EARTHQUAKE RECONSTRUCTION AND REHABILITATION AUTHORITY (ERRA)
THE ISLAMIC REPUBLIC OF PAKISTAN

No.

URGENT REHABILITATION PROJECT: WEST BANK BYPASS DESIGN

UNDER

THE URGENT DEVELOPMENT STUDY ON REHABILITATION AND RECONSTRUCTION IN MUZAFFARABAD CITY

IN

THE ISLAMIC REPUBLIC OF PAKISTAN

FINAL REPORT

MAIN TEXT

MARCH 2008

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD.

SD
JR
08-014

Note: Following exchange rates are applied in the Study.

1 US$ = PKR60.800 = JPY119.410 (As of 1st August, 2007)

PREFACE

In response to the request from the Government of the Islamic Republic of Pakistan, the Government of Japan decided to conduct “The Urgent Development Study on Rehabilitation and Reconstruction in Muzaffarabad City in the Islamic Republic of Pakistan”, and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr. Tetsu NAKAGAWA of Nippon Koei Co., Ltd. to the Islamic Republic of Pakistan from February 2007 to November 2007. The team conducted Basic Design and Detailed Design for the “Urgent Rehabilitation Project: West Bank Bypass Design under the Urgent Development Study on Rehabilitation and Reconstruction in Muzaffarabad City in the Islamic Republic of Pakistan” based on field surveys, holding a series of discussions with and presentations to the officials concerned of the Government of the Islamic Republic of Pakistan.

I hope that this report will contribute to the development of Pakistan and to the enhancement of friendly relationship between the two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of the Islamic Republic of Pakistan for their close cooperation and friendship extended to the Study.

February, 2008

Eiji Hashimoto
Vice President
Japan International Cooperation Agency

February, 2008

Mr. Eiji Hashimoto
Vice President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

We are pleased to submit herewith the Final Report on the "Urgent Rehabilitation Project: West Bank Bypass Design under the Urgent Development Study on Rehabilitation and Reconstruction in Muzaffarabad City in the Islamic Republic of Pakistan". This study was entrusted to Nippon Koei Co., Ltd. under a contract with Japan International Cooperation Agency, during the period from February 2007 to February 2008.

This report contains Basic Design and Detailed Design of 5.1 km of the West Bank Bypass in Muzaffarabad City including 250m of extra-dosed bridge called Naluchi Bridge. In Basic Design phase, alignment and typical cross sections were determined, including preparation of tentative construction schedule, draft cost estimates and economic evaluation, which were compiled collectively as Interim Report. In the Detailed Design phase, all the established basic design features were further refined and tender documents and detailed design drawings are prepared.

We wish to take this opportunity to express our sincere gratitude to your agency and the Ministry of Foreign Affairs, and also wish to express our deep appreciation to the Government agencies concerned in the Islamic Republic of Pakistan, especially the counterpart agencies of the Earthquake Reconstruction and Rehabilitation Authority, Government of Azad Jammu and Kashmir and National Highway Authority for the close cooperation and assistance extended to us during the study.

We hope this report will contribute to the development of the Islamic Republic of Pakistan.

Yours Faithfully,

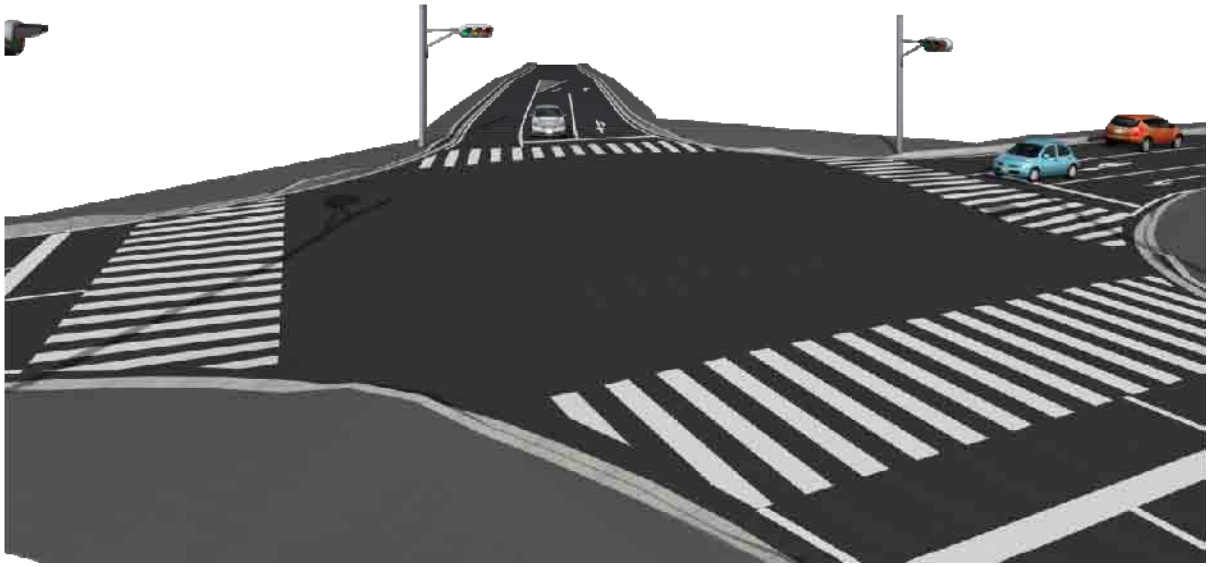
Tetsu NAKAGAWA
Team Leader,
JICA Study Team for
The West Bank Bypass Construction Project
in the Islamic Republic of Pakistan

The Urgent Development Study on Rehabilitation and Reconstruction in Muzaffarabad City in the Islamic Republic of Pakistan (Uregent Rehabilitation Project: West Bank Bypass Design)

Location Map


Perspective View of New Naluchi Bridge
Designed by JICA Study Team

Perspective View of Intersection No.4



EXECUTIVE SUMMARY

INTRODUCTION

The West Bank Bypass Construction Project (hereinafter referred to as "the Project") was recommended as the top priority project in "the Urgent Development Study on Rehabilitation and Reconstruction in Muzaffarabad City in the Islamic Republic of Pakistan" (hereinafter referred to as "the M/P Study"), conducted by Japan International Cooperation Agency (hereinafter referred to as "JICA") from February 2006 to March 2007.

Considering the urgency and importance of the Project, the Government of Pakistan decided on June 2006 to allocate part of the counterpart funds from the JBIC Emergency Earthquake Recovery Loan to the Project, and consequently requested technical assistance, including detailed design, to the Government of Japan.

Based on said request from Pakistan, JICA performed the preliminary design of the Project from September to December 2006, as part of the M/P Study. As a result, geometric criteria, and route alignment of the bypass were established, with the extra-dosed bridge as the optimum for the Naluchi Bridge site. The proposed recommendations were accepted by Pakistan side on 14 December 2007.

JICA decided to proceed further with the design activities by executing the basic and detailed design phases of the Project, entitled "Urgent Rehabilitation Project: West Bank Bypass Design under the Urgent Development Study on Rehabilitation and Reconstruction in Muzaffarabad City in the Islamic Republic of Pakistan" (hereinafter referred to as "the Study"). A designated team was then mobilized to perform the Study.

As mentioned above, the Study is divided into two phases: basic design and detailed design. The basic design phase was conducted form February to March 2007. During this phase, basic design of the alignment and cross sections for the roads, including the Naluchi Bridge and viaducts, were performed. The activity included preparation of tentative construction schedule, draft cost estimates and economic evaluation, which were complied collectively as Interim Report. These were submitted to Pakistan side, together with the Prequalification Document and PC-1 (Proforma) in March, 2007.

The detailed design was conducted from July to October 2007. During this stage, further refinement of all the established basic design features were performed as its main task. It also includes preparation of tender documents and detailed design drawings.

As a result of the Study, the Draft Final Report (DFR) was prepared and submitted to Pakistan side on October, 2007. The presentation on the Draft Final Report was conducted on the end of October, 2007 and the comments on the DFR were received from Pakistan side on 12 February, 2008. This Final Report reflected such comments was finalized in Japan and comprises Main Text, with 10 appendices

consisting of supporting information and data, presented as a separate volume. The final part of the Main Text enclosed two annexes that present minutes of meetings, minutes of discussion, list of key official concerned. Furthermore, the tender documents and tender drawings for the established Construction Packages I and II were also submitted as separate volumes.

BASIC DESIGN CONCEPTS

The proposed West Bank Bypass runs along the west bank of the Jhelum River and Neelum River, starting from intersection in front of the Supreme Court on Kohala Muzaffarabad Road, and ending at the intersection on the northern side of Chela Bandi Bridge in Neelum Valley Road.

The function and role of the Project Road are to:

- provide alternative route to access Muzzafarabad city centre;
- decongest the traffic at Muzzafarabad city centre by diverting east-west external traffic, through the Jhelum road and Muzzafarabad-Balakot road;
- provide a community road for residents on the west bank of the Neelum River;
- increase river crossing facilities at Naluchi bridge site

Considering the above, the following key approaches were reflected in the design:

Environmentally Friendly Alignment: The control points affected by the selected route are assessed individually, and rated accordingly. Based on assessments, several alternative routes were also identified and investigated. The factor for selecting the most feasible option, upon consultation also with ERRA and AJK, is to consider a route which will cause the least environmental adverse effects.

Structural Design of Earthquake-Resistant Structures: One of the basic principles of the Project is to design all related structures, (Naluchi Bridge, viaducts, etc.) against severe earthquake conditions. Design methods shall be based on the requirements of NHA, where applicable, and considering strict compliance with AASHTO Standard Specification for Highway Bridges 2004 and the Specifications for Highway Bridges Part V Seismic Design 2002 by Japan Road Association. Based on this, all structures in the Project are expected to remain stable against future earthquakes of anticipated magnitudes.

Smooth Project Implementation: Considering that the Project is part of the rehabilitation and reconstruction in Muzaffarabad City, which suffered severe earthquake damages, one of the key approaches is to promote smooth implementation for achieving project completion the earliest possible. For this matter , approaches applied in the study include (1) Early commencement of pre-qualifying bidders, (2) Preparation of pertinent and reasonable cost estimate to avoid re-biding, (3) Formulation of the most practical construction schedule, (4) Application of the most reliable construction methods;

and (5) Adoption of local procurement of construction materials in accordance with the project requirements.

Pertinent Cost Estimate and Project Viability: In order to achieve a successful bidding, the cost estimate is carried out based on the latest unit rates of materials, labors and equipments. In addition, the project cost should be restrained by the Economic Internal Rate of Return (EIRR), which should be more than the social discount rate of about 12%.

Technology Transfer: Transfer of technological to ERRA, AJK and NHA is initiated by means of technical presentations and on-the-job trainings. Related subjects include earthquake-resistant structural engineering, intersection designs, disaster prevention measures, environmental consideration on road designs, and introduction to JBIC Standard Tender Documents.

In addition, significant environmental issues are considered in the preparation of LARP and EMMP, which deals with the local communities and people who suffered property loss and temporary settlements during the earthquake.

SUPPLEMENTAL FIELD CONDITION STUDY

In this study, supplemental topographic surveys and geotechnical investigations were conducted in addition to those conducted during the preliminary design phase.

For purposes of obtaining additional topographic maps and profiles for hydraulic criteria for the bridge design, the following were carried out:

- topographic mapping survey of 135,000 m^2,
- profile survey of 1,530 m, and
- flood level survey.

Laboratory tests for samples obtained from three additional bore holes and one test pit and were carried out, to ensure subsoil properties for the Naluchi Bridge (river pier), and other bridges.

For the hydrological and hydraulic design, discharge and design flood water level of small rivers and its tributaries were estimated. At the Naluchi Bridge site, discharges with 100-year and 50-year return period were applied, which were estimated as 7160 m^3/s and 6220 m^3/s respectively. Flood water levels with 5-year and 2-year return period considered for temporary work planning are EL. 661.8 m and 660.5 m respectively. Flood water level of Neelum River with 100 year rerun period at the flooded the section from Sta.3+100 to Sta.4+800 is also estimated ranging from EL.678.0 m to EL.681.4 m.

ROAD DESIGN

The project road is a 5 km-long bypass, running on the west side of Neelum and Jhelum Rivers, linking north and south of Muzaffarabad.

The route selected during the preliminary design in October 2006 was reviewed and refined based on supplemental topographic map used during the basic design and the detailed design phases. The route is carefully examined and optimized in order to minimize adverse environmental effects, considering topography, accessibility of intersections, locations of bridges, culverts, and drainage structures.

Design Standards applied in the Study include Standards For Roads In Pakistan by National Highway Authority (NHA) and A Policy On Geometric Design Of Highways And Streets (2004) by AASHTO.

The Project Road is classified from administrative and functional view points as Provincial road and Primary road, respectively taking into account the NHA Standard.

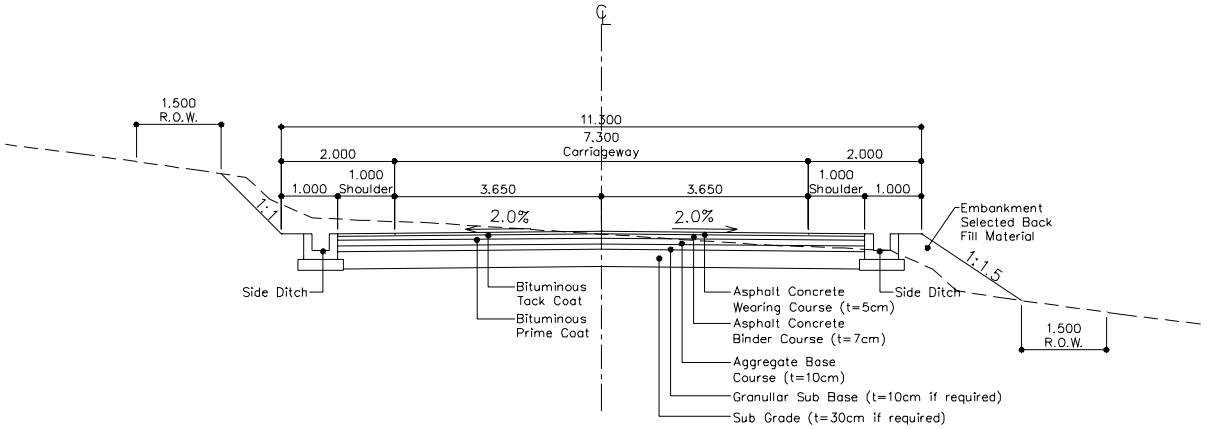
The major geometric design criteria for design speeds are shown in the following table, considering the existing road conditions and applicable Design Standards.

Design Items	Unit	As per Standard		Applied Design Criteria	
Design Speed	km/hr	50	40	50	40
Minimum Radius	m	79	43	150	45
Maximum Gradient	%	14	15	6	6

It should be noted that the design speed of 50 km/hr is applied in principle to all sections except for those at intersections and at winding curved section -5, where design speed of 40 km/hr is applied. The formation width of the Project road is 11.3 m with 7.3 m-wide carriageway (3.65 m x 2). It also consists of 1.0 m shoulder on each side. Side ditch and retaining wall are installed on the soft shoulder.

The vertical clearance at grade-separation over Intersection No.1 is 5.1 m. However, 3 m is provided for local roads, where heavy vehicles are not expected to pass.

Embankment slope is 1.5: 1 (H:V) while the slope of 1 : 1 (H:V) is considered for cutting, considering geological conditions along the road.



Typical Cross Section

The alignment was subjected to extensive evaluation and was finalized after a series of detailed discussions were conducted with designated representatives of ERRA, NHA and AJK government, presenting various alternatives. The control points are carefully examined to minimize natural and social environmental impacts.

Intersection Design

There are four intersections included in the Project. One intersection defined as Intersection-A, which is designed simultaneously with Intersection No. 1, due to their proximity from each other. All intersections are designed based on future traffic volume in 2019 estimated during Preliminary Study conducted in November, 2006.

At intersection No. 1, located beside the Supreme Court of AJK, alternative study between at-grade intersection and grade separation was conducted. Taking into account the safety features and tolerance to the future demand, grade separation design was found suitable for Intersection No. 1.

Intersection No. 2 is defined as the junction Muzaffarabad-Balakot Road and the Project road. This was designed as T-shaped, with additional right-turn lane with two legs.

Intersection No. 3 is located at Sta. 3+038, located near the bus terminal of Muzaffarabad - Balakot Road. It was also designed with T-shaped, with one right turn lane added on the bypass road from the south.

Intersection No. 4 is located at Sta. 4+952. Alternative studies were performed for this intersection located near the end of the proposed route, using detailed topographic survey. The preferred alternative considered was found to simplify traffic flow, and ensure the sight clearance with the improvement of its intersecting angle.

Signal systems were proposed at Intersection A and Intersection No. 4.

Traffic safety facilities (traffic signs, guardrail, kilo-meter post and lighting) were also designed at appropriate locations and incorporated into the design.

Pavement Design

The pavement design was carried out in accordance with AASHTO GUIDE FOR DESIGN OF PAVEMENT STRUCTURE 1993. In the pavement design the entire road section is divided into two sections based on traffic volume: Section 1-6, and Section 7-9. The pavement composition as per the design results is summarized in the following table.

Section	Designed Thickness (cm)			
	Surface Course	Binder Course	Base Course	Sub base Course
Section 1~6 (Sta0-121.0~Sta3 +157.8)	5	7	10	10
Section 7~9 (Sta3 +157.8 ~ Sta4+951.995)	5	7	10	N/A

Drainage Design (Side Ditch)

From the viewpoint of traffic safety and extending road service life, side drains with sufficient capacity against anticipated runoff discharge should be provided.

The drainage design criteria applicable in the design are shown in the following table:

Design Criteria for Side Ditch

Catchment Area:	As calculated from the Topographical Survey Map
Runoff Coefficient :	Road Surface : 0.95 Cut Slope Surface : 0.60
Return Period:	3 years
Design Storm Duration:	10 minutes
Rainfall Intensity:	72mm/h (10minutes) at 3years' return period
Roughness Values:	Concrete : 0.015

The features of the side ditch were studied considering drainage capacity, ease of maintenance, road width and construction cost. A concrete rectangular-type side ditch was selected with varying dimensions determined to accommodate design run off discharge from each drainage site.

Slope Protection and Retaining Wall Design

On the cross section design, retaining walls were proposed to reduce earthwork volume derived from topographical slope and/or minimize land acquisition at the sites. A suitable type of retaining wall was selected based on applicable design criteria and standard, available space, subsoil conditions and construction cost. Based on these, types of retaining walls selected as appropriate include

- At cut sections: concrete leaning retaining wall, concrete L-shaped retaining wall, leaning stone masonry retaining wall were selected for various cut sections, and
- At fill sections: concrete inverted T shaped retaining wall and leaning stone masonry retaining wall was selected.

Between Sta.3+800 and Sta.4+800, the project route passes on the existing road along the river side. The appropriate revetment type for this section was studied in conjunction with the comparison of four structural types. The stone pitching & gravity wall by stone masonry is selected considering practicality in construction.

BRIDGE AND STRUCTURE DESIGN

Applicable Design Standard and Design Criteria

Based on the usual standard practice in Pakistan,, Design of Bridges on National Highway by NHA and Standard Specifications for Highway Bridges by AASHTO (17^{th} Edition), 2004, are considered in the design.. In addition to the above standards, both AASHTO and Japanese standards, "Specifications for Highway Bridges (Japan Road Association)" are applied for seismic design.

Because of the complexity of Naluchi Bridge and west approach viaduct, special attention on seismic design was rendered in the Study, by strictly complying with AASHTO and the Specifications for Highway Bridges (Japan Road Association).

Optimization of Naluchi Bridge

During the Preliminary Design Study conducted by JICA, the extra-dosed bridge type was selected as appropriate for Naluchi Bridge. In the Basic Design Phase, the structural optimization of Naluchi Bridge was studied to determine its basic dimensions and configuration. Detailed structural analysis was meanwhile carried out during the Detailed Design Phase. The bridge configuration for optimization includes refinement of span length, selection of suitable foundation type, configuration of high pier and box girder type, and selection of stay cable considering anti-corrosion measure.

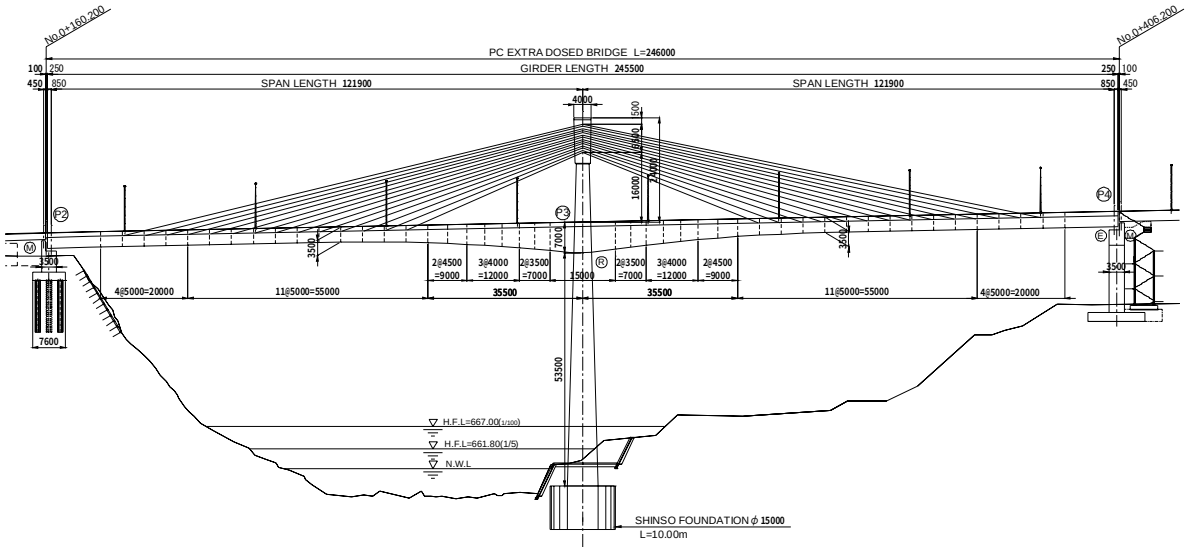
The span length was refined considering location and type of foundation of Piers P2 & P3 which are positioned at cliff edge on the left bank (east side) and at water edge on the right bank of Jhelum River. Consequently the minimum clear span length of bridge crossing Jehelum River determined to be 123 m. The arrangement of the bridge span shall be symmetrical to achieve structural balance. Thus, total length of the river-crossing portion of the bridge was determined to be 246 m.

