PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY

DASU HYDROPOWER PROJECT

ENVIRONMENTAL MANAGEMENT ACTION PLAN

Volume 4: AQUATIC ECOLOGY

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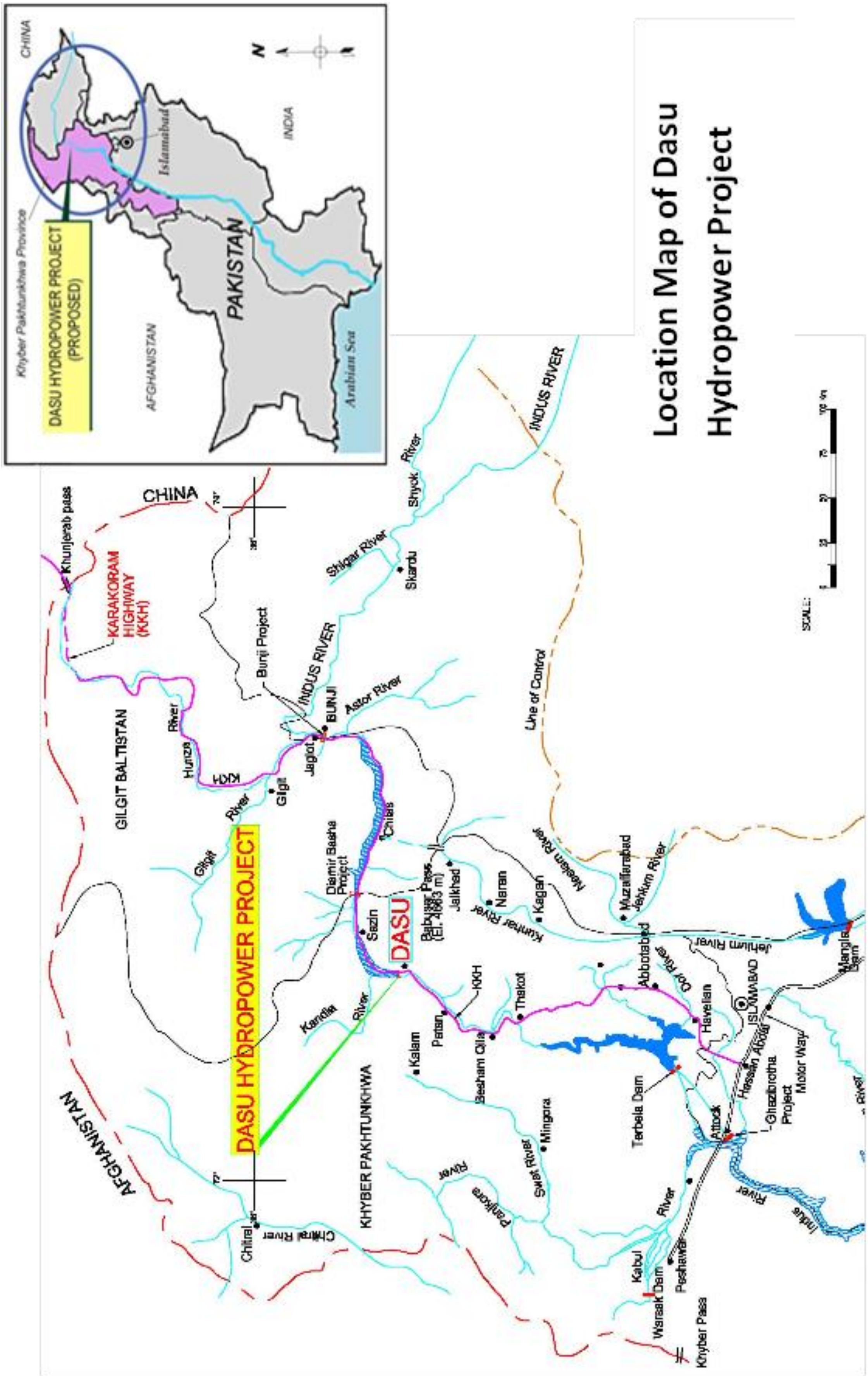
Location Map of Dasu Hydropower Project
DASU HYDROPOWER PROJECT (PROPOSED)
Khyber Pakhtunkhwa Province
CHINA
INDIA
AFGHANISTAN
PAKISTAN
Islamabad
Arabian Sea
N
DASU HYDROPOWER PROJECT
DASU
CHINA
AFGHANISTAN
GILGIT BALTISTAN
KHYBER PAKHTUNKHWA
KARAKORAM HIGHWAY (KKH)
Khunjerab pass
Hunza River
KKH
Gilgit River
Gilgit
Jaglot
BUNJI
Bunji Project
INDUS RIVER
Astor River
Shigar River
Skardu
Shyok River
Line of Control
Chilas
Diamir Basha Project
Sazin
Babusar Pass (El. 4663 m)
Jalkhad
Naran
Kunhar River
Kagan
Neelam River
Muzaffarabad
Jehlum River
Abbottabad
Dor River
Havelian
ISLAMABAD
Mangla Dam
Hassan Abdal
Ghazi Barotha Project
Motor Way
Tarbela Dam
Attock
Thakot
Besham Qila
Pattan
Kalam
Kandia River
Mingora
Swat River
Panjkora River
Chitral
Chitral River
Kabul River
Warsak Dam
Peshawar
Khyber Pass
Indus River
SCALE

ENVIRONMENTAL MANAGEMENT ACTION PLAN

ABBREVIATIONS

BHP	Bunji Hydropower Project
DBD	Diamer Basha Dam
DHC	Dasu Hydropower Consultants
DHP	Dasu Hydropower Project
EIA	Environmental Impact Assessment
EMAP	Environmental Management Action Plan
EMP	Environmental Management Plan
FSL	Full Supply Level
IUCN	International Union for Conservation of Nature
KKH	Karakorum Highway
KP	Khyber Pakhtunkhwa
KWh	Kilowatt Hour
LLO	Low Level Outlet
MOL	Minimum Operating Level
MW	Megawatt
SWHP	Surface Water Hydrology Project
TGP	Total Gas Pressure
TR	Tail Race
UNEP	United Nations Environment Programme
WAPDA	Water and Power Development Authority
WWF	World Wildlife Fund

Volume 4
AQUATIC ECOLOGY

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1. INTRODUCTION

This volume of the Dasu Hydropower Project (DHP or the Project) environmental assessment presents an assessment of potential impacts of DHP on aquatic ecology and a management plan to address possible effects. This is volume 4 of environmental assessment documentation, Environmental Management Action Plan (EMAP), of the Project. The report makes use of data in the EIA undertaken during the feasibility stage (WAPDA 2009), other secondary data sources and field surveys conducted in April and August, 2012.

DHP is a run-of-river project planned for development on the Indus River near Dasu, Kohistan, in four phases with a final power generation capacity of 4320 MW. Water and Power Development Authority (WAPDA) is the proponent of DHP.

DHP is receiving financial support from the World Bank. The Bank is guided by its policy on Environmental Assessment and other policies intended to reduce potential environmental impact of construction and operation.

1.1 PROJECT BACKGROUND

Since its creation in 1947 the energy requirements of Pakistan have been steadily increasing with rising industrial, agriculture and domestic demands. Pakistan is at present facing an acute shortage of electricity. The per capita electricity generation has traditionally been low in recent years (450 KWh as against the world average of 2730 KWh). The present demand in the country is about 25,000 MW which is expected to surpass 107,000 MW by the year 2019.

WAPDA has prepared Vision 2025 program for improving hydropower generation capacity and to meet future water needs of the Indus irrigation system. DHP is included in the medium term projects of vision 2025 program.

1.2 PROJECT LOCATION

DHP location is shown in Figure 1.**1**. The dam is proposed for placement on the Indus River 7 km upstream of Dasu bridge in Kohistan District of KP province.

1.3 PROJECT FEATURES

DHP will be comprised of a 242 m high concrete gravity dam and 73 km long reservoir behind the dam. The reservoir will have average width of 365 m and, at full supply level (FSL) of El 950, an area of 24 km^2. The dam will be situated 74 km downstream of the planned Diamer Basha dam. The project will have an underground powerhouse housing 12 turbines, each of which will produce 360 MW power, and a final maximum capacity to produce 4320 MW.

The dam, powerhouse and other project facilities are shown in Figure 1.**2**; the reservoir is shown in Figure 1.3. Additional project information is provided in Section 3 (Project Description) of Volume 2: Environmental Impact Assessment (EIA).

1.4 STUDY OBJECTIVES

Objectives of the aquatic ecology study are:

- To identify potential adverse impacts on aquatic ecology;
- To develop an action plan to mitigate the adverse impacts; and
- To formulate a development plan for a potential reservoir fishery.

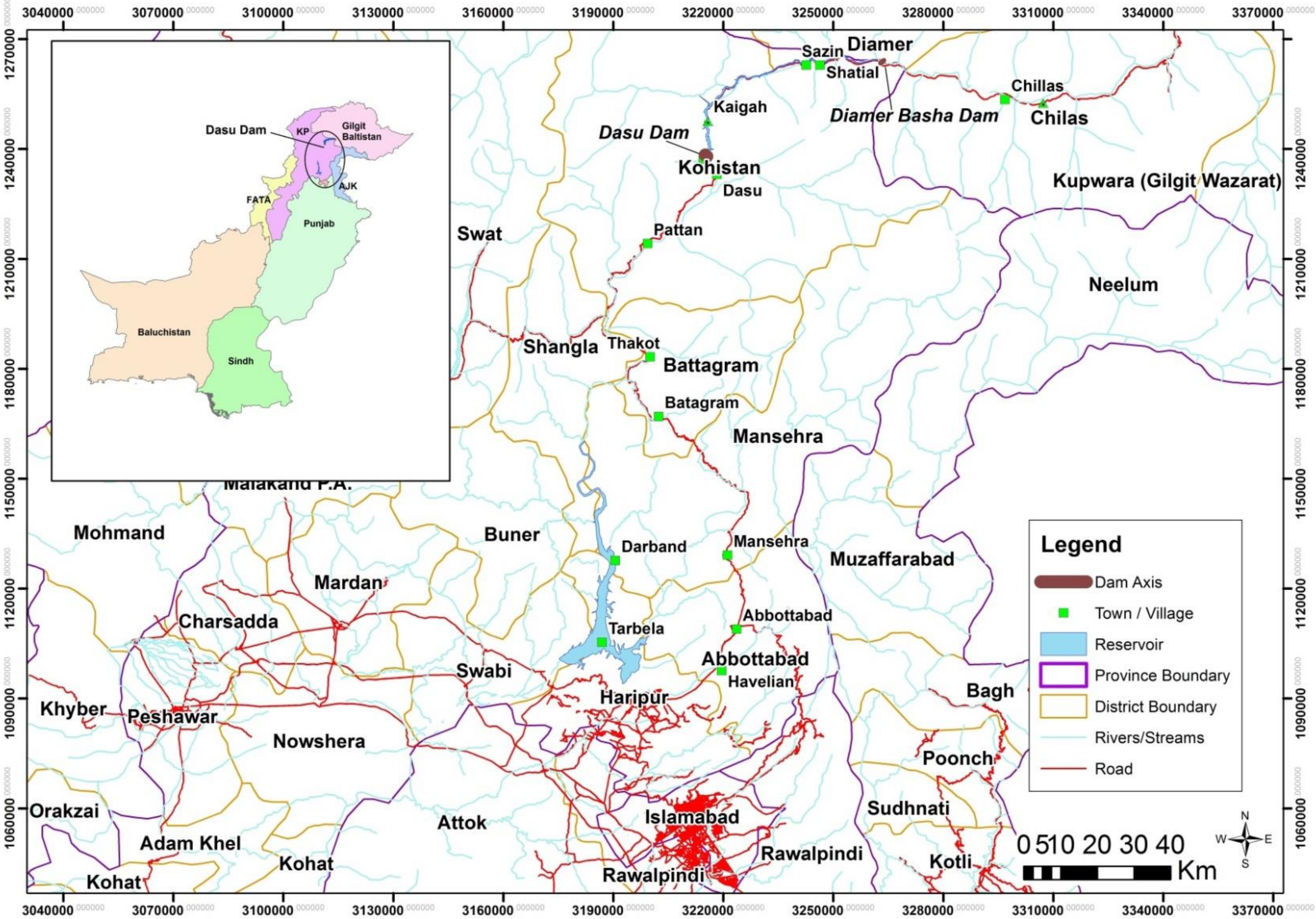

Figure 1.1: DHP Project Location

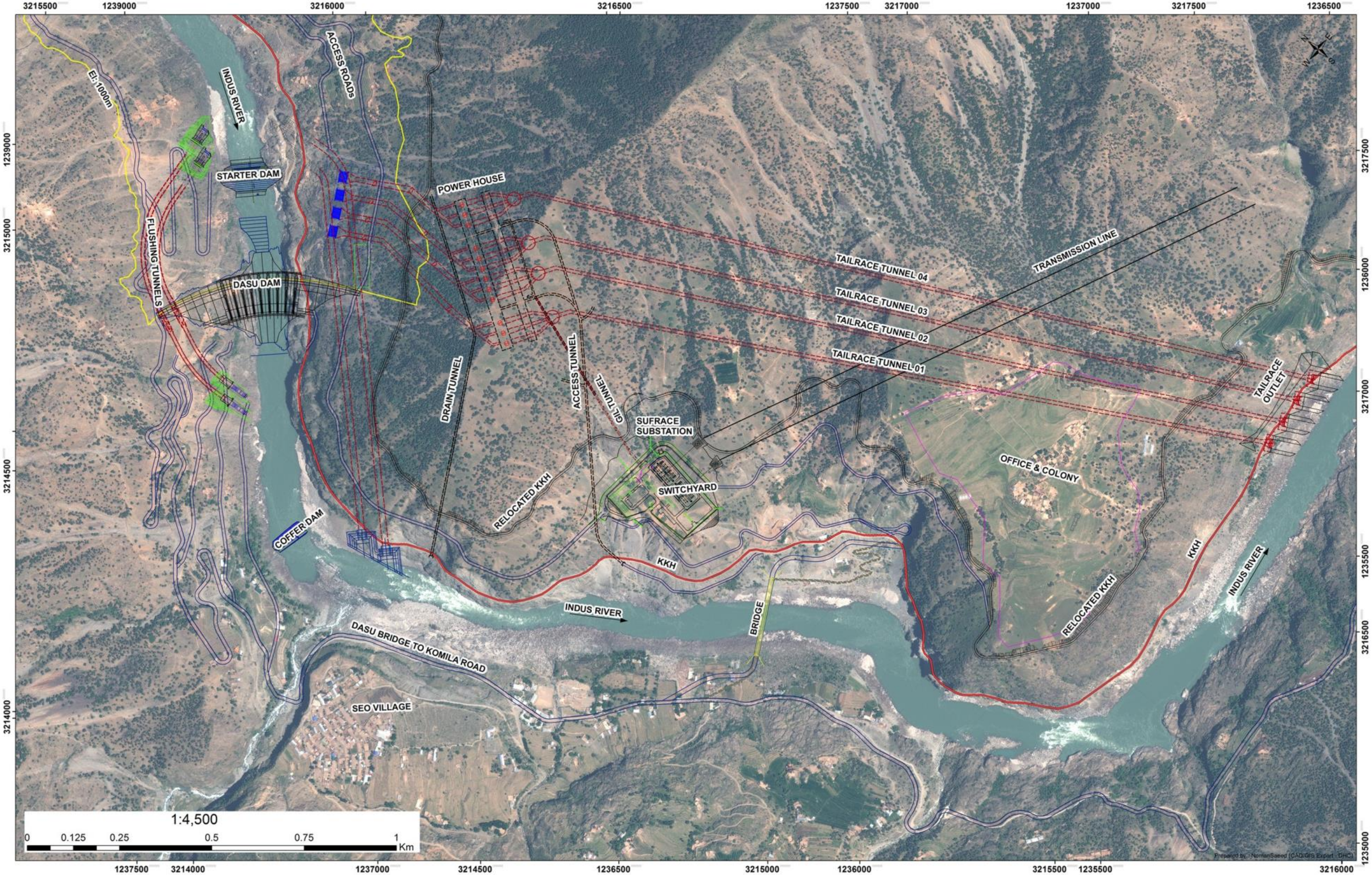

Figure 1.2: Layout Plan of Project Components marked on Satellite Imagery

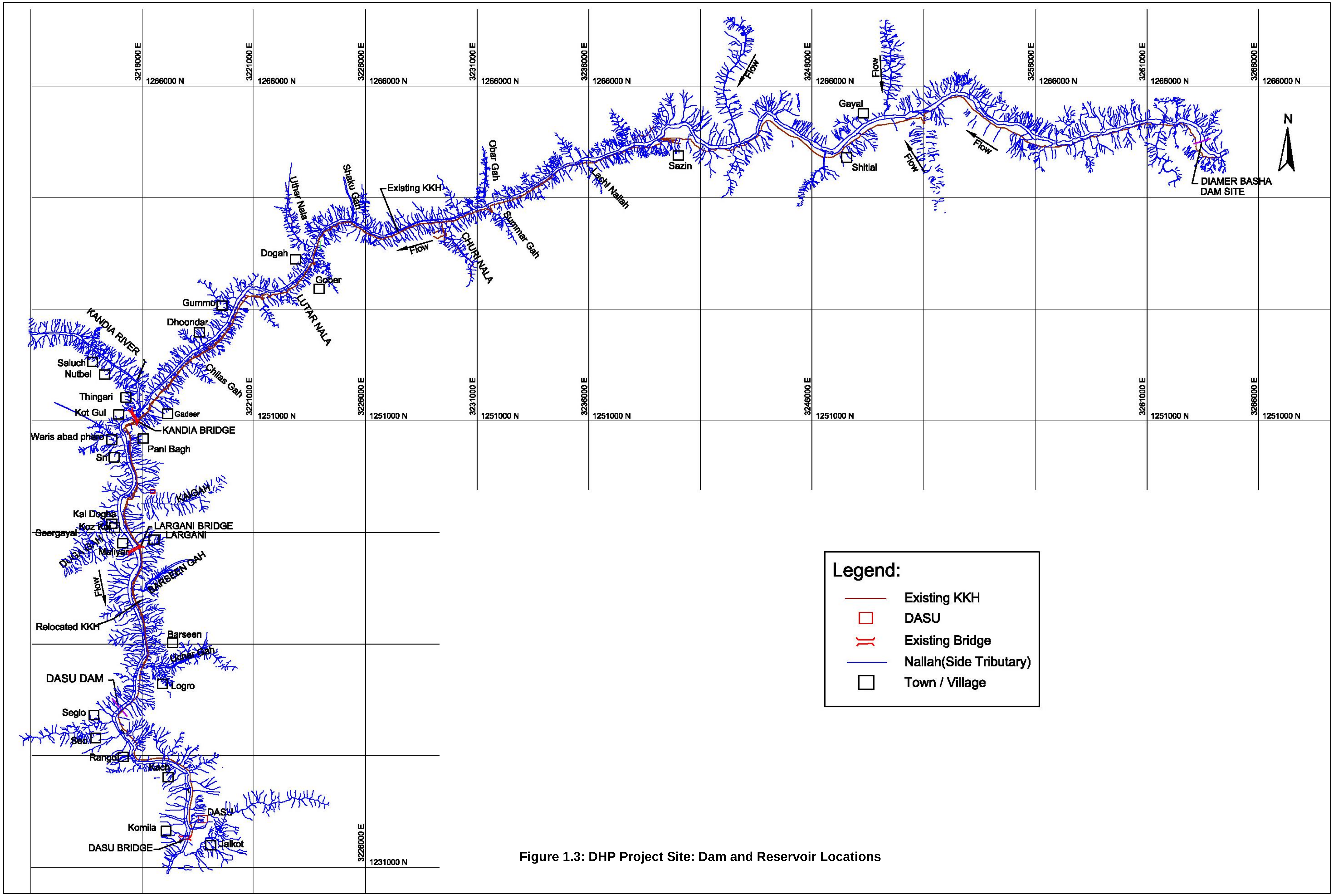

Figure 1.3: DHP Project Site: Dam and Reservoir Locations

2. APPROACH AND METHODS

This study draws upon information presented in the project feasibility study environmental assessment (WAPDA 2009), results of brief field surveys in 2012, and review of literature on the aquatic biota found in the upper Indus River. WAPDA 2009 presents results of a small aquatic ecology study conducted for the project in June 2007 and associated impact analysis and results of brief public consultation discussions related to aquatic ecology. Those results were used to guide development of study area boundaries and scope of topics for onward consideration in this aquatic ecology report and aid description of baseline conditions.

2.1 STUDY AREA BOUNDARIES

The study area limits for DHP project impact assessment were defined to extend upstream from Tarbela Dam to the upper limit of the planned Diamer Basha project reservoir (refer Volume 2 EIA). The DHP project area (physical footprint for the dam, powerhouse, reservoir and associated facilities such as construction work areas, resettlement sites, KKH re-alignment, access roads) occupies the upper portion of this area (Figure 1.3).

2.2 FIELD DATA COLLECTION

A site reconnaissance was conducted by Professor Tahir Omer in February 2012 to meet with local government personnel and select sites for biological data collection; biological field data were collected from the project footprint area by Professor Tahir Omer in early April (Appendix 2.1). In August 2012 Professor Tahir Omer and Dr. William George designed and executed field data collection intended to rapidly collect information representing the end of the seasonal high flow period (Appendix 2.2). Data were collected from Indus River and tributary sites (shown in Appendix 2.3) in the project footprint area and additional locations downstream between Dasu and Pattan (approximately 40 km downstream of the dam axis).

Field data from previous studies are included in this report: data from the WAPDA 2009 aquatic ecology studies as noted above; and data from the Diamer Basha Dam Project Feasibility Study EIA (2006) which includes sample-sites that overlap with the upstream end of the DHP project footprint. Field data included physical-chemical parameters, biological data and interviews of local fishermen and government officials.

2.3 SECONDARY INFORMATION

In addition to data from earlier studies in the project area (WAPDA 2009) and nearby Diamer Basha project (WAPDA 2010), other information sources include international and national literature on study area aquatic biota (e.g., Sehgal 1999; Petr 1999; Rafique and Kahn 2012), WAPDA consultant's reports and document files on reservoir fisheries.

2.4 IMPACT ANALYSIS

Impact analysis (Section 4.0) was comprised of identification of potential effects of project elements on baseline conditions in the aquatic environment of the study area (Section 3.0), possible mitigation measures, data gaps or uncertainties that limit interpretation of effects or assumptions regarding mitigation efficacy, and anticipated residual effects after implementation of mitigation measures.

Significance of potential adverse effects was assessed using the following criteria:

- Magnitude
- Geographic Extent

- Duration/frequency
- Reversibility
- Likelihood of Occurrence

Evaluative categories (low, moderate, high) used for each criterion are summarized in Table 2.1. Assessment of significant adverse effects is summarized in Section 5.0. Possible enhancement activities associated with development of a reservoir fishery is presented in Section 6.0. Cumulative effects on aquatic ecology of the DHP project and other activities taking place or planned in the study area are summarized in Section 7.0.

As noted in Section 4.0, the knowledge base for aquatic resources in the study area is weak and creates uncertainty regarding the need for and design of measures to mitigate effects on aquatic ecosystem components. Investigations to support refinement of plans to manage potential effects of the project on aquatic resources are outlined in Section 7.0.

Table 2.1: Significance Assessment Criteria

Criteria	Low	Moderate	High
Magnitude	Slight negative change in abundance or characteristics of ecosystem component, not expected to affect viability.	Negative change in abundance or characteristics of ecosystem component, which leads to a limited impairment	Negative change in abundance or characteristics of ecosystem component which leads to severe impairment.
Geographic Extent	Within the footprint of the facility.	In close proximity to the project.	Regional, extending to edges of DHP Study area
Duration/ Frequency	Ecosystem component exposed continuously or intermittently for less than 3 years.	Ecosystem component exposed continuously or intermittently for 3 to 9 years.	Ecosystem component exposed continuously or intermittently 10 years or more.
Reversibility	Negative change is fully reversed upon decommissioning of the project.	Negative change is partially reversed upon decommissioning of the project and fully reversed within 10 years.	Negative change is irreversible or reversed over a protracted period.
Likelihood of Occurrence	Negative change is unlikely to occur, or may occur rarely on an accidental basis.	Reasonable likelihood that the negative change will occur.	Negative change is certain to occur.

3. BASELINE CONDITIONS

3.1 FISHERY OVERVIEW OF INDUS RIVER

Indus River originates in Mansorawar Lake in Tibet, is approximately 3058 km long and drains an area of 963,480 km² before discharging into the Arabian Sea (Sehgal 1988).

Physical geological, meteorological and hydro biological conditions vary substantially along the river as do corresponding important human uses of the river and dependent economic conditions. The river ecosystem has been broadly divided into five categories: (i) Mountain peak area; (ii) Foothill mountains; (iii) Plain area; (iv) Semi-desert area; and, (v) Delta region (M.R. Mirza 1975).

The uppermost section of the river flows east-west for about 950 km before it reaches the Dasu damsite and is mainly in the mountain peak zone. The catchment in the area is mountainous and characterised by towering peaks covered with snow & glaciers. At Dasu damsite, riverbed is about an elevation of 765 m - the river is mainly fed by melting of mountain snow; having high flow during summer and contribution from rainfall is very small.

During summer, river water is very turbid and carries a large sediment load. The sediment load brought by adjoining streams / nullahs, plays an important role in the existence and distribution of fish and other aquatic life. Physico-chemical conditions of river water changes between the summer and winter seasons. Changes in temperature and sedimentation motivate the fishes to migrate for feeding and spawning.

Fish diversity in the Indus River is low compared to other major rivers. The Indus River has 177 fish species including 12 exotic species (Appendix 3.1; M. Rafique 2000), which is substantially lower than other major rivers in Asia like Ganges (350 species), Brahamputra, Mekong (400) & Hwang Hu (320 species). The main reason for poor diversity is long torrential upper courses in the Himalayas, glacier fed water and high sediment load or low mean discharge rate of water. Most species in the Indus River are members of the carp family (Cyprinidae) and loach family (Noemachcilidae) Table 3.1

Table 3.1: Fish fauna of Indus river in Pakistan

Sr. No.	Family	No. of Species	Sr. No.	Family	No. of Species
1.	Clupeidae	03	15.	Cyprinodontidae	01
2.	Notopteridae	02	16.	Poeciliidae	02
3.	Salmonidae	02	17.	Channidae	04
4.	Cyprinidae	70	18.	Chandidae	03
5.	Cobitidae	02	19.	Nandidae	01
6.	Noemacheilidae	33	20.	Badidae	01
7.	Bagridae	09	21.	Mugilidae	03
8.	Sisoridae	13	22.	Gobiidae	03
9.	Siluridae	04	23.	Osphronemidae	02
10	Heteropneustidae	01	24.	Cichlidae	03
11.	Amblycipitidae	01	25.	Synbranchidae	01
12.	Schilbeidae	07	26.	Mastacembelidae	03
13.	Belonidae	01	27.	Pristidae	01
14.	Aplocheilidae	01			

Source: *M. Rafique (2000) Pak. Museum of National History, Islamabad.*

Fish fauna diversity and abundance in the northern Pakistan, including the project study area, is generally low due to high-altitude tributaries, low water temperature, high water velocity, low benthic productivity and long stretches of gorges. In comparison, maximum numbers of fishes are found downstream of the study area in the Indus plain comprising Punjab, Sindh and eastern Baluchistan. Hazara (Tarbela region) is situated where mountain foothills meet the lowland plains and serves as the transitional zone between the cold water fish fauna of the mountain area and warm water fish fauna of the plain area. Major component of endemic species belong to the snow carp sub-family Schizothoricinae and loaches of the genera *Triplophysa*, *Schistura* & *Glyptothorax* (Table 3.2). All these taxa inhabit torrential and swift streams and rivers of the mountain region and have evolved morphologic features adapted to these habitat conditions.

Table 3.2: Fish species of Northern Pakistan

Family / Species			Local Name
A – Indigenous species			
1.	Family – Cyprinidae		
	Sub family – Schizothoracinae		
	1.	Schizothorax plagiostomus	Gahi, Cheemo
	2.	Schizothorax labiatus	Chochan
	3.	Schizothorax esocinus	Chakhat
	4.	Schizothorax skarduensis	Khaduk
	5.	Schizothorax intermedius	Khaduk
	6.	Schizothorax longipinnis	Khaduk
	7.	Schizopygopsis stoliczkai	-
	8.	Schizocypris curviforms	-
	9.	Ptychobarbus conirostris	-
	10.	Diptychus maculatus	-
	11.	Racoma labiata	Snowcarp
2.	Family – Sisoridae		
	12.	Glyptosternum reticulatum	-
3.	Family – Noemacheilidae		
	13.	Triplophysa stoliczkai	-
	14.	Triplophysa gracilius	-
	15.	Triplophysa yaseenis	-
	16.	Triplophysa trawovasea	-
	17.	Triplophysa tenuicauda	-
	18.	Triplophysa microps	-
B – Exotic species			
4.	Family – Salmonidae		
	19.	Salmo trutta faria	Brown Trout
	20.	Oncorhynchus Mysis	Rainbow Trout
5.	Family – Cyprinidae		
	21.	Cyprinus carpio	Chinese carp / Gulfam

Source: *M. Rafique (2000) Pak. Museum of National History, Islamabad.*

In accordance with M. Rafique (2000), 21 species belonging to family Cyprinidae, Sisoridae, Noemocheilidae, & Salmonidae are found. About 11 species belong to subfamily – Schizothoraxcinae having dominating genus Schizothorax. Due to their food values snow carps (previously known as Snow Trout) are commonly found which are considered as source of subsistence for local population. In order to enhance the fish sources two species of family – Salmonidae (brown trout & rainbow trout) were introduced in Gilgit river and adjoining streams in early nineties. Trout is angler's favourite species. Northern Area Fisheries department has established small hatchery at Chilas where Seed of Chinese carp (Cuprinus carpio) is produced and also stocked in adjoining streams of Indus river.

3.2 PHYSICO-CHEMICAL FEATURES OF STUDY AREA

The study area aquatic ecosystem and biodiversity is strongly influenced by rugged topographic conditions and related hydrologic features and high sediment loads.

3.2.1 Topography

The active geological process in this region has produced active steep-sloped valleys and relatively steep gradient river and stream channels in the study area (e.g., Figure 3.1).

Figure 3.1: Pallas Nullah Confluence with Indus near Pattan

(narrow gorge like steep, banks covered with vegetation, violent flowing water transparent and colorless conforming a confluence area with Indus river)

Throughout the region, gorge walls are very steep with little vegetation. Variations in day and night temperatures are extreme and cause cracking and disintegration of rocks, glacial erosion, landslides on unstable slopes of the main Indus, and mud flows from side valleys. The river also derives sediments from moraine deposits formed along its banks. Short period obstructions occur in the river caused due to landslides.

In the region between Basha and Dasu the Indus flows in a narrow gorge and at steep gradient of about 2.1 m/km. Several river tributaries join the Indus between Basha & Dasu (Figure 1.3).

3.2.2 Temperature

Air temperature and its influence on snowmelt is the key parameter in determining river flow rather than rainfall.

Temperature at lower elevations of the project area may rise to 41°C - 42°C in summer. Indicative minimum and maximum temperature at Chilas, Kandia, Pattan and Besham are shown in Table 3.3. The weather station at Kandia was established recently by WAPDA (2005) and reflects data collected over a shorter time period compared to other stations.

Table 3.3: Monthly Maximum & Minimum Air Temperature (ºC) of Project Environment

Month	Chilas		Kandia		Pattan		Besham	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
January	11	0.27	1.6	-1.1	19.2	3.3	21.7	3.3
February	17.7	2.8	-5	-7.2	19.3	4.9	27.8	2.2
March	19.8	9.2	-0.5	-2.7	25.1	9.5	35.2	8.9
April	24.5	12.6	21.6	16.6	33.0	13.1	38.3	10.0
May	30.7	16.8	32.7	22.2	37.6	16.1	43.4	9.2
June	35.7	22.7	36.1	28.3	37.6	19.6	45.6	17.8
July	39.6	26.8	35.5	30	38.5	27.4	44.5	18.9
August	38.7	26.3	32.2	27.7	38.0	22.3	40.0	18.3
September	35.2	23.6	27.7	23.3	35.2	18.2	39.5	17.2
October	27.1	13.7	26.1	19.4	31.2	12.6	34.5	10.0
November	19.7	10.5	15.0	10	27.0	9.2	28.9	6.7
December	13.2	2.61	3.3	0.5	20.2	5.1	25.6	4.4

Source: *H&S Stations, DHC 2012*

3.2.3 Precipitation

The mean annual rainfall in the study area is about 330 mm. The monsoon effect is not felt in the project area above Besham Qila due to shielding orographic effect of Himalayas. Isohyetal maps of the upper Indus area show average rainfall of 1000mm at Besham Qila with values decreasing northward (Chilas receives less than 200 mm). Main monthly rainfall data at Chilas, Kandia, Pattan and Besham are given in Table 3.4.

Table 3.4: Precipitation in mm of Project area

Month	Chilas	Kandia	Pattan	Besham Qila
January	11.1	40.93	148.1	94.5
February	16.9	62.03	242.0	138.3
March	32.3	29.08	169.2	158.4
April	32.3	40.19	130.8	111.4
May	36.8	27.20	85.6	64.8
June	29.5	04.92	61.1	67.8
July	10.0	19.62	114.1	124.4
August	13.3	26.68	67.5	123.5
September	6.2	10.72	46.8	70.1
October	10.1	24.18	38.3	48.7
November	5.8	08.51	64.4	37.2
December	10.1	38.62	109.7	58.8
Annual	214.4	332.7	1277.6	1097.9

Source: *H&S Stations, DHC 2012*

3.2.4 Hydrological Characteristics

The river is fed largely by the snows and glaciers of the Himalaya, Karakorum and Hindu Kush mountains.

Unregulated mean annual flows at different hydrological stations are presented in Table 3.5. Monthly mean flow in the project area is shown in Figure 3.2 (Diamer Basha), Figure 3.3 (Dasu damsite) and Figure 3.4 (flows from sources in the intervening area between Diamer Basha and Dasu dam site).

Table 3.5: Mean Annual Flow at various Hydrological stations

Sr. No.	Name of Station	Mean Annual Flow (m³/s)
1.	Indus river at Bunji	1,796
2.	Indus river at Shatial Bridge	2,034
3.	Indus at Diamer Basha dams site	2,005
4.	Indus at Dasu dam site	2,116
5.	Area between Dasu & Diamer Basha	111
6.	Indus river at Besham Qila	2,425

Source: *DHC Hydrological Report 2012*

Approximately 80% of the water flows in the summer months (May to October) every year. Additional flow data are presented in Section 4 of Volume 2 EIA.

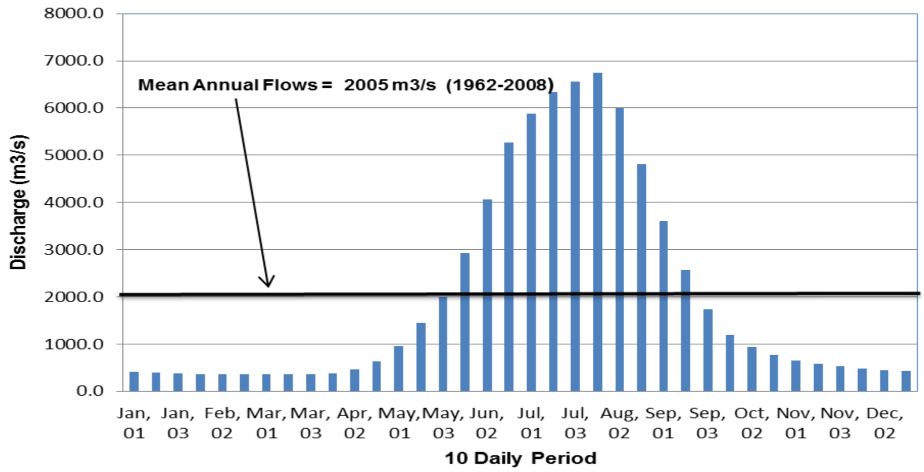

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Figure 3.2: 10-daily mean and mean annual flows of Indus river at Diamer Basha damsite (1962-2008)

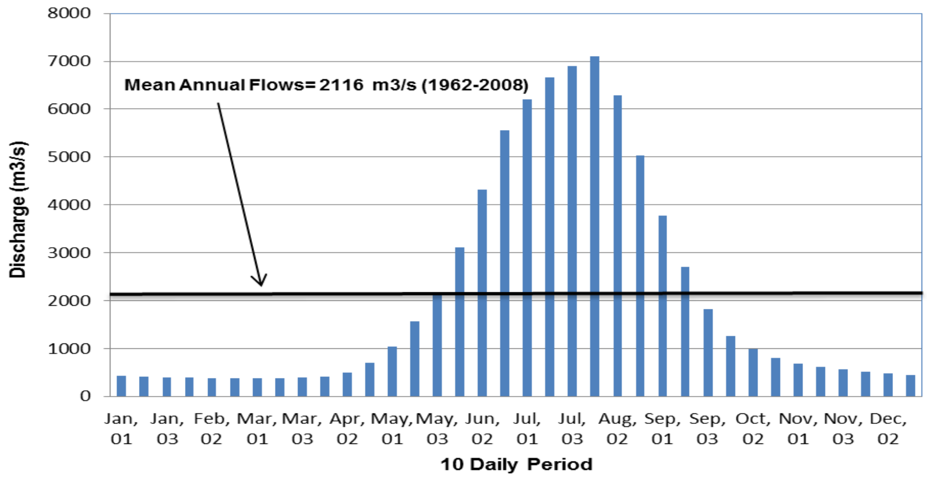


Figure 3.3: Natural unregulated 10-daily mean and mean annual flows of Indus river at Dasu damsite (1962-2008)

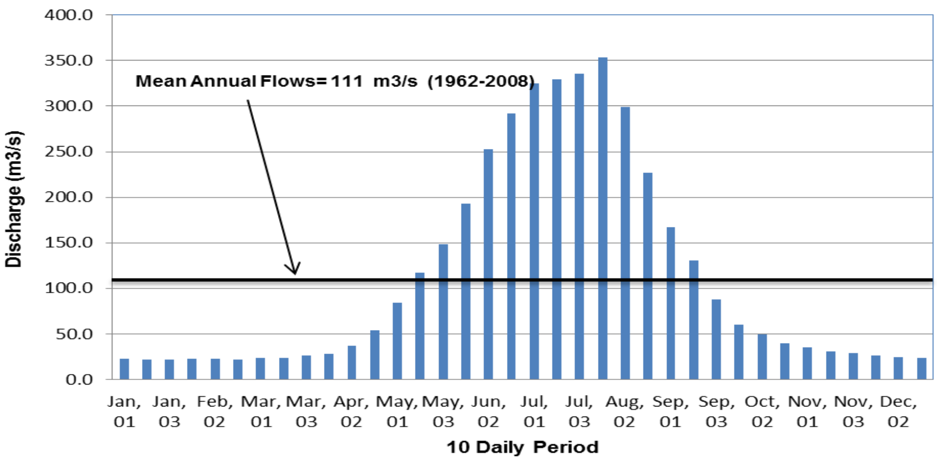


Figure 3.4: Natural unregulated 10-daily mean and mean annual flows of Indus river from intervening areas between Dasu and Basha damsite (1962-2008)

3.2.5 Suspended Sediment

During summer river water is muddy due to large suspended sediment load which comes from the erosion of soils, but mostly from moraines and terraces in upper catchment area. Suspended sediment yields estimated by the Surface Water Hydrology Project (SWHP), WAPDA, on selected main stem stations are given in Table 3.6.

