



COMMUNICATION AND WORKS DEPARTMENT (C&W) PUNJAB

**TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD -
CHINIOT - SARGODHA ROAD**

(LENGTH=67KM)

TECHNICAL FEASIBILITY STUDY REPORT

NOVEMBER 2020

PUBLIC PRIVATE PARTNERSHIP MODALITY

NES National Engineering Services
PAK Pakistan (Pvt.) Limited

KPMG
AXIS

[Type here]

Feasibility Study Report

- This Report has been prepared by Principal and Senior Engineers in NESPAK, Financial Experts in KPMG and Legal Experts in Axis Law Firm.

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SENSITIVITY ANALYSIS 200

RESULTS OF THE SENSITIVITY ANALYSIS 200

EXECUTIVE SUMMARY:

Roads make a crucial contribution to economic development & growth and bring important social benefits. They are of vital importance in order to make a nation grow and develop. In addition, for providing access to employment, social, health and education services, roads and bridges network play a critical role. Roads networks open up more areas and stimulate economic and social development. In short, for progress and development of any country, Roads/Bridges infrastructure plays an important role by providing efficient mobility of people and goods, especially when major portion of the freight transport is through roads.

The road network in Pakistan carries over 96 percent of inland freight and 92 percent of passenger traffic and is undoubtedly the backbone of the economy. With this large share in carrying the passenger and goods traffic all across the country, roads play a major role in the transportation system and provide connectivity between the centres of production and areas of consumption of agricultural and industrial goods facilitating economic growth, integrating the country, and helping reduce poverty. Due to various economic factors including the declining share of railways in the carriage of passengers and goods and the consequent shift towards their movement by road, the traffic volumes have been on the rise not only in the urban regions of Pakistan but also on the rural roads during the last three decades. The increase in the road traffic, especially the heavy goods vehicles, coupled with a backlog of maintenance due to non-availability of sufficient funds, has resulted in the deterioration of the road infrastructure, economic losses due to travel delays and higher vehicle operating costs, environmental pollution due to traffic congestion and above all severe traffic hazards. All these factors reflect towards an immediate need for the widening and improvement of road infrastructure to meet the rising demand for roadway capacity and pavement strength to sustain the imposed heavy loads in a reliable, safer, economical and environment-friendly manner.

Pakistan was previously facing inadequate transportation system few years ago. Currently, it has developed lot of Motorways as well as improved the network of National/Provincial Highways and many are under progress. Motorways are a network of multiple-lane, high-speed, controlled-access highways in Pakistan, which are owned, maintained, and operated federally by Pakistan's National Highway Authority. As of 18 March 2020, 1973 km of motorways are operational, while an additional 1763 km are under construction or planned. Motorways are an important part of Pakistan's National trade Corridor and plays an important role from regional perspective, which aims to link Pakistan's three Arabian Sea ports (Karachi Port, Port Bin Qasim and Gwadar Port) to the rest of the country through its National Highways and Motorways network and further north with Afghanistan, Central Asia and China and Iran.

One of the most important trade corridor M4 is a north–south motorway in Pakistan. The 309 km motorway connects M2 to M3 & M5. The M4 begins near the M2 Pindi Bhattian Interchange and continues on a southwest course connecting the cities of Faisalabad, Gojra, Toba Tek Singh, Shorkot, Abdul Hakeem, Khanewal and Multan and ends at Sher Shah Interchange giving exit to Multan Cantt over Shujabaad Road & itself continues as M5 Multan-Sukkur Motorway. It is connected to M3 Motorway (Lahore to Abdul Hakeem Motorway) near a village named Darkhana a few kilometers northeast of Abdul Hakeem Interchange. The importance of Faislaabd- Chiniot- Sargodha road improvement is closely related in connection with Motorway M2 ,M3 and M4 in terms of direct linkage, trade route, time saving as well as socio economic activities of the local community and surrounding areas.

The Faisalabad-Sargodha Road is very important Inter District and Inter Provincial Highway Link of almost 90 km in length running between the Punjab cities of Faisalabad, Chiniot and Sargodha. Faisalabad-Sargodha Road connecting two important and major cities of Punjab, as the name implies. It is very busy route. A portion of this road between Faisalabad and Chiniot is in poor condition. The road surface is rough resulting in severe impediment in the smooth flow of traffic.

The alignment from Faisalabad-Chiniot to Sargodha onward passes through plain terrain. At some locations thickly populated small towns and green fields on both sides. In between these two Major cities one major city is Chiniot. Following villages and populated areas are also come into the alignment e.g., Chak 4 JB, Chak 2 JB, Bhutto Colony, Muslim Colony, Chenab Nagar, Dar-ul-Sadr, Ahmad Nagar, Lalian, Qasaeyan Wala and Chak 46 etc. The ground elevation of the Subject road ranges from EL. 187 m at the Faisalabad city to EL. 189m at the Sargodha city. The levels will be confirmed in detail topographic survey. One Major crossing of River Chenab, where the alignment is already dualized. One main Canals (Jhang Branch), one main saim Nullah, along with few distributaries are also crosses the road.

Communication and works Department, Government of Punjab, has hired the National Engineering Services Pakistan (NESPAK) (Pvt.) Ltd as the Project Consultants through open competition for Transaction advisory services for preparing project Feasibility Study report and Detailed Design.

NESPAK conducted Traffic Study, Hydrological Study, EIA, Conceptual and preliminary design, Cost Estimate and Economic Analysis as part of the Feasibility Study. Frequent site visits with experts including road, traffic engineers and material specialist was also carried out. The current traffic pattern of present commuters has been considered as criteria to decide about the Dualization of the existing single road. Accordingly, the most feasible alignment including upgrading of has been finalized keeping in view the topography, existing site conditions and local connectivity. A traffic study is an elaborate investigation and meticulous analysis of the transportation system in a specific area,

which is supported by an expansive collection of data. Usually, traffic studies are used to determine the required level of transportation facility in terms of Level of Service and geometric features.

A cost estimate is necessary to give the stakeholders a reasonably accurate idea of the project cost to help them decide whether the work can be undertaken as proposed or needs to be curtailed or abandoned, depending upon the availability of funds and prospective direct and indirect benefits. The cost estimation is carried out based on MRS 2020 (District Chiniot, Punjab). The project cost is estimated to be Rs. 11,678 Million.

1. INTRODUCTION

1.1 GEOGRAPHY

Faisalabad District, having a total area of 5856 Km is situated between longitude 73° and 74° East, Latitude 30° and 31.5° North and at an elevation of 610 feet above mean sea level. It is bound by Hafizabad, Jhang and Toba Tek Singh districts towards North and North West. Sheikhpura, Okara and Sahiwal lie in its East and South East. The district is not separated by any natural boundaries from the adjoining districts. It comprises of six tehsils namely; Faisalabad City, Faisalabad Saddar, Samundri, Jaranwala, Tandiwala, and Chak Jhumra.

River Chenab flows about 30 Km in the North West while River Ravi meanders about 40 Km off the city in the South East, across which lies Okara. Lower Chenab canal is the key source of water for agriculture purpose and caters about 80% of the total requirements of the cultivated land.

Sargodha is the 11th largest city in Pakistan with a population of 1.5 million. It is also an administrative centre of Sargodha Division located in the Punjab province, Pakistan and one of the fastest growing cities in Pakistan. Sargodha is located 172 kilometres northwest of Lahore, in Sargodha District. It lies about 30 miles from the M-2 motorway, which connects Lahore and Islamabad. It is connected to the M-2 by several interchanges at different locations. Sargodha is roughly 94 km from Faisalabad, due southeast. Directly east connected by the M-2 motorway are Lahore and the route to Rawalpindi and Islamabad. Due east is the city of Jhang; toward the west are the city of Mianwali and the Chashma Barrage. Dera Ismail Khan is located 232 km southwest from the city.

1.2 PROJECT DESCRIPTION

For progress and development of any country, National highways and road infrastructure plays an important role in progress of that country by providing efficient mobility of people and goods. Especially when major portion of the freight transport is through roads. Roads connects the country's various parts and ensure efficient transport communications between different locations. Better transportation leads not only to the development of a country but also helps in boosting countries economy. In short, better the transportation system, the more prosperous would be the country.

Communication and works Department (C&W) Punjab, entrusted National Engineering Services Pakistan (NESPAK) Pvt. Ltd as the project consultants for preparing Feasibility Study and Design for Dualization of existing Faisalabad – Chiniot Sargodha road. As part of the preliminary implementation of this project, NESPAK has carried out a Feasibility Study of the proposed road. This report details, the method and findings of

the feasibility study. Location map of project is attached as figure.1-a.

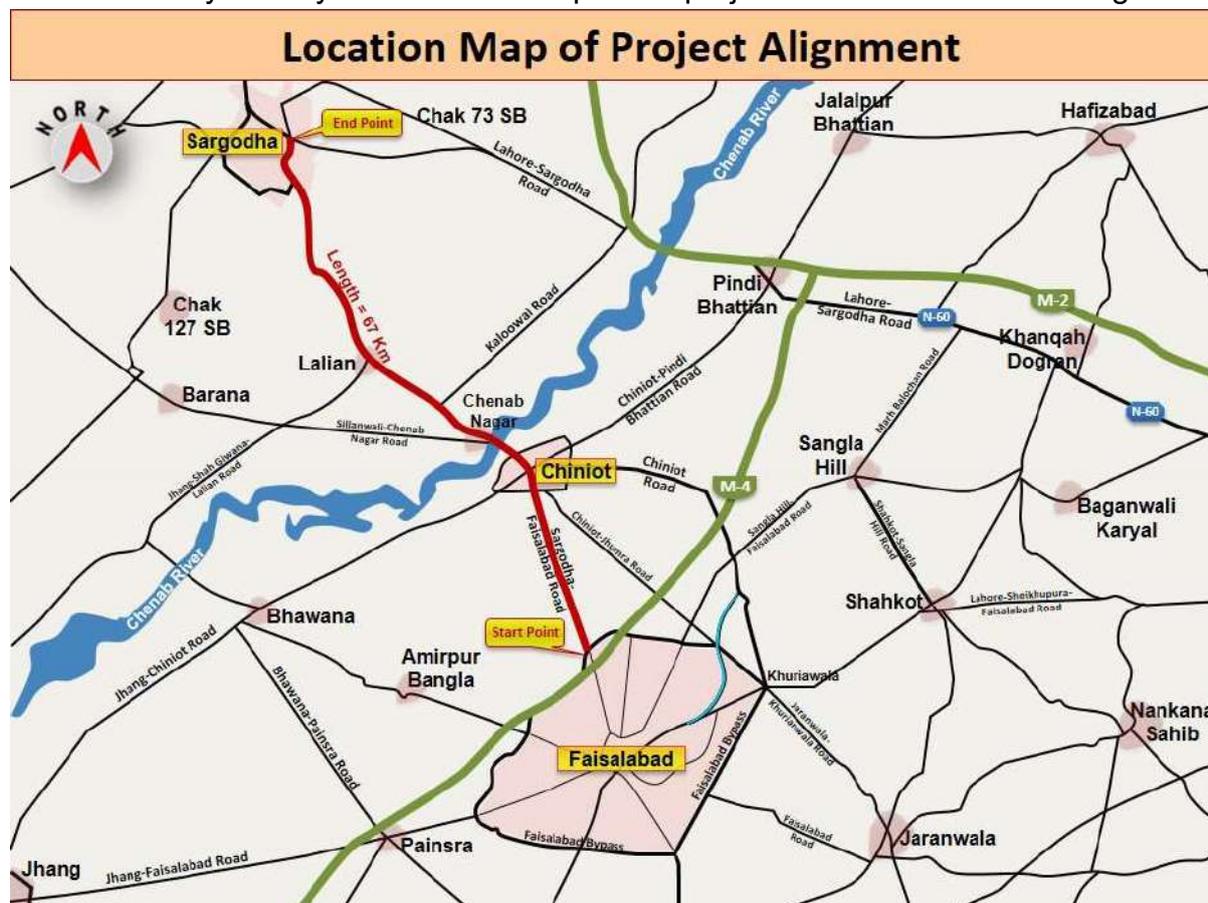


Figure. 1a LOCATION MAP OF PROJECT AREA

1.3 AIMS OF ASSESSMENT

The overall objective of the assessment is to carry out a feasibility study of the proposed dual carriageway in terms of economic and technical evaluation and to come up with feasible recommendations about the project.

The assessment requires following studies for all options:

- i. Traffic Study
- ii. Topographic Survey
- iii. Geometric Design
- iv. Soil Investigation
- v. Hydrologic and Hydraulic Study
- vi. Pavement Design

- vii. Structural Design
- viii. Cost Estimation
- ix. Economic Analysis

2. PRELIMINARY CONSIDERATION

2.1. PROJECT BACKGROUND

In Punjab, keeping in view the trade routes flowing in the province, Government of Punjab has formulated a program to upgrade and improve the Highway network in province that forms the part of road network to international standards. As per the vision of the Punjab Government, the Communication and Works Department selected 08 Major Roads for PPP Modality. The government of the Punjab is striving to meet its development objective focusing to engage Private Parties for financing, planning, designing, execution and operation of the projects for sustainable development in the Province.

As far as the importance of this corridor is concerned, Government of Punjab has initiated dualization of Faisalabad - Chiniot - Sargodha Road (66.6 km) on PPP Mode. This project is among one of those 08 major road projects. Due to presence of Industrial zones and stone crushing industry in Sargodha, high traffic flow rate between Faisalabad and Chiniot Industrial zones and Sargodha city derives the concept of extension of Dualized Faisalabad Chiniot Road upto Sargodha.

The Faisalabad - Chiniot - Sargodha Section, after dualization with improved facilities shall provide an efficient / intelligent transport corridor. Main objective of this road is to provide a safe, congestion free and high speed facility to the commuters of project area and heavy traffic travelling from Faisalabad to Sargodha.

Similar benefits associated with the proposed project include:

- Smooth flow of traffic.
- Saving of Vehicle Travel Time and Vehicle Operating Costs of commuters.
- Reduction of traffic accidents and casualties.
- It will also contribute to ensure efficient movement of trade, goods and traffic in relatively shorter time.
- Economic growth leading to provision of additional employment opportunities for the local residents.
- Quicker transports of products including perishable goods to final destination.

Currently this road is incapable to cope with the existing as well as future traffic volume and does not have safe and smooth riding quality. Therefore, after its completion, the availability of better road network from/towards different residential units as well as Faisalabad, Chiniot and Sargodha city, will further facilitate rapid access of goods and services besides improving the commercial activity of the area.

2.2. ALIGNMENT STUDY

NESPAK Team of Technical and Design experts conducted a field visit to Faisalabad - Chiniot - Sargodha Road (Project corridor) in July 2020. After that, meetings were held with C&W Punjab Officials time to time for finalization of selected alignment along with further necessary tasks. Based on ground conditions and series of meetings with Client, road alignment have been finalized for Dualization which was submitted and approved by the Client respectively. Road approved alignment is marked as figure. 2-a.



FIGURE. 2a

2.2.1. Dualization of Faisalabad - Chiniot - Sargodha Road Alignment (L=66.6km)

The Faisalabad-Sargodha Road is very important Inter District and Inter Provincial Highway Link of almost 67 km in length running between the Punjab cities of Faisalabad, Chiniot and Sargodha. Faisalabad-Sargodha Road connecting two important and major cities of Punjab, as the name implies. It is very busy route. A portion of this road between Faisalabad and Chiniot is in poor condition. The road surface is rough resulting in severe impediment in the smooth flow of traffic.

The alignment from Faisalabad-Chiniot to Sargodha onward passes through plain terrain. At some locations thickly populated small towns and green fields on both sides. In between these two Major cities one major city is Chiniot. Following villages and populated areas are also come into the alignment e.g., Chak 4 JB, Chak 2 JB, Bhutto

Colony, Muslim Colony, Chenab Nagar, Dar-ul-Sadr, Ahmad Nagar, Lalian, Qasaeyan Wala and Chak 46 etc. The ground elevation of the Subject road ranges from EL. 188 m at the Faisalabad city to EL. 186.5m at the Sargodha city. One Major crossing of River Chenab, where the alignment is already dualized. One main Canals (Jhang Branch), one main saim Nullah, along with few distributaries are also crosses the road.

The alignment off takes from Faisalabad city at Faisalabad bypass Chowk near Bharia Town and proceeds towards Chiniot City and ends at Sargodha. The first 19.1km is single carriageway road with metalled width of 7.3m. There is a no median for this section. Two-way traffic is operating. At km -19+100 this alignment has three (03) options to pass on Chiniot city. First option is to pass through city. The distance cover for this stretch is 4.8km 4 lane dual carriageway. The other two options available to pass on city are eastern and western bypass having length 16.0km and 9.2km respectively. Both bypasses have two lane single carriageway with poor geometry. Selection of the route in this area is finalized after discussion with Client. The final alignments of this section is passing through western side having length 9.2km. The alignment further proceeds towards River Chenab crossing. This road section is already dualized in a length of 4.8km. The alignment further proceeds passing through populated area of Chenab Nagar, Dar-ul-Sadr and Ahmad Nagar. The next 8.0km road passes through the area where fields on either side. The alignment reaches Lalian town another populated area. Travelling further the alignment take right turn and passes through Qasaeyan Wala and Chak 46. Few distributaries and saim Nullahs are also crossing the road, exact chainage will be mentioned in detailed plan. The alignment terminates at Sargodha Bypass. The end point is finalized after discussion with Client. Alignment plan is shown as figure. 2b to 2f.

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)

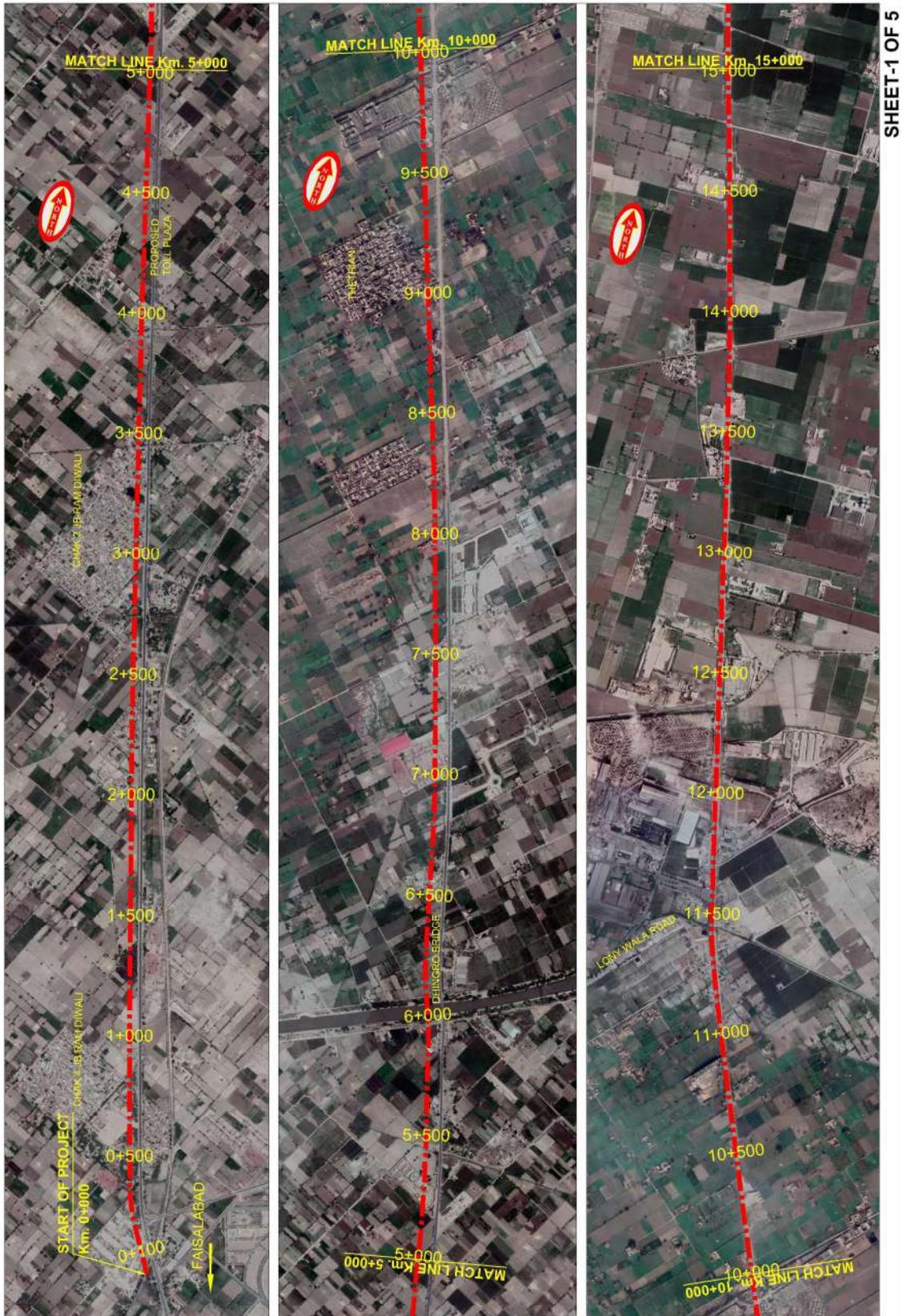


FIGURE 2-b

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)



FIGURE 2-c

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)

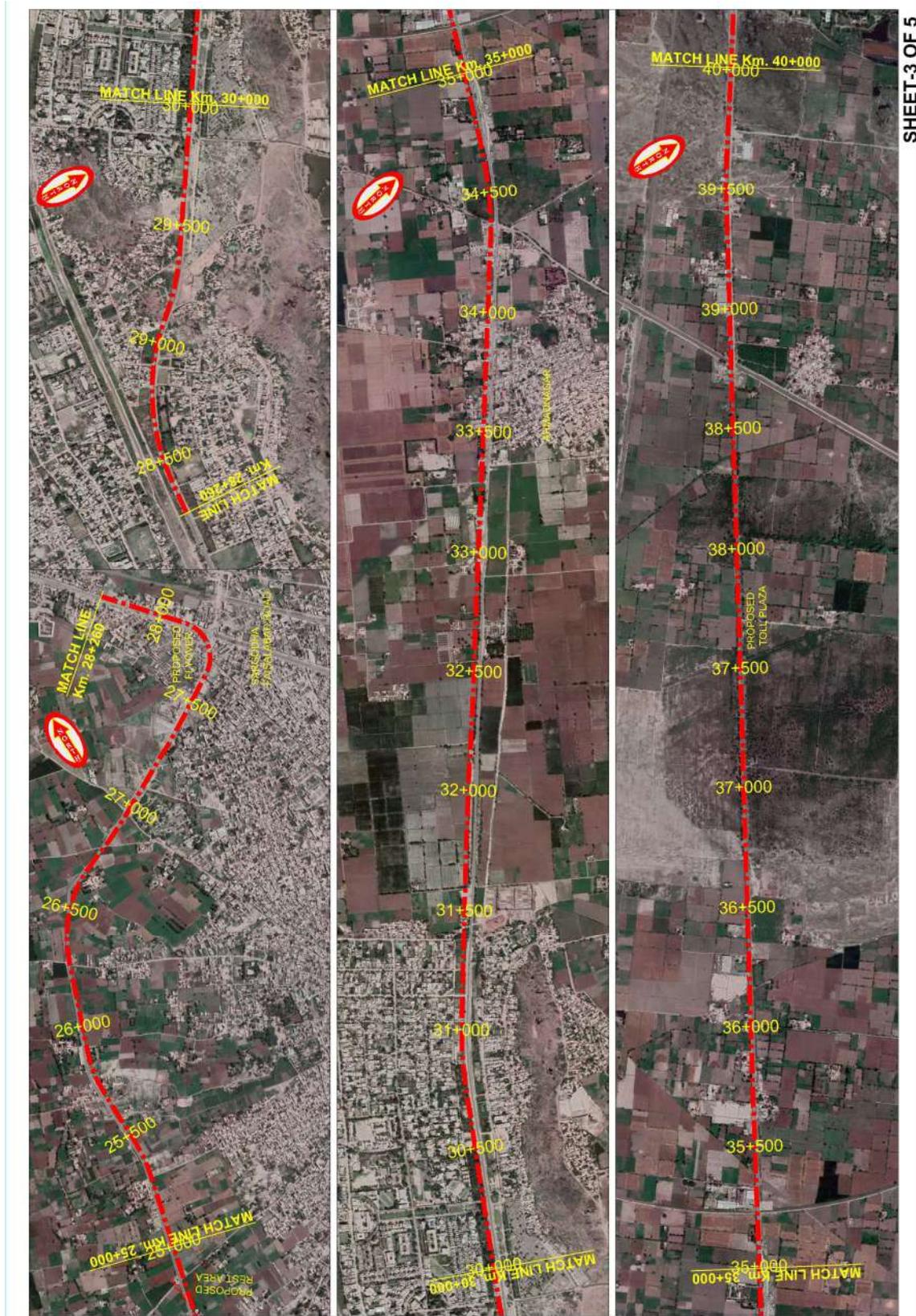


FIGURE 2-d

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)

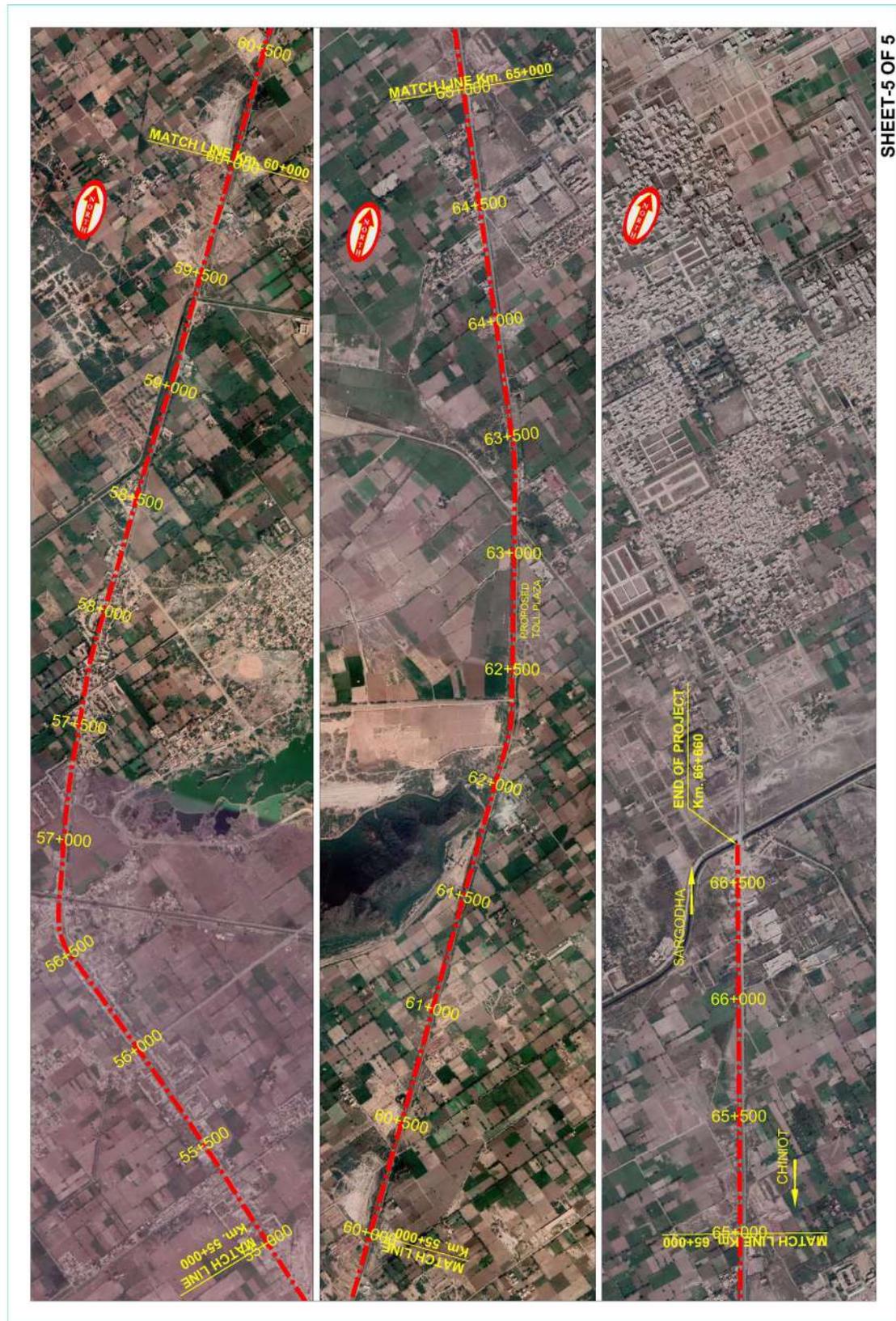


FIGURE 2-e

The pictorial view of alignment is shown as under.

2.2.2. Pictures showing the terrain and existing road are captioned below:



START POINT OF PROJECT JUST AFTER FAISALABAD BYPASS CHOWK



FAISALABAD – CHINIOT-SARGODHA ROAD NEAR KM 2+500



TYPE OF TRAFFIC LOADING ON ROAD



**EXISTING 2- LANE CANAL CROSSING BRIDGE (JHANG BRANCH)
KM 6+000 (APROX.)**



DRAINAGE CONDITION ON ROAD



ROAD CONDITION AT KM 7+100



START OF CHINIOT WESTERN BYPASS KM 19+100



EXISTING CHINIOT WESTERN BYPASS KM 23+000

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)



START OF CHENAB NAGAR - SARGODHA SECTION KM 28+300

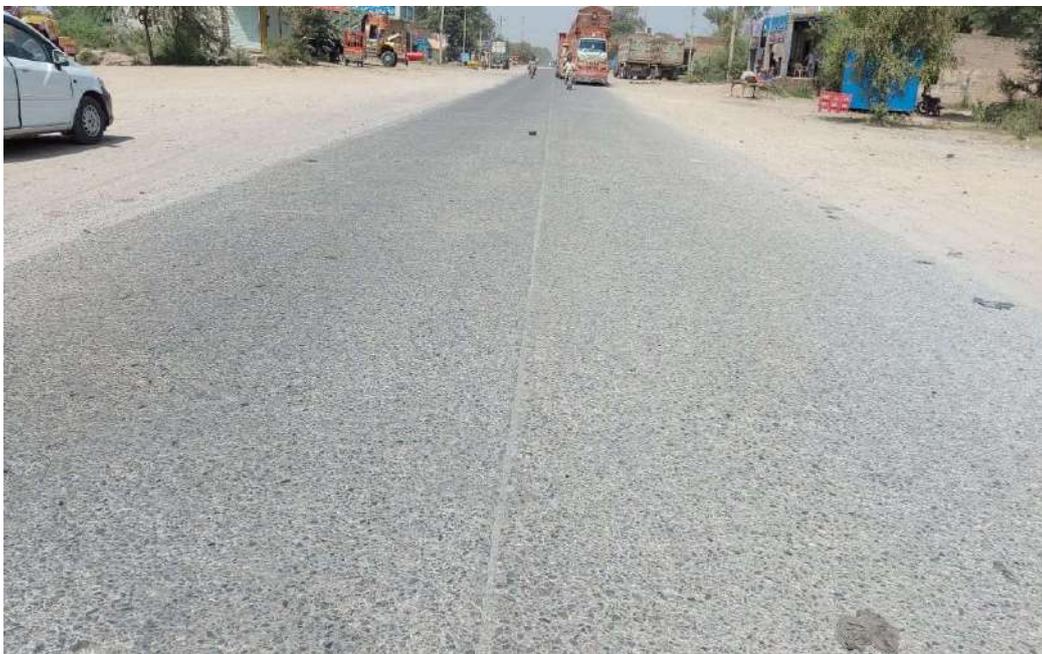


EXISTING DUALIZED BRIDGE ON RIVER CHENAB

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)



EXISTING ROAD AT KM 38+800



EXISTING ROAD AT KM 44+800 (AFTER LALIAN)

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)



BUILT-UP AREA AT KM 49+500 (CHAK - 46)



BUILT-UP AREA NEAR PULL 111 AT KM 55+000



EXISTING ROAD NEAR END POINT (SARGODHA)

2.3. SIGNIFICANCE OF THE PROJECT:

The Dualization of the existing road will result in facilitating the local commuters as well as commercial traffic in the vicinity. After its completion, there will be rapid access to the destinations. Resultantly, due to rapid access, their travel time and running cost will be reduced. Conclusively, there would be improvement of economic condition of the region through commercial activity which will also facilitate the traffic of the proximity areas.

The construction of the proposed road will surely save the travel time and vehicle operating costs with increased level of ease and comfort for the commuters.

2.4. PROJECT OBJECTIVES:

The Faisalabad - Chiniot - Sargodha Section of 67km, after Dualization with improved facilities shall provide an efficient / intelligent transport corridor. Main objective of this road is to provide a safe, congestion free and high speed facility to the commuters of project area and heavy traffic travelling from Faisalabad to Sargodha.

The corridor will largely contribute to the economic and social development of the region as well as monetary benefits to Provincial Government through tolling. The Project will bring more population into the stream of benefits, which in turn will improve the social complexion of people around this corridor.

Apart from the usual benefits of saving in time this link will transform the entire pattern of transportation in the surrounding areas resulting in uplift of economic condition of local community.

This link will bring about further revolution in road transport and time saving journey for passengers. It will also contribute to ensure smooth and efficient movement of trade, goods and traffic in relatively shorter time.

1.1

2.5. BENEFITS OF THE PROJECT:

Expected benefits associated with the proposed project include:

- Smooth flow of traffic.
- It will also ease out the traffic of the adjacent villages/areas
- Saving of Vehicle Travel Time and Vehicle Operating Costs of commuters.
- Reduction of traffic accidents and casualties.
- It will also contribute to ensure efficient movement of trade and traffic in relatively shorter time. Quicker transports of perishable goods to final destination.
- Economic growth through providing employment opportunities for the local residents.
- Massive impact of the project on Land use will surely help in the progress of area and local people.
- The availability of dual carriageway and road network will further facilitate rapid access of goods and services through heavy duty vehicles.

2.6. METHODOLOGY

This section provides a description of how the Feasibility study was carried out by the NESPAK Team deployed for the assignment. Site visits, Data collected from site and various departments as well as desk study are the main input for finalization of report.

Following are the studies taken place for this assignment which are detailed below:-

- i. Topographic Survey report
- ii. Geometric Design report
- iii. Traffic Study Report

- iv. Pavement Design report
- v. Soil Investigation report
- vi. Hydrologic and Hydraulic Study
- vii. Structural Design report
- viii. Cost Estimation
- ix. Economic Analysis report

3. TECHNICAL FEASIBILITY REPORTS

This section provides a detailed description of how the Feasibility study was carried out by the NESPAK Team deployed for the assignment. Site visits, data collection from site and various civil departments as well as indoor desk study are the main input for finalization of report.

Following reports have been prepared based on the studies conducted for this assignment.

- I. Topographic Survey report
- II. Geometric Design report
- III. Traffic Study Report
- IV. Pavement Design report
- V. Hydrologic and Hydraulic Study
- VI. Structural Design report
- VII. Cost Estimation
- VIII. Soil Investigation report has been attached as separate report
Annexure-1

3.1. TOPOGRAPHIC SURVEY REPORT

3.1.1 METHODOLOGY

3.1.1.1. General

Accurate topographical studies are basic requirement for detailed design and construction of any highway project. NESPAK has in-house capability to complete this task. Accordingly, detailed topographic survey for Dualization of Faisalabad-Chiniot Sargodha Road Project was carried out using state of the art techniques and latest instruments.

Location map of subject project is given as Annexure-2.

3.1.1.2. Scope of work

Scope of survey and mapping tasks was as follows:

- Fixing / Erection of permanent control point
- Observation of Horizontal and Vertical control in the project area using high accuracy Triple Frequency Differential GPS (Trimble R10) in static mode.
- Detailed topographic survey of new proposed alignment including Interchanges by recording field details / features (natural / man-made) with Electronic equipment i.e. Total station, Differential GPS in RTK mode and spot leveling for generation of contours.
- Preparation of topographic survey plans on 1:1000 scales. The mapping is in computer-aided format suitable for computer-aided planning and design of the project structures.

3.1.1.3. Equipment Used for the Project

- Trimble GNSS R-10 (1 base & 1 rover).
 1. Trimble DGPS Model # R-10, Serial # 5611457120
 2. Trimble DGPS Model # R-10, Serial # 5614459092
- Electronic Total Station
 1. Nikon Electronic Total Station (S/No.E-180483)

3.1.1.4. Reference Benchmark

Horizontal and Vertical survey control was established using real time positioning of Differential GPS receiver in static mode zone 43 UTM System.

3.1.1.5. Establishment of Survey Control Network

Location selection of survey control points

The 114 locations of the survey control points was selected on accuracy, stability and safety criteria. The main objective was to locate the survey control points such that those remain safe and will be available for the detailed topographic survey. The Consultant team selected the most suitable locations of survey control points by using the satellite images and field visits.

Fixation of the survey control points

In order to carry out topographic survey and mapping work with maximum possible accuracy and minimal spatial variations in both horizontal and vertical plans, and keeping in view the terrain, it is time saving and very accurate to establish the control network by using GNSS (Global Navigational Satellite System) .

The latest GNSS survey equipment Trimble R-10 (Global Positioning system) (Fig. 3-1a) instrument was used in Static mode to establish the survey control network in the project area. The data was observed and processed by using the Trimble Business Centre (TBC) software to achieve the corresponding results at desired level. The observations made at any point were processed on computer in the field office in order to check the accuracy of results.

For control points, at least 2 DGPS instruments were used simultaneously, making triangulations for 30 minutes were used simultaneously, making triangulations. To receive the signals from satellite, the receiver should have minimum obstructions like building, trees, power lines etc, around it which was ensured. The signals were received at minimum cut of angle of 15° or more.

