
Plecoptera *Stonefly nymph*	*Stonefly nymphs*	4

Exhibit 2.10: Macro-Invertebrates Collected from Marai Dab

Classification	*Macro-Invertebrates*	*Collected from One Square Meter*
Diptera *(Midge)*	*Midges*	13
Ephemorptera *(Mayfly)*	Heptageniidae, *mostly re-adult*	5
Odonata Dragonfly	*Dragonfly nymphs*	3
Plecoptera Stonefly	*Stonefly nymph*	1
Platyhelmenthes	Dugesia	4

Exhibit 2.11: Macro-Invertebrates Collected from Garm Chashma (1 km Upstream of Marai Dab)

Classification	*Macro-Invertebrates*	*Collected from One Square Meter*
Diptera (Midge)	Midges *Tendipedidae*	2
Ephemorptera (Mayfly)	*Stenonema*	8
Trichoptera (Caddis-fly)	Caddis-fly nymphs	1
Platyhelmenthes	*Dugesia*	1

Exhibit 2.12: Macro-Invertebrates Collected from Campsite near Pecko

Classification	*Macro-Invertebrates*	*Collected from One Square Meter*
Diptera *(Midge)*	*Midges*	5
Ephemorptera *(Mayfly)*	*Mayfly nymphs*	
	Pre-adult	3
	Young	2
Odonata *(Dragonfly)*	*Dragonfly nymphs*	2
Platyhelmenthes	Dugesia	2
	Other species	1

Exhibit 2.13: Macro-Invertebrates Collected from Patai Banda

Classification	*Macro-Invertebrates*	*Collected from One Square Meter*
Ephemorptera *(Mayfly)*	Heptageniidae	1
	Cast of mayfly nymph	
Trichoptera *(Caddis-fly)*	*Caddis-fly nymphs* (Rhyacophilidae)	1
Diptera *(Midge)*	Tabanidae	8
	Young, adult, premature	
Odonata Dragonfly	*Dragonfly nymph*	1
Hemiptera *(Insects)*	Gerridae	2
	Water strider	
Platyhelmenthes	Dugesia	5
Detritus	*Cast of different insect parts*	

Exhibit 2.14: Macro-Invertebrates Collected Downstream of Munda Bridge[1]

Classification	*Macro-Invertebrates*	*Collected from One Square Meter*
Diptera *(Midge)*	Tabanidae	13
	Different species	
Ephemorptera *(Mayfly)*	*Mayfly nymph*	5
Hemiptera *(Insects)*	Gerridae	1
	Water strider	
Platyhelmenthes	Dugesia	10

[1] Turbid water, anthropogenic pollution, oil pollution from vehicle washing

Exhibit 2.15: Macro-Invertebrates Collected Upstream of Munda Bridge (Near Canal Inlet)

Classification	*Macro-Invertebrates*	*Collected from One Square Meter*
Diptera *(Midge)*	*Midges*	1
Ephemorptera *(Mayfly)*	Stenonema	2
	Heptageniidae	3
Odonata *(Dragonfly)*	*Dragonfly nymphs*	1
Hemiptera *(Insects)*	Nepidae	1
	Water Scorpion	
Platyhelmenthes	Dugesia	7

Exhibit 2.16: Macro-Invertebrates Collected from Dabar

Classification	*Macro-Invertebrates*	*Collected from One Square Meter*
Diptera *(Midge)*	*Midges*	1
Ephemorptera *(Mayfly)*	*Mayfly nymphs*	3
Plecoptera (Stonefly)	*Stonefly nymphs*	1
Odonata *(Dragonfly)*	*Dragonfly nymph*	1
Crustacea	*Crab*	1

Exhibit 2.17: Macro-Invertebrates Collected from Abazai[1] (Near Frontier Constabulary Post)