Table 3.6: Suspended Sediment Yields

Gauging Station	Drainage Area (km²)	Period of Record	Suspended Sediment Yield (Tons/km²/yr)
Partab Bridge	142,700	1963-95	1,290
Barsin	157,500	1974-79	1,430
Besham Qila	167,400	1969-2000	1,600

***Source:** DHP Feasibility Report, February 2009.*

Annual sediment inflow at damsite is about 200 million tons and 97% of it occurs during high flow season of June to September. The suspended sediment data given in Table 3.6 were based on low flow period and flood season period and are shown graphically in Figure 3.5.

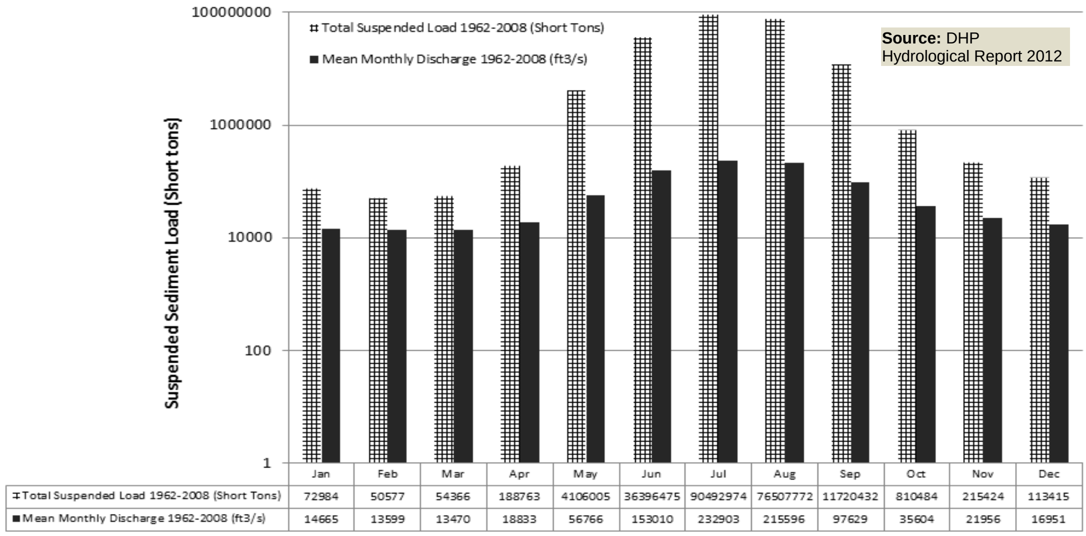


Figure 3.5: Suspended Sediment Load at Dasu Damsite (1962-2008)

3.2.6 River Gradient

Over the summer high flow period the river flow in the study area is rapid and very turbulent. Table 3.7 shows the gradient of the Indus River bed every 10 km in the project area. Variations in riverbed slope contribute to formation of habitat features, characterized by rapids during the summer and riffle and pool areas during the winter low flow period.

Table 3.7: River bed slopes in the project area

Sr. No.	Distance from Dam Axis	Bed Elevation (m.a.s.l)	Slope in %age
1.	0.0 km	765	-
2.	10 km	770	0.05
3.	20 km	795	0.25
4.	30 km	825	0.30
5.	40 km	860	035
6.	50 km	890	0.30
7.	60 km	920	0.30
8.	70 km	930	0.10
9.	80 km	935	0.05

Source: Hydrology Report DHC 2012.

3.2.7 Water Quality

Water quality data were collected for the Indus and its tributaries by the aquatic ecology study teams and by separate EIA water quality survey teams (EMAP Volume 6: Environmental Baseline Quality 4).

Data collected by the aquatic ecology field team during the summer high flow period are shown in Table 3.8. Among sample stations, ranges of parameter values were: water temperature 15 - 24°C; conductivity 63 – 149 µS/cm; calcium carbonate hardness 30 – 110mg/l; dissolved oxygen 4.8 – 7.4; and NO_3 0.20 – 1.20mg/l. At that time river water was generally muddy. During summer season, contains maximum sediment load (sand, clay and silt). Additional water quality data are presented in EMAP Volume 6.

Table 3.8: Physico-Chemical Observations of Main Stem Indus River

Sampling Station	Upstream			Downstream			
	Main river near Tangir Bridge	Main river near Kaigah	Main river before Dasu Bridge	Main river near Dasu	Main river from conflu-ence Jalkot	Main river near Jalkot	Main river 8 km from Dasu
Sampling Station No.	**(9)**	**(15)**	**(17)**	**(16)**	**(14)**	**(18)**	**(19)**
Parameters							
- Sample Date	28.08.12	31.08.12	31.08.12	31.08.12	01.09.12	01.09.12	01.90.12
- Sample Time	03:30 pm	13:30 pm	05:30 pm	05:30 pm	11:15 am	05:30 pm	05:30 pm
- Air Temperature (ºC)	32	31	35	35	33	33	22
- H_2O Temperature (ºC)	15	24	15	15	19	16	18
- H_2O depth (ft)	50	50	18.0	70	15.0	15.0	15.0
- Secchi disc depth (m)	0.15	0.15	0.5	0.3	0.5	0.5	0.5
- H_2O Color	Muddy	Muddy	Muddy / Sandy	Muddy	Muddy / Sandy	Muddy / Sandy	Muddy / Sandy
- pH	6.5	6.5	7.0	7.0	6.5	7.0	7.0
- Conductivity (µS/cm)	75	63	149.0	149.3	148.0	132.3	154.4
- Alkalinity (mg/l)	45	46	90	190	72	65	75

Sampling Station	Upstream			Downstream			
	Main river near Tangir Bridge	Main river near Kaigah	Main river before Dasu Bridge	Main river near Dasu	Main river from conflu-ence Jalkot	Main river near Jalkot	Main river 8 km from Dasu
Sampling Station No.	**(9)**	**(15)**	**(17)**	**(16)**	**(14)**	**(18)**	**(19)**
- Hardness (mg/l)	110	51	60	60	30	48	42
- Dissolved Oxygen (DO) mg/l	6.8	4.8	7.4	7.4	7.4	5.5	5.5
- Dissolved carbon dioxide (DCO_2) mg/l	13	10	16	10	12.5	12.5	12.5
- NO_3 (mg/l)	1.20	0.41	0.50	0.20	0.40	0.30	0.84

Source: *Data collected during investigational survey in August 2012*

3.2.8 Tributaries

Main tributaries in the project area (upstream) at left hand bank (Table 3.9) are Shatial, Summer, Chori, Lutter, Kaigah, Barseen, Uchar nullah and at right hand bank (Table 3.10) are Darel, Tangir, Obargah, Shakugah, Uttar, Kandia river, Duga & Seglo nullah which bring snow melt water throughout the year and bring coarse sand sediment also.

Table 3.9: Streams located at Left-hand Bank

Sr. No.	Streams	Elevation	Catchment Area	Length	Mean Annual Flow (m^3/s)
1.	Uchar	814.3 m	70.568 km^2	-	2.57
2.	Barseen	834.0 m	15.342 km^2	2902 m	0.59
3.	Kaigah	875.0 m	42.964 km^2	13166 m	1.65
4.	Lutter	957.9 m	09.5054 km^2	8723 m	0.36
5.	Summar	957.9 m	82.627 km^2	22640 m	2.21
6.	Shatial	991.1 m	09.161683 km^2	7736 m	0.35
Streams at Right Bank (upstream) from Dam Axis					
7.	Duga	891.7 m	-	12993 m	-
8.	Kandia	840.5 m	2242.0 km^2	84334 m	79.92
9.	Uttar	814.3 m	28.036 km^2	10763 m	1.08
10.	Tangir river	1073.4 m	62.4598 km^2	46798 m	2.39
11.	Darel	980.0 m	95.5890 km^2	37585 m	2.56

Table 3.10: Downstream Nullahs located at Left & Right Bank

Sr. No.	Nullah	Elevation (m)	Catchment Area (km)	Length (m)	Mean Annual Flow (m^3/s)
1.	Sieglo	776	4559	12.419	1.73
2.	Jalkot	797	247.7	30.353	-
3.	Goshali	753	1491.5	80.993	53.17
4.	Palas	700	1238	75.197	44.12
5.	Keyal	715	15059	22.708	4.09
6.	Dubair	647	514	35.702	18.32

Catchment areas vary greatly among the streams. All streams pass along steep gradients through rocky areas of high mountains, exhibiting variable cascades, riffles and pools and, at confluences with the Indus River, gravel and sand where most spawning sites of snow carp and other species are believed to be located.

During the summer high flow period when snowmelt water flows down from the peaks, water flows become very violent and rapid, eroding stream banks and shifting rocks toward the river. Streambeds mainly are covered with boulders, cobbles and gravels. Small numbers of riffles and pools were observed by field personnel during the high flow season. Banks of some streams have patches of vegetation such as herbs, shrubs and trees. Examples of stream features are shown in Figure 3.6, Figure 3.7, Figure 3.8 & Figure 3.9.

At the left bank Summer, Kaigah, Goshali stream presented the violent and rapid flow of water. Along the right bank, the rivers Tangir and Kandia are characterized by lower stream gradients and water velocity compared to other tributaries, stream beds comprised of cobbles and gravels and sequences of rapids and riffles.

Figure 3.6: Jalkot stream before confluence (stream rapids)

(rapid flow conforming riffles & pools)

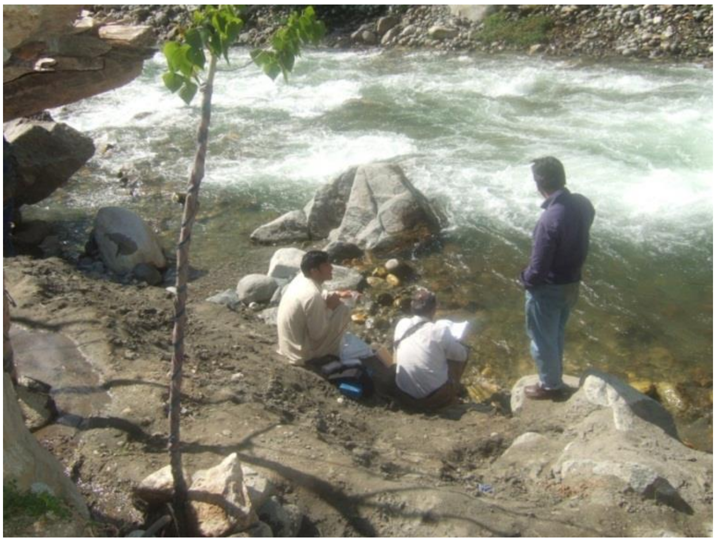


Figure 3.7: Sampling at Kaigah (Riffles & Rapids)

(rapid flow conforming riffles & pools)

Figure 3.8: A river stretch of Goshali with vegetation on banks

(Steep slope, flowing water of Goshali, banks with vegetation)

Figure 3.9: Flow at Summer Stream (Riffles & Rapids)

Maximum flows occur in summer months (May to September); lowest flows are in winter (October – April). Among project area streams along the left bank upstream of the dam site, Uchar nullah and Summer nullah have greatest flows. Along the right bank, Kandia River has highest flow. In the downstream area Goshali & Palas streams from left hand bank bring maximum water. Photos of different streams have been described through photo-log (Appendix 3.2).

3.2.9 Water quality of tributaries

Data collected from tributaries during August, 2012 is summarized in Table 3.11 (upstream of dam site) and Table 3.12 (downstream of dam site). Data collected during preparation of the feasibility study (September 2007 and January 2008) is presented in Table 3.13.

Table 3.11: Physico-Chemical features of tributaries upstream of dam site, August 2012

Sampling Station	Uchar Stream	Berseen Stream	Kandia River	Kaigah Stream	Chori Stream	Summar Stream	Darel River	Tangir River
Sampling Station No.	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
Parameters								
- Sample Date	26.08.12	26.08.12	31.08.12	27.08.12	27.08.12	27.08.12	28.08.12	28.08.12
- Sample Time	10:20 am	11:45 am	10:30 pm	10:15 am	02:00 pm	12:20 pm	11:20 am	01:45 pm
- Air Temperature (ºC)	31	32	32	32	37	38	30	31
- H_2O Temperature (ºC)	20	27	14	21	20	18	17	14
- H_2O depth (ft)	1.5	2.0	5	1.5	2.0	2.0	2.5	1.5
- Secchi disc depth (ft)	1.0	1.0	0.15	0.45	0.3	0.6	0.45	0.45
- H_2O Color	Color-less	Color-less	Color-less	Color-less	Color-less	Color-less	Green-ish	Color-less
- PH	6.5	6.5	6.5	6.5	6.5	6.5	7.0	6.5
- Conductivity (µS/cm)	55	105	57	56.7	28.2	30.6	80.6	68
- Alkalinity (mg/l)	50	15	50	150	35	135	90	40
- Hardness (mg/l)	30	120	90	150	30	180	120	84
- Dissolved Oxygen (DO) mg/l	10	5	5.2	5.5	6.5	6	6.5	7
- Dissolved Carbon Dioxide (DCO_2) mg/l	10	20	0	10	10	50	15	15
- NO_3 (mg/l)	1.40	1.70	1.50	1.50	0.34	0.46	0.90	1.50

Source: *Data collected during investigational survey in August 2012*

Water of sampled tributaries generally were colorless, odorless, transparent and cool. Dissolved oxygen concentrations ranged from 5.0 to 10.0 mg/l among streams. Conductivity ranged from 28 µS/cm (Chori stream) to 105 µS/cm (Berseen) indicating variable but generally low concentrations of dissolved solids. Low concentrations of NO_3 suggest mainly low nutrient levels and oligotrophic conditions. Additional water quality data are presented in Volume 2: EIA.

Table 3.12: Physico-Chemical features of tributaries in areas downstream of dam site, August 2012

Sampling Station	Goshali Stream	Sieglo Stream	Jalkot Stream	Palas Stream	Keyal Stream
Sampling Station No.	**(3)**	**(10)**	**(11)**	**(12)**	**(13)**
Parameters					
- Sample Date	26.08.12	29.08.12	29.08.12	30.08.12	30.08.12
- Sample Time	05:00 pm	11:00 am	04:45 pm	12:45 pm	04:30 pm
- Air Temperature (ºC)	32	26	34	37	31
- H_2O Temperature (ºC)	21	19	19	19	16
- H_2O depth (ft)	3.5	2.5	2.0	2.5	1.5
- Secchi disc depth (ft)	2.5	1.5	1.0	2.5	1.5
- H_2O Color	Colorless	Colorless	Colorless	Colorless	Colorless
- pH	7.2	7.0	6.5	7.0	7.0
- Conductivity (µS/cm)	123.8	168.2	43.2	69	32.3
- Alkalinity (mg/l)	90	105	50	50	60
- Hardness (mg/l)	144	92	75	90	90
- Dissolve Oxygen (DO) mg/l	70	7.0	6.0	6.5	7.0
- Carbon dioxide (DCO_2) mg/l	29	15	14	13	15
- NO_3 (mg/l)	0.50	0.81	1.70	0.40	0.81

Source: *Data collected during investigational survey in August 2012*

Table 3.13: Water quality of tributaries, September 2007 and January 2008

Parameter	Uchar		Barseen		Summar		Kandia		Darel	
	Sep. 07	Jan. 08	Sep. 07	Jan. 08	Sep. 07	Jan. 08	Sep. 07	Jan. 08	Sep. 07	Jan. 08
- H_2O Temperature	12.6	7.5	12.9	7.5	14	7.2	12.5	7.2	12.2	7.2
- Odor	Dark-ness	Dark-ness	Od.	Od.	Od.	Od.	Od.	Od.	Od.	Od.
- Taste	Taste -less	Taste-less	Taste-less	Taste -less	Taste-less	Taste-less	Taste -less	Taste-less	Taste-less	Taste-less
- pH	6.6	7.9	6.7	7.8	6.8	8.0	6.8	8.2	7.7	8.1
- DO (mg/l)	8.5	8.1	8.7	8.2	8.0	7.8	8.0	7.9	7.6	7.7
- Turbidity (N.T.U)	7.4	9.1	6.2	9.5	7.0	8.2	7.1	9.2	14.5	7.9
- Conductivity (µS/cm)	28.8	44.8	37.3	46.3	18.1	43.6	28.7	46.2	37.7	40.8
- T.D.S (mg/l)	17.3	29.8	21.73	30.0	41.5	26.1	28.0	28.1	20.2	26.8
- NO (mg/l)	0.9	2.64	1.1	2.58	1.62	2.59	1.4	2.6	0.9	2.5
- Cl (mg/l)	2.0	3.3	1.75	3.0	2.5	2.8	1.4	3.5	2.8	2.6

Source: *Feasibility report 2009 Sampling 28.09.07, 28.01.08*

3.3 AQUATIC BIOTA

3.3.1 Fish Species

Fish fauna of project area comprised on representative of families Cyprinidae, Noemacheilidae, Sisoridae and Salmonidae commonly. Field samplings carried out by the investigation team and available informations (secondary data) indicated that fish fauna is dominated by representative of family – Cyprinidae, subfamily – Schizothoracinae, Genus Schizothorax and species S. plagiostomus. Particularly the adjoining streams are mostly dominatedly the snow carp – Schizothorax plagiostomus. In order to reflect better picture, different areas (upstream of Dam axis, downstream area and adjoining streams / nullahs) have been sampled, investigated and studied. Area-wise occurrences are given below.

3.3.1.1 Upstream of Project Area (Diamer Basha Area)

In upstream of Dasu Hydropower Project (about 74km), Daimer Basha Dam has been planned whose EIA report, section fishery (WAPDA 2009) provided the related information about fish species and their occurrence in the adjoining areas, as described under Table 3.14.

Table 3.14: Composition of Fish Stock in DBP Area

Sr. No.	Group	Local Name	Locality	Total Samples	Length range (in cm)	Weight range (in gm)
I-Family Cyprinidae						
Subfamily – Schizothoracinae						
	1. Schizothorax plagiostomus	Gahi Swati	-Indus river mainstem -Khanbarigah -Thor gah -Buto gah -Thor gah	54 23%	16.0-31.0	20.0-100.0
	2. Schizothorax esocinus	Chakhat	-Khanbari gah -Thor gah -Thakgah -Kinar gah	55 10.50%	8.0-26.0	30.0-100.0
	3. Schizothorax intermededius	Khadule	-Khanbarigah -Thor gah -Kinar gah -Indus river mainstem	11	8.5-16.5	10.0-65.0

Sr. No.	Group	Local Name	Locality	Total Samples	Length range (in cm)	Weight range (in gm)
	4. Ptychobarbus spp.	Siarrian	-Khanbari gah -Thor gah -Thak gah -Kinar gah	5 .07%	19.0-29.8	15.0-55.0
	5. Racoma labiata	Chohan	-Khanbari gah -Thor gah -Buto gah -Thak gah	13 15.78%	15.0-20.0	20.0-30.0
Subfamily - Cyprininae						
	6. Cyprinus carpio (induced spp)	China carp	-Khanbari gah -Thor gah	13 3.3%	13.0-28.0	10.0-65.0
	7. Carassius (induced spp)	Gold fish	Indus river near Chilas	03 1.75%	8.5-22.0	15.0-35.0
Subfamily – Luciscinae						
	8. Ctenopharyngodon	Grass carp	-Khanbari gah -Indus river mainstem	02 35.%	17.0-32.0	20.0-31.5
	9. Aristis chithys nobilis	Silver carp	Indua river stem	1 1.75%	15.0-17.0	17.0-23.0
II-Family Noemacheilidae						
	10. Triplophysa gracilus	Jungli Chemo	-Khanbari gah -Kinar gay	2 3.5%	6.5-8.5	6.0-13.2
	11. Triplophysa microps	-	-Khanbari gah -Kinar gah	2 3.5%	6.5-8.5	6.0-13.0
III-Family – Sisoridae						
	12. Glyptosternum reticulum	Konoz-obo	-Khanbari gah -Kinar gah	2 3.5%	6.5-9.5	7.5-15.0
IV-Family – Salmonidae						
	13. Salmo trutta (induced spp)	Angrazi	Indus river	2 3.5%	-	-
	14. Salmo gairdneri (induced spp)		Indus river	2 3.5%	-	-

Source: *EIA Report of DBD, August 2010*

3.3.1.2 Dasu Hydropower Project Area

During field investigations (April 2012, June 2012, August 2012), aquatic team carried out fishing speditions in river mainstem which resulted into limited number of specimen caught and are given in Table 3.15.

Table 3.15: Fish Species caught in Indus River mainstem (upstream from dam axis)

Fish Species	Common Name	River at Kaigah	River mainstem near Tangir	River mainstem at Summar	Total No.
Family – Cyprinidae					
Sub-family – Schizothoracinae					
1. Schizothorax plagiostomus	*Gahi / Swati*	2	1	2	5
2. Schizopyge esocinus	*Chakhat*	-	1	1	2
3. Racoma labiata	*Chohan*	-	-	1	1
Family – Noemachielidae					
4. Triplophysa gracilis	*Jungli Chemo*	1	-	1	2
Total No.		**3**	**2**	**5**	**10**

Note: *At Kaigah stream, Juvenile of brown trout (salmo trulta) were observed in a small fish ponds.*

Catches of river mainstem (upstream) are dominated by three species of snow carp (Schizothorax plagiostomus, Schizopyge esocinus, Racoma labiate). Specimen of hillstream loach (Triplophysa spp.) were also caught. Sampling in high flow season revealed out very limited no. of species caught.

Field survey and investigation of the study area are categorized (i) upstream area from Dasu dam axis (River mainstem & left & right banks streams) (ii) downstream area from dam axis including river mainstrem and adjoining streams. Team members of aquatic biology carried out field survey in April 2012, June 2012 & August 2012 whose findings are presented in following Tables Table 3.16 to

Table 3.19.

Table 3.16: Fish caught from Left Bank Streams during Sampling of April 2012

Fish Species		Uchar	Barseen	Kaigah	Summar	Shatial	Harban	Total
Cyprinidae								
Schizothoracinae								
1.	Schizothorax plagiostomous (Gahi)	-	2	1	1	1	3	8
2.	Schizopyge esocinus (Chakhat /Swati)	-	-	-	-	1	-	1
3.	Triplophysa spp. (Jungli Chemo)	-	1	-	-	-	-	1
	Sub Total	**-**	**3**	**1**	**1**	**2**	**3**	**10**

Table 3.17: Fish caught from Right Bank Streams during Sampling of April 2012

Fish Species		Duga	Kandia	Utter	Tangir	Darel	Total
Cyprinidae							
Schizothoracinae							
1.	Schizothorax plagiostomous (Gahi)	-	-	-	-	-	2
2.	Triplophysa spp. (Jungli Chemo)	-	-	-	-	1	2
	Sub Total	**-**	**-**	**-**	**-**	**1**	**4**

Table 3.18: Fish caught from Left Bank Streams during Sampling of Aug. 2012

Fish Species		Uchar	Barseen	Kaigah	Summar	Shatial	Total
Cyprinidae							
Schizothoracinae							
1.	Schizothorax plagiostomous (Gahi)	-	1	2	4	-	7
2.	Schizopyge esocinus (Chakhat /Swati)	-	1	-	1	-	2
	Sub Total	**-**	**2**	**2**	**5**	**-**	**9**

Table 3.19: Fish caught from Right Bank Streams during Sampling of Aug. 2012

Fish Species		Duga	Kandia	Tangir	Darel	Total
Cyprinidae						
Schizothoracinae						
1.	Schizothorax plagiostomous (Gahi)	-	5	3	3	11
2.	Schizopyge esocinus (Chakhat /Swati)	-	1	-	1	2
3.	Triplophysa spp. (Jungli Chemo)	-	-	1	1	2
4.	Glyptosternum reticulum	-	-	-	1	1
	Sub Total	**-**	**6**	**4**	**6**	**16**

Above given tables revealed the occurrence of snowcarps in most of tributaries and river mainstem. However, fishing efforts by consultant team resulted into limited catch of snowcarp species. In addition to snow carps, mountain loaches (species – *Triplophysa* spp.) and catfish (*Glyptosternum reticulatum"* belonging to family –

Sisoridae) have been also caught and sampled. Primary and secondary data confirm the dominance of snow carp species. Limited sampling doesn't reveal the exact picture of fish fauna, for which intensive fishing is required to confirm the fish species of the project area. From both sources aquatic team exploration and secondary data, fish fauna is diversified and contain more species also. In accordance with M. Rafiq (2000), M.R. Mirza (1995), Nasim Akhtar (2002) and T. Petre (2006), fish fauna of said region contain many other species belonging to Dasu project area which could be confirmed after further exploration.

3.3.1.3 Downstream of Dam Site

(1) Dasu to Pattan

Fish species captured from the Indus River mainstem near Dasu in June 2007, April 2012 and August 2012 are summarized in Table 3.20.

Table 3.20: Fish Species caught in Indus River mainstem, Project Area, June 2007, April 2012 and August 2012

Fish Species	Common Name	River mainstem before Dasu	River mainstem near Jalkot
Family – Cyprinidae			
Sub-family – Schizothoracinae			
1. Schizothorax plagiostomus	Gahi / Swati	+	+
2. Schizopyge esocinus	Chakhat	–	–
3. Racoma labiata	Chohan	+	+
Family – Noemachielidae			
4. Triplophysa gracilis	Jungli Cheno	–	+
Family – sisoridae			
5. Glyptosternum reticulatum	Konozobo	–	–

Fish caught from Sieglo Creek, on the right bank, in April 2012 are shown in Table 3.21.

Table 3.21: Fish caught from Right Bank Streams during Sampling of April 2012

Fish Species		Total
Cyprinidae		
Schizothoracinae		
1.	Schizothorax plagiostomous (Gahi)	**2**
2.	Triplophysa spp. (Jungli Chemo)	**1**
	Sub Total	**3**

Fish caught at the left and right bank tributaries in August 2012 are summarized in Table 3.22.

Table 3.22: Fish caught from Left & Right streams of downstream from Dam Axis, August 2012

Fish Species		Sieglo	Keyal	Jalkot	Goshali	Palas	Total
Cyprinidae							
Schizothoracinae							
1.	Schizothorax plagiostomous (Gahi)	11	1	3	2	1	**18**
2.	Schizopyge esocinus (Chakhat /Swati)	-	-	1	-	-	**1**
3.	Triplophysa spp. (Jungli Chemo)	1	-	1	-	-	**2**
4.	Glyptosternum reticulum	1	-	1	-	-	**2**

Fish Species	Sieglo	Keyal	Jalkot	Goshali	Palas	Total
Sub Total	**13**	**1**	**6**	**2**	**1**	**23**

Species in the total catch of all DHP sampling events is summarized in Table 3.23. *Schizothorax plagiostomus* was the dominant species in catches from tributaries (about 77%); *Schizopyge esocinus* represented about 12% of the catch and *Glyptosternum* spp. about 6% and hill stream loach, Triplophysa spp. also 6%.

Table 3.23: Catch Composition of adjoining streams of the Project Area

Fish Species		Upstream	Downstream	Total	% age
Cyprinidae					
Schizothoracinae					
1.	Schizothorax plagiostomous (Gahi)	18	18	36	76.5
2.	Schizopyge esocinus (Chakhat /Swati)	4	1	5	12.0
3.	Triplophysa spp. (Jungli Chemo)	1	2	3	06.4
4.	Glyptosternum reticulum	1	2	3	06.4

Five fish species (three species of snow carps and two species of catfishes) were reported in the DHP Feasibility report (2009); the fifth species reported from tributaries in that study was the snow carp *Racoma labiata*.

Seven species have been reported for the section of the Indus River and tributaries near Pattan (Schizothorax plagiostomous, Racoma labiata Schyzopyge esocinus, Triplophysa choprai, Glyptothorax stocki, Schistura naseeri, and Glyptosternum reticulatum) (Lahmeyer International 2007). Glyptosternum reticulatum and Schizothorax plagiostomous were captured in Keyal Khwar during those studies, the latter restricted to lower reaches.

(2) Besham area

Fish species reported near Besham and near by Khan Khwar (Sarhad Hydel Development Organization 1996) are:

- Indus River – snow carp (*Schizothorax* spp.), *Labeo dyochilus* as forage species; and
- Khan Khwar – (snow carp) *Schizothorax* spp., *Oreinus* spp., forage species and rainbow trout (*Salmo gairdneri*) above proposed dam site.

The report indicates that *Schizothorax* is represented by three or four species and during summer numbers increase while anglers easily catch 20 to 30 fish in a few hours. The report describes the movement of snow carp from Khan Khwar to the Indus River when the water level in Khan Khwar is low (i.e., at the end of December – early January) and return movement into the stream during March/April, when water temperatures increase and water levels rise.

At least seven species of fish have been reported in Allai Khwar (Schizothorax plagiostomous Schizopyge esocinus, Labeo dero, Glyptosternum reticulatum, Tor putitora, Hypophtalmichtys molotrix, Cyprinus carpio) (Dastigir 2011). Schistura naseeri has also been reported (Mirza 2006). Fish mainly migrate to the Indus River in winter and ascend Allai Khawar in spring/summer (Ministry of Water and Power 2000).

Golden mahaseer (*Tor putitora*) is also reported to spawn in Allai Khwar (Dastigir *et.al.* 2011) ascend the Indus River to Besham Qila and above (Ansari 1974).

(3) Tarbela Reservoir

Prior to construction of Tarbela dam, 35 fish species were recorded in the Indus river and tributaries around Tarbela (Ali et al, 1980). Mahaseer (*Tor putilora* and *Tor tor*), snow carp (*Schizothorax plagiostomus*, other *Schizothorax* species) were common and utilized as food fish. Other *Schizothorax* species and *Labeo dyochcilus* were common but not popular as food fish. Due to permanent deep submergence of many natural breeding grounds of mahaseer in the reservoir, natural propagation of that species drastically declined. Mahaseer migrated upstream and into tributaries where breeders were indiscriminately fished where enforcement of protective regulations were very difficult. A post-impoundment list of fish species is presented in Table 3.24.

Table 3.24: Fish Fauna of Tarbela Reservoir

Sr. No.	Type of Fish	Local Name	% of Total Catches
1.	Ambassis baculis (Hamilton, 1822)	Kangee	0.75
2.	Ambassis nama (Hamilton, 1822)	Kangee	4.36
3.	Ambassis sanga	Shisha	1.26
4.	Aspidoparia morar		
5.	Chela gora (Hamilton, 1822)	Chilwa	0.78
6.	Cirrihinus mrigala	Mori	3.0
7.	Cirrihinus reba (Hamilton, 1822)	Suni	0.7
8.	Cyprinus carpio (Linaeus, 1758)	Gulfam	3.3
9.	Ctenopharyngodon idella (Linaeus, 1758)	Grass carp	2.5
10.	Gagat cenia		0.2
11.	Labco dyocheilus (Hamilton, 1822)	Tourki	7.9
12.	Labco microphthalamus (Day, 1877)	Bhagan	2.1
13.	Mastacembelus armatus	Bam	3.0
14.	Ophiocephalus punctatus (Block, 1794)	Danla	0.4
15.	Puntius Sophore (Day, 1829)	Chidu	2.9
16.	Puntius ticto (Day, 1829)	Chidu	1.5
17.	Schizothorax plagiostomus (Heckel 1839)	Mallah	7.4
18.	Salmostoma bacaila (Hamilton, 1822)	Chilwa	0.8
19.	Salmostoma punjabensis (Day, 1872)	Chilwa	0.3
20.	Securicula gora (Day 1872)	Chilwa	0.1
21.	Tor putitora (Hamilton, 1822)	Mahseer	8.1
22.	Tor tor (Hamilton, 1822)	Mahseer	7.0

Source: *Survey Investigation Report of FAO/PK/TCP 6657 (1987-88)*

Fishery production of the reservoir is dependent upon stocking of fish seed fingerlings, and is mainly comprised of three or four species (major and Chinese carps). Tarbela hatchery at Ghazi [Wapda colony] produces fish seed which are stocked in reservoir. Mahaseer present in reservoir, attract the anglers (sport fishermen) to the reservoir.

River Siren & Daur stream offer breeding site of Mahaseer in Khalabat pocket.

3.3.1.4 Biological Features of fishes captured from DHP area

1. *Schizothorax plagiostomus*

Local Name:	Gahi in Northern Areas (Swati in KP)
Common Name:	Himalayan Snow carp
Genus:	Schizothorax Heckal (1938) / Day (1889)
Sub-family:	Schizothoracinae
Family:	Cyprinidae
Order:	Cypriniformes

Distinct Features:

D2/9; P1/17-18; V1/10-9; A7; C19

A medium sized fish with both profiles arches. Its standard length is 78.9% of total length.

Colour:	Dorsally bluish grey with yellowish pink at ventral side
Head:	Large conical, flattened on ventral side.
Snout:	Painted and compressed at interior end, its length is 45.5% of head length.
Eyes:	Large, dorsal lateral in position and situated in anterior half of the head.
Mouth:	Inferior, horizontal and greatly arched, bounded by thick fleshy lips which are continuous at angles of the mouth. Interior part of lower lip is well depending horny pad. Nostrils present, nearer the interior margin of the eye.
Barbels:	Two pairs present, rostral and maxillary barbels almost equal in length.
Scales:	Small: covering the entire body except head. Lateral line complete and distinct.
Fins:	Either yellow or pink

Occurrence: Inhibited in different rivers, lakes and tributaries throughout Himalayan region.

Feeding habits: Feeds on phytoplankton (diatoms & algae), zooplankton (rotifer, cyclops) mostly at bottom region (Benthivorous) scarps algae from substratum rocks of stones.

Habitat: Thrive in the snow fed river habitat of clear, shallow water of stony substratum with an average depth from 0.5 to 3 meters, and river flows with low to high velocities (0.5 to 1.5 m/s). Average temperature requirements are 4 to 20 ^{o}C and dissolved oxygen requirements are 8 to 12 mg/l.

Migration: Short distant migrants with summers in head waters of the streams and winters in the lowe altitudes of the streams. The triggers for migrations are high flows, high sediment load and low temperatures.

Spawning Female fishes spawn in two seasons, one in September-October and other in March - April. Sexually matured snow carp (when they reach 18-24 cm length, at the age of 2-3 years) spawn in tributaries in clear water on gravelly/stony ground or on fine pebbles at 10-30 cm depth. Low water currents of 0.5- 1.5 m/sec, pH 7.5, dissolved oxygen concentration of 8-12 mg/L and gravel sizes of 50-60 mm are the optimum conditions for spawning.

Development: Fertilized eggs undergoes a series of development process. Morula stage is attained after 10-12 hrs of fertilization. Hatching takes place 110-112 hrs after fertilization. Hatchlings appears thin and yellow coloured yolksac bulbous in appearance. 2 days larva were more active but rests most of time at bottom. 3rd day larva still lays at bottom.

Distribution (in Pakistan): KP, northern Punjab, northeastern Balochistan, Azad Kashmir. **(outside):** Afghanistan, Iran (sistan), India (Indus System only), China.

(in Project Area): Kaigah, Summer, Goshali, Pallas, Pattan, Sieglo, Kandia, Tingir, Darel stream/nullahs.

Importance: Very important food fish in the cold waters of the Himalayan region

Source: 1. T. Petr. 2002 Cold Water Fish And Fisheries In Countries Of The High Mountain Arc Of Asia (Hindu Kush-Pamir-Karakoram-Himalayas). (Cold water fisheries in the trans-Himalayan countries. Edited by T. Petr and S.B. Swar) FAO Fisheries Technical Paper 431.
2 . M.R. Mirza (1975) Freshwater Fishes & Zoogeography of Pakistan
3. M. Rafique (2001) Fish Fauna of Himalayans in Pakistan
4. S.N. Bahuguna (2006) & study of S. plagiostomus Project Report No. 4 (10) 2000/ASR-I/ 2003-2006

2. ***Racoma labiata*** **(Mirza 1990)**

Local Name:	Chun (very similar to Swati)
Common Name:	Kunar Snow carp
Genus:	Racoma Mcelelland
	Schizothorax labiatus (Hora, 1934)
	Racoma labiatus (McClelland and Griffith, 1842)
Sub-family:	Schizothoracinae
Family:	Cyprinidae

Distinct Features:

Colour:	Greyish brown on dorsal side, yellowish below, dorsal and caudal fin grayish; other finds pinkish.
Head:	Large & snout arches, Head length 20% of the total body, Both lips are large and upper lip cover the mouth, lower lip lobed, surrounded by four barbels (2 rostral & two maxillary)

Feeding Habits: It feeds on different types of algae, scrap on rocks and also minor organisms. Its feeding habits are more similar with Swati (Schizothorax plagiostomus). Gut analysis endorses that Racoma labiata species depends mostly on phyto and minor zooplankton.

Breeding: Breeding season falls in the month of August. DHC's sampling could not reveal its ripeness. All fish caught were stout, strong and healthy. Their feeding conditions were quite promising.

3. ***Schizopyge esocinus*** **(Heckel, M.R. Mirza 1990)**

Local Name:	Asala
Common Name:	Chirrun Snow carp
Genus:	Schizopyge Heckel
Sub-family:	Schizothoracinae
Family:	Cyprinidae
Order:	Cypriniformes

Distinct Features:

Colour:	Silvery with black spots on the dorsal and lateral side (very similar to Brown Trout)
Body:	Stout and stronger
Head:	Large and about 22% of the body length, snout relatively conical, Mouth big but lips are thinner, surrounded by Four barbels.

Feeding Habits: It depends upon smaller organisms and predates smaller and minor fishes also.

