UNDERSTANDING OF THE PROJECT

Background of the Project:

The proposed project is located in Punjab and KPK Province starting from Rajanpur and terminates at DG-Khan. Total length of the project is 237 kilometres and it falls in Rajanpur, DG Khan and Dera Ismail Khan Districts.

The proposed project by National Highway Authority is the**Detailed Design of Construction of Rajanpur – DG Khan Section as 4-Lane Highway and Dualization and Rehabilitation of DG Khan – DI Khan Section of N-55**. Rehabilitation and maintenance includes all sorts of repairs including resurfacing, overlays, and reconstruction of pavement, base and even sub base course.

Pakistan has a very significant location as it is the connecting point between South Asia and Central Asia. It also connects China through KKH. It is therefore the need of time to improve the Highway network in Pakistan that forms the part of CAREC road network to international standards.

As, road infrastructure provides a fundamental foundation to the performance of all national economies, delivering a wide range of economic and social benefits. So, adequately maintaining road infrastructure is essential to preserve and enhance those benefits. Therefore,NHA looks after nearly all of Pakistan's major inter-provincial road links, main transport corridor linking ports to major population centres and to neighbouring countries.

Objectives:

Theprojectshall develop the Rajanpur – DI Khan Section of N-55 after Dualization and rehabilitation with the improved facilities. It shall provide an efficient intelligent corridor for domestic as well as international traffic contributing largely to the economic and social development of the region.

The purpose of rehabilitation oftheroadis togetabetterlevelofservice (LOS)andtoimprove thestructural capacityoftheroad by making it **4-Lane Highway.**The main objective of the launched project is to achieve the intended design life of overlay by increasing its capacity and rehabilitation works.

TENDER DOCUMENTS

FOR

GEOTECHNICAL INVESTIGATION FOR DETAILED DESIGN OF RAJANPUR – DG KHAN SECTION AS 4-LANE HIGHWAY AND DUALIZATION & REHABILITATION OF DG KHAN – DI KHAN SECTION OF N-55

TERMS OF REFERENCE

Geotechnical Investigation for Structures:

Sub-Surface investigations consisting of boreholes / drill holes / test pits of required depth, supplemented by field and laboratory testing to accurately assess the engineering properties of underlying soil strata for detailed design of foundations, substructures and roads shall be undertaken. A separate report will be prepared to this effect and will be submitted to NHA for approval. Original lab reports shall be attached in the soil report along with colored photographs.

Bore logs shall be included in the soil investigation report along with the laboratory results. Testing of samples collected from site shall be carried out in a reputed laboratory, under strict quality control and adherence to relevant ASTM procedures / standards. Depth of boring shall be decided by the geological formation at site and the type of foundations proposed for the structures. Standard penetration test shall be started from the ground surface and carried out in accordance with ASTM D1586 Penetration test and split barrel sampling of soils. Where clayey soils are encountered, undistributed samples shall be obtained in accordance with ASTM thin-walled sampling of soils.

The site investigation to be undertaken shall be consist of the following:

- Deep machine boring to a maximum depth of fifty 50 meter below ground level and associated field-tests for river bridge piles and 30 meter for small bridges.
- Detail of test to be carried out is attached as **ANNEXUE-I.**
- Pile capacity curves will be developed by contractor for 0.76m, 1m, 1.2m and 1.5m diameters piles.
- Contractor shall quote the rates for complete testing and report of each location for a total of 50 locations. Financial form is attached as **ANNEXURE-II.**
- Submission of proper site investigation report comprising all relevant notes and pertinent information required by this specification together with laboratory test results. The above scope of work may be varied or deleted depending on the findings as the investigation proceeds.

SP-414 SOIL INVESTIGATIONS AT BRIDGE SITES

414.1 SCOPE OF WORK

The Contractor shall carry out confirmatory boring at bridge and Flyover sites at locations marked on the drawings or as directed by the Engineer's Representative.