Classification	*Macro-Invertebrates*	*Collected from One Square Meter*
Diptera *(Midge)*	*Midges*	7
Ephemorptera *(Mayfly)*	Stenonema	2
	Other	3
Trichoptera *(Caddis-fly)*	*Caddis-fly nymph*	1
Odonata *(Dragonfly)*	Aeschidae	5
	Dragonfly nymphs	
Mollusca *(Snails)*	Physidae	1
	Physa sp	
Platyhelmenthes	Dugesia	3

Exhibit 2.18: Macro-Invertebrates Collected from Khalyai Tangi[2]

Classification	*Macro-Invertebrates*	*Collected from One Square Meter*
Diptera *(Midge)*	*Midges*	12
Ephemorptera *(Mayfly)*	Stenonema	1
	Heptagenidae	7
Trichoptera *(Caddis-fly)*	*Caddis-fly nymph*	3
Plecoptera *(Stonefly)*	*Stonefly*	5
Odonata *(Dragonfly)*	*Dragonfly nymphs*	3
Platyhelmenthes	Dugesia	7

[1] Turbid water.

[2] Turbid water, cast of different insects in detritus.

Exhibit 2.19: Macro-Invertebrates Collected from Salai Patti[1]

Classification	*Macro-Invertebrates*	*Collected from One Square Meter*
Diptera *(Midge)*	Tendipedidae *(Midges)*	3
Ephemorptera *(Mayfly)*	Stenonema	1
	Heptageniidae	9
Tricoptera *(Caddis-fly)*	*Caddis-fly nymph*	1
Plecoptera *(Stonefly)*	*Stonefly*	1
Hemiptera	Nepidae *(Water scorpion)*	1
Platyhelmenthes	Dugesia	2
Annelida	*Tubifex*	1

Exhibit 2.20: Ranking by Distribution and Abundance of Macro-Invertebrates of 15 Sampling Sites

Classification	*Ranking by Distribution*	*Numbers Found at Site*	*Ranking by Abundance*	*Number of Organisms*
Diptera *(Midge)*	II	14/15	I	107
Ephemorptera *(Mayfly)*	I	15/15	II	103
Platyhelminthes *(Flat worm)*	III	13/15	III	65
Odonata *(Dragonfly)*	IV	10/15	IV	20
Trichoptera *(Caddis-fly)*	IV	10/15	V	18
Plectoptera *(Stonefly)*	V	6/15	VI	14
Hemiptera *(Insects)*	V	6/15	VII	7
Hydracarina *(Water mite)*	VI	1/15	VIII	1
Crustacea *(Crab)*	VI	1/15	VIII	1
Mollusca	VI	1/15	VIII	1
Protozoa	VI	1/15	VIII	1

Exhibit 2.21: Water Quality Analysis

Location	*Time*	*Air Temperature (°C)*	*Water Temperature (°C)*	*pH*	*Dissolved Oxygen (mg/l)*	*Chloride (mg/l)*	*Nitrite (mg/l)*	*Nitrate (mg/l)*	*Total Phosphate (mg/l)*
River Swat (Totakan)	9.45	20	14	8.2	4.0	17.93	0.07	0.7	1.85
Mastora Bridge on the Swat River	11.15	21	16	8.35	3.5	11.41	0.06	0.85	1.20
Pinjkora River	9.50	19	14	8.38	3.80	11.41	0.06	0.80	1.30
Reservoir Area	9.10	15.5	13	8.44	3.40	9.78	0.05	0.95	0.65
Site of Confluence of Pinjkora and Swat Rivers	9.45	21	14	8.25	4.0	17.93	0.07	0.70	1.80
Marai Dab	9.00	19	12	8.15	4.2	10.59	0.80	1.00	2.00
Campsite	9.30	19	12	8.15	4.25	10.59	0.85	0.55	2.10
Before Munda Bridge	10.10	24	15	8.14	4.30	13.86	0.75	0.80	1.50
After Munda bridge	10.20	20	15	8.14	4.20	13.86	0.50	1.35	1.20
Abazai River near Frontier Constabulary Post	10.50	24	15	8.15	4.20	13.86	0.90	1.30	2.10
Khalai River near Tangi	11.20	24	15	8.18	4.20	13.86	0.85	1.30	1.50

Notes: Analytical Method employed: US EPA 1501; US EPA 352.1; US EPA 360.2; US EPA 354.1; ASTMD 515.