Breeding: July 2006 samples showed developed sex organs but not of spent conditions. This showed that breeding was due in month of July 2006. Most of the mature samples were caught from upper reaches of Khanbari and Thak nullahs, which endorses its spawning grounds (upstream of Hydel Power Station). Its breeding takes place normally in the middle of July.

4. ***Schizopyge Intermedius*** **(McClalland)**

Local Name:	Anborochumo, Damnian
Common Name:	Snow carp
Genus:	Schizopyge
Sub-family:	Schizothoracinae
Family:	Cyprinidae

Distinct Features:

Colour:	Silvery grey. Very similar to Chun fish but no black spots on the body.
Head:	Head is 22% of total body length, Mouth large and opens in front surrounded by four barbels, dorsal fin opposite to pelvic fins.

Feeding Habits: It depends on algae and other plankton. Gut contents of few specimens were examined and mostly phytoplankton and minor organisms observed. Due to digested contents, authenticated identification could not be made.

Breeding: During July 2006 sampling, fish gonads were note ripe, and were in developing stage. It was assumed that spawning took place in July / August.

5. ***Glyptosternum reticulatum***

Local Name:	Jungli Chemo, (Chikar)
Genus:	Glyptosternum McClelland 1842
Sub-family:	
Family:	Sisoridae
Order:	Siluriformes

Distinct Features:

Colour:	Grayish at dorsal & yellowish at ventral with yellowish spots (similar to rocky spotting). Fins yellowish having distinct lines.
Head:	Head flattered and round. Mouth at dorsal surrounded by eight barbels lives attaches beneath rocks and pebbles.
Size:	Maximum size is 23cm.

Feed Habits: It depends on aquatic organism, insect, larva and minor organisms.

Breeding: It breeds in mouth of August, are differentiated easily.

Importance: Being predatory fish it balances the production of plankton. Even survives in the dry seasons. Not a food fish.

3.3.1.5 Fish Species of Special Importance

Plagiostomus (snow carp also known as snow trout) is the dominant fish species in Dasu area representing more than 75% of total fish catch and other two species of snow carp (*Racoma labiata* and *Schizopyge esocinus*) represent about 15% of total fish catch. None of these species are listed in IUCN Red List. Mahaseer (*Tor putitora*), is other important cold water fish species of Indus (long distant migrant and endangered), but its habitat starts about 70 to 80 km downstream of the damsite. Golden mahaseer is reported to ascend the Indus River to Besham Qila and above (Ansari 1974) and to spawn in Allai Khwar which has been described as the last upstream safe-haven for this species (Dastgir et. al. 2011).

Snow Carp (Schizothorax plagiostomus)

Habitat of snow carp: In the project area fish found mainly in the tributaries, while in the mainstem they are found near the confluences during low flow season of winter. Tributaries with snow carp fish habitat on the upstream side of the dam site are Kandia, Tangir, Darel, Kaigah, Summar, and Goshali. While tributaries on the downstream side with snow carp fish habitat are Sieglo, and Jalkot. Snow carps thrive in the snow fed river habitat of clear, shallow water of stony substratum with an average depth from 0.5 to 3 meters, and river flows with low to high velocities (0.5 to 1.5 m/s). Average temperature requirements are 4 to 20 ^{o}C and dissolved oxygen requirements are 8 to 12 mg/l. Snow carps are bottom feeders and mainly feed on peryphyitic algae and diatoms.

Migration of snow carp: Snow carps are short distance migrants. In the project area, they migrate within the tributaries (head waters areas to lower elevations and to Indus confluence areas; and vice versa), not along the mainstem Indus. During April to September (spring and summer, high flows), they prefer upstream head waters habitat at higher elevations. During September to April (low flows and winter), they prefer lower elevations and confluence zone with Indus. The triggers for migrations are high flows, high sediment load and low temperatures. During spring, when flows started increasing in the rivers due to melting of snow, the fish migrate upstream from April and May (within tributaries) due to high flows and turbidity at lower elevations. During autumn, when the temperatures are starts to drop at higher elevations, the fish migrate downstream from September and October.

Spawning of snow carp: Female fishes spawn in two seasons, one in September-October and other in March - April. Sexually matured snow carp (when they reach 18-24 cm length, at the age of 2-3 years) spawn in tributaries in clear water (along stream banks, backwater pools and near confluences of other tributaries and Indus) on gravelly/stony ground or on fine pebbles at 10-30 cm depth. Low water currents of 0.5- 1.5 m/sec, pH 7.5, dissolved oxygen concentration of 8-12 mg/L and gravel sizes of 50-60 mm are the optimum conditions for spawning.

Mahaseer species (Tor putitora)

Mahaseer is a sport fish, source of attraction for anglers and also primary quality food fish in the region. It has ecological and economical significance. Tor species are habituated in slow moving streams & rivers in foothill region and very conveniently breed in gravels & sandy beds. Further detailed biological information of Mahaseer is given in Appendix 3.3.

Construction of dams & barrages created a barrier for free movement & migration and also submerged the breeding grounds. Further its habitats have been reduced which impacted the population occurrence and distribution also. Particularly Tarbela Dam on Indus river, Mangla dam on Jhelum river & small dams in mountain foothill stream like Rawal dam on Korang river, Simly dam on Soan river have generated impacts on Mahaseer fisheries. Although major carp of exotic carps have been introduced into reservoirs to compensate the losses but mahaseer species could not be induced due to lack of its artificial breeding.

Status of Mahaseer and impact of Tarbela on Mahaseer poorly understood. Some authors have exaggerated the Mahaseer status and impact of Tarbela. Of course there was considerable impact on Mahaseer fishery due to construction of Tarbela dam but still reasonable proportion of Mahaseer of total catches are be maintained. The occurrence of Mahaseer in river Haro, Soan and Korang are given in Tables 3.26 to 3.28. Further presence of Mahaseer in Tarbela reservoir and its proportion is given in

Table 3.29. Recent study on Mahaseer (WWF Proj. 50018801) has revealed out its sustainability in streams and nullahs of foothill areas.

Table 3.25: Percentage of Mahseer fish composition from the flowing waters of Haro and Soan/Korang rivers systems

Visit Place	Total Fish Captured (Number)	Mahseer *(Tor putitora)*	Percentage of *Tor putitora*
Nala Gummara (upper reaches)	55	44	80.00
Korang River	32	28	87.5
Simli Dam Nala	22	18	81.81
Nala Gummara (lower reaches)	34	22	64.70
TOTAL	**206**	**172**	**83.49**

Source: *Studies on Mahaseer in Himalayan Foothill rivers (N. Akhtar, 2003)*

Table 3.26: Composition of fish in Rawal Dam Reservoir on Korang river

Fish species	Percentage Composition by Number	Percentage Composition by Weight
Catla catla	0.17	0.43
Tor putitora	10.60	18.9
Labeo calabasu	5.90	0.97
L. rohita	0.17	3.30
L. dero	7.80	3.90
L. dyocheilus	26.0	25.8
Cirrhinus mirgila	14.0	14.4
C. reba	26.3	18.1
Cyprinus carpio	2.80	8.80
Hypopthalmichthys molitrix	1.60	4.00
Puntius sarana	0.34	0.01
Puntius tieto	0.33	3.20
Crossocheilus latius diplocheilus	1.90	0.90
Ompok bimaculatus	3.80	0.17
Ophiochephalus punetatus	0.17	0.34

Source: *Studies on Mahaseer in Himalayan Foothill rivers (N. Akhtar, 2003)*

Table 3.27: Fish Species Composition of Khanpur Reservoir ranges

Fish species	Number	Composition (%)	Weight ranges (g)	Length ranges (cm)
Labeo dyocheilus	21	4.3	100-450	20.0-39.0
Cyprinus carpio	25	5.1	15-550	10.5-37.0
Tor putitora	260	53.3	10-650	7.0-4.3
Hypopthalmicchthys molitrix	5	1.0	210-350	21.5-25.0
Puntius sarana	12	2.4	122-260	12.0-26.0
Barilius vagra	20	4.1	2.6-5.0	6.0-9.0

Oreochromis nilotcus	106	21.7	6.0-16.5	7.3-60.0
Schizothorax labiatus	24	4.9	206-219	20.0-21.0
Ompok bimaculatus	7	1.4	202-250	18.0-25.0
Hetropneustes fossilis	8	1.6	80-91	14.0-16.0

Source: *Studies on Mahaseer in Himalayan Foothill rivers (N. Akhtar, 2003)*

Table 3.28: Fish Catch Composition of Tarbela Reservoir

Year	Common Carp (Cyprinus carpio)		Major Carps - Rahu - Mori - Silver Carp		Mahaseer (Tor putitora)		Tilapia		Total (in kg)
2000 – 01	60,872	70.0%	11,250	12.9%	5,852	6.7%	8,953	10.3%	86,925
2001 – 02	66,430	68.9%	19,950	20.7%	5,276	5.5%	4,842	5.0%	96,428
2002 – 03	67,200	68.4%	20,135	20.5%	4,920	5.0%	5,930	6.0%	98,285
2003 – 04	69,040	66.8%	21,300	20.6%	5,663	5.5%	7,420	7.2%	103,423
2004 – 05	47,449	48.8%	36,008	37.1%	8,784	9.0%	4,899	5.0%	87,140
2005 – 06	52,040	50.1%	28,380	27.3%	11,601	11.2%	11,914	11.5%	103,935

Source*: WAPDA Fisheries Unit, Tarbela Dam Project*

As Khalabat pocket (eastern pocket of Tarbela reservoir) is main source of fish yield and Mahaseer has maintained its breeding ground in surrounding streams of Khalabat pocket, particularly northern tributaries “river siran”. Upstream of reservoir Darband pocket and Unhar streams are good source of Mahaseer breeding. Upto Thakot (150 km above Tarbela dam), Mahaseer have been caught (Sadaqat, M.Phil. Thesis 2002). He stated that upstream of river Indus at Thakot, Schizothorax spp., Crossocheilus spp. & Schitura spp. dominate the streams. At Qila Besham and Karora area again Schizothorax plagiostomus is found quite frequent.

As explained above, Mahaseer is still available in Indus and statements made by some authors that the Mahaseer is declined due to construction of Tarbela and other dams is highly questionable.

Mahaseer is not reported near Dasu. During fish sampling at Dasu project area, no Mahaseer specimen could be caught. Even EIA study of Daimer Basha Dam did not reveal the occurrence of Mahaseer in its catches.

3.3.2 Other Biota

Aquatic biota includes bacteria algae, protozoans, cladocerans, copepods, molluscans and vertebrates like pisces amphibians and other organisms: producers play an essential role by using sunlight to produce chemical energy. In river the major source of energy is the leaves that fall or wash into the river from stream vegetation. Bacteria and other decomposer decompose the dead material and convert them into food for higher organisms. A food chain describes the feeding pattern of the river ecosystem.

Aquatic macro-invertebrate such as larval insects, crustaceans and molluscs play an important role in river food web. River productivity concept depends upon changes in organisms. Environmental variations are interdependent upon the variation in organism types and abundance. During field visits at DHP area, exploration could into be made on micro-organisms and invertebrates due to time constraint and only plankton sampling were carried out. Just to provide the basic information, secondary data of Bunji hydropower power project report of Indus river is given in the following Table 3.29.

Table 3.29: Macro-invertebrates species of Bunji project area

Sr.	Organism	Critical Reach	Non critical Reach

No.		Khalola gah	Shahtot Nullah	Sessi Nullah	Gilgit river	Indus river at Bunji
1.	Chironomus	30	24	19	5	7
2.	Mosquito pupa	2	-	-	-	-
3.	Mosquito larva	-	50	27	4	4
4.	Caddis fly larva Nymph	15	-	-	-	12
5.	May fly Nymph	-	-	8	5	-
6.	Water mite	1	-	-	-	-
7.	Stonefly Nymph	2	-	-	1	-
8.	Stonefly	-	1	-	-	-
9.	Leech	-	-	-	-	2
10.	Winged Insects	-	1	-	-	-
11.	Larval hoses	-	-	Un-countable	Un-countable	Un-countable

Source: *BHP – EIA report, Oct 2008*

3.3.2.1 Phytoplankton

Algae occupy unique position in the aquatic ecosystem because they utilize light energy in the process of reducing CO_2 to oxidation state of cellular carbon. Algae assimilate large amount of nutrients and metal trace element during growing. Different groups of algae indicate the biological water quality such as chrysophyta indicate low trophic level. Presence and occurrence of blue green algae show grade of pollution and green algae “Chlorophyta” show the basic elements of food chain. Changes and variation in algae occurrence helps in determination of aquatic productivity.

Phytoplankton identified in plankton samples collected during DHP field survey in August 2012 are shown in Table 3.30 (Indus River main-stem), Table 3.31 (tributaries upstream of the proposed dam site) and Table 3.32 (tributaries downstream of the proposed dam site).

Fifty-nine species of phytoplankton were identified in plankton samples from stations upstream of the proposed dam site, belonging to the following major groups: blue green algae – Cyanophyto (7 species); Chlorophyta – green algae (10 species); brown algae - Chrysophyta (24 species); Xanthophyta (one specie). Thirty-five species of phytoplankton were identified in samples from stations downstream of the proposed dam site. Phytoplankton samples from stations both upstream and downstream of the dam site were dominated by Chlorophyta (green algae) and Chrysophyta (brown algae).

Phytopankton are a source of nutrition for some planktivorous fish species.

Table 3.30: Phytoplankton Identification of River Mainstem

Sampling Station / Algae groups	Upstream			Downstream		
	Indus river near Tangir	Main river near Kaigah	Main river before Dasu	Main river near confluence Jalkot	Main river after Jalkot	River 8km away from Dasu
Cyanophyta						
– Cyanophyacoe						
• Anaebanc spp	-	+	-	+	+	-
• Oscillatoria spp	-	+	+	+	+	-
• Phormidium spp	-	-	-	-	-	+
Chlorophyta						
– Chlorophyceae						
• Closteriopsis spp	+	-	-	+	-	+
• Oedogonium spp	-	+	-	-	+	-
• Ulothorix spp						

Sampling Station / Algae groups	Upstream			Downstream		
	Indus river near Tangir	Main river near Kaigah	Main river before Dasu	Main river near confluence Jalkot	Main river after Jalkot	River 8km away from Dasu
Chrysophyta						
– Chrysophyceae						
• Navicula spp	-	-	+	-	+	-
• Cymbella spp	-	+	+	-	+	-
• Nitzschia spp	-	+	-	+	+	+
• Pinnularia spp	+	-	+	+	-	-
• Synedra spp	+	+	-	+	+	+

Source: *Sampling during August / September 2012 trip at project site.*

Table 3.31: Phytoplankton Identification of Upstream Tributaries

Group	Uchar	Barseen	Kaigah	Chori	Summer	Darel	Tangir	Kandia
Cyanophyta								
– Cyanophyacoe								
• Anaebanc spp	-	-	+	-	+	+	-	+
• Johanneslaptista spp	-	-	-	-	-	+	+	-
• Oscillatoria spp	-	+	-	-	-	-	+	+
• Phormidium spp	-	+	-	-	-	-	+	-
• Spirulina spp	-	-	-	-	-	+	-	-
Chlorophyta								
• Schroederica spp	-	-	-	-	+	-	-	-
• Closteriopsis spp	-	-	-	-	+	+	-	-
• Cladophora spp	-	-	-	+	-	-	-	+
• Tetradon spp	-	-	-	-	-	-	+	-
• Ulothorix spp	+	+	+	-	+	-	-	+
• Nitzschia spp	-	-	+	-	-	+	+	-
• Fragilaria	-	+	-	-	+	-	-	+
• Synedra spp	+	-	-	+	-	+	+	+
• Tabellari spp	-	-	-	+	-	-	+	-
Melasiraceac								
• Melosira spp	-	-	-	-	+	-	-	+
• Clorella spp	+	-	-	-	+	-	+	-
Xanthophyta								
• Tribonema spp	+	-	-	-	-	+	-	-

Source: *Sampling during August / September 2012 trip at project site.*

Table 3.32: Phytoplankton Identification of Downstream Tributaries

Sampling Station / Algae groups	Left hand Streams			Right hand Streams		
	Sieglo	Kayal	Dubair	Jalkot	Goshali	Pallas
Cyanophyta						
– Cyanophyceae						
• Anaebana spp	-	+	+	-	+	-
• Oscillatoria spp	-	-	-	+	+	-
• Cylindrospernum spp	+	-	+	-	-	+
• Phormidium spp	-	-	-	+	-	+
• Spirulina spp	-	-	-	-	+	-
• Cyanobactonia ssp	+	-	-	-	-	-
Chlorophyta						
• Closteriopsis spp	-	-	-	-	+	-
• Cladophora	-	-	+	-	-	-
• Tetaredrsus spp	-	-	-	-	-	-

Sampling Station / Algae groups	Left hand Streams			Right hand Streams		
	Sieglo	Kayal	Dubair	Jalkot	Goshali	Pallas
• Closterium spp	-	+	-	+	-	-
• Spirogyra spp	-	-	+	-	-	-
• Ulothorix spp	-	-	-	+	-	-
Chrysophyta						
• Acanthes	-	-	-	-	+	-
• Cymbella spp	+	-	-	-	-	+
• Navicula spp	+	-	-	-	-	-
• Pinnularia spp	+	-	+	+	-	-
• Nitzschia spp	+	-	-	+	-	+
• Fragiluria spp	-	-	-	-	-	+
• Synedra spp	+	-	+	-	-	+
• Diatoma spp	-	-	-	+	-	-
Xanthophyta						
• Tribonema spp	-	-	+	-	-	-

Source: *Sampling during August / September 2012 trip at project site.*

3.3.2.2 Micro fauna

Zooplankton samples were identified and it was found only on espeies of protozoan, posifera, two species of rotifers and one species of arthropodo and slatyhelminth in upstream and downstream are of the project. Detail of zooplankton is given in Table 3.33 to Table 3.35.

Table 3.33: Zooplankton Identification of River Main stem

Group	Upstream		Downstream	
	River Main stem Kaigah	River Main stem before Dasu	River Main stem Jalkot	River Main stem 8km down from Dasu
Protozoa				
• Paramecium spp	-	+	+	-
Rotifer				
• Koratella spp	-	-	-	-
• Euchlanus	-	+	-	-
• Branchionus spp	+	+	-	+
Cladocera				
• Bosmina spp	-	-	+	-
Decapods				
• Cyclops spp	-	+	-	-
Insecta				
• Damsel Nymph	+	-	+	-
• Caddish Larvae	-	+	-	-

Source: *Sampling during August / September 2012 trip at project site.*

Table 3.34: Zooplankton Identification of upstream tributaries

Group	Uchar	Barseen	Kaigah	Chori	Summer	Darel	Tangir	Kandia
Protozoa								
• Paramecium spp	-	+	-	-	+	-	-	-
Rotifer								
• Koratella spp	-	-	-	-	+	-	-	+
• Branchionus spp	-	-	-	-	-	-	+	-
• Tansignus spp	-	-	-	-	+	+	+	-
Cladocera								
• Bosmina spp	+	-	-	-	-	+	-	-

Decapods								
• Cyclops spp	-	-	+	-	+	-	-	-
Insecta								
• Caddish fly Larva	-	-	-	-	-	+	+	-

Source: *Sampling during August / September 2012 trip at project site.*

Table 3.35: Zooplankton Identification of downstream tributaries

Group	Left hand Streams			Right hand Streams		
	Sieglo	Kayal	Dubair	Jalkot	Goshali	Pallas
Protozoa						
• Paramecium spp	-	-	-	+	-	-
• Tintinnidum spp	-	-	-	-	+	-
Rotifer						
• Koratella spp	-	-	+	-	-	-
• Branchionus spp	-	+	-	-	-	-
• Tansignus spp	-	-	+	-	+	-
Cladocera						
• Bosmina spp	+	-	-	-	-	-
• Daphnia	-	+	-	-	+	-
• Ceriodaphnia	-	-	-	-	-	+
Decapods						
• Cyclops spp	-	+	-	-	+	-
• Diaptomus	-	-	-	+	-	-
Insecta						
• Caddish fly Larva	+	-	+	-	-	+
• Damsel fly Nymph	-	+	-	+	-	-
Mulluscans						
• Limnxea spp	-	-	-	-	-	-
• Valvata spp	+	-	+	-	+	-

Source: *Sampling during August / September 2012 trip at project site.*

3.3.2.3 Wildlife

(1) Amphibians and Reptiles

Common amphibians and reptiles found along the Indus River in the project area are listed in Table 3.36.

Table 3.36: Amphibians and Reptiles Recorded in project area

Sr. No.	Scientific Name	Common Name	Family	Status	Remarks
1.	*Bufo viridis*	Green Toad	BUFONIDAE	C	Near Dasu
2.	*Laudakia pakistanica*		AGAMIDAE	NE	Near Razika
3.	*Agama agrorensis*	Agrore Valley Agama	-do-	NE	Near Dasu; Shori Nullah
4.	*Macrovipera lebetina*	Blunt-nosed viper	Viperidae	NE	Killed by someone near Gobar Nullah; identification is tentative as specimen was not in good condition
5.	*Ptyas mucosus*	Dhaman	Colubridae	NE	Killed near dam site area; identification is tentative as specimen was not in good condition
6.	*Goh Lizard*	Varanis monitor		NE	

Status: C=Common; NE=Not Evaluated; Source: (www.wwfpak.org/images/reptiles_list.pdf. visited on 4-10-2012)

(2) Aquatic Birds

Aquatic and wetland birds observed or reported to occur in the project area are listed in Table 3.37.

Table 3.37: Aquatic / Wetland Birds of Project Area

Sr. No.	Common Name	Scientific Name	Family	Remarks
1.	Great or Eurasian Cormorant	*Phalacrocorax carbo sinensis*	Phalacrocora-cidae	Kandian river-shallow water
2.	Water rail	*Rallus aquaticus*	Rallidae	Kandian Valley
3.	Red-wattled lapwing	*Vanellus indicus*	Charadriidae	Chochung Village
4.	Common sandpiper	*Actitis hypoleucos*	Tringinae	Near Dasu on Right bank
5.	Common kingfisher	*Alcedo atthis*	Alcedinidae	Kandian Valley
6.	White-breasted kingfisher	*Halcyon smyrnesis*	Alcedinidae	Near Dasu on Right bank
7.	Marsh harrier	*Circus aeruginosus*	Accipitridae	Kandian Valley
8.	Yellow wagtail	*Motacilla flava*	Motacillidae	Dasu
9.	Grey wagtail	*Motacilla cinera*	Motacillidae	Melar
10.	White/pied wagtail	*Motacilla alba*	Motacillidae	Summar Nallah, Kandian valley, Dasu, Lachai
11.	Large wagtail	*Motacilla maderaspatensis*	Motacillidae	Kandian Valley, Dasu
12.	Brown dipper	*Cinclus pallasii*	Cinclidae	Kandian river –shallow river area
13.	Black redstart	*Phoenicurus ochruros*	Turdidae	Dasu, Kandian valley, Lachai
14.	White-bellied Redstart	*Hodgsonius phoenicuroides*	Turdidae	Goshali Village-on left bank of supit nallah-downstream
15.	Plumbeous water Redstart	*Rhyacornis fuliginosus*	Turdidae	Kandian river, Shallo water
16.	Grey Heron	*Ardea Cinerea*	Ardeidae	Reported in secondary data/ literature. Further field surveys during migratory season/ winter may confirm their distribution/ occurrence
17.	Grelag Goose	*Anser anser*	Anatidae	Reported in secondary data/ literature. Further field surveys during migratory season/ winter may confirm their distribution/ occurrence
18.	Ruddy shelduck	*Tadorna ferruginea*	Anatidae	Reported in secondary data/ literature. Further field surveys during migratory season/ winter may confirm their distribution/ occurrence
19.	Wigeon	*Anas penelope*	Anatidae	Reported in secondary data/ literature. Further field surveys during migratory season/ winter may confirm their distribution/ occurrence
20.	Gadwall	*Anas strepera*	Anatidae	Reported in secondary data/ literature. Further field surveys during migratory season/ winter may confirm their distribution/ occurrence
21.	Common teal	*Anas crecca*	Anatidae	Reported in secondary data/

Sr. No.	Common Name	Scientific Name	Family	Remarks
				literature. Further field surveys during migratory season/ winter may confirm their distribution/ occurrence
22.	Mallard	*Anas platyrynchos*	Anatidae	Reported in secondary data/ literature. Further field surveys during migratory season/ winter may confirm their distribution/ occurrence
23.	Ferruginous duck	*Aythya nyroca*	Anatidae	Reported in secondary data/ literature. Further field surveys during migratory season/ winter may confirm their distribution/ occurrence
24.	Pintail	*Anas acuta*	Anatidae	Reported in secondary data/ literature. Further field surveys during migratory season/ winter may confirm their distribution/ occurrence
25.	Shoveler	*Anas clypeata*	Anatidae	Reported in secondary data/ literature. Further field surveys during migratory season/ winter may confirm their distribution/ occurrence
26.	Common Pochard	*Aythya ferina*	Anatidae	Reported in secondary data/ literature. Further field surveys during migratory season/ winter may confirm their distribution/ occurrence
27.	Tufted duck	*Aythya fuligula*	Anatidae	Reported in secondary data/ literature. Further field surveys during migratory season/ winter may confirm their distribution/ occurrence
28.	Common crane	*Grus grus*	Gruidae	Reported in secondary data/ literature. Further field surveys during migratory season/ winter may confirm their distribution/ occurrence
29.	Demoiselle crane	*Anthropoides virgo*	Gruidae	Reported in secondary data/ literature. Further field surveys during migratory season/ winter may confirm their distribution/ occurrence
30.	Pheasant-tailed Jacana	*Hydrophasianus chirugus*	Jacanidae	Reported in secondary data/ literature. Further field surveys during migratory season/ winter may confirm their distribution/ occurrence
31.	Curlew sandpiper	*Calidris ferruginea*	Scolopacidae	Reported in secondary data/ literature. Further field surveys during migratory season/ winter may confirm their distribution/ occurrence
32.	Ruff	*Philomachus pugnax*	Scolopacidae	Reported in secondary data/ literature. Further field surveys during migratory season/ winter may confirm their distribution/ occurrence
33.	Common snipe	*Gallinago gallinago*	Gallinagininae	Reported in secondary data/ literature. Further field surveys during migratory season/ winter

Sr. No.	Common Name	Scientific Name	Family	Remarks
				may confirm their distribution/ occurrence
34.	Red shank	*Tringa tetanus*	Tringinae	Reported in secondary data/ literature. Further field surveys during migratory season/ winter may confirm their distribution/ occurrence
35.	Green shank	*Tringa nebularia*	Tringinae	Reported in secondary data/ literature. Further field surveys during migratory season/ winter may confirm their distribution/ occurrence
36.	Marsh sandpiper	*Tringa stagnatilis*	Tringinae	Reported in secondary data/ literature. Further field surveys during migratory season/ winter may confirm their distribution/ occurrence
37.	Common sandpiper	*Actitia hypoleucos*	Tringinae	Reported in secondary data/ literature. Further field surveys during migratory season/ winter may confirm their distribution/ occurrence
38.	Caspian tern	*Sterna caspica*	Sternidae	Reported in secondary data/ literature. Further field surveys during migratory season/ winter may confirm their distribution/ occurrence
39.	Water pipit	*Anthua spinoletta*	Motacillidae	Reported in secondary data/ literature. Further field surveys during migratory season/ winter may confirm their distribution/ occurrence

(3) <u>Mammals</u>

Mammals known to occur along the Indus River are listed in Table 3.38. The Eurasian otter (Lutra lutra) was not identified during aquatic ecology or terrestrial ecology field surveys in the DHP project area but was reported in the Diamer Basha area (WAPDA 2010); the Eurasian otter is listed as Near Threatened in the IUCN red list (IUCN 2008).

Table 3.38: Mammals Recorded in the Study Area

Sr. No.	Common Name	Scientific name	Family	Status	Remarks
1.	Asiatic jackal	*Canis aureus*	Canidae	NT	Pellet Laachi Nullah, Malyar
2.	Indian wolf	*Canis lupus*	Canidae	EN	Reported by locals from Laachi nullah and Kandia Valley
3.	Hill or Kashmir fox	*Vulpes velpes griffithi*	Canidae	NT	Pellet near Malyar Village, reported by locals from Kandia valley, Laachi Sazin kot area
4.	Common Leopard	*Panthera pardus*	Felidae	CR	Reported rarely by locals of Kandia, Laachi
5.	Leopard cat	*Prionilurus bengalensis*	Felidae	DD	Preserved skin at house-Laachi Nullah
6.	Caracal	*Felis caracal*	Felidae	CR	Crossed KKH near Kandia suspended bridge in evening time; also reported by locals of Kandia valley
7.	Asiatic Black bear	*Ursus thibetanus*	Ursidae	V	Reported from higher elevation of Laachi, Kandia, Sazin and Choochang

Sr. No.	Common Name	Scientific name	Family	Status	Remarks
8.	Himalayan musk deer	*Moschus chrysogaster*	Moschidae	EN	Young one captured from Palas by local of Dasu and sold in Pakistan Rupees 15000. It is also reported from higher valleys of Kandia, Laachi and Palas valley
9.	Markhor	*Capra falconeri falconeri*	Bovidae	EN	Stuffed specimens at Laachi nullah, Sazin kot, Kandia valley-Aliel village. Summar Nullah police check post-hunted one female; reported from Kaigah, Laachi, Sazin and Kandia Valley
10.	Rhesus macaque	*Macaca mulatta*	Cercopitheidae	NT	Reported by locals from Laachi nullah, Kandia, Sazin kot, Choochang, Jalkot areas at higher elevation

Source: EIA Volume 4 Terrestrial Ecology

Status: NT=Near threatened; EN=Endangered; CR=Critically Endangered; V=Vulnerable; DD=Data deficient

3.4 RESOURCE USE

Indus River is very strong potential water body to produce fish protein, source of recreation and adventures, and source of livelihood and employment. Commercial fishery is well organized, developed and contribute towards the national economy significantly. Magnitude of subsistence fishery, sport and recreational fishery and commercial fishery vary region to region. Delta region, plain area region and mountain area fishery varied from one another. Former two regions present strong, intensive and more productive where many thousands of individuals are earning their livelihood. Relatively mountain area Indus river is limited, confined and play smaller role in the local economy due to its topographical and hydro-biological conditions.

3.4.1 Fishing for Subsistence

Fishing is very limited in the project area and it is carried out mainly in tributaries for self consumption. Fisher men apply castnet, gillnet and dragnet in fast flow streams and river. After 2 or 3 hours fishing efforts, they hardly catch 250 – 600 gm for their family. Part time fishing is not regular and continuous activity. Occasionally group of people (2 or 3) set their nets collectively and organize their fishing in groups to catch the maximum. Setting the gillnet at night (6 hrs) brings out 3 – 4 kg catches only.

3.4.2 Fishing for Sports and Recreation

The Indus in mountainous areas attract lot of anglers, swimmers, divers and water sports. Particularly downstream area of DHP, Besham and Thakot and Tarbela reservoir are visited by anglers. Even collectively angling competition are also organized by fishery organizations and government establishments. Tarbela Fishery Unit used to organize annual angling competition where hundreds of angler used to participate. Some private angling association also organize their competition also. Fishery establishment issue angling permits at payment of angling fees. Northern Area fishery department reported about few hundred anglers. In addition to local anglers, tourists and foreign visitors perform also angling in Northern Area Indus river.

KP province fishery at Pattan used to issue angling license. Mostly local people don't bother to get issued the angling permission and are not being recorded anywhere. At Darband & Tarbela Khalabat pocket angling permission is being issued by fishing contractor during fishing contract tenure (annual or 3 years contract). During closed fishing season, fishery department official used to issue Angling License. Table 3.39 presents the anglers statistics of Tarbela.

Table 3.39: Angling record of Tarbela reservoir

Year	No. of Angling License	Year	No. of Angling License
1990-91	275	1995-96	610
1991-92	396	1996-97	550
1992-93	350	1997-98	570
1993-94	448	1998-99	600
1994-95	502	1999-2000	620

3.4.3 Commercial Fishing

There is very limited commercial fishing in Upper Indus River above Tarbela. Particularly in DHP area, there is no commercial fishery. Occasionally part-time fishermen succeed in catching 250 – 600 grams. They may sell surplus fish (after meeting their own requirement) to local restaurants or small hotels. Sometime young persons have been also observed selling 3 or 4 fishes at road side (hanging at their sticks). At Besham market, fishermen used to sell their few fishes to the travellers. Hotel owners engage their employee to catch fishes for their customers. Just crossing the Thakot bridge, a roadside shop roasts meat or fish for their customers.

In downstream area, only Tarbela reservoir has proper organized commercial fishing. Fishing rights of reservoirs is being leased out annually or for maximum three year period through open auctions. Fishing contractor engaged fishermen on wages basis (Rs. 20/kg). Skilled fishermen possess already fishing boats, nets. In Tarbela reservoir, gillnet, set nets and cast nets are applied. Yield and catches are supervised, monitored and transported to the market by contractors' manpower. Catches are being sorted out and auctioned in Rawalpindi & Islamabad and Peshawar fish markets.

Application of fishing gears and methodology depends upon the fishermen skill and experience which were imparted by their forefathers. Table 3.40 shows statistics recorded by Tarbela Fisheries Unit.

Commercial fishery activities at Tarbela were at a lower scale as compared to Mangla or Chashma reservoirs. Fisheries productivity of the main reservoir was much lower due to it's oligotrophic condition; the eastern pocket (Khalabat Area) is more productive as a result of much more shallow conditions and fertile soils along the shore which are seasonally inundated. Ninety percent of the fishery production came from Khalabat pocket. Fishing activities, engagement of fishermen and mobile landing center were centered at Khalabat pocket which was accessed through Haripur – Tarbela road. Mostly gill nets of different mesh sizes were used which showed varied efficiency and mesh selectivity.

Table 3.40: Commercial Fishing of Tarbela Reservoir

Year	Catches (in tons)	No. of Fishermen	Seed Stocking	Revenue (Rs. in million)
1990-91	50	167	0.150	0.410
1991-92	61	196	0.180	0.490
1992-93	50	250	0.250	0.483
1993-94	120	380	0.300	0.500
1994-95	132	410	0.300	0.600
1995-96	156	450	0.400	0.620
1996-97	173	460	0.600	0.700
1997-98	162	450	0.300	0.650
1998-99	120	350	0.400	0.650
1999-2000	175	400	0.650	0.750

Source: *Wapda Fisheries Annual Report, 2001*

In execution of Federal Govt. regulation, Tarbela and Khanpur commercial fisheries control have been transferred to provincial fishery department in 2006. Government of KP province is managing and developing the Tarbela reservoir fisheries since 2007. Fishing rights have been auctioned in 2008 for three year lease agreement. Fishing contractor is not only fishing out but also stocking the fish fingerlings in the reservoir.

Fish catch composition mainly is comprised of 22 – 22 species which includes 6 to 7 species of market-valued fishes. Forty percent of the catches consisted of fish species of low market importance. Table 3.41 shows the proportion of different species of commercial catches which contains 63% of the induced species such as Chinese carp, Indian carps and silver carps whose fries are being hatched, reared and stocked in reservoir. The significant fishes from indigenous species are mullah (*Labeo dero*) and mahaseer (*Tor pitutora*) which still breed in Daur and river siren and live in Khalabat pocket due to its eutrophic status. There is group of indigenous species which breed up stream and line in reservoir and enhance the proportion of catches.

Table 3.41: Species wise proportion (in %) of Catches of Tarbela reservoir

Sr. No.	Species	Common Name	Proportion in %
Cultured Species			
1.	Labeo rohita	Rohee	8.3%
2.	Cirrihinus mrigala	Mori	3.1%
3.	Catla catla	Thaila	-
4.	Hypo pthalamichthyes molitrix	Silver Carp	13.8%
Exotic			
5.	Cyprinus carpio	Gulfam	39.5%
6.	Orechromic aurius	Tilapia	6.7%
Indigenous Species			
7.	Labeo dero	Mullah	9.5%
8.	Tor putitora	Mahaseer	5.5%
9.	Ompok bimaculatus	Baula	2.5%
10.	Mastacembelus armatus	Bam	2.3%
Others			
11.	- Neomocheilus spp - Barilius vagra - Aspidoparia morar - Crossocheilus latius - Labeo dyocheilus - Pimtius saroma - Puntius sphore		6.0%

Source: Wapda fisheries annual report 2002

3.4.3.1 Fish processing and marketing

No fish processing or storing centres are located in the project area due to lack of financial resources and awareness. Fish caught are kept in sacks moistened with frequent water sprays. There are no fish shops or fish markets in the project area.

4. POTENTIAL IMPACTS AND MITIGATION

Potential adverse effects of DHP on key components of the aquatic ecosystem are summarized in Table 4.1. Hydropower projects elsewhere have had serious impacts on aquatic ecosystems, particularly in relation to blockage of migratory aquatic organisms, notably fish, and effects on downstream environments (World Commission on Dams 2000; UNEP 2007; Krchnak 2009). In this section Potential impacts are assessed in this section for: the pre-construction and construction phase; movement of fish at the dam site; operation and maintenance phase (upstream aquatic environment, downstream aquatic environment) and, the Karakorum Highway (KKH) realignment. For each main topic, the assessment identifies: potential effects; proposed mitigation; data gaps and uncertainties that limit impact predictions and assumptions regarding adequacy of proposed mitigation; and, expected residual effects.

The knowledge base for aquatic biodiversity in the upper Indus River study area is weak (Section 3.0) which imposes limits on the ability to predict likely effects and define mitigation measures. Where uncertainties exist, precautionary predictions and mitigation assumptions are put forward and studies to enable refinement of predictions and mitigation measures are identified. Data gaps, uncertainties and studies recommended to address information deficiencies are summarized in Table 4.2. Enhancement opportunities (reservoir fishery) are described in Section 5.0.

4.1 PRE-CONSTRUCTION AND CONSTRUCTION PHASES

Potential sources of effects on aquatic resources during dam pre-construction and construction activities are summarized in Table 4.3. Potential effects during pre-construction and construction of KKH are described separately in Section 4.5.