If the signal is weak due to unfavorable weather conditions like rainfall, clouds and vehicle noise, the observations were repeated till found satisfactory results. It was

ensured that for all time observations, at least 4 satellites should be available with GDOP/PDOP value of less than 2.

One DGPS unit was kept to act as reference or base station and others as rover. The observed point coordinates serve as reference for further observing points to make a triangle or large polygon.



Figure3-1a: Trimble R10 GNSS System (Receiver and data controller)

3.1.1.6. FIELD DATA PROCESSING

The raw data for baselines was post processed to remove the further errors such as time clock error, atmospheric error (ionosphere and hemispheric error) and air noise to ensure the 3D quality of results in the Software Trimble Business Centre (TBC).

In case any baseline failed or did not fulfil the accuracy criteria it was repeated. As the DGPS reading is based upon the WGS 84 in static mode, the coordinates of the survey control points were converted into the UTM zone 43N by using desktop applications as the area to be surveyed falls in the aforementioned UTM Zone-43.

3.1.1.7. ACCURACY OF THE SURVEY CONTROL POINTS

The survey control points were established by using the DGPS in static mode. The designed accuracy in static and rapid static is given as:

Static (phase) with long	Horizontal: 3 mm + 0.1 ppm (rms)
Observations	Vertical: 3.5 mm + 0.4 ppm (rms)
Rapid static (phase)	Horizontal: 5 mm + 0.5 ppm (rms)
Static mode after initialization	vertical: 10 mm + 0.5 ppm (rms)

3.1.1.8. UNITS OF MEASUREMENT

The angular units of the measurement were the degrees, minutes and seconds, and linear units were in meters.

3.1.1.9. TOPOGRAPHIC SURVEY DATA ACQUISITION

Electronic total station and DGPS in RTK mode was used for detailed topographic survey. All the data was recorded electronically and downloaded in computer for further analysis and processing.

Bulk of the topographic field survey data was acquired using electronic total stations and data recorder on digital format having x, y, z coordinates with reference to the control stations established earlier. All manmade features (Buildings, agriculture lands, roads, tracks, electric poles, telephone poles, channels etc.) and natural features (nullah, rivers etc) were picked during detailed topographic survey. The field topographic survey data acquired in sufficient detail (number of spot levels) to fully depict the manmade and natural physical features plus be able to generate contours at the desired interval. The data was downloaded to the computer at site for further processing.

The data was computer processed to create DTM and computer aided mapping carried out at the desired scale. Contours were generated at 1-meter contour interval from the DTM. The mapping was verified in field and topographic maps were finalized.

ANNEXURE-2

LOCATION PLAN OF TOPOGRAPHIC SURVEY AREA

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)

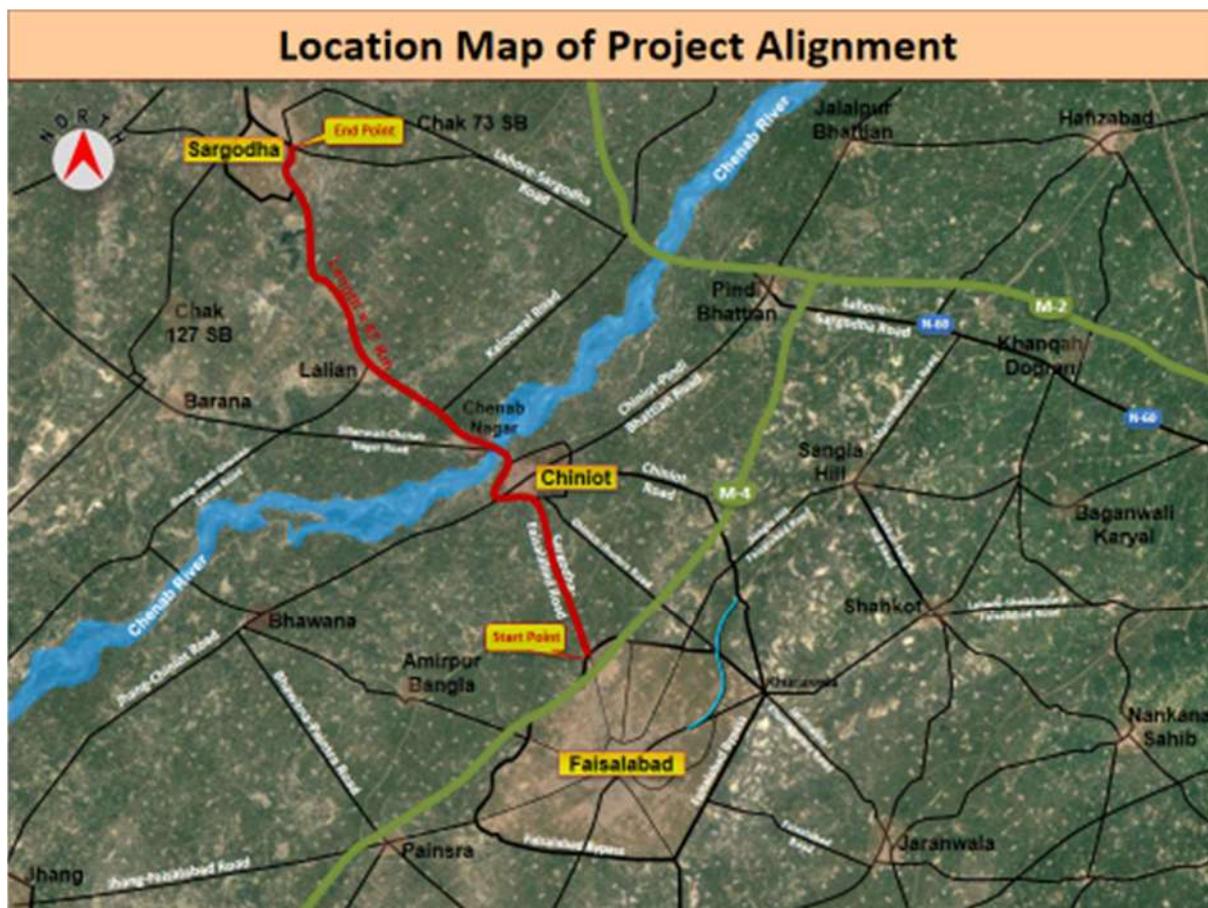


FIGURE. 3.1b LOCATION PLAN OF SURVEY AREA

LIST OF CONTROL POINTS

FAISALABAD-CHINIOT SARGODHA ROAD

LIST OF CONTROL POINTS

Sr. #	POINT	EASTING(m)	NORTHING(m)	ELEVATION(m)
1	FS1	315938.117	3490498.266	187.887
2	FS2	315829.993	3490686.404	188.179
3	FS3	315729.354	3490949.039	187.822
4	FS4	315672.357	3491168.092	187.664
5	FS5	315525.752	3491644.185	187.584
6	FS6	315432.378	3491931.974	187.795
7	FS7	315299.279	3492377.797	188.121
8	FS8	315184.927	3492798.713	188.116
9	FS9	315036.504	3493312.721	188.362
10	FS10	314930.053	3493689.697	188.507
11	FS14	314534.697	3495123.128	188.315
12	FS15	314444.871	3495450.189	188.508
13	FS16	314317.969	3495807.952	188.604
14	FS17	314170.240	3496226.408	190.808
15	FS20	313764.441	3497374.174	187.723
16	FS22	313436.490	3498233.019	188.419
17	FS23	313199.333	3498810.105	188.516
18	FS24	313010.264	3499286.168	188.797
19	FS25	312831.340	3499691.326	189.072
20	FS26	312626.896	3500222.087	189.458
21	FS27	312478.655	3500578.812	189.211
22	FS31	312004.524	3502077.595	180.658
23	FS32	311946.635	3502418.179	180.814
24	FS33	311851.993	3502829.313	180.804
25	FS35	311657.708	3503614.336	182.343
26	FS36	311543.488	3504036.636	180.965
27	FS37	311414.277	3504510.043	181.122
28	FS38	311314.409	3504891.506	181.344
29	FS39	311171.647	3505382.674	181.857
30	FS40	311078.210	3505780.446	181.840
31	FS44	310665.939	3507054.426	181.749
32	FS45	310537.232	3507444.152	182.105
33	FS49	310130.553	3508763.837	182.863

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)

34	FS50	309841.476	3508788.757	182.580
35	FS53	308696.170	3508824.085	182.243
36	FS54	308295.213	3508806.012	182.470
37	FS58	306821.749	3508790.612	181.330
38	FS59	306358.375	3508821.092	183.317
39	FS62	305453.417	3509155.652	181.420
40	FS65	306356.460	3509848.737	181.780
41	FS66	306444.264	3510270.092	182.227
42	FS67	306551.363	3510702.345	182.675
43	FS70	306872.922	3512180.821	182.777
44	FS73	307778.179	3512785.023	184.214
45	FS74	308007.831	3512928.949	184.221
46	FS75	308118.716	3513039.538	184.539
47	CS1	303868.104	3514980.208	183.656
48	CS2	303593.659	3515100.055	184.524
49	CS6	302687.380	3515824.620	187.101
50	CS8	301913.943	3516379.874	186.636
51	CS7	302316.308	3516084.369	187.376
52	CS9	301524.992	3516772.775	183.284
53	CS10	301149.649	3517172.259	183.151
54	CS11	300834.600	3517483.449	181.157
55	CS12	300498.172	3517832.123	181.013
56	CS13	300108.317	3518231.299	181.225
57	CS17	298794.598	3519305.528	182.595
58	CS19	297948.033	3519807.929	181.342
59	CS20	297547.858	3520057.524	180.925
60	CS21	297209.830	3520259.315	181.099
61	CS23	296373.066	3520760.323	182.031
62	CS24	295754.826	3521122.481	183.055
63	CS27	294274.505	3522089.423	180.595
64	CS28	293993.448	3522284.185	181.796
65	CS30	293119.776	3522893.586	181.476
66	CS31	292724.823	3523211.283	181.514
67	CS36	291434.479	3524288.404	181.740
68	CS39	290939.978	3525516.633	187.583
69	CS38	291055.794	3525222.060	187.133
70	CS37	291251.410	3524718.859	183.079
71	CS40	290801.942	3525889.305	187.739
72	CS41	290629.916	3526308.802	187.874

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)

73	CS42	290534.386	3526550.061	187.861
74	CS43	290418.222	3526865.509	187.825
75	CS44	290296.298	3527124.720	187.417
76	CS45	290189.299	3527443.589	186.788
77	CS46	290079.149	3527791.054	188.073
78	CS47	289904.345	3528350.975	187.168
79	CS50	289572.500	3529441.765	187.329
80	CS51	289457.222	3529801.573	187.209
81	CS53	289273.179	3530437.511	187.700
82	CS54	289129.827	3530714.483	187.716
83	CS54	289129.827	3530714.483	187.716
84	CS55	288879.678	3531053.766	187.862
85	CS56	288549.832	3531492.268	188.134
86	CS57	288268.937	3531885.038	188.435
87	CS58	288056.472	3532181.315	188.988
88	CS59	287880.656	3532445.889	189.084
89	CS62	287134.680	3533525.080	190.305
90	CS64	286657.389	3533962.805	189.631
91	CS65	286424.315	3534185.087	189.528
92	CS67	286018.252	3534536.481	189.135
93	CS68	285770.837	3534733.833	190.185
94	CS69	285558.874	3534913.479	190.829
95	CS70	285497.457	3535000.893	191.090
96	CS71	285385.313	3535644.097	189.353
97	CS72	285358.987	3535933.125	188.756
98	CS74	285355.468	3536598.611	189.290
99	CS75	285349.642	3536880.789	189.146
100	CS78	285370.648	3538296.745	188.778
101	CS79	285375.503	3538945.385	189.020
102	CS80	285376.062	3539333.818	189.026
103	CS83	285382.571	3540392.512	188.743
104	CS84	285383.227	3540642.718	189.297
105	CS85	285258.519	3541105.075	188.832
106	CS86	285164.513	3541468.503	189.198
107	CS88	284876.406	3542235.862	188.546
108	CS89	284718.812	3542613.039	188.107
109	CS93	284073.841	3544129.343	186.808
110	CS94	283905.664	3544527.019	186.510

**DESCRIPTION SHEETS OF
HORIZONTAL AND VERTICAL CONTROL**

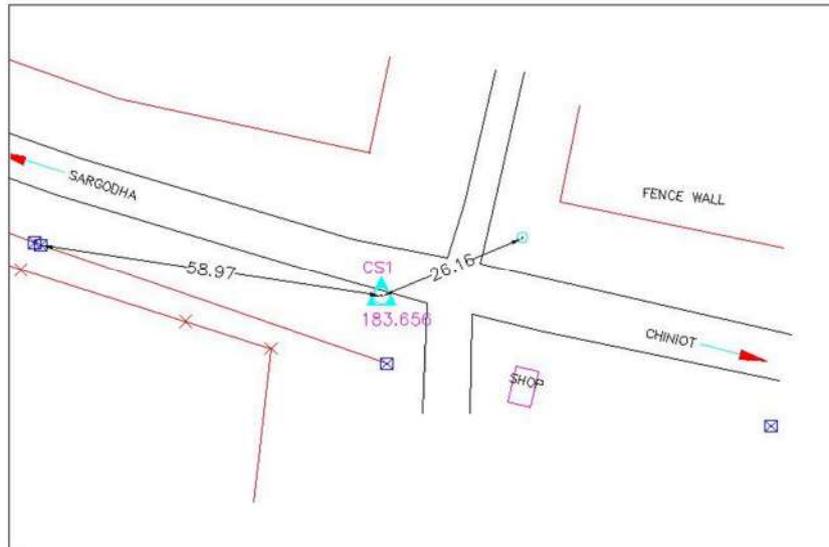
**DUALIZATION OF FAISALABAD-CHINIOT SARGODHA
ROAD PROJECT
CONTROL POINT DATA SHEET**

CONTROL POINT CS1

EASTING 303868.104 m
 NORTHING 3514980.208 m
 ELEVATION 183.656 m

DATE: OCTOBER, 2020
 COORDINATE SYSTEM XYZ. UTM/WGS84/43N

LOCATION PLAN



SURVEY & MAPPING
 Lahore PAKISTAN

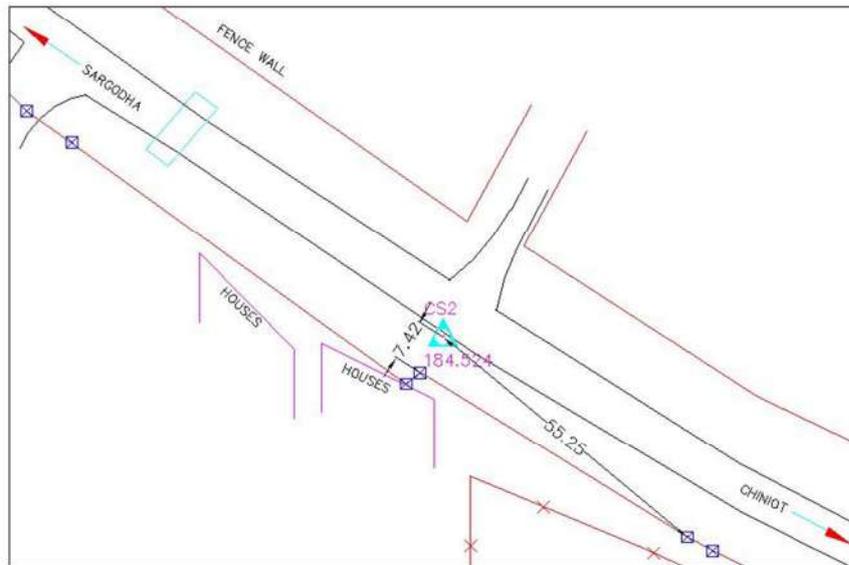
**DUALIZATION OF FAISALABAD-CHINIOT SARGODHA
ROAD PROJECT
CONTROL POINT DATA SHEET**

CONTROL POINT CS2

EASTING 303593.659 m
 NORTHING 3515100.055 m
 ELEVATION 184.524 m

DATE: OCTOBER, 2020
 COORDINATE SYSTEM XYZ. UTM/WGS84/43N

LOCATION PLAN



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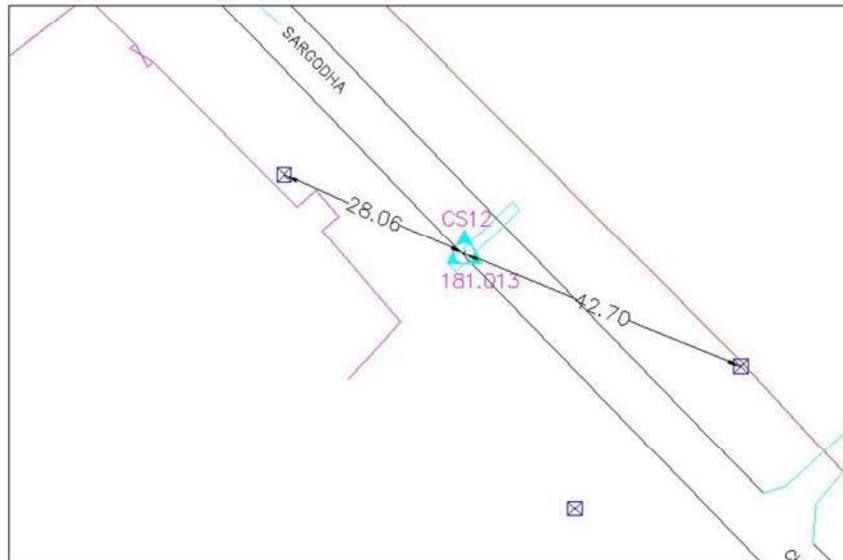
**DUALIZATION OF FAISALABAD-CHINIOT SARGODHA
ROAD PROJECT
CONTROL POINT DATA SHEET**

CONTROL POINT CS12

EASTING 300498.172 m
 NORTHING 3517832.123 m
 ELEVATION 181.013 m

DATE: OCTOBER, 2020
 COORDINATE SYSTEM XYZ. UTM/WGS84/43N

LOCATION PLAN



SURVEY & MAPPING
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**DUALIZATION OF FAISALABAD–CHINIOT SARGODHA
ROAD PROJECT
CONTROL POINT DATA SHEET**

CONTROL POINT CS13

EASTING 300108.317 _m
 NORTHING 3518231.299 _m
 ELEVATION 181.225 _m

DATE: OCTOBER, 2020
 COORDINATE SYSTEM XYZ. UTM/WGS84/43N

LOCATION PLAN



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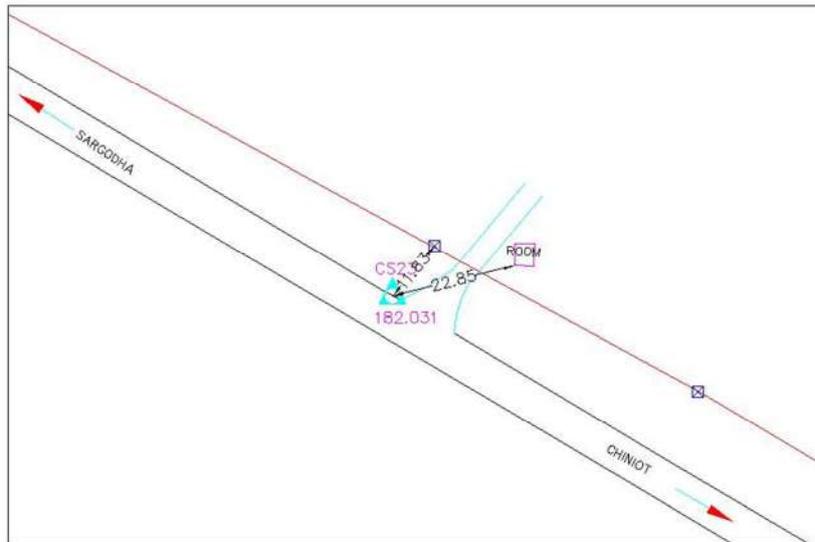
**DUALIZATION OF FAISALABAD-CHINIOT SARGODHA
ROAD PROJECT
CONTROL POINT DATA SHEET**

CONTROL POINT CS23

EASTING 296373.066 m
 NORTHING 3520760.323 m
 ELEVATION 182.031 m

DATE: OCTOBER, 2020
 COORDINATE SYSTEM XYZ. UTM/WGS84/43N

LOCATION PLAN



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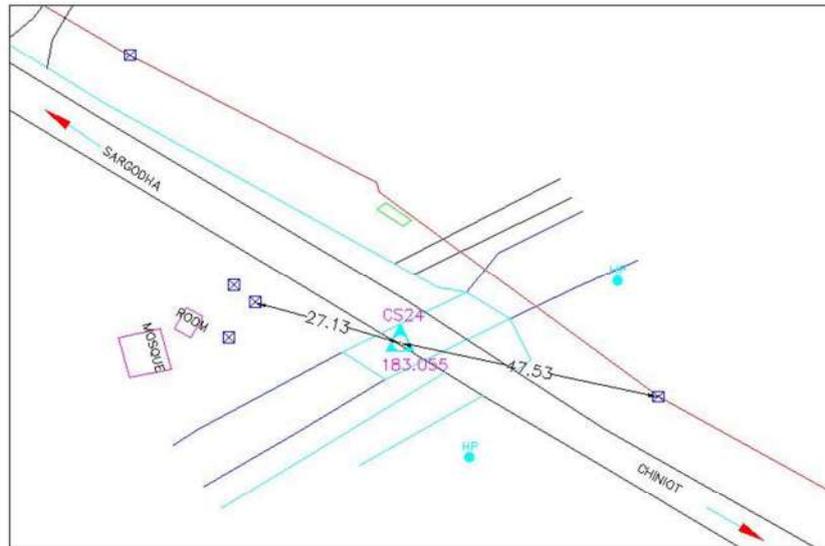
**DUALIZATION OF FAISALABAD–CHINIOT SARGODHA
ROAD PROJECT
CONTROL POINT DATA SHEET**

CONTROL POINT CS24

EASTING 295754.826_m
 NORTHING 3521122.481_m
 ELEVATION 183.055_m

DATE: OCTOBER, 2020
 COORDINATE SYSTEM XYZ. UTM/WGS84/43N

LOCATION PLAN



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**DUALIZATION OF FAISALABAD–CHINIOT SARGODHA
ROAD PROJECT
CONTROL POINT DATA SHEET**

CONTROL POINT CS36

EASTING 291434.479_m
 NORTHING 3524288.404_m
 ELEVATION 181.74_m

DATE: OCTOBER, 2020
 COORDINATE SYSTEM XYZ. UTM/WGS84/43N

LOCATION PLAN



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**DUALIZATION OF FAISALABAD–CHINIOT SARGODHA
ROAD PROJECT
CONTROL POINT DATA SHEET**

CONTROL POINT CS50

EASTING 289572.500_m
 NORTHING 3529441.765_m
 ELEVATION 187.329_m

DATE: OCTOBER, 2020
 COORDINATE SYSTEM XYZ. UTM/WGS84/43N

LOCATION PLAN



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 Lahore PAKISTAN

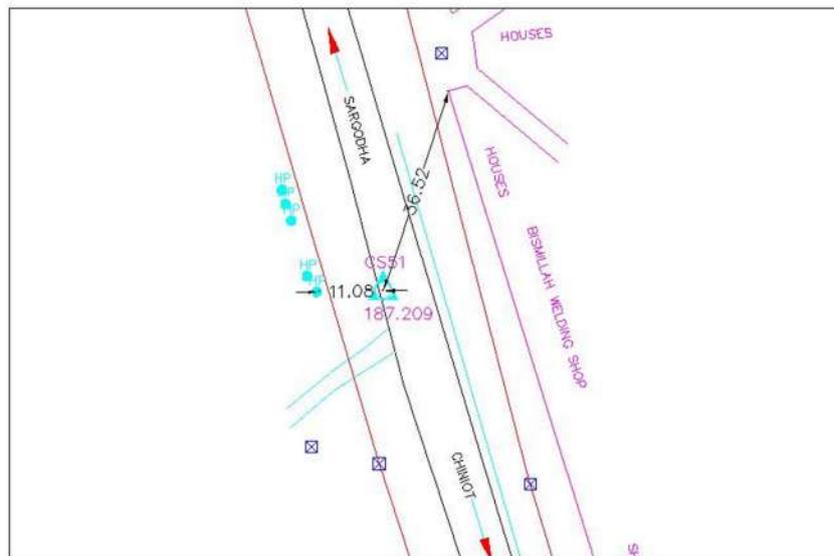
**DUALIZATION OF FAISALABAD–CHINIOT SARGODHA
ROAD PROJECT
CONTROL POINT DATA SHEET**

CONTROL POINT CS51

EASTING 289457.222 m
 NORTHING 3529801.573 m
 ELEVATION 187.209 m

DATE: OCTOBER, 2020
 COORDINATE SYSTEM XYZ. UTM/WGS84/43N

LOCATION PLAN



SURVEY & MAPPING
 Lahore PAKISTAN

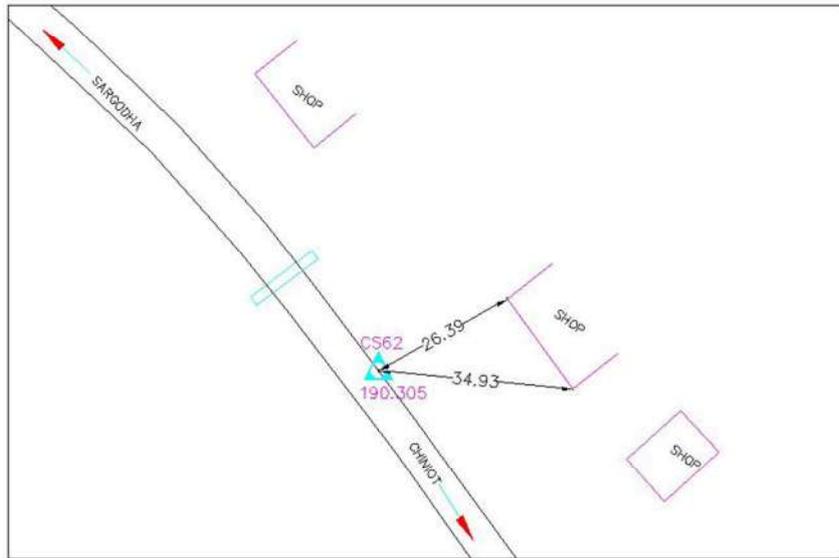
**DUALIZATION OF FAISALABAD-CHINIOT SARGODHA
ROAD PROJECT
CONTROL POINT DATA SHEET**

CONTROL POINT CS62

EASTING 287134.680 m
NORTHING 3533525.080 m
ELEVATION 190.305 m

DATE: OCTOBER, 2020
COORDINATE SYSTEM XYZ. UTM/WGS84/43N

LOCATION PLAN



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**DUALIZATION OF FAISALABAD-CHINIOT SARGODHA
ROAD PROJECT
CONTROL POINT DATA SHEET**

CONTROL POINT CS65

EASTING 286424.315_m
 NORTHING 3534185.087_m
 ELEVATION 189.528_m

DATE: OCTOBER, 2020
 COORDINATE SYSTEM X,Y,Z. UTM/WGS84/43N

LOCATION PLAN



SURVEY & MAPPING
 Lahore PAKISTAN

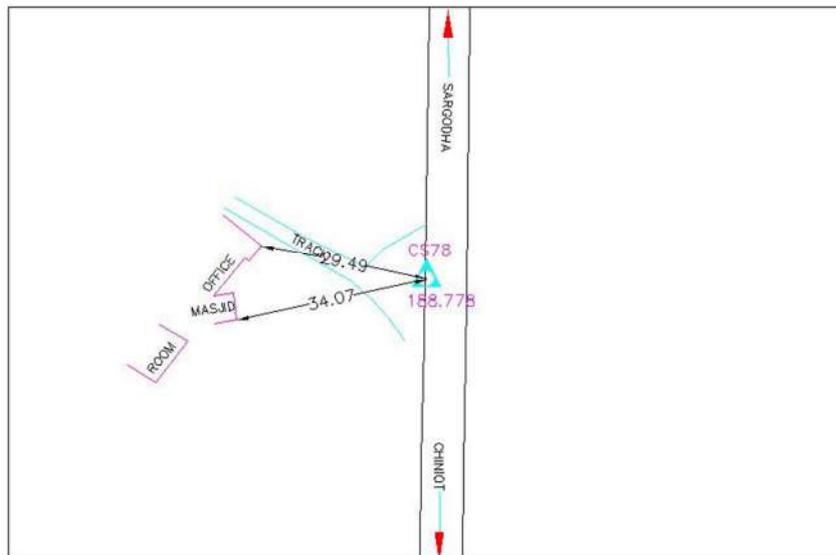
**DUALIZATION OF FAISALABAD–CHINIOT SARGODHA
ROAD PROJECT
CONTROL POINT DATA SHEET**

CONTROL POINT CS78

EASTING 285370.648 m
 NORTHING 3538296.745 m
 ELEVATION 188.778 m

DATE: OCTOBER, 2020
 COORDINATE SYSTEM XYZ. UTM/WGS84/43N

LOCATION PLAN



SURVEY & MAPPING
 Lahore PAKISTAN

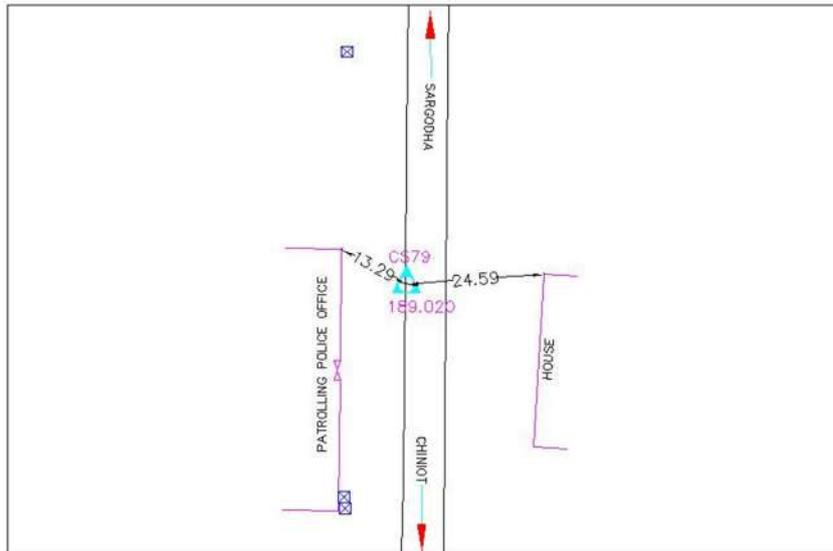
**DUALIZATION OF FAISALABAD-CHINIOT SARGODHA
ROAD PROJECT
CONTROL POINT DATA SHEET**

CONTROL POINT CS79

EASTING 285375.503 m
 NORTHING 3538945.385 m
 ELEVATION 189.020 m

DATE: OCTOBER, 2020
 COORDINATE SYSTEM XYZ. UTM/WGS84/43N

LOCATION PLAN



SURVEY & MAPPING
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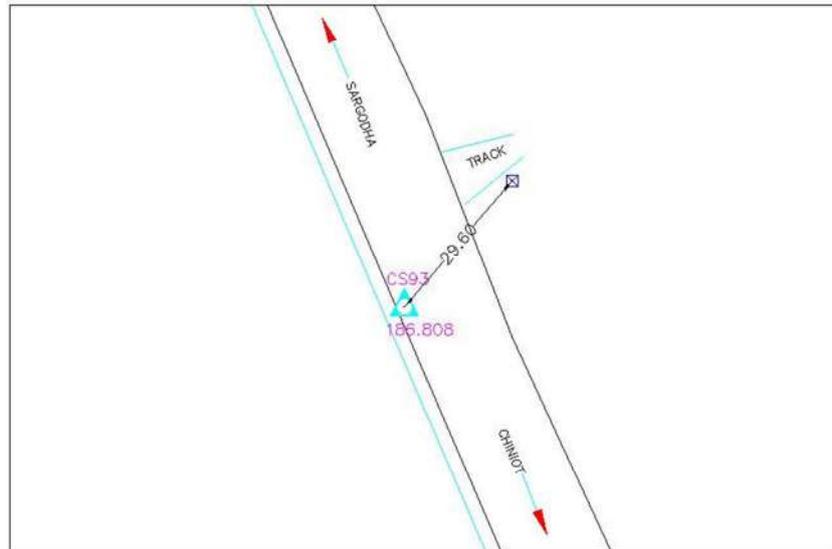
**DUALIZATION OF FAISALABAD-CHINIOT SARGODHA
ROAD PROJECT
CONTROL POINT DATA SHEET**

CONTROL POINT CS93

EASTING 284073.841 m
 NORTHING 3544129.343 m
 ELEVATION 186.808 m

DATE: OCTOBER, 2020
 COORDINATE SYSTEM X,Y,Z. UTM/WGS84/43N

LOCATION PLAN



SURVEY & MAPPING
 Lahore PAKISTAN

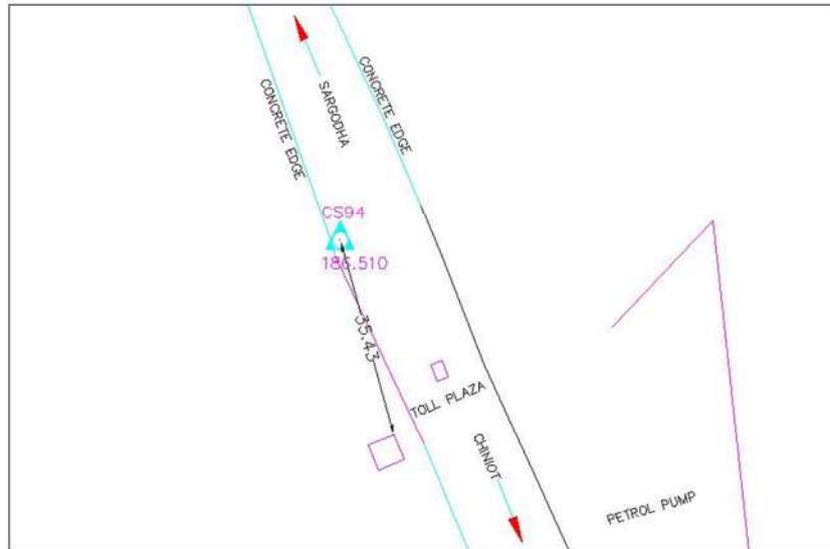
**DUALIZATION OF FAISALABAD-CHINIOT SARGODHA
ROAD PROJECT
CONTROL POINT DATA SHEET**

CONTROL POINT CS94

EASTING 283905.664 m
 NORTHING 3544527.019 m
 ELEVATION 186.510 m

DATE: OCTOBER, 2020
 COORDINATE SYSTEM XYZ. UTM/WGS84/43N

LOCATION PLAN



SURVEY & MAPPING
 Lahore PAKISTAN

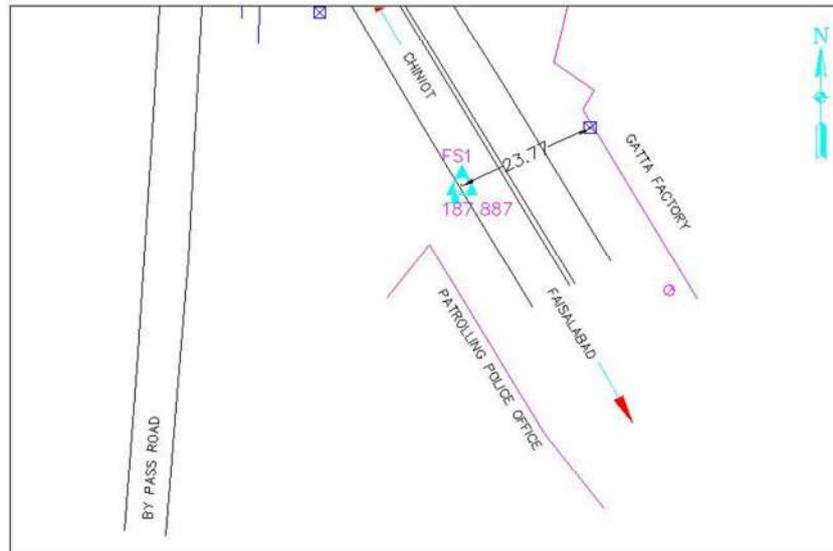
**DUALIZATION OF FAISALABAD-CHINIOT SARGODHA
ROAD PROJECT
CONTROL POINT DATA SHEET**

CONTROL POINT FS1

EASTING 315938.117 m
 NORTHING 3490498.266 m
 ELEVATION 187.887 m

DATE: OCTOBER, 2020
 COORDINATE SYSTEM XYZ. UTM/WGS84/43N

LOCATION PLAN



SURVEY & MAPPING
 Lahore PAKISTAN

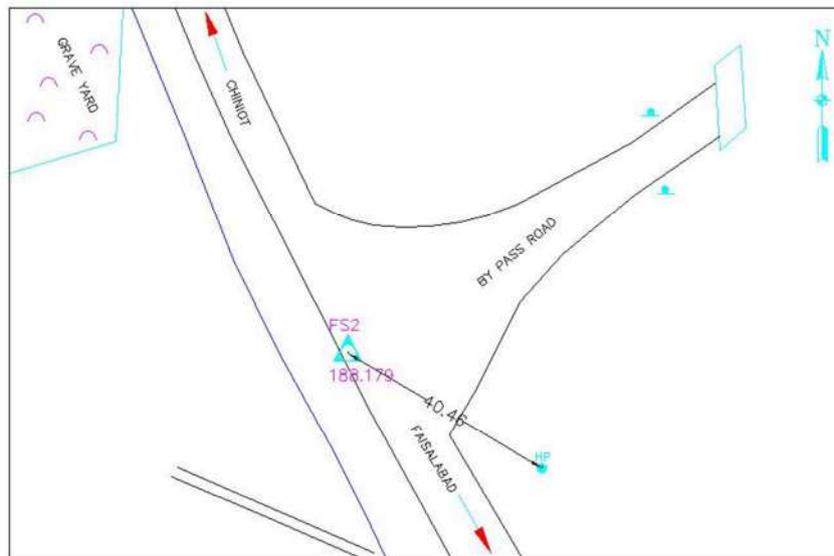
**DUALIZATION OF FAISALABAD-CHINIOT SARGODHA
ROAD PROJECT
CONTROL POINT DATA SHEET**