Exhibit 2.22: Water Quality Parameters for Fish (Safety Levels)

Parameter	*Value*
Dissolved Oxygen	3 to 4 mg/l
Nitrite	0.1 mg/l max.
Nitrate	100 mg/l max.
pH	Not below 6

Source: Lone, K P, 1983.

[1] Pristine water.

Exhibit 3.1: Licenses Issued from 1994 to 1999 by the Assistant Director, Fisheries for Districts Malakand and Dir

Year	*General Permits*	*Rod and Line Permits*	*Daily Permits*	*Permits for Reserved Area*	*Cast Net Permits*
1992-93	7	4	–	13	–
1993-94	90	22	57	–	–
1994-95	126	15	116	–	–
1995-96	65	18	202	–	369
1997-98	57	101	1	–	7

Exhibit 3.2: Fish Stocking in the Swat River (Mohmand Agency)

Year	*Number of Fry*	*Species/Breed*
1986-87	4,450	*Cyprinus carpio*
1988-89	400	*Cyprinus carpio*
1989-90	2,400	*Cyprinus carpio*
1990-91	4,700	*Cyprinus carpio*
1991-92	4,100	*Cyprinus carpio*
1992-93	Not Available	Mahseer and Torki

Exhibit 3.3: Fish Farms in the Project Area

Owner	*Year Established*	*Area*	*Fish Stock*	*Production (kg)*
Amir Nawab	1990-91	1 acre	Rohu, Mori, Silver Carp, and Grass Carp	889 (in 1995-96)
Ghani Mohammad	1994-95	0.19 acres	Rohu, Mori, Silver and Grass Carp	Not known
Jamil	1995-96	0.25 acres (Farm I) 1 acre (Farm II)	Rohu, Mori, Silver and Grass Carp	100

Exhibit 3.4: Fish Production in Malakand and Dir (Capture Fisheries)

Year	*Production (Metric Tons)*	*Remarks*
1991-92	0.812	The catch mainly consists of the Swati, Chinese Carp, Torki and Taelk (Schizothrorex sp)
1992-93	17.070	
1993-94	7.795	
1994-95	8.639	
1995-96	7.388	
1996-97	3.047	

Source: Assistant Director Fisheries, Malakand and Dir.

Exhibit 3.5: Fish Production (in Metric Tons) in District Charsadda

	1993-94	*1994-95*	*1995-96*	*1996-97*	*1997-98*
Rivers	13.847	34.219	34.344	43.043	29.318
Private Fish Farms	3.500	0.800	0.500	5.350	–
Demonstration Fish Farm	–	1.020	–	–	–

Exhibit 5.1: 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%	60%
Excellent	30%	50%
Good	20%	40%
Fair or Degrading	10%	30%
Poor or Minimum	10%	10%
Severe Degradation	10% of average flow to zero flow	

Source: Tennant, D. L., "In-Stream Flow Regimes for Fish, Wildlife Recreation and Related Environmental Resources," *Fisheries*, Volume 1 (4): 6-10.