The followings are alternatives in optimization of the bridge component with the corresponding result of evaluation:

Bridge Component for Optimization	Alternatives Considered	Selected Alternative/ Option	Aspects Considered in Selection of Optimum Alternative
Type of River Pier Foundation (Pier P3)	Spread foundation Caisson type pile (Shinso)	Caisson type pile (Shinso)	Construction cost, Construction period, Structural aspect, hydraulic aspect
River Pier Configuration	Elliptical and non-uniform section with hollow column Triangular and uniform section with hollow column Triangular and non-uniform section with hollow column	Triangular and uniform section with hollow column	Construction cost, Construction period, Structural aspect, Aesthetic aspect
Height of Pylon (Cable Stay Arrangement)	H=20 m H=23 m H=26 m	H=23 m	Construction cost (the least quantity of PC tendon)
Configuration of Main Girder	One box with two cell girder One box with one cell girder	One box with two cell Girder	Construction cost, Structural aspect, Rigidity of deck slab

Anti-corrosion measure for the cable stay system was studied. It was found that semi fabricated cable with polyethylene coated strands protected with polyethylene tubular pipe is ideal, based on vast track record of application, reliability of anti-corrosion measure, practicality in construction and quality control assurance.

Resulting from above optimization of the bridge components, configuration of Naluchi Bridge was finalized accordingly.



Side view of Naluchi Bridge

Detailed Design of Naluchi Bridge

In the detailed design, service load combinations assigned to bridges are checked using allowable stress design method while limit state load combinations were checked using strength design method.

For seismic design, Naluchi Bridge and west side approach viaduct is checked by dynamic analysis (time-history response analysis) due to complexity of their vibration responses. El Centro earthquake wave data in the United States (maximum acceleration 0.35g) was applied as the input earthquake waveform in the analysis.

Structural safety and stability during each construction stage of the Naluchi Bridge is also checked due to the proposed balanced cantilever method to be adopted during construction. In the calculation, both thermal and creeping effect of concrete were considered due to varying properties of the erection blocks, pier and pylon.

From the analysis result, the PC cable arrangement, reinforcement arrangement, members stresses on pylon, superstructure, pier P2, pier P3 and Pier P4 and tensile force of cable stay were verified against the most adverse conditions.

Design of Viaducts

- **East side Approach Viaduct**

  East side approach viaduct is a grade separated bridge which has underpass to accommodate traffic to/from Muzaffarabad city centre. The bridge length of 59m is determined by the intersection improvement plan. The structural type of this viaduct needs to consider lower structural height of girder to minimize the exiting road excavation and to lower elevation of the viaduct. Two span continuous PC box girder with four cells is selected as an appropriate alternative which has the lowest structural height among three alternatives. In seismic design, since the vibration characteristic of this bridge is relatively simple, the static analysis is applied for checking bridge seismic performance. The static analysis was conducted using 0.35G as the design horizontal seismic coefficient, derived from the design response spectrum. From the result of structural analysis, PC cable arrangement, reinforcement arrangement and members stresses on the superstructure, abutment A1, and pier P1 are verified against the most adverse conditions.

- **West side Approach Viaduct**

  The west side approach viaduct is designed as a curved bridge since the horizontal alignment has a curve with 150m radius. As a result of comparative studies, 4-spans continuous PC-Box girder was selected as the appropriate configuration based on economical aspects and structural aspects (ductility and seismic resistance). In the detailed design, its seismic performance is checked by dynamic analysis similar to the main portion of Naluchi Bridge. From the result of calculations, PC cable arrangement, reinforcement arrangement and members stresses on superstructure, pier P5, pier P6, pier P7 and abutment A2 were verified against the most adverse conditions.

Minor Bridges and Culverts

- **Minor Bridges**

  The cross sections of minor bridges were designed in accordance with "Standardization of Bridge Superstructure (January, 2005)" published by NHA. The bridge lengths were designed with sufficient opening below the girder soffit to accommodate estimated run off discharge. Considering these concepts, the bridge locations and span lengths were designed accordingly. PC-I shape girder type, widely applied in Pakistan, was preferred for minor bridges since as it has been identified as the most economically viable alternative. The PC girder section is referred to the Standardization of Bridge Superstructures, NHA, January, 2005. The design calculation procedure for superstructure and substructure for Minor Bridges No.1 at Sta. 1+745, No. 2 at Sta. 3+515 & No. 3 at Sta. 4+730 were carried out using the similar method as the east approach viaduct of Naluchi Bridge.

- **Culvert Design**

  There are 21 culverts included along the Project road. Geometry of the culverts was classified into several types: box culverts (Type I to IV), portal culvert (Type V) and pipe culvert, for practicality of construction and in consideration of the discharge capacity and vertical clearance.

NATURAL DISASTER HAZARD STUDY

The natural hazards categorized as slope disasters, which identified along the proposed alignment are classified into four types: collapse, rock fall, land slide, and debris flow.

Based on the site survey, respective slope disasters are classified according to geological conditions, anticipated causes, shape, mechanism, and scale of failures, and appearance.

In the basic design, possible counter measures selected for each different slope disaster were determined using standard procedure of suitable counter measures in Japan and comparative study of several alternatives. From this study, cribs work was selected as suitable countermeasure for collapse and rock fall sections. For landslide area, realignment is the most appropriate counter measure based on technical and economical aspects. As countermeasure for debris flow, raising the bridge grade and extension of bridge to accommodate debris flow is selected as the first option while installation of check dam and diversion dyke upstream is considered as the second option.

The detailed design crib works at Sta. 0 + 160, Sta. 3 + 530, Sta. 0 + 575 ~ Sta. 0+720, Sta. 2 + 100 ~ Sta. 2 +210, and Sta. 3 + 310 ~ Sta. 3+ 410 were designed based on criteria established to determine dimensions, arrangement and size of cribs and reinforcing bars.

ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

Recognizing that the situation of the local society remains unstable after the earthquake, special attention was rendered to exercise careful and extensive environmental and social considerations throughout the implementation of the Project.

The main objectives of the EIA Study in the Basic Design and Detailed Design Phases are to identify, assess and mitigate potential impacts on social/natural environments caused by the Project, and to assist the Government of AJK in preparing an EIA document which includes a Land Acquisition and Resettlement Plan (LARP) and an Environmental Management & Monitoring Plan (EMMP). The entire exercise is conducted under the relevant laws and regulations of the Government of Pakistan and the Government of AJK. One of the focal points of the EIA Study is conducting public consultations at various places in the Project Area. The stakeholders include the affected persons by the Project, and decision makers and staff in the relevant authorities.

Field works including interviews to local residents and census, and land measurement surveys are conducted in February – March and August 2007. Alongside these field works, relevant information on the environments is collected. Baseline information on air, noise and water are also measured in the Project area in March 2007.

The findings in the EIA Study are simultaneously incorporated as much as possible to the Basic Design. The following four (4) aspects are considered in the Basic Design Phase to avoid and / or minimize the impacts: 1) high risk areas of natural disaster; 2) width of the Right of Way; 3) control points; and 4) traffic accidents.

It was found that the environmental impacts by the Project are expected to occur throughout the Project duration including the operation stage. In order to avoid, minimize and mitigate these impacts, the EMMP is developed, and appropriate mitigation measures are also incorporated into the Detailed Design to as much extent as possible.

To identify induced impacts associated with land acquisition and resettlement, LARP was developed. The Study has found that the Project requires acquisition of 6.81 hectares of land, affecting 180 households with 993 persons. The Project also affects 66 residential buildings, 171 shops or small business enterprises, and 135 community and public structures mostly consisting of electric and telephone poles. The estimated cost for the land acquisition, compensation, implementation, and monitoring is 323.272 millions Pakistan Rupees. The above-mentioned figure is calculated based on prevailing market prices of land and replacement cost of structures. It should be noted that “land for land” compensation is not applied for the Project because of non-availability of appropriate government land in the nearby vicinity compounded by the lack of firm commitment from the state and the APs’ unwillingness to be relocated away from their current locations.

It is recommended that the Government of AJK should securely implement the EMMP and LARP for smooth implementation of the Project. In particular the land acquisition and resettlement is the critical issue for the Project, and it is highly appreciated that the LARP based on the APs' interests, materializes without further delays.

CONSTRUCTION SCHEDULE AND COST ESTIMATE

In costing and formulating construction schedule, special attention was rendered to safety and efficiency of the work, assured quality control of concrete work, reliable construction method and environmental aspects.

Major construction materials are available in Pakistan. Maximum utilization of the local materials has been proposed provided its quality meets the requirement. From this aspect, only high-early-strength portland cement and cable stay will be imported.

Most of the equipment and plant required are available from markets in Peshawar or Lahore. However, they are obsolete and poorly in maintained. General purpose equipment such as excavator, crane, etc should therefore be sourced abroad. Tower crane, form traveler, and equipment of shotcrete will also be sourced abroad. Frame scaffolding has been adopted in design for safety and efficient work, in stead of pipe scaffolding/support generally used in Pakistan.

Only casual labors are available in project area due to limited skilled labors. It was therefore proposed that the skilled labors be recruited outside Muzaffarabad. Construction of Naluchi Bridge, utilizing balanced cantilever erection, requires experienced technicians in PC work to assure that quality is acceptable and timely construction is achieved.

Based on the study for contract packaging, the project is divided into two Packages: Package I and Package II, according to nature of the work. Package I consists mainly of bridge works, while Package II of road construction. The construction period of Package I is governed by Naluchi Bridge construction estimated at 33 months, while construction of Package II takes 25 months after issuance of the notice to proceed.

Basically, CSR rates on September 2006 (Mansehra) were adopted in the project cost estimate considering adjustment for distant transportation (+7%), price hike of material (+5%) and difficulties of employment of skilled labor (+20%). However, no CSR rates were applicable for bridges of Package II, thus, new rates were prepared according to standard production rates in Japan with some adjustments based on local conditions. Engineering cost was estimated at 10% of the construction cost. Employer's contingency was estimated at 5 % of the construction cost and engineering cost. The project cost is then estimated at Rs.1,620,780,576 as at October, 2007 as shown below:

Description	Package I (Rs)	Package II (Rs)	Total (Rs)
Construction Cost	1,041,104,984	362,168,242	1,403,273,226
Engineering Cost	104,110,498	36,216,824	140,327,323
Contingency	57,260,774	19,919,253	77,180,027
Project Cost	1,202,476,257	418,304,320	1,620,780,576

In addition, land acquisition and compensation, and administration cost was estimated as shown below:

Description	Package I (Rs)	Package II (Rs)	Total (Rs)
Land Acquisition and Compensation	71,832,000	251,440,000	323,272,000
Administration Cost	10,479,703	3,576,177	14,055,880
Additional Expenses Born by the Government	82,311,703	255,016,177	337,327,880

PROJECT EVALUATION AND IMPLEMENTATION SCHEDULE

Project Evaluation

Economic evaluation was carried out based on the results of detailed design to ascertain the economic viability of the Project in terms of overall benefits to the national economy. Major advantages brought by the construction of the bypass include reduction in vehicle operation costs and travel time cost savings due to the improvement of the urban traffic conditions in the city.

In the project evaluation, it is considered that the opening year of the bypass is set in 2011 and evaluation period is set for 25 years after the opening, considering the nature of road in urban area. Opportunity cost of capital or discount rate is set at 12% per annum.

The Project is evaluated by three indicators such as Economic Internal Rate of Return (EIRR), Net Present Value (NPV), Benefit Cost Ratio (B/C). The evaluation results are shown in below:

Case	EIRR	NPV	B/C
Entire Package	19.90%	1110.63	1.94
Package -I	21.54%	858.52	2.15
Package -II	17.33%	259.36	1.60

NPV: million Rs.

It could be concluded that the Project is economically viable for all the cases of evaluation.

Sensitivity analysis for the whole section is also carried out in the combined 5 x 5 cases of cost and benefit fluctuation as the below;

Cost : 20% up, 10% up, original, 10% down, 20% down

Benefit : 20% up, 10% up, original, 10% down, 20% down

The results shown below suggest that the Project is viable in such combined case, as 20% increase in project cost, as long as the benefit from the project remains at the original level.

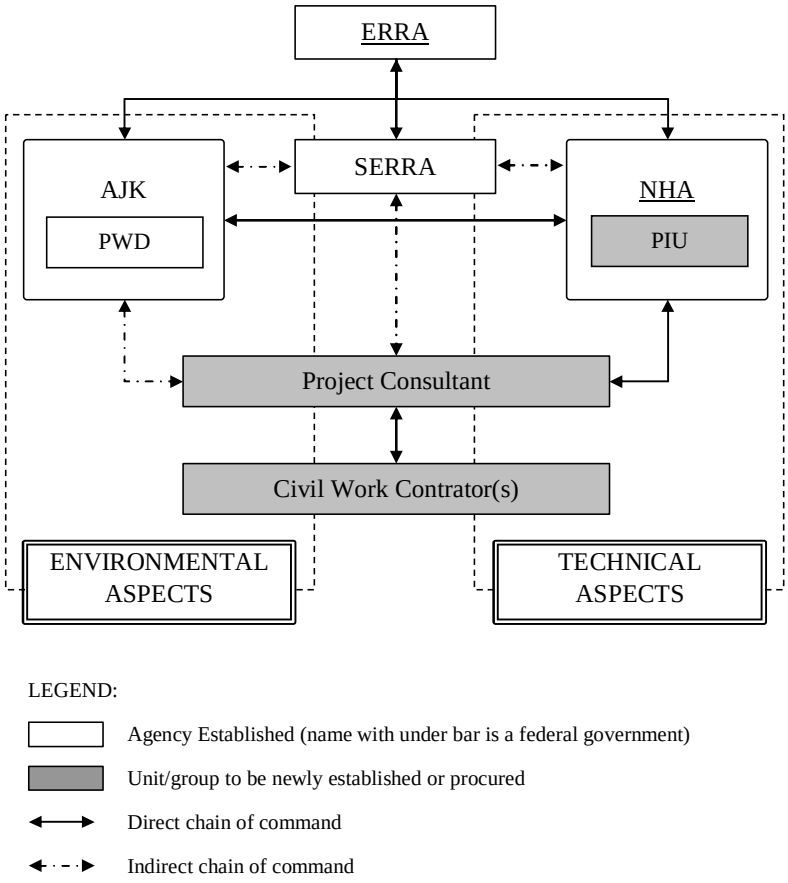
Benefit Cost	-20%	-10%	Original	+10%	+20%
-20%	19.90%	21.61%	23.22%	24.78%	26.28%
-10%	18.30%	19.90%	21.42%	22.88%	24.26%
Original	16.95%	18.46%	19.90%	21.27%	22.59%
+10%	15.79%	17.23%	18.60%	19.90%	21.15%
+20%	14.78%	16.16%	17.47%	18.71%	19.90%

Implementation Schedule

Through the study on contract packaging, the Project road was divided into two contract packages considering clearly different feature of civil works, i.e. bridge work in packages I & road work in package II. Package-I includes the starting point to the point of proposed alignment reaching the existing Naluchi Road, while Package II includes the remaining road section up to the end of the proposed road. Stations included in each package are tabulated below:

Package	Beginning of Package	End of Package	Length (km)
Package I	Sta. 0 -120.000	Sta.0+925.000	1.045
Package II	Sta. 0+925.000	Sta.4+ 951.995	4.027

Considering the present institutional frameworks for rehabilitation and reconstruction of the 2005 earthquake damages and memorandum from ERRA with regard to said matters, overall institutional framework of the Project implementation is depicted below:



In the above institutional framework, it is presumed that: Earthquake Reconstruction and Rehabilitation Authority (ERRA) is the sponsoring agency of the Project, while State Earthquake Reconstruction and Rehabilitation Agency (SERRA) represents ERRA through delegated powers at the state level for the Project implementation. Public Works Department (PWD) in AJK is responsible for undertaking all environmental matters of the Project, while National Highway Authority (NHA) is the project executing agency.

Considering significant features of Package I & II, it is recommended that contractor for Package I be procured through International Competitive Bidding (ICB) through prequalification and bidding. During bidding, two envelopes (technical and financial) system is applied since sophisticated technology and vast experience of bridge construction are envisaged for the construction of Naluchi Bridge.

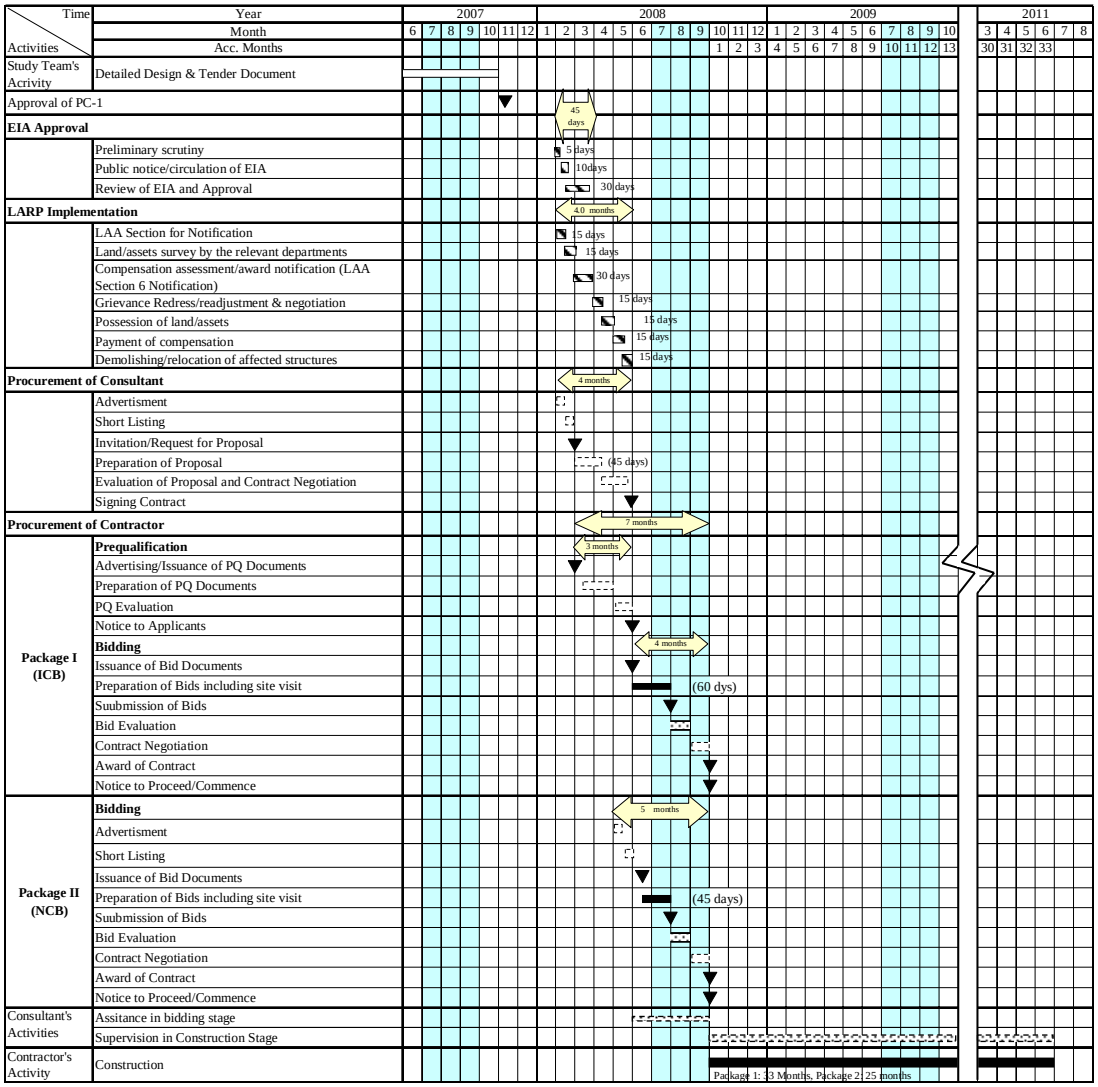
Since Package II mainly involves the standard road construction no special technology is required. It is therefore recommended that the contractor for Package II be procured through National Competitive Bidding (NCB), selected among the registered and interested contractors (post-qualification) on Cost Based Selection (CBS).

Taking into account the procurement method of contractor(s) for Package I & Package II through ICB and NCB respectively, the bid documents for the respective packages were prepared on the basis of

the "Sample Bidding Documents under JBIC ODA Loans" issued by JBIC on November 1999 and the "Standard Form of Bidding Documents (Civil Work)" published by the Pakistan Engineering Council, Islamabad on August 2002.

For procurement of a project consultant responsible for both packages in tender assistance and construction supervision, Quality Based Selection (QBS) shall be applied according to selection method of procurement of the consultant, considering scope and magnitude of the civil works.

Upon approval of PC-1, pre-construction activities should commence without further delay. Pre-construction activities, prior to commencement of the civil works, comprise procurement of project consultant and contractor(s) for civil works, and settlement of environmental matters of EIA approval and LARP implementation. This will take about 8 months, while construction of Packages I and II will be completed within 33 months and 25 months respectively, after issuance of the Notice to Proceed. The tentative implementation schedule is presented below:



CONCLUSION AND RECOMMENDATIONS

To cope with the various issues on road sectors in Muzaffarabad city, it is obviously justified that the execution of the Project is implemented within the earliest possible time, but not later than time of full operation of the rehabilitation and reconstruction works related to the October 2005 earthquake damages.

The detailed design including economic evaluation indicates that the Project is technically and economically viable for all cases of evaluation, and its implementation is urgently required.

Resulting from the detailed design, JICA Study Team strongly recommends following issues will be taken into account by Pakistan side during the Project Implementation.

Procurement Method of Civil Work Contractors: Considering the difference in scope of works for Package I (bridge work requiring advanced bridge construction technology) and Package II (road works by standard practice), it is recommended that international competitive bidding (ICB) and national competitive biding (NCB) be applied to Package I and II respectively. Subsequently, Quality Cost Based Selection (QCBS) by two envelop method, and Cost Based Selection (CBS) by one envelop method shall be applied to Package I and Package II, respectively.

Need of Close Monitoring of Environmental Issues: Prior to commencement of the civil work, procurement of supervision consultant and contractor and compensation for houses/buildings land acquisition must be completed. It is envisaged that the former is based on normal practice under NHA's responsibility while the latter is under PDW in AJK, which is complex due to involvement of compensation on price negotiation of individual property owners. Hence, close monitoring of the latter will be required in order to prevent delay of the commencement.

Secure and Timely Implementation of EMMP and LARP: It is essential in the implementation of Land Acquisition and Resettlement Plan (LARP) to involve the local comminutes, especially affected persons (APs), and reflect on their concerns on the land acquisition and resettlement issues. It is therefore recommended to apply the prevailing market rates for land valuation, timely compensation, disclosure of the information on LARP to the APs in a timely manner and cooperation of local authorities (Municipal Corporation Muzaffarabad (MCM) and Muzaffarabad Development Authority (MDA)).