The purpose of the Work specified herein is to determine the type, nature, arrangement, thickness and texture of the various subsurface strata, the conditions and the Engineering characteristics of the subsurface materials as they exist to the depth and at the locations specified. This is to be accomplished by means of drilling, in-situ testing, collection of disturbed and undisturbed soil and water samples and laboratory testing.

The Contractor shall carry out the specified works under the supervision of the Engineer's Representative.

414.1.1 Plant and Equipment

The Contractor shall keep at-least one rotary drill machine and one percussion winch along with accessories on the site to meet the requirements of the Work. The plant and equipment shall be in good operating condition and capable of performing efficiently the Work as set forth.

414.1.2 Drillers and Supervisory Staff

The Contractor shall provide qualified, experienced, orderly and thoroughly competent persons at all times including geotechnical engineers or engineering geologists who shall conduct and supervise drilling, sampling, logging and in-situ testing at the site. The Contractor shall remove any of his employees from the site that in the opinion of the Engineer does not meet these requirements.

The Contractor shall make his own arrangements for housing of his personnel, security and storage of the equipment and supplies at the site.

414.1.3 Setting up at each Hole

The Contractor shall make all the necessary arrangements for setting-up plant and equipment at each location, carrying out the work specified, preparation and reinstatement of the work areas, improvement to access routes and all other temporary works.

414.1.4 Measurement of Quantities

The quantities shown in the Bill of Quantities are only approximate. The payment shall be made on the basis of actual work performed in accordance with the Specifications.

414.1.5 Submission of Field and Laboratory Data

The Contractor shall supply complete field and laboratory investigation data to the Engineer's Representative within the time set-forth for completion of works.

This data shall include copies of all the approved logs and test records provided during the course of the Contract including any alterations or amendments required by the Engineer's Representative.

414.1.6 Location of Investigation Points

a) The locations of investigation points shall be established in the field by the Contractor on the basis of the Drawings to be provided later or as directed by the Engineer's Representative. Locating the boreholes accurately in the field shall be the sole responsibility of the Contractor.

b) It is to be understood that further Drawings may be issued by the Engineer showing the revised locations of investigation points.

c) All the investigation points shall be located by the Contractor through field survey to an accuracy of 1 m in plan and 0.05 m in ground elevation.

414.2 WORK METHODOLOGY

414.2.1 Investigated Areas

The location of the boreholes will be selected as directed by The Engineer. The Engineer will specify from time to time during the Contract period, the exact location and reference number of all holes. To locate the holes accurately in the field shall however be the Contractor's responsibility.

414.2.2 Casing

A hole shall be cased in any stratum which is friable or not sufficiently strong to stand unsupported, or as and when directed by the Engineer's Representative.

The Contractor shall ensure that casings are of a suitable size and inserted in such a manner as to render them recoverable. The Contract Rates for drilling shall be deemed to include the supply, insertion and recovery of casing including any damage, loss or delay caused by difficulty or failure in recovering casing.

414.2.3 Removal of Casing

Casing shall neither be removed from any hole nor any filling introduced into it until permission is given by the Engineer. This permission will normally be given as soon as work in the hole is completed and the groundwater level has been measured.

As far as possible the Contractor shall avoid leaving a hole overnight after he has begun to withdraw the casing and before he has finished.

414.2.4 Supplementary Holes

Abandoned holes and / or the holes from which unsatisfactory samples have been obtained and/or in which unsatisfactory field tests have been performed due to the negligence of the Contractor shall be supplemented by other holes adjacent to the original location. The exact location of such supplementary holes shall be specified by the Engineer in the field.

The depth where the unacceptable holes were abandoned or to the depths where unsatisfactory samples were obtained or unsatisfactory field testing was

performed may be made by any method selected by the Contractor that in the opinion of the Engineer will permit satisfactory field testing and sampling below those depths at which original hole was abandoned shall be carried out using only the specified method of advancing the hole.

No payment will be made for that portion of the supplementary hole above the depth paid for in the unacceptable hole.