Appendix A: Sample and Observation Sites

Place	*Coordinates*
Qosar	Not available
Totakan	N 34 37 18.9 E 71 48 54.5
Sershai Tangi	N 34 37 28.5 E 71 48 31.7
Mastosar Bridge	N 34 38 28.3 E 71 47 22.5
Pinjkora River	N 34 39 35.2 E 71 45 34.6
Reservoir Area	N 34 39 33.3 E 71 45 36.0
Reservoir Area Downstream beyond Bridge at Beginning of Gorge	N 34 39 33.3 E 71 45 36.0
Marai Dab	N 34 20 59.23 E 71 31 34.3
Garm Chasma 1 km Upstream from Marai Dab	*N 34 20 56.3* *E 71 31 22.6*
Camp Site Near Peeko	N 34 21 20.7 E 71 22 23.0
Pattai Banda	N 34 20 29.6 E 71 33 31.9
Munda Bridge down stream	N 34 19 38.2 E 71 34 20.7
Munda Bridge Upstream near Canal Inlet	N 34 20 00 E 71 34 07
Dabar	N 34 28 14.7 E 71 36 5.8
Abazai Tributary near Frontier Constabulary Post	N 34 18 51.3 E 71 35 39.7
Khayali Tangi	N 34 17 09 E 71 37 00
Tor Landkai	Not available
Sali Patai	N 34 38 50.8 E 71 44 23.2

Appendix B: Secondary Data about Fish

Exhibit B.1: Food/Forage Fish Distribution in Project Area, Other Parts of Pakistan and Extra Limit

Fish Species	*Common Name*	*Breeding Season*	*Status*	*Food*	*Distribution in Project Area*	*Distribution in Pakistan and Extra Limit*
Barabus vagra (Hamilton)	*Chilwa*	*Not known*	*Forage fish*	*Phytoplankton (algae), Chironomid mayfly, caddis-fly nymph*	*Abazai (Swat River), Pinjkora River*	*Indus River, DG Khan, DI Khan and North Wazirstan, Tarbela. India, Sri Lanka, Bangladesh.*
B. bendelisis	*Patha Chilwa*	*Not known*	*Forage fish*	*Phytoplankton (algae), Insect larvae*	*Sher shai Tangi, Khayali (Swat River)*	*India, Sri Lanka, Bangladesh.*
Labeo dero	*Pehari Rohu*	*July – August*	*Food fish*	*Algae, insect, mollusk*	*Swat River*	*Chashma Lake, DI Khan and North Wazirstan. India, Nepal, Burma, China.*
L. dyocheilus	*Torki*	*Not known*	*Food fish*	*Phytoplankton (algae)*	*Swat River*	*Rawal Dam, Indus River, (DI Khan), North Wazirstan and Punjab. Also in India.*
Tor puttora	*Mahseer*	*April – September, breeds many time in a year*	*Food fish*	*Phytoplankton. Insect larvae, Turbellarian, cyclops, Daphania, Mollusk, small fish*	*Dabar, Camp Site, Munda Barrage, Marai Dab, Abazai*	*Tarbela Reservoir, Pinjkora River, Rawal Dam, Indus (DI Khan) and North Wazirstan, Kurram River, Haro River, Siren River, Hub River, Bolan and Zhob Rivers. India, Nepal, Bangladesh, Burma.*
Puntius ticto	*Ticto popra*	*Not known*	*Forage fish*	*Dragonfly, Caddis-fly nymph, mosquito larvae and small fish*	*Totakan, Shershai Tangi*	*Chashma Lake, Rawal Dam, Indus River (DI Khan and North Wazirstan), Tarbela (Indus River). Also common in Punjab, Sindh and Balochistan. India, Thailand, Bangladesh, Burma, Sri Lanka.*
P. sophora	Sophore popra	Not known	Forage fish	Chironmus mosquito larvae, algae	Totakan, Mostosar Bridge, Munda Barrage, Abazai, Selai Patti	Chashma Lake, Indus River, DI Khan, North Wazirstan, Tarbela (Indus River). India, Bangladesh, Burma, Nepal.
Gara gotyla	Pathar chat	*Not known*	Forage fish	Phytoplankton, Insects larvae, Euglena and Diatoms	Totakan, Mostosar Bridge, Munda Barrage, Abazai, Selai Patti	*Indus River, DI Khan, North Wazirstan, Tarbela (Indus River) and also common in Balochistan. India, Bangladesh, Nepal.*
Schizothorax plagostomus	Swati	June – September in sandy gravel areas	Food fish	Phytoplankton algae and algae attached to substratum	Dabar, Selie Patti, Camp Site, Pinjkora, Reservoir area, Marayae Dab, Totakan	Tarbela and other reservoirs, Bajaur Agency (Pinjkora River) Indus River, DI Khan, North Wazirstan and Northern Areas. India, Nepal, Afghanistan.
Ptychobarbus conirostris	Ladakhi snow carp	June – A ugust	Food fish	Phytoplankton and Insect larvae, scraped from algae mass.	Fish collected from Totakan fish seller.	Northern Areas. Afghanistan.
Schizopyge esocicus	Asala Fish	June – August	Food fish	Macro-invertebrates and fish	Fish collected from Totakan fish seller, Chakdarra, Landaki, Swat River	Northern Areas, Azad Kashmir. Afghanistan.
Racoma labiata	*Chun Mahi*	*June – August*	*Food fish*	*Insect larvae, Phytoplankton.*	*Dabar*	*Azad Kashmir, Parachinar, Chakdara (Swat River), Chitral, Northern Areas, Haro River, Balochistan.*
Glyptothorax cavia	*Sulemani Kan kapor*	*Not known*	*Food fish*	*Fish, Bugs, Chiromid larvae*	*Munda Barrage, Abazai*	*Chashma Lake, common in Punjab. India, Bangladesh, Burma.*
Carassius auratus	*Goldfish*	*February – March*	*Aquarium fish*	*Phytoplankton and Zooplankton.*	*Munda Barrage*	*Common in Punjab and Sindh. China, Europe and India.*
Clupisoma naziri	*Sher Mahi*	*June – August*	*Food fish*	*Insect larvae, nymph, seeds and vegetable materials*	*Dabar, Safai Patti, Camp site, Munda Barrage, Pinjkora River*	*Chashma Lake, Kabul River, Indus River. Afghanistan.*
Channa punctatus	*Daula*	*April – June*	*Food fish*	*Insect larvae. Phytoplankton, algae, fish*	*Collected from fish seller at Totakan, Pinjkora River*	*Indus River, DI Khan and North Wazirstan. Afghanistan, India, Nepal, Burma, Bangladesh.*