Table 4.1: Sources and Types of Potential Effects on Aquatic Biota

Sources of Potential Effects	Potential Effects
Site preparation	Effects on biota and habitat from: sediment; water pollution including toxic compounds (e.g., oils and fuels); solid waste
Dam construction; Diversion tunnel and coffer dam construction	Blockage of fish movement Effects on biota and habitat from: sediment; including toxic compounds (e.g., oils and fuels)toxic compounds; solid waste Mortality/injury of biota from explosives
Material and equipment staging and maintenance areas; Quarry and borrow-pit areas; Cement-making areas; Access roads	Effects on biota and habitat from: sediment; including toxic compounds (e.g., oils and fuels) toxic compounds; solid waste
Construction of powerhouse and associated intake and tailrace facilities	Effects on biota and habitat from: sediment; including toxic compounds (e.g., oils and fuels) toxic compounds; solid waste
Construction Camps	Effects on biota and habitat from: sediment; including toxic compounds (e.g., oils and fuels) toxic compounds; solid waste Illegal fishing

4.1.1 Potential Effects and Mitigation

During preconstruction and construction the aquatic environment could potentially be affected by in-stream/riverbed activities at the dam site, project infrastructure work, water pollution, use of explosives and vegetation clearing activities.

Table 4.2: Summary of Potential Adverse Effects

Ecosystem Component	Potential Adverse Effect	Proposed Mitigation	Desired Residual Effect	Uncertainty	Significance Criteria					Significance
					Magnitude	Geographic Extent	Duration/Frequency	Reversibility	Likelihood	
Pre-construction/ Construction										
Fish Populations	**Barrier to Fish movement:** Indus at the dam site is not a migratory zone for fish. However, fish movement in the Indus during lfow flow season could be impared by the instream barriers such as coffer dams and main dam.	Further studies are required. If needed, several options, such as compensation hatchery and fish passage facilities, are available to mitigate impaired upstream and downstream fish passage.	A. Populations will not be affected because the dam site is not on an important corridor for fish movement. *Or* B. Mitigation measures enable sufficient numbers of fish adults to move upstream and juveniles downstream to ensure viable natural populations Or C. The reservoir provides suitable habitat to maintain life-cycle linkages of populations that currently spawn upstream of the damsite and overwinter downstream	Current amount of fish movement/use is not known Mitigation design and costs Numbers and timing of fish that move downstream and potentially could be entrained over spillway or into powerhouse intakes, or lower level outlets Presence of genetically distinct populations (sub-species) not known	L	L	L	L	L	Low significant impact on fish populations and human use Assessment is constrained by lack of information on fish longitudinal movement patterns and distances in relation to dam site

Ecosystem Component	Potential Adverse Effect	Proposed Mitigation	Desired Residual Effect	Uncertainty	Significance Criteria					Significance
	Fish entrainment: high mortalities as fish pass through diversion tunnels	Diversion tunnel screens	Mitigation measures minimize mortalities caused by entrainment of fish downstream to ensure viable natural populations	As above	M	L	M	L	M	Potentially significant adverse effects on fish populations and human use Assessment is constrained by lack of information on fish longitudinal movement patterns and distances in relation to dam site
	Habitat impairment: Water quality and debris from multiple sources: • Dam construction • Access road • Construction Camps • Material and equipment Areas • Quarries Mahseer habitat could be impaired if effects extend downstream to the upper limit of golden mahseer distribution (Thalkot-Besham)	Water quality and other management protocols (Environmental Management Report)	No degradation of aquatic habitat or adverse effect on aquatic biota	-	L	L	L	L	L	No significant effect if environmental manage-ment protocols are adhered to
	Population reductions: fishing by work force	Fishing prohibited in Contractor EMP	No reduction in fish populations	-	L	L	L	L	L	No significant effect if environmental manage-ment protocols are adhered to
Other aquatic biota	No adverse effects on threatened species of aquatic birds, mammals and other biota; minor effects on some taxa.	Water quality and other management protocols (Environmental Management Report) will protect area taxa	No effects on local populations of aquatic birds, mammals and other taxa	-	L	L	L	L	L	No significant effect if environmental manage-ment protocols are adhered to

Ecosystem Component	Potential Adverse Effect	Proposed Mitigation	Desired Residual Effect	Uncertainty	Significance Criteria					Significance
Operation and Maintenance										
Fish Populations	**Reservoir net reduction in fish:** Approximately 73 km river-length will be converted from river habitat to lake-like habitat Large change in river features; likely loss of nullah spawning and rearing habitat – expected impairment Replacement with lake-like habitat though water velocities will be high relative to natural lakes and storage reservoirs and reservoir size will rapidly decrease as a result of sedimentation Fish entrainment downstream over spillway or through intakes Future production limited by drawdown during peaking operations	Compensation hatchery and stocking of juveniles in the upstream tributaries. Reservoir fish production and management plan Entrainment screens	Production of fish along the Indus River mainstem and in affected tributaries will not be significantly reduced by reservoir creation	Prediction of amounts of fish production potentially lost - for comparison with potential gains Location and amounts of key spawning and other habitat	M	M	M	L	H	Potentially significant adverse effects on fish population sizes and human use Assessment is constrained by lack of information on the amount fish use in river and tributaries in the reservoir area (including stream spawning areas), effect of entrainment losses, and species-responses to lake-like environment. Fish production and harvest will steadily decline as the reservoir size decreases during Stage 1. During Stage 2 (peaking operation) fish production and harvest will also be reduced from Stage 1 levels mainly due to drawdown effects on benthic biota.
	Reservoir oxygen: reduction on oxygen concentration in hyoplimnion	Reservoir tree clearing plans	Adequate oxygen for aquatic life	Oxygen levels after reservoir filling, especially first several years	L	L	L	L	L	No significant effect if environmental manage-ment protocols are adhered to
	Reservoir eutrophica-tion	Reservoir tree clearing plans	Adequate oxygen for aquatic life	Concentrations of nutrients and other water quality parameters after reservoir filling, especially first several years	L	L	L	L	L	No significant effect if environmental manage-ment protocols are adhered to

Ecosystem Component	Potential Adverse Effect	Proposed Mitigation	Desired Residual Effect	Uncertainty	Significance Criteria					Significance
	Downstream: **First-filling:** Reduced flows cause habitat impairment and subsequent fish mortalities	Reservoir operations protocols allow for sufficient water release to protect downstream aquatic life	Downstream habitat changes that result from flow alteration during reservoir first filling do not affect viability of fish populations	populations Seasonal characteris-tics and use of key habitats for life-stages in Indus River not known	L	L	L	L	L	No significant impact as complete hold backing of flows is not required.
	Flushing flows: During refill Reduced flows cause habitat impairment and subsequent fish mortalities	Reservoir operations protocols allow for sufficient water release to protect downstream aquatic life	Refill after flushing do not significantly affect viability of fish populations and harvests	-As above-	M	M	M	M	M	Potentially significant adverse effects on fish populations and human use
	Routine Flows: **Both Stage 1 and Stage 2** *Dam to TR outlet*: 1. 4km length of river habitat lost or impaired, mainly over winter; small loss in fish production and harvest Almost 100% of 4km length from dam to outlet	Downstream flows per reservoir operations procedures, developed to protect aquatic resource values	Stage 2 peaking flows do not significantly affect viability of fish populations and harvests	Size of environmental flows needed to maintain viable downstream populations	L	L	M	L	M	Adverse effects are expected, but may not be significant
	TR outlet to Tarbela: **Stage 1:** no change in flow; possible water quality changes Uncertain impairment downstream for unknown distance downstream from TR outlet, possibly until the major tributaries join the Indus	Downstream flows per reservoir operations procedures, developed to protect aquatic resource values	Stage 1 flows do not significantly affect viability of fish populations and harvests	Critical habitat locations and use are not known Mahseer movement patterns and use of the Indus River upstream from Tarbela Reservoir	L	L	L	L	L	Adverse effects are expected, but may not be significant Assessment is constrained by lack of information on distribution of fish presence/abundance and along the river in the downstream up to Tarbela
	Stage 2: Potential severe reduction in flow	Downstream flows per reservoir operations	Stage 2 peaking flows do not significantly affect	Critical locations are not known	M	H	M	L	M	Adverse effects are expected, but may not be

Ecosystem Component	Potential Adverse Effect	Proposed Mitigation	Desired Residual Effect	Uncertainty	Significance Criteria					Significance
	over winter Severe habitat reduction could occur downstream for substantial distance downstream from TR outlet, possibly to Tarbela Possible large reduction in fish populations and harvests	procedures, developed to protect aquatic resource values	viability of fish populations and harvests	Mahseer movement patterns and use of the Indus River upstream from Tarbela Reservoir						significant Assessment is constrained by lack of information on distribution of critical habitat, water quality parameters exiting dam facilities, fish presence/abundance and along the river
	Mortalities from stranding: water ramp-down causes high mortalities and reduced populations downstream resulting from fish stranding	Flow rate changes for reservoir operations developed to minimize fish mortality caused by stranding	Amounts of fish stranded during ramp-down of DHP flows will not significantly reduce fish populations	Acceptable ramp rates to prevent high mortalities from stranding Diurnal/lateral movement patterns not known	M	M	M	L	M	Potentially significant adverse effects on fish populations and human use Assessment is constrained by lack of information on fish use of the river downstream of the dam site
	Habitat impairment: Reduction in downstream sediment - loss of substrate material;	No mitigation planned – during operation assess scale of habitat change and fish production loss and develop fish production offset measures	Fish production and harvests are not affected	Use of habitat with types of sediment that will be lost	M	M	L	L	M	Potentially significant adverse effects on fish populations and human use Assessment is constrained by lack of information on sediment flows from the downstream tributaries.
	Temperature changes	Reservoir operations procedures: flow releases from low level outlets, powerhouse and over spillway adjusted to minimize possible adverse effects	No effect on fish production and harvests	Reservoir temperature-depth profiles	M	L	L	L	L	Potentially significant adverse effects on fish populations and human use Assessment is constrained by lack of information on fish use of the river downstream of the dam site
	Total Gas Pressure: Supersaturation leading	Reservoir operations procedures containing	No effect on fish production and harvests	Total gas concentrations in release water	M	L	M	L	L	Low significant adverse effects on fish populations

Ecosystem Component	Potential Adverse Effect	Proposed Mitigation	Desired Residual Effect	Uncertainty	Significance Criteria					Significance
	to gas bubble disease	provisions to reduce TGP levels if supersaturation and gas bubble disease are detected								and human use since this will occur in high flow season when fish in Indus is low. Assessment is constrained by lack of information on how far the effect will continue on the downstream
	Re-settlement Sites: Construction and Use	EMP is adhered to	No effect on fish production and harvests	-	L	L	L	L	L	No significant effect if environmental manage-ment protocols are adhered to
	KKH re-alignment: Construction and Operation	EMP is adhered to	No effect on fish production and harvests	-	L	L	L	L	L	No significant effect if environmental manage-ment protocols are adhered to
Other aquatic biota	No adverse effect on threatened of aquatic birds, mammals and other biota; minor effects on some taxa.	Water quality and other management protocols (Environmental Management Report) will protect area taxa	No effects on local populations of aquatic birds, mammals and other taxa	-	L	L	L	L	L	No significant effect if environmental manage-ment protocols are adhered to
Resource Use/Harvest	Reductions in numbers of fish caught along river length and tributaries to be inundated	Mitigation and enhancement of fish production with compensation hatchery and other fisheries support facilities	DHP will not significantly affect location, amounts and timing of fish harvests	Prediction of change in amount of fish harvest and livelihood after physical commence-ment of project implementation Locations, amounts, timing of harvest; post-harvest Severity of factors confounding data and resource management (e.g., illegal fishing)	M	M	M	L	M	No significant effect if environmental manage-ment protocols are adhered to

Ecosystem Component	Potential Adverse Effect	Proposed Mitigation	Desired Residual Effect	Uncertainty	Significance Criteria					Significance
	Possible limits on consumption of fish from reservoir if high concentrations of mercury detected; preliminary data suggest high concentrations unlikely	Guidelines on fish species safe consumption limits	DHP will not cause a significant increase in Hg concentrations in fish used for human consumption	Contamination of fish with mercury after inundation	M	L	M	L	L	Potentially significant adverse effects on fish populations and human use. Monitoring required after inundation to identify true status

Table 4.3: Summary of Studies to Address Data Gaps and Uncertainties

Potential Adverse Effect	Desired Residual Effect After Mitigation	Gaps in Available Information	Uncertainties	Proposed Follow-on Studies
Dam creates a barrier to fish movement	Populations will not be affected because the dam site is not on an important corridor for fish movement. *Or* Mitigation measures enable sufficient numbers of fish adults to move upstream and juveniles downstream to ensure viable natural populations	Longitudinal movement patterns and distances in relation to dam site not known	Mitigation design and costs: Numbers and timing of adult fish that move upstream to spawning areas and associated infrastructure and cost of compensation hatchery, catch and haul or alternate methods	Movement patterns/distances of adults within Indus River main-stem and to and from nullah spawning areas (e.g., fish marking/tagging, and/or intensive fish sampling over short time-periods)
			Numbers and timing of fish that move downstream and potentially could be entrained over spillway or into powerhouse intakes, or lower level outlets	Movement patterns/distances of juveniles within Indus River main-stem and to and from nullah spawning areas
Habitat quality and fish numbers are reduced downstream during operation	Downstream habitat changes that result from flow alteration during reservoir first filling, refill after flushing and Stage 2 peaking do not significantly affect viability of fish populations and harvests	Seasonal characteristics and use of key habitats for life-stages in Indus River not known	Size of environmental flows needed to maintain viable downstream populations	Seasonal investigation of fish/life-stage presence in different habitat types In particular winter low-flow season.
				Amount/location of key winter habitat; habitat mapping
				Benthic/fish-food resources in selected habitat types
Water ramp-down causes high mortalities and reduced populations downstream resulting from fish Stranding	Amounts of fish stranded during ramp-down of DHP flows will not significantly reduce fish populations	-as above-	Acceptable ramp rates to prevent high mortalities from stranding Diurnal/lateral movement patterns not known	Collect empirical data on fish life-stage behavior/stranding during receding and rising flows
				Collect empirical data on fish life-stage diurnal movement patterns
Reservoir inundation – altered habitat and reduced fish production	Production of fish along the Indus River mainstem and in affected tributaries will not be significantly reduced by reservoir creation	Location and amounts of key spawning and other habitat	Prediction of amounts of fish production potentially lost - for comparison with potential gains	Identify and map key spawning and other habitat important for fish production in the affected/inundated portion of the Indus River and tributaries
		Fish production potential of key habitats in the Indus River main-stem and tributaries and in the reservoir as it progressively decreases in size during Stage 1 and is subject to habitat change (drawdown and flushing) during Stage 2		Estimation of potential fish production from habitat areas identified and quantified based on field data collection and review of species-specific knowledge at locations elsewhere

Potential Adverse Effect	Desired Residual Effect After Mitigation	Gaps in Available Information	Uncertainties	Proposed Follow-on Studies
Mahseer	DHP will not affect the viability of Mahseer populations	Mahseer movement patterns and use of the Indus River upstream from Tarbela Reservoir	Size and timing of downstream flows needed to maintain viable populations	Fish sampling programs to confirm uppermost limit of Mahseer upstream from Tarbela Reservoir
				Identification of Mahseer seasonal habitat use of Indus River between Tarbela and uppermost limit
Resource Use/Harvest	DHP will not significantly affect location, amounts and timing of fish harvests	Locations, amounts, timing of harvest; post-harvest	Prediction of change in amount of fish harvest and livelihood after commencement of project implementation	Supplementary baseline data on locations, amounts and timing of fish catch and post-harvest activities
		Severity of factors confounding data and resource management (e.g., illegal fishing)		Baseline data on the scope of illegal fishing and how illegal fishing activity will affect data interpretation during monitoring
	DHP will not cause a significant increase in Hg concentrations in fish used for human consumption	Contamination of fish with mercury – current baseline condition		Supplementary baseline data on mercury concentration in fish in areas to be inundated by reservoir

4.1.1.1 Dam Construction – Instream/riverbed Activities

Potential Effects: At the damsite coffer dams will be placed upstream and downstream of the work areas for construction of the dam and spillway plunge pool (Figure 3 1.2). Habitat in the riverbed work area will no longer exist; that stream segment will be kept dry by diverting water through tunnels from just upstream of the upper coffer dam to a release point downstream of the lower coffer dam. Coffer dam placement and associated use of tunnels potentially will increase downstream suspended sediment concentrations.

Placement of the coffer dams and use of the diversion dam will be the first of several barriers to fish movement along the Indus River mainstem; barrier effects and mitigation measures are described in Section 4.2.

Aquatic biological production will be eliminated from approximately 980m of stream length, part of which (the dam footprint) will be removed for the life of the dam. Current use by fish and other biota of the streambed to be dried is not known – physical conditions suggest that the main use by fish during the summer high flows is as a fish passage corridor at least at the onset of high flows (Section 4.2) and possibly as over-wintering habitat (large pool areas are not evident in remote imagery during low-flow conditions so over-wintering use may not be large). The magnitude of reduced fish production over the construction period likely would not be large in relation to the long river-length of comparable habitat.

Downstream habitat could be affected by high sediment loads produced during placement of the coffer dams, when water first passes through the work area after completion of dam and plunge pool construction (other residual material such as remains of hydraulic leaks or fuel spills may also be present), and when water first passes through the water diversion tunnels.

The Indus River in the DHP area has naturally high sediment concentrations, particularly during the summer high flow period, which likely has been a major factor in determining current biotic assemblages. Sediment concentrations above natural levels can cause mortality of biota directly; for fish, damaged gills and sediment clogging of gill chambers eventually leads to death. Indirectly, sediment deposition downstream can affect biota by altering habitat features for example by covering previously clean rock habitat used for spawning or feeding, causing impairment of those areas including smothering and mortality of freshly laid eggs or newly hatched larvae and reduced benthic production and food abundance for herbivorous fish such as snow carp and fish preying on algae-feeding invertebrates. Additional sediment loads can affect primary production (plankton, aquatic plants) and accordingly organisms higher in the food chain, including birds and mammals that feed on or make use of such aquatic organisms for food or habitat, and humans who derive an economic or protein benefit. Population sizes of organisms in the Indus River downstream from the in-stream/riverbed activities could be reduced at least temporarily.

Mitigation: Potential effects on aquatic habitat will be mitigated by planned measures to prevent entry of sediment, toxic compounds, and solid wastes and control use of explosives (these measures are outlined in a series of environmental management sub-plans and codes of practice in EIA Section 7.0; these are listed in Table 4.4)

Table 4.4: List of Environmental Management Plan Sub-Plans containing Measures that will Protect Aquatic Resources

EMP Sub-Plan 1: Construction Management
EMP Sub-Plan 2: Operational Management
EMP Sub-Plan 3: Physiography and Geology
EMP Sub-Plan 4: Hydrology & Surface Water Management
EMP Sub-Plan 7: Noise and Vibration Management
EMP Sub-Plan 8: Waste Management
EMP Sub-Plan 9: Hazardous Substances Management
EMP Sub-Plan 11: Aquatic Ecology Management

Site-specific mitigation should include measures to: avoid coffer dam placement during the start and middle of low flow winter season when fish are likely to be using pool areas as refuges and sediment levels are seasonally low; utilize coffer dam material with as little fine material (e.g., <2mm) as possible; for diversion tunnel construction, avoid initial activation during the winter low flow season; ensure construction material, including from the diversion tunnel, is not dumped into the river and is transported to designated disposal areas (EMP Sub-plan for waste management) which should be situated well above seasonal high flow levels; clear all residual material and accumulations of sediment and debris from construction sites before flooding. In addition, fish trapped in the intended dewatered area when water is diverted through tunnels around the coffer dam work area could be harvested for consumption by members of the local community; a salvage strategy should be developed before diversion based on estimates of species to be kept for human for consumption or sale and fish not to be kept and to be released downstream.

4.1.1.2 Project Infrastructure

Potential Effects: Project infrastructure sites include: construction work and storage areas, quarries, concrete preparation sites, and camps for construction workers; access roads; project management sites; and, powerhouse facilities. Work activities associated with these locations could affect freshwater ecology by increasing sediment loads (as described above), construction and other material washed into the watercourse, and construction of inappropriate bridges (partial damming of streams, extensive modification of streambed/banks).

Mitigation: Measures to prevent entry of sediment, toxic compounds and solid wastes are outlined in EMP Sub-plans dealing with construction management, hydrology and surface water management, waste management and hazardous substance management will minimize potential effects on aquatic resources.

4.1.1.3 Water Pollution

Potential Effects: Fuels and chemicals will be stored and used at various locations project work areas. Spills of these materials can affect aquatic biota, directly and indirectly, and people and animals that consume them.

Mitigation: Measures to prevent entry of toxic compounds and solid wastes are outlined in EMP Sub-plans dealing with construction management, hydrology and surface water management, waste management and hazardous substance management will minimize potential effects on aquatic resources.

4.1.1.4 Use of Explosives

Potential Effects: Fish and other aquatic organisms can be killed immediately by explosives or eventually die from damage to internal organs which can occur at long distances. No explosives are planned for use underwater during construction. Explosives are used for illegal fishing in the project study area; interest may develop among workers for acquisition of explosives from site storage leading to possible theft for illegal fishing. Use of explosives is an inefficient fishing method - many killed fish cannot be recovered and explosives damage fish habitat. Elsewhere explosives use has been a concern at dam construction sites associated with temporary workers.

Mitigation: Measures to prevent misuse of explosives are outlined in the EMP sub-plan for hazardous substance management. Explosives should not be used on the river bed; the provincial ban on fishing with explosives should be strictly applied to the construction workforce.

4.1.1.5 Vegetation Clearing

Potential Effects: Large areas of disturbed soil will likely exist in areas cleared of vegetation leading to a short-term increase in sediment load in river during heavy rains and during initial filling of the reservoir and impaired habitat quality.

Trees will be removed from the reservoir area prior to flooding. This will reduce the amount of organic matter available for anaerobic breakdown and associated changes in water quality that typically develop in initial years after reservoir inundation. Nutrients released from biodegradation of residual matter can contribute to a surge in reservoir trophic conditions and fish production for a number of years after inundation.

Mitigation: Measures to guide site clearing and waste disposal activities are outlined in EMP Sub-plans dealing with construction management, hydrology and surface water management, and waste management will minimize potential effects on aquatic resources.

4.1.2 Significance of Potential Adverse Effects

Proposed mitigation measures should prevent long-term or irreversible adverse effects on aquatic habitat and biota (Table 4.1). If these measures are not applied or are applied incorrectly damage to habitat and mortality of fish and other aquatic biota is likely.

4.1.3 Data Gaps and Uncertainties

Proposed mitigation measures mainly are standard for protection of aquatic resources in construction areas; additional site specific measures are identified above.

4.2 MOVEMENT OF FISH AT THE DAMSITE

Snow carp are believed to make short migrations within the tributaries or from confluence areas of main rivers to head waters of the in tributaries. Snow carp mainly inhabit Indus near confluence areas in winter during low flow season. The endangered golden mahaseer (*Tor putitora*) reportedly do not ascend beyond approximately Thakot-Besham, 70-80 km downstream of the dam site; upstream migration should not be affected by the dam. Placement of the dam may have low to negligible long-term effect on fish, requiring no mitigation, or may affect viability of some populations and require some form of mitigation or compensation.

4.2.1 Potential Effects and Mitigation

Impairment of movement of fish would commence during the construction phase with placement of coffer dams and operation of the diversion tunnels and continue with dam construction and operation. Fish attempting to move downstream or entrained in water conduits (powerhouse intakes, spillways, lower level outlets) will potentially be subjected to high levels of mortality and injury.

4.2.1.1 Upstream Movement of Fish

Potential Effects: Fish such as snow carp that may use slower-moving parts of the Indus River main-stem for overwintering potentially will be prevented from reaching tributary spawning streams upstream initially by placement of the coffer dam and diversion tunnel; fish migrants could be affected in the Indus main-stem and Siglo Creek (which enters the Indus River approximately one km downstream from the dam axis):

- *Indus River:* Upstream fish movement will be blocked by the coffer dams. Fish are not likely to use the diversion tunnels mainly on account of high water velocities; strong laminar flows and absence of low-energy rest areas in the tunnels likely will prevent all fish passage upstream.
- *Siglo Creek:* Siglo Creek is a small but productive stream; fish are caught for consumption by people from the adjacent community. Fish will be able to move upstream into Siglo Creek after the lower of two downstream coffer dams is in place; the lower coffer dam will be situated upstream from the mouth of Siglo Creek though at times high flows exiting the diversion tunnels could cause a hydraulic barrier to fish movement into the stream.

At the end of the four year construction period the completed dam will form a permanent barrier to upstream fish movement in the river.

At times turbulent flows exiting the plunge pool could impair or eliminate fish access to Siglo Creek.

Long-term potential effects on fish populations are uncertain but impairment of fish movement may result in some decline in fish populations.

Mitigation: Actual fish movement at the dam site may be low or negligible for the viability of fish populations (notably snow carp). Further studies are recommended to confirm that the river segment is not used for fish migration, and if it is used to identify species and numbers of migrating fish. If supplementary studies indicate that effects on fish movement must be mitigated, options in concept include fish passage strategies and compensation facilities; fish passage options include:

- Natural by-pass – utilizing a natural channel as much as practicable
- Trap/Catch and haul – trapping fish in a capture device downstream from the dam and transporting them for release upstream
- Fishway – construction of a passageway based on species-specific design criteria
- Lifts – some form of elevation device to move groups of fish over the dam

Fish passage facilities are typically expensive, particularly fishways and lifts, and have practical limits related to site conditions, such as dam heights and topography, and biological characteristics of target species. Detailed species-specific data would be required to support design of suitable fish passage facilities and prevent the types of fish-passage failures that have occurred frequently at facilities elsewhere. Available biological data for the likely main target taxa (snow carp) do not appear to be sufficient to enable definition of design criteria, so would require a focused research program to support biological design features.

A natural by-pass does not appear to be viable at the Dasu location but could be examined further as an option if need is justified; the least costly fish passage alternative likely is a trap/catch and haul system (at least as a possible interim measure) though all systems require feasibility analyses based on biological design criteria for the target species and technical/financial assessments.

An alternative is a hatchery with a compensation component; a single facility could be used to produce juveniles for stocking streams for which spawning populations have been affected by the project (for example using broodstock captured in river to maintain biodiversity characteristics) , and additional fish for reservoir-stocking or to supply local grow-out facilities. The facility would require a research and development component to improve local methods and capacity for snow trout hatchery production.

Though fish passage is not required for the Dasu dam, a fish compensation hatchery is recommended for DHP as compensation measure to overall impact on the fish habitat by the Project.

Exclusion Screening: If the dam site is found to be an important corridor for fish migration, exclusion screens may be required at the tailrace outlet to prevent mortality of adults attempting to enter the tailrace and eventually dying as they succumb to exhaustion. Similarly, exclusion screens may be necessary at the diversion-tunnel outlets during the construction phase.

4.2.1.2 Downstream Movement of Fish

Potential Effects: Fish upstream of the dam potentially will be entrained in the diversion tunnels during dam construction and water release portals during reservoir routine operation.

Diversion tunnels: Fish drawn into the upstream end of the diversion tunnel will be subject to high water velocity and possible abrasion along the tunnel walls as they pass along the 900-1200m tunnel lengths. Survival of some fish is possible though if fish try to maintain a position facing up-current or seek slow-current areas along the tunnel walls high rates of weakened and injured fish likely will occur.

Fish moving downstream from Siglo Creek similarly should be able to move into the Indus River near the lower coffer dam though at times could be deterred by high flows from the diversion tunnels.

Reservoir Routine Operation: Reservoir fish that wander close to water release structures may be entrained in dam/powerhouse outlet structures. Mortality is the likely outcome for almost all entrained fish. Fish entrainment could occur at three locations:

- Powerhouse Intakes
- Spillway – especially during the high flow season
- Lower Level Outlets during reservoir flushing

Powerhouse Water Intakes will be approximately 25m below MOL and 75m below FSL – at water depths of 25m there may be larger fish but likely not smaller fish. An inclined trash rack is planned for the intake service area and potentially would block larger fish (trash rack bar spacing will be 7.5cm). However water velocity will be relatively high (~8 m/s) and likely would exceed the burst speed of snow carp and other affected fish; fish near the intake service area likely will be drawn rapidly against the trash rack and swept upward along the incline possibly enabling the fish to swim to lower velocity areas if not damaged by contact with the trash rack.

Spillway. If fish pass over the spillway survival likely will be very low; fish will be exposed to approximately 80m entrainment down the spillway slope to the flip-bucket followed by an additional 100m free-fall to the plunge pool. Snow carp likely would not be present in mid-channel near-surface portions of the reservoir in the vicinity of the spillway entrances; vulnerability of other species is uncertain.

Lower Level Outlets. After the first 15 years of reservoir operation lower level outlets are planned to be operated annually over approximately one month during late spring to early summer to flush sediments from the reservoir.

At the start of flushing the intake portals for the LLO will be approximately 140m below the surface (FSL); the LLO depth will be reduced to essentially 0m as the water surface is lowered during the flushing process. Fish residing close to the shoreline at higher elevations during FSL will be brought close to the LLOs and relatively high water velocities at the LLO entrances (~14m/s), as reservoir volume decreases. This could mean displacement downstream of a relatively large number of fish during the planned late spring to early summer flushing period. Numbers and life-stages of species that will be vulnerable to being drawn into the LLOs are not known.

Mitigation: Temporary or permanent measures will be needed to assist movement of migrating fish from upstream of the diversion tunnel intake (e.g., fish attempting to move to downstream overwintering habitat) to downstream of the tunnel outlet if migrant populations are identified during proposed studies. This could include use of a small by-pass channel or trap and haul methods.

Measures proposed to minimize fish entrainment are:

- *Diversion tunnel screens*: upstream intake screens to prevent entrainment of fish downstream and likely high mortality.
- *Powerhouse intakes, Spillway and Lower level outlets:* Entrainment screens emplacement at the spillway, powerhouse intakes and low level outlets to prevent entrainment of fish into those structures in combination with fisheries management procedures. Site-specific designs would have to address high water velocities.

The type and amount of fish entrainment into facility downstream flows is uncertain and has important implications for assumptions regarding the viability of a possible reservoir fishery and associated stocking rates. A range of devices has been used or experimented with elsewhere to minimize fish entrainment at facilities. These include physical devices such as wire mesh screens and bar racks, and behavioural methods such as bubbles, lights and acoustic devices (Larinier 1999; Turpenny and O'Keefe 2005). The type and design of screening device that would be appropriate for DHP project must be based on species, life-stages/sizes and movement patterns of fish expected to be present in the reservoir. For the Dasu facility design should include removable fish-screening, either physical or sonic devices, for full or partial placement in front of the penstock intakes, spillway and lower level outlets. Designs should be based on specific fish fauna at risk and assessment of benefit-costs of installation and operation. Some form of screening is assumed to be needed to minimize entrainment; a costing allowance is made for installation and operation/maintenance, together with approximate costs for studies to aid development of design criteria.

4.2.2 Significance of Potential Adverse Effects

Significant adverse effects on fish populations if movement is impaired; effects potentially will be insignificant if proposed mitigation measures are applied and are effective (Table 4.1). Significance before mitigation is summarized in Table 4.5 (this also reflects conditions if mitigation is not effective).

Table 4.5: Significance of Potential Adverse Effects of the Project on Fish movement before Mitigation

	Habitat Change	Potential Effect on Population Sizes	Potential Effect on Human Use
Magnitude	Migration Corridor – expected impairment of fish movement at dam site; current amount of fish movement/use is not known	Uncertain – expected reduction; data from comparable mountain reservoirs in India and Nepal indicate blocked migration and fragmented populations	Uncertain; expected reduction
Spatial Extent	Disconnection from spawning areas – Probable spawning tributaries were identified during field surveys but critical locations are not known	Uncertain; data from comparable mountain reservoirs in India and Nepal indicate blocked migration and fragmented populations	Uncertain; expected reduction

Duration/ Frequency	Long-term/sustained	Long-term/sustained	Long-term/sustained
Reversibility	Potentially reversible with mitigation or dam removal	Possible over number of generations (of species) – presence of sub-specific populations unknown	Likely over a number of generations (of species)
Likelihood	High	High	High
Significance before mitigation	Potentially significant adverse effects on fish populations and human use Assessment is constrained by lack of information on fish use of the river at the dam site (as a corridor for movement between river areas and stream spawning areas)		

4.2.3 Data Gaps and Uncertainties

An adaptive approach is recommended to address uncertainties and data-gaps beginning with near-term investigations on fish movement to confirm that the dam site is not located on an important corridor for migration of snow trout and other taxa. Longer-term investigations should be conducted to support prediction of movement patterns of snow carp and other species in the reservoir and their vulnerability to entrainment (filling of the reservoir is not planned until at least 2019). Those data would be used to identify how entrainment losses would affect reservoir populations and assumptions regarding viability of a potential reservoir fishery and possible stocking efforts (Section 5.0).

4.3 OPERATIONS PHASE: UPSTREAM OF THE DAM SITE

Residual adverse effects on populations of snow trout, including Himalayan snow trout, and other fish species upstream of the dam site and associated resource use are not expected – potential adverse effects related to submergence of spawning and rearing habitat in tributaries and losses resulting from entrainment downstream can be mitigated through a combination of habitat enhancement, artificial propagation and use of devices to minimize entrainment downstream. Supporting studies to confirm assumptions and design suggested mitigation and enhancement measures (Section 5.0) will be needed prior to first-filling of the reservoir.

4.3.1 Potential Effects and Mitigation

4.3.1.1 First Filling of the Reservoir

Potential Effects: Habitat upstream of the dam along the Indus River will be changed from current riverine habitat to lake-like habitat over the planned three-month period for first-filling of the reservoir. The reservoir will reach a maximum depth of approximately 185 m (the deepest part of the reservoir will be adjacent to the dam). As physical changes take place chemical and biological conditions also will be altered. With reduced water velocities as water depth increases, a sedimentation process will commence whereby larger sediment fractions will sequentially settle along the reservoir length.

Mitigation: No mitigation measures are proposed for the reservoir during first-filling beyond those outlined below for the reservoir routine operations and flushing events.

4.3.1.2 Routine Operation

Potential Effects: Ecological conditions and fisheries production opportunities in the new river will be governed by physical changes that will occur as a result of rapid sedimentation and transition from run-of-river to peaking operation, submergence of tributary habitat, and corresponding changes in temperature, water chemistry and biological conditions and resource use.

i) Physical Habitat Features:

Habitat conditions along the 73km length of the river at FSL will be characterized by a long transition along the former river gradient featuring river-like fast-moving water in the upstream end and deep slower moving water in the downstream end (Figure 1.3). Reservoir ecology will not be typical of a natural lake environment and will undergo rapid reduction in size caused by rapid sedimentation and changes associated with transition of reservoir operation from run-of-river to peaking (notably, drawdown during cycle of water storage and release for power generation). Relatively high water velocities and narrow width will maintain river-like features along much of the reservoir.

Habitat Changes from Sedimentation: The reservoir length will decrease from 73 km to approximately 9-10km during the first 15 years as a result of sedimentation (Figure 4.1), after which annual flushing is planned to remove sediment.

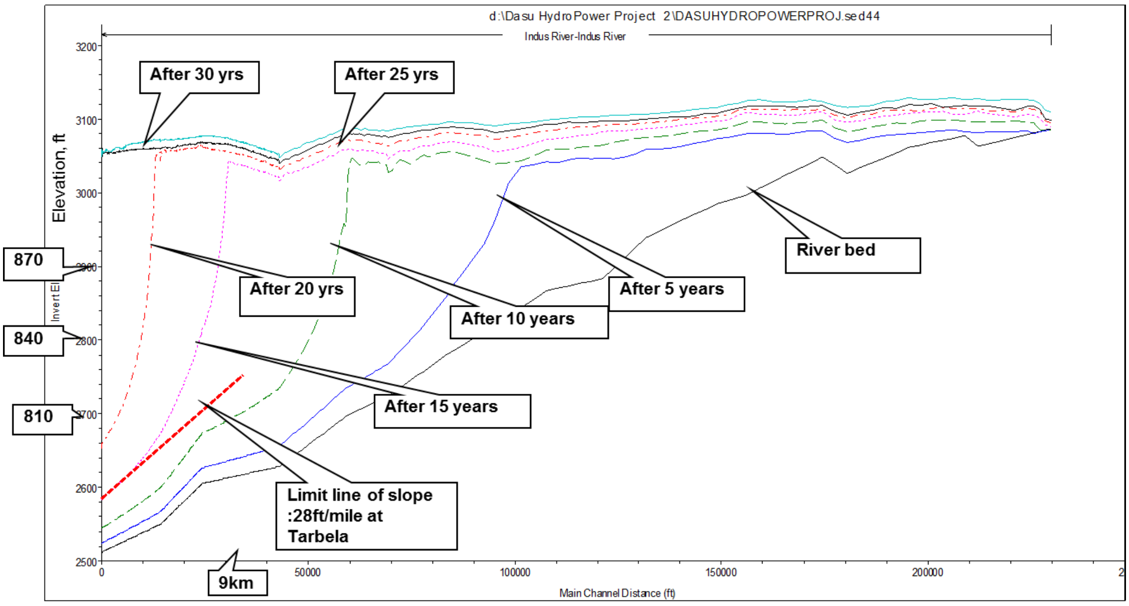


Figure 4.1: Sedimentation Profiles after every 5 years (without flushing)

Types and amounts of effect on the aquatic ecosystem will shift as operational flow volumes and features (run-of-river versus peaking) change. As noted, the four development phases have been grouped into two Stages (Table 4.6).

Table 4.6: Summary of Stage 1 and Stage 2 Operating Conditions

▪ **Stage 1** includes phases I and II and reflects operating conditions (full run-of-river, base-load facility) before commencement of operation of the planned upstream Diamer Basha project. Phase I currently is planned to commence operation in 2019 and Phase II is planned to commence operation in 2022 (based on the most recent analysis of construction-schedule alternatives).
▪ **Stage 2** includes phases III and IV and reflects intended operating conditions after commencement of operation of and in concert with the Diamer Basha Project. In Stage 2, there is a potential that Dasu could be used as peaking plant (to meet afternoon-evening peak demand) due to guaranteed water releases from Basha reservoir. However, peaking operation produces about 1000 Gwh of less power annually compered to ROR (base load) operation. Hence the current planning is also to use Dasu as base-load facility in Stage 2. In this case the impacts of Stage 2 will be similar to Stage 1. However, in the current assessment on impacts to downstream aquatic ecology, it is assumed that DHP will be operated as peaking plant.

During Stage 1 and Stage 2 operation will be in summary:

- *During High Flow Season, May to September,* the same for both run-of-river operation (Stage 1) and peaking operation (Stage 2). The reservoir is expected to remain mainly at FSL (950m) over this period, providing shoreline habitat approximating without-dam conditions during both Stages.
- *Surface Water During Low Flow Season, October to April,* for the initial period of routine operation (Stage 1) reflect water maintained at FSL with all flow passing through the powerhouse intakes . Habitat features at this time will be relatively stable in the reservoir.