414.2.5 Groundwater Level

The groundwater level in holes shall be determined after completion of the hole or when required by the Engineer, as follows:

Clear water shall be added or the hole shall be bailed-out as necessary to bring the water level to the expected groundwater level as directed by the Engineer and the water level shall be measured and recorded at intervals of 6 hours for a period of twenty four (24) hours thereafter.

414.2.6 Backfilling Holes

Boreholes shall be backfilled with grout as directed by the Engineer.

Grouting for backfilling holes shall consist of a mud formed by mixing one (1) part by weight of bentonite with ten (10) parts of water, to which two parts by weight of cement shall be added after the bentonite and water have been thoroughly mixed. Alternatively, holes may be backfilled with purpose-made pellets of bentonite or bentonite/cement, provided they are of a size which, in the opinion of the Engineer, is compatible with the size of hole. If there is no standing water in the hole, grout may be poured in from the top. If there is standing water in the hole, the grout shall be fed into the bottom of the hole by a tremie pipe, the end of which shall always be below the groundwater junction while grouting is being carried out.

Grout backfill shall be taken up to 30 cm below the original ground level. Any apparent loss of grout due to leakage or consolidation within one week shall be made-up with fresh grout and then the remaining depth of the hole shall be filled with concrete.

414.2.7 Logs

Logs of boreholes shall be provided on an approved specimen. These shall include descriptions of all strata including details of the soil macro fabric (such as frequency, orientation and nature of fissures) and details of samples taken, and an account of all observations and field tests. Logs of boreholes shall include notes on the nature, quantity and colour of the drilling fluid returns. All logs shall be subject to the approval of the Engineer and two draft copies shall be submitted to the Engineer, not more than two days after the hole is backfilled. Soil descriptions shall conform to ASTM designation D 2488 and classified according to ASTM designation D 2487. All depths and thicknesses of topsoil and strata shall be recorded in meters and all reduced levels shall be recorded in meters with reference to Survey of Pakistan datum. Accurate determination of ground levels at all the hole points is the Contractor’s responsibility for which no extra payment shall be made.

414.2.8 Contractor's Responsibility for Records

The presence of the Engineer or any of his staff and their keeping separate drilling records shall not relieve the Contractor of any of his responsibilities for keeping records.

414.2.9 Order of Work

The order in which the work is to be accomplished shall be determined and approved in the field by the Engineer.

414.3 DRILLING

414.3.1 Depth of Drilling

Drilling would generally be required up to a minimum of 45 meters depth or at least 5 m below the pile tip level, whichever is more or as directed by the Engineer.

414.3.2 Accuracy of Alignment of Holes

Boreholes will be within 2 degrees of the vertical unless the Engineer's Representative has ordered the drilling of an angled hole in which case the hole angle shall be within 5 degrees of the angle specified.

414.3.3 Drilling Plant

The drilling plant and ancillary equipment to be mobilized at the site should be adequate to advance the boreholes in an efficient manner, to the required depths.

Rotary drilling rigs shall be of the hydraulic feed type equipped with side discharge type fish tail and tricone bits for drilling. Bits and casing shall conform to B.S. 4019; Part I; 1974 or an approved equivalent.

Drilling bits shall be of side discharge type designed to prevent unnecessary disturbance of soil at bottom of the hole by flow of drilling fluid, unless the Engineer directs otherwise.

414.3.4 Drilling Procedure

The method of drilling shall be of any approved standard and accepted method by means of which a hole of specified diameter is extended to the desired depth. The normal method of drilling shall be rotary unless gravelly strata are encountered where percussion may be used.

During drilling the Contractor shall regulate the drilling operation which ensures minimum disturbance in the underlying material in which the in-situ testing and sampling is to be carried out.