CONTROL POINT FS2

EASTING 315829.993 m
 NORTHING 3490686.404 m
 ELEVATION 188.179 m

DATE: OCTOBER, 2020
 COORDINATE SYSTEM X,Y,Z. UTM/WGS84/43N

LOCATION PLAN



SURVEY & MAPPING
 Lahore PAKISTAN

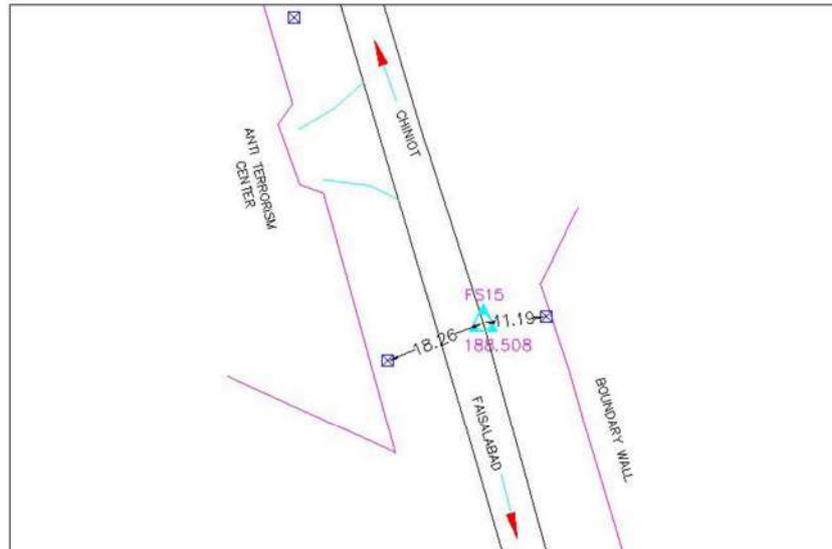
**DUALIZATION OF FAISALABAD–CHINIOT SARGODHA
ROAD PROJECT
CONTROL POINT DATA SHEET**

CONTROL POINT FS15

EASTING 314444.871 m
 NORTHING 3495450.189 m
 ELEVATION 188.508 m

DATE: OCTOBER, 2020
 COORDINATE SYSTEM X,Y,Z. UTM/WGS84/43N

LOCATION PLAN



SURVEY & MAPPING
 Lahore PAKISTAN

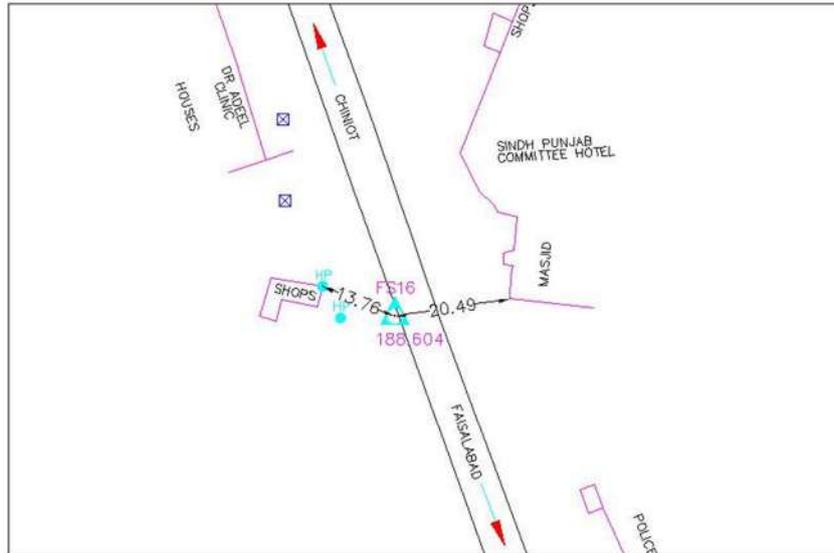
**DUALIZATION OF FAISALABAD-CHINIOT SARGODHA
ROAD PROJECT
CONTROL POINT DATA SHEET**

CONTROL POINT FS16

EASTING 314317.969 m
 NORTHING 3495807.952 m
 ELEVATION 188.604 m

DATE: OCTOBER, 2020
 COORDINATE SYSTEM X,Y,Z. UTM/WGS84/43N

LOCATION PLAN



SURVEY & MAPPING
 Lahore PAKISTAN

**DUALIZATION OF FAISALABAD-CHINIOT SARGODHA
ROAD PROJECT
CONTROL POINT DATA SHEET**

CONTROL POINT FS26

EASTING 312626.896 m
 NORTHING 3500222.087 m
 ELEVATION 189.458 m

DATE: OCTOBER, 2020
 COORDINATE SYSTEM X,Y,Z. UTM/WGS84/43N

LOCATION PLAN



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**DUALIZATION OF FAISALABAD-CHINIOT SARGODHA
ROAD PROJECT
CONTROL POINT DATA SHEET**

CONTROL POINT FS27

EASTING 312478.655 m
 NORTHING 3500578.812 m
 ELEVATION 189.211 m

DATE: OCTOBER, 2020
 COORDINATE SYSTEM XYZ. UTM/WGS84/43N

LOCATION PLAN



SURVEY & MAPPING
 Lahore PAKISTAN

**DUALIZATION OF FAISALABAD-CHINIOT SARGODHA
ROAD PROJECT
CONTROL POINT DATA SHEET**

CONTROL POINT FS39

EASTING 311171.647 m
 NORTHING 3505382.674 m
 ELEVATION 181.857 m

DATE: OCTOBER, 2020
 COORDINATE SYSTEM XYZ. UTM/WGS84/43N

LOCATION PLAN



SURVEY & MAPPING
 Lahore PAKISTAN

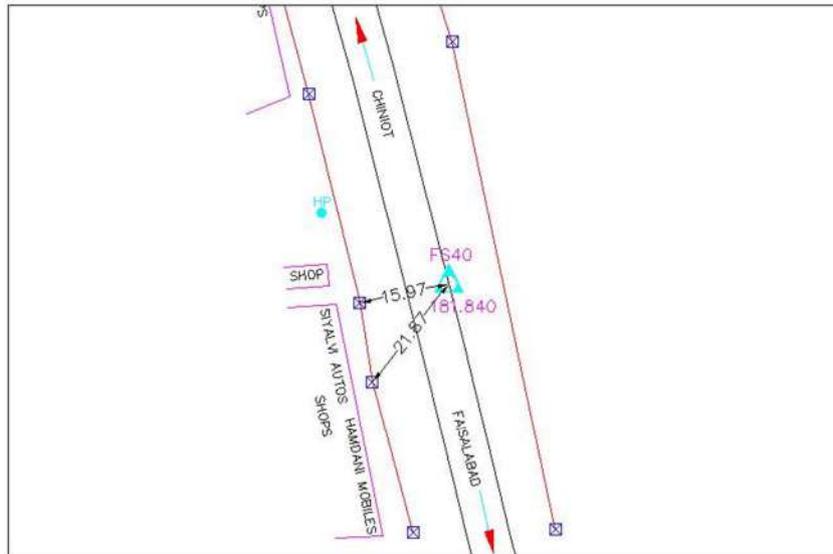
**DUALIZATION OF FAISALABAD-CHINIOT SARGODHA
ROAD PROJECT
CONTROL POINT DATA SHEET**

CONTROL POINT FS40

EASTING 311078.210 m
 NORTHING 3505780.446 m
 ELEVATION 181.840 m

DATE: OCTOBER, 2020
 COORDINATE SYSTEM X,Y,Z. UTM/WGS84/43N

LOCATION PLAN



SURVEY & MAPPING
 Lahore PAKISTAN

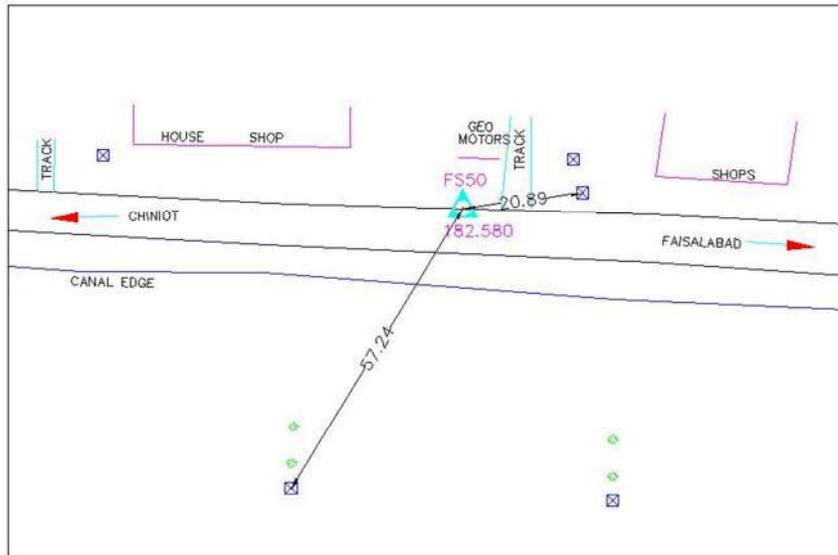
**DUALIZATION OF FAISALABAD-CHINIOT SARGODHA
ROAD PROJECT
CONTROL POINT DATA SHEET**

CONTROL POINT FS50

EASTING: 309841.476 m
 NORTHING: 3508788.757 m
 ELEVATION: 182.580 m

DATE: OCTOBER, 2020
 COORDINATE SYSTEM XYZ. UTM/WGS84/43N

LOCATION PLAN



SURVEY & MAPPING
 Lahore PAKISTAN

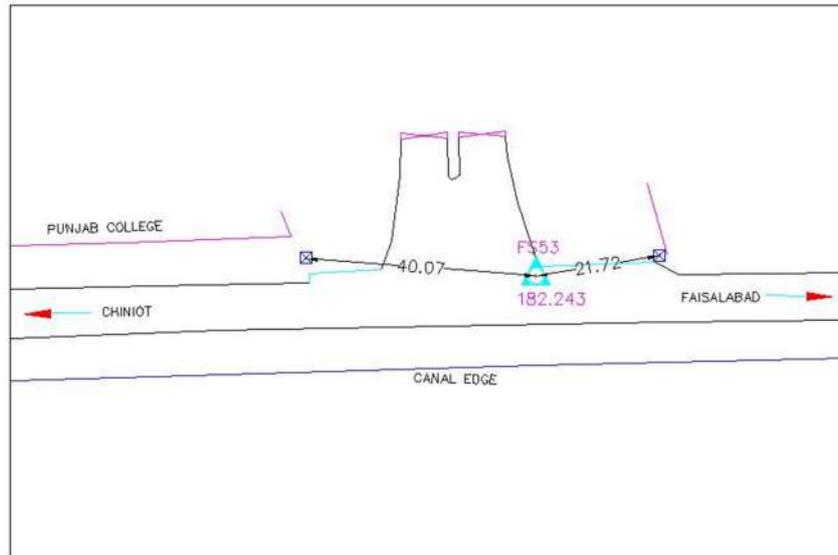
**DUALIZATION OF FAISALABAD-CHINIOT SARGODHA
ROAD PROJECT
CONTROL POINT DATA SHEET**

CONTROL POINT FS53

EASTING: 308696.17 m
 NORTHING: 3508824.085 m
 ELEVATION: 182.243 m

DATE: OCTOBER, 2020
 COORDINATE SYSTEM XYZ. UTM/WGS84/43N

LOCATION PLAN



SURVEY & MAPPING
 Lahore PAKISTAN

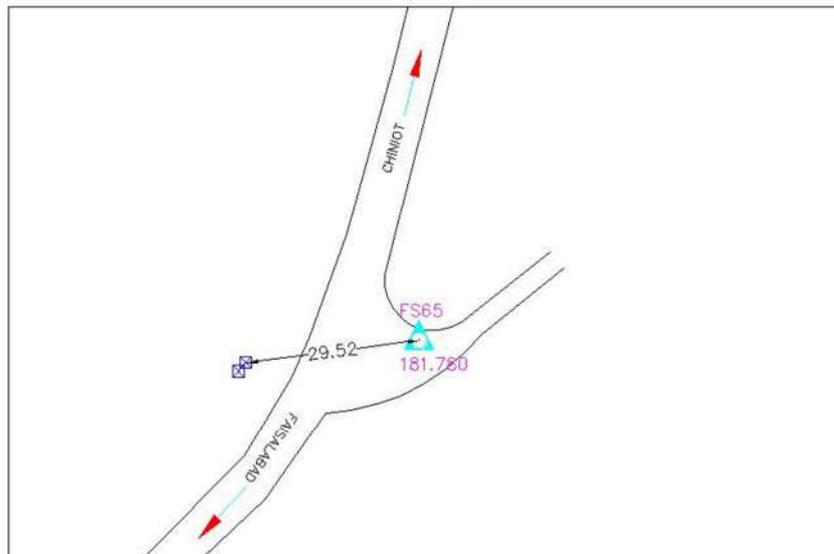
**DUALIZATION OF FAISALABAD-CHINIOT SARGODHA
ROAD PROJECT
CONTROL POINT DATA SHEET**

CONTROL POINT FS65

EASTING 306356.460 m
 NORTHING 3509848.737 m
 ELEVATION 181.780 m

DATE: OCTOBER, 2020
 COORDINATE SYSTEM XYZ. UTM/WGS84/43N

LOCATION PLAN



SURVEY & MAPPING
 Lahore PAKISTAN

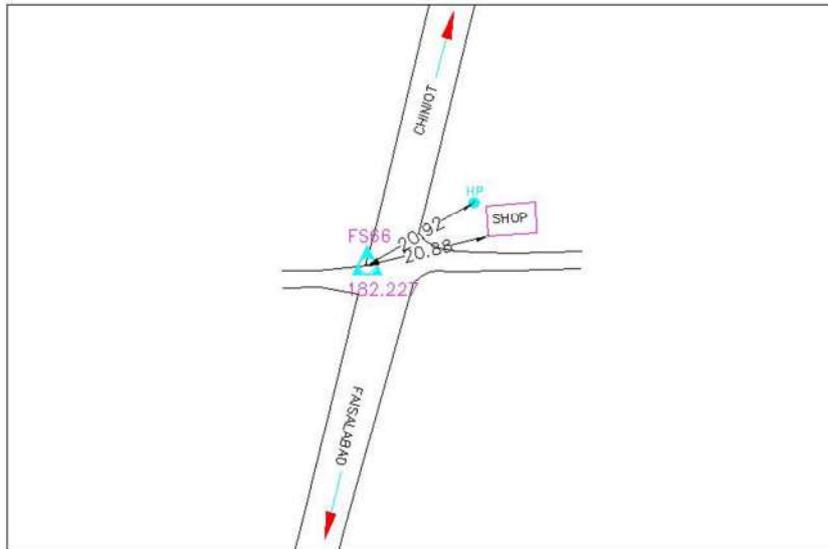
**DUALIZATION OF FAISALABAD-CHINIOT SARGODHA
ROAD PROJECT
CONTROL POINT DATA SHEET**

CONTROL POINT FS66

EASTING 306444.264 m
NORTHING 3510270.092 m
ELEVATION 182.227 m

DATE: OCTOBER, 2020
COORDINATE SYSTEM XYZ. UTM/WGS84/43N

LOCATION PLAN



SURVEY & MAPPING
Lahore PAKISTAN

**DUALIZATION OF FAISALABAD-CHINIOT SARGODHA
ROAD PROJECT
CONTROL POINT DATA SHEET**

CONTROL POINT FS73

EASTING 307778.179 m
 NORTHING 3512785.023 m
 ELEVATION 184.214 m

DATE: OCTOBER, 2020
 COORDINATE SYSTEM X,Y,Z. UTM/WGS84/43N

LOCATION PLAN



DESCRIPTION



SURVEY & MAPPING
 Lahore PAKISTAN

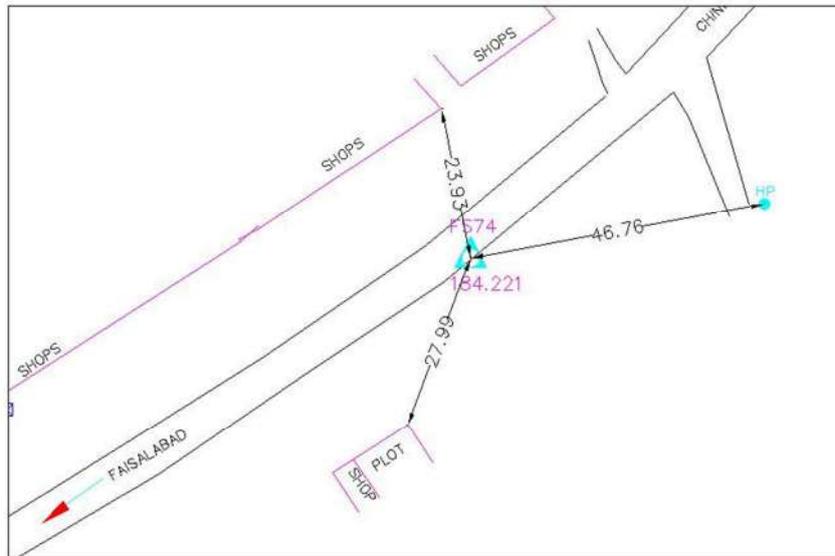
**DUALIZATION OF FAISALABAD-CHINIOT SARGODHA
ROAD PROJECT
CONTROL POINT DATA SHEET**

CONTROL POINT FS74

EASTING 308007.831 m
 NORTHING 3512928.949 m
 ELEVATION 184.221 m

DATE: OCTOBER, 2020
 COORDINATE SYSTEM XYZ. UTM/WGS84/43N

LOCATION PLAN

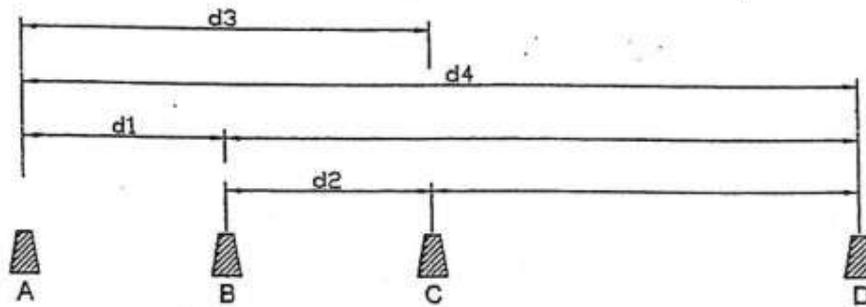


SURVEY & MAPPING
 Lahore PAKISTAN

CALIBRATION OF SURVEY INSTRUMENTS

NATIONAL ENGINEERING SERVICES
PAKISTAN (PVT)LIMITED

EDM CALIBRATION BASELINE
UET - LAHORE
SOKKIA SET 630RK#146259



LENGTH A-D. ($d4$) = 300.053m. (Fixed)

NATIONAL ENGINEERING SERVICES PAKISTAN (PVT) LTD.**BASE LINE MEASUREMENT****UNIVERSITY OF ENGINEERING AND TECHNOLOGY (UET) ,LAHORE**

Instrument No SOKKIA Set 630RK 146259

Date.17-12-2019

A-B	Prism # 1	Prism #2	Prism #3	Remarks
	20.008	20.016	20.007	PPM = 0
	20.006	20.015	20.006	PC = -30
	20.006	20.016	20.006	
	20.007	20.015	20.006	
(d1) Mean.	20.007	20.016	20.006	20.0095
A-C	40.011	40.012	40.011	
	40.013	40.013	40.012	
	40.011	40.014	40.012	
	40.012	40.012	40.013	
(d3) Mean	40.012	40.013	40.012	40.0122
A-D	300.050	300.050	300.050	
	300.050	300.050	300.051	
	300.051	300.050	300.051	
	300.051	300.052	300.052	
(d4) Mean	300.051	300.051	300.051	300.0507
B-C	20.009	20.011	20.005	
	20.008	20.012	20.005	
	20.009	20.013	20.006	
	20.009	20.012	20.005	
(d2) Mean	20.009	20.012	20.005	20.0087

1-Measurements

Form.BLM-01/1

Prism # 1

D4 = 300.053 (FIXED /FROZEN VALUE)
 C = -0.0038
 S = 0.0063
 Sppm = 20.8297

Prism #2

D4 = 300.053 (FIXED /FROZEN VALUE)
 C = -0.014750
 S = -0.01225
 Sppm = -40.8261

Prism #3

D4 = 300.053 (FIXED /FROZEN VALUE)
 C = 0.0005
 S = 0.0025
 Sppm = 8.332

Sppm Mean = -3.888

Mean Distance

D4 = 300.053 (FIXED /FROZEN VALUE)
 C = -0.0060
 S = -0.0037
 Sppm = -12.220

Accuracy $5\text{mm} + \text{ppm} * D / 1000000$

= **-3.887**

The result is within the limit

Status of Equipment : A

SITE PHOTOGRAPHS



FS 5 CONCRETE MONUMENT WITH STEEL NAIL AT CENTER



FS6 CONCRETE MONUMENT WITH STEEL NAIL AT CENTER



FS 20 CONCRETE MONUMENT WITH STEEL NAIL AT CENTER



FS 17 CONCRETE MONUMENT WITH STEEL NAIL AT CENTER



GPS BASE STATION AT POINT FS 25 COLLECTING DATA



STATIC POINT OBSERVATION FS31

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)



STATIC POINT (FS50) OBSERVATION ALONG THE ROAD



STATIC POINT (FS36) OBSERVATION ALONG THE ROAD

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)



STATIC POINT (FS49) OBSERVATION ALONG THE ROAD AT BRIDGE



STATIC POINT OBSERVATION ALONG THE ROAD

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)



STATIC POINT (FS33) OBSERVATION ALONG THE ROAD



STATIC POINT (FS24) OBSERVATION ALONG THE ROAD

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)



STATIC POINT (FS36) OBSERVATION ALONG THE ROAD



TOPOGRAPHIC SURVEY OF PROJECT AREA WITH TOTAL STATION

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)



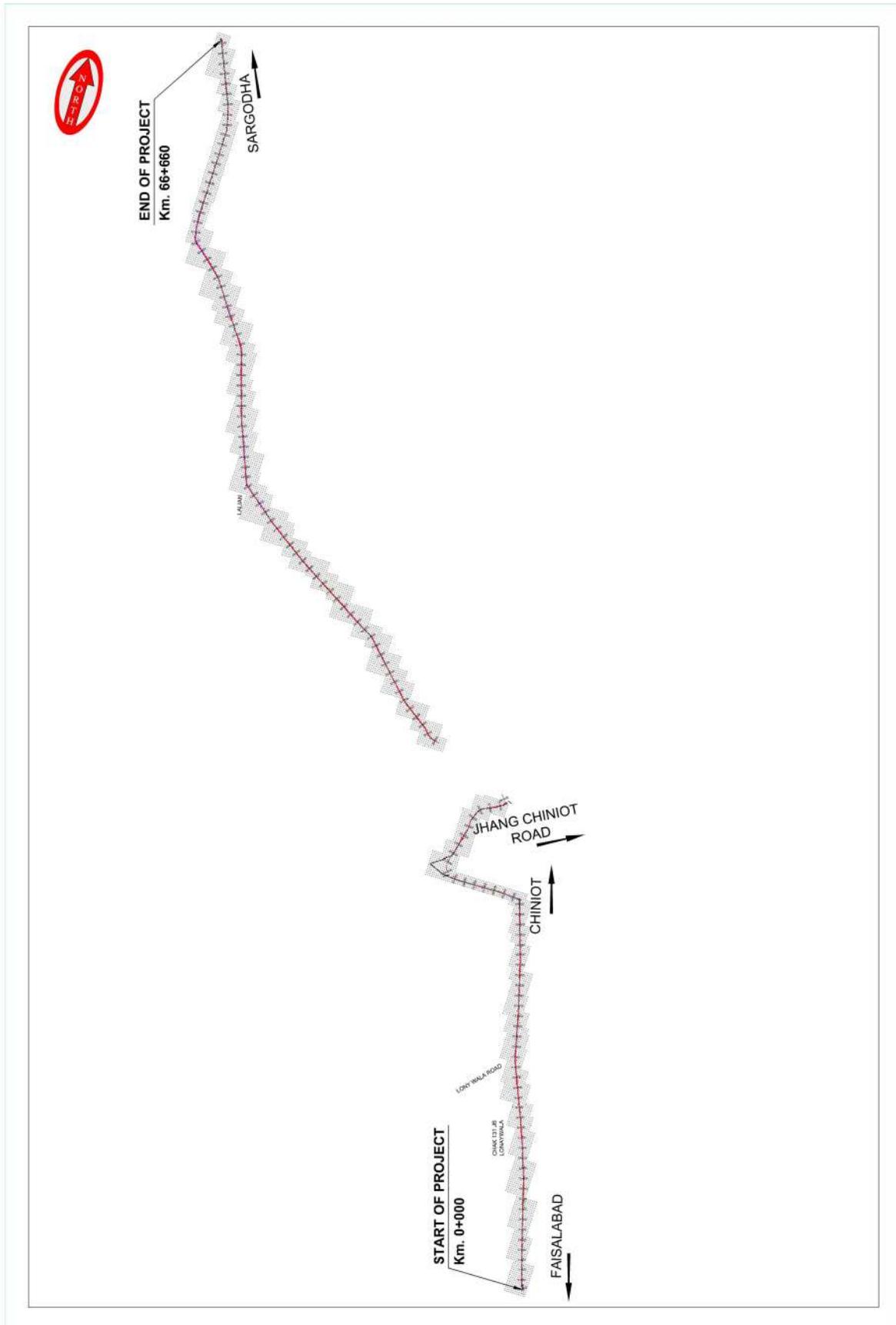
TOPOGRAPHIC SURVEY OF PROJECT AREA WITH TOTAL STATION



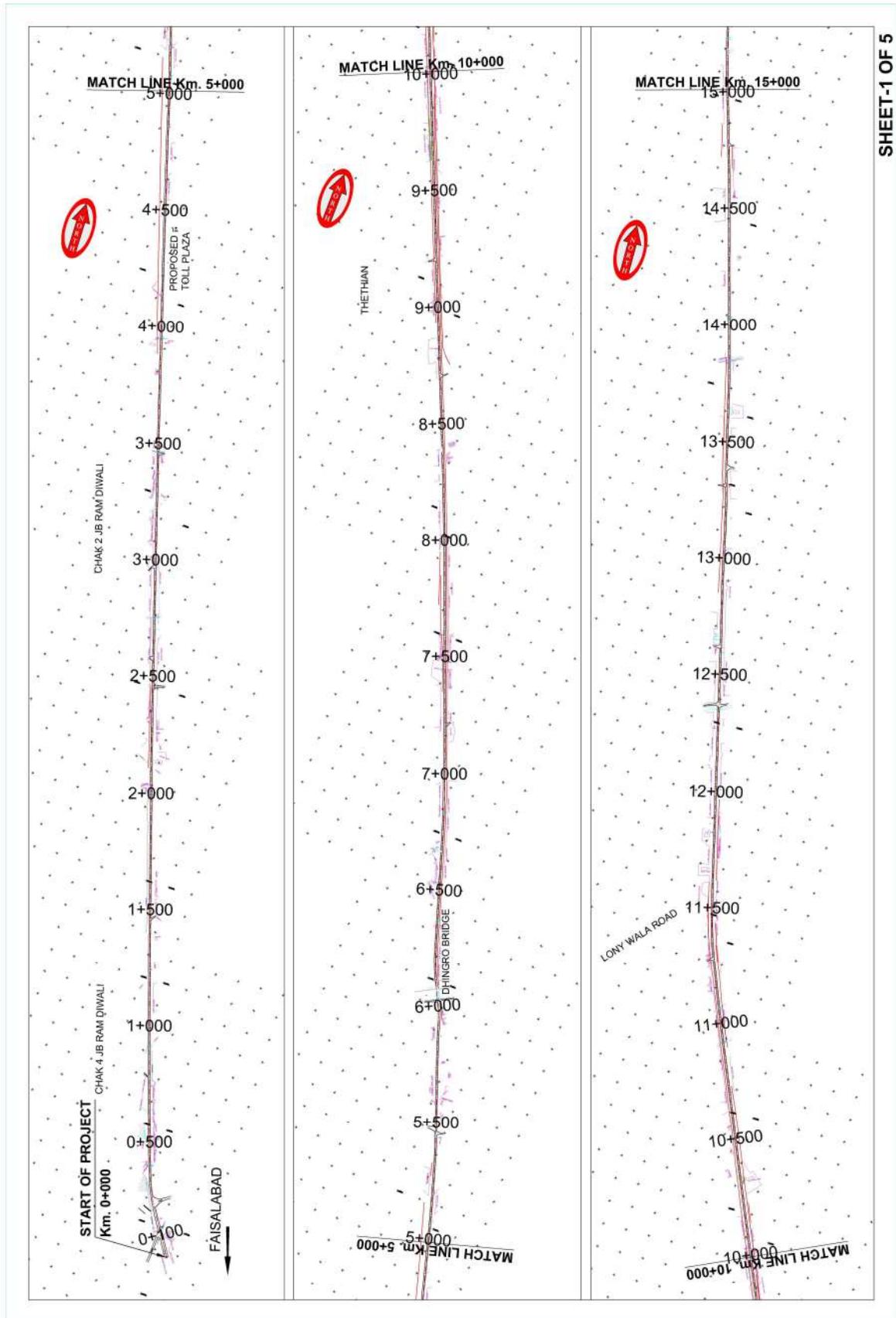
TOPOGRAPHIC SURVEY OF PROJECT AREA WITH TOTAL STATION

TOPOGRAPHICAL MAP SHEETS

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)

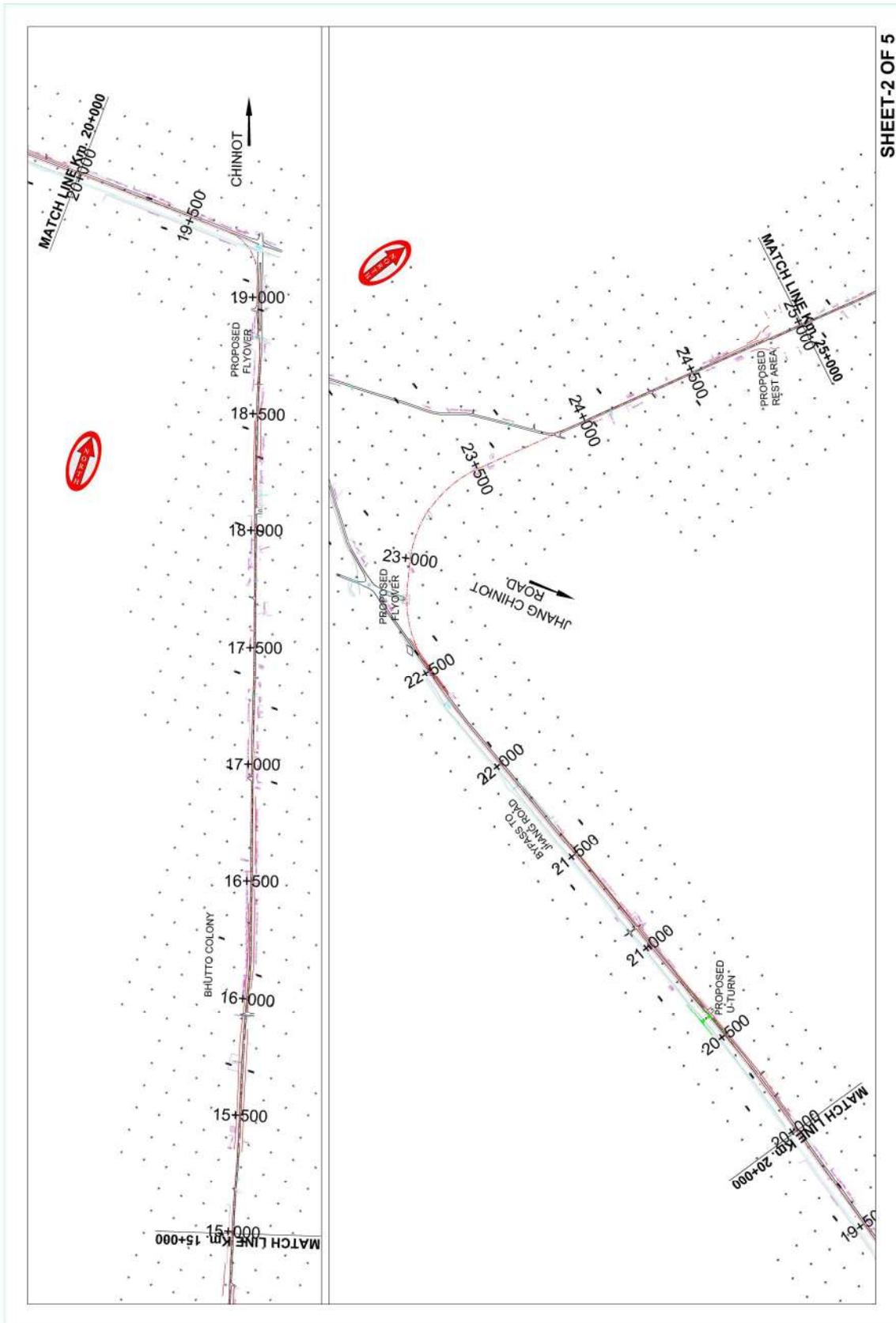


TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)



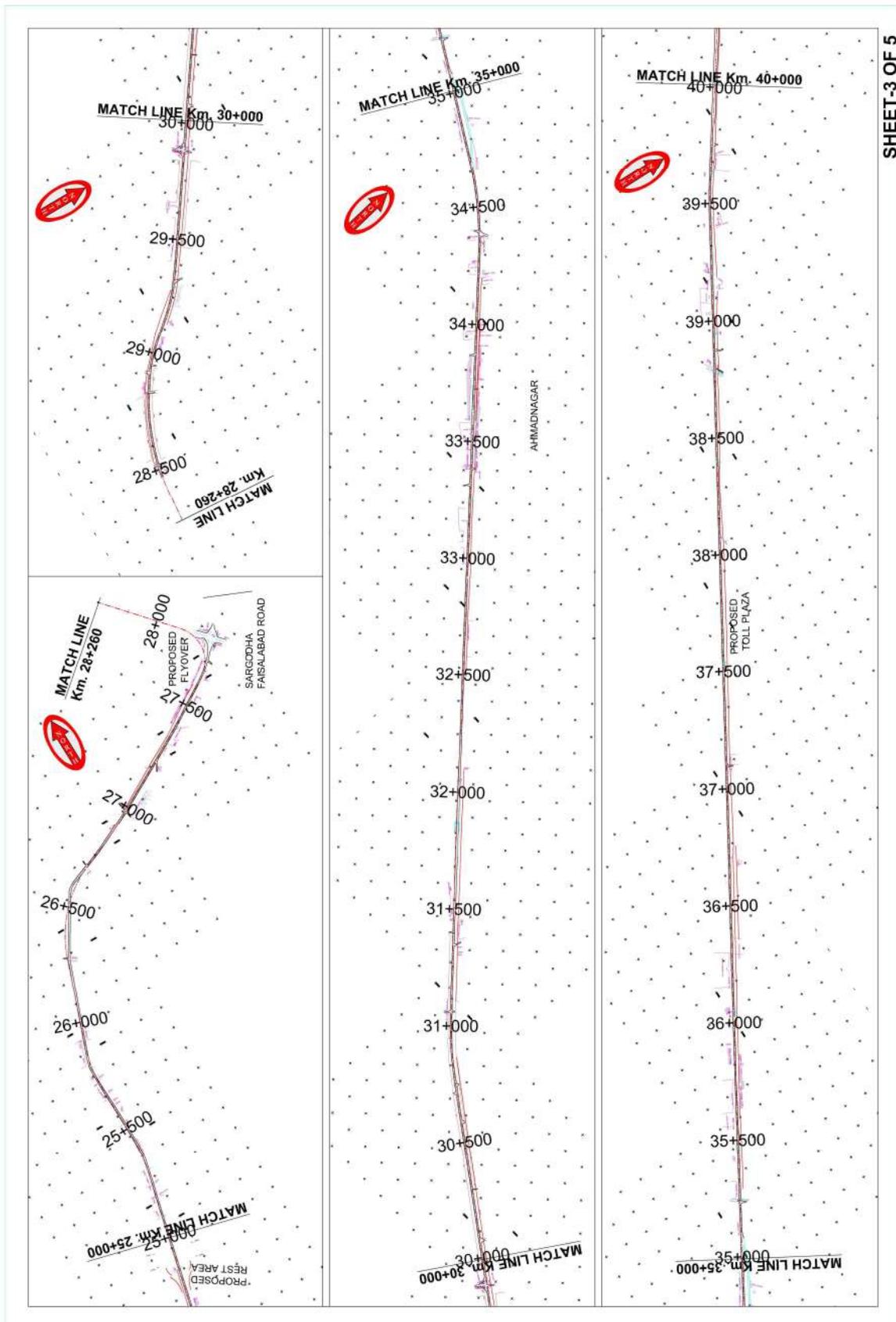
SHEET-1 OF 5

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)