Urgent Need of Project Implementation: Considering that fact that a few of houses/ buildings were newly constructed within the proposed right of way (ROW) and continuous price hike in the Project site, it is essential to commence the construction within the earliest possible time.

Technology Transfer and Enhancement of Pakistanis Engineers' Capability: It is strongly recommended that Pakistanis' Bridge Engineers in NHA and AJK should be assigned as counterpart engineers on a full time basis to smoothly impart transfer of technological knowledge during the entire project implementation. The Study Team is confident that the successful transfer of technological knowledge to Pakistanis Bridge Engineers will enhance Pakistan's bridge engineering standards and eventually contribute to building major future bridges in the country. An example of possible future bridge could be that required to cross the Indus River (with related tributaries), which presently divides the country into several territories.

Acknowledgement

Finally, we would like to express our sincere thanks to all the concerned officials of ERRA, SERRA, AJK, NHA, and many other related organizations in Pakistan, for their kind cooperation and guidance to JICA Study Team of West Bank Bypass Design.

TABLE OF CONTENTS

Preface

Letter of Transmittal

Location Map

Perspective View of New Naluchi Bridge

Perspective View of Intersection No. 4

Executive Summary

Table of Contents

Abbreviations

1. INTRODUCTION 1-1

1.1 Background of the Study 1-1

1.2 Objectives of the Study 1-2

1.3 Study Area 1-2

1.4 Outline of Preliminary Design Results 1-2

1.5 Scope of the Study 1-5

1.6 Major Events and Records of Discussion over the Study Period 1-7

1.7 Key Officials Related to the Study 1-8

1.8 Composition of the Reports 1-8

2. BASIC DESIGN CONCEPTS 2-1

2.1 Functions and Roles of the Project Road 2-1

2.1.1 Existing Road Network 2-1

2.1.2 Functions and Roles of the Project Road 2-3

2.2 Key Design Approaches 2-3

2.3 Extensive Environmental Considerations 2-6

2.3.1 Considerations on Communities under Special Circumstances 2-6

2.3.2 Integration of Environmental Considerations and Design 2-7

3. SUPPLEMENTAL FIELD CONDITION STUDY 3-1

3.1 Natural Condition 3-1

3.1.1 Topography 3-1

3.1.2 Climate 3-1

3.1.3 Geological Condition 3-6

3.2 Supplemental Topographical Survey 3-10

3.2.1 Scope of the Survey 3-10

3.2.2 Survey Results 3-10

3.3 Supplemental Geotechnical Investigation 3-13

3.3.1 Scope of Works 3-13

3.3.2 Survey Results 3-16

3.4 Hydrological and Hydraulic Survey 3-21

3.4.1 Purpose and Methodology of the Survey 3-21

3.4.2 Data Collection and Analysis 3-23

3.4.3 Hydrological Study Results 3-25
3.4.4 Hydraulic Study including Local Scouring Depth 3-26

4. Road Design 4-1
4.1 General 4-1
4.2 Applicable Design Standard and Design Criteria 4-3
4.3 Refinement of Alignment Design 4-8
4.4 Intersection Design 4-17
4.4.1 Site Condition of Proposed Intersection 4-17
4.4.2 Traffic Demand at Intersections 4-18
4.4.3 Comparative Study and Design Result 4-19
4.4.4 Signal System 4-25
4.5 Pavement Structure Design 4-28
4.5.1 Traffic Volume and Equivalent Single Axle Load (ESAL) 4-28
4.5.2 Design Condition 4-28
4.5.3 Required Structural Number (SN) 4-30
4.5.4 Thickness design 4-31
4.6 Drainage Design (Side Ditch) 4-33
4.6.1 Design Criteria 4-33
4.6.2 Drainage Design 4-34
4.6.3 Side Ditch Applied 4-37
4.7 Slope Protection Design 4-38
4.7.1 Applicable Design Criteria and Standards 4-38
4.7.2 Slope Protection Design 4-41
4.7.3 Design Results 4-44
4.8 Traffic Safety Facility 4-47
4.8.1 Traffic Signs 4-47
4.8.2 Road Marking 4-48
4.8.3 Guardrails 4-48
4.8.4 Kilometer Posts 4-48
4.8.5 Lighting 4-48

5. Bridge and Structure Design 5-1
5.1 Applicable Design Standards and Design Criteria 5-1
5.1.1 Applicable Design Standards 5-1
5.1.2 Applicable Design Criteria 5-1
5.2 Optimizaton of Naluchi Bridge 5-10
5.2.1 General 5-10
5.2.2 Refinement of Span Length 5-10
5.2.3 Refinement of Substructure 5-12
5.2.4 Refinement of Superstructure 5-15
5.3 Detailed Design of Naluchi Bridge 5-19
5.3.1 Design Method 5-19
5.3.2 Normal Condition Design 5-20
5.3.3 Seismic Design 5-24
5.3.4 Summary of Structure Analysis and Cable Arrangement 5-31

5.4 Design of Viaducts 5-49
5.4.1 East Side Approach Viaduct 5-49
5.4.2 West Side Approach Viaduct 5-64
5.5 Minor Bridge and Culvert Design 5-82
5.5.1 Design of Minor Bridges 5-82
5.5.2 Culvert Design 5-91
6. NATURAL DISASTER HAZARD STUDY 6-1
6.1 Hazard Assessment along Proposed Alignment 6-1
6.1.1 Collapse 6-3
6.1.2 Rock Fall 6-3
6.1.3 Landslide 6-4
6.1.4 Debris Flow 6-5
6.2 Basic Design for Slope Disasters 6-6
6.2.1 Collapse 6-6
6.2.2 Rock Fall 6-7
6.2.3 Landslide 6-8
6.2.4 Debris Flow 6-8
6.3 Detailed Design of Slope Protection 6-10
6.3.1 Detailed Design of Crib Works with Rock Bolts against Slope Collapse at Naluchi Bridge 6-10
6.3.2 Detailed Design of Crib Works against Rock Fall 6-12
7. ENVIRONMENTAL AND SOCIAL CONSIDERATIONS 7-1
7.1 Introduction 7-1
7.1.1 Background 7-1
7.1.2 Legal and Regulatory Framework 7-1
7.2 Objectives 7-3
7.3 Scope of the Study 7-4
7.3.1 Scope 7-4
7.3.2 Methodology 7-4
7.4 Environmental and Social Settings 7-5
7.4.1 Introduction 7-5
7.4.2 Description of Physical Environment 7-5
7.4.3 Description of Natural Environment 7-5
7.4.4 Description of Social Environment 7-6
7.4.5 Physical Environment of the Project Area 7-8
7.4.6 Socio-Economic Environment of the Project Area 7-12
7.5 Study on Alternatives 7-18
7.5.1 Alternatives for the Project 7-18
7.5.2 Alternative routes for the Western Bypass 7-18
7.5.3 Alternative Design for Intersection No.4 7-19
7.6 Conceivable Impacts 7-20
7.7 Incorporation of the Findings into the Basic Design Phase 7-22
7.7.1 Introduction 7-22
7.7.2 High risk areas of natural disaster 7-22

7.7.3 Width of the Right of Way 7-22
7.7.4 Control Points 7-22
7.7.5 Traffic accidents 7-23
7.8 Environmental and Social Impacts, and Mitigation Measures 7-23
7.8.1 Introduction 7-23
7.8.2 Public Consultations 7-23
7.8.3 Environmental Impact Assessment 7-24
7.8.4 Land Acquisition and Resettlement Plan 7-32
7.8.5 Incorporation of the Findings into the Detailed Design 7-41
8. CONSTRUCTION SCHEDULE AND COST ESTIMATE 8-1
8.1 Basic Concepts of Construction Schedule and Cost Estimate 8-1
8.1.1 Special Considerations for Package I 8-1
8.1.2 Special Considerations for Package II 8-2
8.1.3 Cost Estimates 8-3
8.2 Bases of Scheduling and Cost Estimates 8-3
8.3 Summary of Work Quantity 8-5
8.3.1 Major material used in the Project 8-7
8.3.2 Employment of local labors 8-7
8.4 Procurement Conditions 8-7
8.4.1 Labor 8-7
8.4.2 Materials 8-7
8.4.3 Equipment 8-8
8.5 Construction Method and Schedule 8-9
8.5.1 Basic Concepts of Construction Scheduling 8-9
8.5.2 Bridge Construction Plan 8-10
8.5.3 Conceivable Location of Temporary Camp, Borrow Pit and Pit for Construction Waste Materials 8-15
8.5.4 Construction Method and Sequence of Main Work Items 8-16
8.5.5 Construction Schedule 8-21
8.6 Operation and Maintenance Plan 8-22
8.6.1 Maintenance Plan 8-23
8.7 Composition of the Project Cost 8-24
8.8 Unit Price Analysis 8-25
8.8.1 Labor Cost 8-26
8.8.2 Materials Cost 8-27
8.8.3 Equipment Cost 8-27
8.8.4 Other Cost 8-28
8.9 Project Cost Estimate 8-28
8.9.1 Unit Price 8-28
8.9.2 Construction Cost 8-30
8.9.3 Head Office Overhead and Profit 8-30
8.9.4 Engineering Cost 8-30
8.9.5 Land Acquisition and Compensation Cost 8-31
8.9.6 Administration Cost 8-31

8.9.7 Employer's Contingency 8-31
8.9.8 Income Tax 8-31
8.9.9 Project Cost 8-31

9. PROJECT EVALUATION AND IMPLEMENTATION SCHEDULE 9-1
9.1 General 9-1
9.2 Economic Evaluation 9-1
9.2.1 Economic Project Cost and Cost Disbursement Schedule 9-1
9.2.2 Estimation of Benefits 9-2
9.2.3 Project Evaluation 9-7
9.2.4 Sensitivity Analysis 9-10
9.2.5 Conclusion 9-10
9.3 Study on Contract Packaging 9-11
9.4 Project Implementation 9-12
9.4.1 Institutional Framework of the Project Implementation 9-12
9.4.2 Procurement of Contractor(s) for Civil Works 9-14
9.4.3 Procurement of Project Consultant 9-19
9.4.4 Project Implementation Schedule 9-20

10. CONCLUSIONS AND RECOMMENDATIONS 10-1
10.1 Urgent Need for the Project 10-1
10.2 Special Considerations in the Design 10-2
10.3 Outline of the Detailed Design Results 10-3
10.4 Environmental Considerations 10-5
10.5 Project Viability 10-5
10.6 Recommendations 10-6
10.7 Acknowledgement 10-9

LIST OF TABLES

Table 1.8.1	Composition of Report	1-8
Table 3.1.1	Monthly Temperature (1995-2004)	3-2
Table 3.1.2	Annual Precipitation (1990-2006)	3-3
Table 3.1.3	Monthly Precipitation (1985-2006)	3-3
Table 3.1.4	Maximum Daily Precipitation in mm at Muzaffarabad (1987 – 2005)	3-4
Table 3.1.5	Average Number of Rainy Days (1971-2000)	3-4
Table 3.1.6	Monthly Wind Velocities (1995–2004)	3-5
Table 3.1.7	Monthly Relative Humidity (1974–2004)	3-6
Table 3.1.8	Stratigraphy of Muzaffarabad	3-8
Table 3.1.9	Geological Component along the Proposed Road Alignment	3-9
Table 3.2.1	Quantity of Topographic Survey	3-10
Table 3.2.2	List of Small Bridges	3-11
Table 3.2.3	List of Culverts	3-11
Table 3.3.1	Summary of Existing Boreholes from the Preliminary Design Stage	3-13
Table 3.3.2	Borehole Locations and Depths for Naluchi Bridge	3-13
Table 3.3.3	Quantities of Geotechnical Survey	3-14
Table 3.3.4	Summary of Results of Drilling Survey	3-16
Table 3.3.5	Design Parameters for Gravely Soil	3-17
Table 3.3.6	Design Parameters for Rock	3-17
Table 3.3.7	Design Parameters for Rock	3-17
Table 3.3.8	Summary of Laboratory Test Results	3-18
Table 3.3.9	Pavement Thickness and Soil Property of Subgrade	3-20
Table 3.3.10	Summary of CBR Test	3-20
Table 3.4.1	Selected Hydrological Gauging Stations	3-23
Table 3.4.2	Discharge of Neelum River at Muzaffarabad (1992-2003) m3/s	3-23
Table 3.4.3	Estimated Discharges for Small Rivers and Tributaries	3-25
Table 3.4.4	Results of Probable Discharge Analysis	3-27
Table 3.4.5	Results of Flood Water Level	3-27
Table 3.4.6	100 Year Flood Water Level of Neelum River Along Proposed Road Alignment	3-28
Table 4.1.1	Division of the Entire Project Route by Sections	4-2
Table 4.2.1	Geometric Design Standard of the Project Road	4-4
Table 4.3.1	Applied Design and Site Description for Each Section for Package 1	4-8
Table 4.3.2	Result of Comparative Study on Section-5	4-12
Table 4.3.3	Result of Comparative Study on Section-7	4-13
Table 4.3.4	Result of Comparative Study on Section-9	4-15
Table 4.3.5	Minor Road List	4-16
Table 4.4.1	Comparative Study Table for Intersection No.1&A	4-21
Table 4.4.2	Comparison Study on At-Grade Alternatives	4-24
Table 4.5.1	The Accumulated Traffic Volumes and its ESAL for 15 years from the Opening Year of 2010	4-28
Table 4.5.2	Summary of Pavement Design Criteria by AASHTO Method	4-29
Table 4.5.3	Summary of Existing Road CBR	4-29
Table 4.5.4	Designed Pavement Thickness for Bypass Road	4-31
Table 4.6.1	Design Criteria for Side Ditch	4-33

Table 4.6.2 Design Discharge and Required Drainage Capacity of Each Catchment Area (Left side Drainage) 4-35
Table 4.6.3 Design Discharge and Required Drainage Capacity of Each Catchment Area (Right side Drainage) 4-36
Table 4.7.1 Standard Gradients of Cut Slopes from Japanese Standards 4-38
Table 4.7.2 Standard Gradients of Slopes Corresponding to Fill Materials and Heights of Fill 4-38
Table 4.7.3 Preventive Measures against Slope Collapse 4-39
Table 4.7.4 Retaining Wall Types and Features 4-40
Table 4.7.5 Station Limit of Respective Retaining Walls Selected 4-41
Table 5.1.1 Loading Case Table for Service Load Design 5-7
Table 5.1.2 Loading case table for Load Factor Design 5-7
Table 5.1.3 Classification of Concrete 5-8
Table 5.1.4 Specification of Prestressing Steel 5-9
Table 5.3.1 Design Conditions for Naluchi Bridge 5-20
Table 5.3.2 Materials' Properties for Naluchi Bridge 5-21
Table 5.3.3 Summary of Modelling 5-26
Table 5.3.4 Support Conditions 5-26
Table 5.3.5 Design Summary for Service Load Design (1) 5-32
Table 5.3.6 Design Summary for Service Load Design (2) 5-33
Table 5.3.7 Summary of Tensile Force for Stay Cable 5-35
Table 5.3.8 Service Load Design for Stay Cable 5-36
Table 5.3.9 Design Summary for Pier P2 (1) 5-38
Table 5.3.10 Design Summary for Pier P2 (2) 5-39
Table 5.3.11 Design Summary for Pier P2 (3) 5-40
Table 5.3.12 Design Summary for Pier P3 (1) 5-41
Table 5.3.13 Design Summary for Pier P3 (2) 5-42
Table 5.3.14 Design Summary for P4 Pier (1) 5-44
Table 5.3.15 Design Summary for P4 Pier (2) 5-45
Table 5.3.16 Design Summary for P4 Pier (3) 5-46
Table 5.3.17 The Most Severe Load Combination 5-48
Table 5.4.1 Design Conditions for East Side Viaduct 5-53
Table 5.4.2 Material Properties 5-53
Table 5.4.3 Design Seismic Coefficient for P1 Pier 5-54
Table 5.4.4 Design Summary of A1 Abutment (1) 5-58
Table 5.4.5 Design Summary of A1 Abutment (2) 5-59
Table 5.4.6 Design Summary of A1 Abutment (3) 5-60
Table 5.4.7 Design Summary for P1 Pier (1) 5-61
Table 5.4.8 Design Summary for P1 Pier (2) 5-62
Table 5.4.9 Design Summary for P1 Pier (3) 5-63
Table 5.4.10 Design Conditions for West Side Viaduct 5-68
Table 5.4.11 Material Properties 5-68
Table 5.4.12 Design Summary of Service Load Design 5-70
Table 5.4.13 Design Summary for P5 Pier (1) 5-73
Table 5.4.14 Design Summary for P5 Pier (2) 5-74
Table 5.4.15 Design Summary for P6 Pier (1) 5-75
Table 5.4.16 Design Summary for P6 Pier (2) 5-76
Table 5.4.17 Design Summary for P7 Pier (1) 5-77
Table 5.4.18 Design Summary for P7 Pier (2) 5-78

Table 5.4.19 Design Summary of A2 Abutment (1/3) 5-79
Table 5.4.20 Design Summary of A2 Abutment (2/3) 5-80
Table 5.4.21 Design Summary of A2 Abutment (3/3) 5-81
Table 5.5.1 Culverts Dimension according to Discharge 5-82
Table 5.5.2 Calculation Result of Superstructure 5-85
Table 5.5.3 Calculation Result of Bridge No.1 Substructure 5-86
Table 5.5.4 Calculation Result of Bridge No.2 Substructure 5-87
Table 5.5.5 Calculation Result of Bridge No.3 Substructure(A1&A2) (1/2) 5-88
Table 5.5.6 Calculation Result of Bridge No.3 Substructure(A1&A2) (2/2) 5-89
Table 5.5.7 Calculation Result of Bridge No.3 Substructure(P1) (1/2) 5-89
Table 5.5.8 Calculation Result of Bridge No.3 Substructure(P1) (2/2) 5-90
Table 5.5.9 Culverts Dimension according to Discharge 5-92
Table 5.5.10 Design Conditions 5-93
Table 5.5.11 Loading Cases for Culverts 5-94
Table 5.5.12 Required Bearing Capacity 5-95
Table 6.1.1 Typical Features and Characteristics of Slope Disasters 6-1
Table 6.1.2 Collapse Slope Hazard Assessment 6-3
Table 6.1.3 Rock Fall Hazard Assessment 6-4
Table 6.1.4 Landslide Hazard Assessment 6-4
Table 6.1.5 Debris Flow Hazard Assessment 6-5
Table 6.2.1 Comparison of Protection Measures 6-8
Table 6.2.2 Expected Debris Flow Discharge 6-9
Table 6.3.1 Design Parameters 6-10
Table 6.3.2 Design Condition and Parameters for Concrete Crib Work 6-10
Table 6.3.3 Design Condition and Parameters for Rock Bolt 6-11
Table 6.3.4 Summary of Stress Analysis for Concrete Crib 6-11
Table 6.3.5 Design Parameters 6-13
Table 6.3.6 Design Condition and Parameters for Concrete Crib Work 6-13
Table 6.3.7 Summary of Stress Analysis for Crib 6-13
Table 7.1.1 Relevant Sections of the Land Acquisition Act 1894 7-3
Table 7.4.1 Present Housing Profile of the Project Area and Its Surrounding Areas 7-7
Table 7.4.2 Analysis of Ambient Air Quality 7-9
Table 7.4.3 Analysis of Noise Level 7-10
Table 7.4.4 Guidelines for Community Noise by WHO 7-11
Table 7.4.5 Chemical Analysis of the Sampling Water 7-12
Table 7.4.6 Microbiological Analysis of the Sampling Water 7-12
Table 7.4.7 General Profiles 7-13
Table 7.4.8 Education Facilities 7-14
Table 7.4.9 Literacy and Education Level 7-14
Table 7.4.10 Professional Status 7-14
Table 7.4.11 Income Levels 7-15
Table 7.4.12 Basic Facilities at Home 7-15
Table 7.4.13 Types of Construction 7-15
Table 7.4.14 Concerns and Expectations from the Local People 7-17
Table 7.5.1 Evaluation of the Alternatives 7-18
Table 7.5.2 Evaluation of Alternative Sections 7-19
Table 7.5.3 Evaluation of Alternative Routes 7-19

Table 7.6.1 Conceivable impacts at each stage of the Project 7-20
Table 7.8.1 Environmental Management Plan (Design/Pre-Construction Stage) 7-25
Table 7.8.2 Environmental Management Plan (Construction Stage) 7-25
Table 7.8.3 Environmental Management Plan (Operation Stage) 7-27
Table 7.8.3 Environmental Management Plan (Operation Stage) 7-28
Table 7.8.4 Environmental Monitoring Plan 7-30
Table 7.8.5 Entitlement Matrix 7-33
Table 7.8.6 Number of Affected Households 7-34
Table 7.8.7 Extent of Affected Land 7-34
Table 7.8.8 LARP Implementation Timeframe 7-37
Table 7.8.9 LARP Tasks Process 7-37
Table 7.8.10 Indicative Resettlement Budget 7-40
Table 8.3.1 Overview of West Bank Bypass 8-5
Table 8.3.2 Main Work Quantity 8-6
Table 8.3.3 Major Material 8-7
Table 8.4.1 Material Available in Pakistan 8-8
Table 8.4.2 Material to be Imported 8-8
Table 8.4.3 Equipment Arrangement 8-8
Table 8.5.1 Cycle time of girder segment with no stay cable 8-14
Table 8.5.2 Cycle time of girder segment with stay cable 8-14
Table 8.6.1 Annual recurring expenditure 8-22
Table 8.6.2 Maintenance Intervals 8-23
Table 8.6.3 Inspection 8-24
Table 8.8.1 Labor Cost 8-26
Table 8.8.2 Expatriate Wages 8-27
Table 8.8.3 Material Price 8-27
Table 8.8.4 Equipment Cost 8-28
Table 8.8.5 Transportation Cost 8-28
Table 8.9.1 Summary of Construction Cost 8-30
Table 8.9.2 Project Cost 8-31
Table 8.9.3 Additional Expense 8-31
Table 8.9.4 Proportion of the Project Cost in Local and Foreign Currency 8-32
Table 8.9.5 Summary of Project Cost in Local and Foreign Currency 8-32
Table 9.2.1 Project Cost in Economic Prices by Disbursement 9-1
Table 9.2.2 Compensation Cost in Economic Prices 9-1
Table 9.2.3 Maintenance Cost 9-2
Table 9.2.4 Future Daily Traffic Volume on the Bypass 9-2
Table 9.2.5 Unit VOC by Speed and Road Surface Condition (in Economic Prices) 9-4
Table 9.2.6 Additional Fuel Consumption by Gradient of Road 9-5
Table 9.2.7 Time Value per Vehicle 9-5
Table 9.2.8 Distance and Gradient by Section of Road 9-6
Table 9.2.9 Road Surface Condition 9-6
Table 9.2.10 Estimated Future Yearly Benefit 9-6
Table 9.2.11 Result of Economic Evaluation 9-8
Table 9.2.12 Cash Flow for Economic Evaluation 9-8
Table 9.2.13 Result of Sensitivity Analysis (Case 1: Whole Section) 9-10
Table 9.2.14 Reference; Result of Economic Evaluation in the Interim Report 9-11