In rock, core drilling shall be carried out in such a manner and using such sizes of bits, that the maximum core is recovered. This requires close surveillance of the flushing media, drilling pressures, and lengths of runs, use of appropriate core barrels and other factors relevant to the nature of the material drilled. The drill bit shall be withdrawn and core removed as often as may be necessary to secure the maximum possible amount of core. In soft or friable formation, dry drilling techniques may be required using single tube core barrel with tungsten carbide bits as directed by the Engineer. The cores would be placed in core boxes in a proper manner.

414.3.5 Stabilizing of Holes

Drilling mud of suitable consistency shall be used during rotary cum wash boring to stabilize the walls of boreholes by preventing caving-in and to avoid disturbance of the sampling horizons. The drilling mud shall be a mixture of bentonite and water with approved chemical additives being used, if required, to assist in modifying its density and viscosity. The density and viscosity shall be selected considering such factors as hole stability, cutting operation and undisturbed samples recovery.

Where drilling mud is not effective, casing of appropriate size and strength may be used subject to the approval of the Engineer. It will be responsibility of the Contractor to use appropriate means to stabilize the walls of the boreholes.

It shall be ensured that there is no jetting action of the drilling fluid. The minimum amount of drilling fluid necessary to carry away the cuttings shall be used. During drilling the Contractor shall regulate the pressure of the drilling fluid to ensure minimum disturbance to the underlying material in which the in-situ testing and sampling is to be carried out.

414.4 SAMPLING

414.4.1 General

The Contractor shall take disturbed or undisturbed samples from any borehole when ordered to do so by the Engineer. This shall include the provision of all necessary sampling equipment, tubes and containers, crates and boxes, as well as handling and transportation to the approved laboratory or store at site.

414.4.2 Approval of Equipment

No equipment or containers shall be used unless and until approved by the Engineer.

414.4.3 Care of Samples

The Contractor shall be responsible for the safe keeping of samples of all kinds until these have been handed over to the designated laboratory or disposed-of on the Engineer’s instruction as the case may be. Any sample lost, damaged or showing signs of deterioration while in the Contractor’s care shall be replaced by the Contractor at no expense.

414.4.4 Labeling Samples

All disturbed and undisturbed soil samples and water samples taken from holes shall be clearly labeled. Each label shall include the following information:

a) Name of Contract
b) Reference number of the holes

c) Reference number of sample
d) Date of sampling
e) Brief description of the sample (e.g. stiff brown silty clay)
f) Depth of the top and bottom of the sample below ground level
g) Number of the sampler tube

Tubes and crates for undisturbed samples shall be labeled “Do not jar or vibrate” and “Haul and transport in a horizontal position”.

414.4.5 Disturbed Samples

In all the boreholes, small disturbed samples shall be taken at the top of each stratum, and at intervals as directed by the Engineer. Material from the cutting shoes of open drive undisturbed samples, and from the split spoon sampler used for Standard Penetration Tests, shall also be taken as disturbed samples.

414.4.6 Undisturbed Sampling

Undisturbed sampling from boreholes shall be done by Shelby tube or Pitcher/Denison sampler or as directed by the Engineer. The undisturbed samples should be properly sealed and preserved as directed by the Engineer.

414.4.7 Cores

The cores obtained from boreholes shall be carefully removed from the core barrel and placed in the boxes in the correct sequence, with increasing depth from left to right and top to bottom in the box. Coloured photographs of cores shall be taken at site.

Where the core is contained in an expandable triple tube liner, the ends of the tube shall be sealed and waxed as directed by the Engineer.

Each core run shall be segregated by labeled wooden blocks 25 mm thick and the depth of the bottom of each run shall be marked on the partitions in the core box with paint.

No box shall contain more than 3 meters of core.

414.4.8 Core Samples

Selected cores, preferably not less than 30 cm in length, shall be preserved as core samples. The preservation would consist of clearance of any loose sludge, waxing of cores, packing in wooden boxes using sawdust and labeling before transportation to the testing laboratory.