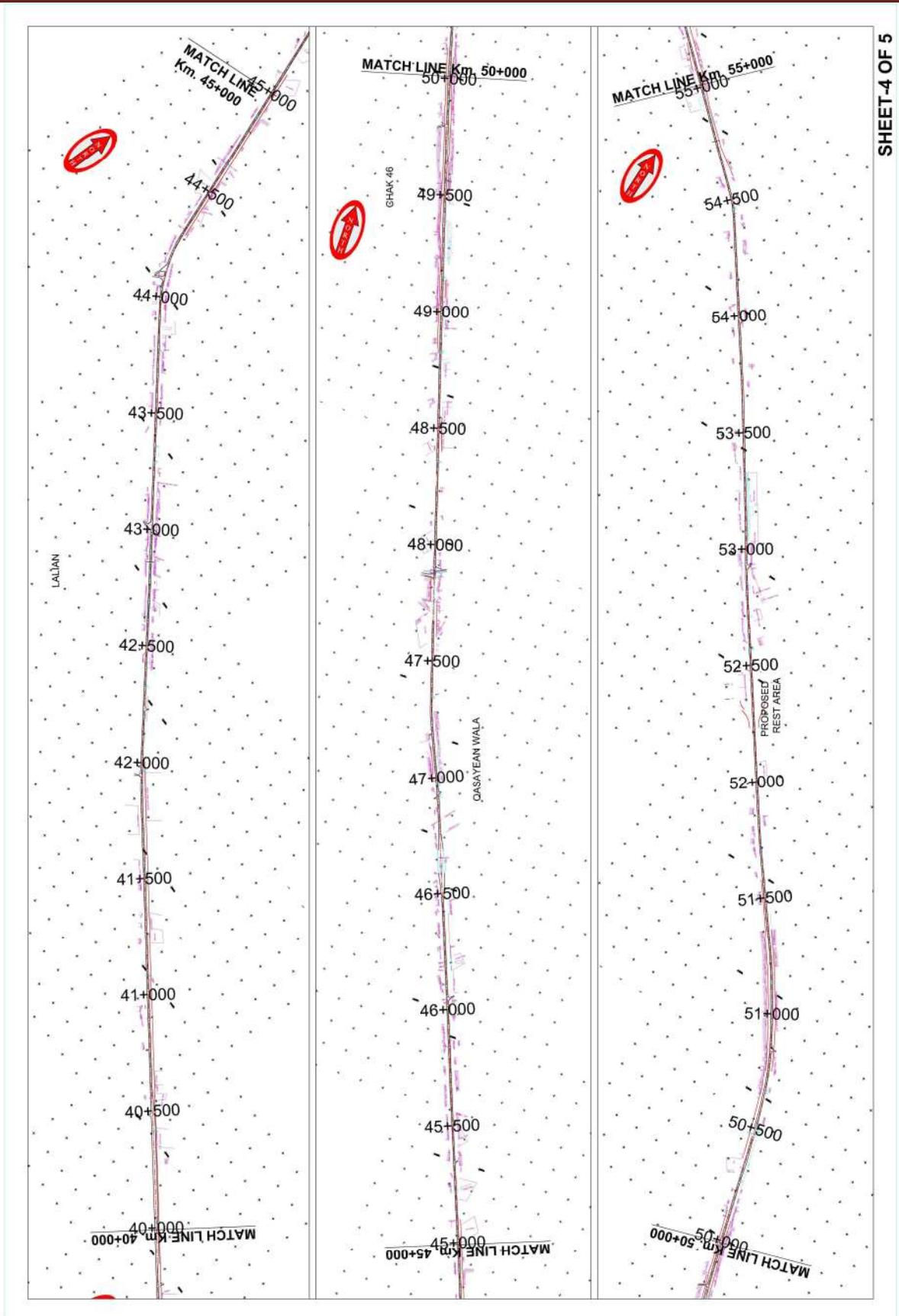
SHEET-2 OF 5

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)

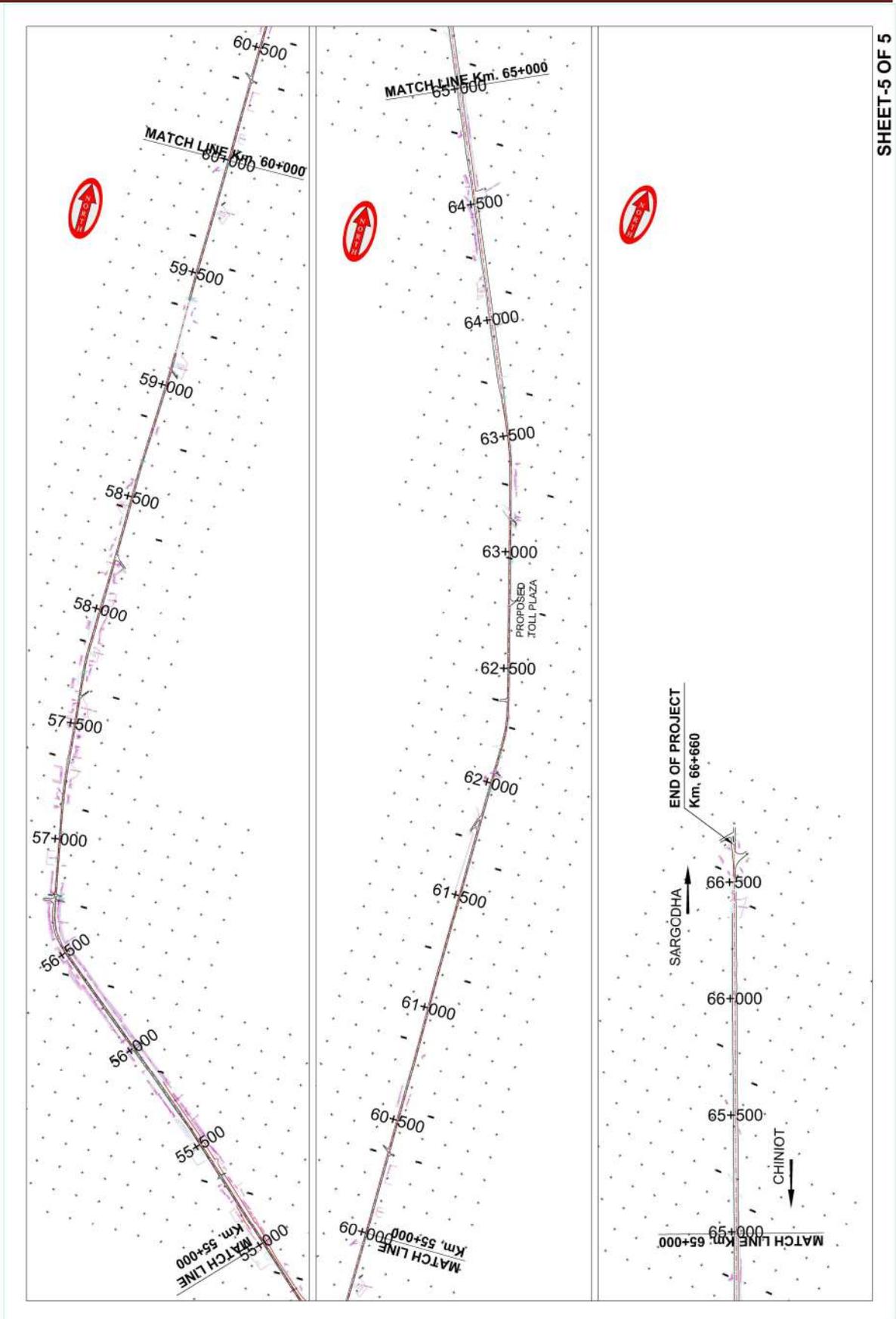


SHEET-3 OF 5

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)



TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)



SHEET-5 OF 5

3.2. GEOMETRIC DESIGN REPORT

3.2.1 GENERAL

The detailed design of the road is based on a set of design criteria that represents the best internationally accepted engineering practice for the level of facility being planned. At the same time, the specific local site conditions and constraints are also effectively considered in the interpretation of design criteria. It is to be emphasized that engineering design is an integrated process of information collection, analysis, synthesis and evaluation. The ultimate objective of this process is achievement of the desired performance in the constructed facility. The design criteria should effectively represent the performance objectives while satisfying the economic constraints. The stipulated design criteria (given below) shall be subject to engineering judgment.

3.2.2 INTRODUCTION AND BRIEF DESCRIPTION:

Communication and works Department (C&W) Punjab, entrusted National Engineering Services Pakistan (NESPAK) Pvt. Ltd as the project consultants for preparing Feasibility Study and preliminary design for Dualization of existing single road of Faisalabad – Chiniot-Sargodha section.

- The project road is located in Punjab Province Pakistan
- The project road length is estimated to be 67 km
- An effective and secure road network is essential in order to guarantee the mobility and supply for the whole population.

Location map of project is attached as figure.3.2a.

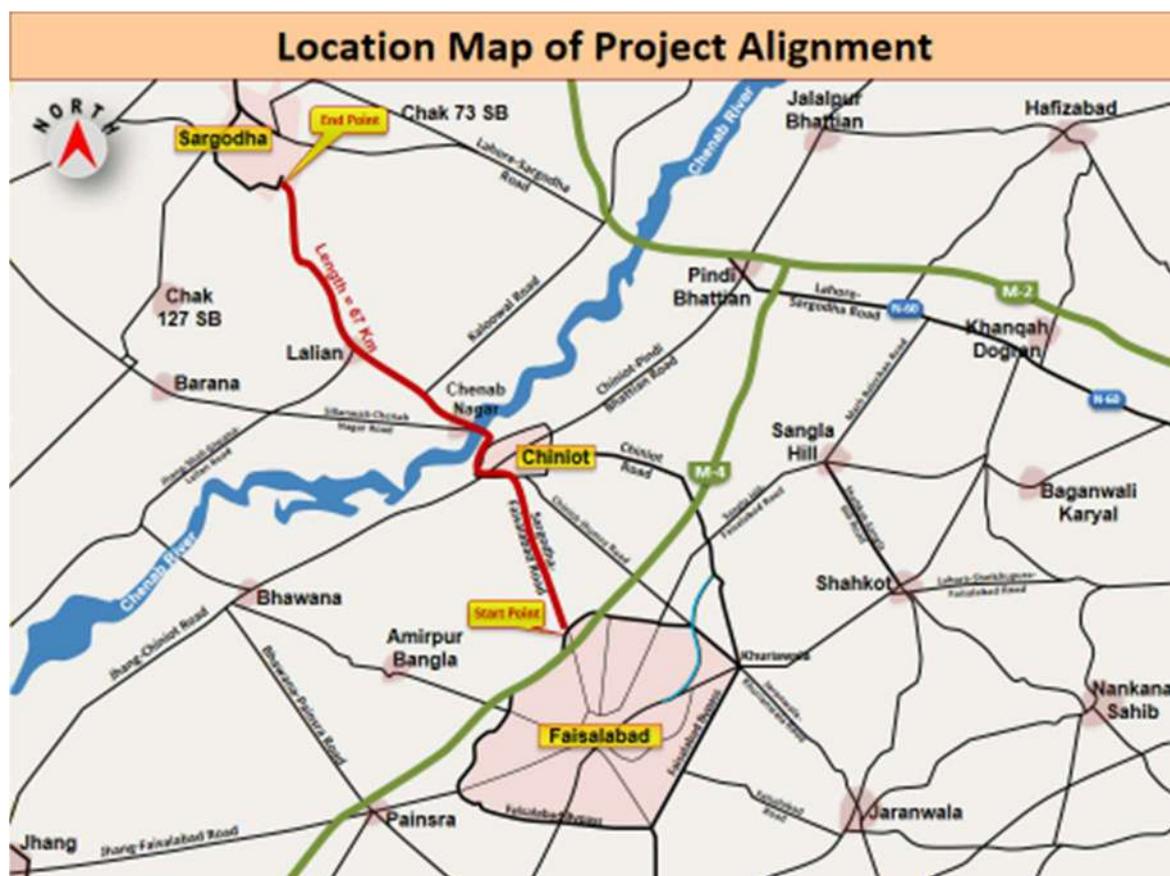


Figure. 3.2a LOCATION MAP OF PROJECT AREA

3.2.3 GEOMETRIC DESIGN:

Geometric design of highway refers to the design of the visible dimension of such features as horizontal and vertical alignments, cross sections, intersections. The main objective of geometric design is to produce a highway with safe efficient and economic traffic operations while maintaining esthetic, environment quality. Geometric design is influenced by the vehicle, driver and traffic characteristics.

Road design is traditionally a manual technique in which the problem is considered separately in three views. i.e.

- a) Plan
- b) Longitudinal profile
- c) Cross section

A. HORIZONTAL ALIGNMENT:

The alignment comprised of a variety of elements joined together to create a facility that serves the traffic in a safe and efficient manner, consistent with the facilities intended function. Each alignment element should harmonize the others to produce a consistent, safe efficient and responsible design. Horizontal alignment must afford at least the minimum stopping sight distance for the design speed at all points on the highway.

I. DESIGN SPEED:

Speed reduces the visual field, restricts peripheral vision, and limits the time available for drivers to receive and process information. Design Speed is a selected speed based on the various geometric features of the roadway. Conversely the geometric design features should correspond with the desired design speed. The selected design speed should be consistent with the speeds that drivers are likely to expect on a given highway facility.

Design Speed for the project on main carriageway was taken 120 Kilometres per Hour (Km/hr). However at few location the design speed is reduced due to site constraints.

II. CURVE RADIUS:

The minimum radius is a limiting value of curvature for a given design speed and is determined from the maximum rate of super elevation and the maximum side friction factor selected for design (limiting value of f).

The Design Consultant has studied the existing Geometry and has made improvements where required.

- Minimum radius at relevant design speed and maximum super elevation is taken as 756m.
- Absolute minimum curve radius at turnings/channelizing islands is taken as 15m.

III. SUPER ELEVATION:

Super elevation is the banking of a roadway around a curve. The purpose of employing super elevation of the roadway cross section is to counter balance the centrifugal force, or outward pull of a vehicle traversing a horizontal curve. Side friction developed between the tires and the road surface also counter balances the outward pull of the vehicle. A combination of these two concepts allows a vehicle to negotiate curves safety at higher speeds.

There are practical upper limits to the rate of super elevations on a horizontal curve.

- Maximum super elevation on the project is taken 6%.

B. VERTICAL ALIGNMENT:

Topography of the land traversed has an influence on the alignment of roads and streets. Topography affects horizontal alignment, but has an even more pronounced effect on vertical alignment. The highways vertical alignment plays a significant role in highway safety, aesthetics and project costs. Vertical curves are normally parabolic. A simple vertical curve may be crest vertical curve or a sag vertical curve. The design of vertical alignments involves, to a large extent, complying with specific limiting criteria. These includes maximum and minimum grades, sight distance at vertical curves and vertical clearances. The project lies in the plan area.

I. GRADIENT:

Road and streets should be designed to encourage uniform operation throughout. Grades are important to facilitate the road users. The desirable maximum grade is taken as 6 %.

II. K VALUE FOR VERTICAL CURVES:

The major control for safe operation on crest & a sag vertical curve is the provision of ample sight distances for the design speed which depends on rate of vertical curvature "K". For this project the "K" value, based on stopping sight distance is taken "52" for Crest vertical curve & "45" for Sag vertical curve.

A. ROAD CROSS SECTION ELEMENTS:

Road Cross Section Elements were as follows:

a) Width of Roadway

Width of Roadway consists of travelled way width and shoulder width. These elements on the Project Road are as follows;

i) Lane Width

Lane width on the Project is 3.65 m and 2 Lanes on Either travelled way of the Project are provided.

ii) Shoulder Width

Paved / TST shoulder on the outer edge (both sides) of travelled way is 1.2m wide for urban areas and 2.45m for rural areas.

b) Cross Slope

On highways cross slope across the entire width of the travelled way is generally provided for surface drainage. For main carriageway design, the cross slope on either side taken as 2.0%.

3.2.4. COMPUTER PROGRAMME:

Computer programs Eagle point/Road Calc. was used for the analysis and design of the road components.

3.2.5. DESIGN CRITERIA

Design criteria are basic to good geometric design and adhering to them will enhance the visual qualities of the roadway. In Pakistan most design parameters and criteria for road design are based on AASHTO guidelines.

The geometric design was carried out as per "A Policy on Geometric Design of Highways and Streets 2011" by AASHTO based on the following main parameters.

ROADS DESIGN CRITERIA:

Sr. no.	Description	Main road	Intersection
1	Length of Project Right of way (Available) Design Vehicle	67 km 110' to 127' Tractor Trailer 6- axle	Tractor Trailer 6- axle
2	Design speed Posted speed	120 Kph 100 Kph	50 Kph
3	Cross section Lane width No of Lanes Travel Lane width Shoulder Inner (Paved) Outer (Rural) Outer (Urban)	3.65m 2 each side 7.3m 0.9m 2.45m + 0.5m rounding 1.2m	3.65m 0.6m 2.45m + 0.5m rounding 1.2m
4	Carriage way cross slope Pavement Outer shoulder TST Inner shoulder	2% 2% 2%	2% 2% 2%
5	Horizontal Alignment Minimum Radius Minimum radius with no super elevation Absolute Minimum Curve radius at turnings/Channelizing Islands (m) Maximum super elevation	756m 4770m 15m 6%	6%

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)

	Minimum stopping sight distance	185m	
	Acceleration length to entrance	360m	n/a
	Deceleration length to 50km/hr.	170	n/a
6	Vertical Alignment		
	Maximum Gradient	6%	6%
	Minimum Gradient	-	-
	K value for crest vertical curve	52	
	K value for sag vertical curve	45	
7	Design life of pavement	10 Years	10 Years
	Pavement Lane marking		
	White Line	Between two lanes	Between two lanes
	Yellow line	Roadway edge/ Shoulder line	Roadway edge/ Shoulder line
	Studs (white, yellow, green)	Lines, Chevron	As required
		As required	
8	Divider (Highway)	NJB (Chevron signs at curves)	-
	Median (Highway)	Curb Type	
	Brick on edge	At shoulder	Curb Type

3.3. TRAFFIC STUDY REPORT

3.3.1 GENERAL

The main objective of this traffic study is to assess the volumes and composition of traffic load likely to use dual road from Faisalabad to Sargodha. The projected volumes of traffic are used to compute the expected future load of vehicles on the project road in future years and this traffic is also used for toll calculation. Capacity analysis of the dualization of Faisalabad - Chiniot - Sargodha Road (67 km) is also carried out and the justification of geometric improvements are recommended on the basis of these analysis.

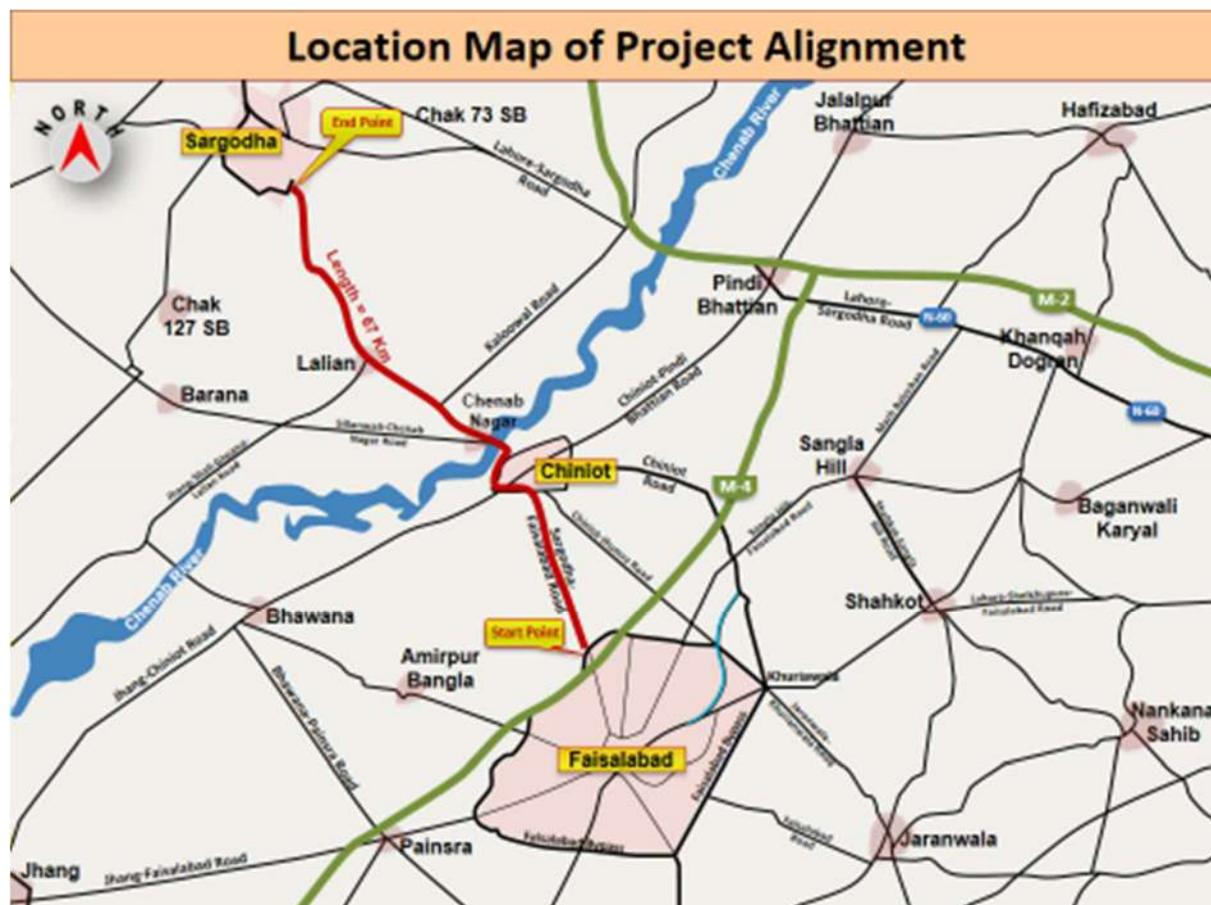


Figure 3.3-a: Google Map-Based Location of Project Area

3.3.2 Study Objectives

This single carriageway road between Faisalabad and Sargodha via Chiniot is an important link road and the traffic volume on this road is increasing continuously. The project is primarily aimed to provide a high capacity and efficient road facility to cater for future travel demand to help and relieve this important section by alleviating congestion and pressure of extraneous traffic. Figure 2-1 highlights the overall road network that needs to be developed. The overall network shows that this road is the major means to connect three big cities and development of this route will provide relief to the traffic on this road. As increasing in traffic demand, the Level of Service (LOS) on existing road is deteriorating with already low travel speed and diminishing safety on the road. Additionally, increase of opposing traffic volume on undivided roads make them dangerous requiring conversion to at least 4-lanes dual carriageways with median in centre to enhance safety and capacity of road.

The typical milestones intended to be achieved include:

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)

- To study and review the existing conditions.
- Provision of an efficient facility to connect.
- To alleviate congestion.
- To provide quick passage with less noise pollution.
- To provide much needed relief.

A comprehensive traffic survey for traffic studies was made, by M/s NESPAK in September, 2020, based on following methodology:

- Collection of traffic data.
- Review of previous studies.
- Development of base year ADT.

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)



Figure 3-1: Survey Locations along Project Area

3.3.3 Study Methodology

The methodology adopted for this study comprised the following major activities:

- Updating and use of data collected for previous study reports.
- Review of previous studies in the light of future requirements.
- Traffic Surveys.
- Transport Planning and Traffic Sensitivity Analysis

3.3.4 Benefits

The traffic study for subject project is aimed at getting the following benefits;

- Saving in travel time and cost.
- Reduced accidental cost.
- Reduced air and noise pollution.
- Relief from traffic congestion.
-

3.3.5 Traffic Survey and Data Collection

3.3.5.1 Introduction

Traffic surveys were planned and conducted on Faisalabad - Chiniot - Sargodha road. The basic objective of traffic studies would be to assess the problems being experienced by existing road users and determine the present traffic volumes and types of vehicles operating on the existing road network so as to make judicious estimate of the future traffic likely to use the facility over the design life of the project.

NESPAK conducted Manual Classified Traffic Counts (MCC) and Origin-Destination (OD) surveys on the road sections/ segments at significant locations. A comparison of the traffic growth, traffic trends, projections and O/D studies were drawn vis-à-vis historical data. The traffic surveys carried out consisted of:

- Manual Classified Counts (MCC)
- Origin / Destination Surveys (O/D)

3.3.5.2 Manual Classified Counts (MCC)

Traffic volume counts (TVC) were conducted to determine the number of vehicles passing through a specified point on a road. These counts have immense significance in traffic evaluation, planning, design, and operation. Manual Classified Counts (MCC's) have been carried out at 06 locations by deputing survey staff at roadside. These counts were undertaken for 15 min. intervals over a 24 hour period in order to cover overnight freight movements and identify peak hourly volumes. Vehicles were classified for MCC's into the following categories given in Table 3.3.1:

Table 3.3.1: Modal Types

Sr. No.	Modal Type
1	Bicycle
2	Motorcycle/ Scooter
3	Rickshaw, Qingqi (Motorcycle Rickshaw)
4	Car, Taxi, Jeep, Land Cruisers, Single/ Twin-Cabin
5	Hiace Wagon
6	Loader Pickup
7	Med Bus, Flying Coach
8	Large Bus
9	Loader Pick –Up
10	2 Axle Truck
11	3 Axle Truck
12	4 Axle Truck
13	5&6 Axle Truck Trailer
14	Tractor Trolley
15	Animal Driven

Special traffic survey counting forms were used by the surveyors to record the traffic data. All the traffic survey staff was trained prior to the start of work. All the work was supervised on site by experienced staff.

3.3.5.3 Daily Traffic Volumes

Vehicle-wise volumes for each hour of the surveys were worked out from the recorded data and these were further grouped into motorized and non-motorized traffic. Hourly volumes for the two directions recorded at various count stations were then compiled.

3.3.5.4 Average Daily Traffic (ADT)

Manual Classified count data is required to be adjusted for daily variations during a week. For this purpose, Average weekly variation factors calculated from NESPAK survey data. The status of days relative to the week is given below in table 3.2.2:

Table 3.3.2: Status of Days Relative to the Week

Sr. No.	Day*	Status of the day
1	Sunday	Closed day
2	Monday	Mixed day
3	Tuesday	Full working day

*Tuesday being normal working day, represents Wednesday and Thursday.

Sunday being weekend day represent Saturday.

Monday being mixed day represent Friday.

In order to calculate ADT (Average Daily Traffic) during a week, the factors for both motorized and non-motorized traffic are given below in table 3.3.3:

Traffic Survey information will be used to:

- Measuring and establishing trends in traffic volume.
- Evaluating the present traffic flow with respect to the existing road network system.

3.3.5.5 Origin / Destination (O/D) surveys

The proposed road when completed would provide a better and faster facility to most of the long route (inter-city) as well as short route (intra-city) traffic volume as compared to the existing roads/ routes.

In order to make assessment for such traffic, MCCs and Origin-Destination Surveys were conducted at following Locations shown below in Table 3.3.3 OD Interviews were conducted at same where MCC counts were undertaken with a random sample of various vehicle categories. The basic purpose of the O-D surveys was to assess:

- The volume of traffic likely to divert to the proposed facility.
- The volume of traffic likely to continue using the existing roads/routes.

O-D Surveys were conducted for the representative vehicles such as Motorcycles, Cars, Buses, Wagons and Trucks / Trailers. Survey data was compiled in the form of O-D Matrices for the above mentioned vehicles and these matrices when compiled were used as input to the traffic model for the assessment of fair estimates of the base year traffic likely to use the proposed loop.

Table 3.3.3: Locations and Schedule of MCC and O-D Surveys

Sr. No.	Survey Location	Surveys (MCC & OD)	
		Duration	Date
1	DINGRU PULL (DC- 1)	24 Hours	18-09-2020 To 24-09-2020
2	BYCO PETROL PUMP (DC- 2)	24 Hours	18-09-2020 To 24-09-2020
3	RAVI HOTEL NEAR ATTOCK PUMP (DC- 3)	24 Hours	18-09-2020 To 24-09-2020
4	CHINIOT RING ROAD (DC- 4)	24 Hours	20-09-2020
5	THANA LANGRANA (DC- 5)	24 Hours	21-09-2020
6	LAKSIAN TOLL PLAZA (DC- 6)	24 Hours	22-09-2020

These surveys required the driver of the vehicle to be stopped and asked sample questions. The questions asked/information collected consisted of:

- Vehicle type, number of occupants
- Vehicle origin (address or area of start of journey)
- Purpose of trip (work, home, shopping, pleasure etc.).
- Vehicle destination (address of final destination of journey)

A sample of approximately 05% of the total vehicles was selected for OD Surveys. Within the sample a disproportionately larger percentage of heavy vehicles were surveyed due to greater impact of heavy vehicles.

NESPAK employed 5 persons at each site for conducting O/D survey. Prior to the surveys all members of staff received extensive briefing/ training and were instructed as to the operation of the site. Traffic Police assistance was also enlisted at each location to conduct the O/D traffic survey. The origin/ destination surveys were conducted for vehicles traveling in both directions.

3.3.6 Traffic Survey Results

Traffic Surveys were conducted on various points mentioned in previously.

Traffic data was collected in shape of classified counts. From the results of these surveys we will able to predict;

- Congested areas
- Modal split of traffic
- Entering and exiting traffic at start and end of the project.

Traffic survey results of above mentioned survey points are shown in Table 3.3.4 through 3.3.9

3.3.7 Future Growth Rate

Traffic forecast have been made for 20 years (2020-2040) period by using growth rates estimated based on the following macro as well as regional level factors affecting traffic growth.

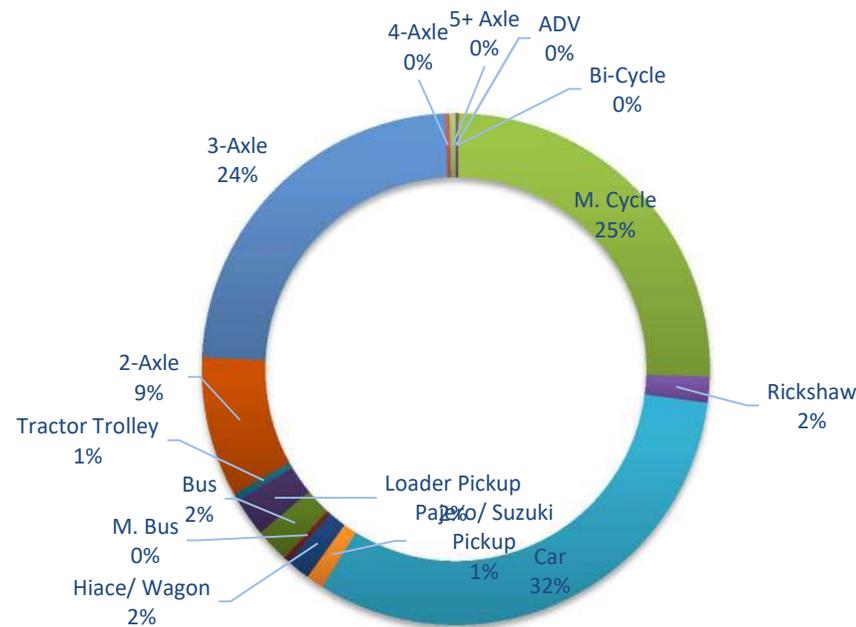
- Growth of registered vehicles in Faisalabad, Chiniot and Sargodha, Punjab Province, Pakistan.
- Rate of increase in fuel consumption by the transport sector Pakistan
- Trend in growth in GDP

The Geometric mean of these variables is taken to predict the future growth rates which have been used to forecast future year traffic for this project. These growth rates are mentioned in Annexure-3.

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)

Table 3.3.4: Dingru Pull (DC- 1) Average Daily Traffic (ADT) 2020

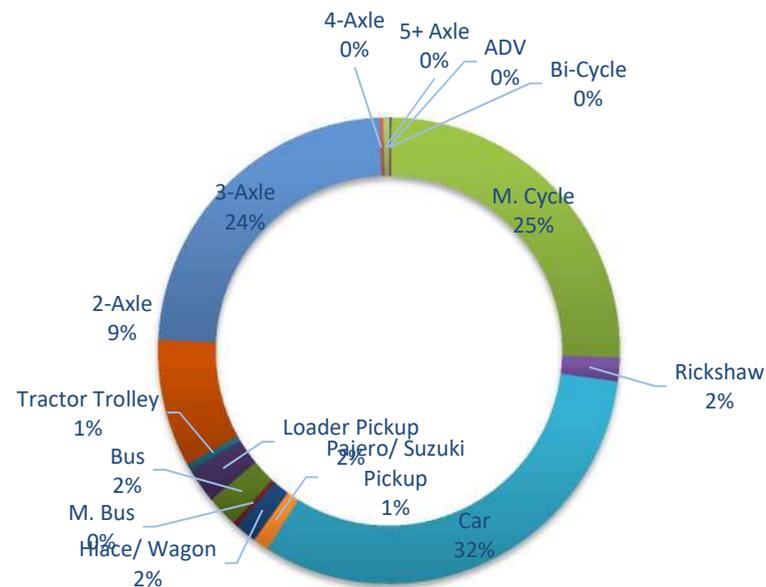
FROM	TO	Animal Drawn	Bi-Cycle	Motor Cycle	Rickshaw	Car/ Taxi/ Jeep	Pajero/ Suzuki Pickup	Hiace/ Wagon	Mini Bus/ Coaster	Bus	Loader Pickup	Tractor Trolley	Trucks				Total
													2-Axle	3-Axle	4-Axle	Trailer / 5-Axle & Above	
Faisalabad	Chiniot	48	18	3324	441	1952	153	358	90	93	290	112	513	823	72	45	8,334
Chiniot	Faisalabad	27	25	3046	350	1564	195	304	85	74	242	103	526	1049	66	46	7,704
Both Direction		75	43	6370	791	3516	348	662	175	168	532	215	1039	1873	138	91	16,038



TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)

Table 3.3.5: Byco Petrol Pump (DC- 2) Average Daily Traffic (ADT) 2020

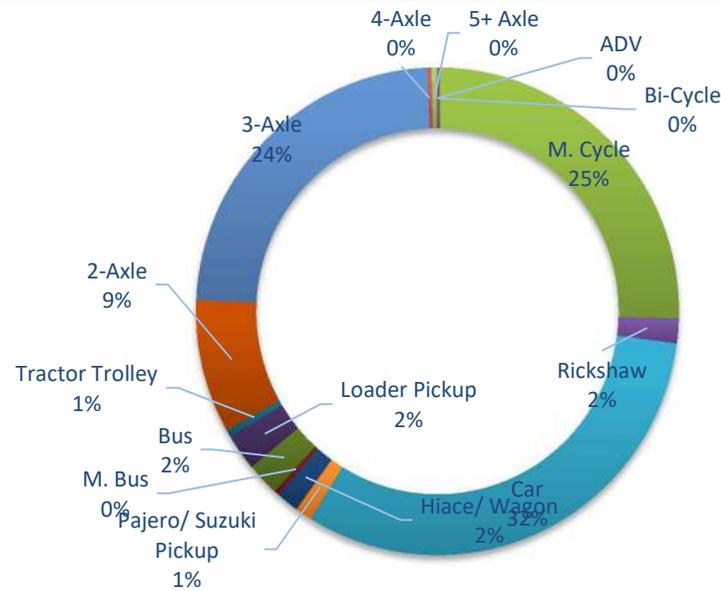
FROM	TO	Animal Drawn	Bi-Cycle	Motor Cycle	Rickshaw	Car/ Taxi/ Jeep	Pajero/ Suzuki Pickup	Hiace/ Wagon	Mini Bus/ Coaster	Bus	Loader Pickup	Tractor Trolley	Trucks				Total
													2-Axle	3-Axle	4-Axle	Trailer / 5-Axle & Above	
Chanab Nagar	Lalian	29	29	4133	803	1848	247	410	170	138	227	171	534	2119	92	76	11,025
Lalian	Chanab Nagar	103	143	4315	750	2661	378	628	305	165	426	214	527	1964	154	130	12,864
Both Direction		132	172	8447	1553	4509	625	1037	475	303	653	386	1061	4083	246	206	23,889



TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)

Table 3.3.6: Ravi Hotel near Attock Pump (DC - 3) Average Daily Traffic (ADT) 2020

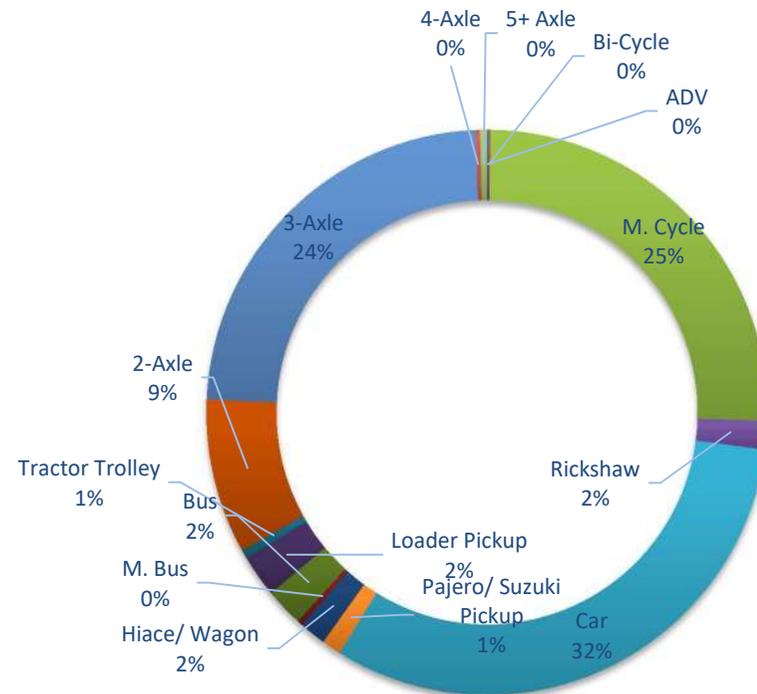
FROM	TO	Animal Drawn	Bi-Cycle	Motor Cycle	Rickshaw	Car/Taxi/Jeep	Pajero/Suzuki Pickup	Hiace/Wagon	Mini Bus/Coaster	Bus	Loader Pickup	Tractor Trolley	Trucks				Total
													2-Axle	3-Axle	4-Axle	Trailer / 5-Axle & Above	
Sargodha	Lalian	24	29	5754	852	1599	98	200	36	74	151	165	207	2137	38	63	11,425
Lalian	Sargodha	19	17	5364	794	1739	45	161	62	58	161	175	171	1872	70	40	10,749
Both Direction		43	46	11118	1645	3338	143	361	97	132	312	340	378	4009	109	103	22,174



TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)

Table 3.3.7: Thana Langrana Average Daily Traffic (ADT) 2020

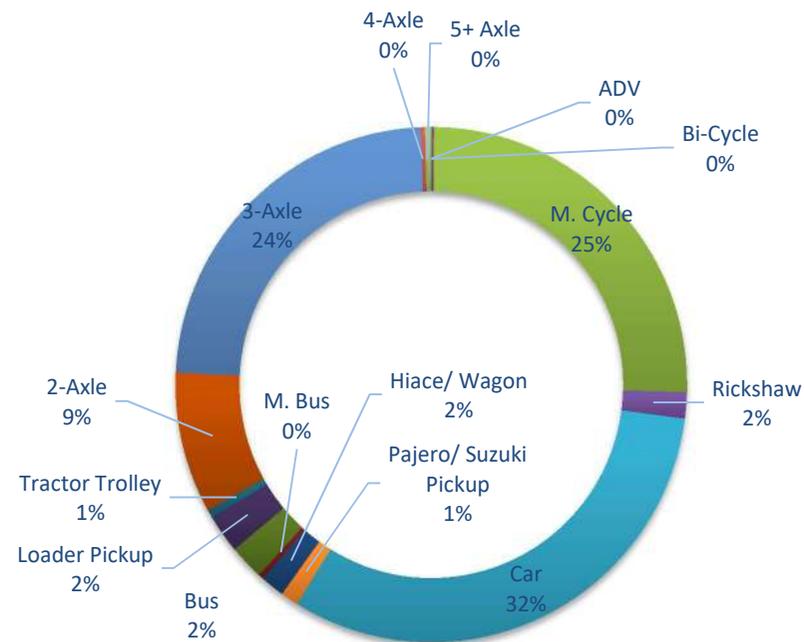
FROM	TO	Animal Drawn	Bi-Cycle	Motor Cycle	Rickshaw	Car/ Taxi/ Jeep	Pajero/ Suzuki Pickup	Hiace/ Wagon	Mini Bus/ Coaster	Bus	Loader Pickup	Tractor Trolley	Trucks				Total
													2-Axle	3-Axle	4-Axle	Trailer / 5-Axle & Above	
Bhawana	Painsara	14	1	1582	125	413	12	87	14	2	228	74	184	322	1	6	3,065
Painsara	Bhawana	4	8	1921	145	424	64	59	7	4	158	39	169	231	3	5	3,241
Both Direction		18	9	3503	270	837	76	146	21	6	386	113	353	553	4	11	6,306



TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)

Table 3.3.8: Laksian Toll Plaza Average Daily Traffic (ADT) 2020

FROM	TO	Animal Drawn	Bi-Cycle	Motor Cycle	Rickshaw	Car/Taxi/Jeep	Pajero/Suzuki Pickup	Hiace/Wagon	Mini Bus/Coaster	Bus	Loader Pickup	Tractor Trolley	Trucks				Total
													Motor Cycle	Rickshaw	Car/Taxi/Jeep	Pajero/Suzuki Pickup	
Pindi Bhattian	Sargodha	6	7	2113	202	2665	94	152	40	271	220	34	143	924	18	32	6,921
Sargodha	Pindi Bhattian	12	10	2974	128	3707	131	157	24	170	270	62	1638	3817	39	49	13,188
Both Direction		18	17	5087	330	6372	225	309	64	441	490	96	1781	4741	57	81	20,109



TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)**Table 3.3.9: Chiniot Ring Road Average Daily Traffic (ADT) 2020**

FROM	TO	Animal Drawn	Bi-Cycle	Motor Cycle	Rickshaw	Car/Taxi/Jeep	Pajero/Suzuki Pickup	Hiace/Wagon	Mini Bus/Coaster	Bus	Loader Pickup	Tractor Trolley	Trucks				Total
													2-Axle	3-Axle	4-Axle	Trailer / 5-Axle & Above	
Pindi Bhattian/Chiniot	Chenab Nagar	8	7	416	60	68	16	3	5	1	65	27	14	4	1	0	695
	Faisalabad	1	6	85	30	54	6	4	2	1	20	6	15	8	5	3	246
	Bhawana	28	32	4437	1100	875	109	53	23	15	114	144	28	17	6	7	6,988
Chenab Nagar	Pindi Bhattian/Chiniot	12	4	197	40	116	12	8	4	5	20	75	31	34	6	9	573
	Bhawana	14	4	1441	164	359	50	49	17	9	39	92	220	918	8	3	3,387
	Faisalabad	17	6	502	75	198	8	42	10	13	53	79	457	1317	51	33	2,861
Faisalabad	Pindi Bhattian/Chiniot	2	0	101	18	69	6	1	3	2	7	22	17	5	0	0	253
	Bhawana	7	1	680	32	422	6	60	24	23	19	31	157	152	24	15	1653
	Chenab Nagar	103	74	432	120	545	157	129	46	79	113	158	466	910	81	108	3,521
Bhawana	Pindi Bhattian/Chiniot	33	23	4094	716	820	37	51	1	5	74	84	9	0	0	2	5,949
	Faisalabad	5	2	573	16	313	17	33	11	45	40	73	88	72	8	8	1,304
	Chenab Nagar	6	2	501	72	180	3	15	1	1	38	14	155	316	108	17	1,429

3.3.8 Traffic Analysis

It is evident that when the project road will be operational, the number of trips by commuter will increase because of smooth ride, less travel time, travel ease, direct connection and safety. This road will also act as link major arterial and attraction for heavy vehicles.

Following factors were taken in calculating LOS as summarized in table 3.3.10:

PHF	0.92
N	2
f_{HV}	0.91
FM	0
f_{LW}	0
f_{LC}	1.5
f_A	0.7
FFSi	80
FFS	77.8
f_p	1
ET	1.5
E_R	1.2

10% traffic is added as generated traffic which is generated due to provision of improved facility. The present road facility is not in good condition and change in traffic pattern is not expected. Improved facility always create attraction for inhabitation thus generator of traffic.

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)**Table 3.3.10: Year Wise Level of Service on Road Segments**

Year	From	To	No of Lanes	Level of Service (LOS)
2020	Faisalabad	Chiniot	2+2	A
	Chiniot	Lalian	2+2	B
	Lalian	Sargodha	2+2	A
2030	Faisalabad	Chiniot	2+2	B
	Chiniot	Lalian	2+2	C
	Lalian	Sargodha	2+2	B
2040	Faisalabad	Chiniot	2+2	C
	Chiniot	Lalian	2+2	C
	Lalian	Sargodha	2+2	C

Projected Traffic Data

Table 1: Projected Traffic from Faisalabad to Chiniot at Dingru Pull (DC- 1)

Years	VEHICLES													Total Traffic
	Motor Cycle	Rickshaw	Car/Jeep	Pajero/Suzuki Puckup	Hiace Wagon	Mini Bus	Bus	Loader/ pickups	TRACTOR TROLLY	TRUCKS				
										2-Axle	3-Axle	4-Axle	Trailer / 5-Axle & Above	
2020	3324	441	1952	153	358	90	93	290	112	513	823	72	45	8,267
2021	3509	464	2028	159	366	92	95	305	118	530	850	74	47	8,637
2022	3694	487	2103	165	375	94	98	320	124	547	877	77	48	9,008
2023	4268	561	2396	188	421	106	110	368	143	620	995	87	55	10,317
2024	4472	586	2479	194	431	108	112	385	149	639	1025	89	57	10,726
2025	4677	612	2563	201	440	110	115	402	155	657	1055	92	58	11,137
2026	4882	637	2647	207	449	113	117	418	162	676	1085	95	60	11,548
2027	5089	663	2731	214	458	115	119	435	168	695	1115	97	62	11,961
2028	5295	689	2815	220	468	117	122	452	175	714	1146	100	63	12,376
2029	5503	714	2900	227	477	120	124	469	182	733	1176	103	65	12,792
2030	5711	740	2985	234	486	122	127	486	188	752	1207	105	67	13,210
2031	5920	766	3070	240	495	124	129	503	195	771	1238	108	68	13,629
2032	6130	792	3155	247	505	127	131	520	201	791	1269	111	70	14,050
2033	6341	818	3241	254	514	129	134	538	208	810	1300	113	72	14,473
2034	6553	845	3328	261	523	131	136	555	215	829	1331	116	73	14,897
2035	6766	871	3414	267	533	134	139	573	222	849	1363	119	75	15,324
2036	6979	897	3501	274	542	136	141	590	229	869	1394	122	77	15,752
2037	7194	924	3589	281	551	138	144	608	235	889	1426	124	79	16,182
2038	7409	951	3677	288	561	141	146	626	242	908	1458	127	80	16,614
2039	7626	978	3765	295	570	143	148	644	249	928	1490	130	82	17,049
2040	7844	1005	3853	302	580	145	151	662	256	948	1522	133	84	17,485
2041	8062	1032	3942	309	589	148	153	680	263	969	1554	136	86	17,923
2042	8282	1059	4032	316	598	150	156	698	270	989	1587	138	88	18,363
2043	8502	1086	4122	323	608	153	158	717	277	1009	1620	141	89	18,806
2044	8724	1114	4212	330	617	155	161	735	285	1030	1653	144	91	19,250
2045	8947	1141	4302	337	627	157	163	754	292	1050	1686	147	93	19,697
2046	9169	1169	4393	344	637	160	166	772	299	1071	1719	150	95	20,143
2047	9392	1196	4483	351	646	162	168	791	306	1091	1752	153	97	20,589
2048	9615	1224	4574	358	656	165	171	810	313	1112	1785	156	98	21,037
2049	9840	1252	4665	365	665	167	173	829	321	1133	1818	159	100	21,487
2050	10065	1280	4757	372	675	169	176	847	328	1154	1852	162	102	21,939

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TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)**Table 2: Projected Traffic from Chiniot to Faisalabad at Dingru Pull (DC- 1)**

Years	VEHICLES													Total Traffic
	Motor Cycle	Rickshaw	Car/Jeep	Pajero/Suzuki Puckup	Hiace Wagon	Mini Bus	Bus	Loader/ pickups	TRACTOR TROLLY	TRUCKS				
										2-Axle	3-Axle	4-Axle	Trailer / 5-Axle & Above	
2020	3046	350	1564	195	304	85	74	242	103	526	1049	66	46	7,652
2021	3215	368	1624	202	312	87	76	255	108	544	1084	69	48	7,992
2022	3385	387	1685	210	319	90	78	267	113	561	1118	71	49	8,332
2023	3910	446	1920	239	359	101	88	308	130	636	1268	80	56	9,539
2024	4097	466	1986	248	366	103	90	321	136	655	1306	83	57	9,915
2025	4285	486	2053	256	374	105	91	335	142	674	1345	85	59	10,291
2026	4473	506	2120	264	382	107	93	349	148	694	1383	88	61	10,669
2027	4662	527	2188	273	390	109	95	363	154	713	1422	90	62	11,048
2028	4851	547	2255	281	398	112	97	377	160	733	1460	93	64	11,428
2029	5042	567	2323	289	406	114	99	391	166	752	1499	95	66	11,810
2030	5232	588	2391	298	414	116	101	406	172	772	1539	97	67	12,193
2031	5424	609	2459	306	422	118	103	420	178	791	1578	100	69	12,578
2032	5616	629	2528	315	429	121	105	434	184	811	1617	102	71	12,964
2033	5810	650	2597	324	437	123	107	449	190	831	1657	105	73	13,352
2034	6004	671	2666	332	445	125	109	464	197	851	1697	108	74	13,742
2035	6198	692	2735	341	453	127	111	478	203	871	1737	110	76	14,133
2036	6394	713	2805	350	461	129	113	493	209	891	1777	113	78	14,526
2037	6591	734	2875	358	469	132	115	508	215	912	1818	115	80	14,921
2038	6788	755	2945	367	477	134	117	523	222	932	1858	118	81	15,317
2039	6987	777	3016	376	485	136	119	538	228	953	1899	120	83	15,716
2040	7186	798	3087	385	493	138	121	553	234	973	1940	123	85	16,116
2041	7386	820	3158	394	501	141	122	568	241	994	1981	126	87	16,518
2042	7587	841	3230	403	509	143	124	583	247	1015	2023	128	89	16,922
2043	7789	863	3302	411	517	145	126	598	254	1036	2065	131	91	17,328
2044	7993	885	3374	420	525	147	128	614	260	1057	2106	133	92	17,736
2045	8197	907	3447	430	534	150	130	629	267	1078	2149	136	94	18,146
2046	8401	929	3519	439	542	152	132	645	274	1099	2191	139	96	18,556
2047	8604	950	3591	448	550	154	134	660	280	1120	2233	141	98	18,965
2048	8809	972	3664	457	558	157	136	676	287	1141	2275	144	100	19,376
2049	9015	994	3737	466	566	159	138	692	293	1162	2317	147	102	19,789
2050	9222	1017	3811	475	574	161	140	708	300	1184	2360	150	103	20,204

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)**Table 3: Projected Traffic from Chenab Nagar to Laliana at Byco Petrol Pump (DC- 2)**

Years	VEHICLES													Total Traffic
	Motor Cycle	Rickshaw	Car/Jeep	Pajero/Suzuki Puckup	Hiace Wagon	Mini Bus	Bus	Loader/ pickups	TRACTOR TROLLY	TRUCKS				
										2-Axle	3-Axle	4-Axle	Trailer / 5-Axle & Above	
2020	4133	803	1848	247	410	170	138	227	171	534	2119	92	76	10,967
2021	4363	845	1919	256	419	174	142	238	180	551	2188	95	79	11,450
2022	4593	887	1990	266	429	178	145	250	189	569	2258	98	81	11,933
2023	5306	1022	2268	303	482	201	163	288	217	645	2560	111	92	13,658
2024	5560	1069	2346	314	493	205	167	301	227	664	2637	114	95	14,192
2025	5814	1115	2426	324	504	209	170	314	237	684	2715	118	98	14,727
2026	6070	1162	2505	335	514	214	174	327	247	703	2792	121	100	15,263
2027	6326	1208	2584	345	525	218	177	340	257	723	2870	124	103	15,802
2028	6583	1255	2664	356	535	222	181	353	267	743	2949	128	106	16,342
2029	6841	1302	2744	367	546	227	184	367	277	763	3027	131	109	16,884
2030	7100	1349	2825	377	556	231	188	380	287	783	3106	134	112	17,429
2031	7360	1396	2905	388	567	236	192	393	297	803	3186	138	115	17,975
2032	7621	1444	2986	399	578	240	195	407	307	823	3265	141	118	18,524
2033	7883	1491	3068	410	588	245	199	420	317	843	3346	145	120	19,075
2034	8147	1539	3149	421	599	249	202	434	328	863	3426	148	123	19,629
2035	8411	1587	3231	432	610	253	206	448	338	883	3507	152	126	20,184
2036	8677	1636	3314	443	620	258	210	462	348	904	3588	155	129	20,743
2037	8943	1684	3396	454	631	262	213	475	359	924	3670	159	132	21,304
2038	9211	1733	3480	465	642	267	217	489	369	945	3752	162	135	21,867
2039	9481	1782	3563	476	653	271	221	503	380	966	3834	166	138	22,433
2040	9751	1831	3647	487	663	276	224	518	391	987	3917	170	141	23,002
2041	10023	1880	3731	499	674	280	228	532	401	1008	4001	173	144	23,573
2042	10296	1930	3816	510	685	285	231	546	412	1029	4084	177	147	24,147
2043	10570	1980	3901	521	696	289	235	560	423	1050	4168	180	150	24,724
2044	10846	2030	3986	533	707	294	239	575	434	1071	4253	184	153	25,303
2045	11123	2080	4072	544	718	298	243	589	445	1093	4338	188	156	25,885
2046	11399	2130	4157	556	729	303	246	604	456	1114	4423	191	159	26,468
2047	11676	2180	4243	567	740	307	250	618	467	1136	4508	195	162	27,049
2048	11954	2231	4329	578	750	312	254	633	478	1157	4593	199	165	27,633
2049	12233	2282	4415	590	761	316	257	648	489	1179	4679	203	168	28,220
2050	12513	2332	4502	602	772	321	261	663	500	1200	4765	206	171	28,810

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)**Table 4: Projected Traffic from Laliana to Chenab Nagar at Byco Petrol Pump (DC- 2)**

Years	VEHICLES													Total Traffic
	Motor Cycle	Rickshaw	Car/Jeep	Pajero/Suzuki Puckup	Hiace Wagon	Mini Bus	Bus	Loader/ pickups	TRACTOR TROLLY	TRUCKS				
										2-Axle	3-Axle	4-Axle	Trailer / 5-Axle & Above	
2020	4315	750	2661	378	628	305	165	426	214	527	1964	154	130	12,617
2021	4555	789	2764	392	643	312	169	448	225	545	2029	159	134	13,163
2022	4795	828	2866	407	657	319	173	470	236	562	2093	164	139	13,710
2023	5539	954	3266	464	739	359	194	541	272	637	2374	186	157	15,683
2024	5805	997	3380	480	756	367	198	566	285	657	2445	192	162	16,287
2025	6070	1040	3493	496	772	375	203	590	297	676	2517	197	167	16,893
2026	6337	1084	3608	512	788	382	207	615	309	695	2589	203	172	17,500
2027	6605	1127	3722	528	804	390	211	639	322	715	2661	209	176	18,110
2028	6873	1171	3837	545	821	398	215	664	334	734	2734	214	181	18,721
2029	7142	1215	3952	561	837	406	220	689	347	754	2807	220	186	19,335
2030	7413	1259	4068	577	853	414	224	714	359	773	2880	226	191	19,951
2031	7684	1303	4184	594	869	422	228	739	372	793	2953	232	196	20,570
2032	7957	1347	4301	611	886	430	232	765	385	813	3027	237	201	21,191
2033	8231	1392	4418	627	902	438	237	790	398	833	3102	243	206	21,815
2034	8505	1436	4536	644	918	446	241	816	410	853	3176	249	210	22,441
2035	8781	1481	4654	661	935	454	245	842	423	873	3251	255	215	23,070
2036	9059	1526	4773	678	951	461	249	868	436	893	3327	261	220	23,702
2037	9337	1571	4892	694	967	469	254	894	450	914	3402	267	225	24,337
2038	9617	1617	5011	711	984	477	258	920	463	934	3478	273	230	24,975
2039	9898	1663	5132	728	1000	485	262	946	476	955	3555	279	236	25,615
2040	10180	1708	5252	746	1017	494	267	973	489	975	3632	285	241	26,259
2041	10464	1754	5374	763	1033	502	271	1000	503	996	3709	291	246	26,905
2042	10749	1801	5495	780	1050	510	276	1026	516	1017	3787	297	251	27,555
2043	11036	1847	5618	797	1067	518	280	1053	530	1038	3865	303	256	28,207
2044	11323	1894	5741	815	1083	526	284	1081	544	1059	3943	309	261	28,863
2045	11612	1941	5864	832	1100	534	289	1108	557	1080	4022	315	266	29,521
2046	11901	1988	5988	850	1117	542	293	1135	571	1101	4101	322	272	30,180
2047	12190	2035	6111	867	1134	550	297	1163	585	1122	4179	328	277	30,838
2048	12480	2082	6235	885	1150	558	302	1190	599	1143	4258	334	282	31,499
2049	12772	2129	6359	903	1167	566	306	1218	613	1165	4338	340	287	32,163
2050	13064	2176	6484	920	1184	575	311	1246	627	1186	4418	347	293	32,830

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)**Table 5: Projected Traffic from Sargodha to Laliana at Ravi Hotel Near Attock Pump (Point 3)**

Years	VEHICLES													Total Traffic
	Motor Cycle	Rickshaw	Car/Jeep	Pajero/Suzuki Puckup	Hiace Wagon	Mini Bus	Bus	Loader/ pickups	TRACTOR TROLLY	TRUCKS				
										2-Axle	3-Axle	4-Axle	Trailer / 5-Axle & Above	
2020	5754	852	1599	98	200	36	74	151	165	207	2137	38	63	11,373
2021	6074	896	1660	102	205	36	76	159	174	213	2207	39	65	11,906
2022	6395	941	1722	105	209	37	78	167	182	220	2277	41	67	12,441
2023	7387	1084	1962	120	235	42	87	192	210	250	2582	46	76	14,273
2024	7741	1133	2031	124	240	43	89	201	220	257	2660	48	78	14,864
2025	8096	1182	2099	128	246	44	91	209	229	265	2738	49	80	15,455
2026	8451	1231	2168	133	251	45	93	218	239	272	2816	50	83	16,049
2027	8808	1281	2236	137	256	46	95	227	248	280	2895	52	85	16,644
2028	9166	1330	2305	141	261	47	97	235	258	288	2974	53	87	17,242
2029	9525	1380	2375	145	266	47	99	244	267	295	3053	55	89	17,842
2030	9886	1430	2444	149	271	48	101	253	277	303	3133	56	92	18,444
2031	10248	1480	2514	154	277	49	103	262	287	311	3213	57	94	19,049
2032	10612	1530	2584	158	282	50	104	271	297	319	3293	59	97	19,656
2033	10977	1581	2655	162	287	51	106	280	307	326	3374	60	99	20,265
2034	11343	1632	2725	167	292	52	108	289	317	334	3455	62	101	20,877
2035	11711	1683	2796	171	297	53	110	298	327	342	3537	63	104	21,492
2036	12081	1734	2868	175	303	54	112	308	337	350	3618	65	106	22,110
2037	12453	1785	2939	180	308	55	114	317	347	358	3701	66	108	22,731
2038	12826	1837	3011	184	313	56	116	326	357	366	3784	68	111	23,354
2039	13201	1889	3083	189	318	57	118	336	367	374	3867	69	113	23,980
2040	13577	1941	3156	193	324	58	120	345	378	382	3950	71	116	24,609
2041	13955	1993	3229	197	329	59	122	354	388	390	4034	72	118	25,241
2042	14336	2046	3302	202	334	60	124	364	398	398	4119	74	121	25,876
2043	14717	2098	3375	206	339	60	126	373	409	407	4204	75	123	26,514
2044	15101	2152	3449	211	345	61	128	383	419	415	4289	77	126	27,155
2045	15487	2205	3523	215	350	62	130	393	430	423	4375	78	128	27,800
2046	15872	2258	3598	220	355	63	132	402	441	432	4460	80	131	28,444
2047	16257	2311	3672	225	361	64	134	412	451	440	4546	81	133	29,087
2048	16644	2365	3746	229	366	65	136	422	462	448	4632	83	136	29,733
2049	17033	2418	3821	234	371	66	138	432	473	456	4719	84	138	30,383
2050	17423	2472	3896	238	377	67	140	442	483	465	4806	86	141	31,035

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)**Table 6: Projected Traffic from Laliana to Sargodha at Ravi Hotel Near Attock Pump (Point 3)**

Years	VEHICLES													Total Traffic
	Motor Cycle	Rickshaw	Car/Jeep	Pajero/Suzuki Puckup	Hiace Wagon	Mini Bus	Bus	Loader/ pickups	TRACTOR TROLLY	TRUCKS				
										2-Axle	3-Axle	4-Axle	Trailer / 5-Axle & Above	
2020	5364	794	1739	45	161	62	58	161	175	171	1872	70	40	10,712
2021	5662	835	1806	47	165	63	59	169	184	177	1934	73	41	11,215
2022	5961	876	1873	48	169	65	60	178	192	183	1995	75	43	11,719
2023	6886	1010	2135	55	190	73	68	205	222	207	2263	85	48	13,446
2024	7216	1056	2209	57	194	74	70	214	232	213	2331	88	50	14,003
2025	7547	1101	2283	59	198	76	71	223	242	220	2399	90	51	14,560
2026	7878	1147	2358	61	203	77	72	232	252	226	2468	93	53	15,120
2027	8211	1193	2433	63	207	79	74	242	262	232	2537	95	54	15,681
2028	8545	1240	2508	65	211	81	75	251	272	239	2606	98	56	16,245
2029	8880	1286	2583	67	215	82	77	260	282	245	2675	101	57	16,810
2030	9216	1333	2659	69	219	84	78	270	292	251	2745	103	59	17,378
2031	9553	1379	2735	71	223	85	80	279	303	258	2815	106	60	17,948
2032	9892	1426	2811	73	228	87	81	289	313	264	2886	108	62	18,520
2033	10232	1473	2888	74	232	89	83	299	324	271	2957	111	63	19,095
2034	10574	1520	2965	76	236	90	84	308	334	277	3028	114	65	19,672
2035	10917	1568	3042	78	240	92	86	318	345	284	3099	116	66	20,252
2036	11262	1616	3119	80	244	93	87	328	355	290	3171	119	68	20,834
2037	11608	1664	3197	82	249	95	89	338	366	297	3243	122	69	21,419
2038	11956	1712	3276	84	253	97	90	348	377	303	3316	125	71	22,007
2039	12305	1760	3354	87	257	98	92	358	387	310	3389	127	72	22,597
2040	12656	1808	3433	89	261	100	94	368	398	317	3462	130	74	23,190
2041	13009	1857	3512	91	266	101	95	378	409	324	3535	133	75	23,786
2042	13363	1906	3592	93	270	103	97	388	420	330	3609	136	77	24,385
2043	13719	1955	3672	95	274	105	98	398	431	337	3684	138	79	24,986
2044	14077	2005	3752	97	278	106	100	408	442	344	3759	141	80	25,590
2045	14437	2054	3833	99	283	108	101	419	454	351	3834	144	82	26,198
2046	14796	2104	3914	101	287	110	103	429	465	358	3909	147	83	26,805
2047	15155	2154	3994	103	291	111	104	439	476	365	3984	150	85	27,411
2048	15515	2204	4075	105	296	113	106	450	487	372	4059	153	87	28,021
2049	15878	2254	4156	107	300	115	107	460	499	378	4135	155	88	28,633
2050	16242	2304	4238	109	304	116	109	471	510	385	4211	158	90	29,248

Survey Form

[Type here]

Table 7: OD Survey Form

ORIGIN / DESTINATION SURVEY SHEET
HYDERABAD - SUKKAR MOTORWAY

DATE: _____
DAY: _____
TIME: _____
LOCATION: _____

ENUMERATOR: _____
CHECKED BY: _____
ROAD: _____
DIRECTION: _____

S.NO	CAR/JEEP/TAXI	SUZUKI LOADER PICKUP	HIACE WAGON	MINIBUS/ COASTER	BUS	TRUCK				ORIGIN	DESTINATION
						2-Axle	3-Axle	4-Axle	5-Axle & Above		
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											

[Type here]

Annexure-3

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=60KM)**Table 8: Future Rates of Traffic Growth (% / Annum)**

YEARS	MOTOR CYCLE	RICKSHAW	CAR/JEEP/ TAXI/PICK-UP/	BUS / MINI- BUS	DILIVERY VAN / LOADER PICK-UP	TRUCK / TRAILER
2018	8.5789	7.8324	4.9993	2.6005	6.3483	3.8185
2019	7.9573	7.2958	4.7772	2.5225	5.9869	3.6818
2020	7.3705	6.7844	4.5438	2.4336	5.6350	3.5359
2021	6.8643	6.3415	4.3336	2.3524	5.3235	3.4024
2022	6.4232	5.9540	4.1430	2.2779	5.0455	3.2796
2023	6.0354	5.6120	3.9694	2.2091	4.7959	3.1663
2024	5.6918	5.3078	3.8104	2.1454	4.5704	3.0612
2025	5.3852	5.0353	3.6642	2.0860	4.3657	2.9634
2026	5.1100	4.7899	3.5293	2.0306	4.1788	2.8721
2027	4.8615	4.5675	3.4043	1.9787	4.0076	2.7866
2028	4.6361	4.3652	3.2882	1.9299	3.8502	2.7065
2029	4.4306	4.1802	3.1800	1.8839	3.7048	2.6311
2030	4.2426	4.0104	3.0790	1.8405	3.5702	2.5600
2031	4.0699	3.8540	2.9843	1.7994	3.4451	2.4928
2032	3.9107	3.7095	2.8954	1.7604	3.3287	2.4293
2033	3.7635	3.5755	2.8118	1.7233	3.2199	2.3690
2034	3.6270	3.4509	2.7330	1.6881	3.1182	2.3118
2035	3.5001	3.3348	2.6587	1.6544	3.0227	2.2575
2036	3.3817	3.2263	2.5883	1.6223	2.9330	2.2057
2037	3.2711	3.1246	2.5216	1.5916	2.8485	2.1563
2038	3.1674	3.0293	2.4584	1.5622	2.7687	2.1092
2039	3.0702	2.9396	2.3983	1.5341	2.6934	2.0642
2040	2.9787	2.8551	2.3411	1.5070	2.6221	2.0211
2041	2.8926	2.7753	2.2867	1.4810	2.5545	1.9798
2042	2.8112	2.7000	2.2347	1.4561	2.4903	1.9402
2043	2.7344	2.6286	2.1851	1.4320	2.4293	1.9023
2044	2.6616	2.5609	2.1377	1.4088	2.3712	1.8658
2045	2.5926	2.4966	2.0923	1.3865	2.3159	1.8307

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=60KM)**Table 9: Future Rates of Traffic Growth Factors**

YEARS	MOTOR CYCLE	RICKSHAW	CAR/JEEP/ TAXI/PICK-UP/	BUS / MINI- BUS	DILIVERY VAN / LOADER PICK-UP	TRUCK / TRAILER
2018	1.0858	1.0783	1.0500	1.0260	1.0635	1.0382
2019	1.0796	1.0730	1.0478	1.0252	1.0599	1.0368
2020	1.0737	1.0678	1.0454	1.0243	1.0564	1.0354
2021	1.0686	1.0634	1.0433	1.0235	1.0532	1.0340
2022	1.0642	1.0595	1.0414	1.0228	1.0505	1.0328
2023	1.0604	1.0561	1.0397	1.0221	1.0480	1.0317
2024	1.0569	1.0531	1.0381	1.0215	1.0457	1.0306
2025	1.0539	1.0504	1.0366	1.0209	1.0437	1.0296
2026	1.0511	1.0479	1.0353	1.0203	1.0418	1.0287
2027	1.0486	1.0457	1.0340	1.0198	1.0401	1.0279
2028	1.0464	1.0437	1.0329	1.0193	1.0385	1.0271
2029	1.0443	1.0418	1.0318	1.0188	1.0370	1.0263
2030	1.0424	1.0401	1.0308	1.0184	1.0357	1.0256
2031	1.0407	1.0385	1.0298	1.0180	1.0345	1.0249
2032	1.0391	1.0371	1.0290	1.0176	1.0333	1.0243
2033	1.0376	1.0358	1.0281	1.0172	1.0322	1.0237
2034	1.0363	1.0345	1.0273	1.0169	1.0312	1.0231
2035	1.0350	1.0333	1.0266	1.0165	1.0302	1.0226
2036	1.0338	1.0323	1.0259	1.0162	1.0293	1.0221
2037	1.0327	1.0312	1.0252	1.0159	1.0285	1.0216
2038	1.0317	1.0303	1.0246	1.0156	1.0277	1.0211
2039	1.0307	1.0294	1.0240	1.0153	1.0269	1.0206
2040	1.0298	1.0286	1.0234	1.0151	1.0262	1.0202
2041	1.0289	1.0278	1.0229	1.0148	1.0255	1.0198
2042	1.0281	1.0270	1.0223	1.0146	1.0249	1.0194
2043	1.0273	1.0263	1.0219	1.0143	1.0243	1.0190
2044	1.0266	1.0256	1.0214	1.0141	1.0237	1.0187
2045	1.0259	1.0250	1.0209	1.0139	1.0232	1.0183

Table 10: Fuel Consumption

YEARS	Tonnes	Growth Rate (%)
2006-2007	7981893	4.53
2007-2008	9384482	
2008-2009	8837197	
2009-2010	8860880	
2010-2011	8892268	
2011-2012	9265883	
2012-2013	9817546	
2013-2014	10299718	
2014-2015	11372924	14.51
2015-2016	13022573	11.98
2016-2017	14582925	10.04
2017-2018	16047392	8.91
2018-2019	17476711	8.41
2019-2020	18947246	7.76
2020-2021	20417781	7.20
2021-2022	21888316	6.72
2022-2023	23358851	6.30
2023-2024	24829386	5.92
2024-2025	26299921	5.59
2025-2026	27770455	5.30
2026-2027	29240990	5.03
2027-2028	30711525	4.79
2028-2029	32182060	4.57
2029-2030	33652595	4.37
2030-2031	35123130	4.19
2031-2032	36593665	4.02
2032-2033	38064200	3.86
2033-2034	39534735	3.72
2034-2035	41005270	3.59
2035-2036	42475804	3.46
2036-2037	43946339	3.35
2037-2038	45416874	3.24
2038-2039	46887409	3.14
2039-2040	48357944	3.04
2040-2041	49828479	2.95
2041-2042	51299014	2.87
2042-2043	52769549	2.79
2043-2044	54240084	2.71
2044-2045	55710619	2.64
2045-2046	57181153	

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=60KM)**Table 11: CNG Consumption (mm/cft)**

YEARS	MM/CF	Growth Rate (%)
2006-2007	56446	14.48
2007-2008	72018	
2008-2009	88236	
2009-2010	99002	
2010-2011	113055	
2011-2012	119000	
2012-2013	138863	
2013-2014	152703	
2014-2015	166544	8.31
2015-2016	180384	7.67
2016-2017	194225	7.13
2017-2018	208065	6.65
2018-2019	221905	6.24
2019-2020	235746	5.87
2020-2021	249586	5.55
2021-2022	263427	5.25
2022-2023	277267	4.99
2023-2024	291108	4.75
2024-2025	304948	4.54
2025-2026	318789	4.34
2026-2027	332629	4.16
2027-2028	346470	3.99
2028-2029	360310	3.84
2029-2030	374151	3.70
2030-2031	387991	3.57
2031-2032	401832	3.44
2032-2033	415672	3.33
2033-2034	429512	3.22
2034-2035	443353	3.12
2035-2036	457193	3.03
2036-2037	471034	2.94
2037-2038	484874	2.85
2038-2039	498715	2.78
2039-2040	512555	2.70
2040-2041	526396	2.63
2041-2042	540236	2.56
2042-2043	554077	

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=60KM)**Table 12: Gross Domestic Product (fc)**

YEARS	MM/CF	Growth Rate (%)
2006-2007	56446	14.48
2007-2008	72018	
2008-2009	88236	
2009-2010	99002	
2010-2011	113055	
2011-2012	119000	
2012-2013	138863	
2013-2014	152703	
2014-2015	166544	8.31
2015-2016	180384	7.67
2016-2017	194225	7.13
2017-2018	208065	6.65
2018-2019	221905	6.24
2019-2020	235746	5.87
2020-2021	249586	5.55
2021-2022	263427	5.25
2022-2023	277267	4.99
2023-2024	291108	4.75
2024-2025	304948	4.54
2025-2026	318789	4.34
2026-2027	332629	4.16
2027-2028	346470	3.99
2028-2029	360310	3.84
2029-2030	374151	3.70
2030-2031	387991	3.57
2031-2032	401832	3.44
2032-2033	415672	3.33
2033-2034	429512	3.22
2034-2035	443353	3.12
2035-2036	457193	3.03
2036-2037	471034	2.94
2037-2038	484874	2.85
2038-2039	498715	2.78
2039-2040	512555	2.70
2040-2041	526396	2.63
2041-2042	540236	2.56
2042-2043	554077	

Table 13: Vehicle Registered In Punjab

YEAR	Car/Jeep /Wagon	Motor Cycle	Truck	Bus	Delivery Van	Rickshaw	Others	TOTAL
2010	1174570	5253715	698829	72103	102681	175921	6041	7483860
2011	1276719	6251043	740927	74219	108599	203527	24807	8679841
2012	1316608	7309223	760893	76147	175550	229596	25356	9893373
2013	1569912	8427062	792387	83817	182104	258164	21958	11335404
2014	1628764	10389810	841198	88573	192321	319215	25601	13485482
2015	1684608	11218816	885130	101125	267370	346979	28325	14532353
2016	1932280	13144241	891012	94629	238346	415764	26610	16742882
2017	2025273	13424092	534135	170988	259728	484836	8477	16907529
2018	1758370	13424062	534135	128499	259728	484836	7124	16596754