Table 9.3.1 Pros and Cons and Contract Packages 9-12
Table 9.4.1 Evaluation Criteria of Technical Proposal 9-19
Table 10.3.1 Overview of West Bank Bypass 10-3
Table 10.3.2 Major Work Quantities 10-4
Table 10.3.3 Project Cost 10-4
Table 10.3.4 Additional Expense 10-5

LIST OF FIGURES

Figure 1.5.1	Study sequence	1-6
Figure 2.1.1	Existing Road Network in Muzaffarabad	2-2
Figure 3.1.1	Isohyets Map of Pakistan	3-2
Figure 3.1.2	Monthly Temperature (1995-2004)	3-3
Figure 3.1.3	Monthly Precipitation (1985-2006)	3-4
Figure 3.1.4	Number of Rainy Days (1971-2000)	3-5
Figure 3.1.5	Monthly Wind Velocities (1995–2004)	3-5
Figure 3.1.6	Monthly Relative Humidity (1974-2004)	3-6
Figure 3.3.1	Location Map of Geotechnical Survey	3-15
Figure 3.4.1	Flowchart of Hydrological Analysis	3-21
Figure 3.4.2	Location Map of Drainage Number for Crossing the Road, and Gauging Station of Neelum River & Jhelum River	3-22
Figure 3.4.3	Monthly Discharge of Neelum River at Muzaffarabad	3-24
Figure 4.1.1	Sub-divided sections of the Project	4-2
Figure 4.2.1	Computer Graphic for Stopping Sight Distance	4-5
Figure 4.2.2	Typical Cross Section	4-7
Figure 4.2.3	Typical Cross Section with Side Walk (Flat Type)	4-7
Figure 4.2.4	Typical Cross Section with Side Walk (Mount Up Type)	4-7
Figure 4.4.1	Site of Intersection No.4	4-18
Figure 4.4.2	Hourly Traffic Volume of Each Direction	4-19
Figure 4.4.3	Layout of Intersection No.2	4-22
Figure 4.4.4	Layout of Intersection No.3	4-22
Figure 4.5.1	Design Chart for Flexible Pavement.	4-30
Figure 4.5.2	Pavement composition for Section 1～6 (Sta.0-121.0～Sta3+157.8)	4-31
Figure 4.5.3	Pavement composition for Section 7～9 (Sta.3+157.8～Sta4+951.995)	4-31
Figure 4.6.1	Typical Cross Section for Side Drains	4-37
Figure 4.7.1	Study for Structural Type of River Bank Protection	4-43
Figure 4.7.2	Typical Structural Detail for Leaning Type Retaining Wall	4-44
Figure 4.7.3	Typical Structural Detail for Stone Masonry (Leaning)	4-44
Figure 4.7.4	Typical Structural Detail for Inverted L-Shaped Retaining Wall (Bound Grave)	4-45
Figure 4.7.5	Typical Structural Detail for T-Shaped Retaining Wall	4-45
Figure 4.7.6	Typical Structural Detail for Stone Masonry (Leaning)	4-46
Figure 4.7.7	Typical Section for River Bank Protection	4-46
Figure 4.7.8	Typical Structural Detail for Stone Masonry (Gravity)	4-47
Figure 5.1.1	Bridge Cross Section of Naluchi Bridge	5-2
Figure 5.1.2	Design vehicle Load (Type “A”)	5-3
Figure 5.1.3	Seismic Ground Acceleration Map	5-5
Figure 5.1.4	Seismic Design Flowchart	5-6
Figure 5.1.5	Applied Earthquake Wave (El Centro Wave 1940 USA)	5-6
Figure 5.2.1	Options of Foundation on Left-bank Pier	5-11
Figure 5.2.2	Bridge Profile	5-11
Figure 5.2.3	Comparison for Pier Foundation Type	5-13
Figure 5.2.4	Comparison for River Pier Configuration	5-14
Figure 5.2.5	Comparison Stay Cable Arrangement	5-16
Figure 5.2.6	Comparison for Cross Section of Main Girder	5-17

Figure 5.2.7 Comparison of Stay Cable....5-18
Figure 5.3.1 Applied Earthquake Wave (El Centro Wave 1940 USA) 5-19
Figure 5.3.2 Weight of Anchorage of Stay Cable 5-22
Figure 5.3.3 Weight of Traveller....5-22
Figure 5.3.4 Skeleton of Bridge 5-23
Figure 5.3.5 Bending Moment during Cantilever Construction....5-23
Figure 5.3.6 Bending Moment Diagram at Dead Load 5-24
Figure 5.3.7 Bending Moment Diagram at Dead Load + Live Load....5-24
Figure 5.3.8 Applied stiffness model....5-25
Figure 5.3.9 Analysis Model....5-26
Figure 5.3.10 The relationship Between Frequency and Damping Coefficient....5-28
Figure 5.3.11 Maximum Displacement 5-29
Figure 5.3.12 Maximum Acceleration....5-29
Figure 5.3.13 Response Sectional Force Diagram 5-30
Figure 5.3.14 Bending Moment Diagram of Girder....5-31
Figure 5.3.15 Bending Stress Diagram of Girder for Service Load Design 5-31
Figure 5.3.16 Flexural Strength Diagram of Girder for Load Factor Design 5-34
Figure 5.3.17 Required Shear Reinforcement Diagram of Girder for Load Factor Design....5-34
Figure 5.3.18 Section of Internal PS-Steel Arrangement 5-37
Figure 5.3.19 Check of Response Force of Pier P3....5-43
Figure 5.3.20 Check of response force of P4 wall 5-47
Figure 5.4.1 Profile of East Side Approach Viaduct 5-49
Figure 5.4.2 Plan of East Side Approach....5-49
Figure 5.4.3 Comparison for Superstructure of the Viaduct....5-51
Figure 5.4.4 General View of East Side Approach Viaduct 5-52
Figure 5.4.5 Design Response Spectral....5-54
Figure 5.4.6 Analysis Frame Model....5-54
Figure 5.4.7 Bending Moment Diagram....5-55
Figure 5.4.8 Bending Stress Diagram for Service Load Design 5-56
Figure 5.4.9 Flexural Strength Diagram for Load Factor Design 5-57
Figure 5.4.10 Cable Arrangement (Section)....5-57
Figure 5.4.11 Cable Arrangement Elevation 5-57
Figure 5.4.12 Profile of the Viaduct....5-64
Figure 5.4.13 Plan of the Viaduct 5-64
Figure 5.4.14 Comparison for West side Approach Viaduct....5-66
Figure 5.4.15 General View of Viaduct....5-67
Figure 5.4.16 Analysis Frame Model....5-69
Figure 5.4.17 Bending Stress Diagram for Service Load Design Group-I....5-71
Figure 5.4.18 Bending Stress Diagram for Service Load Design Group-IV 5-71
Figure 5.4.19 Flexural Strength Diagram for Load Factor Design 5-71
Figure 5.4.20 Cable Arrangement (section)....5-72
Figure 5.4.21 Cable Arrangement (elevation)....5-72
Figure 5.5.1 Standard Bridge Cross Section for 2 Lane Carriageway....5-83
Figure 5.5.2 Typical Structural Detail for 1 cell Box Culvert....5-92
Figure 5.5.3 Vertical Clearance for S8 culvert....5-93
Figure 5.5.4 Typical Structural Detail for Pipe Culvert....5-95
Figure 6.1.1 Location Map of Disaster Hazards along Proposed Alignment....6-2

Figure 6.2.1 Flowchart for Selection of Slope Protection Method....6-7
Figure 6.2.2 Selection of Countermeasure against Debris Flow....6-9
Figure 6.3.1 Scale and Model of Potential Collapse for the Slope Protection Design....6-10
Figure 6.3.2 Detailed Design of Crib Works and Rock Bolts Arrangement against Slope Collapse at Naluchi Bridge....6-12
Figure 6.3.3 Scale and Model of Potential Collapse of Rock Fall Sections for the Slope Protection Design....6-12
Figure 6.3.4 Detailed Design of Crib Works for Slope Protection against Rock Fall....6-14
Figure 7.1.1 Flow of an IEE and EIA for a development project....7-2
Figure 7.3.1 Framework of the Study....7-4
Figure 8.1.2 Concrete Crib Construction by Shotcrete....8-3
Figure 8.5.1 Mean discharge of Neelum River....8-11
Figure 8.5.2 SHINSO foundation....8-11
Figure 8.5.3 General View and Scaffolding of P3 Pier....8-12
Figure 8.5.4 Construction of Pier Table and Form Traveler....8-13
Figure 8.5.5 Scaffolding of Pylon and Saddle....8-13
Figure 8.5.6 Construction of East Side Approach Viaduct....8-16
Figure 8.5.7 Construction of West Side Approach Viaduct....8-20
Figure 8.5.7(a) Construction Sequence of Naluchi Bridge (1/3)....8-17
Figure 8.5.7(b) Construction Sequence of Naluchi Bridge (2/3)....8-18
Figure 8.5.7(c) Construction Sequence of Naluchi Bridge (3/3)....8-19
Figure 8.5.8 Drilling anchor hole on steep slope....8-21
Figure 8.5.9 Construction Schedule for Package I....8-21
Figure 8.5.10 Construction Schedule for Package II....8-22
Figure 8.7.1 Project Cost Components....8-25
Figure 9.4.1 Institutional Framework of Project Implementation....9-13
Figure 9.4.2 Tentative Project Implementation Schedule....9-21

LIST OF ANNEXES

(Enclosed in Main Text)

Annex 1 Minutes of Meeting/Minutes of Discussion

Annex 2 List of Key Officials

LIST OF APPENDIXES

(Separate Volume)

APPENDIX A SUPPORTING DATA FOR ROAD DESIGN
APPENDIX B STRUCTURAL CALCULATION (East Side Approach Viaduct)
APPENDIX C STRUCTURAL CALCULATION (Naluchi Bridge)
APPENDIX D STRUCTURAL CALCULATION (West Side Approach Viaduct)
APPENDIX E STRUCTURAL CALCULATION (Three Small Bridges)
APPENDIX F STRUCTURAL CALCULATION (Culvert and Retaining Wall)
APPENDIX G QUANTITY CALCULATION
APPENDIX H COST ESTIMATION
APPENDIX I REPORT ON ENVIRONMENTAL IMPACT ASSESSMENT
APPENDIX J REPORT ON RESETTLEMENT ACTION PLAN

Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
AJK	Azad Jammu and Kashmir
APs	Affected Persons
ASTM	American Society for Testing and Materials
B/C	Benefit Cost Ratio
CBR	California Bearing Ratio
CMS	Construction and Management Supervision
CSR	Composite Schedule Rate
DBNH	Designing of Bridges on National Highways
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EMA	External Monitoring Agency
EMMP	Environmental Monitoring and Management Plan
ERRA	Earthquake Reconstruction and Rehabilitation Authority
FGDs	Focus Group Discussions
GRC	Grievance Redress Committee
HCM	Highway Capacity Manual
HFT	Himalayan Frontal Thrust
ICB	International Competitive Bidding
IEE	Initial Environmental Examination
JBIC	Japan Bank for International Cooperation
JICA	Japan International Cooperation Agency
JRSO	Japan Road Structure Ordinance
LAA	Land Acquisition Act
LARP	Land Acquisition and Resettlement Plan
MBT	Main Boundary Thrust
MCM	Municipal Corporation Muzaffarabad
MCT	Main Central Thrust
MDA	Muzaffarabad Development Authority
NCB	National Competitive Bidding
NEQS	National Environmental Quality Standards
NESPAK	National Engineering Service Pakistan
NGO	Non Governmental Organizations
NHA	National Highway Authority
NPV	Net Present Value

O/M	Operation and maintenance
ODA	Official Development Assistance
PC	Prestressed Concrete
PC-1	Planning Commission Document
PCPHB	Pakistan Code of Practice for Highway Bridges
PCU	Passenger Car Unit
PGA	Peak Ground Acceleration
PQ	Pre-qualification
PWD	Public Work Department
QCBS	Quality and Cost Based Selection
REI	Request of Expression of Interest
RFP	Request for Proposal
ROW	right-of-way
RQD	Rock Quality Designation
SBS	Standardization of Bridge Superstructures
SCF	Standard Conversion Factor
SERRA	State Earthquake Rehabilitation and Reconstruction Authority
SN	Structural Number
SPT	Standard Penetration Test
TTC	Travel Time Cost
UBC	Uniform Building Code
VOC	Vehicle Operation Cost
WAPDA	Water Power Development Authority
WBB	West Bank Bypass
WHO	World Health Organization
WPCPHB	West Pakistan Code of Practice for Highway Bridges

CHAPTER 1

INTRODUCTION

1. INTRODUCTION

1.1 Background of the Study

On October 8, 2005, an earthquake measuring 7.6 on the Richter scale occurred at 8:50 a.m. (Pakistan Standard Time). The earthquake caused severe damages to a widespread area, including Muzaffarabad City, the capital of Azad Jammu and Kashmir (hereinafter referred to as "AJK"). Muzaffarabad City suffered heavy losses because the epicenter was located near the city. After the earthquake, the Government of Japan accepted the Government of Pakistan's request to conduct "The Urgent Development Study on Rehabilitation and Reconstruction in Muzaffarabad City in the Islamic Republic of Pakistan" (hereinafter referred to as "the M/P Study"). The Scope of Work for the M/P Study and the Minutes of Meeting regarding said Scope of Work, were signed by both the Governments of Pakistan and Japan on 26 December 2005. In compliance with this agreement, the M/P study was carried out from February 2006 to March 2007 by Japan International Cooperation Agency (hereinafter referred to as "JICA").

In the progress report of the M/P Study submitted on September 2006, "the West Bank Bypass Construction Project" (hereinafter referred to as "the Project") was selected as the top priority project among the other nine identified projects. The proposed bypass runs along the west bank of the Jhelum River and Neelum River, starting from intersection in front of the Supreme Court on Kohala Muzaffarabad Road, and ending at the intersection on the northern side of Chela Bandi Bridge in Neelum Valley Road. The bypass is expected to facilitate urgent rehabilitation and reconstruction of Muzaffarabad and of the towns and villages located at further north of Muzaffarabad.

Considering the urgency and importance of the Project, on June 2006, the Government of Pakistan decided to allocate to the Project, a part of the counterpart fund of JBIC commodity loan. Consequently, the Government of Pakistan requested technical assistance from the Government of Japan for the detailed design of the West Bank Bypass Project, taking into account that the proposed bridge over Jhelum River (known as the Naluchi Bridge) shall be designed to withstand severe earthquake conditions.

Thus, realizing the urgency of the Project, JICA conducted preliminary design of the Project from September to December 2006, as a part of the M/P Study. During the preliminary design, the geometric criteria and route alignment of the bypass were studied. It was then realized that an extra-dosed bridge type is the optimum bridge type for the Naluchi Bridge. These findings were accepted by AJK during M/P Study team's presentation of study results to Earthquake Rehabilitation and Reconstruction Authority (hereinafter referred to as "ERRA") & AJK on 14 December 2007.

Based on said study results, JICA initiated further study on the basic design and detailed design of the project named as "Urgent Rehabilitation Project: West Bank Bypass Design" (hereinafter referred to as "the Study").

A designated team for the Study was organized separately from the M/P Study Team, and dispatched to Pakistan on February 2007. The Study was completed by the end of October 2007.

This Final Report presents all the study results and findings obtained from the Study. The design drawings and appendices are prepared in separate volumes of this report.

1.2 Objectives of the Study

The main objective of the Study is to carry out basic design and detailed design of West Bank Bypass Project. In order to facilitate implementation of the Project, the basic and detailed designs was based on the preliminary designs included in the M/P Study.

Furthermore, the Study also aims to promote transfer of technology to Engineers of ERRA, AJK and National Highway Authority (hereinafter referred to as "NHA"), concerning rehabilitation and reconstruction of roads and bridges in a disaster prone area, with particular emphasis on earthquake resistance design technology.

1.3 Study Area

The Study area covers a proposed 5.0 km road selected in the Preliminary Design Phase. This road commences from the Supreme Court, located in Kohala-Muzaffarabad Road, and ends at the intersection on the northern side of Chela Bandi Bridge on the Neelum Valley Road. This also includes the site of the bridge crossing the Jhelum River.

1.4 Outline of Preliminary Design Results

The Preliminary Design was carried out by the JICA Study Team during the M/P Study phase in September to December 2006. The salient features of the study are as follows:

Chapter	Main Contents
Topographic and Geotechnical Survey	The topographic and geotechnical survey and investigation of the existing concrete piles of Naluchi Bridge were conducted under the preliminary design. Topographic mapping survey covers 55 ha. Geotechnical investigation meanwhile includes mechanical boring at 9 locations and CBR tests at 5 locations. In addition, tests were carried out to assess soundness and capacity of the pile foundation, including concrete coring tests at three piles, concrete strength test by 30 core samples and pile integrity test and static load test. Result of such tests indicated that the existing piles are no longer usable.

<table>
<tr><th>Chapter</th><th>Main Contents</th></tr>
<tr><td>Traffic Survey and Demand Forecast</td><td>Traffic count survey at 5 locations (6:00-24:00, 18 hr); road side interview survey (O-D survey) at 2 locations (6:00-24:00, 18 hr); and travel speed survey through 2 routes were conducted from 27th to 30th November 2006. The projected years of the traffic demand forecast are 2009, 2014 and 2019, and the corresponding results of the demand forecast analysis are as follows:

(Unit:100 PCU/day in total of both direction)
<table><tr><th>Year</th><th>Naluchi Bridge – Balakot Road</th><th>Balakot Road – Hyder Road</th><th>Hyder Road – Neelum Valley Road</th></tr><tr><td>2009</td><td>55 - 79</td><td>66</td><td>15</td></tr><tr><td>2014</td><td>74 - 123</td><td>77</td><td>33 – 34</td></tr><tr><td>2019</td><td>98 - 169</td><td>94</td><td>43 - 50</td></tr></table></td></tr>
<tr><td>Road Alignment Study</td><td>Taking into account the alignments of the existing roads, topographic condition and future traffic volumes, the proposed road is categorized under the road classification system as a primary provincial road with adopted design speed of 50 km/hr, in accordance with provisions of NHA and AASHTO standards related to the Project. The following shows major geometric design criteria applied in the Study.

<table><tr><th>Classification</th><th>Applied Criteria or Value</th></tr><tr><td>Road Classification</td><td>Primary provincial roads</td></tr><tr><td>Design Speed</td><td>50 km/hr</td></tr><tr><td>No of lanes
▪ Lane width
▪ Shoulder width</td><td>2
3.65 m
1.00 m (Min.)</td></tr><tr><td>Horizontal Alignment
▪ Min. Radius
▪ Max. Super Elevation</td><td>
75 m
10 %</td></tr><tr><td>Vertical Alignment
▪ Max. Grade *1
▪ Crest Curve
Stopping Sight Distance
Passing Sight Distance
▪ Sag Curve
Stopping Sight Distance</td><td>
14 %

65 m
345 m

65 m</td></tr></table>Notes: *1 A max of 8 % will be applied due to site conditions.

Considering various control points such as pylons, schools, hospitals, graveyards and buildings, alternative route study was conducted , which suggests the following route details:

The total road length of proposed West Bank Bypass Project is 5,069.6 m: New construction section is 1,064 m, and improvement section is 4,005.6 m. The proposed road starts at the intersection in front of the Supreme Court on Kohala- Muzaffarabad Road, and crosses the Jhelum River through Naluchi Bridge. It turns northward with a radius of 250 m on a viaduct, and connects with Naluchi Road. From this point, West Bank Bypass utilizes the existing Naluchi road and a part of Muzaffarabad- Balakot Road. At the hair-pin curve of Balakot road before the bus terminal, West Bank Bypass runs river terrace beside switch yard to connect Chela Bandi Bridge-Alama Iqbal Bridge road (river side road). After that point, the road follows Chela Bandi Bridge-Alama Iqbal Bridge road (river side road) and ends at the northern side intersection of Chela Bandi Bridge along Neelum Valley Road.</td></tr>
</table>

<table>
<tr><th>Chapter</th><th>Main Contents</th></tr>
<tr><td>Naluchi Bridge Alternative Study</td><td>
During river crossing site study for Naluchi Bridge, the proposed route starting from the intersection at the end of Kohala road in front of the Supreme court gate, and crossing Jhelum River was selected among three alternatives, considering the following issues:

shortest route,
most economical alternative,
relatively smooth alignment,
less adverse effect on the socio-economic environment

The existing piles constructed by a local contractor were assessed by means of integrity tests, concrete strength tests and static load tests to verify whether these piles remain structurally safe, or to examine the possibility of utilizing these for further bridge construction. Based on the tests, it was found that the existing piles are substandard, and not suitable to support further bridge construction. Therefore, it is recommended to construct and plan for a completely new bridge rather than expanding the existing bridge foundation as per the basic design.

The bridge design criteria are established, as shown below, in accordance with NHA Designing of Bridges on National Highways, July 2006 and other relevant standards.
<table>
<tr><th>Items</th><th>Design Value</th><th>Remarks</th></tr>
<tr><td>Lane width</td><td>3.6m *2 = 7.30m</td><td>2 lanes</td></tr>
<tr><td>Shoulder width</td><td>1.20m</td><td></td></tr>
<tr><td>Walkway (Both sides)</td><td>1.50m</td><td></td></tr>
<tr><td>Live Load</td><td>Class A Loading</td><td>As per WPCHB</td></tr>
<tr><td>Peak Ground Acceleration</td><td>0.35</td><td></td></tr>
</table>
During the study of alternative configurations for Naluchi Bridge, five alternatives were considered taking into account the topographic site conditions and required span for the bridge. Each alternative was evaluated from view points of construction cost, construction aspect, structural aspect, construction period, maintenance aspect and technology transfer aspect. Based on the evaluation, a two-span continuous PC, extra dosed bridge, was determined as the optimum alternative.
</td></tr>
<tr><td>Preliminary Environmental Study</td><td>
From the preliminary environmental study, the following conclusions and recommendations were made:

Based on the initial examination of potential impacts due to the proposed West Bank Bypass Road Construction Project, it was concluded that the project will have no significant natural environmental impacts.
However, the Project is likely to instigate significant involuntary resettlement, and corresponding total project cost amounting to more than Rs.50 million. Therefore, it was finally concluded that an Environmental Impact Assessment (EIA) for the West Bank Bypass Project will be required. Similarly, there is a need for a detailed environmental management and monitoring plan (EMMP) including mitigation measures to be implemented during all project stages.
From the focus group discussions (FGDs) that were held 25 times during the Study, it was found that majority of the people have not been informed by respective government agencies regarding the upcoming West Bank Bypass Project,. Therefore, further public consultation will be required.