  When the Diamer Basha becomes operational (Stage 2) water will be stored and released on a daily cycle of approximately 18-20 hours storage followed by 4-6 hours release for power production (expected to take place approximately from 4-5pm to 8-11pm). The current operational concept is for the reservoir to be drawn down 1-2m/day over the 4-6 hour followed by partial refill during storage, gradually creating a seasonal draw down zone of up to 50 m (Figure 4.2); operational features during peaking were not firm during this assessment.

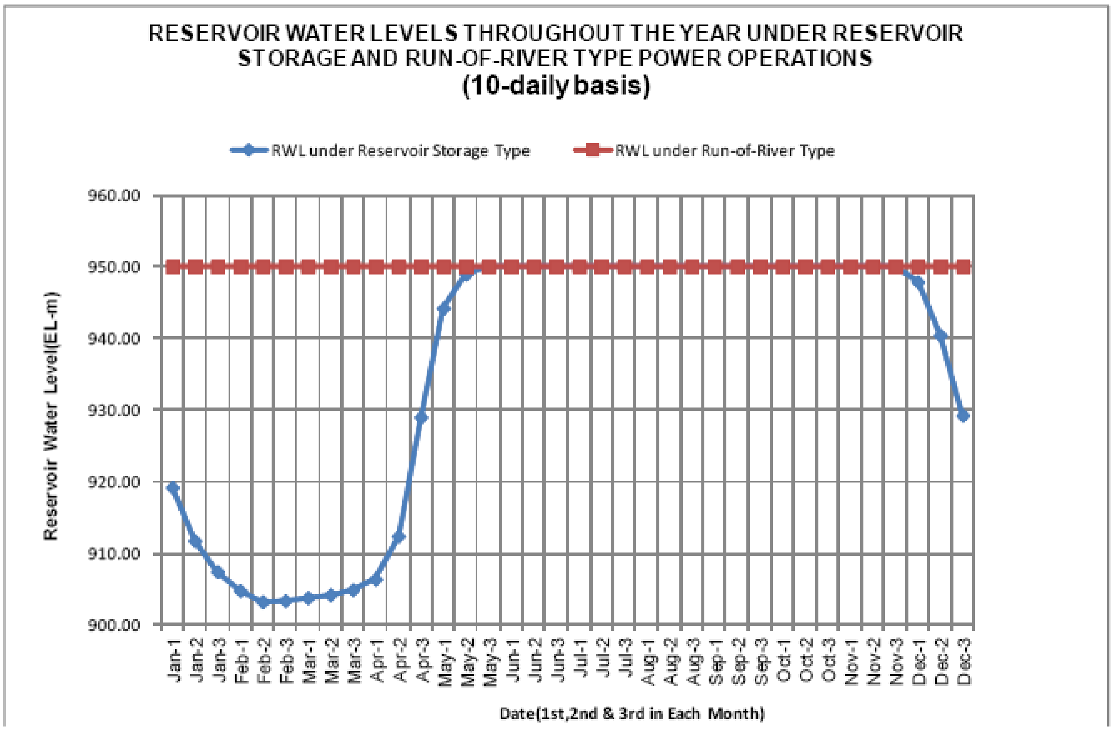


Figure 4.2: Reservoir Water Levels throughout the Year under Run-of-River (Stage 1) and Storage (Stage 2) Power Generation Operations

Habitat Effects of Peaking Operation Drawdown: A daily cycle of shoreline drying and wetting around the perimeter of the reservoir together with a seasonal maximum drawdown of 50m has potential to greatly reduce production of benthic biota in the affected drawdown zone; this will greatly reduce food for fish species such as the snow carp and other fauna such as aquatic birds that depend on benthic biota. The result would be a reduction in fish production and harvest compared to Stage 1 conditions.

Water velocities: Water velocities along the length of the reservoir would be relatively high, ranging from 3-5m/s at the head end to 0.2-0.5m/s at the downstream end.

Water velocities along the length of the reservoir will generally be less than pre-reservoir river conditions. Although reservoir features will be lake-like surface water velocities will be high compared to most lakes and storage reservoirs (Table 4.7). The relatively high water velocities suggest that conditions may be mainly compatible for riverine fish species, particularly along the reservoir shoreline.

Table 4.7: Surface Water Velocities Expected along the Reservoir

Discharge conditions	Water velocity (at water surface)				
	At dam face	15km from dam face	30km from dam face	50km from dam face	65km from dam face
6000m3/s during flushing	0.4 m/s	0.4 m/s	3.1 m/s	4.4 m/s	4.8 m/s
6000m3/s reservoir water level maintained at 950m	0.1 m/s	0.2 m/s	0.5 m/s	3.1 m/s	-
1000m3/s reservoir water level maintained at 950m	0.02 m3/s	0.03 m3/s	0.04 m3/s	0.5 m3/s	-

Source: DHP sediment modeling data

Water velocities in deeper areas close to the dam will be mainly influenced by facility operation:

- 900-950m – relatively high water velocity; determined by intake/spillway use
- 875-900m – relatively high water velocity; determined by intake use
- 810-875m – relatively low water velocity except during periodic flushing; mainly stagnant water upstream - annual/periodic flushing will rejuvenate
- 724-810m – low water velocity; mainly stagnant water upstream

Flushing on an annual basis during the summer high flow period, according to current planning

ii) Submergence of Tributary Habitat

Lengths of tributaries that will be submerged are summarized in Table 4.8 together with fish species captured in those streams during project field surveys. Habitat in submerged portions of tributaries appears to be mainly rearing and possibly spawning habitat for snow carp. The reservoir tributaries characteristically have steep gradients and torrential flows; newly formed embayments will likely fill rapidly with sediment brought downstream from each tributary.

Table 4.8: Reservoir Penetration in the Nullah/Stream Valleys

Sr. No.	Name of Stream	Distance Penetrated (m)	Stream Length (m)	Fish Species Captured During Field Surveys
Left Bank Nullah/Stream Valleys				
1.	Ucchar	1534	-	-
2.	Barseen	685	2902	SP, SE, T spp.
3.	Kaigah	1265	13166	SP
4.	Chilasgah	555	-	-
5.	Lutar	615	8723	-
6.	Shori	757	-	-
7.	Summar	584	22640	SP, SE
8.	Shatial	100	7736	SP, SE
9.	Harban	355	-	SP
Right Bank Nullah/Stream Valleys				

Sr. No.	Name of Stream	Distance Penetrated (m)	Stream Length (m)	Fish Species Captured During Field Surveys
1.	Duga	1448	12993	-
2.	Kandh	1050	-	-
3.	Kandia	6083	84334	SP, SE
4.	Uthar	768	-	-
5.	Shaku	430	-	-
6.	Obar gah	2500	10763	-
7.	Tanger	995	46798	SP, T spp.
8.	Darel	464	37585	GR, SP, SE, T spp.

GR – *Glyptosternum reticulum*; SP – *Schizothorax plagiostomus*; SE – *Schizopyge esocinus*;
T spp. – *Triplophysa* spp.

iii) Water Temperature and Chemistry

Temperature and chemistry of the reservoir will differ from river conditions: expected temperature and water chemistry of reservoir habitat are summarized in Table 4.9.

Table 4.9: Summary of Expected Water Temperature and Chemistry

Item	Summary
Temperature	Thermal stratification modeling has not been undertaken. During both summer high flows and winter low flows water is expected to move quickly along the reservoir length (Table 4.7) with little vertical stratification over much of the reservoir length; stratification may develop over approximately mid-spring to early-fall as surface temperatures rise and decline over spring-summer-fall. A small amount of water-surface temperature data is available for the Indus River at the reservoir location; temperatures were 14-18C (September) and 6-9C (January). Vertical temperature profiles have not been calculated or modeled; provisionally water temperatures in deeper areas, below the elevation of the lower-level outlets (810 m), are assumed would approximate winter-season surface temperatures (6-9C). Water retention time is estimated to be 18 days during winter low flow conditions. Thermal conditions for aquatic biota in the surface layers of the reservoir (e.g., to depths of approximately 50-60 m) during the summer period are expected to be similar to conditions in the pre-impoundment river though temperatures may be slightly higher on account of the slower moving water. Flushing on an annual basis during the late spring to early summer high flow period, according to current planning, would disrupt possible temperature stratification.
Turbidity/ sediment:	Sediment concentration will progressively decrease along the reservoir from upstream to downstream. Turbidity is relatively high in the Indus River; project measurements in the Study Area were 45-81 NTU with little variation between the early fall and mid-winter sample periods. These high turbidity levels mean light penetration and photosynthetic activity would be very limited throughout most of the year. During the summer high flow period water in the reservoir is projected to carry suspended particles of 14u to 1.5 mm over much of the reservoir at high discharge/water-velocity (i.e., 6000m3/s;). Particles are expected to be relatively large near the dam given the relatively high water velocity short water retention time (water entering at the head of the reservoir will pass along the 70km length to the dam in approximately 4 days). Water movement will be slower during the low flow season (approximately 1 month for water to move from the head of the reservoir to the dam). More sediment will settle along the reservoir length, with particle sizes projected to be 0.2 to 100u over most of the reservoir.
Oxygen:	Dissolved oxygen levels in bottom areas of new reservoirs typically decrease as microbes decompose residual organic material in soils and remnant vegetation from

Item	Summary
	pre-filling vegetation clearing. Surface water is expected to be relatively well oxygenated along the length of the reservoir mainly from turbulent inflow. The expected relatively high turbidity levels, in spite of settling of larger sediment fractions, will restrict light penetration and mean little oxygen production through photosynthetic activity from plant-life in the reservoir. For several years after impoundment decomposition of remnant vegetation from pre-impoundment clearing may contribute to low oxygen concentration near the reservoir bottom; amounts of leftover material are not expected to be large. Seasonal anoxic conditions above the reservoir bottom will occur if periodic stratification occurs. Fish in the reservoir are not expected to be affected by possible low oxygen concentrations, likely restricted to in deeper areas in the downstream portion of the reservoir, because taxa likely will tend to make use of benthic food at shallower depths.
Nutrients:	Nutrients will be released into the water column possibly for several years after filling as submerged vegetation is decomposed. This potentially will contribute to a 'trophic upsurge' typical of newly created reservoirs, though the amount of biological production resulting from the nutrients released in the Dasu reservoir likely will be low on account of expected low photosynthetic activity imposed by high turbidity levels.
Mercury:	Mercury methylation, uptake in the food chain and high concentrations in fish tissue is a concern in new reservoirs. Mercury concentrations in soils that will be submerged as the reservoir is filled are not high, reflecting the mainly exposed rock surfaces, steep slopes and low soil-cover that characterize the land area to be inundated. Accordingly little mercury is expected to be available for methylation and be biologically available for entry into the food chain. Background levels were low in fish tissue taken from fish specimens in areas to be flooded (Section 3.0).

iv) Biological Conditions

Biological conditions in the reservoir will differ from river conditions: expected biological conditions in the reservoir are summarized in Table 4.10.

Table 4.10: Summary of Expected Biological Conditions in the Reservoir

Item	Summary
Plankton	Phytoplankton production in the new reservoir is expected to be higher than currently found in the river but generally low in the reservoir compared to clear lakes and reservoirs because light penetration will be limited by relatively high turbidity over most of the reservoir. Phytoplankton biomass may be high at the downstream end of the reservoir compared to upstream locations but still low compared to natural lake environments. Zooplankton abundance and community formation also will be negligible.
Benthos and Shoreline Macrophytes	Periphyton, benthic invertebrates and macrophytes likely will not develop substantively in the shoreline areas due to high water velocity and turbidity over summer and steep slopes. When the facilities eventually shift to serving peak energy demand during winter months (Stage 2) daily desiccation of the drawdown zone would occur over winter. During Stage 1, benthic communities will develop along the bottom particularly in shallower shoreline areas as a layer of sediment builds. Abundance and species-composition of benthic invertebrates will be determined by organic matter that is present in the sediments; at this stage sediments are expected to mainly mineral so invertebrate abundance and composition is expected to be low.
Fish Species Composition and Abundance	The degree to which species currently found in the portions of the Indus River and tributaries that will be submerged by the reservoir will continue to use the newly formed reservoir is uncertain though *Schizothorax* species including *S. plagiostomus* and *S. esocinus* occur in lakes elsewhere (e.g., Lake Dal in Kashmir - Raina no date). Habitat change likely will negatively affect some species. For example, gravel/sandy spawning areas of snow carp in submerged areas of tributaries around the reservoir may no longer have suitable flow or substrate conditions (resulting from accumulations of fine sediment) for continued spawning. Relatively large quantities of sand,

Item	Summary
	gravel and cobble are expected to be brought downstream in tributaries and will be deposited in low-energy embayments at mouths of tributaries. Species such as snow carp that currently use the river are expected to also use the reservoir, though abundance of all species is difficult to predict given weak knowledge regarding habitat-use and abundance of those species in lakes and reservoirs. Snow carp are likely to be found mainly close to shore, utilizing during high flow periods low energy areas such as submerged portions of tributaries. Low energy areas behind boulders along the main river during high flow will no longer be available to them so fish numbers may be substantially lower. During low flow periods when water velocities are lower fish will be able to move up and down the steep shoreline during the daily storage-release cycle (900m to 950m) but food will not be abundant in that zone during Stage 2 on account of daily drying. Food sources at that time likely would be restricted to elevations below 900-910m; at those elevations and corresponding water depths food abundance likely would be low for reasons noted above. Fish that move downstream during the low-flow period, possibly including fry/juveniles after hatching/rearing in tributaries may be entrained in dam/powerhouse outlet structures and will not be able to return as adults to spawning locations upstream from the dam (survival will be very poor as they pass through the powerhouse turbines or through the spillway; Section 4.2). Rate of daily drawdown in the low flow season during Stage 2 is expected to be 1-2 m/d; at high drawdown rates there is potential for fish stranding in flatter areas such as along submerged portions of tributaries – the amount of these areas and stranding-potential around the reservoir is low, possibly being a problem in just a few locations (e.g., drawdown reaches of Kandia River).
Other Biota	Other biota, in particular waterfowl, likely will be attracted to the slower moving downstream portions of the reservoir; potential effects of the project on wildlife, including migratory birds, are described in Volume 4 (Terrestrial Ecology).

iv) Resource Use

Fishing currently takes place along the segment of the Indus River and tributaries that will be submerged; fish are used mainly for domestic consumption. Clearly fishing will no longer be possible at the traditional locations. Fishing may be possible in some of the same tributaries at higher elevations upstream from new stream mouths formed where the streams enter the reservoir. Conditions along the reservoir will be different than those that currently exist in the river and are expected to provide a fishery based on different methods and catch quantities. Development potential for a reservoir fishery is outlined in Section 6.0.

Mitigation: Measures are proposed to mitigate loss of riverine fish production, enhance reservoir fisheries production and minimize fish losses from entrainment.

Fish Production in the Reservoir: Loss of fish production along portions of the Indus River and tributaries that will be submerged likely will be offset by fish production in the new reservoir though the mix of species may vary. Natural production may be limited by low recruitment of fish from natal tributaries if comparable amounts of spawning or stream-rearing habitat are not available upstream of submerged areas and later during Stage 2, when Basha is planned to be in operation, by daily drawdown (tentatively estimated to be 1-2m but possibly up to 50m). Potential development of a reservoir fishery to mitigate losses attributed to the new reservoir and to enhance production beyond this minimum need is outlined in Section 6.0.

Fish Entrainment and Mortality at Dam and Powerhouse: Measures to mitigate fish losses from reservoir fish populations and resultant high mortality from fish entrainment in powerhouse intakes, spillway and low level outlets are described in Section 4.2.1.

4.3.1.3 Periodic Flushing of Sediment

Potential Effects: Current plans are to flush the reservoir 15 years after filling once per year, by releasing relatively large volumes of water (potentially, up to 10,800 m3/s) through the lower level outlets over approximately 20 days within one month during May and June as seasonal flows are increasing. Water level in the reservoir will drop to an elevation of 842m, approximately 108 m below FSL (950 m). Water depth close to the dam will reduce to approximately 78m, meaning the reservoir will extend approximately 7 km upstream from the dam (Figure 4.2), a reduction of 2-3 km from the 9-10km at FSL estimated to exist at year 15. Fish in the reservoir will be compressed into a greatly reduced volume and those reliant on benthic organisms, especially periphyton, for food will find very little to feed upon because benthic production below the productive littoral zone (likely extending to depths of only several meters given the relatively turbid conditions expected in the reservoir) will be poor. The perimeter/shoreline length for fish feeding will be reduced. A substantial number of fish likely would be entrained into the outlet structures and deposited downstream (Section 4.2). The number of fish remaining in the reservoir after completion of flushing and reservoir refilling would be lower than before flushing; condition of many remaining fish likely would be poor.

These factors will tend to limit potential for fish production in the reservoir and viability of a reservoir fishery when annual flushing takes place. Water velocities will be relatively high during flushing especially when water elevation reaches minimum levels; safety distances will be needed to keep fishermen at safe distances from the dam spillway and powerhouse intakes.

Mitigation: Mitigation measures include screening at the lower level outlet to prevent fish entrainment in combination with fisheries management protocols to minimize fish numbers vulnerable to the effects of extreme drawdown that will occur during each flushing event.

4.3.1.4 Fish Stranding and Mortality during Reservoir Flushing

Potential Effects: Drawdown for flushing sediment from the reservoir will be kept to a rate meant to minimize risk of landslides; the drawdown rate likely will be adequate to prevent excessive stranding and mortality of species in the reservoir. Taxa such as Himalayan snow trout (*S. plagiostomus*) are benthic feeders with physical adaptations designed for adherence to benthic substrates such as cobbles. They may not respond quickly to a rapid drop in water level and could be vulnerable to stranding.

Mitigation: In the absence of species- and site-specific information a drawdown maximum rate of 5-10cm/hr is recommended until further data are available to minimize stranding. Site-specific ramp-down criteria are often developed for fish downstream from hydropower projects elsewhere and are recommended for DHP project (Section 4.4.1). Results of recommended studies could be used to develop guidelines and monitoring protocols for drawdown during reservoir-flushing and refine expectations for success of a reservoir fishery.

4.3.2 Significance of Potential Effects

The project could have significant adverse effects on fish populations and associated human use as a result of fish entrainments and, during peaking operation, effects of drawdown; effects potentially will be insignificant if proposed mitigation measures are applied and are effective (Table 4.1). Significance before mitigation is summarized in Table 4.11 (this also reflects conditions if mitigation is not effective).

Table 4.11: Significance of Potential Adverse Effects of the Project on Fish upstream of the Dam before Mitigation

	Habitat Change	Effect on Population Sizes	Effect on Human Use
Magnitude	Large change in river features; likely loss of nullah spawning and rearing habitat – expected impairment but amount of current use is not known Replacement with lake-like habitat though water velocities will be high relative to natural lakes and storage reservoirs	Change in species composition expected Change in net abundance of indigenous species uncertain – but possibly net reduction from entrainment during regular operation and flushing under Stage 1 conditions Under Stage 2 – reduced shoreline biological production will reduce fish production	Uncertain Expected reduction
Spatial Extent	Approximately 25% of study area river-length will be converted from river habitat to lake-like habitat	Reservoir area plus linked habitat-use areas in (e.g., nullahs) Uncertain	Reservoir area and nullahs Uncertain
Duration/ Frequency	Long-term/sustained; slow reversion as sediment infill occurs	Long-term; life of reservoir	Long-term
Reversibility	Slow reversion of upper parts of reservoir as sediment infill occurs and possible full reversal with dam removal	Likely over number of generations (of species) – timeframe and full recovery uncertain	Likely over a number of generations (of species)
Likelihood	High	High	High
Significance before mitigation	Potentially significant adverse effects on fish population sizes and human use Assessment is constrained by lack of information on the amount fish use the river and nullahs in the reservoir area (including stream spawning areas), effect of entrainment losses, and species-responses to lake-like environment. Stage 2 likely will cause overall reduction in fish production and harvest		

4.3.3 Data Gaps and Uncertainties

Proposed follow-on studies to address information deficiencies in relation to the amount fish use the river and tributaries in the reservoir area (including stream spawning areas), effect of entrainment losses, and species-responses to lake-like environment are summarized in Table 4.2. Studies should include data collection from reservoirs/lakes in similar environmental settings, including the narrow upper reaches of Tarbela reservoir. Information should include: fish species/locations in the water column and use/movement along shoreline; fish species & sizes at spillway-depth/surface, intake depth, outlet depth; seasonal presence at above locations. Data collected during these studies will benefit planning and design of other dams under consideration for the upper Indus River. Information gaps and uncertainties and proposed follow-on studies to address those deficiencies in relation to interpretation of potential effects upstream of the dam site.

4.4 OPERATION PHASE: DOWNSTREAM OF THE DAM SITE

DHP operation has potential to adversely affect the downstream aquatic ecosystem through alteration of flows, temperature regimes, sediment concentrations and water chemistry. Potential effects could occur during: reservoir first-filling; and longer-term operation and maintenance of the powerhouse, dam and reservoir facilities. Effects of hydroelectric reservoirs on downstream aquatic ecosystems, particularly alteration of flows, have been long-standing concerns (e.g., King 1999, Krchnak 2009).

4.4.1 Potential Effects and Mitigation

4.4.1.1 Downstream Flows during Reservoir First Filling

Potential Effects: The first impounding will start around mid-June. The area between river bed elevation (765m) and crest of starter dam (798m) will be already filled with water during construction. From crest of starter dam to LLO (833m), the filling rate will be done in 1 to 2 daysa few hours. A filing rate of 2m/day will be followed to gradually rise the reservoir level from 833 to 950 m, by releasing the excess flow through LLOs. Once the level 950 m is reached, LLOs will be completely closed. It will take about 60 days for impounding the reservoir. About 215 m^3/s of flow is required to achieve this filling rate, and the remaining flows (above 4,000 m^3/s will be released through LLOs). Even if the reservoir impounding starts in low flow season of February (when the flows are about 385 m^3/s), about 170 m^3/s of flow will be released downstream.

Mitigation: No mitigation measures are proposed since no complete holding back of flows is expected during first filling.

4.4.1.2 Downstream Flows during Stage 1 Routine Operation

Potential Effects: Potential effects of DHP discharge on the downstream aquatic environment are summarized in Table 4.12.

Dam to Powerhouse Tailrace Outlet: This segment of the river, at least downstream from the plunge pool, possibly will be used as an overwintering refuge by fish that spawn and rear in Seglo Creek. Habitat use would be limited to individual fish and other taxa potentially using Seglo Creek or downstream tributaries.

Potential effects during high flow and low flow seasons are:

- *High Flow Season - May to September:* Relatively large water volumes will pass over the spillway during the summer high flow season. Flow and habitat conditions downstream of the plunge pool at that time would be similar to existing conditions. The plunge pool will receive water directly from the spillway – highly turbulent conditions will occur during high flows and habitat will be largely unsuitable for fish and other in-stream biota. The plunge pool essentially would be an exclusion zone for fish and fisheries, with habitat potentially useable by fish from downstream end of plunge pool to tailrace outlet.

  Fish access to Seglo creek could be impaired by turbulence immediately downstream of the plunge pool.

  High discharge from the lower level outlets when the reservoir is periodically flushed to remove sediment is expected to create very turbulent conditions along this stream segment. Habitat conditions would be poor at that time with mobile biota likely displaced downstream during initial stages of water release.

- *Low Flow Season – October to April:* Potentially there could be periods of no inflow to this segment of the river during the low flow season (e.g., if all flow passes through the powerhouse) which would eliminate productive capability of the associated habitat.

Table 4.12: Summary of Potential Downstream Effects during DHP Routine Operation [Stage 1 – Stage 2]

Location	High-flow Season	Low-flow Season
Dam/Powerhouse Operation	Up to 2600 m3/s through Powerhouse Surplus over spillway	**Stage 1:** Run-of-River **Stage 2:** Daily storage to supply max possible during peak-demand hours (approx. 5-10 pm). No or minimal daily release over spillway
Effects on Downstream Aquatic Ecology and Fisheries		
Dam to Tailrace Outlet	**Stage 1 and Stage 2:** Physical habitat defined by natural hydrograph minus up to 2600 m3/s Plunge Pool – turbulent; mainly unsuitable conditions for fish and other biota Downstream from Plunge Pool – similar to existing habitat conditions; at times lower water volumes providing more favourable conditions for fish and other in-stream biota; likely seasonal intrusion by taxa capable of moving into or using low-energy micro-habitat in the otherwise fast-flowing/turbulent conditions	**Stage 1 and Stage 2:** Potentially, all flow could pass through the powerhouse for electricity generation, with no flow from dam spillway to Indus River, apart from a small natural inflow from Seglo Creek and groundwater sources Plunge-pool – possible periodic presence of fish or other biota that enter during low flow conditions Downstream from Plunge Pool – likely seasonal use of residual flow areas by taxa life-stages suitable for small-creek habitat similar to Seglo Creek
Tailrace Outlet to Tarbela Reservoir	**Stage 1 and Stage 2:** Physical habitat defined by natural hydrograph (all Indus River water entering the reservoir will pass through the Powerhouse or over the spillway) Aquatic ecological conditions are expected to be the same as pre-dam conditions	**Stage 1:** Conditions are expected to be similar to those described for the high-flow season **Stage 2:** At times during 24-hour day possibly no flow will pass over spillway or through Powerhouse would be defined by flow from tributaries and base flow for the approximately 18 hour storage cycle, with attenuation downstream of flow release-pulses and habitat effects. In-stream habitat area/volume and wetted-width potentially could be greatly reduced on a daily basis compared to existing conditions; distance between water edge and riparian vegetation/habitat will increase Consequences of reduced amount of in-stream habitat will include: reduced food abundance; reduced growth and survival (from a combination of reduced food and space-competition); increased exposure to predators; increased likelihood of over-harvest Daily pulse of high flow when stored water passes through powerhouse/tailrace followed by sharp flow reduction for storage potentially could cause ratchet-like downstream displacement of some taxa/life-stages Taxa potentially will experience stranding/mortality of individuals in some areas as water-edge recedes during daily reduction of downstream flow for reservoir storage Humans engaged in activities such as fishing or other water edge activities may be

Location	High-flow Season	Low-flow Season
		subject to effects of rising water when daily pulse of powerhouse release-water passes downstream
Tarbela Reservoir	**Stage 1 and Stage 2:** Physical habitat defined by natural hydrograph (all Indus River water entering the reservoir will pass through the Powerhouse or over the spillway) Aquatic ecological conditions are expected to be the same as pre-dam conditions	**Stage 1:** Conditions are expected to be similar to those described for the high-flow season **Stage 2:** Physical changes to habitat from daily cycle of low and high flows may be greatly attenuated by the time flows enter Tarbela Reservoir Tentatively, there potentially would be a daily reduction and increase in water elevation, perhaps most noticeable in the narrow upstream portion of the reservoir In turn this could lead to reductions in habitat features such as reservoir volume and surface area, and creation of a band of shoreline along affected portions of the reservoir which will be characterized by a daily cycle of drying and inundation and reduced biological productivity

Powerhouse Tailrace Outlet to Tarbela Reservoir: Downstream effects on aquatic resources and fishing activity are not expected to be large during Stage 1 (run-of-river) routine operation and may not be measurable/detectable. Run-of-river powerhouse release-flows will reflect natural flow conditions during regular operation (combined powerhouse and spillway flows will meet at the tailrace outlet), with the following seasonal ecological effects:

- *High Flow Season - May to September:* Fish and other organisms should not be affected by flows from the power project; short lag-times (when water flow is diverted or reduced to powerhouse turbines) would cause periodic reductions in downstream flow.
- *Low Flow Season – October to April:* Reservoir inflow is expected to be discharged to this segment of the river during the low flow season with water continuously passing either through the powerhouse or over the spillway. As long as there is no flow interruption, for example for water storage in the reservoir, the functions and productive capability of downstream aquatic habitat and resource use should not be affected.

Tarbela Reservoir: Run-of-the-river operation of the DHP facility, with downstream flows matching those that would occur in the absence of the hydropower facility will result in no change in aquatic habitat features and ecosystem functions. Accordingly, ecological conditions in Tarbela Reservoir and the commercial fishery in the southern portion of the reservoir are not expected to be affected by reservoir operation during Stage 1.

Mitigation: Environmental flows are recommended for the river segment between the dam and tailrace outlet. Following four approaches were considered for designing the environmental flows;

- Montana or Tennant method
- Wildlife Institute of India method
- Experience from Tarbela/Ghazi Barotha hydropower project on Indus
- Hydraulic modeling method

Montana Method: Instream flow regimens in Table 4.13 are based on one of the earliest and simplest environmental flow methods (Montana method), which continues to have widespread application, often modified to suit local conditions. The original method identified percent of average annual flow necessary for suitable conditions in instream habitat: 10% as a minimum *instantaneous* flow to sustain short-term survival; 30% to sustain good survival; and 60% for excellent to outstanding habitat conditions. More recent methods place emphasis on biological and site data in relation to habitat physical features and habitat use by key taxa (King 1999, BC 2003, Krchnak et al. 2009). For the DHP Project there is a paucity of information on characteristics and use of habitat by fish species and other aquatic taxa in the Indus River between Dasu and Tarbela. In the absence of such information, initial use of the Montana values is recommended, with these being refined as information from recommended aquatic ecosystem studies (Table 4.2) becomes available.

According to Montana method, instantaneous flows should not go below 212 m^3/s (10% of mean annual flow, per Table 4.13) to prevent severe degradation. This amount possibly exceeds flows needed to maintain habitat features in order to support the numbers of fish expected.

Table 4.13: Montana Method: Instream Flow Regimens for Fish, Wildlife, Recreation and related Environmental Resources

Narrative description of flows1.	Recommended base flow regimens2.	
	Oct. – Mar.	Apr. – Sept.
Flushing or Maximum	200% of the average flow	
Optimum Range	60%-100% 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 1976

1. Most appropriate description of the general conditions of stream flow for fish, wildlife, recreation and related environmental resources.

2. Percent of average annual flow; months are those presented in the region (northern US) for which values were developed – for the upper Indus River winter flow conditions in December – October are likely more comparable to the ecologically sensitive April-September period shown in the table.

Wildlife Institute of India Method: Wildlife Institute of India (Rajvanshi,et.al 2012) has recommended the environmental flows for hydropower projects on Alakananda and Bhagirathi basin of Ganges (Table 4.14). Snow carps are also the major species in these rivers. The environmental flows in this study are estimated based on 'Building Block Method. According to this method, instantaneous flows at Dasu should not go below 100 m^3/s (20% of mean winter flow) to sustain riverine ecology.

Table 4.14: Minimum flow required to sustain riverine ecology with special reference to fishes in the dry zones of HEPs in the Alakananda and Bhagirathi basins

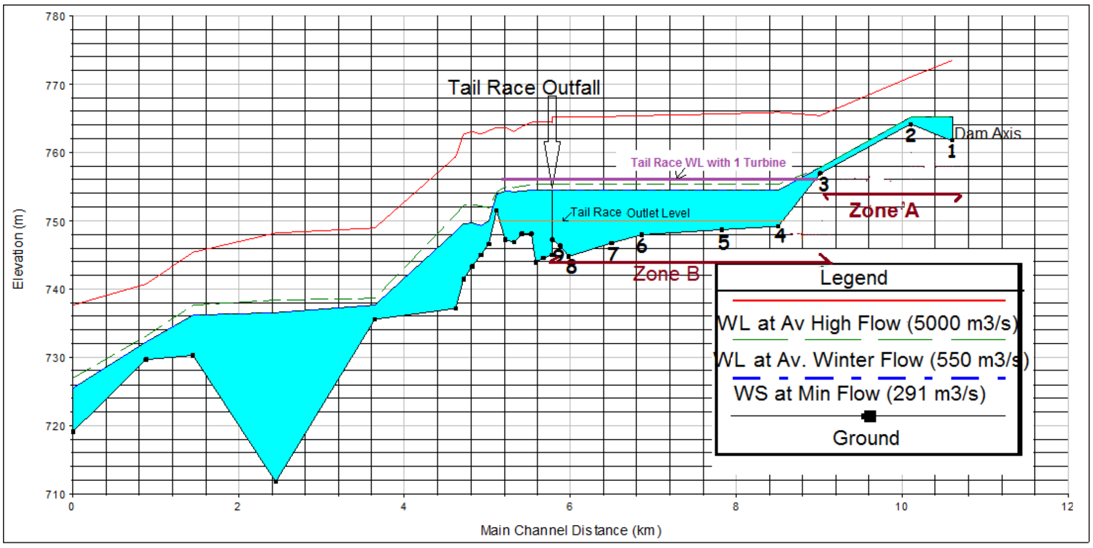
Month	Percentage of Mean Seasonal Flow suggested (%)
June	30
July	30
August	30
September	30
October	25
November	20
December	20
January	20
February	20
March	20
April	25
May	30

Source: Rajvanshi, et.al 2012

Ghazi Barotha Experience: Ghazi Barotha Hydropower project is located on Indus about 200 km downstream of Dasu. It has a 54 km of dewatered section between barrage and tailrace and it is being compensated by 28 m^3/s, which is found to be adequate through a 5-year monitoring program by WAPDA Environmental Cell (WEC 2009). DHP would probably require less flows than the Ghazi Barotha since it has only 4.4 k of dewatered section.

Hydraulic Modelling Method: The river profile on the downstream of the damsite is presented Figure 4.3. The figure also shows the river water levels for lowest recorded flows (291 m^3/s), average winter flows (550 m^3/s) and high flows (5,000 m^3/s). The river between damsite and tailrace is divided in to 10 cross sections. The river profile can be divided in to two zones based on the extent of backwater flows from tailrace: 1.2 km long Zone A, from cross sections 1 to 3 (excluding 0.4 km dam structure and plunge pool), which is located at an elevation above tailrace level (750m); and 3.2 km long Zone B, from cross sections 3 to 10, which is located at an elevation below tailrace water level.

Thus, out of 4.4 km section between plunge pool and tail race, the 3.2 km section (Zone B) upstream of tailrace will receive water from backwater flows of tailrace and the rest 1.2 km (Zone A) will be dry during low flow season.



Source: River bed profile was drawn from sonic survey data of river profile.

Figure 4.3: River Profile on the Downstream of Damsite and River Water Level

Hydraulic modelling has been carried out for this section with a release of 20 m^3/s from dam and release 222.5 m^3/s of water from tailrace, which are tentatively recommended as environmental flows. Summary of expected hydrological characteristics between dam and tailrace for these flows are presented in Table 4.15. The hydrological characteristics for average low season flow of 550 m^3/s are also given in Table 4.15. Release of these environmental flows in Zone A represents 4% of average winter flows, 20 to 25% of average winter depth, 34 to 45% average winter wetted perimeter, and 34 to 45% of average winter velocities. While in Zone B, the release of environmental flows represents 44% of average winter flows, 67 to 97% of average winter depth, 72 to 95% average winter wetted perimeter, and 40 to 60% of average winter velocities.

Table 4.15: Hydrological Characteristics Between Dam and Tailrace for Average Winter Flows and Recommended Environmental Flows

Cross section Number	Distance from Dam, m	Pre-Dam Scenario for an average winter flow of 550 m³/s				Post-Dam Scenario with 20 m³/s from dam and backwater from tailrace (with one turbine flow of 222 m³/s)				Remarks
		River width (m)	Average water depth (m)	Wetted Perimeter (m)	Velocity (m/s)	River width (m)	Average water depth (m)	Wetted Perimeter (m)	Velocity (m/s)	
1 (Dam axis)	0	68.84								This section mostly consists of dam structure and plunge pool (412m)
2	508	73.31	2.59	75.37	2.9	34.01	0.59	34.41	0.99	
3	1,598	50.67	2.29	51.37	4.75	20.37	0.46	20.49	2.14	No backwater flows from tail race.
4	2,107	93.94	4.84	100.74	1.21	76.07	3.25	79.71	0.8	Includes baclwater flows from tailrace
5	2,780	57.24	4.76	63.16	2.02	48.14	3.27	51.21	1.2	*do.*
6	3,750	69.74	4.77	74.79	1.65	65.9	3.69	69.54	0.8	*do.*
7	4,120	78.44	5.04	84.59	1.39	64.08	4.91	68.83	0.6	*do.*
8	4,633	85.66	5.3	95.54	1.21	79.42	4.74	86.42	0.5	*do.*
9	4,733	68.98	6.11	73.5	1.3	66.59	5.36	69.93	0.6	*do.*
10 (Tailrace)	4,833	96.62	5.1	100.59	1.12	97.02	5.15	94.72	0.5	*do.*

Note: the above calculations are approximate and based on the available river bed profile from Sonic Survey (not based on detailed hydrographic surveys)

Conclusion on Mitigation: The results from hydraulic modeling suggest that the release of 242 m^3/s (20 m^3/s from dam and 222 m^3/s from tailrace) will maintain adequate depths and velocities to maintain the winter habitat of snow carps (see Section 3.3.1.5). Sieglo is the only productive tributary in this section and these flows will maintain a depth of 0.5 m and velocity of 2 m/s at Seiglo confluence. These flows will also maintain about 44% of average winter flows and 72 to 95% average winter wetted perimeter in most of the dewatered section. Hence environmental flows of 20 m^3/s from dam and 222 m^3/s from tailrace is recommended for the DHP. A downstream environmental effects monitoring program will be put in place to enable assessment of changes in ecological components and adjust the environmental flows if required.

4.4.1.3 Downstream Flows During Stage 2 Routine Operation

Potential Effects: When the Dasu powerhouse begins functioning as a peaking facility, the daily operation cycle potentially would adversely affect the downstream ecosystem.

Dam to Powerhouse Tailrace Outlet: Potential seasonal effects on aquatic resources are:

- *High Flow Season - May to September:* Effects on aquatic ecology and fish in the dam-to tailrace-outlet segment of the river during Stage 2 will be similar to conditions during Stage 1, though there will be potential for diversion of substantially more flow from the spillway to the powerhouse (more turbines in place). During periods of relatively low natural river flow, especially near the beginning and end of the summer high-flow period, full use of the powerhouse capacity potentially could eliminate flows over the spillway and impair amount and function of aquatic habitat in this stream segment.

- *Low Flow Season – October to April:* Again, similar to Stage 1, potentially there could be periods of no inflow to this segment of the river during the low flow season if all flow is directed to the powerhouse which would eliminate productive capability along the associated river-length.