Table 14: Future Projection and Growth Rates

Present Data and Future Projection									Future Growth Rates (%)							
YEAR	Car/Jeep /Wagon	Motor Cycle	Truck	Bus	Delivery Van	Rickshaw	Others	TOTAL	Car/Jeep /Wagon	Motor Cycle	Truck	Bus	Delivery Van	Rickshaw	Others	TOTAL
2010	1174570	5253715	698829	72103	102681	175921	6041	7483860	7.88	15.14	4.27	5.30	15.81	13.81	27.19	13.26
2011	1276719	6251043	740927	74219	108599	203527	24807	8679841								
2012	1316608	7309223	760893	76147	175550	229596	25356	9893373								
2013	1569912	8427062	792387	83817	182104	258164	21958	11335404								
2014	1628764	10389810	841198	88573	192321	319215	25601	13485482								
2015	1684608	11218816	885130	101125	267370	346979	28325	14532353								
2016	1932280	13144241	891012	94629	238346	415764	26610	16742882								
2017	1997789	14097374	936519	103490	286897	435031	32527	17889628								
2018	2119256	15407650	970279	108269	313372	474176	34990	19427992	5.73	8.50	3.48	4.41	8.45	8.26	7.04	7.92
2019	2240722	16717925	1004038	113048	339848	513321	37454	20966356	5.42	7.84	3.36	4.23	7.79	7.63	6.58	7.34
2020	2362189	18028201	1037797	117827	366323	552465	39918	22504720	5.14	7.27	3.25	4.06	7.23	7.09	6.17	6.84
2021	2483656	19338476	1071557	122606	392798	591610	42382	24043085	4.89	6.78	3.15	3.90	6.74	6.62	5.81	6.40
2022	2605122	20648751	1105316	127386	419273	630755	44846	25581449	4.66	6.35	3.05	3.75	6.31	6.21	5.49	6.01
2023	2726589	21959027	1139075	132165	445749	669899	47310	27119813	4.45	5.97	2.96	3.62	5.94	5.84	5.21	5.67
2024	2848055	23269302	1172834	136944	472224	709044	49774	28658177	4.26	5.63	2.88	3.49	5.61	5.52	4.95	5.37
2025	2969522	24579578	1206594	141723	498699	748189	52237	30196542	4.09	5.33	2.80	3.37	5.31	5.23	4.72	5.09
2026	3090988	25889853	1240353	146502	525175	787334	54701	31734906	3.93	5.06	2.72	3.26	5.04	4.97	4.50	4.85
2027	3212455	27200128	1274112	151281	551650	826478	57165	33273270	3.78	4.82	2.65	3.16	4.80	4.74	4.31	4.62
2028	3333922	28510404	1307872	156060	578125	865623	59629	34811634	3.64	4.60	2.58	3.06	4.58	4.52	4.13	4.42
2029	3455388	29820679	1341631	160840	604600	904768	62093	36349999	3.52	4.39	2.52	2.97	4.38	4.33	3.97	4.23
2030	3576855	31130955	1375390	165619	631076	943912	64557	37888363	3.40	4.21	2.45	2.89	4.20	4.15	3.82	4.06
2031	3698321	32441230	1409149	170398	657551	983057	67021	39426727	3.28	4.04	2.40	2.80	4.03	3.98	3.68	3.90
2032	3819788	33751505	1442909	175177	684026	1022202	69484	40965091	3.18	3.88	2.34	2.73	3.87	3.83	3.55	3.76

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2033	3941254	35061781	1476668	179956	710502	1061347	71948	42503456	3.08	3.74	2.29	2.66	3.73	3.69	3.42	3.62
2034	4062721	36372056	1510427	184735	736977	1100491	74412	44041820	2.99	3.60	2.24	2.59	3.59	3.56	3.31	3.49
2035	4184188	37682332	1544187	189514	763452	1139636	76876	45580184	2.90	3.48	2.19	2.52	3.47	3.43	3.20	3.38
2036	4305654	38992607	1577946	194294	789927	1178781	79340	47118548	2.82	3.36	2.14	2.46	3.35	3.32	3.11	3.26
2037	4427121	40302882	1611705	199073	816403	1217925	81804	48656913	2.74	3.25	2.09	2.40	3.24	3.21	3.01	3.16
2038	4548587	41613158	1645464	203852	842878	1257070	84268	50195277	2.67	3.15	2.05	2.34	3.14	3.11	2.92	3.06
2039	4670054	42923433	1679224	208631	869353	1296215	86731	51733641	2.60	3.05	2.01	2.29	3.05	3.02	2.84	2.97
2040	4791520	44233708	1712983	213410	895829	1335360	89195	53272005	2.54	2.96	1.97	2.24	2.96	2.93	2.76	2.89
2041	4912987	45543984	1746742	218189	922304	1374504	91659	54810370	2.47	2.88	1.93	2.19	2.87	2.85	2.69	2.81
2042	5034454	46854259	1780502	222968	948779	1413649	94123	56348734	2.41	2.80	1.90	2.14	2.79	2.77	2.62	2.73
2043	5155920	48164535	1814261	227748	975254	1452794	96587	57887098	2.36	2.72	1.86	2.10	2.71	2.69	2.55	2.66
2044	5277387	49474810	1848020	232527	1001730	1491938	99051	59425462	2.30	2.65	1.83	2.06	2.64	2.62	2.49	2.59
2045	5398853	50785085	1881779	237306	1028205	1531083	101515	60963827	2.25	2.58	1.79	2.01	2.57	2.56	2.43	2.52
2046	5520320	52095361	1915539	242085	1054680	1570228	103978	62502191	2.20	2.52	1.76	1.97	2.51	2.49	2.37	2.46
2047	5641786	53405636	1949298	246864	1081156	1609373	106442	64040555	2.15	2.45	1.73	1.94	2.45	2.43	2.31	2.40
2048	5763253	54715912	1983057	251643	1107631	1648517	108906	65578919	2.11	2.39	1.70	1.90	2.39	2.37	2.26	2.35
2049	5884720	56026187	2016817	256422	1134106	1687662	111370	67117284	2.06	2.34	1.67	1.86	2.33	2.32	2.21	2.29
2050	6006186	57336462	2050576	261202	1160581	1726807	113834	68655648	2.02	2.29	1.65	1.83	2.28	2.27	2.16	2.24
2051	6127653	58646738	2084335	265981	1187057	1765951	116298	70194012								

Table 15: Vehicle Registered In Faisalabad

YEAR	Car/Jeep /Wagon	Motor Cycle	Truck	Bus	Delivery Van	Rickshaw	Others	TOTAL
2010	75342	469002	31529	5418	6487	15631	45	603454
2011	77638	529726	32509	5428	6691	17535	56	669583
2012	80933	611682	32915	5456	7722	18688	57	757453
2013	82922	709376	33829	5523	7994	19424	47	859115
2014	87643	881098	34779	5571	8399	20510	83	1038083
2015	90042	946623	38917	5653	11943	21292	101	1114571
2016	94136	1112180	35701	5736	11902	24236	104	1283995
2017	95418	1120119	22331	8030	15511	22152	181	1283742
2018	88781	1120119	22331	7575	15511	22152	180	1276649
2012	80933	611682	32915	5456	7722	18688	57	757453

Table 16: Future Projection and Growth Rates

Present Data and Future Projection									Future Growth Rates (%)							
YEAR	Car/Jeep /Wagon	Motor Cycle	Truck	Bus	Delivery Van	Rickshaw	Others	TOTAL	Car/Jeep /Wagon	Motor Cycle	Truck	Bus	Delivery Van	Rickshaw	Others	TOTAL
2010	75342	469002	31529	5418	6487	15631	45	603454	3.62	14.15	3.49	0.87	10.01	6.72	13.95	12.34
2011	77638	529726	32509	5428	6691	17535	56	669583								
2012	80933	611682	32915	5456	7722	18688	57	757453								
2013	82922	709376	33829	5523	7994	19424	47	859115								
2014	87643	881098	34779	5571	8399	20510	83	1038083								
2015	90042	946623	38917	5653	11943	21292	101	1114571								
2016	94136	1112180	38990	5736	11902	24236	104	1283995								
2017	96651	1184633	40076	5758	12652	24638	112	1362640								
2018	99790	1292945	41400	5812	13632	25894	123	1477363	3.15	8.38	3.20	0.93	7.19	4.85	8.52	7.77
2019	102929	1401258	42723	5866	14611	27149	133	1592085	3.05	7.73	3.10	0.92	6.70	4.62	7.86	7.21
2020	106069	1509570	44047	5920	15591	28404	144	1706808	2.96	7.18	3.01	0.92	6.28	4.42	7.28	6.72
2021	109208	1617882	45371	5975	16570	29660	154	1821530	2.87	6.69	2.92	0.91	5.91	4.23	6.79	6.30
2022	112347	1726194	46694	6029	17550	30915	165	1936253	2.79	6.27	2.83	0.90	5.58	4.06	6.36	5.92
2023	115487	1834507	48018	6083	18529	32171	175	2050975	2.72	5.90	2.76	0.89	5.29	3.90	5.98	5.59
2024	118626	1942819	49342	6137	19509	33426	186	2165698	2.65	5.58	2.68	0.88	5.02	3.76	5.64	5.30
2025	121765	2051131	50665	6192	20488	34681	196	2280420	2.58	5.28	2.61	0.88	4.78	3.62	5.34	5.03
2026	124904	2159444	51989	6246	21468	35937	206	2395143	2.51	5.02	2.55	0.87	4.56	3.49	5.07	4.79
2027	128044	2267756	53313	6300	22447	37192	217	2509865	2.45	4.78	2.48	0.86	4.36	3.38	4.82	4.57
2028	131183	2376068	54636	6354	23427	38447	227	2624588	2.39	4.56	2.42	0.85	4.18	3.27	4.60	4.37
2029	134322	2484380	55960	6409	24406	39703	238	2739310	2.34	4.36	2.37	0.85	4.01	3.16	4.40	4.19
2030	137462	2592693	57284	6463	25386	40958	248	2854032	2.28	4.18	2.31	0.84	3.86	3.07	4.21	4.02
2031	140601	2701005	58607	6517	26365	42214	259	2968755	2.23	4.01	2.26	0.83	3.72	2.97	4.04	3.86
2032	143740	2809317	59931	6571	27345	43469	269	3083477	2.18	3.86	2.21	0.83	3.58	2.89	3.89	3.72

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2033	146879	2917630	61255	6626	28324	44724	280	3198200	2.14	3.71	2.16	0.82	3.46	2.81	3.74	3.59
2034	150019	3025942	62578	6680	29304	45980	290	3312922	2.09	3.58	2.12	0.81	3.34	2.73	3.61	3.46
2035	153158	3134254	63902	6734	30283	47235	301	3427645	2.05	3.46	2.07	0.81	3.23	2.66	3.48	3.35
2036	156297	3242566	65226	6788	31263	48491	311	3542367	2.01	3.34	2.03	0.80	3.13	2.59	3.36	3.24
2037	159437	3350879	66549	6843	32242	49746	322	3657090	1.97	3.23	1.99	0.79	3.04	2.52	3.25	3.14
2038	162576	3459191	67873	6897	33222	51001	332	3771812	1.93	3.13	1.95	0.79	2.95	2.46	3.15	3.04
2039	165715	3567503	69197	6951	34201	52257	343	3886535	1.89	3.04	1.91	0.78	2.86	2.40	3.06	2.95
2040	168854	3675816	70520	7005	35181	53512	353	4001257	1.86	2.95	1.88	0.77	2.78	2.35	2.96	2.87
2041	171994	3784128	71844	7060	36160	54768	363	4115980	1.83	2.86	1.84	0.77	2.71	2.29	2.88	2.79
2042	175133	3892440	73168	7114	37140	56023	374	4230702	1.79	2.78	1.81	0.76	2.64	2.24	2.80	2.71
2043	178272	4000752	74492	7168	38119	57278	384	4345425	1.76	2.71	1.78	0.76	2.57	2.19	2.72	2.64
2044	181412	4109065	75815	7222	39099	58534	395	4460147	1.73	2.64	1.75	0.75	2.51	2.14	2.65	2.57
2045	184551	4217377	77139	7277	40078	59789	405	4574869	1.70	2.57	1.72	0.75	2.44	2.10	2.58	2.51
2046	187690	4325689	78463	7331	41058	61045	416	4689592								

Table 17: Vehicle Registered

YEAR	Car/Jeep /Wagon	Motor Cycle	Truck	Bus	Delivery Van	Rickshaw	Others	TOTAL
2010	11526	170524	31315	2231	3708	5635	106	225045
2011	11661	205275	32543	2244	3750	6240	106	261819
2012	12176	250034	33005	2231	4367	7908	109	309830
2013	12329	297687	33895	2300	4398	11014	57	361680
2014	13534	353589	35217	2322	4440	18339	117	427558
2015	13800	377499	37011	2432	5727	21965	133	458567
2016	15474	436407	34724	2361	4934	18339	123	512362
2017	31524	408024	23097	3364	5712	37232	86	509039
2018	27932	408024	23097	3123	5712	37232	78	505198

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Table 18 Future Projection and Growth Rates

Present Data and Future Projection									Future Growth Rates (%)							
YEAR	Car/Jeep /Wagon	Motor Cycle	Truck	Bus	Delivery Van	Rickshaw	Others	TOTAL	Car/Jeep /Wagon	Motor Cycle	Truck	Bus	Delivery Van	Rickshaw	Others	TOTAL
2010	11526	170524	31315	2231	3708	5635	106	225045	4.25	15.82	2.42	1.20	6.00	23.15	2.20	13.95
2011	11661	205275	32543	2244	3750	6240	106	261819								
2012	12176	250034	33005	2231	4367	7908	109	309830								
2013	12329	297687	33895	2300	4398	11014	57	361680								
2014	13534	353589	35217	2322	4440	18339	117	427558								
2015	13800	377499	37011	2432	5727	21965	133	458567								
2016	15474	436407	34724	2361	4934	18339	123	512362								
2017	15426	476667	37012	2425	5576	24205	123	561434	3.89	8.54	2.02	1.25	4.70	10.56	3.17	8.03
2018	16050	521154	37776	2456	5851	27062	127	610476								
2019	16674	565642	38539	2487	6126	29919	132	659518								
2020	17299	610129	39302	2517	6401	32775	136	708560								
2021	17923	654617	40066	2548	6676	35632	140	757602								
2022	18547	699105	40829	2578	6951	38489	144	806644								
2023	19171	743592	41593	2609	7227	41346	148	855686								
2024	19796	788080	42356	2640	7502	44203	152	904727								
2025	20420	832567	43119	2670	7777	47060	156	953769								
2026	21044	877055	43883	2701	8052	49917	160	1002811								
2027	21669	921542	44646	2732	8327	52774	164	1051853								
2028	22293	966030	45409	2762	8603	55631	168	1100895								
2029	22917	1010518	46173	2793	8878	58487	172	1149937								
2030	23541	1055005	46936	2823	9153	61344	176	1198979								
2031	24166	1099493	47700	2854	9428	64201	180	1248021								
2032	24790	1143980	48463	2885	9703	67058	184	1297063								

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2033	25414	1188468	49226	2915	9978	69915	188	1346105	2.46	3.74	1.55	1.05	2.76	4.09	2.15	3.64
2034	26039	1232955	49990	2946	10254	72772	192	1395147	2.40	3.61	1.53	1.04	2.68	3.93	2.10	3.52
2035	26663	1277443	50753	2976	10529	75629	196	1444189	2.34	3.48	1.50	1.03	2.61	3.78	2.06	3.40
2036	27287	1321931	51517	3007	10804	78486	200	1493231	2.29	3.37	1.48	1.02	2.55	3.64	2.02	3.28
2037	27911	1366418	52280	3038	11079	81343	204	1542273	2.24	3.26	1.46	1.01	2.48	3.51	1.98	3.18
2038	28536	1410906	53043	3068	11354	84199	208	1591315	2.19	3.15	1.44	1.00	2.42	3.39	1.94	3.08
2039	29160	1455393	53807	3099	11630	87056	212	1640357	2.14	3.06	1.42	0.99	2.37	3.28	1.90	2.99
2040	29784	1499881	54570	3129	11905	89913	216	1689399	2.10	2.97	1.40	0.98	2.31	3.18	1.87	2.90
2041	30409	1544368	55334	3160	12180	92770	220	1738441	2.05	2.88	1.38	0.97	2.26	3.08	1.83	2.82
2042	31033	1588856	56097	3191	12455	95627	224	1787483	2.01	2.80	1.36	0.96	2.21	2.99	1.80	2.74
2043	31657	1633344	56860	3221	12730	98484	228	1836525	1.97	2.72	1.34	0.95	2.16	2.90	1.77	2.67
2044	32281	1677831	57624	3252	13005	101341	232	1885567	1.93	2.65	1.32	0.94	2.12	2.82	1.74	2.60
2045	32906	1722319	58387	3282	13281	104198	236	1934609	1.90	2.58	1.31	0.93	2.07	2.74	1.71	2.53
2046	33530	1766806	59151	3313	13556	107055	240	1983651								

3.4. PAVEMENT DESIGN REPORT



3.4.1 PAVEMENT DESIGN ACTIVITIES:

Pavement design depends upon two basic parameters; traffic and soil strength. The pavement design of the project road has been carried using AASHTO 1993 approach. The AASHTO procedure uses Serviceability Indices, environment, drainage and reliability, Structural Numbers, layer thicknesses.

3.4.2 TRAFFIC STUDIES:

Traffic studies are intended to provide necessary input data for determination of the magnitude and pattern of the traffic load for the project highway through the design period. This entails collection, verification and analysis of the traffic data. From the collected data, the projected traffic for the design life of the subject highway is determined. For details, refer Traffic Study Report.

3.4.3 DESIGN LIFE:

Design life is the number of years reckoned from the completion of pavement construction and application of traffic load until the time when major maintenance is required so that it can continue to carry traffic satisfactorily for further period.

A design period of 10 years has been adopted, which is a normal practice, taking base year as 2023 to calculate the traffic load and eventually carrying out pavement design. However, the ESALs have been calculated for 25 years from base year to work out the thickness requirement of unbound layers, in order to provide a foundation that can sustain 25 years structural life. For asphalt layers, stage construction is opted; the asphalt requirement for 10 years design life is ascertained and shall be placed so that the pavement can perform satisfactorily for 10 years subject to adopting quality control measures during execution of the project.

3.4.4 EQUIVALENT STANDARD AXLE LOAD:

In order to determine the cumulative axle load damage that a pavement will sustain during its design life, it is necessary to express the total number of heavy vehicles that will use the road during the design period, in terms of the cumulative number of Equivalent Single Axle Load (ESALs).

3.4.4.1 Equivalent Axle Load Factors:

The damage caused by vehicles to a road depends on the axle loads and wheel configuration of the vehicles. It is, therefore, important to determine the axle loads of



Heavy commercial vehicles in the projected traffic mix that is likely to use project road in future.

For pavement design purposes the damaging power of axles is related to a standard axle of 8.16 tones (18000 lbs) using equivalence factors which have been derived from empirical studies.

Equivalent Axle Load Factors (EALF) are determined separately, for different types of axle configurations. The EALF obtained by NTRC Survey 1995 have been adopted.

3.4.4.2 Calculation of Cumulative Equivalent Single Axle Loads (ESALs):

In order to determine the cumulative ESALs over the design period the following procedure has been adopted.

- AADT has been determined.
- Direction Factor value has been selected.
- Annual traffic in design lane has been determined.
- Equivalent Axle Load Factors (EALF), for each class of vehicle i.e. Loaded and Empty has been used.
- Equivalent Single Axle Load (ESALs) has been estimated.

3.4.4.3 Total ESALs for the Design Life:

The pavement design procedure is based on the cumulative number of expected Equivalent Single-Axle Loads (ESALs) during the design period. The projected cumulative ESALs for the aforementioned project road has been computed over the design life of the project and mentioned in the Annexure-4.

3.4.5 DESIGN CBR:

The pavement design is based on minimum soaked CBR 10% @ 95 % M.D.D. for Subgrade.

3.4.6 PAVEMENT DESIGN ANALYSIS:

The pavement design process is the technique of developing a combination of top layers of different materials in most economical manner to cater for the total axle load over the



design life of the pavement. In other words, this is an art through which the stresses as induced in the top layers of a highway due to movement of heavy wheel load are disseminated and minimized to safe level through selection of different type and appropriate thickness of pavement layers.

The AASHTO Guide for Design of Pavement Structure 1993 has been used to compute the pavement thicknesses.

3.4.6.1 AASHTO Procedure for Flexible Pavement Design:

The AASHTO Guide for design Pavement Structures 1993 outlines this procedure for determination of flexible pavement thickness by solving AASHTO equations manually, by using different monographs or by using the computer software. For accuracy the computer program is preferred. Basically, the Structure Number (SN) required to be assigned to the proposed pavement structure for a given set of conditions is determined by solving the following numerical equation.

The required variable data to be substituted into this equation is:

$$\log_{10} W_{18} = Z_R * S_o + 9.36 * \log_{10}(SN + 1) - 0.20 + \frac{\log_{10}[\Delta PSI/4.2-1.5]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32 * \log_{10} M_R - 8.07$$

- The estimated future traffic in terms of ESAL, for the design period, W_{18}
- The Reliability Level, R
- Standard Normal Deviate Value, Z_R
- The overall Standard Deviation, S_o
- The roadbed soil Resilient Modulus, M_R
- The design serviceability loss, $\Delta PSI = P_o - P_t$.

The above General Design Variables have been discussed in the following paragraphs.

- **Reliability (R)**

Design reliability refers to the degree of certainty that a given design alternative will last for the entire design period. A design reliability level of 90% has been adopted for pavement design of the project road.

- **Standard Normal Deviation (Z_R)**

The standard normal deviation value of -1.282 corresponding to reliability (R) of 90% has been adopted in the design and is based on the recommended values of standard normal deviation (Z_R) by AASHTO Guide 1993.



- **Standard Deviation (S_o)**

The reliability factor is a function of the overall standard deviation that accounts for standard variation in materials and construction, the probable variation in the traffic prediction and the normal variation in pavement performance for a given design traffic application. The recommended value of standard deviation for total variation in material properties and in traffic estimation for flexible pavement is 0.45 and has been adopted for pavement design of the project road.

- **Performance Criteria**

The serviceability of a pavement is defined as its ability to serve the type of traffic that uses the facility. Initial and terminal serviceability indices have been established to compute the total change in serviceability that will be used in the design equations.

- **Initial Serviceability Index (P_o)**

The initial serviceability index is a function of pavement design and construction quality. For flexible pavement design the typical value, as recommended by AASHTO Road Test, is 4.2 which has been adopted.

- **Terminal Serviceability Index (P_t)**

The terminal serviceability index is the lowest index that will be tolerated before rehabilitation, resurfacing or reconstruction, becomes necessary and it generally varies with the importance or functional classification of the pavement. Recommended value of terminal serviceability index is 2.5 for the project road.

- **Resilient Modulus M_R**

The basis for material characterization in the AASHTO Guide 1993 is Elastic or Resilient Modulus (MR). The following correlation between CBR and M_R has been used to determine resilient modulus of unbound layers. (Refer NCHRP National Cooperative Highway Research Programme and MEPDG (Mechanistic Empirical Pavement Design Guide).

$$M_R = 2555 (\text{CBR})^{0.64}$$

Where;

CBR =California Bearing Ratio in percentage.

M_R = Resilient modulus in psi



3.4.6.2 Computation of Required Pavement Thickness:

The structure number (SN) requirement as determined through adopting the design parameters as discussed above is balanced by providing adequate pavement structure. Under AASHTO design procedure the following equation provides the means for converting the structural number into actual thicknesses of surfacing, base and sub base materials:

$$SN = a_1 D_1 + a_2 D_2 m_2 + a_3 D_3 m_3$$

Where:

- a_1, a_2, a_3 = layer coefficients representative of surface, base and sub base courses respectively
- D_1, D_2, D_3 = actual thicknesses (in inches) of surface, base and sub base courses respectively
- m_2, m_3 = drainage coefficients for base and sub base layers respectively

- **Layer Coefficients:**

In order to transform the structural number of different pavement layers into respected pavement layer thicknesses, following layer coefficients have been adopted (Refer Figure 2.5 ~ 2.7 of AASHTO Guide for Design of Pavement Structure).

Asphaltic Wearing Course, a_1	=	0.42 / inch (0.165/cm)
Asphaltic Base Course, a_1	=	0.42/ inch (0.165/cm)
Water Bound Macadam, a_2	=	0.13 / inch (0.051/cm)
Granular Sub base, a_3	=	0.12 / inch (0.047/cm)



3.4.7 DESIGN THICKNESS:

The minimum pavement thicknesses thus worked out, based on AASHTO approach for pavement design of the subject roads have been mentioned below subject to enforcement of Axle Load restrictions:

Asphalt Concrete Wearing Course	50 mm
Asphalt Concrete Base Course	180 mm
Water Bound Macadam	300 mm
Granular Sub base	200 mm

Subgrade shall have a minimum soaked CBR of 10% @ 95% M.D.D.



ANNEXURE-4

Traffic Projections and ESALs Calculations



TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)

TRAFFIC PROJECTIONS						
Lalian to Chenab Nagar						
YEAR	LARGE BUSES	TRUCKS				TRACTOR TROLLEYS
		2 -AXLE	3 -AXLE	4 -AXLE	5 -AXLE AND ABOVE	
2020	165	527	1964	154	130	214
2021	169	545	2029	159	134	225
2022	173	562	2093	164	139	236
2023	194	637	2374	186	157	272
2024	198	657	2445	192	162	285
2025	203	676	2517	197	167	297
2026	207	695	2589	203	172	309
2027	211	715	2661	209	176	322
2028	215	734	2734	214	181	334
2029	220	754	2807	220	186	347
2030	224	773	2880	226	191	359
2031	228	793	2953	232	196	372
2032	232	813	3027	237	201	385
2033	237	833	3102	243	206	398
2034	241	853	3176	249	210	410
2035	245	873	3251	255	215	423
2036	249	893	3327	261	220	436
2037	254	914	3402	267	225	450
2038	258	934	3478	273	230	463
2039	262	955	3555	279	236	476
2040	267	975	3632	285	241	489
2041	271	996	3709	291	246	503
2042	276	1017	3787	297	251	516
2043	280	1038	3865	303	256	530
2044	284	1059	3943	309	261	544
2045	289	1080	4022	315	266	557
2046	293	1101	4101	322	272	571
2047	297	1122	4179	328	277	585
2048	302	1143	4258	334	282	599
2049	306	1165	4338	340	287	613
2050	311	1186	4418	347	293	627



TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)**Projection of ESALS in Design Life****Lalian to Chenab Nagar**

Direction Factor = 1

Lane Factor = 0.9

Buses = 100% Loaded

Trucks = 80% Loaded

Axle Load Factors 2.5 4.67 8.84 10.35 10.84 3.45

YEAR	LARGE BUSES	TRUCKS				TRACTOR TROLLY	ESALS	CUMMULATIVE ESALS	CUMMULATIVE ESALS (LOADED ONLY) (Million)
		2-AXLE	3-AXLE	4-AXLE	5-AXLE AND ABOVE				
2023	159334	782237	5514538	506391	448082	246887	7657469	7657469	
2024	162830	805786	5680553	521636	461571	257984	7890361	15547830	
2025	166323	829420	5847168	536936	475110	269132	8124090	23671920	
2026	169815	853146	6014425	552295	488700	280333	8358714	32030635	
2027	173308	876967	6182358	567716	502345	291590	8594284	40624919	
2028	176801	900889	6350997	583202	516048	302905	8830843	49455762	
2029	180297	924914	6520370	598755	529810	314280	9068427	58524189	
2030	183797	949047	6690500	614378	543634	325716	9307072	67831260	
2031	187300	973290	6861406	630072	557521	337215	9546805	77378065	
2032	190808	997646	7033109	645839	571473	348777	9787652	87165717	
								87.17	



TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)

Projection of ESALS in Design Life									
Lalian to Chenab Nagar									
Direction Factor = 1									
Lane Factor = 0.9									
Buses = 100% Loaded									
Trucks = 20% Empty									
Axle Load Factors 0.07 0.1 0.41 0.41									
YEAR	LARGE BUSES	TRUCKS				TRACTOR TROLLY	ESALS	CUMMULATIVE ESALS	CUMMULATIVE ESALS (LOADED + EMPTY) (Million)
		2-AXLE	3-AXLE	4-AXLE	5-AXLE AND ABOVE				
2023	00	2931	15595	5015	4237	00	27779	27779	
2024	00	3020	16065	5166	4364	00	28615	56394	
2025	00	3108	16536	5317	4493	00	29454	85848	
2026	00	3197	17009	5470	4621	00	30297	116144	
2027	00	3286	17484	5622	4750	00	31143	147287	
2028	00	3376	17961	5776	4880	00	31992	179279	
2029	00	3466	18440	5930	5010	00	32845	212125	
2030	00	3556	18921	6084	5140	00	33702	245827	
2031	00	3647	19404	6240	5272	00	34563	280390	
2032	00	3739	19890	6396	5404	00	35428	315818	
								87.48	



3.5. HYDROLOGY STUDY REPORT



3.5.1 GENERAL

Faisalabad and Sargodha districts are thickly populated cities and both are divisional headquarters as well. Large population from Mianwali, Khushab, Jauharabad, Sargodha and Chiniot districts travels to Faisalabad on daily basis due to industrial and business nature of Faisalabad. The existing road is single and also in deteriorated condition. Furthermore, stone crushing plants are located near Chak 46 and 111 which deploys heavy traffic comprises crushing machinery equipment and loader trucks which creates frequent traffic jams and hurdles.

The dual carriage way shall provide transportation ease to a large population. the Government of the Punjab intends to upgrade this important road link to dual carriage way.

3.5.1.1 Scope of Hydrological Studies

The scope of hydrological studies is to locate, check and evaluate catchments of the streams, nullahs and drains along with assessment of discharge against 100 yr and 25 yr. The scope includes assessment of capacity of the existing natural drainage across the route and recommendations for the upgradation, if any.

3.5.1.2 Route Alignment and Water Infrastructure Crossings the Alignment

Total length of the Faisalabad to Sargodha road is about 60 kilometres. The existing alignment passes through industrial and thickly populated area of Faisalabad city, several important settlements i.e. Chiniot district, Chenab Nagar, Ahmad Nagar, Lillian, etc. The road also passes through an important business activity of stone crushing plants near Chak 46 and 111.

The area between Faisalabad and Sargodha is mostly culturable command area and existing route passes through lush green fields and orchards, therefore several irrigation channels from main canal to minor channels cross the road at different locations.

Several drains, constructed under the Salinity Control and Reclamation Project (SCARP) also cross the route alignment. Currently, these drains only carry the sewerage water from the nearby settlements. These drains are usually not designed for storm water.

In addition to the irrigation channels and drains, some natural streams/flood channels also exist at different location for carrying localised sheet flows during rain events. The structures on the road have been provided to cross the flow. As the area is of flat terrain, the rain water can flow to either side depending upon rainfall intensity and standing water accumulation.

The project area map including existing road alignment and road crossings at different RDs is given in the Figure No. 3.5.1.



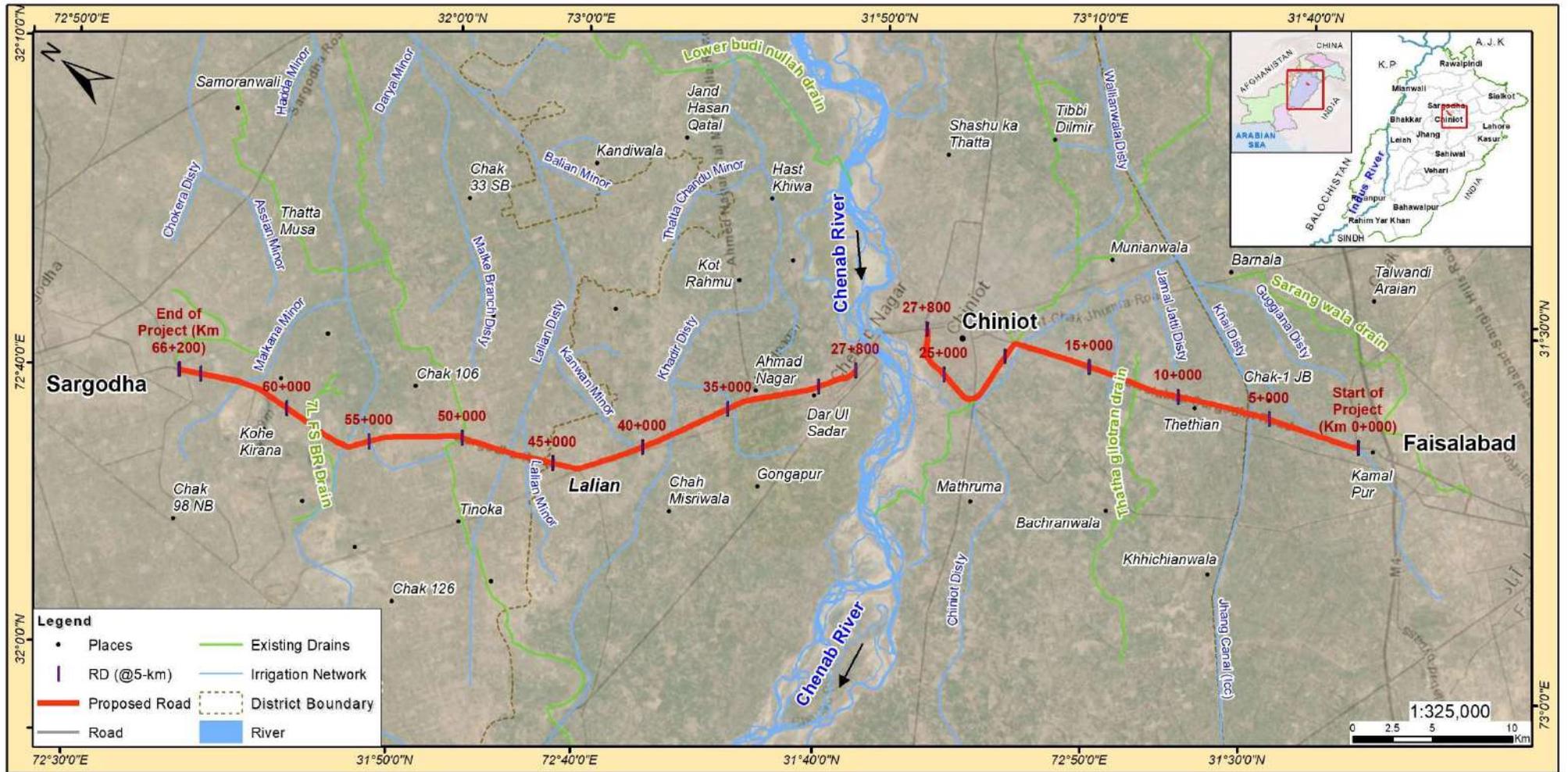


Figure 3.5.1: Project Area Map and Existing Road Alignment

3.5.1.3 Drainage Requirements for the Roads/ Highways

The influence of hydrology and drainage considerations is of key importance in planning, design, rehabilitation and upgradation of the existing roads/highways. Drainage requirements for such developments are established in consideration of:

- The implications associated with the routes i.e. passing in densely populated area, traffic load and etc;
- The number of cross drainage locations encountered and location of major bridges/culverts as potential fixed points along the alignment;
- Anticipated levels of flooding, scour and provision of associated protection structures.

Existing hydrological details of the road crossings were not available to the Consultants therefore, the catchment delineations, stream network generation and assessment of drainage locations have been carried out by the Consultants in current studies.

3.5.2 HYDROLOGICAL AND HYDRAULIC STUDIES

Understanding of regional hydrological phenomenon is an important task for determining the discharge estimations, locations, and dimensions/sizing of cross drainage structures. Climate of the project area.

The climate of the project area is very hot with humid summers and dry cool winters. In summer when conditions are dry, dust storms are common. The monsoon and the western disturbance are the two main factors that change the weather in the area. Main factors that influence the weather of the area are; western disturbances, fog, dust storm, heat waves and monsoon rains. Faisalabad is the nearest climate station which is operated and maintained by Pakistan Meteorological Department (PMD). Climate station of Faisalabad provides a fair representative estimate for the climate parameters of the project site.

Western disturbances generally occur during the winter months and cause moderate rainfall. Monsoon occur in the summer from the month of June till September. Monsoon rains bring much awaited relief from the scorching heat of the summer. These monsoon rains are quite heavy. The maximum recorded temperature in the pre-monsoon season of April to June is 40.2 °C, whereas in winter the minimum temperature recorded is 4.7 °C. The average annual rainfall is 377 mm and maximum amount of rainfall is observed during the monsoon period. Temperature and rainfall trends at Faisalabad station are presented in Figure-3.5.2.

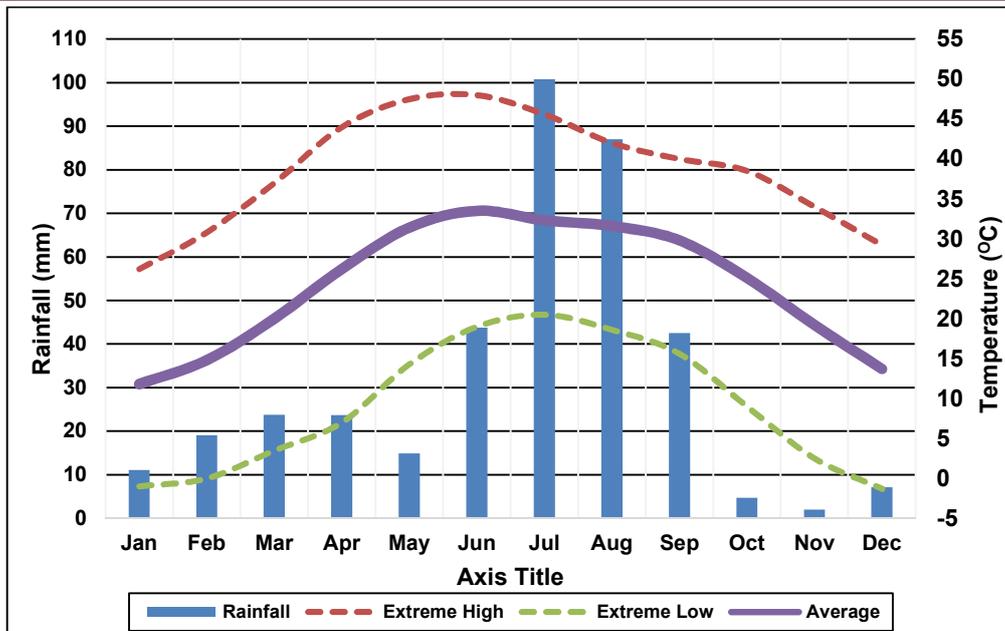


Figure 3.5.2: Temperature and Rainfall Trends at Faisalabad

3.5.2.1 General Topography of the Area

General topography of the area features very flat terrain with no definitive drainage pattern comprising stream and/or nullahs etc. Most of the area remains covered with seasonal agriculture round the year and there are some towns/villages settled along the road. For identification of drainage pattern and slopes around the study area, Digital Elevation Model (DEM) of Shuttle Radar Topography Mission (SRTM) having a resolution of 30 meter has been used. Catchment characteristics like impervious, roughness, hydrologic conditions of area, soil cover, land use & treatments, soil type and extents and other flow controlling parameters have been investigated through satellite and Google Earth imagery. Stream network suggests that the general slopes of the area is from Sargodha to Faisalabad direction. The deskwork observations have also been validated using strip survey details and data. The sample cross verification of the digital data and strip survey is shown in Figure 3.5.3.