</td></tr>
</table>

1.5 Scope of the Study

The study is divided into two phases: the Basic Design Phase and the Detailed Design Phase.

The first phase, Basic Design Phase, was conducted from February to March 2007. Summary of activities carried out during this phase is as follows:

- Road design and its ancillary structures including, the preliminary design of the bridge, were refined based on supplemental surveys carried out in February
- Preliminary quantity survey, construction schedule, project cost estimates, and economic evaluation were conducted in March
- Prequalification documents and PC-1 were also prepared in March

The second phase, Detailed Design Phase, commenced in July 2007 and completed in October 2007. Activities undertaken during this phase includes:

- Conducting the detailed design of all the roads and bridges and preparation of tender drawings
- Developing design for road ancillary structures such as drains, road safety facilities and intersections
- Preparation of structural analysis, quantity calculations, examination of project costs, preparation of tender documents and the final report.

The confirmed scope of the design phases is defined in the tasks below:

(1) Basic Design Phase

Based on the results of Preliminary Design, the following key tasks were carried out during the Basic Design Phase:

1. Basic Design

    a. Road Design,
    b. Design of Ancillary Structures,
    c. Intersection Design,
    d. Preliminary design of Naluchi Bridge,
    e. Preliminary design of Small Bridges and Culverts,
    f. Hydrological Survey,
    g. Design of Disaster Prevention Facilities,
    h. Preparation of Preliminary Construction Schedule,
    i. Preparation of Preliminary Cost Estimation, and
    j. Preparation of Economic Evaluation.
    k. Preparation of EIA report
        - Scoping of the Target Area,
        - Land Acquisition and Resettlement,
        - Effects Derived from Roads, and
        - Other Effects.

2. Preparation of Draft Prequalification (PQ) Document

3. Assistance in Preparation of PC-1

(2) Detailed Design Stage

Based on the results of the Basic Design, the following key tasks are carried out;

1) Detailed Design

a. Road Design,
b. Design of Ancillary Structures,
c. Intersection Design,
d. Design of Naluchi Bridge,
e. Design of Other Bridges and Culverts,
f. Preparation of Construction Schedule
g. Preparation of Cost Estimation.

2) Preparation of the Draft Tender Document

3) Preparation of EIA and LRAP.

4) Preparation of Project Evaluation and Recommendations

The duration of the entire study is twelve months commencing with the preparatory work at the end of January 2007, and concludes with the submission of the Final Report on the end of February 2008. The Study sequence is presented in **Figure 1.5.1**.

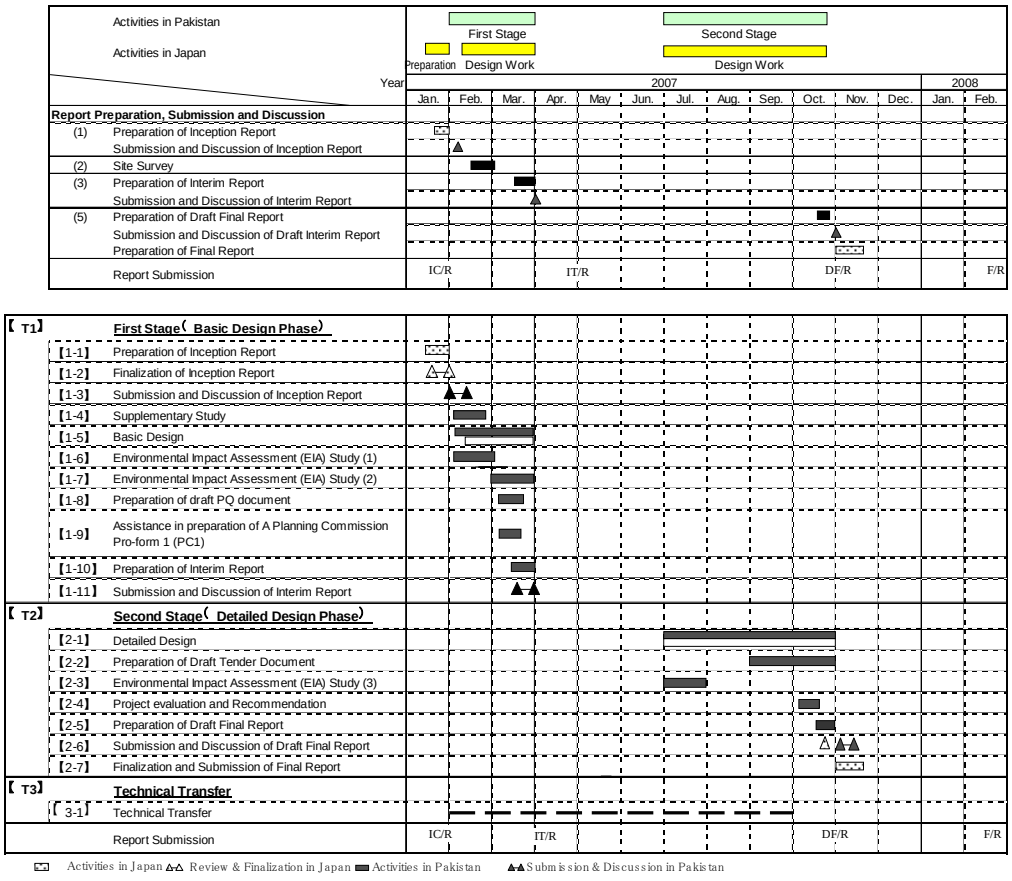


Figure 1.5.1 Study sequence

1.6 Major Events and Records of Discussion over the Study Period

Immediately on arrival of the Study Team at Islamabad, the presentation of Inception Report was held on 17 February, 2007 at ERRA office meeting room,, attended by the Study Team and representatives from ERRA and NHA. This was followed by similar presentation meeting held on 19 February 2007 at AJK office meeting room, attended by the Study Team and representatives of AJK. Minutes of these meetings are attached in **Annex -1** (Minutes of Meeting on Inception Report), which was signed on 27 February 2007 by Pakistan representatives, from ERRA and AJK, and JICA Study Team.

During the basic design phase, a joint site survey was carried out several times with representatives from AJK and ERRA, to confirm proposed alignment and the scope of the design. All the counter proposals suggested by Pakistan representatives were evaluated by the Study Team, as presented in the Report, and optimum schemes were selected during work shops. As a result of the basic design, Interim Report, Prequalification Document, and PC-1 were prepared and submitted to Pakistan representatives during a presentation meeting held on 4 April 2007. The Minutes of Meeting on Interim Report as shown in Annex -1 was signed on 4 April 2007 by Pakistan Representatives from ERRA and AJK, and JICA Study Team.

After submission of the Interim Report, two sets of comments on Interim Report (Refer to Annex-1) were received from Pakistan representatives: 1st on 11 May 2007, and 2nd on 31 May 2007. The 1st set of comments implies the following issues:

- ERRA preferred shifting of alignment on mountainous side in Intersection No.4, instead of its improvement;
- ERRA suggests conventional PC box girder instead of the Extra-dosed type for Naluchi Bridge.

The 2nd set of comments meanwhile stated that the Extra-dosed type for Naluchi Bridge is accepted by ERRA.

Nevertheless, representatives of ERRA and Team Leader of the Study Team had full discussion and joint site survey concerning these two outstanding issues, on 14 June and 16 June 2007 respectively. It was finally agreed by both parties, as shown in Annex-1, that Extra-dosed bridge type and at grade improvement scheme of Intersection No.4 would be considered as the preference, provided that alternative study of the improvement scheme should be conducted to determine the optimum scheme, prior to the detailed design.

Immediately after commencement of the detailed design, alternative study of the improvement scheme for Intersection No.4 was conducted, as agreed. Results of study were presented to Pakistan representatives on 30 July 2007, indicating Alternative B of at-grade intersection as

the optimum scheme. The Minutes of Discussion on Improvement Scheme of Intersection No.4 was signed on 30 July 2007, as shown in **Annex-1** by Pakistan representatives from ERRA and AJK, and the JICA Study Team.

As a result of the Detailed Design, Draft Final Report presenting all the study results, with the relevant data and information including Tender Document for the Project, was prepared and submitted to Pakistan side during presentation meeting held on 22 October, 2007. Minutes of this meeting are attached in **Annex -1** (Minutes of Meeting on Draft Final Report) which was signed on 1st November, 2007 by ERRA, AJK and JICA Study Team.

PC-1 (Proforma) for the West Bank Bypass Construction Project was approved in Capital Development Working Parties (CDWP) on 3rd November 2007.

The comments on the Draft Final Report were received from Pakistan side on 12 February, 2008 and Final Report reflected all those comments together with 10 Appendixes and two sets of Bid Documents including Bid Drawings for Packages I and II were finalized in Japan and submitted to Pakistan side.

1.7 Key Officials Related to the Study

The main counterpart agency for the Study is Earthquake Rehabilitation and Reconstruction Authority (ERRA). Other agencies related to the Study are State Earthquake Rehabilitation and Reconstruction Authority (SERRA); Public Work Department in AJK (PWD, AJK); Muzaffarabad Development Authority in AJK, National Highway Authority (NHA); and Planning Commission (PC). The key officials from these agencies involved in the Study are listed in **Annex-2**.

1.8 Composition of the Reports

The Final Report submitted as outcome of the Study, consists of the following separate volumes as listed below:

Table 1.8.1 Composition of Report

Title of Booklet	Index
DRAFT BID DOCUMENTS PACKAGE I	BD-I-I
DRAFT BID DOCUMENTS PACKAGE II	BD-II-I
DRAFT BID DOCUMENTS PACKAGE I (DRAWINGS)	BG-I-II
DRAFT BID DOCUMENTS PACKAGE II (DRAWINGS)	BG-II-II
Supporting Data for Road Design	Appendix-A

Structural Calculation (East Side Approach Viaduct)	Appendix-B
Structural Calculation (Naluchi Bridge)	Appendix-C
Structural Calculation (West Side Approach Viaduct)	Appendix-D
Structural Calculation (Three Small Bridges)	Appendix-E
Structural Calculation (Culvert and Retaining Wall)	Appendix-F
Quantity Calculation	Appendix-G
Cost Estimation	Appendix-H
Report on Environmental Impact Assessment	Appendix-I
Report on Land Acquisition and Resettlement Plan	Appendix-J

CHAPTER 2

BASIC DESIGN CONCEPT

2. BASIC DESIGN CONCEPTS

2.1 Functions and Roles of the Project Road

2.1.1 Existing Road Network

The existing road network in and around Muzaffarabad is shown in **Figure 2.1.1**. These roads are classified into Inter-City roads and Intra-City roads by function. The function of Inter-City roads is to serve as arterial roads, while the Intra-City roads are access to the arterial roads. The Inter-City roads are as follows:

- Kohala-Muzaffarabad Road (Kohala-Domal Bridge);
- Jhelum Valley Road (Domal Bridge-Chakhoti);
- Muzaffarabad-Balakot Road (Alama Iqbal Bridge-Mansehra); and
- Neelum Valley Road (Domal Bridge-Kel).

The existing road network also includes three major bridges, namely, Chela Bandi Bridge and Alama Iqbal Bridge on the Neelum River and Domal Bridge on the Jhelum River.

The features and problems with regard to the existing road network are as follows:

- The Neelum Valley road traversing the East Bank along Jhelum and Neelum rivers is the only existing arterial route to the city centre. Thus, due to lack of adequate alternative roads, almost all traffic in the project area merge into this existing route.
- The inter-city roads, namely, Kohala-Muzaffarabad road, Jhelum Valley road, and Muzaffarabad-Balakot road are all leading to Neelum Valley road, which supports the economic and routine activities in the project area. Consequently, the inter-city traffic and urban traffic congests the Neelum Valley road. The traffic conditions are expected to be worse in the future.
- All roads around the project area, including the arterial roads, are only limited to two-lane traffic because further road widening on the steep hilly lands is almost impossible. Since Neelum Valley road is the main link to the road network in the project area, widening of the road is an alternative. However, the anticipated problem associated with this alternative is costly land acquisition due to the existing fully-developed land areas adjacent to the road.
- The present volume of traffic on existing three major bridges crossing the Neelum River and the Jhelum River, particularly the Domal Bridge and Alama Iqbal Bridge, is substantial. It is expected that this river crossing facility will be insufficient in the future.

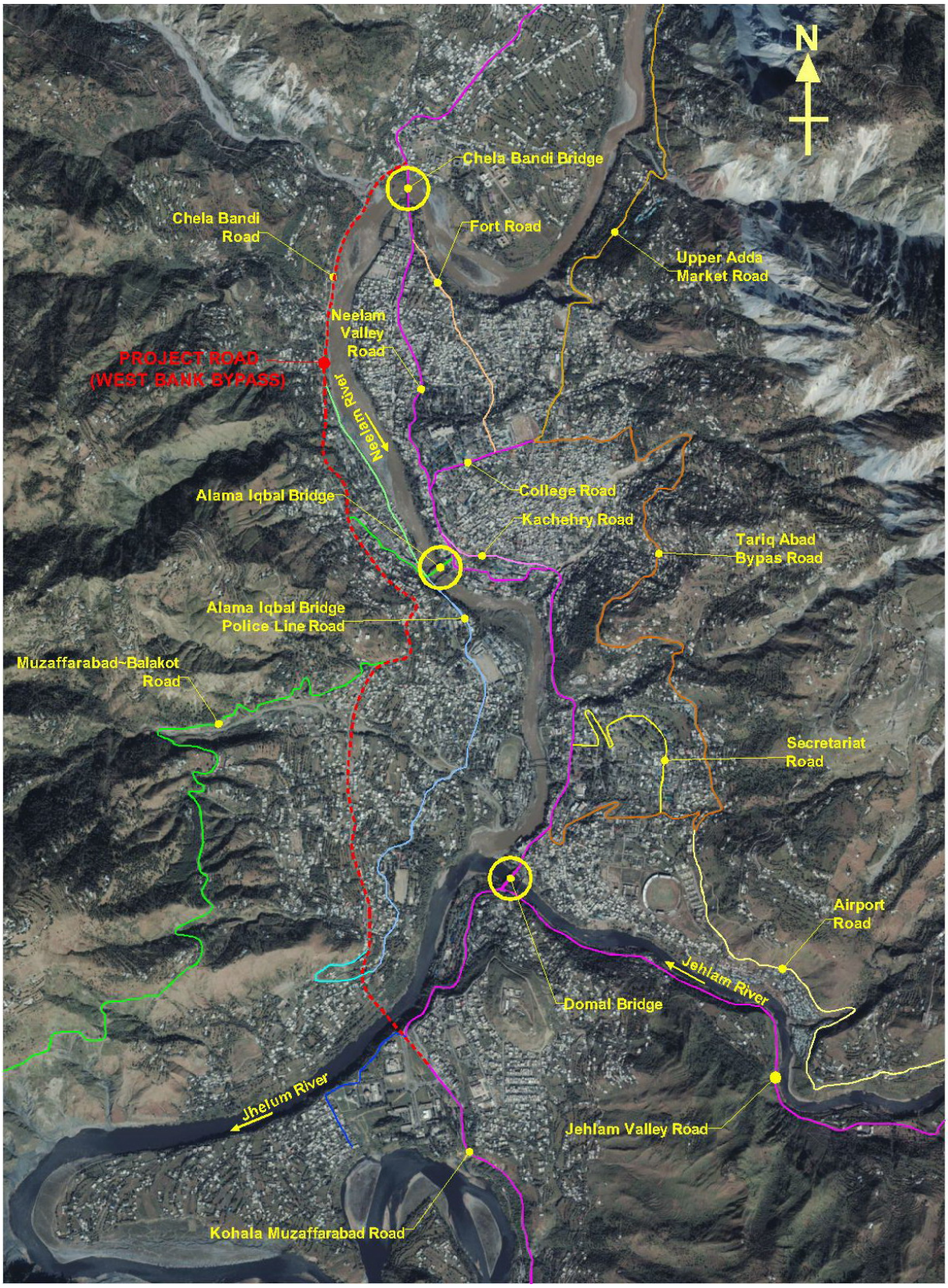


Figure 2.1.1 Existing Road Network in Muzaffarabad

In order to cope with these problems, the West Bank Bypass running along the west bank in parallel with Neelum Valley road is proposed to be connected to Kohala-Muzaffarabad road, by constructing new Naluchi Bridge crossing the Neelum River; and to Neelum Valley road at the intersection on the north side of Chela Bandi Bridge.

2.1.2 Functions and Roles of the Project Road

The West Bank Bypass, which includes the proposed Naluchi Bridge is expected to:

- provide an alternative route to Neelum Valley road approaching Muzaffarabad city centre,
- be utilized as traffic detour, especially east-west external traffic through the Jhelum road and Muzaffarabad-Balakot road, to avoid Muzaffarabad city centre,
- provide a community road for the local residents on the west bank of the Neelum river and promote alleviation of concentration in Muzaffarabad city centre, and
- increase the river crossing facility by constructing Naluchi Bridge

The favourable effects of the West Bank Bypass Road once completed and serviceable, are as follows:

- Reduce travel time in the project area and consequently appreciate savings in vehicle operating cost due to alleviation of traffic congestion and maintaining normal travel speed.
- Promote development on the west bank of the Neelum River and revitalization of economic activity in the project area.
- Facilitate urgent rehabilitation and reconstruction of Muzaffarabad and of villages located at its further north.

The West Bank Bypass Road is requisite to accommodate future traffic due to the rehabilitation and reconstruction activities. Said road will also serve as a kick-off project, which will initiate implementation of various projects including satellite town construction, as suggested in the M/P Study. Hence, the Project should be implemented urgently to improve traffic flow in Muzaffarabad.

2.2 Key Design Approaches

Considering expected functions and roles of the Project Road, the following key approaches are applied in the design.

(1) Environmentally Friendly Alignment

The route alignment in the preliminary design was determined from the topographic map scale of 1:1,000, considering the following:

- Maximum utilization of the existing roads
- Avoid various natural and social environmental control points to minimize the adverse environmental effects by the Project.

It is however realized that some of the residential houses, small shops, small public buildings and small scale land slide area, flooded area and other minor control points are affected by the selected route.

In view of the above, the control points affected by the selected route are assessed individually, and rated accordingly. Based on assessments, several route alternatives are also envisaged and evaluated. The most feasible option as final alignment from this evaluation, upon consultation with ERRA and AJK, is selected keeping special consideration to minimum environmental adverse effects.

(2) Design of Earthquake-Resistant Structures

The devastating earthquake of October 8, 2005 caused widespread loss of property, physical infrastructure and horrendous loss of lives. It was estimated that 73,000 to 80,000 Pakistanis died, over 100,000 were injured and 3.3 million residents were displaced. It was further reported that an earthquake with such magnitude would occur with a certain return period. Meanwhile it was observed that some of the existing infrastructures are likely to fail against severe earthquake.

After the earthquake, the National Highway Authority (NHA) initiated increasing Peak Ground Acceleration (PGA) for bridge design on national highways. No other modification was provided concerning earthquake-resistant designs.

Under such circumstances, all structures in the Project, including the proposed new Naluchi Bridge should be designed to withstand severe earthquake. Design methods are based on the requirements of NHA, where applicable, and considering strict compliance to AASHTO Standard Specification for Highway Bridges 2004 and Specifications for Highway Bridges Part V Seismic Design 2002 by Japan Road Association. Thus, structures in the Project is expected to remain stable against future earthquakes of similar magnitude.

(3) Smooth Project Implementation

Considering that the Project was a part of rehabilitation and reconstruction in Muzaffarabad which suffered severe earthquake damages, one of the key approaches in the design was to promote smooth implementation to achieve project completion as earliest as possible.

In this regard, the Study Team tackled this issue in the following manner:

- PC-I and Prequalification Documents should be submitted together with Interim Report by the end of March 2007, to allow early processing of project approvals from higher authority, prior to commencement of the Detailed Design Phase. This was also expected to initiate early selection of pre-qualified contractors before the end of the Detailed Design Phase.
- The construction cost estimates should be reliably reasonable to reflect the latest market prices for construction, and to avoid any repetitive tendering process.
- The construction schedule should be realistic, considering execution of activities during working days only in the project duration
- The construction method should be planned systematically to eliminate unnecessary methods, and prioritize human safety.
- The construction materials meeting the requirements of the specifications should be procured locally as much as possible in order to promote economic impact in the local market, and to minimize duration of procurement.

(4) Pertinent Cost Estimates and Project Viability

Various small scale and short-term projects are being implemented in the earthquake disaster affected regions, by several international cooperation agencies and NGOs. These projects triggered price escalation of construction materials and labor rates in the project site. In addition, there were reports that biddings of several NHA highway projects after the earthquake were unsuccessful due to costly bid prices exceeding budgetary allocations.

Therefore, the cost estimate shall be carried out based on the latest unit rates of materials, labors and equipments to achieve a successful bidding. In addition, the project cost should be restrained by the economic internal rate of return (EIRR), which should be more than social discount rate of more or less 12%.

(5) Technology Transfer

Extensive technology transfer is one of the purposes of the Study. The Study Team therefore spends every effort to promote technology transfer by means of technical presentation of various reports and on-the-job training to technical staff in ERRA, AJK and NHA. The subjects of technology transfer include the following:

- During the detailed design stage: Design for Earthquake-Resistant Structures, Design of Intersections, Development of Disaster Prevention Measures, Environmental Consideration in Road Design, and Introduction of JBIC Standard Tender Documents.

- During construction stage: Box Girder Erection by Balanced Cantilever Method; Construction Method of High Piers by Sliding Form; Monitoring Method of Construction Schedule; Quality Assurance Method of Civil Works.

It should be noted however that technology transfer during construction stage is beyond the Study Team's scope and can be carried out by a designated supervision consultant.

2.3 Extensive Environmental Considerations

2.3.1 Considerations on Communities under Special Circumstances

Since the local communities are still in the process of rehabilitation/reconstruction from earthquake disaster in 2005, careful environmental considerations must be observed concerning the people affected by the calamity.

Study

- An elaborate social study is conducted.
- Public consultations are conducted with the local people together with the local authorities.
- Careful attention should be attributed to vulnerable groups such as widows, orphans, disables, homeless (those still living in tents) and Christians.
- The Study needs to be conducted in a "gender-sensitive" manner, considering collection of information and opinions from women as much as possible.
- Recognizing that the smooth and elaborate implementation of the Project is a key element for the reconstruction and rehabilitation of the living standards of the people, a sensible Land Acquisition and Resettlement Plan (LARP) and Environment Monitoring and Management Plan (EMMP) should be proposed based on the Study.