Appendix C: Water Quality Characteristics of the Project Area

Exhibit C.1: Water Quality Parameters of the Swat River

Parameter	Value
Temperature (°C)	*16.4*
pH	*7.71*
Dissolved Oxygen (mg/l)	*8.95*
Specific Conductance (µmhos/cm)	*69.5*
Total Dissolved Solids (mg/l)	*55.9*
Alkalinity (mg/l $CaCO_3$)	*41*
Total Hardness (mg/l $CaCO_3$)	*47*
Nitrate Nitrogen (mg/l NO_3-N)	*0.4*
Reactive Phosphorus (mg/l PO_4)	*0.01*

Source: Stockwell, A. 1995. *Open Water Fisheries Management Plan.* NWFP.

Exhibit C.2: Water Quality Parameters of the Pinjkora River (Lower Section)

Parameter	Value
Temperature (°C)	*15.4*
pH	*8.16*
Dissolved Oxygen (mg/l)	*10.5*
Specific Conductance (µmhos/cm)	*129.9*
Total Dissolved Solid (mg/l)	*107.1*
Alkalinity (mg/l $CaCO_3$)	*35*
Total Hardness (mg/l $CaCO_3$)	*43*
Nitrate Nitrogen (mg/l NO_3-N)	*0.6*
Reactive Phosphorus (mg/l PO_4)	*<0.01*

Source: Stockwell, A. 1995. Open Water Fisheries Management Plan. NWFP.