414.4.9 Water Samples

The Contractor shall take water samples from holes when directed by the Engineer before the addition of water to the hole unless it is unavoidable. If necessary, the hole shall be bailed-out before taking the sample to ensure that any potential contaminant is removed. No fuel or other potential contaminant shall be allowed to enter the hole. The method of sampling shall be as approved by the Engineer. Samples shall only be stored in approved, air tight and scrupulously clean, containers and shall not be less than 1 litre in volume.

414.4.10 Transportation of Samples

All samples shall be shifted to the store at the site, the day they are collected. Samples in tubes shall be kept and transported with the tubes in a horizontal position.

The samples shall be continuously transported to the testing laboratory on conclusion of every borehole and on the instructions of the Engineer. The laboratory for testing shall be approved by the Engineer.

414.5 IN-SITU TESTS

414.5.1 Standard Penetration Tests (SPTs)

When directed by the Engineer the Contractor shall carry out Standard Penetration Tests (SPTs) in boreholes. The penetration resistance 'N' shall be expressed as the number of blows of a 63.5 kg hammer freely dropping 76.2 cm required to force the standard split tube sampler 30.5 cm into the soil.

Standard Penetration Test (SPTs) shall be conducted in the boreholes in accordance with ASTM 1586 generally at 1 meter depth interval or as directed by the Engineer at the site.

414.6 LABORATORY TESTING

414.6.1 General

The samples shall be tested in a laboratory approved by the Engineer. The Engineer shall have access to the laboratories to supervise and check the laboratory testing of the samples. The testing shall be carried out in accordance with ASTM, BSS or AASHTO Standards or as directed by the Engineer. The Contractor shall arrange to carry out the following laboratory tests on the specified samples of the subsoil materials. The samples to be tested and the tests to be carried out for each sample shall be specified by the Engineer.

414.6.2 Type of Tests

Sr. No.	Name of Test	Standard
i.	Grain size analysis	ASTM D 422
ii.	Liquid limit, plastic limit	ASTM D 4318
iii.	Specific gravity	ASTM D 854
iv.	Unit weight of soil	
v.	Unconfined compression (soil)	ASTM D 2166
vi.	Unconfined compression (rock)	ASTM D 2938
vii.	Natural moisture content	ASTM D 2216
viii.	Consolidation	ASTM D 2435
ix.	Direct shear	ASTM D 3080
x.	Triaxial compression test	ASTM D 4767
xi.	Sulphate content of Soil	BS 1377
xii.	Organic matter content of soil	BS 1377
xiii.	Total dissolved salts of soil	BS 1377
xiv.	Chloride content of soil	BS 1377
xv	Chemical analysis of water BS 1377 a) Sulphate content of water b) Total dissolved salts of water c) Chloride content of water d) pH of water	

414.7 RECORDS AND REPORTS

414.7.1 Records

a) The Contractor shall keep accurate logs and records of all work accomplished under this item. All such records shall be preserved in good condition and order by the Contractor until these are delivered and accepted by the Engineer. The Engineer shall have the right to examine such records at any time prior to their delivery to him. Separate logs shall be made for each borehole. The following information shall be included on the logs or in the records for boreholes:

   i. Borehole number or designation and elevation of top of borehole.

   ii. Method of drilling holes.

   iii. Dates and time by depths when hole was performed.

   iv. Type of drilling fluid used.

   v. Depths at which samples were recovered or attempts made to collect samples along with designation, thickness and type.

   vi. Record of SPT on borehole log.

   vii. The classification or description by depth of the materials samples including a description of condition of compactness or stiffness of soil materials encountered and moisture conditions.

   viii. Depth of groundwater level if encountered.

   ix. Depth of bottom of borehole.

b) The Contractor shall furnish the Engineer with the record as specified above in duplicate, not later than 48 hours after completion of each borehole.

c) The presence of Engineer or the keeping of separate records by the Engineer shall not relieve the Contractor of the responsibility for the work specified in this Section. Payment shall not be made for any work for which the records have not been furnished by the Contractor.