From Powerhouse Tailrace Outlet to Tarbela Reservoir: Potential effects on aquatic resources and fishing activity during peaking operations could extend downstream for a substantial distance; currently, it appears doubtful that potential effects would extend to the south end of Tarbela Reservoir (approximately 200km downstream) where the commercial fishery is located. Potential seasonal effects are:

- *High Flow Season - May to September:* As with Stage 1, water flows downstream will be the same as those that would occur in the absence of the hydropower project and fish and other organisms should not be affected by flows from the project.
- *Low Flow Season – October to April:* Potentially there could be periods of no inflow to this segment of the river during the low flow season which would eliminate productive capability of the associated habitat, followed by a pulse of water that is directed through the powerhouse and eventually enters the river at the tailrace outlets (described below).

Winter Release-flow Surge: When water is first released (at approximately 17:00) there would be an initial minimum surge of water equivalent to the flow of water passing through one turbine unit (216m³/s; each intake will have a capacity of 648m³/s and will supply water to 3 turbines each with a flow requirement of 216m³/s). The facility will have capability to increase flow in steps of 216m³/s each to the maximum of 2600m³/s. With no further ramp-up capability the initial surge will increase flow from approximately zero flow (which will potentially be the maximum flow over the previous 18 hours when water is stored), to 216m³/s.

The surge would likely cause rapid downstream displacement of fish and other biota (including fish-food organisms) holding in residual pools and channels during the 18 hour storage-period (when downstream flow would be negligible). Smaller fish sizes, notably fry, would be most susceptible to this effect. This effect would occur along the length of the Indus River that experiences the surge until a point is reached where the surge is attenuated to tolerable levels due to inflow from tributaries and groundwater and frictional effects of bottom substrate.

If the potential total release flow would be approximately six to ten times the flow that normally occurs during the winter low flow period. This may occur over approximately 4-5 hours after which release flow potentially would drop to approximately 0m³/s. The high-flow pulse likely would overwhelm the position-holding/swimming ability of species/sizes normally present during flow conditions typical of the winter low flow season.

Repeated daily surges would mean fish use of the Indus River and associated fish production likely would be impaired for the length of stream subject to surge effects.

Timing of surge as it moves downstream would vary along the length of the affected portion of river. Aquatic organisms have differing diurnal patterns of related to feeding, sheltering and so on, with some species for example feeding or sheltering at night and others during the day – biological effects of individual powerhouse surges could vary along the affected length of river.

Fish Stranding/Mortality during Flow Shut-off: High mortality of fish from stranding can occur during rapid ramp down of flows downstream from reservoirs. When DHP flows are reduced after the approximate 4-5 hour energy-generation window, there will be potential for fish to be stranded as the downstream shoreline water level recedes when flow is halted.

The distance downstream that peaking flows would be detectable is not known; flows likely would be attenuated to negligible at some point before reaching the southern end of Tarbela Reservoir. A small daily drawdown in the upper end of Tarbela reservoir may take place potentially leading to reduced biological productivity.

Mitigation: In addition to minimum flow identified for the river segment between the dam and tailrace outlets for Stage 1, measures will be needed for Stage 2 to minimize effects on downstream habitat and biota when flow is reduced downstream during the low flow season.

Flows Downstream of Powerhouse Tailrace Outlet: It is recommended to operate at least one turbine and use additional water for peaking operation. This will ensure release of 222.5 m^3/s from tailrace. The release of 222 m^3/ from tail race and 20 m^3/s from dam will represent 44% of average winter monthly flows on the downstream of tailrace. These flows exceed the recommended environmental flows of hydropower projects in the region. For example, Wildlife Institute of India recommends 20% monthly flows for Alaknanda and Bhagirathi Basins of Ganges during low flow season, Downstream monitoring will be carried out during operation phase and the environmental flows can be increased if required

Ramping Rates: Flow-reduction rates to protect aquatic biota from stranding and mortality downstream from hydropower facilities have been developed in a number of jurisdictions usually based on detailed background knowledge on the biology of target species and site-specific requirements (e.g., PacifiCorp 2004; DFO 2005; Altagas 2010). Such background information is not available for the species known to occur in the project area-of-influence. The period of greatest vulnerability is likely the winter period.

Ramp-down may be possible in finer increments using turbine intake and release water. If the high release flows are moderated by improved ramp-up protocols then stranding can be addressed through improvement of ramp-down procedures.

4.4.1.4 Flows during Reservoir Flushing

Potential Effects: The reservoir will be periodically flushed after 15 years of reservoir operation by releasing water through the lower level outlets. Flow-volumes released during reservoir flushing are not likely to have a sustained negative effect on the downstream ecosystem if peak flows occur within the normal period of seasonal high flows. Relatively high volume discharges are planned for release over approximately one month during late spring. Maximum capacity of the low-level outlets is 10,300 m^3/s; lower discharge amounts may be required to maintain the reservoir drawdown rate within safe limits to prevent landslide events along the reservoir slopes. The potential maximum volume is higher than normal flows over the late spring season and could adversely affect downstream ecological conditions.

High discharge during flushing is expected to create turbulent habitat conditions downstream of the dam though should be similar to conditions that prevail during natural high flow events. Close to the dam habitat conditions would be relatively poor with mobile biota likely displaced downstream during initial stages of water release. There is risk of high mortality of fish resulting from stranding when outlet discharge is reduced in order to fill the reservoir.

Mitigation: Flushing events should not occur earlier than the planned late spring period to prevent possible adverse effects outside the intended timing window especially during the winter low-flow period. Release flows during flushing should be within limits of historical flows for the season over which flows will be released (currently planned for mid-May to mid-June).

A ramp-down rate of 5-10cm/hr, measured at either Tailrace Outlet or Dasu Bridge, is recommended provisionally, and can be refined using recommended project-specific stranding/vulnerability studies (Table 4.2).

Upon completion of flushing during reservoir refill, relatively high release-flows should be adopted to reflect the naturally high minimum flows that occur at that time, if such flows are lower than flows to be released to meet dam safety protocols (to minimize reservoir landslide risks).

4.4.1.5 Sediment

Potential Effects: Under natural conditions, seasonal scouring typically would occur during the summer high flow period, with some particles setting in low-energy areas of the river (e.g., back eddies and small embayments).Downstream habitat, particularly depositional areas where sediments normally would accumulate, will be altered with chronic non-replenishment of particle sizes removed by the reservoir. Some but not all sediment trapped in the reservoir will be released downstream in pulses during periodic flushing of sediment from the reservoir after 15 years of operation. Overall downstream aquatic habitat will experience a net decrease in sediment deposition and associated change in biotic assemblages, likely favoring species that will benefit from reduced amounts of sand and gravel in seasonal deposition and scouring cycles.

Mitigation: Mitigation measures are not proposed because retention of sediment in the reservoir could yield a net benefit to downstream biota and resource use. Environmental effects monitoring during the DHP operations phase should include downstream sample stations and methods selected to assess long-term ecological effects of reduced sediment and, as necessary, with findings used to support development of adaptive mitigation measures.

4.4.1.6 Temperature

Potential Effects: Temperatures are not expected to have large seasonal effects on downstream aquatic biota. Temperature of water passing over the spillway is expected to be the same as the temperature of the reservoir water surface, which is expected to be similar to surface inflow temperatures from the main river possibly with slightly higher temperatures during mid-summer (Section 4.3). Temperature of water released through the powerhouse would reflect temperature in the reservoir at the elevation of the powerhouse intakes (875m, which will be 25-75m below water surface during routine operation) and is expected to be similar to river inflow temperatures because water is expected to be relatively well mixed at those elevations (as noted in Section 4.3, thermal stratification modeling has not been undertaken).

Reservoir flushing is planned to take place over mid-May to mid-June; the reservoir is not expected to be thermally stratified at that time so temperature in release flows is expected to be similar to river temperatures. If flushing takes place over the summer high flow period the reservoir could be weakly stratified with cooler water located in deeper areas where mixing is weak. Cooler water temperatures in discharge from the LLOs temporarily could reduce biological production and temperature-related activities such as fish movement in downstream areas. If water is released before or after the mid-summer high temperature periods, temperature differentials would be relatively low.

Mitigation: Mitigation measures are not proposed but thermal stratification modeling of the reservoir should be undertaken to predict seasonal temperature-depth profiles and aid selection of timing windows for flushing, using results to project temperatures in flushing flows and resultant downstream effects. Environmental effects monitoring during the DHP operations phase should include downstream temperature measurements during key DHP activities for which altered downstream temperatures are most likely, particularly when the lower level outlets are used.

4.4.1.7 Dissolved Oxygen

Potential Effects: Similar to temperature, dissolved oxygen values in water that passes through the powerhouse and over the spillways is expected to be comparable to river inflow values and is not expected to adversely affect downstream biota.

Adverse effects on downstream biota are not expected to result from water released from the low level outlets. Dissolved oxygen concentrations in deeper layers of the reservoir may be reduced in the early years of reservoir operation as remnant organic material decomposes (Section 4.3) and likely during summer as weak stratification occurs. Water released through low-level outlets during summer accordingly may have lower concentration than surface layers, but released water will be very turbulent as it enters the plunge-pool area and oxygen levels would likely increase to ambient levels a short distance downstream.

Mitigation: Mitigation measures are not proposed but thermal stratification modeling of the reservoir should include seasonal oxygen-depth profiles to aid selection of timing windows for flushing, based on projected dissolved oxygen concentrations in flushing flows and resultant downstream effects. Environmental effects monitoring during DHP operations phase should include downstream dissolved oxygen measurements during key DHP activities for which altered downstream oxygen levels are most likely, particularly when the lower level outlets are used.

4.4.1.8 Total Gas Pressure

Potential Effects: Total gas pressure values in the plunge pool and locations further downstream likely would be increased as oxygen and other gases are entrained in water that passes over the spillways and are forced under pressure into plunge-pool water. Spilled water will not enter the plunge pool directly; water will be deflected upwards by the spillway buckets and will enter the plunge-pool at an oblique angle. Entrained gases could reach supersaturation levels in the plunge-pool and for a distance downstream, creating risk of gas bubble disease and subsequent mortality in fish. The oblique angle of spill water entry to the plunge-pool and high turbulence in the plunge-pool likely will limit the amount of excess saturation passing downstream. The amount of gas saturation and distance downstream that elevated levels could occur are not known.

Mitigation: Mitigation measures are not proposed. Environmental effects monitoring during DHP operations phase should include downstream dissolved oxygen measurements during key DHP activities, in particular spillway use, for which altered downstream oxygen levels are most likely.

4.4.2 Significance of Potential Adverse Effects

The project could have significant adverse effects on downstream habitat, fish populations and associated human use especially during Stage 2 peaking operations; effects potentially will be insignificant if proposed mitigation measures are applied and are effective (Table 4.1). Significance before mitigation is summarized in Table 4.15 (this also reflects conditions if mitigation is not effective).

Table 4.16: Significance of Potential Adverse Effects of the Project on Fish downstream of the Dam before Mitigation

	Habitat Change	Effect on Population Sizes	Effect on Human Use
A. STAGE 1: Run-of-River, No Peaking Operation			
Magnitude	1. *Dam to TR outlet*: 4km length of river habitat (5% of study area length) lost or impaired, mainly over winter; use is not known	1. expected small reduction Uncertain	1. expected small reduction Uncertain
	2. *TR outlet to Tarbela*: no change in flow; loss of substrate material; possible water quality changes	2. Possible reduction Uncertain	2. Possible reduction Uncertain
Spatial Extent	Almost 100% of 4km length	Possible reduction	Possible reduction

	Habitat Change	Effect on Population Sizes	Effect on Human Use
	from dam to outlet and uncertain impairment downstream for unknown distance downstream from TR outlet, possibly to Tarbela Critical locations are not known	Uncertain	Uncertain
Duration/ Frequency	Long-term/sustained	Long-term/sustained	Long-term/sustained
Reversibility	Possible over long-term after dam removal	Possible over long-term after dam removal for number of generations (of species) afterwards	Possible over long-term after dam removal for number of generations (of species) afterwards
Likelihood	High	High	High
Significance before mitigation	Adverse effects are expected and may be significant Assessment is constrained by lack of information on distribution of critical habitat, water quality parameters exiting dam facilities, fish presence/abundance and current fish harvest along the river		
B. STAGE 2: Peaking Operation			
Magnitude	1. *Dam to TR outlet*: Same as Stage 1	1. Same as Stage 1	1. Same as Stage 1
	2. *TR outlet to Tarbela*: Potential severe reduction in flow over winter Other factors same as Stage 1	2. Likely large reduction Uncertain	2. Likely large reduction Uncertain
Spatial Extent	*1. Dam to TR outlet*: Same as Stage 1 *2. TR outlet to Tarbela*: Severe habitat reduction could occur downstream for substantial distance downstream from TR outlet, possibly to Tarbela Critical locations are not known	Likely large reduction over long length of stream Uncertain	Likely large reduction over long length of stream Uncertain
Duration/ Frequency	Long-term/sustained	Long-term/sustained	Long-term/sustained
Reversibility	Possible over long-term after dam removal	Possible over long-term after dam removal for number of generations (of species) afterwards – possible permanent effect on sub-specific popula-tions	Possible over long-term after dam removal for number of generations (of species) afterwards
Likelihood	High	High	High
Significance before mitigation	Adverse effects are expected, but may not be significant Assessment is constrained by lack of information on distribution of critical habitat, water quality parameters exiting dam facilities, fish presence/abundance and current fish harvest along the river		

4.4.3 Data Gaps and Uncertainties

Interpretation of potential effects on downstream aquatic resources and assumptions regarding effectiveness or proposed mitigation measures are severely limited by weaknesses in the knowledge base of taxa and ecological communities expected to be affected. Similar weaknesses exist in relation to current resource use amounts, timing, methods and livelihood/consumption linkages. Information gaps and uncertainties and proposed follow-on studies to address those deficiencies are summarized in Table 4.2.

4.5 KARAKORUM HIGHWAY REALIGNMENT

4.5.1 Potential Effects

Potential effects of pre-construction and construction activities on aquatic biota in the Indus River and streams crossed along the realigned Karakorum Highway (KKH) will be similar to those described in Section 4.1 (Pre-construction and Construction Phase) for project infrastructure.

After construction has been completed and the highway is open to traffic the route is expected to function in the same fashion as the old highway. No new potential effects on the aquatic environment are expected.

4.5.2 Mitigation

Mitigation measures outlined in Section 4.1.2 and contained in the Environmental Code of Practices will have to be adhered to in order to protect aquatic ecological resources near the KKH. Monitoring of mitigation measures together with follow-up action will be necessary during pre-construction and construction and at least during the first year after operation and maintenance of the KKH to ensure that unforeseen effects are not occurring.

4.5.3 Gaps and Uncertainties

Inventory of habitat and fish in streams that will be crossed is recommended to support awareness, ecological protection, sustainable fishing and monitoring.

4.5.4 Residual Effects

With proposed mitigation and monitoring programs no residual effects on aquatic resources are expected near the KKH.

5. RESERVOIR FISHERY: POTENTIAL MITIGATION/ENHANCEMENT MEASURES

The slower moving water of the reservoir that will be formed offers potential for development of a reservoir fishery, though relatively fast water velocities will continue to prevail in the upstream portion of the reservoir particularly during the high flow season and sedimentation will rapidly decrease the reservoir size (Figure 4.2).

5.1 MITIGATION

Natural production of fish in the reservoir may be sufficient to offset losses attributed to submergence of fish production areas along the Indus River and tributaries (Section 4.3.2).

Factors that may contribute to lower than expected fish numbers include: fish losses through the powerhouse intakes, over the spillway and through the LLOs (during periodic reservoir-flushing after the first 15 years of operation); mortality caused by fish stranding during reservoir-flushing drawdown; and reduced fish production during Stage 2 when the daily drawdown cycle results in daily drying and desiccation of shoreline areas during winter (with concomitant decrease in fish food production and reproduction sites). Also, mercury contamination of fish tissue as a result of mercury methylation in flooded soils could render the fish unsuitable for human consumption (though this appears doubtful based on initial examination of soil mercury conditions). Fish production assumptions and plans for the reservoir fishery will have to account for these possible sources of fish or fish-use loss.

If natural production is found not to be sufficient to offset losses attributed to reservoir formation or if the fishery is planned to be enhanced beyond that to meet mitigation targets, best practices from a biodiversity perspective include preferential consideration of:

- Indigenous/endemic species [preferred over exotic/introduced species]
- Habitat enhancement for limiting factors, e.g., production of juveniles of reservoir species by improving access to or quality of spawning and rearing habitat within watersheds of affected tributaries [preferred over hatchery production]
- Artificial propagation in hatcheries if habitat enhancement is not viable

For estimating current and future natural production of endemic/indigenous species found in the project area, current biological knowledge regarding habitat use and production should be augmented through further field investigation. Similarly, if a decision is made to produce those fish using hatcheries, knowledge in Pakistan regarding artificial propagation methods for those species is weak and would require a research and development phase to develop and achieve reliable production targets.

Design features and feasibility of components require elaboration and assessment as supporting biological studies on aquatic resources are undertaken (Section 6.0). Development planning for the potential fishery should consider minimum fish production equivalent to estimates of amounts lost, in terms of both fish biological production from pre-reservoir habitat and fish catch for consumption/sale. Planning must also address progressive reduction in reservoir size with possible length of 9-10km by the time that Diamer Basha becomes operational in 10-15 years.

Given weaknesses in biological knowledge in Pakistan of affected indigenous/endemic species development of an R&D component for the proposed hatchery is recommended to undertake applied research on those species, especially Himalayan snow carp, focusing on need to increase biological knowledge related to wild fish and fish habitat management and fish culture. This should be perceived as a facility intended to support information needs of other WAPDA planned and existing facilities in the upper Indus watershed and the KP fisheries agency. Selection of a suitable site will be critical and challenging given the steep topography of the area and frequent occurrence of landslides and washouts; several fish production facilities in the area have been damaged by such events.

Elaboration of the reservoir fishery will require development of detailed plans and designs, including management, monitoring and reporting and surveillance/ enforcement components, and associated technical and financial feasibility analyses.

5.2 ENHANCEMENT

There is opportunity to develop the reservoir fishery beyond that needed to ensure replacement of losses attributed to the reservoir. Plans for expanded development of a reservoir fishery must identify the amount of expected reduction in fish production and reduced harvest that will occur when daily reservoir drawdown takes place during the planned Phase 3 and 4 peaking operation (Stage 2). The reduction in shoreline biological production and fisheries production that will occur as a result of the daily drawdown cycle potentially will reduce benefit of the planned reservoir-fisheries program.

6. RECOMMENDED ACTION PLAN

An adaptive approach is outlined below so that findings of scientific studies recommended to address weaknesses in the knowledge base can be used to refine impact predictions and the type and scale of possible mitigation measures.

6.1 INVESTIGATIONS TO ADDRESS DATA GAPS AND UNCERTAINTIES

Data gaps and uncertainties and recommended studies to address them are summarized in Table 4.2. Studies are directed at: addressing deficiencies in the knowledge base regarding basic biology of key species and assumptions made during impact assessment; and, uncertainties related to the effectiveness of proposed mitigation and enhancement measures.

6.1.1 Biological Knowledge of Key Taxa

Field investigations are recommended to obtain information on:

- Movement patterns and seasonal habitat use (especially over-wintering habitat in the Indus River main-stem) of snow carp and catfish in the Indus River main-stem and adjoining tributaries, to support refinements to impact assumptions and proposed mitigation measures. Development of the downstream Tarbela dam and reservoir has resulted in interference with fish movement, reduction in population abundance of some Indus River fish species and change in species composition of the river length now inundated by Tarbela reservoir (Asianics Agro-Dev Inc 2000). This has occurred in the absence of sufficient knowledge on basic biology to understand and interpret the magnitude and extent of those effects. DHP and additional planned hydropower projects present high risk of incremental contribution to adverse effects on river taxa.
- The proximity of mahaseer to the project site and associated information on seasonal movement timing and type of habitat use.

Studies should have sufficient scope to enable application of acquired data to knowledge-support for other hydropower projects planned or under consideration for the upper Indus River. With this in mind, field data collection should be based on detailed and peer-reviewed study designs and on a long-term multi-year/multi-season data-collection framework. Studies conducted to support hydropower project EIAs thus far appear to have been designed and executed using very short timelines and in a disjointed fashion, weakening the value of data collected.

To aid development of understanding the likely species and their use in the future Dasu reservoir, the upstream portion of Tarbela Reservoir should be used as a surrogate, with comprehensive studies conducted of fish species composition and habitat use and associated limnology. The upstream and central portions of Tarbela reservoir are narrow and deep, comparable to narrow valley conditions at the DHP location, and differ from features in the downstream portion of Tarbela reservoir particularly the relatively wide, shallow basin where the commercial fishery is concentrated. Emphasis should be on obtaining data for species that are known to occur in the Dasu reservoir area and expected to move into the reservoir when created (in particular, snow carp). Study activities should begin by elaboration of information in this document with an expanded review and consolidation of all literature available for key species, augmented with information obtained through meetings/workshops with experts undertaking biological/habitat/culture research on the target indigenous species to focus study objectives and procedures.

Research programs should be developed keeping in mind they will serve needs of all WAPDA and KP projects in the upper Indus River basin.

6.1.2 Effectiveness of Proposed Mitigation Measures

Ability to interpret effectiveness of the proposed mitigation and enhancement measures as part of EA follow-up studies will be hampered in part by the weak knowledge on species in the Study Area as outlined above and on external factors, especially the effect of illegal fishing activities on populations of indigenous species and catch data.

The type and extent of illegal fishing along the upper Indus River and tributaries should be documented to provide estimates of both fish caught and utilized and fish killed but not caught (e.g., left to drift downstream); discussions with local fisheries authorities suggest that widespread use of illegal fishing methods likely have severely affected fish population sizes but data on the magnitude of these effects is not available from government or research institutions. The studies should include estimates of geographical extent and harvest amounts of different types of illegal fishing and effects illegal fishing likely will have on DHP EA post-construction monitoring data regarding fish abundance and estimates of habitat production capability.

6.1.3 Effectiveness of Proposed Enhancement Measures

Predictions of potential fish production and fish harvest in the reservoir should be developed before reservoir creation (planned for 2019) in order to guide needs for tributary enhancement and/or stocking from hatcheries and fisheries management. These predictions can be developed through studies outlined in Section 6.1.1, especially through use of data collected from upper Tarbela Reservoir.

To address possible data-interpretation difficulties related to illegal fishing, potential for development of an area management strategy should be investigated, including consideration for design and implementation of an awareness-building program on sustainable practices, a community-based control or stewardship program and capacity-building for Pattan Fisheries and possible community-level management organizations.

6.2 REFINEMENT OF MITIGATION/ENHANCEMENT MEASURES

Studies should be timed for completion well in advance of project construction and operational activities for which data are to be used, to enable refinement of measures to mitigate effects on aquatic resources and expand on designs for enhancement activities (in particular, development of a reservoir fishery). These investigations are expected to take place over a decade with high priority studies initiated in 2013 prior to planned start of pre-construction and dam-construction activities in 2014, and with additional studies conducted prior to reservoir first-filling in 2019.

6.2.1 2014 - 2015: Prior to start of in-stream pre-construction activities in 2015

The priority before construction activities commence in mid-2014 is to collect data on fish movement patterns to confirm that measures to mitigate potential adverse effects on fish migration are needed. These should be completed far enough in advance of coffer-dam and diversion-tunnel placement (currently scheduled for mid-2014) to enable final mitigation decisions, designs and implementation – with this timing constraint, studies should be undertaken over the expected timing of snow carp adult movement to tributary spawning areas (onset of increasing flows April-June) in 2013 and possible movement out of tributaries into the main-stem (adults and sub-adults) as flows decline in the fall, with supplementary data-collection anticipated for 2014. The proposed hatchery is intended to serve both as a facility to compensate for dam-blockage of indigenous fish movement to upstream spawning areas and to support enhancement of the reservoir fishery or local fish culture. If fish movement and biodiversity is found not to be impaired by the dam, the compensation component and associated broodstock capture activities would be eliminated.

6.2.2 2015-2019: prior to reservoir first-filling in 2019

Additional data collection is recommended before the reservoir is filled and the powerhouse begins operation, scheduled to occur approximately five years after start of construction, to refine mitigation measures to be applied during the operational phase. In summary, recommended investigations include:

- *Seasonal fish habitat-use*: to identify types and locations of critical habitat especially during winter low flow season in the main-stem of the Indus River to confirm seasonal minimum flow requirements and aid design and planning of reservoir fishery – supporting studies, planning and detailed implementation plans completed before reservoir first-filling (planned for 2019). These will also support assessment of potential changes (reductions) in fish production in the reservoir and downstream areas if/when facilities in Stage 2 convert to peaking operation (tentatively 2031).
- *Fish, fish habitat and fisheries in upper Tarbela Reservoir*: to aid design and planning of reservoir fishery - supporting studies, planning and detailed implementation plans completed before reservoir first-filling (2019).
- *Fish production potential of reservoir tributaries*: to assess ability of tributaries to supply natural contribution of juveniles to reservoir fish stocks.
- *Reservoir modeling to confirm predicted likelihood and amount of thermal stratification:* to provide support for interpreting both in-reservoir and downstream potential chemical and biological conditions.
- *Carrying capacity analyses to identify fish production potential of planned reservoir:* based on and in conjunction with the above studies, morphoedaphic conditions, estimates of nutrient concentrations and trophic conditions, and use of nutrient-based production models.
- *Illegal fishing activity in the project study area:* to support interpretation of DHP data on mitigation/enhancement effectiveness during EA follow-up studies.

6.3 INSTITUTIONAL NEEDS AND MANAGEMENT/COORDINATION

To support implementation of mitigation measures and associated studies the following institutional support is anticipated:

- *Dasu Project* – Assistant Director Ecology of the Project Environmental Unit (section 9 of Volume 2: EIA) should be assigned responsibility for long-term planning and coordination/implementation of the fisheries investigations so that study findings are produced in a timely way to support development of mitigation and enhancement measures and associated monitoring programs to assess effectiveness.
- *WAPDA* - must provide timely support for design and implementation of scientific investigations, in particular understanding the need for and assistance with long lead-times for proper preparation of field studies and long-term benefits of these investigations for other HP projects planned for the upper Indus River watershed.
- *Local Fisheries Agency Personnel* – must be actively engaged at all stages to support development of scientific study designs, integration with local fisheries data collection needs, enable skill-training participation and use and dissemination of information collected.

  Capacity-building will be necessary and should be based on an institutional and capacity-building assessment undertaken with the KP fisheries Department of Fisheries. This should encompass and place priority on biodiversity considerations related to protection of habitat and populations of indigenous species, and development of fisheries, including aquaculture, based on those species.

Current staff levels are not adequate to enable oversight of DHP fisheries mitigation and monitoring requirements and likely will require assignment of and support for two senior personnel and four technical assistants to participate in these activities. These individuals should be assisted by six support-personnel for administration, vehicle/boat operation and field activities. Personnel will need: a vehicle; boat; sampling equipment; and, building space sufficient for administration and office-technical functions, boat, and vehicle and equipment storage and maintenance.

6.4 COSTS

Detailed Costs and budget plan for anticipated studies, mitigation and enhancement measures during DHP implementation are given in EMAP Volume 8: EMP and implementation schedule is shown in Table 7.1. Cost estimates are summarized below.

6.4.1 Studies during implementation

Costs of studies recommended for execution before reservoir filling are:

- 2013-2014 - $300,000 (including intensive study preparation and design, which should involve thorough literature review and interviews/meetings with national/international experts)
- 2015-2019 - $300,000
- 2020-2030 - $200,000

6.4.2 Mitigation Measures

Mitigation measure cost allocations are provided below recognizing that outcomes of initial studies to reduce uncertainties could mean that some mitigation may not be necessary.

6.4.2.1 Mitigation of Overall Impact on Fish

Compensation Hatchery: The hatchery would have a component to receive broodstock from natural spawning populations of migrant snow carp and other indigenous species affected by the project and produce young from this broodstock for release to the Indus River or tributaries. It would have additional facilities to support research and development related to culture of the indigenous species and additional fish production facilities to supply fish for stocking the reservoir or local grow-out ponds. Approximately 4 hectares of land would be required; site selection would be based on a water supply with suitable volume and quality, sufficient land area not vulnerable to washout or landslides, and suitable vehicle access. The hatchery would include facilities for hatching and rearing, laboratory analyses, food preparation, storage of equipment, food and supplies, vehicles and administration. Staff would be comprised of one manager, two assistant managers and 15 workers including watchmen and a driver.

The combined hatchery and R&D facility is estimated to cost approximately $600,000 plus annual operating costs ($1,200,000 over ten years).

Table 6.1: Implementation Schedule for Management of Impacts on Aquatic Resources

	Pre-construction						Construction																																Operation Phase II Construction					
	2014				2015				2016				2017				2018				2019				2020				2021				2022				2023				2024-2027			
Activity	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1.Monitoring of Aquatic Ecology & Fishery	■	■	■	■	■	■	■	■		■				■				■				■				■				■				■				■				■		
2.Mitigation of Aquatic Ecology and Fishery impacts; Fish Hatcheries			■	■	■	■	■	■	■	■	■	■																																

Broodstock Capture: Provisional indicative costs are provided for catch of adult fish of target species from locations downstream of the dam and transporting to the hatchery and stocking of the juveniles in the tributaries. Estimated costs are: $200,000 for design, installation of fish-trap/catching facilities, capture and handling equipment, vehicles equipped with fish containers and oxygen, training and operational protocols; allowance for annual operating costs $300,000 ($30,000/yr x 10 years); total $600,000 for installation and operation for ten years.

6.4.2.2 Fish Entrainment and Exclusion Screens

Fish entrainment and exclusion screens may not be necessary. However, an allowance is provided for placement of removable fish entrainment screens on head ends of the two diversion tunnels and the penstock intakes, and removable fish adult-exclusion screens on the outlets of the diversion tunnels and tailrace outlets. Estimated costs for entrainment and exclusion screens are: $400,000, if study results demonstrate need and subject to technical and financial viability and feasibility studies. Fish deterrent devices can be used alternatively if installation of exclusion screens are not technically feasible.

6.4.3 Enhancement Measures

An allowance is provided for opportunities to enhance habitat in reservoir tributaries (improvement of quality of or fish-access to spawning and rearing habitat) to increase natural production of juveniles entering the reservoir. A provisional cost estimate is: $100,000.

Similarly, an allowance is provided to construct fish landing facilities to support fishermen engaged in reservoir fishing activities; the estimated cost is: $200,000.

6.4.4 Institutional Support and Management/Coordination

Capacity-building for assisting with field studies and biodiversity management (KP fisheries personnel): $50,000.

Capacity-building for reservoir fisheries management: $50,000.

Community/fisherman-awareness program (habitat protection; fish resource protection; illegal fishing): $40,000.

6.5 PROPOSED MONITORING PROGRAM

6.5.1 Upstream of Dam

As part of the EA process, the DHP environmental effects monitoring program should include baseline and post-construction data-collection components to address the following:

- Limnological conditions in reservoir: Temperature-depth profiles; DO-depth profiles; turbidity and suspended solids; other water quality parameters
- Fish production in tributary habitat and contribution to reservoir fish populations:
- Fish abundance and composition in reservoir
- Amount of fish entrainment through outlet portals (powerhouse intakes; spillways; lower level outlets) and associated mortalities and loss from reservoir fish populations and/or effectiveness of measures to mitigate entrainment
- Effectiveness of reservoir fishery enhancement measures
- Mercury in tissue of fish species consumed by humans:

- Effectiveness of measures to aid upstream movement of fish, if measures have been implemented based on studies undertaken before pre-construction activities (Section 6.1)
- Confirmation that other aquatic biota including birds, amphibians/reptiles and mammals have not been affected by project activities

6.5.2 Downstream of Dam

The monitoring program should include components to address the following:

- Effects of sediment deposition in the reservoir (not all will be flushed) on downstream habitat and fish abundance, especially pools and other over-wintering habitat (monitoring should include elements to detect changes in habitat substrate particle-sizes and benthic food production)
- TGP levels at distances downstream including the stream segment between the plunge-pool/spillway area and powerhouse tailrace-outlet
- Temperature, dissolved oxygen, suspended solids and turbidity levels, especially during sediment flushing
- Effectiveness of minimum flows in the dam-to-tailrace-outlet segment (during Stage 1 and reservoir refill after flushing) and throughout the zone-of-influence during daily storage-release cycles anticipated for Stage 2
- Effectiveness of ramping rate limits on preventing fish mortality from stranding during flow ramp-down (such reservoir refill after flushing and during Stage 2 when water is held-back for daily storage)
- Confirmation that other aquatic biota including birds, amphibians/reptiles and mammals have not been affected by project activities

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APPENDICES

List of Appendices

APPENDIX – 2.1

METHODS AND FINDINGS OF FIELD VISIT CARRIED OUT IN APRIL 2012 OF THE PROJECT AREA

1. GENERAL

A field survey of the Project area was carried out by Prof. Tahir Omer in the month of April 2012 between 11th and 22nd. The objective of the survey was to collect hydro-biological data from sites previously marked during the survey visit carried out between 7th February and 12th February 2012. Three persons were engaged including two fisher men, Fazal-e-Akbar and Muslim Khan along with one guide Muhammad Noor. Fisheries department of KP made available the services of Mr. Hanseer Khan. Mr. Ahsan Tufail was the representative of WAPDA.

2. METHOD

Thirteen (13) sites were selected as listed below (Table 2.1.1 – Table 2.1.4) from locations identified during February survey visit. In each site netting was carried out, fish samples collected, physico-chemical of water conducted and microfauna samples were collected for further identification.

Table 2.1.1: Left bank sampling sites and their location in the reservoir area

Sr. No.	Name of the Stream	SS GPS Coordinates	Elevation (m)	Distance from Dam Axis along the river (km)
1.	Uchar	N35° 17.363’ E73° 31.300’	814.3	2.2
2.	Barseen	N35° 21.880 E73° 12.033	834.0	5.6
3.	Kaigah	N35° 24.038 E73° 12.195’	879.5	10.7
4.	Lutar	N35° 29.532’ E73° 17.722’	957.9	24.0
5.	Summar	N35° 30.365’ E73° 28.244’	957.9	35.0
6.	Harban	N35° 32.121’ E73° 36.111	1004.2	57.23

Table 2.1.2: Right bank sampling sites and their location in the reservoir area

Sr. No.	Name of the Stream	SS GPS Coordinates	Elevation (m)	Distance from Dam Axis along the river (km)
1.	Duga	N35° 22.89’ E73° 11.09’	891.0	8.6
2.	Kandia	N35° 26.807 E73° 12.454’	845.5	14.51
3.	Uttar	N35° 24.065’ E73° 12.153’	854.8	8.6
4.	Tanger	N35° 31.726’ E73° 30.453’	1073.4	47.98
5.	Darel	N35° 32.549’ E73° 35.007’	980	56.18

Table 2.1.3: D/S Sampling sites left bank

Sr. No.	Name of the Stream	SS GPS Coordinates	Elevation (m)	Distance from Dam Axis along the river (km)
1.	Jalkot Nullah	N35° 15.419’ E73° 13.345’	797.2	9.1

Table 2.1.4: D/S Sampling sites right bank

Sr. No.	Name of the Stream	SS GPS Coordinates	Elevation (m)	Distance from Dam Axis along the river (km)
1.	Sieglo	N35° 18.72’ E73° 10.832’	881.4	2.5

3. FIELD DATA COLLECTION

3.1 Data on Fishes Species & Fishery Activities

Fishing efforts during the trip yielded three species of snowcarps, one species of mountain catfish and one species of mountain loach as field below (Table 2.1.5 – Table 2.1.8). The snowcarps were Schizothorax plagiostomus, Schizopyze esocinus and Racoma labiate. The only catfish species present was Glyptosternum reticulum. The one species of mountain loach was Triplophysa microps.

Table 2.1.5: Fish caught from left bank U/S during sampling of April 2012

Sr. No.	Species	Uchar	Barseen	Kaigah	Lutar	Summar	Shatial	Harban	Total
1.	Schizothorax plagiostomus (Gahi)	1	2	1	1	1	1	3	**10**
2.	Schizopyge esocinus (Chakhat /Swati)	-	-	-		1	1	-	**2**
3.	Triplophysa spp. (Jungli Chemo)	2	1	-		-	-	-	**3**
4.	Glyptosternum spp.	4	-	-	-	-	-	-	**4**
Sub Total		**7**	**3**	**1**	**1**	**2**	**3**	**3**	**19**

Table 2.1.6: Fish caught from right bank U/S during sampling of April 2012

Sr. No.	Species	Duga	Kandia	Uttar	Tangir	Darel	Total
1.	Schizothorax plagiostomus (Gahi)	2	-	-	-	-	**2**
2.	Schizopyge esocinus (Chakhat /Swati)	-	-	-	-	-	**-**
3.	Triplophysa spp. (Jungli Chemo)	1	-	-	-	1	**2**
4.	Glyptosternum spp.	2	-	-	-	-	**2**
Sub Total		**5**	**-**	**-**	**-**	**1**	**6**

Table 2.1.7: Fish caught from left bank D/S from Dam Axis

Sr. No.	Species	Jalkot	Total
1.	Schizothorax plagiostomus (Gahi)	1	**1**
2.	Schizopyge esocinus (Chakhat /Swati)	-	**-**
3.	Triplophysa spp. (Jungli Chemo)	-	**-**
4.	Glyptosternum spp.	2	**2**
	Sub Total	**3**	**3**

Table 2.1.8: Fish caught from right bank D/S from Dam Axis

Sr. No.	Species	Seiglo	Total
1.	Schizothorax plagiostomus (Gahi)	4	4
2.	Schizopyge esocinus (Chakhat /Swati)	-	-
3.	Triplophysa spp. (Jungli Chemo)	-	-
4.	Glyptosternum spp.	2	2
	Sub Total	**6**	**6**

The netting efforts resulted in a yield, 80% composed of snowcarps with Schizothorax plagiostomus being the predominant species. The specimen collected were measured, weighed & placed in 10% formalin.

3.2 Gonads Conditions

The fish collected were examined for their gender and the gonads status. 80% were found to be males and the rest were females. All the females were spent. Two males were still oozing milt.

3.3 Stomach Contents

The gut contents of S. plagiostomus reveals a diet composed mainly of algal matter. The gut contents of S. esocinus reveals a diet composed of algal matter and remnants of insect larvae.