Exhibit C.3: Water Quality Parameters of the Gindai River

Parameter	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*
Air Temperature (°C)	38	44	32	35	29	20
Water Temperature (°C)	21	22	19	26	22	19
pH	7.90	7.90	7.91	8.25	8.26	9.29
Dissolved Oxygen (ppm)	8.89	8.73	9.24	8.12	8.73	9.20
Total Dissolved Solids (ppm)	105	125	109	142.5	161	173.3
Conductivity µs/cm (0-1999)	286.9	345	345	363	380	395
Calcium (Ca^{++})	40	42	46	48	59	72
Magnesium (Mg^{++}) ppm	14.8	18.6	12	36	38	40.8
Bicarbonate (HCO_3)	74.2	79.3	97.6	97.6	60	60.2
Chloride (Cl) ppm	24.8	21.3	18.2	39	27	21.3

Source: Department of Zoology, Peshawar University.

Exhibit C.4: Water Quality Parameters of the Khayali River

Month/Parameters	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*
Air Temperature (° C)	38	44	32	35	29	20
Water Temperature (° C)	24	22	18	25	22	18
pH	7.90	7.96	7.77	8.37	8.41	8.49
Dissolved Oxygen (ppm)	8.41	8.73	9.43	8.26	8.73	9.40
Total Dissolved Solids (ppm)	37.5	37	45.9	60	75	82.5
Conductivity µs/cm (0-1999)	102.3	108.3	142.8	165.4	209	228
Calcium (Ca^{++})	36	40	40	42	43	50
Magnesium (Mg^{++}) ppm	18.6	9.8	12.4	12	29	21.6
Bicarbonate (HCO_3)	73.2	91.5	61	54.9	50	50.5
Chloride (Cl) ppm	28.4	21.3	19.7	35.5	29	21.3

Source: Department of Zoology, Peshawar University.

Appendix D: List of Persons Contacted

1. Mr. Ashaq Ahmad
   Conservation Director
   WWF
   Peshawar
2. Dr. Nasim Akhtar
   Director
   Animal Science Institute (Fisheries Research Institute)
   NARC
   Islamabad
3. Mr. Abdul Rub
   Senior Scientific Officer
   Animal Science Institute (Fisheries Research Institute)
   NARC
   Islamabad
4. Mr. Mohammad Baquar Chohan
   Assistant Director Fisheries
   WAPDA (Tarbela Dam)
   Ghazi
5. Mr. Umar Hayat
   Assistant Director Fisheries
   FATA
   Peshawar
6. Dr. Mohammad Suleman
   Professor of Zoology
   University of Peshawar
7. Dr. Mohammad Arshad
   Professor of Zoology
   University of Peshawar
8. Dr. Mohammad Afzal
   Director
   PASTIC
   Quaid e Azam University
   Islamabad
9. Dr. Mohammad Shafique
   Associate Professor (Hydrology Section)
   Department of Geology
   University of Peshawar
10. Eng. Rashid Ali Khan
    Executive Engineer
    WAPDA House
    Peshawar
11. Dr. Abdul Rehman
    Senior Scientific Officer (Environment Section)
    PCSIR
    Peshawar
12. Dr. Fazli Malik Sarim
    Department of Botany
    University of Peshawar
13. Mr. Tahir Khan
    Fish Contractor
    Tota Kan
    Malakand Agency
14. Mr. Ajab Khan
    Fish Seller
    Sharbatai Village
    Bajaur Agency
15. Mr. Mohammad Afzal
    Fisherman
    Patai Banda
    Mohmand Agency
16. Mr. Guldad Khan
    Fish Merchant, Contractor, Fried Fish Seller
    Hajizai
    Shubqadar Road
17. Mr. Jehanzeb Khan
    Fish Merchant, Contractor, Fried Fish Seller
    Hajizai
    Shubqadar Road
18. Mr. Jan Mohammad
    Fisherman
    Yousuf Khan Kalai
    Dheri Shubqadar
19. Mr. Mohammad Khan
    (Afghan refugee)
    Fisherman
    Afghan Refugee Camp near Munda Barrage
20. Mr. Mohammad Ayaz
    Fried Fish Seller
    Near Chakdarra Bridge

Appendix E: Bibliography

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