414.7.2 Reports

a) The results of each borehole and the field tests carried out shall be communicated to the Engineer as follows:

   i. Oral reports as the work proceeds.

   ii. Three sets of complete data of the work within two (2) days of the date of completion of borehole.

b) The data shall comprise:

i. A site plan showing the position of the boreholes and giving their map reference.

ii. The borehole logs

iii. Complete results of field tests

iv. Comments on any point which the Engineer has put-up to the Contractor for inquiry and investigation during the Works.

c) Complete results of laboratory tests shall be communicated to the Engineer within seven (07) days of the date of completion of borehole.

ANNEXURE-II

FINANCIAL FORM

S.NO	NO. OF LOCATIONS	COST/LOCATION	TOTAL COST
1	50*		

Notes:

1*. These locations can vary between 45 to 55 locations and same cost/location as quoted above will be followed for total payment.

2. Cost quoted as per ANNEXURE-II is the final cost including all applicable government taxes and no other/separate cost will be paid other than the quoted cost what so ever.

3. Payment shall be made directly by NHA to the Contractor after certification of Report by M/s NESPAK and approval of NHA.

TENDER DOCUMENTS

FOR

HYDROLOGY STUDY FOR DETAILED DESIGN OF RAJANPUR – DG KHAN SECTION AS 4-LANE HIGHWAY AND DUALIZATION & REHABILITATION OF DG KHAN – DI KHAN SECTION OF N-55

TERMS OF REFERENCE

11.1

Hydrology & Hydraulic Study

The hydrologic analysis performed on Project shall be compiled in a hydrologic report. The Report shall consist of two sections; a data section, where the hydrological background information shall be recorded. Other part shall be an analysis section, where the design computations shall be recorded.

The following items shall be used as a checklist of the data that shall be included in the hydrological report. The comprehensiveness of the report shall depend upon the nature of the valley, or flood plain to be traversed, the cost of proposed drainage structures, and class of highway.

11.1.1 Hydrological Data

Data shall comprise of following items:

1. Topographic Maps

Maps are required to show the proposed highway alignment in relation to the drainage characteristics of the area being traversed. The available maps in this regard are Survey of Pakistan maps of 1:50,000 scale. Proper catchment areas shall be marked for rivers & nullas. Same shall be made part of the reports.

2. Satellite Imagery

The satellite imagery shall be used for upstream and down stream to identify the land use and drainage characteristics. Photographs shall be taken for all crossings whose design flow exceeds 20 m^3/s. Same shall be made part of the report. These photographs shall be of sufficient quality to enable the engineer to estimate channel roughness characteristics, nature & extent of vegetation cover, and land use. These pictures may be placed in the text or referenced in the text and compiled at the end of the Report.

3. Land Use (Classification by Remote Sensing)

Using the topographic maps, satellite imagery and site visits, the engineer shall comment on the nature of the land use in the affected water sheds. Similarly engineer shall comment on the nature of vegetation and soil characteristics of the basins. Individual types of land use, vegetation, and soil classifications shall be indicated as percentages of basin area. The extent of anticipated changes within any of these areas shall also be indicated.

4. Water Use

Engineer shall comment on the use of the water within the affected drainage basins. If reservoirs are within the watersheds, the operational procedures of these reservoirs shall be described. Condition of bunds of reservoir if made by locals shall also be commented upon.

5. Rainfall Data

Rainfall data for the Project area, obtained from Meteorological department shall be made part of the report. The data shall consist of a brief description, the length of record, the accuracy, and the source (if other than Met department). Data collection shall be responsibility of the Consultant including paying any required fee from any source. If the area consists of ungauged sections than spatial analysis may be performed for predicting the storm discharge.

6. River Discharge Data

In case a major river is encountered, its maximum discharge shall be obtained from the relevant department. In case of current Project, the Model study report is already available. Consultant to confirms the maximum discharge.

7. High Water Marks

Often high water marks can be used to estimate peak flows within a basin. Whenever possible the Engineer shall prepare a brief flood history. This statement shall include the dates of occurrence of the flooding and the elevations of high water marks. If possible photographs of such marks shall be included in the report.