3.3.1 Data on Aquatic Organisms

Plankton samples were identified with the help light microscope with the result tabulated below (Table 2.1.9 & 2.2.10):

Table 2.1.9: Microflora

Sr. No.	Parameters	Sampling Stations						
		I	II	III	IV	V	VI	VII
		Darel	Tanger	Kandia	Summar	Barseen	Uchar	Indus
1	Blue green algae	+	+	+	+	+	+	+
2	Green algae	+	+	+	++	++	++	-
3	Red algae	+	-	-	-	+	-	-
4	Diatom	++	++	++	++	++	++	+

Table 2.1.10: Macrofauna

Sr. No.	Parameters	Sampling Stations						
		I	II	III	IV	V	VI	VII
		Darel	Tanger	Kandia	Summar	Barseen	Uchar	Indus
1	Protozoons			+				
2	Cnidarian		+	+	+	+		
3	Copepods	+	+	+	+	+	+	
4	Insects/larvae	+	+	++	+	+	+	+
5	Molluscans	++	+	++	++	+		+

3.4 Physico-chemical analysis of water

Water samples were collected from the sampling station and tested pH, DO, Conductivity, T.D.S and temperature. Results are given in Table 2.1.11 – 2.1.14).

Table 2.1.11: Physico-chemical analysis result

Sr. No.	Name of the Stream	Water Temp. (°C)	pH	D.O (ml/l)	TDS (mg/l)	Conductivity (µS/cm)
1.	Uchar	15.2	7.1	8.2	51.2	82
2.	Barseen	15.2	7.1	7.1	52.67	82.3
3.	Kaigah	15.2	7.1	11.8	39.1	61.2
4.	Lutar	14.2	7.1	8.25	36.032	56.3
5.	Summar	13.6	7.0	7.2	40.43	66.3
6.	Sazin	17.4	7.2	8.0	69.76	109.8
7.	Harban	17.2	7.0	9.7	19.408	77.2

Table 2.1.12: Physico-chemical analysis result

Sr. No.	Name of the Stream	Water Temp. (°C)	pH	D.O (ml/l)	TDS (mg/l)	Conductivity (µS/cm)
1.	Duga	13.1	7.1	7.3	53.18	83.1
2.	Kandia	15.4	7.2	7.2	52.48	82
3.	Uttar	15.7	7.0	9.0	32.96	51.5
4.	Tanger	17.4	7.2	8	73	114.7
5.	Darel	16.5	7.2	9.7	50.56	79

Table 2.1.13: Physico-chemical analysis result

Sr. No.	Name of the Stream	Water Temp. (°C)	pH	D.O (ml/l)	TDS (mg/l)	Conductivity (µS/cm)
1.	Jalkot	15.4	7.0	7.9	53.24	83.2

Table 2.1.14: Physico-chemical analysis result

Sr. No.	Name of the Stream	Water Temp. (°C)	pH	D.O (ml/l)	TDS (mg/l)	Conductivity (µS/cm)
1.	Sieglo	15.8	7.3	8.9	71.68	112

APPENDIX – 2.2

METHODS AND FINDINGS OF INVESTIGATIONAL TRIP FROM 24TH AUGUST TO 3RD SEPTEMBER, 2012

1. INTODUCTION

A field survey was undertaken from 24th August upto 3rd September 2012 by the aquatic ecologist team comprising Dr. William George, Prof. Tahir Omer, Mr. Weelif Uzziah, and Mr. Nafees Gill. The objective of this survey visit was to collect data on biophysical features of sampling sites, to determine river water resources, water flow pattern, data on water quality, biological information / data, fish fauna & diversity, fishery activities, socio-economic status of fishermen, other micro & macro fauna of the project area.

2. METHODS

2.1 Sampling Station

19 sampling stations were fixed to carry on the sampling. At each station water samples for physic-chemical tests, plankton samples and fish samples were collected to determine the existing condition, information on site location and their surroundings habitat were also collected from satellite images (enclosed as annexures). Flow pattern sedimentation and bed strata were also identified. Information on these sampling stations are given in Table 2.2.1.

Table 2.2.1: Detail of Sampling Stations

Sr. No.	Location	Code	Distance from Dam Axis (km)	Elevation (m)
	Left Bank (upstream) Tributaries			
1.	Ucchar Gah	UG	10.5	833
2.	Barseen Gah	KG	08.0	878
3.	Kaigah	KG	10.0	
4.	Summar Gah	LR	24.00	988
5.	Shatial Stream	SG	54.00	995
6.	Harban Gah	HG	57.23	1000.4
	Right Bank (upstream) Tributaries			
7.	Duga Gah	DG	08.00	891.0
8.	Kandia River	Kr	04.8	845.5
9.	Uttar Gah	UG		
10.	Tangir River	Tr	47.98	1073.4
11.	Darel River	Dr	56.00	980.0
	Downstream of Dam			
	Right hand Tributaries			
12.	Seglo Nullah	SN	2.5	881.4
13.	Keyal Nullah	KN	28.0	797.2
	Left hand Tributaries			
14.	Jal Kot Nullah	JN	9.1	797.2
15.	Pallas Nullah	PN	27.0	701.0
	River Main Passage			
16.	Tangir Bridge (upstream)	TR	18.00	1073.4

Sr. No.	Location	Code	Distance from Dam Axis (km)	Elevation (m)
17.	Near Kaigah (upstream)	KG	10.00	879.5
18.	River before Dasu (downstream)	RD	07.00	840.0
19.	River after Jalkot Nullah (downstream)	RJ	07.50	797.2
20.	River (8 km) from Dasu (downstream)	RD	15.00	797.2

2.2 Field Data Collection

2.2.1 Physico-chemical parameter

Data on air & water temperature, pH, conductivity & Dissolved Oxygen were collected at site with help of Quick Analysis Kits. Through Environmental Kit, titration values of hardness, alkalinity, CO_2, NH_3, Acidity nitrate, phosphate & sulfate were determined. H_2O depth, photic zone, water colour odour & floating vegetation were observed & recorded at site.

2.2.2 Biological data

Plankton nets having varied mesh sizes (#40mm, #60mm, #80mm) were applied to collect plankton samples (phyto & zooplankton). Stones were turned ups & down in order to catch macrophytes. Floating submerged and littoral vegetation were collected and preserved for identification.

2.2.3 Fish species

In order to collect the fish samples local fishermen were engaged who applied gillnets in river mainstem and castnets in adjoining streams. Collected samples were preserved in plastic bottles and jars with 5 – 10% formline and Ethanole immediately at site. Further morphometric features like length, weight, scales on dorsal fin, number of fin – rays were recorded at site. Injures during fishing or abnormalities were also recorded.

2.2.4 Fishery data

Data on fishing, fishermen, fish transportation, processing, dealing and marketing were collected. Catching technique were both active and passive types. Castnets, having #40mm, #50mm were applied in adjoining streams for the occasional fishing.

Gillnets having #15mm, 25mm, #35mm were utilized to set in river passage. At all sampling station, fishermen were contacted and interviewed. Information on their fishing practice, catches & utilization were obtained and recorded in the prescribed proformas.

Subsistence fishery were experienced. Very limited no of fisherman used to sell their catches in local markets or to hotel owners.

2.3 Laboratory investigations

Preserved samples were transported in Limnological Laboratory F. C. College University Lahore where planktons were identified and tabulated (site-wise). Plankton Taxonomic key and related literature were used for identification. Identified fish samples were also verified with help of Taxonomic keys developed by Prof. M.R. Mirza. Fish samples were examined morphologically recording their abnormalities. Fish samples were dissected to study and determine their gonad status.

Gut content material were also examined, identified and documented to confirm the feeding habits of fishes.

3. COLLECTED DATA / FINDINGS

3.1 Data on Sampling Sites

Information on geographical, meterological, hydrological, fishery biological and other biotic community of the project area were collected from the previous study reports and concerned offices and officials.

3.1.1 Geographical

Project site lies in Kohistan district of Khyber Pakhtunkhaw province having total area of 7492 km². Indus river originating from Mansorawar Lake in Tibet runs about 3058 km long and considered as the longest river. Throughout the whole passage, it meets varied type of physical, geological, meterological and hydro-biological conditions. Its ecosystem is categorized into (i) Peak mountain area (ii) Foothill mountain passage (iii) Plain area passage (iv) Semi-desert passage (v) Delta region [M.R. Mirza - 1975].

3.1.2 Meterological

Air temperature is the key parameter in determining the river flows rather than rainfall. The effect of monsoon wind is negligible due to orographic effect. The temperature in the lower parts may rise to 41°C or 42°C in summer. In winter temperature goes -2° upto 21°C. Month-wise data was obtained from surface water and hydrological survey station of wapda. (given in Table 2.2.2 – 2.2.3).

Table 2.2.2: Monthly Maximum & Minimum Air Temperature (ºC) of Project Environment

Month	Chilas		Kandia		Pattan		Besham	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
January	11	0.27	1.6	-1.1	19.2	3.3	21.7	3.3
February	17.7	2.8	-5	-7.2	19.3	4.9	27.8	2.2
March	19.8	9.2	-0.5	-2.7	25.1	9.5	35.2	8.9
April	24.5	12.6	21.6	16.6	33.0	13.1	38.3	10.0
May	30.7	16.8	32.7	22.2	37.6	16.1	43.4	9.2
June	35.7	22.7	36.1	28.3	37.6	19.6	45.6	17.8
July	39.6	26.8	35.5	30	38.5	27.4	44.5	18.9
August	38.7	26.3	32.2	27.7	38.0	22.3	40.0	18.3
September	35.2	23.6	27.7	23.3	35.2	18.2	39.5	17.2
October	27.1	13.7	26.1	19.4	31.2	12.6	34.5	10.0
November	19.7	10.5	15.0	10	27.0	9.2	28.9	6.7
December	13.2	2.61	3.3	0.5	20.2	5.1	25.6	4.4

Source: *Hydrological &Survey Stations, DHC 2012*

Table 2.2.3: Precipitation in mm of Project area

Month	Chilas	Kandia	Pattan	Besham Qila
January	11.1	40.93	148.1	94.5
February	16.9	62.03	242.0	138.3
March	32.3	29.08	169.2	158.4
April	32.3	40.19	130.8	111.4
May	36.8	27.20	85.6	64.8
June	29.5	04.92	61.1	67.8
July	10.0	19.62	114.1	124.4
August	13.3	26.68	67.5	123.5

Month	Chilas	Kandia	Pattan	Besham Qila
September	6.2	10.72	46.8	70.1
October	10.1	24.18	38.3	48.7
November	5.8	08.51	64.4	37.2
December	10.1	38.62	109.7	58.8

Source: *H&S Stations, DHC 2012*

3.1.3 Hydrological features

In order to determine the hydrological Characteristics, mean annual flows measured at different hydrological station as presented in Table 2.2.4.

Table 2.2.4: Mean Monthly Flows at Dasu Dam site

Month/Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Jan	399	457	387	425	408	436	444	486	507	505
Feb	380	399	370	396	393	404	453	474	484	465
Mar	367	374	363	383	424	439	600	472	462	463
April	806	442	482	614	720	711	636	551	1167	495
May	2948	2950	2317	2205	2786	2379	2177	4128	3405	1994
Jun	5458	3526	4711	5190	644	5539	4926	3207	4984	8020
July	7947	5633	6828	5543	6761	5295	10124	7012	5465	6635
Aug	6941	5171	5517	7824	5280	5285	6054	8123	6332	6404
Sept	2879	2843	2011	2215	2773	3393	3788	3602	2797	1969
Oct	1038	951	987	1025	973	1042	1194	1426	981	1054
Nov	679	560	564	666	703	652	750	749	647	687
Dec	455	475	433	489	528	503	550	593	540	561

Source: *Dasu Hydropower Consultants Report "Vol-I, Hydrology", 2012*

3.2 Data on Water Quality

During the investigational visit, physic-chemical parameter (water temperature, scchi disc depth, color, odor, pH, conductivity alkalinity, hardness, Diss. Oxygen, CO_2 and nitrate & others) were measured & observed through environmental kits in order to determine the primary data. At each sampling station, observations were recorded in prescribed proforma (Form Limnological B – Annexure). All field data collected are processed and tabulated which are given in the Table 2.2.5.

Table 2.2.5 provides the results of water quality analysis. The ranges of key water quality parameters are conductivity 63-149 µS/cm, hardness 30 – 110mg/l, Dissolve Oxygen 4.8 – 7.4 and NO_3 0.20 – 1.20mg/l. The water contains high amounts of maximum sediment load (sand, clay & silt).

Water quality of adjoining streams (Nullahs) bring snowmelt and glacier water into Indus river. 14 adjoining streams (6 stream of left hand (upstream) & 5 stream on right hand bank of Indus river & three at downstream) contribute about 8% water into Indus river.

Due to their geo-structural variations, the water parameters of adjoining streams indicated varied observations. The values of these parameters are given in Tables 2.2.6 and 2.2.7.

The data given in Tables 2.2.6 and 2.2.7 represent only value of summer season hence the water parameters determined during feasibility study have been considered and is reproduced in Table 2.2.8.

Source of adjoining streams are melted snow from mountain peaks which flow from high altitude towards river passage through steep gradient.

Water of all nullahs/stream were colorless, clear, odorless, transparent and cold. As the snowmelt water flows rapidly and violently, caries very little contamination. Ifs movement enhanced the quantity of Dissolved Oxygen which ranges 5.0 upto 10.0 mg/l. mostly level of DO remain 5.0 – 7.0, Conductivity remained also lower due to presence of low dissolved solids(30 – 80mg/l) . Due to erosion process, sand & gravel settle down at the bottom. Nutrients (low NO_3) are also limited & reflect the poor productivity of water (oligotrophic status).

Detailed analysis of water quality conducted under the present EIA study is given in Section 3 of Volume 2 EIA. Traces of chromium and mercury & zinc have been detected in the stream waters.

Table 2.2.5: Physico-Chemical Observations of Main Stem Indus River

Sampling Station	Upstream			Downstream			
	Main river near Tangir Bridge	Main river near Kaigah	Main river before Dasu Bridge	Main river near Dasu	Main river from conflu-ence Jalkot	Main river near Jalkot	Main river 8 km from Dasu
Sampling Station No.	**(9)**	**(15)**	**(17)**	**(16)**	**(14)**	**(18)**	**(19)**
Parameters							
- Sample Date	28.08.12	31.08.12	31.08.12	31.08.12	01.09.12	01.09.12	01.90.12
- Sample Time	03:30 pm	13:30 pm	05:30 pm	05:30 pm	11:15 am	05:30 pm	05:30 pm
- Air Temperature (ºC)	32	31	35	35	33	33	22
- H_2O Temperature (ºC)	15	24	15	15	19	16	18
- H_2O depth (ft)	50	50	18.0	70	15.0	15.0	15.0
- Secchi disc depth (m)	0.15	0.15	0.5	0.3	0.5	0.5	0.5
- H_2O Color	Muddy	Muddy	Mudday / Sandy	Muddy	Mudday / Sandy	Mudday / Sandy	Mudday / Sandy
- pH	6.5	6.5	7.0	7.0	6.5	7.0	7.0
- Conductivity (µS/cm)	75	63	149.0	149.3	148.0	132.3	154.4
- Alkalinity (mg/l)	45	46	90	190	72	65	75
- Hardness (mg/l)	110	51	60	60	30	48	42
- Dissolve Oxygen (DO) mg/l	6.8	4.8	7.4	7.4	7.4	5.5	5.5
- Carbon dioxide (DCO_2) mg/l	13	10	16	10	12.5	12.5	12.5
- NO_3 (mg/l)	1.20	0.41	0.50	0.20	0.40	0.30	0.84

Source: *Data collected during investigational survey in August 2012*

Table 2.2.6: Physico-Chemical Observations of adjoining tributaries in Upstream Area

Sampling Station	Uchar Stream	Berseen Stream	Kandia River	Kaigah Stream	Chori Stream	Summar Stream	Darel River	Tangir River
Sampling Station No.	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
Parameters								
- Sample Date	26.08.12	26.08.12	31.08.12	27.08.12	27.08.12	27.08.12	28.08.12	28.08.12
- Sample Time	10:20 am	11:45 am	10:30 pm	10:15 am	02:00 pm	12:20 pm	11:20 am	01:45 pm
- Air Temperature (ºC)	31	32	32	32	37	38	30	31
- H_2O Temperature (ºC)	20	27	14	21	20	18	17	14
- H_2O depth (ft)	1.5	2.0	5	1.5	2.0	2.0	2.5	1.5
- Secchi disc depth (m)	1.0	1.0	0.15	0.45	0.3	0.6	0.45	0.45
- H_2O Color	Colorless	Colorless	Colorless	Colorless	Colorless	Colorless	Greenish	Colorless
- PH	6.5	6.5	6.5	6.5	6.5	6.5	7.0	6.5
- Conductivity (µS/cm)	55	105	57	56.7	28.2	30.6	80.6	68
- Alkalinity (mg/l)	50	15	50	150	35	135	90	40
- Hardness (mg/l)	30	120	90	150	30	180	120	84
- Dissolve Oxygen (DO) mg/l	10	5	5.2	5.5	6.5	6	6.5	7
- Carbon dioxide (DCO_2) mg/l	10	20	0	10	10	50	15	15
- NO_3 (mg/l)	1.40	1.70	1.50	1.50	0.34	0.46	0.90	1.50

Source: *Data collected during investigational survey in August 2012*

Table 2.2.7: Physico-Chemical Observations of adjoining tributaries in Downstream Area

Sampling Station	Goshali Stream	Sieglo Stream	Jalkot Stream	Palas Stream	Keyal Stream
Sampling Station No.	**(3)**	**(10)**	**(11)**	**(12)**	**(13)**
Parameters					
- Sample Date	26.08.12	29.08.12	29.08.12	30.08.12	30.08.12
- Sample Time	05:00 pm	11:00 am	04:45 pm	12:45 pm	04:30 pm
- Air Temperature (ºC)	32	26	34	37	31
- H_2O Temperature (ºC)	21	19	19	19	16
- H_2O depth (ft)	3.5	2.5	2.0	2.5	1.5
- Secchi disc depth (m)	2.5	1.5	1.0	2.5	1.5
- H_2O Color	Colorless	Colorless	Colorless	Colorless	Colorless
- PH	7.2	7.0	6.5	7.0	7.0
- Conductivity (us)	123.8	168.2	43.2	69	32.3
- Alkalinity (mg/l)	90	105	50	50	60
- Hardness (mg/l)	144	92	75	90	90
- Dissolve Oxygen (DO) mg/l	70	7.0	6.0	6.5	7.0
- Carbon dioxide (CO_2) mg/l	29	15	14	13	15
- NO_3 (mg/l)	0.50	0.81	1.70	0.40	0.81

Source: *Data collected during investigational survey in August 2012*

Table 2.2.8: Water Analysis of Tributaries performed in Sampling Sept. 2007 & Jan. 2008

Parameter	Uchar		Barseen		Summar		Kandia		Darel	
	Sep.07	Jan.08	Sep.07	Jan.08	Sep.07	Jan.08	Sep.07	Jan.08	Sep.07	Jan.08
- H_2O Temperature	12.6	7.5	12.9	7.5	14	7.2	12.5	7.2	12.2	7.2
- Ordor	Darkness	Darkness	Od.	Od.	Od.	Od.	Od.	Od.	Od.	Od.
- Taste	Tasteless	Tasteless	Tasteless	Tasteless	Tasteless	Tasteless	Tasteless	Tasteless	Tasteless	Tasteless
- pH	6.6	7.9	6.7	7.8	6.8	8.0	6.8	8.2	7.7	8.1
- DO (mg/l)	8.5	8.1	8.7	8.2	8.0	7.8	8.0	7.9	7.6	7.7
- Turbidity (N.T.U)	7.4	9.1	6.2	9.5	7.0	8.2	7.1	9.2	14.5	7.9
- Conductivity (us/cm)	28.8	44.8	37.3	46.3	18.1	43.6	28.7	46.2	37.7	40.8
- T.D.S (mg/l)	17.3	29.8	21.73	30.0	41.5	26.1	28.0	28.1	20.2	26.8
- NO (mg/l)	0.9	2.64	1.1	2.58	1.62	2.59	1.4	2.6	0.9	2.5
- Cl (mg/l)	2.0	3.3	1.75	3.0	2.5	2.8	1.4	3.5	2.8	2.6

Source: *Feasibility report 2009 Sampling 28.09.07, 28.01.08*

3.3 Data on Fishes Species & Fishery Activities

Fish catch data is given in Tables 2.2.9 to 2.2.14.

Table 2.2.9: Fish caught from Left Bank Streams during Sampling of April 2012

		Uchar	Barseen	Kaigah	Summar	Shatial	Harban	Total
Cyprinidae								
Schizothoracinae								
1.	Schizothorax plagiostomous (Gahi)	-	2	1	1	1	3	**8**
2.	Schizopyge esocinus (Chakhat /Swati)	-	-	-	-	1	-	**1**
3.	Triplophysa spp. (Jungli Chemo)	-	1	-	-	-	-	**1**
	Sub Total	**-**	**3**	**1**	**1**	**2**	**3**	**10**

Table 2.2.10: Fish caught from Right Bank Streams during Sampling of April 2012

		Sieglo	Duga	Kandia	Utter	Tangir	Darel	Total
Cyprinidae								
Schizothoracinae								
1.	Schizothorax plagiostomous (Gahi)	2	-	-	-	-	-	**2**
2.	Schizopyge esocinus (Chakhat /Swati)	-	-	-	-	-	-	**-**
3.	Triplophysa spp. (Jungli Chemo)	1	-	-	-	-	1	**2**
	Sub Total	**3**	**-**	**-**	**-**	**-**	**1**	**4**

Table 2.2.11: Fish caught from Left Bank Streams during Sampling of Aug. 2012

		Uchar	Barseen	Kaigah	Summar	Shatial	Total
Cyprinidae							
Schizothoracinae							
1.	Schizothorax plagiostomous (Gahi)	-	1	2	4	-	**7**
2.	Schizopyge esocinus (Chakhat /Swati)	-	1	-	1	-	**2**
	Sub Total	**-**	**2**	**2**	**5**	**-**	**9**

Table 2.2.12: Fish caught from Right Bank Streams during Sampling of Aug. 2012

		Duga	Kandia	Tangir	Darel	Total
Cyprinidae						
Schizothoracinae						
1.	Schizothorax plagiostomous (Gahi)	-	5	3	3	**11**
2.	Schizopyge esocinus (Chakhat /Swati)	-	1	-	1	**2**
3.	Triplophysa spp.	-	-	1	1	**1**
3.	Glyptosternum reticulum	-	-	-	1	**1**
	Sub Total	**-**	**6**	**4**	**5**	**15**

Table 2.2.13: Fish caught from Left & Right Streams of downstream from Dam Axis

		Sieglo	Keyal	Jalkot	Goshali	Palas	Total
Cyprinidae							
Schizothoracinae							
1.	Schizothorax plagiostomous (Gahi)	11	1	3	2	1	**18**
2.	Schizopyge esocinus (Chakhat /Swati)	-	-	1	-	-	**1**
3.	Triplophysa spp. (Jungli Chemo)	1	-	1	-	-	**2**
4.	Glyptosternum reticulum	1	-	1	-	-	**2**
	Sub Total	**13**	**1**	**6**	**2**	**1**	**23**

Table 2.2.14: Catch Composition of adjoining streams of the Project Area

		Upstream	Downstream	Total	% age
Cyprinidae					
Schizothoracinae					
1.	Schizothorax plagiostomous (Gahi)	18	18	36	76.5
2.	Schizopyge esocinus (Chakhat /Swati)	4	1	5	12.0
3.	Triplophysa spp. (Jungli Chemo)	1	2	3	06.4
4.	Glyptosternum reticulum	1	2	3	06.4

Most of the catches (nearly 77%) are snowcarp (Schizothorax plagiostomus). Other fishes like Catfish, Glyptosternum reticulum were rarely caught.

3.4 Fish biological data

3.4.1 Morphometric data & occurrence

Morphometric data catches collected are presented in Table 2.2.15.

Table 2.2.15: Morphometric data of Fish samples

Fish Species	Common Name	Total samples	Average Length range	Average Weight range
Family – Cyprinidae			**(cm)**	**(gm)**
1. Schizothorax plagiostomus	Swati	36 ♂ – 21 ♀ – 15	15.0 – 30.0	25.0 – 115.0
2. Schizopyge esocinus	Chakhat	5 ♂ – 2 ♀ – 3	16.0 – 31.0	34.0 – 137.0
3. Racoma labiate	Chohan	3 ♂ – 1 ♀ – 2	19.0 – 35.0	35.0 – 157.0
Family – Noemachielidae				
4. Triplophysa spp	Jungli Cheno	2 ♂	6.5 – 8.5	7.0 – 14.0
Family – Sisoridae				
5. Glyptostesnum reticulum	Konozobo	2 ♂ – 1 ♀ – 1	7.0 – 11.0	8.0 – 15.0

Among snowcarps, Racoma labiate offers better size & taste relatively. Varied length & weight of S. plagiostomus showed slow growth in cold water.

3.4.2 Feeding habits of Snowcarps

In order to determine the feeding habits, gut content of some fish samples were removed at site, preserved in 7 – 10% formalin, transported in the laboratory and were investigated in the F.C. Limnological Lab. Very limited number of fish samples could be examined and investigated, although more samples were preserved, the gut content were decayed, so could not identified. Gut content analysis is given in the Table 2.2.16. Gut content analysis of snowcarp.

Gut content of fish revealed that S. plagiostomus feed mostly on phytoplankton (Diatoms & Algae). Some samples have eaten rotifers & Cyclops (Zooplankton). Stomach was full with 80% material which was digested by 60%. Only undigested material could be identified by 40%.

Table 2.2.16: Gut content analysis of Snowcarp

Sr. No.	Sample Location	Fish Sample	Gut Fullness (%)	Condition	Rotifers	Copepod	Phytoplanktons	
							Diatoms	Algae
1.	Seiglo Nullah	Schizothorax plagiostomatus	80%	70% digested 30% undigested	Euchlanis Trichocerca	-	Cymbella spp Diatoma spp Navicula spp Gomphonema spp Syndera spp Fragilaria spp	Ulothrix zonata Closteriopsis longissima Lyngbaya spp
2.	Jalkot Nullah	Schizothorax plagiostomatus	80%	60% digested 40% undigested	-	Cyclops	Fragilaria spp Cymbella spp Achnanthes spp	Closteriopsis longissima
3.	Darel Nullah	Schizothorax plagiostomatus	90%	90% digested 10% undigested	-	-	Fragillaria ssp Cymbella spp Synedra spp Nitzchia spp	Gomophonema mobiliforme
4.	Kandia River	Schizothorax plagiostomatus	70%	80% digested 20% undigested	Proales	-	Fragilaria spp Cymbella spp Navicula spp Gomphonema spp Synedra spp	Ulothrix zonata Lyngbaya spp
5.	Summer Nullah	Schizothorax plagiostomatus	80%	70% digested 30% undigested	-	-	Fragilaria spp Cymbella spp Nitzchia spp	Closteriopsis Longissima Gomophonema moniliforme

3.4.3 Gonads Conditions

As some fish samples were dissected immediately at site in order to preserve their gut content, their gonads status were also examined. Their genders were also identified. Observations are given in Table 2.2.17.

Table 2.2.17: Gonad Status of Schizothorax plagiostomus

Sr. No.	Length (cm)	Weight (gm)	Gender	Gonad Condition
1.	15.0	18.0	n.d.	Developing
2.	17.5	25.0	n.d.	Developing
3.	18.0	35.0	♂	Ripening
4.	19.0	63.0	♀	Spent
5.	19.5	70.0	♀	Spent
6.	20.0	87.0	♂	Spent
7.	21.5	90.0	♀	Spent
8.	23.0	99.0	♀	Spent
9.	27.0	110.0	♂	Spent
10.	30.0	115.0	♀	Spent

n.d. = not determined ♂ – 40% ♀ – 60%

Below 18cm length, sample was not even mature (developing stage). Rest all samples were spent which revealed that they have already spawned.

3.5 Fishery activities data

Investigation on fishing practices, gear, efforts, catches (species & quantity), fishermen status (social & financial), fish consumption, processing & handling & market were conducted. Two local fishermen (Muhammad Ashraf & Sher Khan) were engaged to assist the team in the fish sampling from different sites. Fishing efforts and their success were also recorded in the prescribed forms.

3.5.1 Fishing for samples collection

19 sampling stations were established in both Indua mainstem and in the tributaries to collect fish samples. Fish species caught in river mainstem are given in Table 2.2.18 and from the streams are given in Table 2.2.19.

Table 2.2.18: Fish caught from river Mainstem

Fishing site	Date	Fishing mode	Fishing efforts	Fish Catch		
				T. weight	Species	Frequency
Indus river confluence with Kaigah stream	27.08.12	Cast net	6	210 gms	Schizothorax plagiostomus	8-jovinial
Kaigah Mian river	31.08.12	Gill net	3 hrs	145 gms	Schizothorax plagiostomus	3
River mainstem after confluence of Jalkot	01.09.12	Cast net	6	100 gms	Schizothorax plagiostomus	1
River mainstem before Dasu bridge	01.09.12	Gill net	3 hrs	NIL	-	-

Due to violent rapid flow in the river mainstem, the fishing operation provided partial success. Only one species of snowcarps (Schizothorax plagiostomus) were caught. Both nets (Cast nets & Gill nets) were tried. Cast nets provided better result. Although gill nets were set out in protected area (less water velocity & wind action) but still results were very limited.

Fishing in tributaries provided different results. Mostly cast netting were tried in different riffles and pools. Fishing efforts & output are given in the Table 2.2.19.

Table 2.2.19: Fishing in Tributaries and their catches

Date	Site	Fishing mode	Fishing efforts	Fish Catches			
				T. Weight	Species	Frequency	Size
26.08.12	Uchar Nullah	Cast net	6 (90min)	500gm	S. plagiostomus	1	-
26.08.12	Barseen Nullah	Cast net	4 (30min)	240gm	S. plagiostomus	4	-
		Dip net	2 (20min)	150gm	Glyptosternum reticulum	2	-
27.08.12	Kaigah Nullah	Cast net	6 (60min)	170gm	S. plagiostomus	6	Juveniles
28.08.12 10.00	Summer Nullah	Cast net	4 (40min)	125gm	S. plagiostomus	2	-
28.08.12 11.30	Darel Nullah	Cast net	10 (60min)	170gm	S. plagiostomus	2	-
28.08.12 14.20	Tangir river	Cast net	10 (45min)	NIL	-	-	-
31.08.12 10.30	Kandia river	Cast net	15 (90min)	600gm	S. plagiostomus	7	5 juveniles
29.08.12 10.30	Sieglo Nullah	Cast net	15 (90min)	1300gm	S. plagiostomus	19	7 juveniles
		Dip net					
30.08.12 12.30	Palas Nullah	Cast net	10 (60min)	NIL	-	-	-
30.08.12 16.30	Keyal Nullah	Cast net	8 (45min)	NIL	-	-	-

In the tributaries juveniles were also caught.

3.5.2 Fishermen Interview

During the study in August 2012, fishermen were contacted and interviewed to collect informations on fishermen particulars, their family status, skill & fishing practices, nets applied and their catches (quantity & quality) processing, handling & marketing, their income & expenditure and their concern about fishery. All the informations collected were recorded in prescribed proforma. Summary of recorded data is given under Table 2.2.20.

Table 2.2.20: Fishery Data of Dasu Hydropower Project

Sr. No.	Fishing site / Name of Fisherman	Fishing Practice	Fishing gear	Cost of the nets	Fishing duration / effort	Total catch quantity	Species caught	Use	Income
A.	**Sieglo Nullah**								
1.	Sher Khan	Part time	Cast nets	2500/-	03 hours / 15 efforts	1000gms	02 species snow carp	DC	0.0
2.	Salmbar	Part time	Cast nest	2500/-	03 hours / 15 efforts	400gms	02 species snow carp	DC	0.0
3.	Ashraf Khan	Part time	Cast nets	3000/-	03 hours / 15 efforts	600gms	02 species snow carp	DC	0.0
4.	Saeed Shah	Part time	Cast nets	2500/-	Few hours in evening	300gms	Snow carp	DC	0.0
5.	Muhammad Yahya	Part time	Cast nets	2500/-	Few hours in evening	250gms	Snow carp	DC	0.0
B.	**Kaigah Nullah**								
6.	Saeed Shah s/o Malik Imran Khan	Part time	Cast nets	2500/-	3hrs	300gms	Snow carp	DC	0.0
7.	Kadurat Khan	Part time	Cast nets	2500/-	10 efforts / one hour	400gms	02 species snow carp	DC	0.0
C.	**Barseen**								
8.	Hanseer Khan	Part time	Cast & Gill nets	2500/-	6hrs evening/ night	300gms	Snow carp species	DC	0.0
D.	**Main Passage of Indus river**								
9.	Lall Sharif	Part time	Cast & Gill nets	3000/-	04 hours / night fishing	600gms	02 species snow carp	DC	0.0
10.	Nur Baz s/o Abdul Qadir	Part time	Cast & Gill nets	Fishing months (Feb, Mar, Apr,)	07-10 kg/ day	300gms	Snow carp	DC	0.0
11.	Anwar Fazal	Part time	Cast & Gill Nets	2500/-		350gms	Snow carp	DC	0.0
12.	Sohaib Taj	Part time	Cast & Gill nets	3000/-	04 hours / night operation	300gms	Snow carp	DC	0.0
13.	Noor Baz	Part time	Set net	3000/-	Few hours in evening	300gms	Snow carp	DC	0.0
14.	Mudassar Hussain	Part time	Gill nets	2500/-	Once a week 07-10kg	420gms	Snow carp	DC	0.0
15.	Awais Khan	Part time	Cast & Gill Nets	2500/-		300gms	Snow carp	DC	0.0

DC = Domestic Consumption

Source: Field investigations in August 2012

Table 2.2.20 elaborates that fishermen used to catch fishes occasionally and as part-time fishing only for their domestic utilization. Due to limited fish fauna, the intensive efforts and long duration gave very discouraging results.

Fishermen applied Cast nets mostly in addition to Gill net, Setnet in the mainstem of Indus. Most of the fishermen used to catch limited quantity of fishes comprising of snowcarp species. Normally these fishermen conduct fishing operation in order to meet their domestic requirement. Catches were mostly consumed by themselves. No selling or commercial consumption could be observed. During interview, some fishermen reported to perform fishing in spring season (Feb, Mar, April). Production estimation or yield could not be assumed from the available data.

3.6 Data on Aquatic Organisms

3.6.1 Phytoplankton

Plankton samples were identified in Limnological lab of Biology Department F.C. College Lahore. Lab examination of plankton samples revealed out the presence of 59 different species of phytoplankton belonging to major group, blue green algae – Cyanophyta (7 species); chlorophyta – Green algae (10 species); brown algae Chrysophyta (24 species); Xanthophyta (one species only) in upstream area.

From downstream area, samples 35 species of phytoplankton have been identified. Details of identified species and their occurrence are presented in Table 2.2.21-2.2.23.

Table 2.2.21: Phytoplankton Identification of river Indus mainstem

Sampling Station / Algae groups	Upstream			Downstream		
	Indus river near Tangir	Main river near Kaigah	Main river before Dasu	Main river near confluence Jalkot	Main river after Jalkot	River 8km away from Dasu
Cyanophyta						
– Cyanophyacoe						
• Anaebanc spp	-	+	-	+	+	-
• Oscillatoria spp	-	+	+	+	+	-
• Phormidium spp	-	-	-	-	-	+
Chlorophyta						
– Chlorophyceae						
• Closteriopsis spp	+	-	-	+	-	+
• Oedogonium spp	-	+	-	-	+	-
• Ulothorix spp						
Chrysophyta						
– Chrysophyceae						
• Navi cula spp	-	-	+	-	+	-
• Cymbella spp	-	+	+	-	+	-
• Nitzschia spp	-	+	-	+	+	+
• Pinnularia spp	+	-	+	+	-	-
• Synedra spp	+	+	-	+	+	+

Source: *Sampling during August / September 2012 trip at project site.*

Table 2.2.22: Phytoplankton identification upstream tributaries

Group	Uchar	Barseen	Kaigah	Chori	Summer	Darel	Tangir	Kandia
Cyanophyta								
– Cyanophyacoe								
• Anaebanc spp	-	-	+	-	+	+	-	+
• Johanneslaptista spp	-	-	-	-	-	+	+	-
• Oscillatoria spp	-	+	-	-	-	-	+	+
• Phormidium spp	-	+	-	-	-	-	+	-
• Spirulina spp	-	-	-	-	-	+	-	-
Chlorophyta								
• Schroederica spp	-	-	-	-	+	-	-	-
• Closteriopsis spp	-	-	-	-	+	+	-	-
• Cladophora spp	-	-	-	+	-	-	-	+
• Tetradon spp	-	-	-	-	-	-	+	-
• Ulothorix spp	+	+	+	-	+	-	-	+
• Nitzschia spp	-	-	+	-	-	+	+	-
• Fragilaria	-	+	-	-	+	-	-	+
• Synedra spp	+	-	-	+	-	+	+	+
• Tabellari spp	-	-	-	+	-	-	+	-
Melasiraceac								
• Melosira spp	-	-	-	-	+	-	-	+
• Clorella spp	+	-	-	-	+	-	+	-
Xanthophyta								
• Tribonema spp	+	-	-	-	-	+	-	-

Source: *Sampling during August / September 2012 trip at project site.*

Table 2.2.23: Phytoplankton identification of downstream tributaries

Sampling Station / Algae groups	Left hand Streams			Right hand Streams		
	Sieglo	Kayal	Dubair	Jalkot	Goshali	Pallas
Cyanophyta						
– Cyanophyceae						
• Anaebana spp	-	+	+	-	+	-
• Oscillatoria spp	-	-	-	+	+	-
• Cylindrospernum spp	+	-	+	-	-	+
• Phormidium spp	-	-	-	+	-	+
• Spirulina spp	-	-	-	-	+	-
• Cyanobactonia ssp	+	-	-	-	-	-
Chlorophyta						
• Closteriopsis spp	-	-	-	-	+	-
• Cladophora	-	-	+	-	-	-
• Tetaredrsus spp	-	-	-	-	-	-
• Closterium spp	-	+	-	+	-	-
• Spirogyra spp	-	-	+	-	-	-
• Ulothorix spp	-	-	-	+	-	-
Chrysophyta						
• Acanthes	-	-	-	-	+	-
• Cymbella spp	+	-	-	-	-	+
• Navicula spp	+	-	-	-	-	-
• Pinnularia spp	+	-	+	+	-	-
• Nitzschia spp	+	-	-	+	-	+
• Fragiluria spp	-	-	-	-	-	+
• Synedra spp	+	-	+	-	-	+

Sampling Station / Algae groups	Left hand Streams			Right hand Streams		
	Sieglo	Kayal	Dubair	Jalkot	Goshali	Pallas
• Diatoma spp	-	-	-	+	-	-
Xanthophyta						
• Tribonema spp	-	-	+	-	-	-

Source: *Sampling during August / September 2012 trip at project site.*

3.6.2 Micro fauna

Zooplankton samples were identified under microscopic examination and Taxonomy keys. It was fond only one species of protozoan and prifera, two species of rotifers, one species of arthropods and platyhelminthese in upstream and downstream area of the project. Detail of zooplankton is given in Table 2.2.24-2.2.26.