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Figure 3.5.3: Strip Survey and Data Acquisition

3.5.2.2 Hydro-meteorological Analyses

One-day annual maximum rainfall data of Faisalabad stations has been collected for last 38 years from Pakistan Meteorological Department (PMD) for the estimation of 100-year projections of rainfall magnitudes. Climate of Faisalabad station has already discussed in previous section. Historic data since 1981 suggest an average annual 1-day maximum rainfall value of 63.8 mm, the maximum magnitude of rainfall witnessed till date is 180.3 mm in year 1981. Figure 4 below shows the trends of annual maximum rainfalls observed at Faisalabad station.

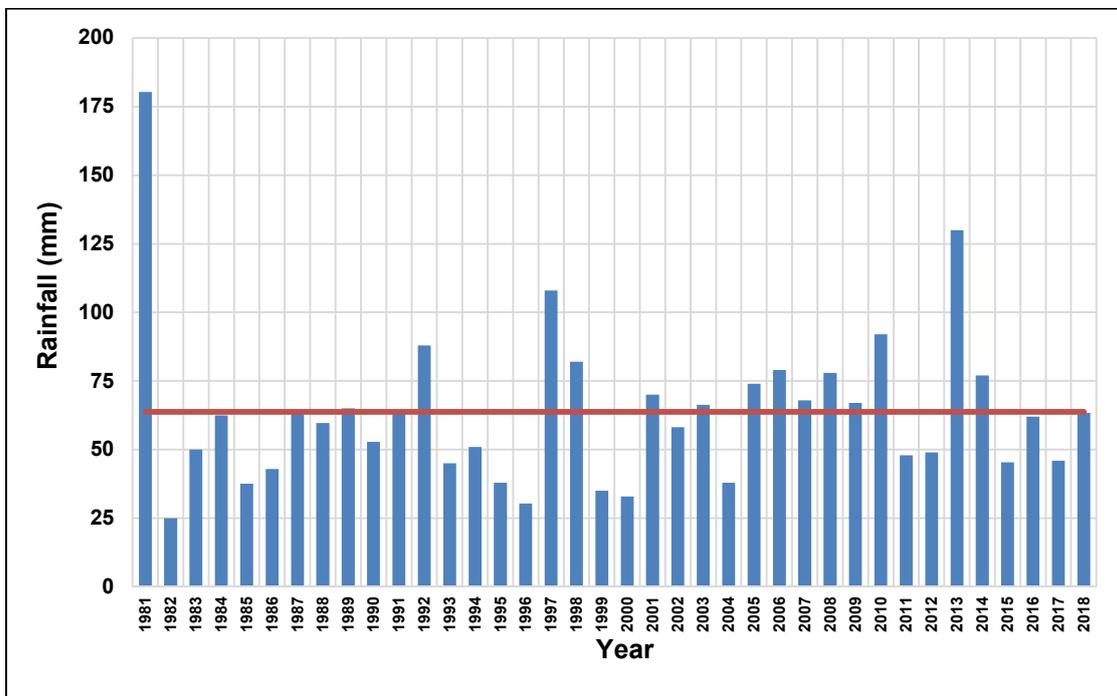


Figure 2: 1-day Annual Maximum Rainfalls at Faisalabad Station

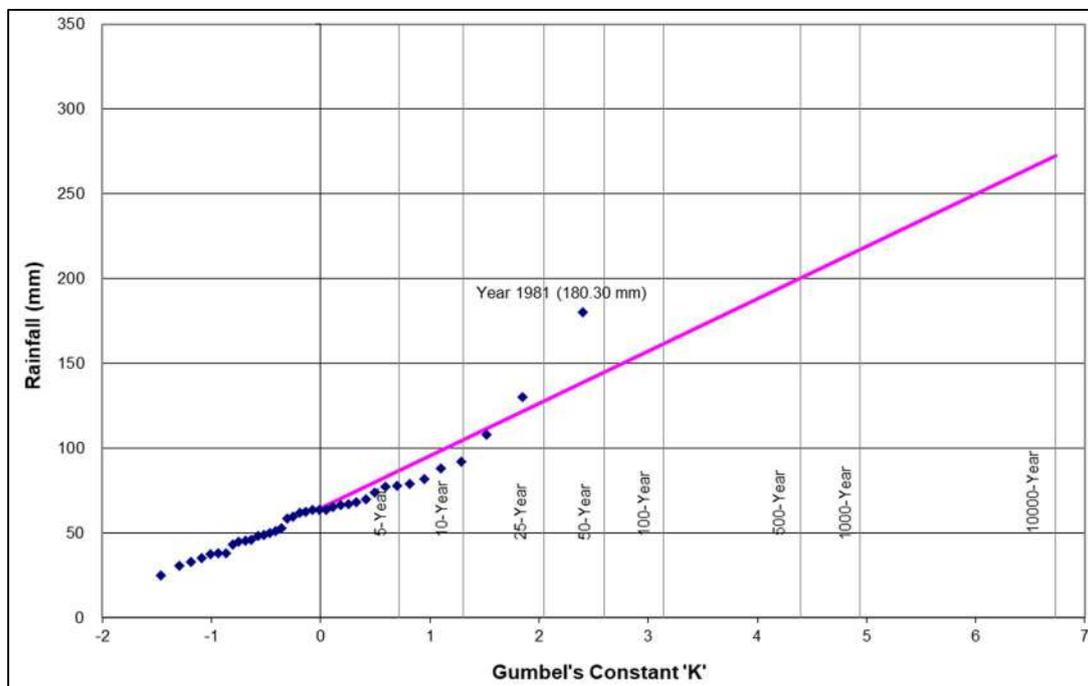
Rainfall frequency analysis for 1-day annual maximum rainfall data of Faisalabad station has been carried out using Gumble’s Extreme Value Type-1 Distribution. Gumbel distribution is a member of family of Extreme Value distributions. It is a two-parameter distribution and is

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widely used in hydrology. For annual maximum series, Weibull formula has been adopted as the standard plotting position method by the U. S. Water Resources Council (1981). Results of frequency analysis present rainfall magnitudes of 87 mm and 128 mm for 5 and 25-year return periods, respectively as given in Table-1 and provided by graph in Figure-5.

Table 2: Rainfall Depth against Various Return Periods

Return Period (years)	Rainfall Depth (mm)
2.33	65
5	87
10	105
25	128
50	145
100	161

**Figure 3: Frequency fitting of 1-day Annual Maxima****3.5.2.3 Water Infrastructure Crossing on Existing Road Network**

Deskwork studies and field observation during the strip survey indicates the classification of water crossing across the existing road. There are three (03) type of channels crossing the road alignment:

1. Irrigation channel crossings
2. Drain crossings
3. Natural channels/Sheet flow crossings

The methodology to address the type of crossing is given in the preceding sections.

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)**3.5.2.4 Irrigation Channel Crossings**

Irrigation canals ranging from main canals to minor level cross the road alignment at various locations. Design section of irrigation canals based on sanctioned discharge as per culture-able command area and an additional contingent canal capacity is also provided in the form of freeboard to cater for any unforeseen situation.

3.5.2.4.1 Major Irrigation Channel Crossings

The inventory of the irrigation channels is developed from the field data collected from the strip survey and data extracted/verified from the Project Management and Implementation Unit (PMIU) of the Punjab Irrigation Department's website. List of major irrigation channels crossing the road alignment is given in Table-2.

Table 3: List of Major Irrigation Channels Crossings and Design Parameters

Sr. No	RD	Channel Name	Type of Existing Structure	Structure Size (m)	Existing Deck Level (m)
1	00+028	Khai Canal	Box Culvert 02 Spans	3.0X1.50	186.95
2	06+000	Jhang Canal (LCC)	Bridge	47m Width	190.58
3	13+850	Rajoa Canal	Box Culvert	2.0X0.75	182.52
4	18+765	Chiniot Canal	Bridge 03 Spans	3.2X1.50	183.48
5	34+772	Pillowal Canal	Bridge	06m Width	-
6	38+310	Khadir Canal	Box Culvert 03 Spans	2.7X1.50	182.90
7	46+450	Lalian Canal	Bridge	6m Width	-
8	47+415	Lalian Distributary	Bridge 02 Spans	2.5X1.50	187.85
9	54+865	Wasauna Canal	Box Culvert 01 Span	1.0X1.0	189.51
10	56+290	Kirana Canal	Bridge 03 Span	3.0X2.0	190.02
11	62+675	Malkana Canal	Box Culvert	1.0X1.0	189.02

3.5.2.4.2 Smaller/Minor Irrigation Channel Crossings

In addition to major channel crossings, there are numerous smaller irrigation channel crossings i.e. sub minors and watercourse outlets and farm channels. The Consultants captured geometrical details of these crossings during the strip survey of the road corridor. The details of these smaller crossings are given below in Table-3:

Table 4: List of Smaller/Minor Irrigation Channels with Design Details

Sr. No.	Chainage/RD	Structure Type	Structure Size No. of Spans*(WXH) in (m)
1	0+103	Box Culvert	1(2.0X1.5)
2	0+397	Box Culvert	1(1.7X1.0)
3	0+910	Box Culvert	1(1.9X1.0)
4	1+992	Box Culvert	1(1.0X1.0)
5	2+753	Box Culvert	1(1.0X1.0)
6	3+461	Box Culvert	1(2.0X1.0)
7	3+945	Box Culvert	2(2.0X1.0)
8	5+073	Box Culvert	1(1.0X1.0)
9	5+441	Box Culvert	1(2.5X1.0)
10	5+866	Box Culvert	1(0.7X0.9)
11	6+050	Bridge	4 Span of 10.5m

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Sr. No.	Chainage/RD	Structure Type	Structure Size No. of Spans*(WXH) in (m)
12	6+366	Box Culvert	1(2.0X1.0)
13	6+827	Box Culvert	1(1.0X1.0)
14	9+975	Box Culvert	1(2.0X1.0)
15	10+918	Box Culvert	2(1.5X1.0)
16	11+066	Box Culvert	1(1.0X1.0)
17	12+352	Box Culvert	1(3.0X1.5)
18	12+590	Box Culvert	1(1.0X1.0)
19	13+846	Box Culvert	1(2.0X0.75)
20	14+031	Box Culvert	4(4.0X2.0)
21	15+225	Box Culvert	1(2.0X0.75)
22	15+496	Box Culvert	2(2.0X1.5)
23	15+922	Box Culvert	1(2.0X1.0)
24	16+834	Box Culvert	1(1.0X1.0)
25	17+293	Box Culvert	1(1.0X1.0)
26	17+784	Box Culvert	1(1.0X1.0)
27	18+411	Box Culvert	1(1.0X1.0)
28	18+825	Bridge	3(3.2X1.5)
29	19+200	Bridge	2 Span of 9.0m
30	22+340	Bridge	3 Span of 7.5m
31	24+117	Box Culvert	1(0.5X0.5)
32	24+524	Box Culvert	1(0.5X0.5)
33	24+864	Box Culvert	1(1.0X1.0)
34	25+088	Box Culvert	1(0.5X0.5)
35	25+234	Box Culvert	1(0.8X0.8)
36	25+517	Box Culvert	1(0.5X0.5)
37	26+619	Box Culvert	1(0.8X0.8)
38	28+890	Box Culvert	2(2.0X1.5)
39	29+297	Box Culvert	2(1.5X1.0)
40	29+364	Box Culvert	2(1.5X1.0)
41	29+845	Box Culvert	1(1.5X1.0)
42	30+645	Box Culvert	1(0.8X0.8)
43	31+395	Box Culvert	1(1.5X1.0)
44	31+890	Bridge	13 Span of (2.2X2.5)
45	32+168	Box Culvert	3(2.0X1.5)
46	32+977	Box Culvert	1(1.2X1.0)
47	33+246	Box Culvert	1(2.0X1.5)
48	33+378	Box Culvert	1(0.8X0.8)
49	34+145	Box Culvert	1(1.0X1.0)
50	34+900	Box Culvert	1(2.0X1.0)
51	35+240	Box Culvert	1(2.0X1.5)
52	35+460	Box Culvert	2(2.0X1.5)
53	36+045	Box Culvert	1(1.5X1.5)
54	36+668	Box Culvert	3(2.5X2.0)
55	37+535	Box Culvert	1(1.0X1.0)
56	37+926	Box Culvert	1(1.0X1.0)
57	38+401	Box Culvert	1(1.0X1.0)
58	38+785	Box Culvert	3(2.7X1.5)
59	38+942	Box Culvert	1(1.0X1.0)

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Sr. No.	Chainage/RD	Structure Type	Structure Size No. of Spans*(WXH) in (m)
60	39+198	Box Culvert	1(1.0X1.0)
61	39+636	Box Culvert	1(1.0X1.0)
62	40+050	Box Culvert	1(1.0X1.0)
63	40+418	Box Culvert	4(1.7X1.8)
64	40+724	Box Culvert	2(2.0X1.5)
65	41+080	Box Culvert	1(1.0X1.0)
66	41+528	Box Culvert	1(1.0X1.0)
67	41+965	Box Culvert	1(1.0X1.0)
68	42+325	Box Culvert	1(2.0X1.0)
69	43+290	Box Culvert	1(1.0X1.0)
70	43+357	Box Culvert	1(1.0X1.0)
71	43+766	Box Culvert	1(1.0X1.0)
72	44+637	Box Culvert	1(1.5X1.0)
73	44+882	Box Culvert	1(2.0X1.5)
74	46+045	Box Culvert	1(1.0X1.0)
75	46+921	Box Culvert	1(2.5X1.5)
76	46+968	Box Culvert	1(1.0X1.0)
77	47+344	Box Culvert	1(1.0X1.0)
78	47+883	Bridge	2(2.5X1.5)
79	48+354	Box Culvert	1(1.0X1.0)
80	48+826	Box Culvert	1(1.0X1.0)
81	49+144	Box Culvert	1(1.0X1.0)
82	49+557	Box Culvert	1(1.0X1.0)
83	50+264	Box Culvert	1(1.0X1.0)
84	50+486	Bridge	2(8.5X4.0)
85	50+660	Box Culvert	1(1.0X1.0)
86	51+133	Box Culvert	1(1.0X1.0)
87	52+570	Box Culvert	1(1.0X1.0)
88	54+459	Box Culvert	1(1.0X1.0)
89	54+854	Box Culvert	1(1.0X1.0)
90	55+331	Box Culvert	1(2.0X1.5)
91	56+010	Box Culvert	1(1.0X1.0)
92	56+750	Bridge	3(3.0X2.0)
93	57+029	Box Culvert	1(1.0X1.0)
94	57+338	Box Culvert	1(1.0X1.0)
95	57+718	Box Culvert	1(1.0X1.0)
96	58+661	Box Culvert	1(1.0X1.0)
97	59+387	Box Culvert	2(3.0X1.5)
98	59+974	Box Culvert	1(1.0X1.0)
99	61+967	Box Culvert	1(1.0X1.0)
100	62+120	Box Culvert	1(1.0X1.0)
101	62+477	Box Culvert	1(1.0X1.0)
102	62+956	Box Culvert	1(1.0X1.0)
103	63+666	Box Culvert	1(1.0X1.0)

3.5.2.5 Drain Crossings across the Route Alignment

Beside Irrigation network, some drains are also crossing the existing road alignment. These drains carry sewage of the area and can also accommodate drainable surplus water of agricultural fields to some extent. The area topography is flat terrain and sheet flow usually do not become flood flow and rainwater is squeezed within local field bunds which are usually 1ft (0.30m) high. Therefore, chances of rainwater coming into these drains after crossing agricultural field is very less.

The locations and details of these drains are given in Table-4 below.

Table 5: List of Drains Crossings the Road Alignment

Sr. No	RD	Name	Type of Structure	Structure Size (m)	Existing Deck Level (m)
1	12+293	Thatha Gilotran Drain	Box Culvert 01 Spans	3.0X1.50	180.98
2	19+200	Marh Chiniot Drain	Bridge 02 Span	9.0m Bay width	183.01
3	50+020	Hadda Branch Drain	Bridge	15m width	-
4	58+927	7L FS BR Drain	Bridge	08m width	-

3.5.2.6 Irrigation and Drainage Channel Crossings

Channel sections for major as well as minor crossings for irrigation and drainage canals are designed to convey maximum possible discharge sanctioned/authorised for the canal command. However, an additional vertical clearance is provided in all irrigation channels to cater for any unforeseen i.e. freeboard. This freeboard is also provided at the bridge sections to allow for additional water. Thus, the bank level of the channels is the maximum water surface level in the channel and freeboard value. Hence, bank levels can be provided as soffit levels for the bridge or culvert structures for road crossings. Furthermore, it is recommended to get the design discharges of the channels from the concerned Irrigation Departments to review the channel section against the discharge. Box culverts of the same size as channel widths may be provided for small channel crossings however, bridge structures shall be proposed for large channel crossings for which fluming ratio (Structure width/Channel width) of 80-90 (%) can be provided to economize the structure

3.5.2.7 Abandoned Natural Cum Flood Channel Crossings

In addition to irrigation and drainage channel crossings, certain natural channel crossing structures over existing road have been identified in the strip survey. No perennial flow is seen in these crossing structures. While investigating these points with the help of satellite data, it has been revealed that in past, sheet flow was generated at these points as natural channel formation is visible at certain points. However, due to increase in cultural command area and settlements, these natural channels became abandoned. These structures are now serving as crossing of rain water collected at these depressed points and can travel to and from either side of the channel crossings. The Consultants have also considered these existing features and evaluated these structures in view of hydrological analysis and catchment characteristics. The Catchment delineation maps of these smaller crossings is given in Figure-6.

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)

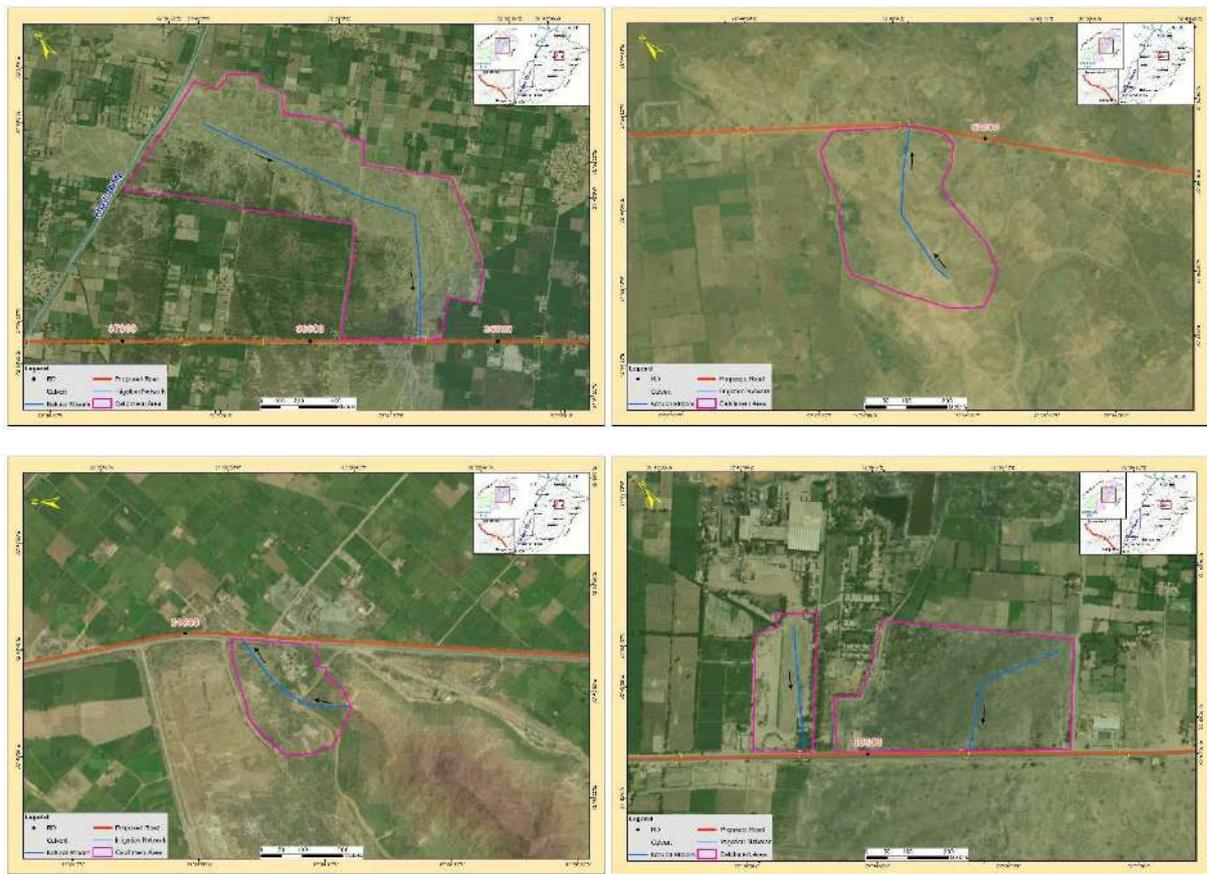


Figure 4: Delineation of Smaller Catchment for Hydrological Analysis

Catchments area of these channels at crossing points are less than 1km² therefore, rational method is used to compute flood at these locations. Rational method technique is as described under:

$$Q = CiA$$

Where,

Q = Peak Discharge (Cusecs)

C= coefficient of discharge

I = Intensity of Rainfall (Inches/hour)

A = Catchment Area (Acres)

i) Time of Concentration

Time of concentration (T_c) is the time required for runoff to travel from the hydraulically most distant point in the watershed to the outlet. Kirpich formula has been used for computation of time of concentration which is given below:

$$T_c = \frac{(L)^{1.15}}{7700 \times (H)^{0.385}}$$

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)

where

- T_c = Time of Concentration (hours)
- L = Length of the longest stream (feet)
- H = Fall in length L (feet)

ii) Rainfall Intensity

Rainfall intensity is defined as the ratio of the total amount of **rain (rainfall depth)** falling during a given period to the duration of the period. It is expressed in depth units per unit time, usually as mm/hour or inch/hour. Intensity-Duration-Frequency curves have been developed for Faisalabad as shown in Figure-7

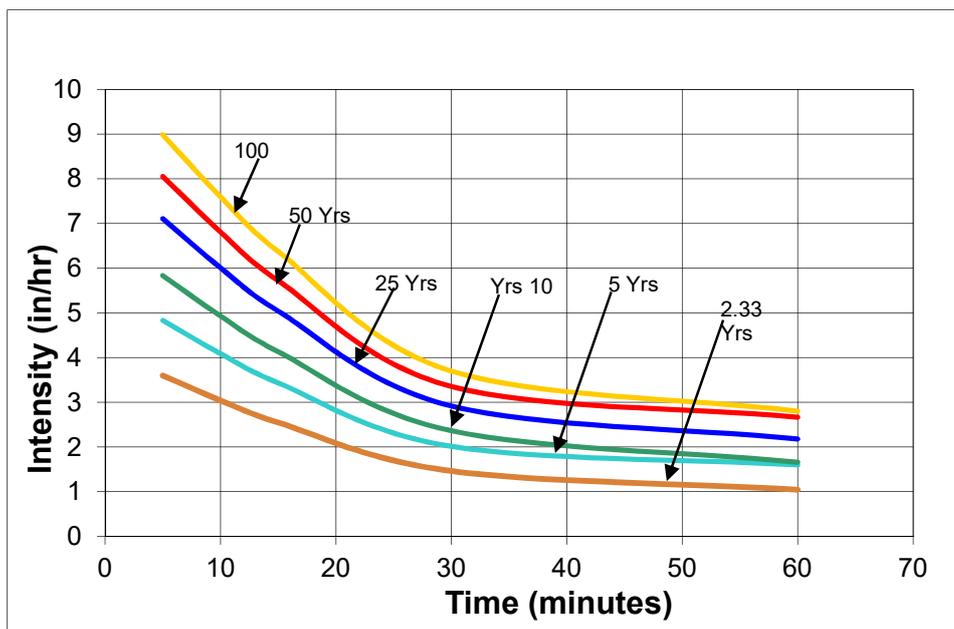


Figure 5: Intensity-Duration- Frequency Curves for Faisalabad

The details of catchment characteristics, results of hydrological analysis in shape of peak flood discharges are given in Table-5:

Table 6: List of Natural Drainage Channels Crossings the Road Alignment

Sr. No.	RD	Catchment Area		Peak Flood Discharges				
				5 yrs	10 yrs	25 yrs	50 yrs	100 yrs
		(km ²)	(Acres)	(cusecs)				
1	36+211	0.64	158.00	41	71	116	155	196
2	39+551	0.09	23.32	25	30	35	45	45
3	39+955	0.05	11.80	15	15	20	25	25
5	61+613	0.04	10.10	25	30	40	45	50

3.5.2.8 Natural Channels Crossing and Evaluation of Existing Capacity

Details of existing parameters collected from strip survey is given below in Table-6.

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)**Table 7: Design Parameters of Existing Natural Crossings**

Sr. No.	RD	Discharge ft ³ /Sec	Discharge m ³ /Sec	Existing Structure Type	No. of Spans	Size of the Structure (m)	Deck Level (m)
1	36+211	116	3.28	Box Culvert	1	2.0X1.0	181.56
2	39+551	35	0.99	Box Culvert	1	1.0X1.0	181.03
3	39+955	20	0.56	Box Culvert	1	1.0X1.0	180.96
5	61+613	40	1.13	Box Culvert	1	1.0X1.0	188.90

Strip survey and satellite data reveals that currently, these natural channels are not fully functional due to increased culturable command area, construction of link road for adjoining areas and populations settlements. However, hydraulic modelling of these channel has been carried out by the Consultants using HY-8 model, as per requirements of the TORs and for hydraulic evaluation of the structures. The results of hydraulic analysis are given in Table-7 below:

Table 8: Design Parameters of Existing Natural Crossings

Sr. No.	Road RD	25 Year flow		Barrel Width (W) (m)	Barrel Height (D) (m)	No. of Barrel	Headwater Level (HWL) (m)	Normal Depth (m)	Outlet Velocity (V) (m/s)
		ft3/Sec	(m ³ /sec)						
1	36+211	116	3.28	2.00	1.00	1	181.17	0.71	2.33
2	39+551	35	0.99	1.00	1.00	1	180.88	0.43	2.13
3	39+955	20	0.57	1.00	1.00	1	180.40	0.37	1.76
5	61+613	40	1.13	1.00	1.00	1	188.62	0.62	2.23

The results of hydraulic analysis on Hy-8 depicts that existing structures are capable of handling of discharges emerged from the smaller catchments. Therefore, it is recommended to provide same sizes as given in the existing road with extension in length. However, protection arrangements shall also be provided on the upstream and downstream of the new structures.

3.5.2.9 Protection Criteria for Crossing Structures

Existing cross drainage structures shall be extended as per design width of dual carriage way. Extension of bridges and culverts, in case of lined channels, shall not be affected from the scour as the lined sections will be connected bridge abutments or box culverts. However, for four (04) natural channels, bank and scour protection shall be provided on bed and side slopes i.e. upstream and downstream side with appropriate sizes i.e. not less than 10 ft along the road on either side of structure. Furthermore, it is recommended to carry out geotechnical investigation before the start of the construction to confirm the protection extents and sizes.

3.5.3 CONCLUSIONS AND RECOMMENDATIONS

- The existing cross drainage structures provided in the road are adequate and these should be extended in dual carriage way by keeping the same slope. However, design methodology for irrigation channels crossing, provided in this report shall also be

discussed with the concerned irrigation divisions of Faisalabad Irrigation Circle of Punjab Irrigation department for cross verification of L-sections, slope, discharge, and channel section.

- Typical crossing design of the small crossings i.e. less than 1.0 m, shall be duly verified by the concerned irrigation division to avoid any command and irrigation operational problems.
- A pre-construction survey shall be conducted by a team comprising Route Engineer, Hydrologist and Hydraulic Engineer to validate the crossing locations and design.
- Hydraulic modelling for natural streams, having smaller catchments, have been carried out on HY-8 model using input data extracted from the strip survey calibrated with the help of 30 m satellite data. A detailed topographic survey should be conducted and model be re-evaluated.
- Geotechnical investigation should be carried out in the entire reach to assess the true values of mean particle dia (d_{50}) for scour determination.

References

1. Climatic Normals of Pakistan (1981-2010), Pakistan Meteorological Department.
2. Chow V. T., "Handbook of Applied Hydrology".
3. Kirpich Z. P., "Time of Concentration of Agricultural Watersheds", Civil Engineering Volume 10, No. 6 Pages 362, June 1940.
4. Open Channel Hydraulics by VEN T CHOW
5. Irrigation and Hydraulic Structures by SK Garg
6. Irrigation and Hydraulic structures by Dr Iqbal Ali
7. Reference Manual HY-8

3.6. STRUCTURE DESIGN REPORT

3.6.1 GENERAL

This feasibility report summarizes the knowledge and skills that our design team has utilized for the design of all the structures that fall on the project alignment. The structural design, suitable design specifications and construction as per specifications are all important parameters to achieve the desired design life of structures.

The concept of influence line is used to analyse the moving track and tank load, which is then combined with other live loads and dead loads to come up with the entire shear force and bending moment envelope along the bridge. However, state of the art software like CSI Bridges, STAAD pro etc. will be used for analysis of relevant structures. Once all the design loads had been determined, detailed computational designs were performed for reinforced concrete girders and concrete decks with respect to bridge design standards.

3.6.2 Design Approach

Design approach followed for preliminary structural design of structures falling on Faisalabad~ Chiniot~ Sargodha road is given in following paragraphs:

3.6.2.1 Inventory of Structures

A site survey of Project road was carried out by the Structural expert for visual inspection of structures falling on the road and all prominent defects in the form of cracks, deteriorated concrete, plaster defects, settlement, movement, or other structural defects have been recorded. The purpose of this survey is to provide a snap-shot of the condition of structures prior to design.

Culverts:

There are total 97 culverts amongst which 96 are Box culverts and 01 Pipe culvert.

Bridges:

There are total 08 bridges.

List of all bridges and culverts are given in list below:

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)**Table 9: List of Culverts**

Sr #	CHAINAGE	TYPE	SIZE
1	0+103	BOX CULVERT	1(2.0X1.5)
2	0+397	BOX CULVERT	1(1.7X1.0)
3	0+910	BOX CULVERT	1(1.9X1.0)
4	1+992	BOX CULVERT	1(1.0X1.0)
5	2+753	BOX CULVERT	1(1.0X1.0)
6	3+461	BOX CULVERT	1(2.0X1.0)
7	3+945	BOX CULVERT	2(2.0X1.0)
8	5+073	BOX CULVERT	1(1.0X1.0)
9	5+441	BOX CULVERT	1(2.5X1.0)
10	5+866	BOX CULVERT	1(0.7X0.9)
11	6+366	BOX CULVERT	1(2.0X1.0)
12	6+827	BOX CULVERT	1(1.0X1.0)
13	9+975	BOX CULVERT	1(2.0X1.0)
14	10+918	BOX CULVERT	2(1.5X1.0)
15	11+066	BOX CULVERT	1(1.0X1.0)
16	12+352	BOX CULVERT	1(3.0X1.5)
17	12+590	BOX CULVERT	1(1.0X1.0)

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)

18	13+846	BOX CULVERT	1(2.0X0.75)
19	14+031	BOX CULVERT	4(4.0X2.0)
20	15+225	BOX CULVERT	1(2.0X0.75)
21	15+496	BOX CULVERT	2(2.0X1.5)
22	15+922	BOX CULVERT	1(2.0X1.0)
23	16+834	BOX CULVERT	1(1.0X1.0)
24	17+293	BOX CULVERT	1(1.0X1.0)
25	17+784	BOX CULVERT	1(1.0X1.0)
26	18+411	BOX CULVERT	1(1.0X1.0)
27	24+117	BOX CULVERT	1(0.5X0.5)
28	24+524	BOX CULVERT	1(0.5X0.5)
29	24+864	BOX CULVERT	1(1.0X1.0)
30	25+088	BOX CULVERT	1(0.5X0.5)
31	25+234	BOX CULVERT	1(0.8X0.8)
32	25+517	BOX CULVERT	1(0.5X0.5)
33	26+619	BOX CULVERT	1(0.8X0.8)
34	28+890	BOX CULVERT	2(2.0X1.5)
35	29+297	BOX CULVERT	2(1.5X1.0)
36	29+364	BOX CULVERT	2(1.5X1.0)

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)

37	29+845	BOX CULVERT	1(1.5X1.0)
38	30+645	BOX CULVERT	1(0.8X0.8)
39	31+395	BOX CULVERT	1(1.5X1.0)
40	32+168	BOX CULVERT	3(2.0X1.5)
41	32+977	BOX CULVERT	1(1.2X1.0)
42	33+246	BOX CULVERT	1(2.0X1.5)
43	33+378	BOX CULVERT	1(0.8X0.8)
44	34+145	BOX CULVERT	1(1.0X1.0)
45	34+900	BOX CULVERT	1(2.0X1.0)
46	35+240	BOX CULVERT	1(2.0X1.5)
47	35+460	BOX CULVERT	2(2.0X1.5)
48	36+045	BOX CULVERT	1(1.5X1.5)
49	36+668	BOX CULVERT	3(2.5X2.0)
50	37+535	BOX CULVERT	1(1.0X1.0)
51	37+926	BOX CULVERT	1(1.0X1.0)
52	38+401	BOX CULVERT	1(1.0X1.0)
53	38+785	BOX CULVERT	3(2.7X1.5)
54	38+942	BOX CULVERT	1(1.0X1.0)
55	39+198	BOX CULVERT	1(1.0X1.0)

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)

56	39+636	BOX CULVERT	1(1.0X1.0)
57	40+050	BOX CULVERT	1(1.0X1.0)
58	40+418	BOX CULVERT	4(1.7X1.8)
59	40+724	BOX CULVERT	2(2.0X1.5)
60	41+080	BOX CULVERT	1(1.0X1.0)
61	41+528	BOX CULVERT	1(1.0X1.0)
62	41+965	BOX CULVERT	1(1.0X1.0)
63	42+325	BOX CULVERT	1(2.0X1.0)
64	43+290	BOX CULVERT	1(1.0X1.0)
65	43+357	BOX CULVERT	1(1.0X1.0)
66	43+766	BOX CULVERT	1(1.0X1.0)
67	44+637	BOX CULVERT	1(1.5X1.0)
68	44+882	BOX CULVERT	1(2.0X1.5)
69	46+045	BOX CULVERT	1(1.0X1.0)
70	46+921	BOX CULVERT	1(2.5X1.5)
71	46+968	BOX CULVERT	1(1.0X1.0)
72	47+344	BOX CULVERT	1(1.0X1.0)
73	48+354	BOX CULVERT	1(1.0X1.0)
74	48+826	BOX CULVERT	1(1.0X1.0)

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)

75	49+144	BOX CULVERT	1(1.0X1.0)
76	49+557	BOX CULVERT	1(1.0X1.0)
77	50+264	BOX CULVERT	1(1.0X1.0)
78	50+660	BOX CULVERT	1(1.0X1.0)
79	51+133	BOX CULVERT	1(1.0X1.0)
80	52+570	BOX CULVERT	1(1.0X1.0)
81	54+459	BOX CULVERT	1(1.0X1.0)
82	54+854	BOX CULVERT	1(1.0X1.0)
83	55+331	BOX CULVERT	1(2.0X1.5)
84	55+399	BOX CULVERT	1(1.0X1.0)
85	56+010	BOX CULVERT	1(1.0X1.0)
86	57+029	BOX CULVERT	1(1.0X1.0)
87	57+338	BOX CULVERT	1(1.0X1.0)
88	57+718	BOX CULVERT	1(1.0X1.0)
89	58+661	BOX CULVERT	1(1.0X1.0)
90	59+387	BOX CULVERT	2(3.0X1.5)
91	59+974	BOX CULVERT	1(1.0X1.0)
92	61+967	BOX CULVERT	1(1.0X1.0)
93	62+120	BOX CULVERT	1(1.0X1.0)

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)