8. **Intensity Duration Curves**

IDF curves of all gauged stations must me mentioned in the report else if the IDF curves are not available with the PMD Department than the method adopted to take the intensity for a given time duration for a predicted frequency must be mentioned in the report.

11.1.2 Hydrologic Analysis (By ARC GIS)

Hydrologic analysis shall comprise of following steps:

1. Drainage Area

This exercise is done usually on the topographic maps. A field inspection of drainage basins is highly desired. If available, DEM model with satellite imagery can be used to simulate the drainage pattern of the area. In the field inspection, in hydrologist shall record manmade features, such as agriculture terraces and dikes, which will intercept all of the runoff from the drainage area. These may include roadway/railway embankments. Once the boundaries of the contributing areas have been established, they shall be delineated on a base map and the areas determined. This is commonly using a scanned map in CAD software.

2. Watershed Parameters

Drainage basin characteristics shall be determined in the field or from available maps. The list of parameters below is based on the information needed by the various models used in the hydrological analysis. Some parameters will be inserted directly into a particular formula and others will be used in comparing one watershed to another for use in transferring data.

a. Basin Length
b. Basin Slope
c. Percent Impervious
d. Infiltration
e. Detention Depression Storage
f. Drainage Basin Roughness coefficient
g. Channel or conduit slope
h. Channel or Conduit Cross-section
i. Channel or Conduit Roughness

3. Flood Models

Listed below are several methods for use in estimating peak runoff from drainage areas.

a. Rational Equation: To be used for areas less than 50 ha
b. Gumbel Distribution: Areas greater than 100 ha with gauging station data at the site.
c. Indirect Estimates: Areas greater than 100 ha with gauging station data from neighboring watersheds.

The recurrence intervals for use with hydrologic computation shall be as follows:

Expressway	100 years (1 percent)
Arterials	50 years (2 percent)
Collectors	50 years (2 percent)

4. Rainfall Intensity

The rainfall intensity value used in the Rational Equation is based on the amount of rainfall that occurs, the time it takes for that rainfall to occur, and the recurrence interval associated with each design class. Statistical approach shall be used to develop IDF curves. Detailed calculations and IDF curves shall be made part of the Report (if available with PMD Department or any other source of IDF Curves).

NOTE:- Goodness of Fit test must be performed for finding the best statistical approach for predicting rainfall for a given return period. Moreover Use of the ArcGIS must be used for proper Hydrological Study and analysis and evidence of the use of ArcGIS must be shown in the report.

A sum of Rs 04 Million is kept in the contract for performing complete Hydraulic Model and Hydrology Study.

The following things must be included in the report

i. Hydraulic model study for Additional Bridges
ii. High resolution DEM (5 meter) for the entire length of 327 km for 500 meter from center line on either side and the same shall be handed over to NHA design section as being the property of NHA.

National Highway Authority Govt. of Pakistan

iii. Evidence of Use of HEC-SSP for statistical approach besides with goodness of fit test.

iv. Retaining structures must also be suggested far away from the roadway to divert the water in case of flood so to protect the road embankment.

v. Although it is mentioned that Topgraphic Maps of Survey of Pakistan of 1:50,000 scale. are required to show the proposed highway alignment in relation to the drainage characteristics of the area being traversed and also the Proper catchment areas shall be marked for rivers & nulla *But*
These may be used as supporting documents. The report will not be acceptable unless and until the latest modern scientific approach for Hydrological study may be adopted. i. e use of ARC GIS, Use of WMS software/Carlson Hydrology Softwares,/Civil 3D, HEC-HMS, Hec-RAS etc and evidence must be shown along with detail background of the study.

FINANCIAL FORM

S.NO	Total Lump sum cost for complete assignment
1	

Notes:

1. This cost includes all applicable government taxes and no other/separate cost will be paid other than the quoted cost what so ever.

3. Payment shall be made directly by NHA to the Consultant after certification of Report by M/s NESPAK and approval of NHA.