Land Acquisition and Resettlement Plan (LARP)

- Based on the results of public consultations, opinions and requests from the local people, especially those directly affected, should appropriately be considered in the plan. Fair and timely compensation is vital for the effective implementation of the LARP.
- Institutional arrangement is proposed for the smooth implementation of the plan.
- In order to avoid and minimize adverse interactions between the affected persons (APs) and the implementing agency, assistance from local authorities such as Municipal Corporation Muzaffarabad (MCM) and Muzaffarabad Development Authority (MDA) should be solicited during the implementation of the plan.

Environment Monitoring and Management Plan (EMMP)

- The EMMP should be established to mitigate social conflicts as well as physical negative impacts.

2.3.2 Integration of Environmental Considerations and Design

The Environmental Considerations and the Design should be integrated to implement the Project smoothly and efficiently, which minimizes adverse environmental impacts.

Considerations in the Design Phase

The following aspects are assessed and the results are incorporated into the Design.

- High risk areas of natural disaster
- Width of Right of Way
- Control points
- Traffic safety

LARP and EMMP

The recommendations and suggestions obtained from the LARP and EMMP are considered in the design as extensively possible.

CHAPTER 3

SUPPLEMENTAL FIELD CONDITION STUDY

3. SUPPLEMENTAL FIELD CONDITION STUDY

3.1 Natural Condition

3.1.1 Topography

Muzaffarabad District has a rolling topography, with the Neelum River serving as its drainage basin. The terrain is mountainous, with valleys and some stretches of alluvial plains. Much of the area is characterized by deeply cut ravines and rolling hills. The mountain ecosystems are relatively unstable and have low inherent productivity. Hill torrents and the intermountain narrow valleys are the frequent physiographic features of the district. The Neelum and Jhelum valleys are famous for their natural scenic landscape.

The proposed road traverses through moderate sloping terrains presently inhabited and cultivated by the local residents. These slopes are subjected to active landslides and erosion, caused mainly by the effects of water flow. The elevation varies significantly over the short distance between the Chela Bandi Bridge at the Jhelum River and at the Bala Pir. The earthquake which has caused landslides that loosened the natural soil, has largely affected the topography of the proposed project areas.

3.1.2 Climate

The area of study, located in the Muzaffarabad District, north of Pakistan, has four (4) seasons namely:

1) Cool dry winter from December through February, 2) hot dry spring from March through May, 3) summer rainy season or southwest monsoon period from June through September, and 4) retreating monsoon period of October and November.

The annual temperature varies from an average daily low of 3ºC in January, to an average daily high of 35ºC in June. The annual average rainfall varies from 1,000 mm to over 2,000 mm depth in high regions in Pakistan. Shown in **Figure 3.1.1** is the Isohyets Map of Pakistan.

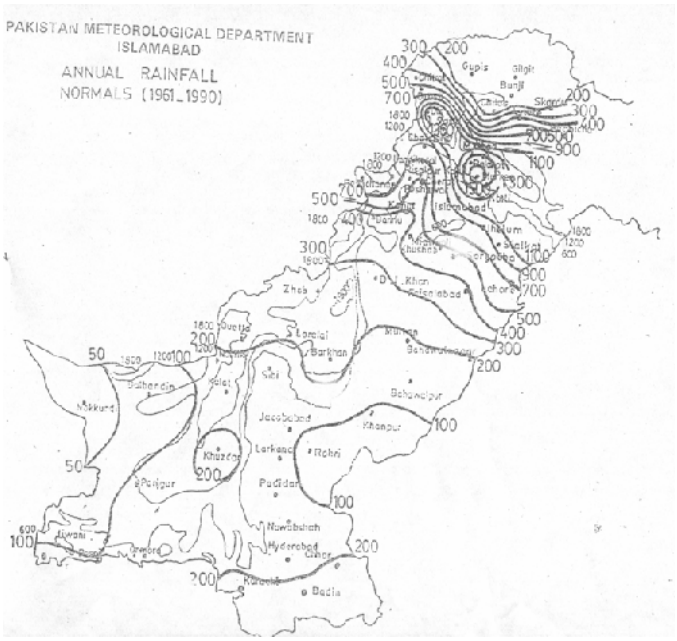


Figure 3.1.1 Isohyets Map of Pakistan

(1) Temperature

The temperature data for a period of ten (10) years (1995–2004) was obtained from the Meteorological station in Muzaffarabad. The mean monthly maximum and minimum temperatures range from 17.2ºC to 37ºC and 3.2ºC to 23.1ºC, respectively. The highest recorded temperature reached up to 46.2ºC in 1995 and the extreme lowest of less than minus 1.4ºC in year 2002. The summary and graphical presentation of these data is shown in **Table 3.1.1** and **Figure 3.1.2**, respectively.

Table 3.1.1 Monthly Temperature (1995-2004)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Extreme Max.	25.8	29.0	35.2	38.0	43.7	46.2	41.7	39.3	37.4	36.9	32.2	26.5
Monthly Max.	17.2	19.1	23.7	29.1	34.7	37.1	35.3	34.0	33.7	30.3	24.8	19.1
Monthly Min.	3.2	5.5	10.0	14.8	18.9	22.0	23.1	22.8	19.9	13.7	8.1	4.2
Extreme Min.	-1.4	0.0	2.5	6.5	7.0	16.2	18.0	16.0	13.0	8.4	1.0	0.0

Source: Meteorological Department, Islamabad, Pakistan

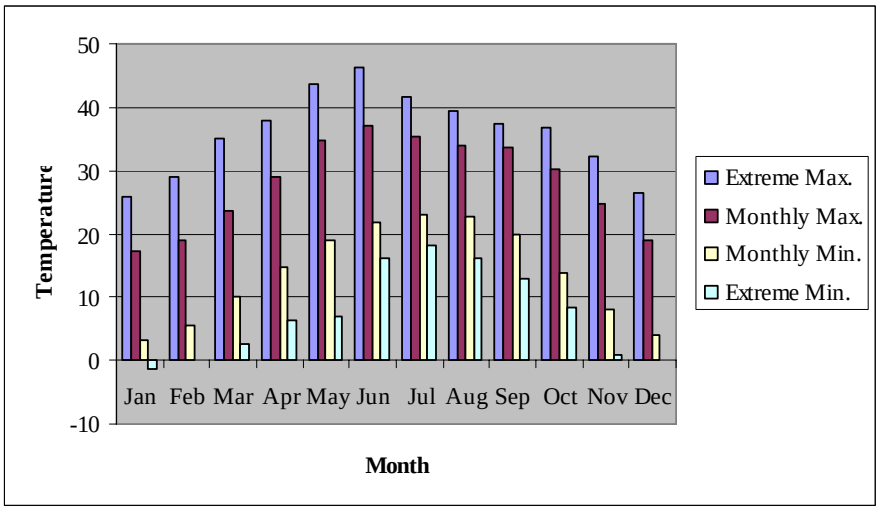


Figure 3.1.2 Monthly Temperature (1995-2004)

(2) Precipitation

a. Annual Precipitation

The annual average precipitation recorded in the project area is about 1,557 mm depth. Record for a period of 17 years (1990 – 2006) was obtained at the meteorological stations in Muzaffarabad and was utilized in the hydrological analysis for the project road. Summary of the annual precipitation is shown in **Table 3.1.2**.

Table 3.1.2 Annual Precipitation (1990-2006)

Year	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Precipitation (mm)	1,830	1,599	1,815	1,771	1,804	1,446	1,546	1,814	1,370
Year	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**Ave.**
Precipitation (mm)	1,498	1,427	970	1,041	1,573	1,487	1,351	2,133	1,557

Source: Meteorological Department, Islamabad, Pakistan

b. Monthly Precipitation

The mean monthly maximum and minimum precipitation recorded in the project area occur during the months of July and November with depths of about 370 mm and 40 mm, respectively. Data for a period of 22 years (1985–2006) was obtained at the meteorological stations in Muzaffarabad and was utilized in the hydrological analysis for the project road. Summary of the monthly precipitation is shown in **Table 3.1.3** and **Figure 3.1.3**.

Table 3.1.3 Monthly Precipitation (1985-2006)

Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Max. (mm)	273.8	357.0	534.7	204.5	241.5	225.9	702.5	533.2	335.2	132.6	176.1	327.7
Mean (mm)	103.1	147.9	173.5	96.3	79.5	113.3	367.7	217.5	117.1	46.4	41.8	85.4
Min. (mm)	2.3	10.4	8.8	4.8	19.1	29.5	74.7	59.8	18.3	7.6	0.0	0.0

Source: Meteorological Department, Islamabad, Pakistan

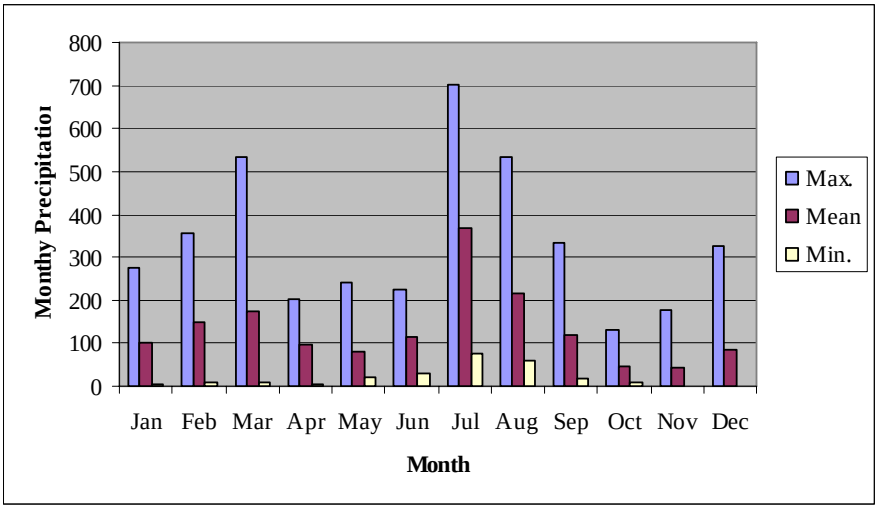


Figure 3.1.3 Monthly Precipitation (1985-2006)

c. Daily Precipitation

The daily maximum precipitation recorded in the project area occurred in years 2005 and 1992, with depths of about 272 mm and 201 mm, respectively. Data for a period of 18 years (1987–2005) was obtained at the meteorological stations in Muzaffarabad and utilized in the hydrological analysis for the project road. Summary of the daily precipitation is shown in **Table 3.1.4**.

Table 3.1.4 Maximum Daily Precipitation in mm at Muzaffarabad (1987 – 2005)

Years	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
EMax	107	175	165	90	66	201	183	94	112	138	67	87
Mean	37	36	45	44	33	60	45	40	34	45	36	31
EMin.	0	4.1	0	6	1	8	0	2	9	1	7	0
Years	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**					
EMax	112	79	50	42	114	77	272					
Mean	34	37	23	29	40	42	53					
EMin.	0	2	2	0	13	4	0					

Source: Meteorological Department, Islamabad, Pakistan

d. Number of Rainy Days

The data for the number of rainy days in the project area for a period of 30 years (1971-2000) was obtained in Muzaffarabad meteorological station. Based on the record, the maximum and minimum monthly average number of occurrence of rains is close to 18 days and 3 days, respectively. Presented in **Table 3.1.5** and **Figure 3.1.4** is the summary for the number of rainy days in the project area.

Table 3.1.5 Average Number of Rainy Days (1971-2000)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Days	7.9	9.0	12.0	10.9	10.2	10.3	17.8	15.7	8.8	4.7	2.9	5.9

Source: Meteorological Department, Islamabad, Pakistan

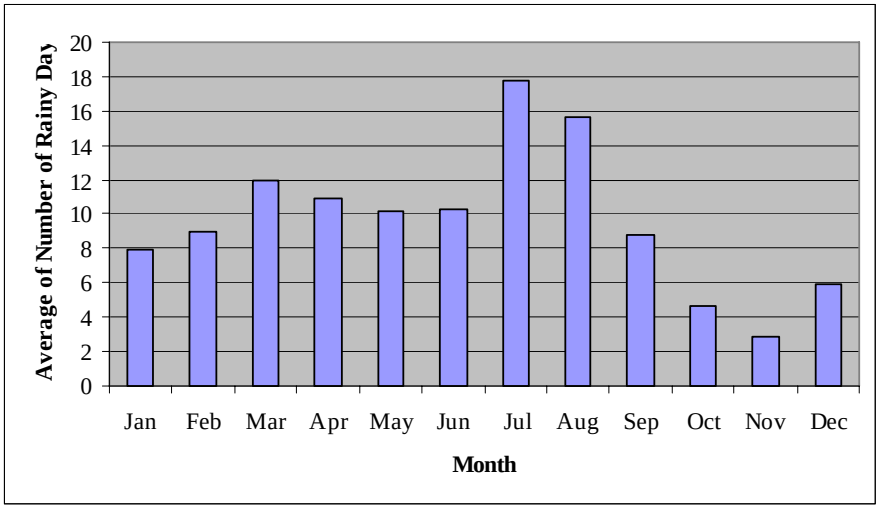


Figure 3.1.4 Number of Rainy Days (1971-2000)

e. Wind Velocity

The wind velocity data for a period of 10 years (1995-2004) was collected at the meteorological station in Muzaffarabad. It varies considerably from a maximum of 14.7 m/s to a minimum of 0.0 m/s. The mean monthly wind velocity ranges from 3 to 6 m/s throughout the year. The monthly wind velocities are shown in **Table 3.1.6** and **Figure 3.1.5**.

Table 3.1.6 Monthly Wind Velocities (1995–2004)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max(m/s)	4.4	5.8	5.8	8.9	9.7	8.9	14.7	8.9	5.8	4.4	5.8	6.4
Mean(m/s)	3.6	4.6	4.6	5.7	5.3	6.1	6.4	4.7	4.7	3.6	3.6	3.2
Min (m/s)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: Meteorological Department, Islamabad, Pakistan

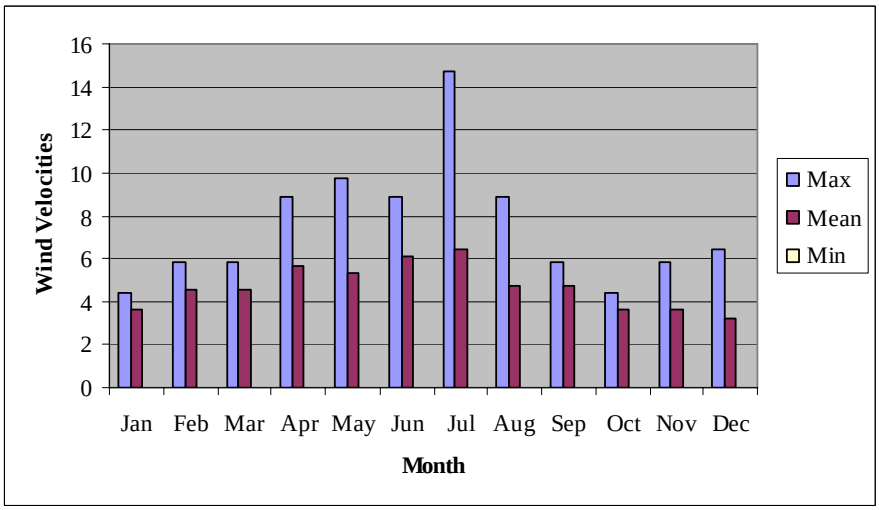


Figure 3.1.5 Monthly Wind Velocities (1995–2004)

f. Humidity

Humidity data for a period of 31 years (1974-2004) was collected at the meteorological station in Muzaffarabad. The maximum and minimum monthly humidity varies from 51% to 72% and 20% to 44%, respectively. Shown in **Table 3.1.7** and **Figure 3.1.6** are the monthly relative humidity.

Table 3.1.7 Monthly Relative Humidity (1974–2004)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max (%)	59	57	55	51	52	53	69	72	61	57	61	66
Mean (%)	51	46	41	38	34	35	54	59	49	44	50	55
Min (%)	39	28	26	25	20	24	36	44	39	29	37	34

Source: Meteorological Department, Islamabad, Pakistan

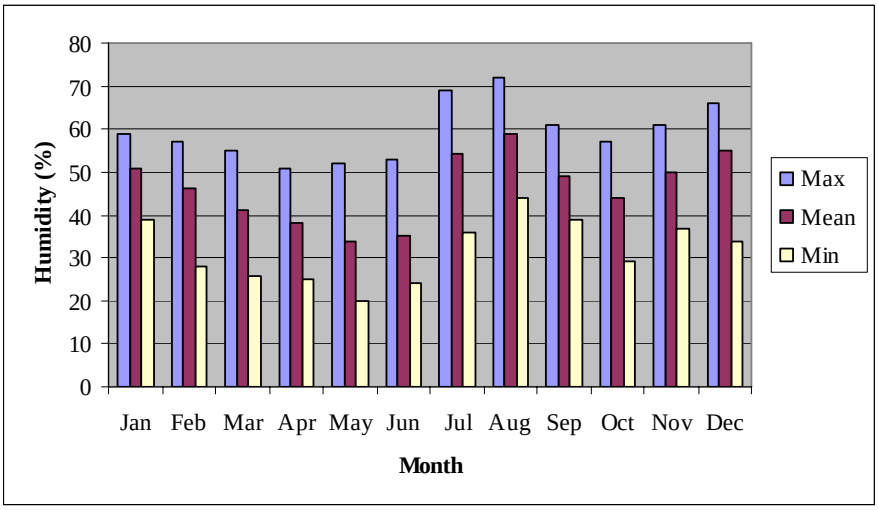


Figure 3.1.6 Monthly Relative Humidity (1974-2004)

3.1.3 Geological Condition

(1) General Geology in Pakistan

The Himalayan Mountains, which includes the Karakoram Mountains, is divided into three mountain ranges from north to south. The first range is called the Great Himalayan Mountains with high peak elevations of more than 6,000 m above the sea level. The second range is called the Lesser Himalayan Mountains with peak elevations ranging from 3,000 m to 4,000 m. The third range is called the Sub Himalayan Mountains with high peak elevations ranging from 900 m to 1300 m.

The Great Himalayan Mountains are formed from Himalayan gneiss of the Precambrian era and sedimentary rock of the Paleozoic era (the Tertiary period). The Lesser Himalayan

Mountains consist of sedimentary rock and meta-sedimentary rock of the Precambrian era and the Paleozoic era. The Sub-Himalayan Mountains consist of the Siwalik Group, which is of fresh water sediment from the Miocene epoch. The Himalayan Mountains are formed during the Pleistocene epoch.

The Main Central Thrust (MCT) is in between the Great Himalayan Mountains and the Lesser Himalayan Mountains, while the Main Boundary Thrust (MBT) forms a boundary between the Lesser Himalayan Mountains and the Sub-Himalayan Mountains. The south edge of the Sub-Himalayan Mountains is bounded by the Himalayan Front Thrust (HFT). Many geo-morphological surfaces like alluvial fans and river terraces are found in the Himalayan Front Zone. These surfaces show great dislocations ranging from 50 m and 300 m high, due to the upheaval caused by movement of faults and the climatic change during the Quaternary period.

(2) Geology of Muzaffarabad Valley

Muzaffarabad is located in a narrow valley, 2 km wide from east to west, and 15 km long from north to south, along the Jhelum and the Neelum Rivers. The Jhelum Fault, considered to be the MBT, crosses the valley diagonally and extends towards the south along the Jhelum River. However, details of this fault remain unknown. On the other hand, at the east side of Muzaffarabad Valley, the Tanda Fault appears parallel to the Jhelum Fault, from the northwest to the southeast. The strong earthquake that occurred in October of 2005 was caused by the movement of this fault. The Tanda Fault accords with the HFT. Generally, earthquakes along the HFT are active compared with the MBT. The stratigraphy of Muzaffarabad Valley is shown in **Table 3.1.8**. In the valley, lower river terraces about 700 m above sea level, are widely distributed on both banks of the Jhelum and Neelum Rivers.

Narrow middle terraces and upper terraces, which are 850 m and 900 m above sea level respectively, are found on the mountain slopes. The river terrace deposits between 15 m and 50 m thick consist of unconsolidated round gravels. Additionally, talus deposits and alluvial fan deposits of the Quaternary period are distributed on the foot of mountain. Main rocks in the valley consist of conglomerate, red shale and gray sandstone of the Siwalik Group, and hard shale and hard sandstone of the Rawalpindi Group. Basement rock consists of Precambrian slate of the Muzaffarabad Formation. These rocks are usually found along the north banks of the Jhelum and the Neelum Rivers.

Table 3.1.8 Stratigraphy of Muzaffarabad

Era	Period	Epoch	Geological Formation	Lithology
Cenozonic	Quaternary	Holocene	Alluvial Deposit (plain, Fan and Talus)	Unconsolidated gravel, sand, silt and clay
		Pleistocene	Terrance Deposit	Unconsolidated silt and strongly cemented red silt
			Upper Siwalik Group (Soan Formation)	Fresh Water Clastic Sediment. Conglomerate, sand stone and clay stone
	Tertiary	Pliocene	Middle Siwalik Group (Soan Formation)	Fresh Water Clastic Sediment. Cyclic alternation of clay, sand stone and gravel.
		Miocene	Lower Siwalik Group (Chinji, Nagri Formation)	Fresh Water Clastic Sediment. Red clay and sand stone
		Eocene	Rawalpindi Group (Murree Formation)	Fresh Water Clastic Sediment. Alternation of sandstone and shale.
		Oligocene		
		Paleocene	Upper, middle and lower Paleocence Sediment	Marine Sediment. (Lime Stone, Shale and Sand Stone)
Mesozoic				
Paleozonic			Lower Paleozic Sediment	Marine Sediment (Sedimentary and Metamorphic Rocks)
Pre-cambrian			Muzaffarabad Formation	Meta-sediment Rock and Igneous Rock

Source: Bedrock of Human Prehistory in Pakistan Syed Muhammad Ashfaque, Pakistan Study Center, University of Karachi, 1996

The geological components found along the proposed alignment are shown in **Table 3.1.9**.

Table 3.1.9 Geological Component along the Proposed Road Alignment

Photograph	Geology
	Old debris flow deposits Clayey gravels including flaky slate fragments of 2-10 cm in diameter. Very stiff in general SPT value: more than 50 Photo was taken at Sta. 3 + 300 left side.
	Terrace deposits Gravelly sand including rounded sandstone,limestone and metamorphic rocks of 10- 20 cm (maximum size 50 cm) in diamenter. SPT value: more than 50 Very dense in general. Photo was taken at Sta. 3 + 400 right side.
	Red shale/Sandstone Alternation of red shale and sandstone. Sandstone is hard. Although red shale is relatively hard, some red shale weathers easily, which when it deteriorates, may cause landslide. Photo was taken at Sta. 4 + 720 left side.
	Slate Relatively hard in general. Weatherd slate flakes easily, which could sometimes cause slope failures. Photo was taken at Sta. 0 + 280 right side.