Table 2.2.24: Zooplankton identification in river mainstem

Group	Upstream		Downstream	
	River Main stem Kaigah	River Main stem before Dasu	River Main stem Jalkot	River Main stem 8km down from Dasu
Protozoa				
• Paramecium spp	-	+	+	-
Rotifer				
• Koratella spp	-	-	-	-
• Euchlanus	-	+	-	-
• Branchionus spp	+	+	-	+
Cladocera				
• Bosmina spp	-	-	+	-
Decapods				
• Cyclops spp	-	+	-	-
Insecta				
• Damsel Nymph	+	-	+	-
• Caddish Larvae	-	+	-	-

Source: *Sampling during August / September 2012 trip at project site.*

Table 2.2.25: Zooplankton Identification upstream tributaries

Group	Uchar	Barseen	Kaigah	Chori	Summer	Darel	Tangir	Kandia
Protozoa								
• Paramecium spp	-	+	-	-	+	-	-	-
Rotifer								
• Koratella spp	-	-	-	-	+	-	-	+
• Branchionus spp	-	-	-	-	-	-	+	-
• Tansignus spp	-	-	-	-	+	+	+	-
Cladocera								
• Bosmina spp	+	-	-	-	-	+	-	-
Decapods								
• Cyclops spp	-	-	+	-	+	-	-	-
Insecta								
• Caddish fly Larva	-	-	-	-	-	+	+	-

Source: *Sampling during August / September 2012 trip at project site.*

Table 2.2.26: Zooplankton Identification of downstream tributaries

Group	Left hand Streams			Right hand Streams		
	Sieglo	Kayal	Dubair	Jalkot	Goshali	Pallas
Protozoa						
• Paramecium spp	-	-	-	+	-	-
• Tintinnidum spp	-	-	-	-	+	-
Rotifer						
• Koratella spp	-	-	+	-	-	-
• Branchionus spp	-	+	-	-	-	-
• Tansignus spp	-	-	+	-	+	-
Cladocera						
• Bosmina spp	+	-	-	-	-	-
• Daphnia	-	+	-	-	+	-
• Ceriodaphnia	-	-	-	-	-	+
Decapods						
• Cyclops spp	-	+	-	-	+	-
• Diaptomus	-	-	-	+	-	-
Insecta						
• Caddish fly Larva	+	-	+	-	-	+
• Damsel fly Nymph	-	+	-	+	-	-
Mulluscans						
• Limnxea spp	-	-	-	-	-	-
• Valvata spp	+	-	+	-	+	-

Source: *Sampling during August / September 2012 trip at project site.*

3.7 Information on Fishery Organization and establishments

(Source: Fishery Directorate Peshawar)

Dasu project area falls in Kohistan district of Khyber Pakhtunkhwa province. KP fishery Directorate (at Peshawar) has deputed fishery officer (District fishery office Grade 17) who has setup his office at Pattan.

KP Fishery department established Dubair Fish Hatchery for Trout culture in 1990 with a production capacity of 0.05 million to 0.10 million fish fries. This hatchery remained functional upto 2010 flood which washed away the whole establishment. Restoration of Dubair Trout hatchery is still in process.

KPK fishery department has also established the following fishery structures to promote the trout culture in the area.

1. **Kaigah Trout Raceways** (constructed in 2011)

   Dimensions:

   Length: 5 meter
   Width: 1.5 meter
   Depth: 1 meter

2. Jalkot Raceways
(constructed in 2004)
02 km of downstream
Dasu bridge left bank

Dimensions:

Length: 3 meter
Width: 1.5 meter
Depth: 1.5 meter

3. Sieglo Raceways
(constructed in 2002)

Dimensions:

Length: 4 meter
Width: 1.5 meter
Depth: 1.5 meter

Trout Raceways at Kandia were also constructed but those were completely washed away during flood 2010.

Details of staff at Fishery department at Pattan are given in Table 2.2.29.

Table 2.2.27: Staff at Kohistan Fishery

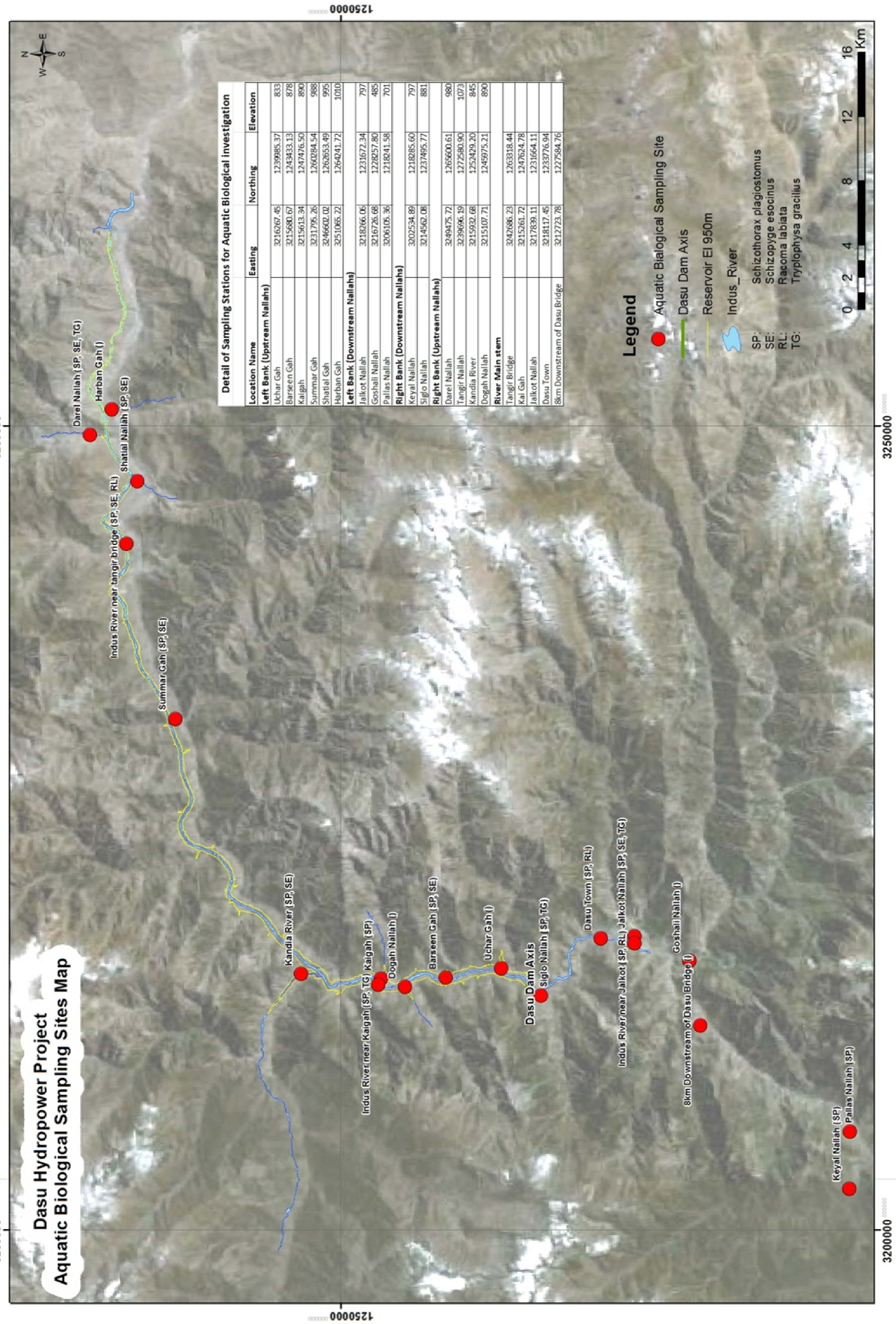
Sr. No.	Designation	BPS	No. of Positions
1.	District Fishery Officer	17	1
2.	Trout Culturist	11	1
3.	Fishery Supervisor	9	1
4.	Head Fishery Watcher	7	1
5.	Junior Clerk	7	1
6.	Fishery Watcher	5	6
7.	Driver	5	1
8.	Naib Qasid	1	1
9.	Chowkidar	2	2
		Total No. of Staff	**15**

Annual Budge (2011 – 12) **Rs. 3,217,290/-**

Salaries = Rs. 2,424,290 Operational = Rs. 793,000

APPENDIX – 2.3

Locations of Aquatic Biological Sampling Sites



Detail of Sampling Stations for Aquatic Biological investigation

Location Name	Easting	Northing	Elevation
Left Bank (Upstream Nallahs)			
Uchar Gah	3216267.45	1239985.37	833
Barseen Gah	3215680.67	1243433.13	878
Kaigah	3215613.34	1247476.50	890
Summar Gah	3231795.26	1260284.54	988
Shatial Gah	3246602.02	1262653.49	995
Harban Gah	3251065.22	1264241.72	1010
Left Bank (Downstream Nallahs)			
Jalkot Nallah	3218266.06	1231672.34	797
Goshali Nallah	3216726.68	1228257.80	485
Pallas Nallah	3206105.36	1218241.58	701
Right Bank (Downstream Nallahs)			
Keyal Nallah	3202534.89	1218285.60	797
Siglo Nallah	3214562.08	1237495.77	881
Right Bank (Upstream Nallahs)			
Darel Nallah	3249475.72	1265600.61	980
Tangir Nallah	3239696.19	1272580.90	1073
Kandia River	3215932.68	1252429.20	845
Dogah Nallah	3215107.71	1245975.21	890
River Main stem			
Tangir Bridge	3242686.23	1263318.44	
Kai Gah	3215261.72	1247624.78	
Jalkot Nallah	3217839.11	1231664.11	
Dasu Town	3218117.45	1233776.94	
8km Downstream of Dasu Bridge	3212723.78	1227584.76	

APPENDIX – 3.1

FISH FAUNA OF THE RIVER INDUS REPRESENTED IN PAKISTAN

Nos.	Fish Fauna	NA	HZ	KASH	CHIT	SW	DIR	VPES	WBN	IND.B	PUNJ.	SIND.
I.	**Family Clupeidae**											
	1. Gonialosa manmina	-	-	-	-	-	-	-	-	-	+	-
	2. Gudusia chapra	-	-	+	-	-	-	-	-	+	+	+
	3. Tenualosa ilisha	-	-	-	-	-	-	-	-	+	-	+
II.	**Family Notopteridae**											
	4. Notopterus notopterus	-	+	-	-	-	-	-	-	+	+	+
	5. Notopterus chitala	-	-	+	-	-	-	-	-	+	+	+
III.	**Family Salmonidae**											
	6. Oncorhynchus mykiss	+	+	+	+	+	-	-	-	-	+	-
	7. Salmo trutta fario	+	+	+	+	+	-	-	-	-	+	-
IV.	**Family Cyprinidae**											
	Sub-family Cultrinae											
	8. Chela cachius	-	+	+	-	-	-	+	+	+	+	+
	9. Chela laubuca	-	-	-	-	-	-	-	-	+	+	+
	10. Salmostoma bacaila	-	+	+	-	-	-	+	+	+	+	+
	11. Salmostoma punjabensis	-	-	-	-	+	-	+	+	+	+	+
	12. Securicula gora	-	-	-	-	-	-	-	-	+	+	+
	Sub-family Rasborinae											
	13. Amblypharyngodon mola	-	-	-	-	-	-	+	-	+	+	+
	14. Aspidoparia morar	-	+	+	-	+	-	+	+	+	+	+
	15. Barilius bendelisis	-	-	-	-	-	-	-	-	-	+	+
	16. Barilius modestus	-	-	-	-	-	-	-	-	-	+	+
	17. Barilius naseeri	-	-	-	-	-	-	-	-	-	+	-
	18. Barilius pakistanicus	-	+	+	-	+	+	+	+	+	+	+
	19. Barilius vagra	-	-	+	-	-	-	-	-	+	+	+
	20. Bengala elanga	-	-	-	-	-	-	-	-	-	+	-
	21. Brachydanio rerio	-	-	-	-	-	-	+	-	-	+	-
	22. Danio devario	-	+	+	-	-	-	+	-	+	+	+
	23. Esomus danricus	-	-	+	-	-	-	-	-	+	+	+
	24. Rasbora daniconius	-	-	-	-	-	-	+	-	+	+	+
	Sub-family Barbinae											
	25. Barbodes sarana	-	+	+	-	-	-	+	-	+	+	+
	26. Cirrhinus mrigala	-	-	+	-	-	-	+	+	+	+	+
	27. Cirrhinus reba	-	-	+	-	-	-	+	+	+	+	+
	28. Cyprinion microphthalmum	-	-	-	-	-	-	-	-	+	-	-
	29. Cyprinion watsoni	-	+	+	-	-	-	+	+	+	+	+
	30. Gibelion catla	-	-	+	-	-	-	-	-	+	+	+
	31. Labeo bata	-	-	-	-	-	-	-	-	-	-	+
	32. Labeo boga	-	-	+	-	-	-	-	-	-	+	-
	33. Labeo boggut	-	-	-	-	-	-	-	-	-	+	+
	34. Labeo caeruleus	-	-	+	-	-	-	-	-	+	+	+
	35. Labeo calbasu	-	-	-	-	-	-	-	-	+	+	+
	36. Labeo dero	-	+	+	-	+	+	+	+	+	+	+
	37. Labeo dyocheilus pakistanicus	-	-	+	-	-	-	-	+	+	+	+
	38. Labeo fimbriatus	-	-	-	-	-	-	-	-	+	+	+
	39. Labeo gonius	-	-	-	-	-	-	-	-	+	+	+
	40. Labeo nigripinnis	-	-	-	-	-	-	-	-	+	+	+
	41. Labeo pangusia	-	-	-	-	-	-	-	-	-	-	+
	42. Labeo rohita	-	-	+	-	-	-	-	-	+	+	+
	43. Naziritor zhobensis	-	-	-	-	-	-	+	+	-	-	-
	44. Osteobrama cotio	-	-	+	-	-	-	+	+	+	+	-
	45. Puntius chola	-	+	+	-	+	+	+	-	-	+	+
	46. Puntius conchonius	-	+	-	-	-	-	-	-	+	+	+
	47. Puntius gelius	-	-	-	-	-	-	-	-	+	-	+
	48. Puntius phutnio	-	-	-	-	-	-	-	-	-	-	-
	49. Puntius punjabensis	-	-	-	-	-	-	+	+	+	+	-

Nos.	Fish Fauna	NA	HZ	KASH	CHIT	SW	DIR	VPES	WBN	IND.B	PUNJ.	SIND.
	50. Puntius sophore	-	+	+	-	-	+	+	+	+	+	+
	51. Puntius terio	-	-	-	-	-	-	-	-	+	+	-
	52. Puntius ticto	-	+	+	-	+	+	+	+	+	+	+
	53. PUntius vittatus	-	-	-	-	-	-	-	-	-	+	-
	54. Puntius waagenii	-	-	-	-	-	-	-	-	-	+	-
	55. Tor putitora	-	+	+	-	+	+	+	+	+	+	+
	Sub-family Garrinae											
	56. Crossocheilus diplocheilus	-	+	+	-	+	+	++	+	+	+	+
	57. Garra gotyla	-	+	+	-	+	+	+	+	+	+	+
	58. Garra rossica	-	-	-	-	-	-	-	+	-	-	-
	59. Garra wanae	-	-	-	-	-	-	-	+	-	-	-
	Sub-family Schizothoracinae											
	60. Diptychus maculatus	+	-	-	-	-	-	-	-	-	-	-
	61. Ptychobarbus conirostris	+	-	-	-	-	-	-	-	-	-	-
	62. Racoma labiate	+	+	+	+	+	+	+	+	-	+	-
	63. Schizocypris brucei	-	-	-	-	-	-	-	+	-	-	-
	64. Schizocypris curvifrons	+	-	+	-	-	-	-	-	-	-	-
	65. Schizocypris niger	-	-	+	-	-	-	-	-	-	-	-
	66. Schizocypris micropogon	-	-	+	-	-	-	-	-	-	-	-
	67. Schizocypris esocinus	+	+	+	+	+	+	-	-	-	-	-
	68. Schizopygopsis stolicxkai	+	-	-	-	-	-	-	-	-	-	-
	69. Schizothorax plagiostomus	+	+	+	+	+	+	+	+	+	+	-
	70. Schizothorax nasus	+	-	+	-	-	-	-	-	-	-	-
	71. Schizothorax longipinnis	+	-	+	-	-	-	-	-	-	-	-
	72. Schizothorax skurduensis	+	-	-	-	-	-	-	-	-	-	-
	Sub-family Cyprininae											
	73. Carassius auratus	-	+	-	-	-	-	-	-	+	+	+
	74. Cyprinus carpio	-	+	+	-	-	-	-	-	+	+	+
	Sub-family Luciscinae											
	75. Ctenopharyngodon idella	-	-	-	-	-	-	-	-	-	+	+
	Sub-family Hypophythalmichthyinae											
	76. Aristichthys nobilis	-	-	-	-	-	-	-	-	-	+	+
	77. Hypophthalmichthys molitrix	-	-	+	-	-	-	-	-	-	+	+
V.	**Family Cobitidae**											
	78. Botia birdi	-	+	+	-	-	-	+	-	+	+	-
	79. Lepidocephalus guntea	-	-	-	-	-	-	+	-	-	-	-
VI.	**Family Noemacheilidae**											
	80. Acanthocobitis botia	-	+	+	-	+	-	+	+	+	+	+
	81. Noemacheilus corica	-	+	-	-	-	-	+	+	-	+	+
	82. Schistura afasciata	-	+	-	-	-	-	-	-	-	-	-
	83. Schistura alepidota	-	+	+	-	+	+	+	+	-	-	-
	84. Schistura anambarensis	-	-	-	-	-	-	-	-	+	-	-
	85. Schistura arifi	-	-	-	-	-	-	-	+	-	-	-
	86. Schistura baluchiorum	-	-	-	-	-	-	-	-	+	-	-
	87. Schistura curtistigma	-	-	-	-	-	-	-	+	-	+	-
	88. Schistura harnaiensis	-	-	-	-	-	-	-	-	+	-	-
	89. Schistura horai	-	-	-	-	-	-	-	-	-	+	-
	90. Schistura kessleri	-	-	-	-	-	-	-	+	+	+	-
	91. Schistura kohatensis	-	-	-	-	-	-	-	+	-	-	-
	92. Schistura lindbergi	-	+	-	-	-	-	-	-	+	-	-
	93. Schistura machensis	-	-	-	-	-	-	-	-	+	-	-
	94. Schistura macrolepis	-	-	-	-	-	-	-	-	-	+	-
	95. Schistura microlabra	-	-	-	-	-	-	-	-	-	+	-
	96. Schistura nalbanti	-	+	-	-	-	-	+	-	-	-	-
	97. Schistura naseeri	-	+	-	-	+	-	-	-	-	-	-
	98. Schistura pakistanica	-	-	-	-	-	-	-	+	-	-	-
	99. Schistura parashari	-	-	-	-	+	-	+	+	-	+	-
	100. Schistura facimaculata	-	-	-	-	-	-	-	+	-	-	-
	101. Schistura punjabensis	-	-	-	-	-	-	-	-	-	+	-
	102. Schistura shadiwalensis	-	-	-	-	-	-	-	-	-	+	-
	103. Triplophysa brahui	-	-	-	-	-	-	-	-	+	-	-
	104. Triplophysa gracilis	+	+	-	-	-	-	-	-	-	-	-
	105. Triplophysa hazaraensis	-	+	-	-	-	-	-	-	-	-	-

Nos.	Fish Fauna	NA	HZ	KASH	CHIT	SW	DIR	VPES	WBN	IND.B	PUNJ.	SIND.
	106. Triplophysa kashmirensis	-	+	+	+	-	-	-	-	-	-	-
	107. Triplophysa microps	+	-	+	-	-	-	-	-	-	-	-
	108. Triplophysa naziri	-	-	-	-	+	-	-	-	-	-	-
	109. Triplophysa stoliczkai	+	-	-	-	-	-	-	-	-	-	-
	110. Triplophysa tenuicauda	+	-	-	-	-	-	-	-	-	-	-
	111. Triplophysa trewavasae	+	-	-	-	-	-	-	-	-	-	-
	112. Triplophysa yasinensis	+	+	+	+	+	+	-	-	-	-	-
VII.	**Family Bagridae**											
	113. Aorichthys aor	-	-	-	-	-	-	-	-	+	+	+
	114. Batasio pakistanicus	-	-	-	-	-	-	-	-	-	+	+
	115. Mystus bleekri	-	+	+	-	-	-	+	+	+	+	+
	116. Mystus tengora	-	+	-	-	-	-	-	-	+	+	+
	117. Mystus cavasius	-	-	-	-	-	-	+	-	+	+	+
	118. Mystus gulio	-	-	-	-	-	-	-	-	+	+	+
	119. Mystus horai	-	-	-	-	-	-	-	-	+	+	+
	120. Mystus vittatus	-	-	-	-	-	-	-	-	+	+	+
	121. Rita rita	-	-	-	-	-	-	-	-	+	+	+
VIII.	**Family Sisoridae**											
	122. Bagarius bagarius	-	-	+	-	-	-	-	-	-	+	+
	123. Gagata cenia	-	+	+	-	-	-	+	+	+	+	+
	124. Glyptosternum reticulatum	+	+	+	+	+	+	-	-	-	-	-
	125. Glyptothorax cavia	-	-	-	-	+	-	+	-	+	+	+
	126. Glyptothorax kashmirensis	-	+	+	-	-	-	-	+	-	-	-
	127. Glyptothorax naziri	-	-	-	-	-	-	+	+	+	+	-
	128. Glyptothorax pectinopterus	-	+	+	-	-	-	-	-	-	-	-
	129. Glyptothorax punjabensis	-	+	+	-	-	+	+	+	+	+	+
	130. Glyptothorax stocki	-	+	+	-	+	+	+	-	-	-	-
	131. Glyptothorax sufii	-	-	-	-	-	-	-	-	-	+	-
	132. Nangra nangra	-	-	-	-	-	-	-	-	-	+	+
	133. Nangra robusta	-	-	-	-	-	-	-	-	+	+	+
	134. Sisor rabdophorus	-	-	-	-	-	-	-	-	+	+	+
IX.	**Family Siluridae**											
	135. Ompok bimaculatus	-	-	+	-	-	-	+	-	+	+	+
	136. Ompok pabda	-	-	+	-	-	-	+	+	-	+	+
	137. Ompok sindensis	-	-	-	-	-	-	-	-	-	-	+
	138. Wallago attu	-	+	+	-	-	-	+	+	+	+	+
X.	**Family Heteropneustidae**											
	139. Heteropneustes fossilis	-	-	-	-	-	-	+	+	+	+	+
XI.	**Family Amblycipitidae**											
	140. Amblyceps mangois	-	-	-	-	-	-	-	-	+	+	+
XII.	**Family Schilbeidae**											
	141. Aillia coila	-	-	-	-	-	-	-	-	+	+	+
	142. Aillia punctata	-	-	-	-	-	-	-	-	+	+	+
	143. Clupisoma garua	-	-	+	-	-	-	-	-	+	+	+
	144. Clupisoma murius	-	-	-	-	-	-	-	-	-	+	+
	145. Clupisoma naziri	-	+	+	-	-	-	+	-	+	-	-
	146. Eutropiichthys vacha	-	-	-	-	-	-	+	-	+	+	+
	147. Pseudeutropeus atherinoides	-	-	-	-	-	-	+	-	-	+	+
XIII.	**Family Belonidae**											
	148. Xenentodon cancila	-	+	+	-	-	-	-	-	+	+	+
XIV.	**Family Aplocheilidae**											
	149. Aplocheilus panchax	-	-	-	-	-	-	-	-	+	+	+
XV.	**Family Cyprinodontidae**											
	150. Aphanius dispar	-	-	-	-	-	-	-	-	+	+	+
XVI.	**Family Poeciliidae**											
	151. Gambusia affinis	-	-	-	-	-	-	-	-	-	+	+
	152. Poecilia reticulate	-	-	-	-	-	-	-	-	-	+	+
XVII.	**Family Channidae**											
	153. Channa gachua	-	+	-	-	+	+	+	+	+	+	+
	154. Channa marulia	-	+	-	-	-	-	+	-	+	+	+
	155. Channa punctate	-	-	+	-	-	-	+	+	+	+	+

Nos.	Fish Fauna	NA	HZ	KASH	CHIT	SW	DIR	VPES	WBN	IND.B	PUNJ.	SIND.
	156. Channa striata	-	-	+	-	-	-	+	-	+	+	+
XVIII.	**Family Chandidae**											
	157. Chanda nama	-	+	+	-	-	-	+	-	+	+	+
	158. Chanda baculis	-	-	+	-	-	-	+	-	+	+	+
	159. Chanda ranga	-	+	+	-	-	-	+	-	+	+	+
XIX.	**Family Nandidae**											
	160. Nandus nandus	-	-	-	-	-	-	-	-	+	+	+
XX.	**Family Badidae**											
	161. Badis badis	-	-	-	-	-	-	-	-	+	+	+
XXI.	**Family Mugilidae**											
	162. Liza abu	-	-	-	-	-	-	-	-	-	+	-
	163. Mugil cephalus	-	-	-	-	-	-	-	-	+	+	+
	164. Sicamugil cascasia	-	-	-	-	-	-	-	-	+	+	+
XXII.	**Family Gobiidae**											
	165. Boleophthalmus dussumieri	-	-	-	-	-	-	-	-	+	-	-
	166. Glossogobius giuris	-	-	-	-	-	-	-	-	+	+	+
	167. Periophthalmus koelreuteri	-	-	-	-	-	-	-	-	+	+	+
XXIII.	**Family Osphronemidae**											
	168. Colisa fasciata	-	-	-	-	-	-	+	-	+	+	+
	169. Colisa lalia	-	+	-	-	-	-	+	-	+	+	+
XXIV.	**Family Cichlidae**											
	170. Oreochromis aureus	-	+	-	-	-	-	-	-	+	+	+
	171. Oreochromis mossambicus	-	+	-	-	-	-	-	-	+	+	+
	172. Oreochromis niloticus	-	-	-	-	-	-	-	-	+	+	+
XXV.	**Family Synbranchidae**											
	173. Monpterus cuchia	-	-	-	-	-	-	-	-	-	+	+
XXVI.	**Family Mastacembelidae**											
	174. Macrognathus aculeatus	-	-	-	-	-	-	-	-	-	+	+
	175. Macrognathus pancalus	-	-	-	-	-	-	-	-	+	+	+
	176. Mastacembelus armatus	-	+	+	-	+	+	+	+	+	+	+
XXVII.	**Family Pristidae**											
	177. Pristis microdon	-	-	-	-	-	-	-	-	-	-	+

Source: M.A. Rafique, Fish Diversity and Distribution in Indus River and its Drainage System (2000)

NA (Northern areas), **HZ** (Hazara area), **KASH** (Kashmir), **CHIT** (Chitral), **SW** (Swat), **DIR** (Dir), **VPES** (Vale of Peshawar), **WBN** (West bank of Indus comprising Southern tribal areas and northern Balochistan drainage by the river Kurram, Gomal and Zhob), **IND.B** (Indus Balochistan including central and southern Balochistan draining into Indus), **PUNJ** (Punjab), **SIND** (Sindh).

APPENDIX – 3.2

Photo-log

Indus at Pattan

Indus River before Dasu Bridge

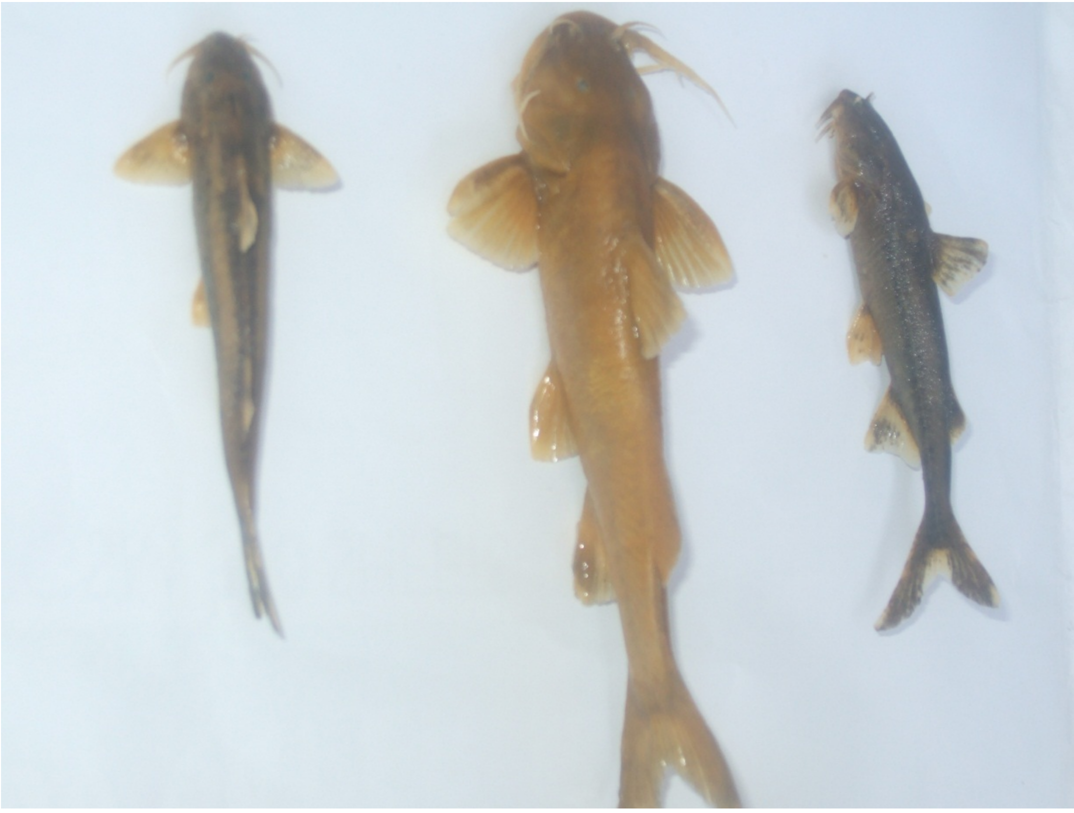
Raceway Structure on Seglo Nullah

Confluence of Darel with Indus

Indus at Besham at High Flow

Flow at Summer Nullah

Confluence of Tangir Nullah



Specimen of Glyptosternum

Specimen of Tryplophysa

Fish specimen of Snow carp (Schizothorax)

Joining of Kaigha Nullah with Indus River

APPENDIX – 3.3

EXOTIC SPECIES (INDUCED SPECIES)

1. ***Ctenopharygodon idella***

Common Name:	Grass carp
Genus:	Ctenopharyngodon
Sub-family:	Luciscinae
Family:	Cyprinidae
Order:	Cypriniformes

Distinct Features:

Colour:	Dark grey on the back. Silver to golden below fins. Dark coloured. Body elongated and stout, covered with scales.
Head:	Round, Mouth open in front upper jaw bigger, no barbels.

Feed Habits: Fingerlings depend on plankton and organism and grownup fish feed on plankton like grasses.

Breeding: Fish spawns in slow moving water in the month of April. Fish lays about 0.5 million eggs every year. Mostly eggs achieve induced breeding upon maturity, the fish attains a Weight 5-7 Kg.

Growth: Growth rate is very rapid. The fish grows two to three by every year.

Importance: Due to its rapid growth rate, it is considered the most appropriate fish for cultivation. It also helps in the regulation of aquatic vegetation and weeds.

2. ***Cyprinus carpio*** **(Linnaeus 1758)**

Common Name:	Common carp (Gulfam)
Genus:	Cyprinus Linnaeus
Sub-family:	Cyprininae
Family:	Cyprinidae
Order:	Cypriniformes

Distinct Features:

Colour: Greenish brown to golden and even reddish, greatly variable under domestication, body compressed covered with scales, abdomen round, mouth slightly downward with long blunt snout and with two pairs of barbels on upper jaw.

Feed Habits: The fish depends on all organisms present at the bottom. It eats all material present (herbivorous).

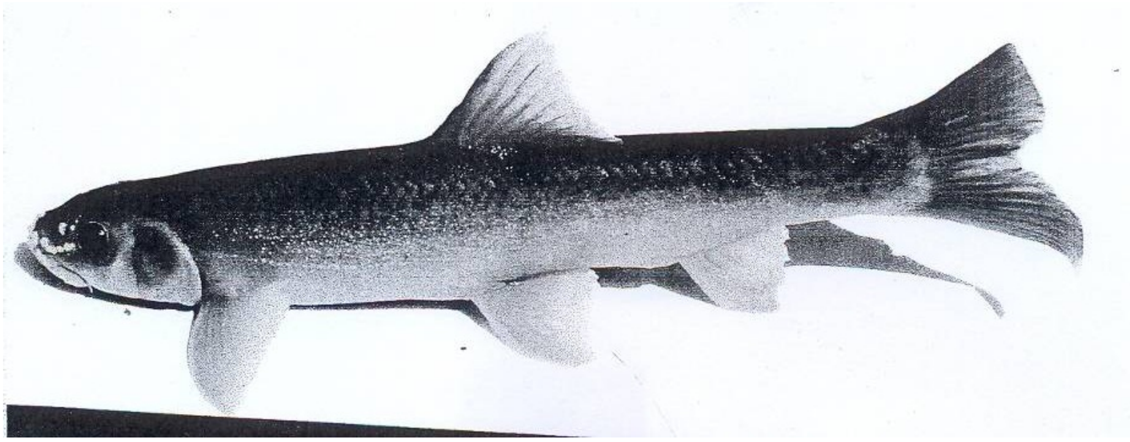
Breeding: Spawns in open water in spring season (January – April) when temperature ranges between 20-25°C. Female of about one kilogram lays about 0.1 million eggs. Hatchlings come out within 4-6days depending upon temperature. Fry and fingerling growth depends upon feed and suitable temperature. Mostly breed in hatcheries through induced breeding.

Growth: Grows rapidly depending upon feed and water quality. In favourable temperatures it grows, 3-4kg/year (particularly grows rapidly in the 2^{nd} year)

Importance: It is important source of fish protein. Its flesh is tasty and liked by the people. Peirong (1989) recorded the largest specimen of 40 kg. in Northern area, it is introduced & propagated through stocking in all rivers and nullahs.

3. ***Salmo trutta*** **(Linnaeus)**

Local Name:	Angrazi Chemo
Common Name:	Brown Trout
Genus:	Salmo
Sub-family:	Salmon
Family:	Salmonidae
Order:	Salmoniformes



Distinct Features:

Introduced in the Northern Areas in 1916 by the British Administration. Propagated through induced breeding in different hatcheries. Since its induction, it is very common in Gilgit and its surrounding nullahs. In Chillas fries of the species are stocked. Found in Thak Nullah (upper reaches). Body is small and stout, covered with gray scales and spots.

Colour: Brownish at dorsal side, greyish at ventral side.

Feed Habits: Being carnivorous, it depends on aquatic organism and similar fish. Cultivated species feed on manufactured food from eggs, liver, meat and wheat.

Growth: Its growth is very slow. Does not accept artificial food immediately.

Breeding: Spawns in the months of December upto February in clear, cold and moving waters. Lays eggs in gravel on banks of nullahs. Mortality rate in natural water body is very low. Reproduced through induced breeding in hatcheries. Fries stocked in nullahs yearly. Spawning rate is very low (300 eggs/fish).

Importance: Very precious fish for anglers, used as delicious food fish. Also the legendary fish in Northern Areas. Its natural population is replenished by stocking.

4. *Salmo giardneri* (Linnaeus)

Local Name:	Trout
Common Name:	Rainbow trout
Genus:	Salmo
Family:	Salmonidae
Order:	Salmoniformes

Distinct Features:

Introduced in the Northern Areas first time in 1973. Now regularly breed in trout hatcheries and stocked in Northern Areas nullahs and rivers. Body very similar to Brown trout covered with small scales.

Colour:	Brownish at dorsal side with dark spots, pinkish band on lateral sides.
Head:	Rounded and snout more conical. Head length is about 25% of the total length. Mouth relatively smaller and without barbels.

Feed Habits: Eat aquatic organisms, small fish and aquatic vegetation.

Breeding: Spawns from January upto May after digging small ditch in gravels, at spawning time. Female is accompanied by two males and facilitate spawning, egg hatches within three days.

Importance: Rainbow trout is more beneficial. It adopts harder conditions more easily, tolerates more temperature variations and survives in lesser-oxygenated water.

(Species of special interest)

1. ***Tor putitora* (Hamilton – 1822)**

Local Name:	Mahaseer
Genus:	Tor (Ahmad, 1943, Misra, 1959)
Sub-family:	Cyprininae
Family:	Cyprinidae
Order:	Cypriniformes
Subclass:	Teleostii
Class:	Teleostomi

Identifying Characters:	D1/8; P14-18; V9: A2/5 C2/19 L.I 22-27 Length range 16 – 26cm Weight upto 2Kg
Distribution:	Pakistan, Punjab, Balochistan, KPK, Bangladesh, India, East Punjab, U.P, West Bengal; Assam, Nepal.
Colour:	Greenish above with light pink sides and silver white abdomen; fins reddish yellow.
Habitat:	Clear shallow stream with gravel bed foothill mountain area (500m – 2000m) altitude.
Morphometry:	Body elongated & stout. Head larger 22% of body length, Eyes smaller & embedded in anterior part of Head, Eyes seem larger in smaller fishes. Mouth larger & have large lips at anterior end. Surrounded by four barbels (two rostal & two maxillary). Dorsal fin located between anal & pelvic fins; pectoral fins are smaller. Body covered with larger scales.
Feeding:	Feeds on plankton, may hunt smaller fishes; become omnivorous; doesn't feed below 16°C under captivity. Never competes with carps species.
Habitat:	Streams, rivers & nullahs of sub-mountain area.
Breeding:	Spawns in clear slow flowing water having rocky & gravel sandy bottom during April to September. Eggs are yellowish, heavy & demersal for hatching (sehgal – 1981) measuring 2.8 upto 3.2mm. It breeds also in confined ponds and response to stripping with hypo-physation or without pituitary gland extract. Artificial breeding very successful in India & Nepal.
Significance:	Good taste food fish and excellent game fish, source of recreation to anglers. In commercial fishery it occupies an important position for its quality. It attracts higher price in market.