3.2 Supplemental Topographical Survey

3.2.1 Scope of the Survey

(1) Scope of Works

Supplemental topographic mapping survey and profile survey were carried out during the basic design phase for the purpose of obtaining topographic map and profile at bridge and culvert sites. These are utilized as basis for hydraulic studies relevant to the bridge/culvert designs. Moreover, supplemental topographic survey for Intersection No.4 was also carried out during the detailed design phase.

(2) Survey Quantities

The survey quantities are summarized in **Table 3.2.1**.

Table 3.2.1 Quantity of Topographic Survey

Items	Unit	Quantity
a. Naluchi/Neelum Rivers		
- River cross section	m	680
b. Other Bridges (4 bridges)		
- Topographic Survey	m^2	40,000
- River cross section	m	400
c. Culvert (9 culverts)		
- River profile	m	450
- Topographic survey	m^2	9,000
d. High flood level	L.S.	1
e. Intersection No. 4		
- Topographic Survey	m^2	86,000

Source: Study Team

3.2.2 Survey Results

(1) Naluchi/Neelum Rivers

River cross section survey was carried out for Naluchi Bridge (Jhelum River) and Neelum River. The cross section width covered up to 5-10 m higher than the high water level.

For Naluchi Bridge, the location of river cross section survey was one at 200 m upstream and second at 250 m downstream from center line of the bridge. For Neelum River, three river cross sections were taken at every 250 m apart.

(2) Four small bridges

Survey works for four small bridges listed in **Table 3.2.2** were carried out as per the following details:

Topographic Survey: Typically for Bridge No. 1 to 3, topographic survey area covered 50 m upstream & downstream from bridge centre line, with an average width of 50 m

along the river/stream/waterway. For bridge No.4, the survey was extended up to 450 meters upstream of the bridge center line with an average width of 50 m.

Cross Section Survey: Cross section survey covered one each at 25 m upstream and 25 m downstream from center of the bridge.

Table 3.2.2 List of Small Bridges

No.	Location	Existing Condition		Proposed Structures in Detailed Design	
		Structural Type	Dimension	Structural Type	Dimension
1	Sta. 0+980 (Sta. 0+992)	Bridge	Span = 5.5m	Box Culvert	5.5m x 2.5m
2	Sta. 1+760 (Sta. 1+750)	Bridge	Span = 10.0m	Bridge	Span = 30.0m
3	Sta. 3+600 (Sta. 3+520)	None	-	Bridge	Span = 30.0m
4	Sta. 4+700 (Sta. 4+750)	Bridge	Span = 2 @ 15.20m	Bridge	Span = 2 @ 30.0m

Note: Station in ( ) indicates station of final section after the detailed design.

(3) Nine culverts

Survey work for nine (9) culverts as listed in **Table 3.2.3** was carried with following details.

Topographic Survey: Topographic survey area for the culverts covered 25 m upstream & downstream of the culvert center line with an average width of 20 m along the river/stream/waterway.

Profile Survey: Profile survey for each culvert was carried out, measuring 50 m width at 25 m upstream and 25 m downstream from the center of culvert.

Table 3.2.3 List of Culverts

No.	Location	Existing Condition		Proposed Structures in Detailed Design	
		Structural Type	Dimension	Structural Type	Dimension
1	Sta. 0+715 (Sta. 0+ 723)	Box Culvert	2.80m x 2.50m	Box Culvert	2.0m x 2.5m
	(Sta. 0+236)[1/]	-	-	Box Culvert	1.0m x 1.0m
	(Sta. 1+460)[1/]	-	-	Box Culvert	1.0m x 1.0m
2	Sta. 2+050 (Sta. 0+062)	Box Culvert	3.50m x 1.50m	Box Culvert	2.7m x 2.0m
3	Sta. 2+650 (Sta. 2+680)	Box Culvert	3.00m x 2.00m	Box Culvert	1.5m x 2.0m
4	Sta. 2+860 (Sta. 2+924)	Box Culvert	3.00m x 2.00m	Box Culvert	1.5m x 2.0m
5	Sta. 3+030 (Sta. 3+053) (Sta. 3+868)[1/]	Box Culvert -	2.00m x 2.00m -	Box Culvert Box Culvert	1.5m x 2.0m 2.0m x 2.5m
6	Sta. 3+230 (Sta.3+297)	None	-	Box Culvert	5.5m x 2.5m
7	Sta. 3+745 (Sta. 3+793)	Box Culvert	3.00m x 3.00m	Box Culvert	1.5m x 2.0m

No.	Location	Existing Condition		Proposed Structures in Detailed Design	
		Structural Type	Dimension	Structural Type	Dimension
8	Sta. 4+090 (Sta. 4+100)	Box Culvert	2.50 m x 2.50m	Box Culvert	4 x (3.5m x 3.0m)
	Sta. 4+289[1/]	-	-	Pipe Culvert	∅ 0.9 m
	Sta. 4+435[1/]	-	-	Pipe Culvert	∅ 0.9 m
	Sta. 4+511[1/]	-	-	Pipe Culvert	∅ 0.9 m
	Sta. 4+544[1/]	-	-	Pipe Culvert	∅ 0.9 m
	Sta. 4+580[1/]	-	-	Pipe Culvert	∅ 0.9 m
	Sta. 4+660[1/]	-	-	Pipe Culvert	∅ 0.9 m
9	Sta. 4+950 (Sta. 4+870)	Pipe Culvert	∅. 0.60 m	Box Culvert	1.5m x 2.0m

Note: - Station in ( ) indicates station of final section after the detailed design.
- Additional Culvert with [1/] was designed based on simple survey from the detailed design.

(4) Profile Survey of Flood Level

High flood profile survey was carried out to collect historic flood observation data along the Neelum River within the project area, and at Naluchi Bridge site. These observations were referred to the project bench mark and plotted with reference to the existing road profile along the Neelum River, which was consequently marked at River Cross Sections.

The details of the topographic, profile and cross section surveys conducted were suitable for standard scale plotting and also utilized for electronic mapping on general arrangement drawings scaled 1:200. These details were suitable to fit A3 size plot scale for reporting purpose.

(5) Intersection No. 4

Topographic survey was conducted for Intersection No.4 at the end point in Chela Bandi, covering 86,000 m^2. Area was bounded by Neelum Valley Road and access road to Army camp. Major part of AJK University and adjacent area was covered in the survey area. In addition, profile and cross section surveys were also conducted on the design centerline of Intersection No.4.

3.3 Supplemental Geotechnical Investigation

3.3.1 Scope of Works

(1) Review of Existing Geological Investigation

Geotechnical investigation including nine boreholes, test pits and laboratory tests carried out during the preliminary design stage as shown in **Table 3.3.1,** were reviewed during the basic design stage.

Table 3.3.1 Summary of Existing Boreholes from the Preliminary Design Stage

Boring No.	Location		Coordinates		Elevation (m)	Depth (m)
			X	Y		
A1	Naluchi Bridge	left bank				20
P2	Naluchi Bridge	right bank	3245207.490	1132173.116	656.33	16
P3	Naluchi Bridge	right bank	3245156.400	1132235.970	607.83	15
A2	Naluchi Bridge	right bank				20
A3	Naluchi Bridge	right bank	3245116.000	1132444.000	720.02	20
SB-1	Bridge No.1		3244883.470	1133562.280	742.49	20
SB-2	Bridge No.2		3244679.000	1135006.350	683.63	20
SB-3	Bridge No.3		3244804.030	1136171.730	680.43	20
LS-2	Landslide	NL64	3244509.310	1135447.870	709.32	50

In addition, NESPAK (National Engineering Services Pakistan, PVT, LTD) conducted borehole investigations during the study on "Bridge over River Jhelum at Naluchi for Foundation Design Recommendation Soil Investigation Data, May 16, 2001" at locations shown below:

Table 3.3.2 Borehole Locations and Depths for Naluchi Bridge

BH No.	Location	Depth (m)
BH 1	Upper Pier of Right Bank	10
BH 2	Middle Pier of Right Bank	30
BH 3	Lower Pier of Right Bank	40
BH 4	Lower Pier of Left Bank	50
BH 5	Upper Pier of Left Bank	10

Source: Geological Survey Report for Bridge over River Jhelum at Naluchi, NESPAK, 2001

These investigation results were also reviewed to obtain geological information in advance.

(2) Supplemental Geotechnical Investigation

Soil sampling from additional three boreholes and one test pit were carried out during the Basic Design stage, for the purpose of obtaining subsurface condition data. The contents of the investigation include:

- Drilling Survey prior to foundation design of the proposed viaduct of Naluchi Bridge, and subsurface condition of cut slope area

- Laboratory test

The survey items and purpose of the drilling survey are shown in **Table 3.3.3**. The location map is shown in **Figure 3.3.1**.

Table 3.3.3 Quantities of Geotechnical Survey

Geological Investigation		Coordinates		Elevation (m)	Length (m)	SPT (nos.)	Purpose
		X	Y				
Drilling hole	Addl-1	3245179.60	1132164.76	663.87	20	2	Foundation design data for a proposed pier of the viaduct
	Addl-2	3245005.57	1132323.12	698.55	22	0	Foundation design data for a proposed pier of the viaduct
	Addl-3	3244701.22	1134781.56	704.79	20	0	Subsurface condition check for cut slope
Test pit	TP	3244890.00	1136275.00	690.03	-	-	Sampling for CBR test at the End point

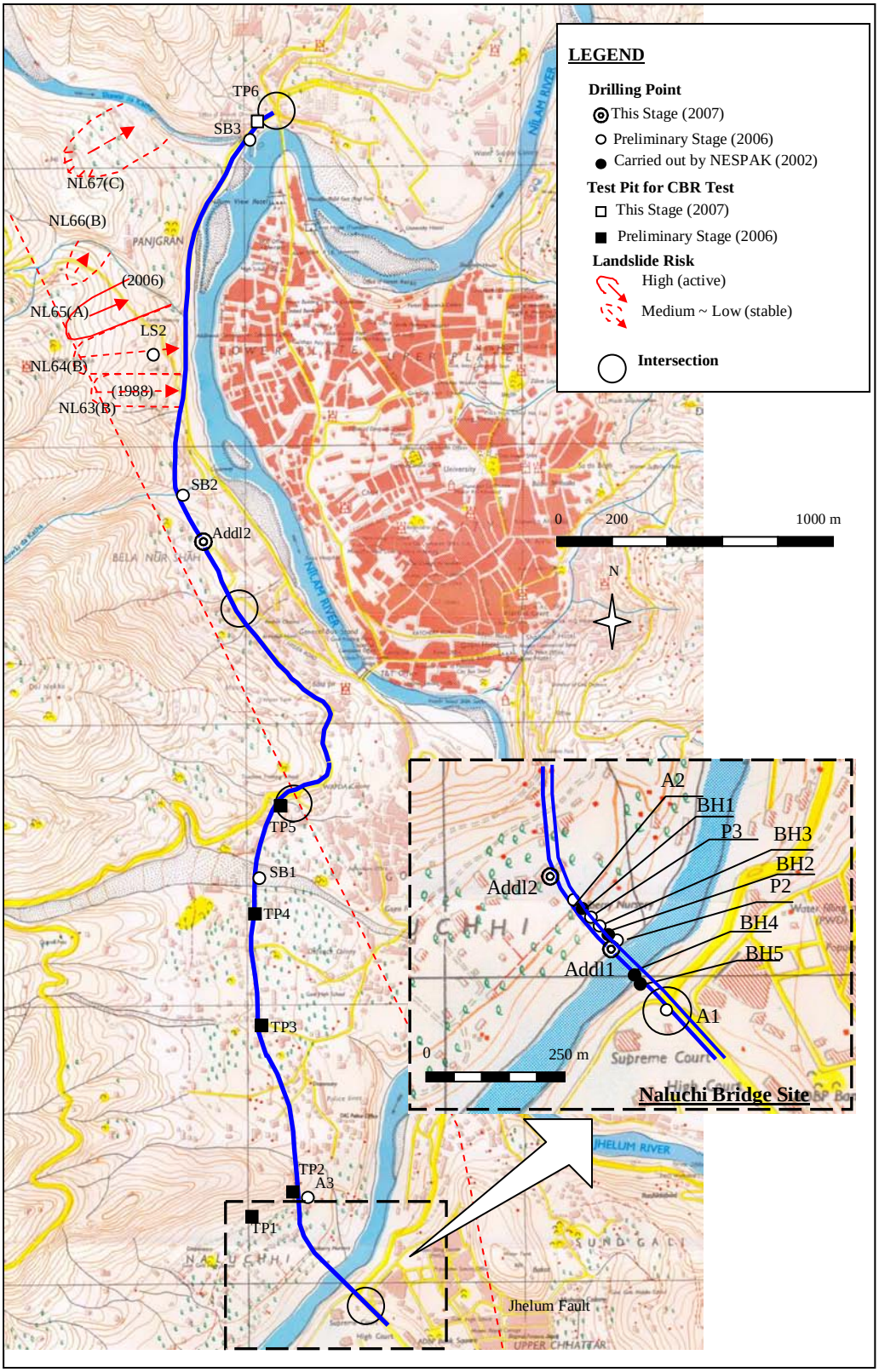


Figure 3.3.1 Location Map of Geotechnical Survey

3.3.2 Survey Results

(1) Survey Results of Drilling Survey

The results of geotechnical investigation are summarized as below.

Table 3.3.4 Summary of Results of Drilling Survey

Drill Hole	Geology		Engineering Property		
	Depth (m)	Geological Condition	Depth (m)	SPT Value	Consistency
Addl-1	0-2.5 2.5-20	Completely weathered slate Slate-Phyllite (fractured)	1-3 3-20	8-10 more than 50	Stiff Hard
Addl-2	0-1.8 1.8-13.7 13.7-20	Silty clay/loam Terrace deposits (sand and gravel, and matrix of upper portion clayey) Slate-phyllite (fractured)	1-1.8 1.8-20	more than 50 slate/phyllite	Dense Very Dense
Addl-2	0-3.8 3.8-7.5 7.5-20	Old debris flow deposits (silty clayey gavels (flaky and elongated gravels) Terrace deposits (sand and gravel) Phyllite (fractured)	1-3.8 3.8-7.5 7.5-20	more than 50 more than 50 phyllite	Very stiff Very dense Hard

Based on the above drilling data and field geotechnical surveys, a geological profile of the Naluchi Bridge is depicted as follows.

The bedrock for the Naluchi Bridge site consists of slate of the Muzaffarabad Formation of the Precambrian era. Said rocks are hard, however, they have high schistocity with wide cracks. This formation strikes at N, 10°W and dips 80°W to the Jhelum River on the left bank. The Slope of the cliff on the left bank is more than 45° and several rock falls are found scattered. On the other hand, the same formation on the right bank shows a plunging structure with moderate slope, which appears stable. RQD (Rock Quality Designation) value of the said rock is approximately 0% due to exfoliation of the rock.

River terraces are widely distributed on both sides of the bank. The elevation of the left bank terrace is 705 m above the sea level, and the terrace gravel is about 15 m in thickness. On the right bank, three terraces with elevations of about 735 m, 724 m and 695 m are distributed. Terrace deposits are very dense indicating SPT values of more than 50.

(2) Laboratory Tests for Foundation Soil/Rock

A series of laboratory tests are performed on soil, rock and concrete samples, which are obtained from either boreholes or test pits. The laboratory test results are shown in **Table 3.3.8**.

a. Design Parameter for Gravelly Soil

Along the proposed route, river gravel, terrace gravel and talus deposit as unconsolidated materials are widely distributed. Distribution of soft layers as clayey soil is very limited.

The design parameters for the soil are estimated from the results of direct shear tests as shown in the **Table 3.3.5**.

Table 3.3.5 Design Parameters for Gravely Soil

Soil Type	Geology	USCS	Angle of Internal Friction (°)	Cohesion (KPa)	Bulk Density (gf/cm^3)	Study Stage
Gravelly Soil	Terrace deposit	GW	37	0.4	2.04	Preliminary
Gravelly Soil	Terrace deposit	GW	34.6	0.7	2.02	Preliminary
Gravelly Soil	Old debris flow deposit	GW	32	0.1	2.02	Preliminary
Gravelly Soil	Terrace deposit	GW	35	0.1	2.01	Preliminary
Gravelly Soil	Terrace deposit	GW	36	0.2	2.03	Preliminary
Gravelly Soil	Old debris flow deposit	GC-GM	32	1.5		This Study

Note: USCS = Unified Soil Classification System

b. Design Parameter for Rock

The rock tests were carried out in the previous study for the slate of the Muzaffarabad Formation, red shale and hard sand stone of the Siwalik Group. Such test results are tabulated in **Table 3.3.6**.

Table 3.3.6 Design Parameters for Rock

BH NO.	Depth (m)	Location	Rock	
*BH4	3.5	Naluchi P1	Slate	
*BH4	22.9	Naluchi P1	Slate	
*BH4	43.5	Naluchi P1	Slate	
BHP2	11.5	Naluchi P1	Slate	
BHP2	14.5	Naluchi P1	Slate	
			Average:	
SB3	7.0	Small Bridge	Sandstone	
LS2	31.0	Land slide	Red shale	
LS2	46.0	Land slide	Sandstone	

The results of direct shear tests carried out in this study using core sample of fractured slate are shows in **Table 3.3.7**. The **Table 3.3.8** summarizes the laboratory test result.

Table 3.3.7 Design Parameters for Rock

BH NO.	Depth (m)	Rock Type	Angle of Internal Friction(°)	Cohesion (KPa)	Specific gravity (gf/cm^3)
Addl-1	7	Slate (fractured)	38	1.5	
Addl-1	13	Slate (fractured)	39	0.2	

Addl-2	15	Slate (fractured)	38	0	2.78
Addl-2	17	Slate (fractured)	38.5	0.2	2.77
Addl-2	21	Slate (fractured)	37.5	0	2.75
Addl-3	5	Slate (fractured)	37.5	0	2.775
Addl-3	11	Slate (fractured)	38.5	1	2.79
Addl-3	15	Slate (fractured)	40.3	0	2.82
Addl-3	18	Slate (fractured)	39.6	0.1	2.8
Average			**38.5**	**0.3**	**2.78**

Table 3.3.8 Summary of Laboratory Test Results

S.No	Bore Hole No	Sample No	Depth	% Passing													Atterberg Limits			Direct Shear Test		Soil Classification	Bulk Density	Natural Moisture Content	Unconfined compression strength	Specific Gravity
				3"	1"	3/4"	1/2"	3/8"	#4	#10	#20	#40	#60	#100	#200	0.005 (mm)	LL	PL	PI	Angle of internal Friction(degree)	Cohesion(kpa)	USCS	gm/cm^3	%	Mpa	gf/cm^3
Additional Bore Hole No. 1 (Naluchi Bridge Site)																										
1	1		1 m	100	72	60	60	60	60	59	58	45	35	20	18		Non-Plastic					(GM)		4.5		
2	1		3 m																					5.1		2.798
3	1		7 m																	38	1.5			6.2		
4	1		13 m																	39	0.2			6.8		
5	1		17 m																				2.32	8.5		2.76
Additional Bore Hole No. 2 (Naluchi Bridge Site)																										
1	2		1 m				100	98	94	92	84	76	75	67	66		28	21	7			(GC-GM)				
2	2		1.5 m				100	99	95	91	82	74	72	68	65		27	21	6			(GC-GM)	2.06	7	0.08	2.574
3	2		5 m																				2.45	2	41	2.85
4	2		8 m																				2.44	2.5	43	2.83
5	2		11 m																				2.46	3.2	42	2.86
6	2		15 m																	38	0			5.09		2.78
7	2		17 m																	38.5	0.2			6.24		2.77
8	2		21 m																	37.5	0			3.59		2.75
Additional Bore Hole No. 3 (Closed to Gird Station)																										
Naluchi Bridge	3		1 m	100	80	73	68	63	56	46	31	28	26	24	22		27	20	7			(GC-GM)		3.8		
Naluchi Bridge	3		2 m	100	85	84	66	62	56	46	35	32	30	28	24		28	21	7	32	1.5	(GC-GM)		4.2	0.1	2.62
Naluchi Bridge	3		5 m																	37.5	0					2.775
Naluchi Bridge	3		7 m																							
Naluchi Bridge	3		11 m																	38.5	1					2.79
Naluchi Bridge	3		15 m																	40.3	0					2.82
Naluchi Bridge	3		18 m																	39.6	0.1					2.8

(3) Survey for Sub-grade Materials of Existing Road

The locations of test pits for the existing road pavement survey are shown in **Figure 3.3.1**. The soil parameters of the sub grade portion are shown in **Table 3.3.9**. Items included in the survey of the existing road pavement are as follows.

- Existing Pavement
- Carriage Way Width
- Formation Width
- Height of Embankment
- Crust Thickness
- In-Situ Density
- Field Moisture Content
- Test Pits
- Laboratory Test for CBR

A series of laboratory tests conducted is based on the following specifications, and the test results are shown in **Table 3.3.10**.

- Soil Classification Test (AASHTO M-145)
- Grain Size Analysis (T27)

- Consistency Limit (AASHTO T89, T90)
- Soil Group Determination (ASTM D2487)
- Moisture Density Relationship (T180)
- Degree of In-situ Compaction (T183)
- Design CBR Test (T193)

All sub-grade soil samples were tested for Design CBR under soaked condition for 96 hours. The CBR moulds were prepared at three levels of compaction, in accordance with AASHTO T193. The ranges of CBR values to be obtained at 0.2 inch penetration are as follows:

- 90% of Compaction : CBR = 8.5% - 19.6%
- 95% of Compaction : CBR = 18.9% - 36.0%
- 100% of Compaction : CBR = 27.5% - 59.5%

Table 3.3.9 Pavement Thickness and Soil Property of Subgrade

Location	Passing % age Through Sieve Size											Atterberg Limit			AASHTO Soil Classification	Lab. Compaction		CBR Value at 2"		
	2½"	2"	1½"	1"	¾"	½"	3/8"	4#	10#	40#	200#	LL	PL	PI		Max Dry Density in g/cc	Opt M.C %	90%	95%	100%
TP-1 km-0+500	-	100	95	86	79	74	72	67	50	20	14	Non-Plastic			A-1-a	2.131	6.8	8.5	19.8	30.7
TP-2 km-0+700	-	-	100	95	89	80	76	65	48	28	23	24	20	4	A-1-a	2.167	6.5	9.8	19.8	31.9
TP-3 km-1+200	-	-	100	99	94	88	82	73	47	30	25	25	20	5	A-1-a	2.120	7.1	10.2	18.9	27.5
TP-4 km-1+600	-	100	94	92	89	83	79	69	55	33	25	25	20	5	A-1-b	2.145	6.9	12.3	22.5	35.8
TP-5 km-2+100	100	78	70	66	63	61	60	58	49	26	19	24	20	4	A-1-a	2.20	6.0	16.3	34.4	50.4
TP-6 km-4+880	-	100	91	71	62	51	42	39	25	9	2	Non-Plastic			A-1-a	2.22	6.8	19.6	36	59.5

Note: TP-1~TP-5 were carried out in Preliminary Stage.

Table 3.3.10 Summary of CBR Test

Location	Mettled Width in meter	Formation Width in meter	Height of Embankment meter	Existing Crust Thickness Sheet in "cm"				Field Dry Density g/cc	Field M.C %	Max Dry Density g/cc	OPT M.C %	Compaction %
				Surfacing	Base	Sub-Base	Total Thickness					
TP-1 km-0+500	-	-	-	TST washed	13.0	22.0	35.0	2.118	6.8	2.131	6.8	98.6
TP-2 km-0+700	7.90	9.10	R/S 3.60 L/S 1.0 Down	3.00	15.0	20.0	38.0	2.000	8.0	2.167	6.5	93.8
TP-3 km-1+200	7.00	10.00	R/S 0.50 L/S NSL	2.50	26.0	22.0	50.0	1.947	8.6	2.120	7.1	91.8
TP-4 km-1+600	7.00	9.50	Built up area	3.50	16.5	30.0	50.0	2.100	6.5	2.145	6.9	97.9
TP-5 km-2+100	6.10	10.00	Hilly area	10.00	25.0	30.0	65.0	-	-	2.200	6.0	-
TP-6 km-4+880	-	-	-	-	-	-	-	2.176	6.5	2.220	6.8	98.0

Note: TP-1~TP-5 were carried out in Preliminary Stage.

3.4 Hydrological and Hydraulic Survey

3.4.1 Purpose and Methodology of the Survey

The objective of the hydrological analysis is to generate rainfall information and river discharges required in established design criteria for the roadway drainage structures such as bridges, box culverts, pipe culverts, cross drains and roadside ditches/canals.

The hydrological analysis was carried out to determine the probable design water level, discharge and velocity for the different return period (probability) at each bridge site, and drainage tributaries crossing the project road. The procedure adopted for the hydrological analysis is presented in **Figure 3.4.1**. Location of the tributaries covered in the study is shown in **Figure 3.4.2**.

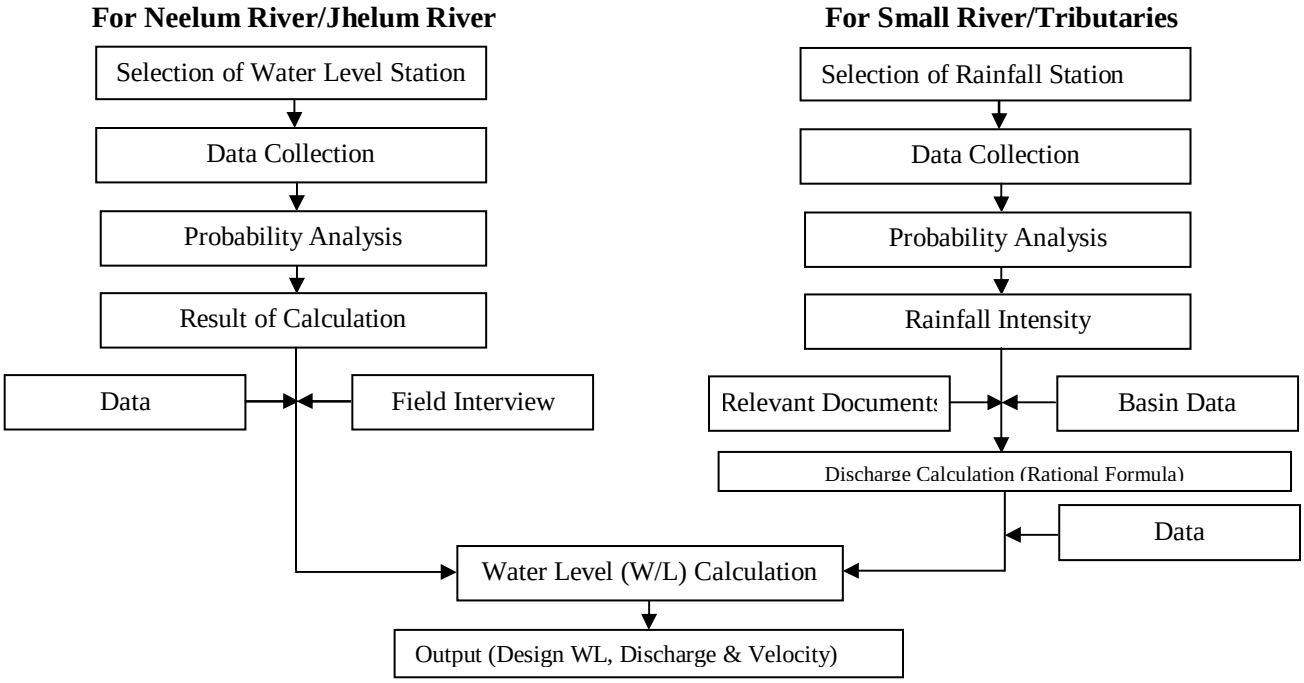


Figure 3.4.1 Flowchart of Hydrological Analysis

The basic data used for the analysis includes water level, discharge and meteorological data such as rainfall, temperature, wind velocity, number of rainy days etc. that were obtained from representative locations near the project area.

In the analysis, the design discharge for the different probability or return period for the small river basin are estimated using rainfall data and parameters of each tributaries. To confirm its correctness, data taken from the site observation are compared with the results of the calculation.

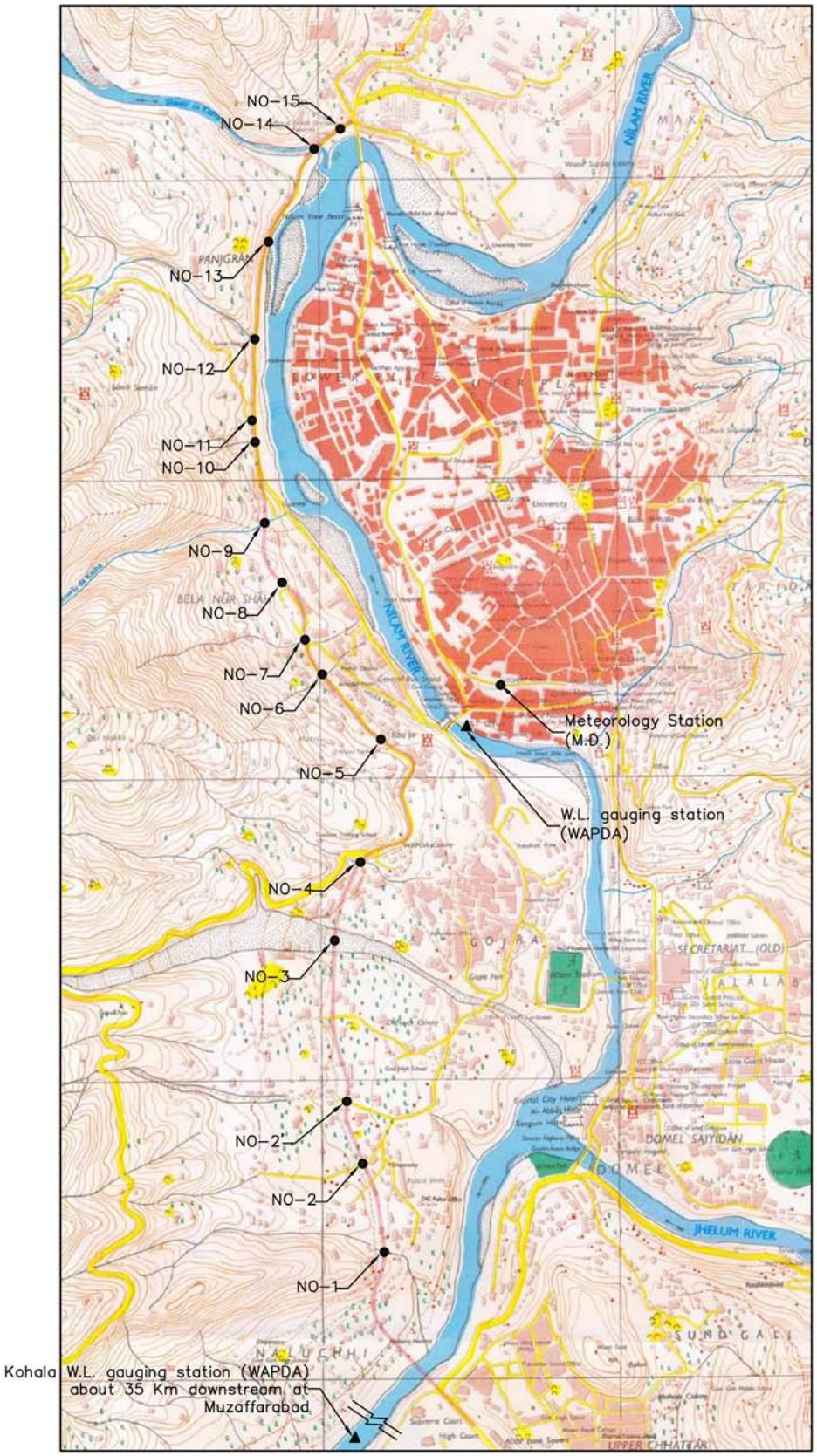


Figure 3.4.2 Location Map of Drainage Number for Crossing the Road, and Gauging Station of Neelum River & Jhelum River

3.4.2 Data Collection and Analysis

Data were collected mainly from Meteorology Department in Islamabad and from Water Power Development Authority (WAPDA) at Lahore. Other sources such as the Preliminary Design Report of West Bank Bypass and field/site investigations were also utilized as supplemental data. The selected gauging stations near the project area are shown in **Table 3.4.1**, and the corresponding locations are illustrated in **Figure 3.4.2**.

Table 3.4.1 Selected Hydrological Gauging Stations

Station No.	Station Name	Location	Elevation/ Catchment Area	Available Date	Available data	Remarks
1	Muzaffarabad	La:34-22' N Lo: 73-29' E	701 m	Rainfall, Wind Velocity, Temperature, Humidity	1995-2004	Meteorology Department
2	Muzaffarabad	La:34-22' N Lo: 73-28' E	670 m 7,278 km^2	Discharge	1963-2003	WAPDA
3	Kohala	La:34-12' N Lo: 73-30' E	560 m 24,790 km^2	Discharge	1965-2003	WAPDA

Source: Study Team

The project road, about 5 km in length, is along the right bank of the Neelum Rivers. There are fourteen (14) small rivers and tributaries crossing the roadway and drains into Neelum and Jhelum rivers. The catchment area of these waterways ranges from 1 km^2 to 15 km^2. Majority however has less than 1 km^2 of catchment area.

(1) Monthly Discharge of Neelum River at Muzaffarabad

Gauging station records showed that discharge in Neelum River during dry season range from 0 m^3/s to 100 m^3/s. The discharge remarkably rised from April, and the largest value of 3,766 m^3/s was recorded on September 1992, during the wet season. (See **Table 3.4.2** and **Figure 3.4.3**)

Table 3.4.2 Discharge of Neelum River at Muzaffarabad (1992-2003) m^3/s

Monthly	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
E.Max	159	191	578	1159	1259	2029	2351	1294	3766	352	152	115
M.Min	31	-1	39	-1	326	-1	152	150	-1	65	-1	35
Mean	60	78	164	474	727	778	904	537	742	123	81	63

Source: Water Power Development Authority in Lahore

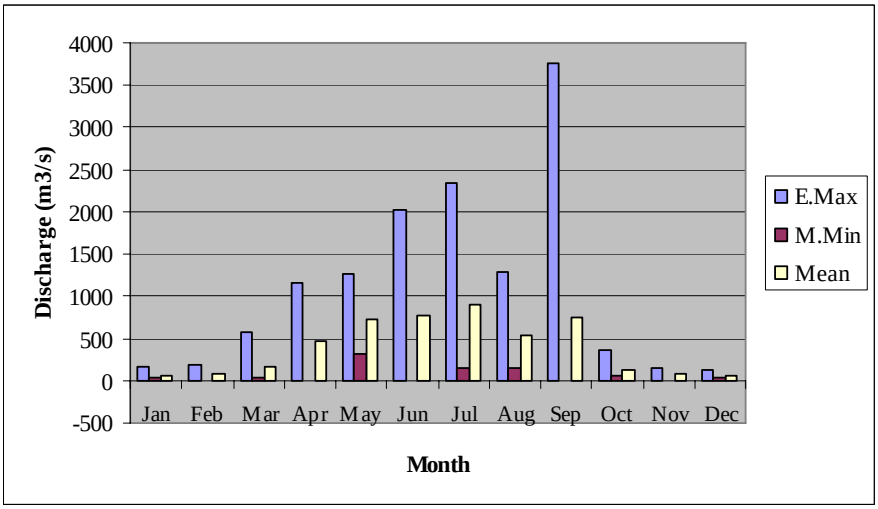


Figure 3.4.3 Monthly Discharge of Neelum River at Muzaffarabad

(2) Probability Analysis Method

Maximum discharges and daily rainfall at different return period were estimated using Gumbel's method.

(3) Determination of Discharge or Run-off Volume

The estimation of the peak or the design flood/discharge caused by rainfall on the watershed is discussed hereunder. Peak discharge or runoff produced in several drainage basins or catchment areas can be computed using the Rational Method.

a. Peak Discharge

Peak discharge or runoff produced in the drainage basins is computed using the Rational Method. The applicable condition of Rational method is 1) No flood control reaches the upper facilities,2) Less than 200 km^2 basin area, 3) Non-consideration of basin storage. The project basin satisfies all the above conditions. The formula for the Rational Method is as follows:

$Qp = (1 / 3.6) \times f \times R \times A$

Where,

Qp: Flood discharge (m^3/s)
f: Runoff coefficient =0.85 (Mountainous area f = 0.75-0.90)
R: Rainfall (mm/h)
A: Catchment area (km^2)

b. Time of Flood Concentration

Time of flood concentration depends on the distance from the critical point to the site or the point of interest, and the average velocity of flow. Time of flood concentration

was calculated using the following formula obtained from Public Works Institute of Japan:

$T = 1.67 \times 10^{-3} \times (L / \sqrt{S})^{0.7}$

Where,

T: Time of flood concentration (hr)
L: Length of waterway from the farthest point to the site or point of interest (m)
S: average slope

c. Rainfall Intensity

Rainfall Intensity is the amount of storm run-off in a given time regularly recurring in a given period. The rainfall intensity at the project site is estimated using the Mononobe and Talbot formulas as follows:

$R1 = R_{24} /24 \times (24 / T)^{2/3}$ (Mononobe formula)

Where,

R1: Rainfall intensity for a given period (mm/hr)
R_{24}: Probable basin mean 1-day rainfall (mm)
T: Time of flood concentration (hr)

$R2 = R_{24} / 24 \times (A /(T + B))$ (Talbot formula)

Where,

R2: Rainfall intensity for a given period (mm/hr)
R_{24}: Probable basin mean 1-day rainfall (mm)
T: Time of flood concentration (hr)
A, B: coefficients (B = 3, A = B + 24)

The adopted rainfall intensity in the project area is the average of the results of the two (2) formulas presented above.

$R= (R1 + R2) / 2$ (average rainfall intensity)

3.4.3 Hydrological Study Results

(1) Probable Discharge for Small Rivers and Tributaries

The calculation results are summarized in **Table 3.4.3**.

Table 3.4.3 Estimated Discharges for Small Rivers and Tributaries

SL No.	Road Station	Each Prob.	C.A (km^2)	T (h)	R24 (mm)	R (mm/h)	f	Q m^3/s
1	0+715 (0+723)	1/20	0.42	0.6	210	82	0.85	8.0
		1/10		0.6	170	67	0.85	6.6
		1/5		0.6	130	42	0.85	4.2
2	0+980 (0+992)	1/20	0.20	0.5	210	86	0.85	4.1
		1/10		0.5	170	70	0.85	3.3
		1/5		0.5	130	43	0.85	2.0

SL No.	Road Station	Each Prob.	C.A (km^2)	T (h)	R24 (mm)	R (mm/h)	f	Q m^3/s
2'	1+330 (1+236)	1/20	0.75	0.5	210	86	0.85	15.0
		1/10		0.5	170	70	0.85	12.4
		1/5		0.5	130	43	0.85	7.6
3	1+760 (1+750)	1/50	2.60	1.0	240	76	0.85	46.7
		1/20		1.0	210	67	0.85	41.1
		1/10		1.0	170	54	0.85	33.2
4	2+050 (2+062)	1/20	0.22	0.5	210	86	0.85	4.5
		1/10		0.5	170	70	0.85	3.6
		1/5		0.5	130	43	0.85	2.2
5	2+650 (2+680)	1/20	0.09	0.5	210	86	0.85	1.8
		1/10		0.5	170	70	0.85	1.5
		1/5		0.5	130	43	0.85	0.6
6	2+860 (2+924)	1/20	0.15	0.5	210	86	0.85	3.0
		1/10		0.5	170	70	0.85	2.5
		1/5		0.5	130	43	0.85	1.5
7	3+030 (3+053)	1/20	0.18	0.5	210	86	0.85	3.7
		1/10		0.5	170	70	0.85	3.0
		1/5		0.5	130	43	0.85	1.8
8	3+230 (3+297)	1/20	0.08	0.5	210	86	0.85	1.6
		1/10		0.5	170	70	0.85	1.3
		1/5		0.5	130	43	0.85	0.8
9	3+600 (3+520)	1/50	2.73	1.2	240	70	0.85	45.1
		1/20		1.2	210	62	0.85	40.0
		1/10		1.2	170	50	0.85	32.2
10	3+745 (3+793)	1/20	0.08	0.5	210	86	0.85	1.6
		1/10		0.5	170	70	0.85	1.3
		1/5		0.5	130	43	0.85	0.8
11	3+865 (3+868)	1/20	0.36	0.5	210	86	0.85	7.3
		1/10		0.5	170	70	0.85	6.0
		1/5		0.5	130	43	0.85	3.7
12	4+090 (4+100)	1/50	4.42	1.5	240	62	0.85	64.7
		1/20		1.5	210	55	0.85	57.4
		1/10		1.5	170	44	0.85	45.9
13	4+570 (4+580)	1/20	0.2	-	210	86	0.85	4.1
		1/10		-	170	70	0.85	3.3
		1/5		-	130	43	0.85	2.0
14	4+700 (4+750)	1/50	15.2	1.9	240	55	0.85	197.4
		1/20		1.9	210	49	0.85	175.9
		1/10		1.9	170	39	0.85	140.0
15	4+950 (4+870)	1/20	0.18	0.5	210	86	0.85	3.7
		1/10		0.5	170	70	0.85	3.0
		1/5		0.5	130	43	0.85	1.8

Note: Station in ( ) means station as per the detailed design.

3.4.4 Hydraulic Study including Local Scouring Depth

(1) Probable Discharge of Neelum River and Jhelum River at Muzaffarabad and Kohala Stations

The calculation results of probable discharges of Neelum River and Jhelum River are shown in **Table 3.4.4**.

Table 3.4.4 Results of Probable Discharge Analysis

Probability	Neelum River	Jhelum River	
	Station No.4+100	Kohala Station	Naluchi Bridge
C.A. (km^2)	7,194	24,890	21,700
1/100	4,210	8,210	7,160
1/50	3,670	7,130	6,220
1/20	2,910	5,640	4,920
1/10	2,270	4,460	3,890
1/5	1,940	3,840	3,350
1/2	1,890	2,860	2,490
Maximum Flood Discharge 10th Sep,1992	5,130	10,200	

Source: JICA Study Team

The probable discharge at the point Road Station No.4+100 is referred to the nearby Muzaffarabad gauging station data. The probable discharge at the Naluchi Bridge site is calculated by using specific discharge data at the Kohala gauging station.

The maximum discharge recorded on 10th Sep 1992 is 5,130 m^3/s at Muzaffarabad Gauging Station and 10,200 m^3/s at the Kohala station. A return period of the largest discharge is estimated at more than one hundred years as shown in **Table 3.4.6**.

(2) Probable Flood Water Level at the point of Proposed Road Station No 4+000 Station and Naluchi Bridge Site

The results of the flood water level analysis by using Manning's formula (n= 0.035 of the roughness coefficient) are shown in **Table 3.4.5**. For the analysis, three profile surveys with 250 m intervals were conducted at the proposed road Station No.4 +000 and Naluchi bridge site.

Table 3.4.5 Results of Flood Water Level

Probability	Road Station No. 4 +000 Site			Naluchi Bridge site		
	Dis.(m^3/s)	W.L.(m)	Vel.(m/s)	Dis.(m^3/s)	W.L.(m)	Vel.(m/s)
E. Max.	5,130	679.1	5.3			
1/100	4,210	678.2	4.9	7,160	667.0	7.0
1/50	3,670	677.6	4.6	6,220	665.8	5.7
1/20	2,910	676.7	4.2	4,920	664.0	5.6
1/10	2,270	675.7	3.9	3,890	662.5	4.6
1/5	1,940	675.2	3.7	3,350	661.8	4.2
1/2	1,890	675.1	3.6	2,490	660.5	3.7

Source: JICA Study Team

(3) Design Water Level of Neelum River Along the Proposed Road

The 100-year flood water level of Neelum River along the proposed road alignment is summarized in **Table 3.4.6**. Furthermore, an allowance of about 0.5 m in height is recommended in the design because of rapid stream (gradient: 1/300) of Neelum River.

Table 3.4.6 100 Year Flood Water Level of Neelum River Along Proposed Road Alignment

Station	Sta. 3 + 800	Sta. 4 + 000	Sta. 4 + 400	Sta. 4 + 800	Note
Design Water Level	678.0 m	678.7 m	679.0 m	681.4 m	Gradient 1/300

(4) Local Scouring

At the Naluchi Bridge site, solid rocks are exposed along the riverbed. The pier of the bridge submerged in water should be sufficiently embedded in sound rock foundation, which should remain stable even if any local scouring occurs.

Bridge No.4 crosses the largest tributary along the alignment. According to the subsoil survey (preliminary stage 2006), sound rock is encountered at a depth of about 2 m. The pier of the bridge should be founded on the sound rock to avoid any occurrence of local scouring.