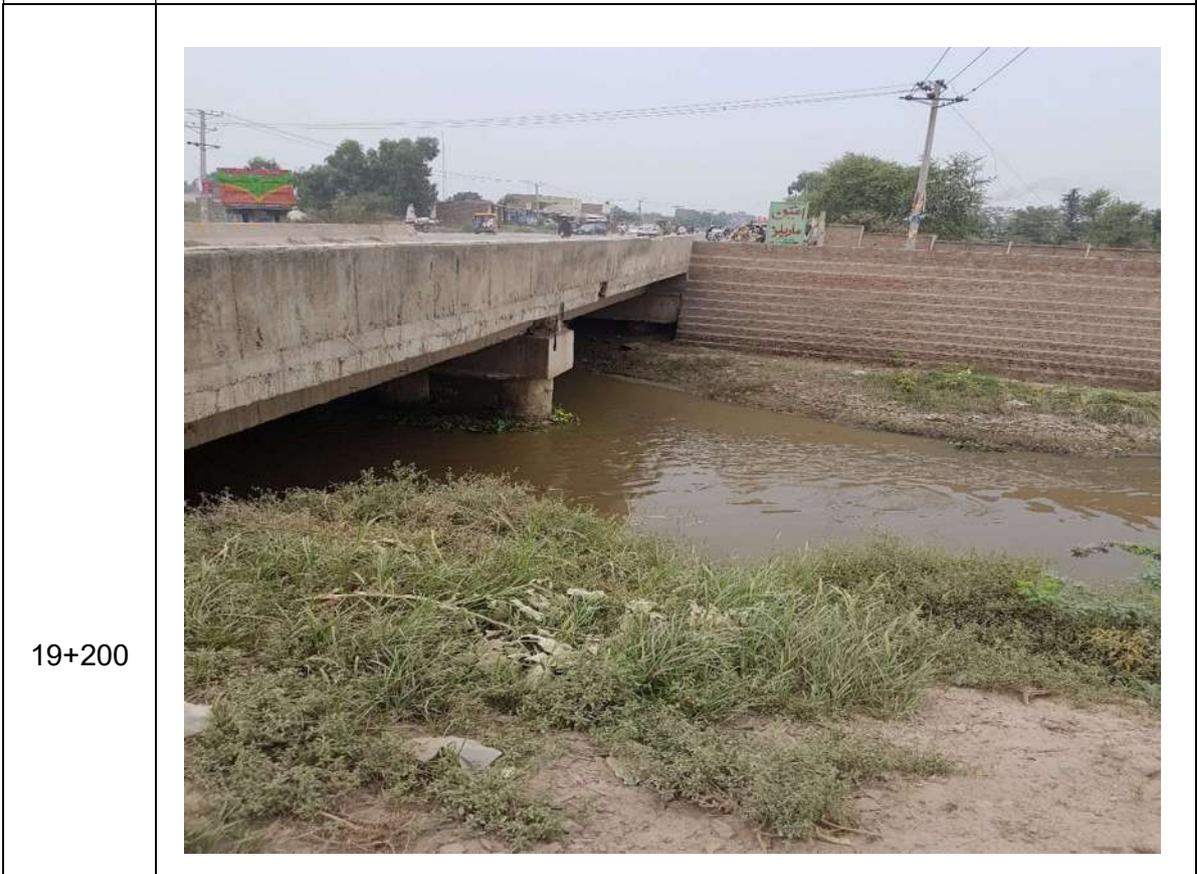
94	62+477	BOX CULVERT	1(1.0X1.0)
95	62+956	BOX CULVERT	1(1.0X1.0)
96	63+131	BOX CULVERT	1(1.0X1.0)
97	63+666	BOX CULVERT	1(1.0X1.0)

Table 10: List of Bridges

Sr. No.	Chainage	Location	No. of Cell/Spans
1	6+050	Dangro Bridge	4
2	18+825	Culvert/Bridge	3
3	19+200	Canal Bridge	2
4	22+340	Bridge	3
5	31+800	Culvert/Bridge	13
6	47+880	Culvert/Bridge	2
7	50+486	Bridge	2
8	56+750	Culvert/Bridge	3

3.6.2.2 Pictorial Description of Bridges

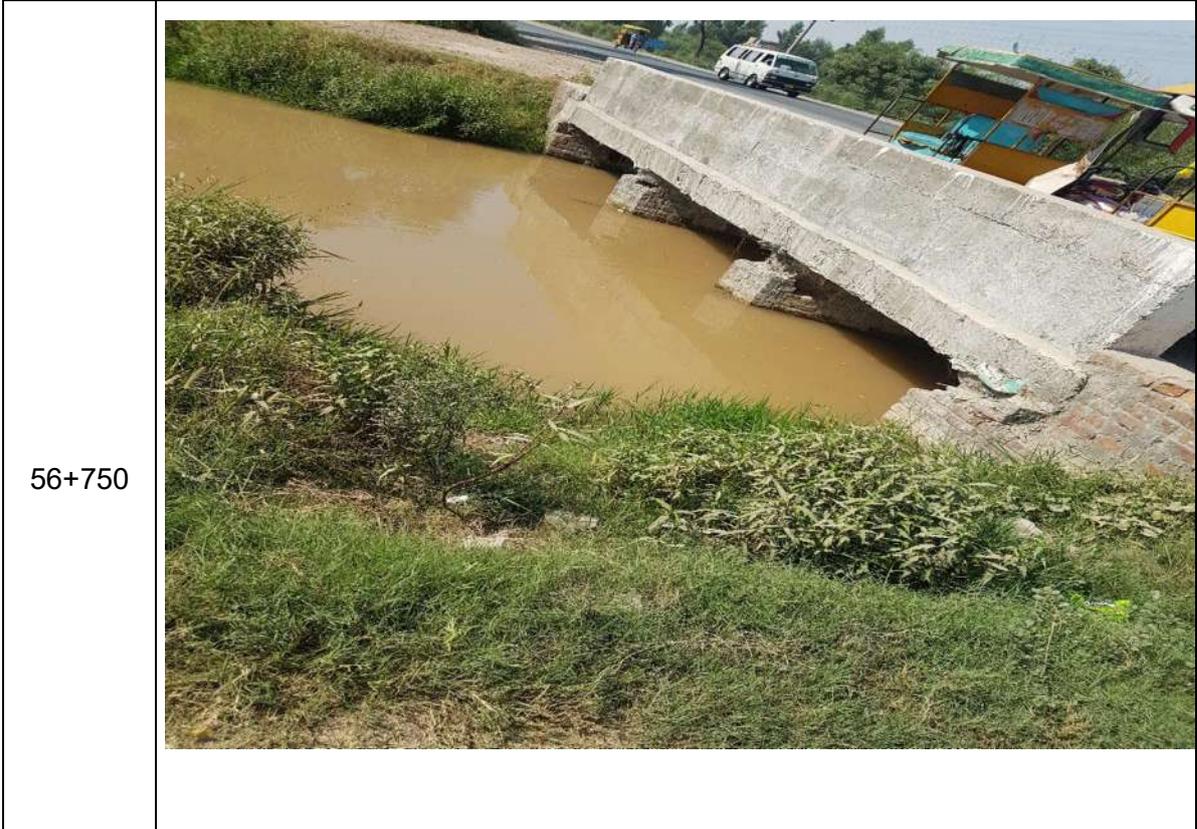
TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)



TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)

<p>31+800</p>	
<p>47+880</p>	

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)



3.6.2.3 Methodology for Extension of Culverts

Based on visual inspection, Culverts have been shortlisted which have capacity to serve and are in reasonable condition. These structures are operating satisfactory and have intact inverts. All of such structures don't need to be replaced and can be extended to the proposed cross section. These structures will be extended and new Inlet and outlet structures will be constructed as per the new extended width of road.

3.6.2.4 Methodology for Extension of Bridges

In case of bridges same concept has been applied to determine that bridges are in reasonable condition and do not need replacement. From the visual inspection, it was assessed that existing bridges should be retained as they are in good shape and serving well. Except one bridge at the entrance of Chiniot City. This bridge appears to constructed in the recent past but it has defected pier. The diameter of this pier is almost 40% reduced (faulty construction) at the joint of pier and transom (see Fig-1).



Fig-1

Nespak recommends to replace of this bridge, but this decision lies with the client.

However, the safety assessment of these bridges structures is not the part of this TOR. If client intends to carryout detailed structural assessment of existing bridge, all

relevant data like as built drawings and other design related documents shall be made available under separate contract.

The cross section of road has been changed and road has been dualized at the location of Bridge No 3 (Km 19+100) over canal towards Chiniot City, therefore, bridge deck has also been dualized. A separate deck has been designed at this location which will have independent super and substructure. Moreover, a Pre-Stressed Girder flyover (09 x 20m Spans) has also been proposed at the same location which will act as an entrance to the bypass of Chiniot City. Furthermore, at KM 22+600, another single deck Pre-Stressed Girder Bridge (03 x 20m Span) over canal towards Jhang~Chiniot Junction along with a Double Deck Flyover of (02 x 20m Span) has been proposed at Km 22+825.

At Km 27+800 a Double Deck Flyover, with independent Super and Substructure arrangements, of 13 ± 03 x 20m Spans has been proposed at Chiniot~Faisalabad-Sargodha Road Junction along with at-grade improvement. All of the above mentioned newly proposed bridges and flyovers shall have a Deck Width Cross Section of 11.4m.

3.6.3 Design Criteria

The main purpose and the objective of the design criteria is to formulate and finalize technical data, design assumptions, codes of practice, methods and procedures to be adopted in the structural design of various structures of the project. The design assumptions and criteria mentioned herein will be used for the structural design of the, bridges, subways, culverts and related works.

3.6.3.1 Units of Measurement

The design has been accomplished using FPS/SI units.

3.6.3.2 Design Codes and Standards

Generally following codes and standards shall be followed:

WPCHB (1967)	-	Government of West Pakistan Highway Bridges Code of Practice Highway Bridges 1967
AASHTO (2017)	-	AASHTO LRFD Bridge Design Specification (For the design of all structural members)

		ASD combination for the calculating length of pile.)
BCP (2007)	-	Building Code of Pakistan
ACI 318-08	-	Building Code Requirements for Reinforced Concrete. American Concrete Institute.
ACI 301-95	-	Specifications for Structural Concrete. American Concrete Institute.
ASTM A-615	-	Specifications for Deformed and Plain Billet Steel Bars for Concrete Reinforcement.
ASTM C-150	-	Specifications for Portland cement
ACI-350 R	-	Environmental Engineering Concrete Structures
ASTM C-33	-	Specifications for Concrete Aggregate
UBC 1997	-	Uniform Building Code of USA.
ASTM C270	-	Standard Specification for Mortar for Unit Masonry.

3.6.3.3 Loads

Structures designed is capable of resisting the following main loads and forces:

- Dead Load
- Live Load
- Impact/ Dynamic Allowance
- Vehicle Collision Force
- Wind Load
- Longitudinal forces due to tractive/braking effort of vehicles
- Earth Pressure
- Earthquake Forces

- Stream flow

Dead loads

Dead Loads will be computed from the unit weights of the materials as given in the Building Code of Pakistan.

Live loads

Vehicle live loads shall be considered in accordance with WPCHB loadings as defined under Class A loading and Class AA loading. The design of structural members shall be made for the severe loadings.

Impact / dynamic allowance

Impact loading on the bridge superstructure shall be in accordance with the WPCHB.

Wind load

Wind loads on the bridges shall be considered in accordance with the provisions of Article 3.15 of AASHTO LRFD Bridges Design Specification; applicable wind Velocity shall be 110 mph for design.

Braking forces

Longitudinal braking /traction forces due to sudden stoppage of vehicles shall be Considered in accordance with WPCHB 1967 Standard Specifications.

Earth pressures

Earth pressure or load on Culverts, Water Courses etc. shall be computed as the weight of earth directly above the slab. When the depth of fill is 600 mm or more, concentrated loads shall be considered as uniformly distributed over a square area, the sides of which are $1\frac{3}{4}$ times the depth of fill. Lateral earth pressure is considered as per requirements of AASHTO LRFD Bridges Design Specification.

Earthquake forces

Seismic design shall be carried out in accordance with the provisions of the Building Code of Pakistan with Zone-2A. The values of peak ground acceleration adopted for analysis and design are 0.08 to 0.16g.

Stream flow forces on Piers and Culverts:



Stream flow forces, where applicable, shall be applied on piers and culverts in accordance with the requirements as per Article 3.18 of AASHTO LRFD Bridges Design Specification.

Loading combination

The design of structures shall be carried out for the load combinations for service and ultimate load conditions in accordance to Article 3.22 of AASHTO LRFD Bridges Design Specification.

3.6.3.4 Materials

Following strengths of construction materials has been used in the design:

Cement:

The limiting value of sulphates in ground water should less than 150 ppm. If it exceeds this value, then OPC cannot be used. Similarly, the limiting value of water soluble chloride ion (Cl-) in concrete is 0.06 & 0.15 (by mass of cement) for Prestressed and reinforced concrete.

Based on published technical paper titled, "Engineering Properties, Mineralogy, Alkali Aggregate Reaction Potential and Provenance of Lawrencepur Sand Pakistan", by Dr. M.Nawaz Chaudhry etc. AI (1997) wherein it has been reported that coarse sand sizes contained in Lawrencepur Sand deposits are reactive in terms of Alkali Silica Reaction (ASR), the detail of recommended cement to be used is as here under:

Ordinary Portland cement containing appropriate pozzolanic materials i.e. Ground Granulated Blast Furnace Slag (GGBFS) in proportion of 40% of the cement content in the concrete.

Concrete:

Four classes of concrete have been used as given below:

- I. Concrete Type A (nominal mix 1:1:2)
- II. Concrete Type B (nominal mix 1:1-1/2:3)
- III. Concrete Type C (nominal mix 1:2:4)
- IV. Lean Concrete (nominal mix 1:4:8)

Concrete strength of Pre-Stressed Girders is Class A. Concrete barriers, sign foundations, chute, catch pit curb stone, duct marker, ROW marker and foundations for posts chain link fabric/wire rope safety fence/ curve delineator/lighting poles is

Class B, whereas for RCC girder, piers, piles, approach slab, curtain wall, wing wall, foundation, transom, abutment seat, diaphragm, deck slab, counterfort and concrete pads it is also Class B.

The concrete strength for median lining, pipe surrounds, service ducts, and duct marker surrounds foundation for steel post of median opening and haunching behind concrete kerb is also Class B.

Reinforcing Steel

High yield strength deformed billet steel bars conforming to Grade 60 AASHTO M31, ASTM A615 shall be used.

3.6.3.5 FOUNDATION PARAMETERS

The geotechnical parameters relating to the bearing capacity, lateral earth pressure and depth of foundations shall be finalized on the geotechnical investigations carried out at site at construction stage.

3.6.3.6 STABILITY CRITERIA

Overturning

The following criteria has been followed;

Resultant of applied forces should lie within middle third of the base for normal loading conditions. Resultant of applied forces should lie within middle half of the base for exceptional loading conditions. Minimum factor of safety against overturning shall be 2.0 for footings on soil.

Sliding

Minimum factor of safety against sliding shall be equal to 1.5. The factor of safety against sliding and overturning failure under seismic loading may be reduced to 75% of the factor of safety listed above.

ANALYSIS / DESIGN AND DRAWINGS

Design has been carried out with 3D finite element grillage analysis using computer software STAAD Pro/CSI Bridges developed by Computers and Structures Inc. Berkeley, for carrying out Linear, Static and Dynamic Analysis and Design of Three Dimensional Structures. The bridges are analyzed and designed for Class A loading and class AA loading. Design of structural members has been carried out for the adverse load combinations as per recommendations of AASHTO LRFD Specifications, 2017. Dynamic analysis using response spectra has been carried out

for the substructure. The substructures has also been designed for stream flow conditions, where applicable. All drawings have been prepared using computer program AutoCAD.

3.6.4 KEY POINTS IN ACHIEVING DURABLE STRUCTURE

In order to secure the long term durability of a concrete and masonry structure following areas have to be monitored:

For Concrete:

1. Determination of concrete components including water cement ratio, type and content of cement as well as aggregate and use of blast furnace slag, sulphate resistant cement where required.
2. Curing methods.
3. Evaporation control to avoid the damaging effects of drying out which can lead to surface cracking.
4. Protect the reinforcement against corrosion by providing adequate clear cover.
5. Protection against chloride in gross and risk of corrosion.
6. Keeping in view the above mentioned durability factors and proper maintenance schedule, the life service of reinforced concrete structures is expected to be 100 years.

For Brick Masonry Structure:

1. All bricks shall be sound, hard, well burnt and of uniform size, colour and texture. Dimensional variation in sizes shall not exceed 1/8".
2. All brick work shall be erected plumb and true to line and level. The maximum variation in any height or any length of wall shall be 1/8" in 10'-0".
3. Mortar used in masonry construction shall have an ultimate compressive strength of not less than 1800Psi and shall confirm to ASTM C270.
4. The average compressive strength of five bricks shall not be less than 2000Psi and shall not be less than 1500Psi for any individual brick.
5. Bricks should be laid "Frog" upward with mortar joint and in English or Flemish bond.
6. All bricks masonry walls shall be plastered with 1:4 cement sand mortar.

3.6.5 COST ESTIMATE

Cost for Extension/Reconstruction of existing structure has been worked out on Local /MRS rates. Cost has been worked out based on preliminary design of structure. However, it may change at detailed design or construction stage depending upon condition of existing structure.

3.7. PROJECT COST ESTIMATE

3.7.1 PROJECT COST ESTIMATION:

The cost estimation is carried out and is based on Latest MRS 2020 (Chiniot city).

Cost Summary is given below:

SUMMARY		
Bill No	Description	Amount (Rs.)
1	Earthwork and Allied Activities	823,870,599
2	Subbase and Base	1,632,690,452
3	Surface Courses & Pavement	4,542,597,939
4	Structures	2,416,085,000
5	Drainage & Erosion Works	601,124,104
6	Ancillary Works	979,401,623
7	General Items	-
8	Electrical Works	117,883,080
9	Toll Plaza 3 No. (P.S)	225,000,000
	Construction Cost =	11,338,652,797
	Horticulture/Replenishment Cost @ 1.0 % of Construction Cost	113,386,528
	Shifting of Services GEPCO, SNGPL, PTCL etc. (P.S)	-
	Consultancy Charges for Design & Construction Supervision @ 2% of Construction Cost	226,773,056
	Land Acquisition & Structural Compensation (P.S)	-
-	Total Project Cost =	11,678,812,381

3.8. ECONOMIC EVALUATION

3.8.1 GENERAL

Economic justification of the project has been established for widening and improvement of Faisalabad-Chiniot-Sargodha Road (Length 66.30 km) by showing its profitability in terms of excess of benefits to the economy over economic costs by using the discounted cash flow technique. The projected stream of economic benefits over the economic life of the project has been compared to the estimated stream of economic costs by bringing the two to a uniform basis through the process of discounting. The economic indicators such as Net Present Value (NPV), Benefit Cost Ratio (B/C Ratio) and Internal Rate of Return (IRR) have been computed.

The economic justification of the proposed project works has thus been substantiated by the following studies:

- i) Economic Analysis, covering
 - a) Quantification of project economic benefits
 - b) Determination of project economic costs
 - c) Calculation of economic indicators such as NPV, B/C Ratio, EIRR.
- ii) Sensitivity Analysis

3.8.2 PROJECT BENEFITS

Benefits attributed to the implementation of the project works have been classified as 'tangible' or direct and 'intangible' or indirect benefits. Tangible benefits are those which can be quantified and to which a monetary value can be assigned. In-tangible benefits comprise of a number of economic and social advantages which though important, however, cannot be quantified in monetary terms.

3.8.2.1 **Tangible Benefits**

Nature of tangible benefits accruing from the implementation of the different roads improvement/widening comprise of vehicle operating cost (VOC) savings as well as travel time cost (VTT) savings. Residual value of the structures at the end of the economic life of the project is added to the benefit stream in the economic evaluation.

3.8.2.2 Parameters required for calculation of tangible benefits

Necessary parameters considered for calculation of tangible benefits are:

- o Existing and projected traffic volumes on the project
- o Average operating speeds under without and with project conditions
- o Economic prices for calculating vehicle operating costs (VOC)
- o VOC per km for various categories of traffic and
- o Distances used in benefit estimation

These are discussed below:

3.8.2.2.1 Traffic likely to use the Faisalabad-Chiniot-Sargodha Road

An estimate of projected traffic likely to benefit from widening of Road is pre-requisite to the calculation of project benefits. Existing and projected traffic volume on the project road has been determined.

3.8.2.2.2 Average Operating Speeds

Average operating speeds adopted for the vehicle likely to ply on the project road (to be used for the analysis) are given as under:

Table-3.8.1 VEHICLE OPERATING SPEEDS (Km/h)

Description	M/Cycle	Car	Bus/Wagons	Truck-Tractors
Without Project (Existing conditions)	35	35	35	30
With Project (After widening & improvement)	55	60	45	40

3.8.2.2.3 Economic Prices used for calculating

For working out VOC/Km, prices of different vehicles such as Motorcycles, Cars, Minibuses, Buses and trucks and those of fuel, lubricants and tyres have been expressed in economic prices by excluding duties and taxes from the financial/ market prices. These are given in Table-3.8.2 (a) to (e).

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)

Sr.No	ITEMS	Motor Cycle	Rickshaw	Car	Wagon/ Toyota Hiace	Mini Bus/ Coaster	Bus	Trucks		
								2-axle	3-axle	4-axle/ & above
1	Financial / Market Price	90000	170000	1900000	5200000	6045098	7020482	8389500	8664450	9209265
2	Taxes/Duties	15300	28900	323000	884000	1027667	1193482	1426215	1472957	1565575
3	Market Price Less	74700	141100	1577000	4316000	5017431	5827000	6963285	7191494	7643690
	Taxea & Duties									
	Economic Price	74700	141100	1577000	4316000	5017431	5827000	6963285	7191494	7643690

Table 3.8.2 (a) Vehicle Prices

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)

Vehicle Type	Financial Prices	Sales Tax	Eco. Price (Market price less sales tax)
TYRE & TUBE PRICEES			
Motor Cycle	1755	255	1500
Rickshaw	2574	374	2200
Car	4680	680	4000
Wagon	8775	1275	7500
Mini Bus	12636	1836	10800
Bus	29507	4287	25220
Truck		-	-
2-Axle	34234	4974	29260
3-Axle	34515	5015	29500
4-Axle & above	34936	5076	29860
Tractor	35685	5185	30500

Table 3.8.2 (b) Tyre (Including Tube) Prices

Sr No.	ITEMS	FINANCIAL PRICE		ECONOMIC PRICE	
		Petrol	Diesel	Petrol	Diesel
1	Ex-Refinery	57.71	61.11	57.71	61.11
2	Excise Duty				
3	Petroleum Dev. Levy	22.85	25.10	22.85	25.10
4	Freight Charges	3.53	0.54	3.53	0.54
5	Distributor's Margin	2.81	2.81	2.81	2.81
6	Dealer's Margin	3.70	3.12	3.70	3.12
	Sub-Total:-	90.60	92.68	90.60	92.68
7	GST (17%)	15.40	15.76		
8	Subsidy				
TOTAL		106.00	108.44	90.60	92.68
Economic Price				90.60	92.68

Table 3.8.2 (c) Fuel Prices (Jan-2021)

CNG Price	(Rupees)
Market Price	69.72
Taxes* / Profit Margins	14.28
Price less Sales Tax	84.00
Economic Price	55.35

Table 3.8.2 (d) CNG Prices (Oct-2020)

Engine oil Price	(Rupees)
Market Price (Avg)	275.00
Sales Tax	46.75
Price less Sales Tax	228.25
Economic Price	228.25

Table 3.8.2 (e) Engine Oil Prices (Oct-2020)

3.8.2.2.4 VOC per Kilometer

To arrive at VOC/Km, the physical values of fuel consumption, engine oil consumption, tyre wear, maintenance cost, depreciation, interest and wages etc. at various speeds as applicable to the without and with project conditions are required. VOC have been based on a set of linear and quadratic equations which have been based on NTRC (National Transport Research Centre) under Ministry of Communication Study. These equations have been derived using HDM-IV model (Refer vehicle Operating cost using HDM-VOC Verions-4.0) published by NTRC Using these equations per kilometer vehicle operating costs for various vehicles against respective operating speeds have been calculated and given in Table-3.8.3 (a) & (b)

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)

SPEED Km/H	Vehicle Operating Cost							
	Motor cycle	Rickshaw	Car	Wagon	Medium Bus	Heavy Bus	Truck (2 Axle)	Truck Trailer
10	6.60	9.91	74.47	72.07	82.68	103.30	152.64	204.96
15	5.75	8.66	62.44	61.49	70.91	88.50	129.26	174.21
20	5.24	8.06	56.27	55.74	64.48	79.98	112.27	150.95
25	4.90	7.70	52.50	52.03	60.31	74.31	98.73	132.03
30	4.67	7.50	49.99	49.41	57.37	70.32	87.66	116.40
35	4.52	7.41	48.26	47.50	55.23	67.54	78.65	103.61
40	4.45	7.30	46.97	46.09	53.66	65.71	71.49	93.43
45	4.43	7.21	46.03	45.07	52.55	64.70	66.06	85.74
50	4.48	7.23	45.45	44.38	51.81	64.42	62.29	80.47
55	4.57	7.33	45.17	43.97	51.40	64.84	60.14	77.56
60	4.73	7.42	45.06	43.82	51.29	65.90	59.58	77.00
65	4.93	7.58	45.17	43.91	51.47	67.59	60.59	78.74
70	5.19	7.77	45.46	44.21	51.90	69.89	63.15	82.78
75	5.50	8.09	46.01	44.73	52.59	72.79	67.25	89.11
80	5.86	8.45	46.72	45.45	53.53	76.27	72.89	97.72
85	6.27	8.91	47.65	46.37	54.70	80.33	80.05	108.59
90	6.73	9.44	48.76	47.48	56.10	84.97	88.74	121.74
95	7.23	10.03	50.04	48.78	57.74	90.18	98.95	137.14
100	7.79	10.68	51.48	50.27	59.59	95.95	110.68	154.80

Table 3.8.3 (a) VOC for Poor Road Conditions

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)

SPEED Km/H	Vehicle Operating Cost							
	Motor cycle	Rickshaw	Car	Wagon	Medium Bus	Heavy Bus	Truck (2 Axle)	Truck Trailer
10	6.06	9.08	67.28	64.83	74.17	96.91	141.31	189.14
15	5.23	7.85	55.32	54.36	62.53	82.40	119.16	160.21
20	4.74	7.26	49.21	48.69	56.20	74.12	103.25	138.56
25	4.41	6.92	45.47	45.04	52.10	68.63	90.66	121.05
30	4.19	6.73	42.99	42.48	49.21	64.78	80.40	106.62
35	4.04	6.64	41.28	40.60	47.10	62.08	72.07	94.83
40	3.97	6.53	39.99	39.20	45.53	60.30	65.45	85.46
45	3.95	6.43	39.04	38.18	44.40	59.28	60.43	78.37
50	3.98	6.43	38.43	37.46	43.62	58.95	56.93	73.49
55	4.06	6.52	38.11	37.01	43.15	59.26	54.91	70.77
60	4.20	6.59	37.95	36.80	42.95	60.17	54.35	70.19
65	4.38	6.71	37.99	36.80	43.02	61.66	55.21	71.72
70	4.61	6.87	38.20	37.01	43.32	63.70	57.49	75.34
75	4.89	7.15	38.66	37.41	43.85	66.30	61.18	81.04
80	5.21	7.47	39.26	37.99	44.60	69.43	66.27	88.82
85	5.58	7.87	40.07	38.76	45.57	73.10	72.75	98.66
90	5.99	8.35	41.04	39.70	46.75	77.29	80.62	110.57
95	6.45	8.87	42.17	40.81	48.13	82.00	89.87	124.54
100	6.96	9.45	43.45	42.09	49.71	87.23	100.50	140.56

Table 3.8.3 (b) VOC for Fair Road Conditions

3.8.2.2.5 Travel Time Costs per Kilometer

Parameters considered for working out travel time costs for passenger vehicles are:

- Average annual income per passenger
- Annual working hours
- Number of occupants per vehicle

Based on the above parameters, economic value of travel time expressed in Rs per hour has been worked out for occupants of Car, Wagon, Coaster/Flying Coach and Bus. Various assumptions regarding monthly income, working hours etc. made in this regard are given in **Table-3.8.4**. Based on these assumptions per kilometer value of travel time for passengers of various vehicles against different operating speeds have been estimated in **Table-3.8.5**.

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)

Description	Motor cycle	Rickshaw	Car	Wagon	Medium Bus	Heavy Bus
TRAVEL TIME VALUE OF PASSENGERS/OCCUPANTS						
Average Income of Passenger (Rs./Month)	39271	30856	65920	28051	34363	22441
Average Income of Passenger (Rs./Annum)	471257	370274	791039	336612	412350	269290
Working Hours /Annum	2496	2496	2496	2496	2496	2496
Rate of passenger Rs./Hour	189	148	317	135	165	108
No. of Occupants	1	2	3	14	25	40
Travel Time Value of occupants---in financial terms (Rs./Hour)	189	223	824	1888	4130	4316
Travel Time Value of occupants---in economic terms (Rs./Hour) 60%	113	134	494	1133	2478	2589

Table 3.8.4. Value of Travel Time



TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)

SPEEDS	Motor cycle	Rickshaw	Car	Wagon	Medium Bus	Heavy Bus
15	7.55	8.90	32.96	75.52	165.20	172.62
20	5.66	6.68	24.72	56.64	123.90	129.47
30	3.78	4.45	16.48	37.76	82.60	86.31
40	2.83	3.34	12.36	28.32	61.95	64.73
50	2.27	2.67	9.89	22.66	49.56	51.79
60	1.89	2.23	8.24	18.88	41.30	43.16
70	1.62	1.91	7.06	16.18	35.40	36.99

Table 3.8.5. Value of Travel Time (per Kilometer)



3.8.2.2.6 Standard Conversion Factor

The most general conversion factor used for converting market prices into economic prices is the standard conversion factor (SCF) which represents the ratio of prices of all goods within the economy to their international prices. The SCF is mainly influenced by the trade policies of the government. It is approximated by the weighted average of import and export tariff, with subsidies excluded. The weights used are based on the magnitude of imports and exports in the total trade during the subject years.

Table - 6 gives the yearly values of the data required to calculate the Standard Conversion Factor for the fiscal years 2009-10 to 2014-15. An average of five years is taken to allow for annual fluctuations in trade, taxes and subsidies. Based on the data given in Table - 6 the Standard Conversion Factor is calculated and is shown below:

Sr. No.	Description/Years	2009-10	2010-11	2011-12	2012-13	2013-14	Average
1.	Total Imports *	2910975	3455287	4009093	4349880	4630521	3871151
2.	Total Exports *	1617458	2120847	2110605	2366478	2583463	2159770
3.	Import Duties **	161504	187695	219589	242989	244946.77	211345
4.	Sales Tax on Imports **	247246	308648	430399	429831	495330	382291
5.	Subsidies on Imports ***	37725	20200	49198	10000	30000	29425
6.	Export Duties **	4551	5685	5762	6832	6595	5885
7.	Export Rebates **	5783	8527	8453	10362	8732	8371

Table 3.8.6 Derivation Of Standard Conversion Factor (in Millions)

$$SCF = \frac{M + X}{(M+T_m) + (X-T_x)}$$

Where

- M is the CIF value of imports
- X is the FOB value of exports
- T_m is the net value of taxes on imports
- T_x is the net value of taxes on exports

The value of SCF thus works out as 0.91

3.8.2.2.7 Distance used in Analysis

Length to be used in the analysis is given as under:

Length used for Analysis

Road	Length(km)
Faisalaba-Chiniot-Sargodha Road	66.30

3.8.2.3 PROJECT BENEFITS

These benefits include VOC (Vehicle Operating Cost) savings and time cost savings due to improved operating speeds on account of rehabilitation of the project roads.

3.8.2.3.1 Vehicle Operating Cost Savings

A major part of the economic benefits from the project implementation is expected to accrue from the VOC savings. It is, therefore, important to have a reliable estimate of vehicle operating costs per Km both under without and with project conditions.

Based on the quadratic equations discussed above and economic prices, vehicle operating cost per kilometer by type of vehicle under without project conditions have already been worked out (refer to Table-5). To arrive at total annual vehicle operating costs (AVOC) both under without and with project conditions, VOC per kilometer have been multiplied with the AADT and distance travelled in a year.

Annual vehicle operating costs have been worked out (at ten year intervals) both under without and with project conditions and given as under:

VOC SAVINGS

(Million Rs.)

Description	VOC		
	2023	2033	2043
Savings	5795.30	7830.30	9222.79

3.8.2.3.2 Savings in value of travel time

Basic parameters required for valuing travel time for Motorcycle, Rickshaws, Car, Wagon, Coaster and Bus passengers have already been determined

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)

above. Value of travel time (km/hr) at various operating speeds (under without and with project conditions) are given in Section-2.2.5

Total Annual value of travel time (AVTT) is a function of VTT per km, ADT and annual distance covered. Based on these parameters worked out earlier, annual AVTT have been estimated. The difference of AVTT under without and with project conditions represents benefits on account of savings in travel time is summarized below:

VTT SAVINGS

(Million Rs.)

Description	VTT		
	2023	2033	2043
Savings	1264.42	2013.38	4139.73

3.8.2.3.3 Total Economic Benefits

Total project benefits for ten-year intervals have been summarized below.

Description	Total savings		
	2023	2033	2043
Total Savings	7059.72	9843.68	13362.52

Annual stream of total project benefits over the period of analysis is given in

Table-3.8.7

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)

YEARS	n	Year of Construction	VOC Benefits	VTT Benefits	Total Benefits
2021	1	1			
2022	2	2			
2023	3		5795.30	1264.42	7059.72
2024	4		6019.59	1335.51	7355.10
2025	5		6243.89	1406.60	7650.49
2026	6		6468.18	1477.69	7945.88
2027	7		6692.48	1548.78	8241.26
2028	8		6916.78	1619.87	8536.65
2029	9		7099.48	1698.57	8798.06
2030	10		7282.19	1777.28	9059.46
2031	11		7464.89	1855.98	9320.87
2032	12		7647.59	1934.68	9582.27
2033	13		7830.30	2013.38	9843.68
2034	14		8005.83	2260.91	10266.74
2035	15		8181.37	2508.43	10689.80
2036	16		8356.90	2755.96	11112.86
2037	17		8532.44	3003.48	11535.92
2038	18		8707.97	3251.01	11958.98
2039	19		8810.94	3428.75	12239.69
2040	20		8913.90	3606.50	12520.39
2041	21		9016.86	3784.24	12801.10
2042	22		9119.82	3961.98	13081.81
2043	23		9222.79	4139.73	13362.52
2044	24		9147.54	4376.08	13523.62
2045	25		9072.30	4612.44	13684.73
2046	26		8997.05	4848.79	13845.84
2047	27		8921.80	5085.15	14006.95
2048	28		8846.56	5321.51	14168.06

Table 3.8.7 Annual Stream of Benefits

3.8.3 PROJECT COSTS

The project costs include capital cost of construction, recurring costs and overlay costs. These are discussed below:

3.8.3.1. Project Investment Costs

Total project investment costs are estimated as Rs. 11678.81 Million. By applying SCF of 0.91 to financial costs, economic costs are calculated as Rs. 10675.60 Million which is spread over one year as given under:

Project Investment Costs

(Million Rs.)

Years	Total Cost	
	Financial Terms	Economic Terms
2021	5839.406	5337.80
2022	5839.406	5337.80
Total	11678.81	10675.60

3.8.3.2. Recurrent Costs & Overlay Cost

Operating and Maintenance (O&M) costs has been estimated as Rs.116.79 Million. By applying SCF of 0.91, the O&M cost in economic terms is estimated as Rs.106.76 Million.

Overlay Cost has been estimated as Rs.1209.27 Million. By applying SCF of 0.91, The Overlay cost in economic term is estimated as Rs. 1105.40 Million.

3.8.3.3. Total Project Economic Costs

Annual stream of Project Economic Costs over the period of analysis is given in **Table-3.8.8.**

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)

Year	n	Year of Construction	Year after Construction	Financial Costs				Economic Costs			
				Investment Costs	Overlay cost	O & M Costs	Total Costs	Investment Costs	Overlay cost	O & M Costs	Total Costs
2021	1	1		5839.41			5839.41	5337.80			5337.80
2022	2	2		5839.41			5839.41	5337.80			5337.80
2023	3		1			116.79	116.79			106.76	106.76
2024	4		2			116.79	116.79			106.76	106.76
2025	5		3			116.79	116.79			106.76	106.76
2026	6		4			116.79	116.79			106.76	106.76
2027	7		5			116.79	116.79			106.76	106.76
2028	8		6			116.79	116.79			106.76	106.76
2029	9		7			116.79	116.79			106.76	106.76
2030	10		8			116.79	116.79			106.76	106.76
2031	11		9			116.79	116.79			106.76	106.76
2032	12		10			116.79	116.79			106.76	106.76
2033	13		11		1209.27	116.79	1326.06		1105.40	106.76	1212.15
2034	14		12			116.79	116.79			106.76	106.76
2035	15		13			116.79	116.79			106.76	106.76
2036	16		14			116.79	116.79			106.76	106.76
2037	17		15			116.79	116.79			106.76	106.76
2038	18		16			116.79	116.79			106.76	106.76
2039	19		17			116.79	116.79			106.76	106.76
2040	20		18			116.79	116.79			106.76	106.76
2041	21		19			116.79	116.79			106.76	106.76
2042	22		20			116.79	116.79			106.76	106.76
2043	23		21			116.79	116.79			106.76	106.76
2044	24		22			116.79	116.79			106.76	106.76
2045	25		23			116.79	116.79			106.76	106.76
2046	26		24			116.79	116.79			106.76	106.76
2047	27		25			116.79	116.79			106.76	106.76
2048	28		26			116.79	116.79			106.76	106.76
				11678.81	1209.27	3036.49	15924.58	10675.60	1105.40	2775.66	14556.65

Table 3.8.7 Annual Stream of Project Financial and Economic C



TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)**3.8.4 RESULTS OF THE ANALYSIS**

The discounted cash flow of net benefits is given in **Table-3.8.9**. The economic indicators, thus computed are summarized below:

n	Year	Year of Construction	Year after Construction	Financial Costs			Economic Costs		
				PROJECT ECONOMIC COSTS	PROJECT ECONOMIC BENEFITS	NET BENEFITS A	B	C	D
1	2021	1		5337.80	0.00	-5337.80	-5337.80	-5871.58	-5871.58
	2022	2		5337.80	0.00	-5337.80	-5337.80	-5871.58	-5871.58
2	2023		1	106.76	7059.72	6952.96	6246.99	6942.29	6236.31
3	2024		2	106.76	7355.10	7248.35	6512.84	7237.67	6502.16
4	2025		3	106.76	7650.49	7543.73	6778.69	7533.06	6768.01
5	2026		4	106.76	7945.88	7839.12	7044.53	7828.44	7033.86
6	2027		5	106.76	8241.26	8134.51	7310.38	8123.83	7299.71
7	2028		6	106.76	8536.65	8429.89	7576.23	8419.22	7565.55
8	2029		7	106.76	8798.06	8691.30	7811.49	8680.62	7800.82
9	2030		8	106.76	9059.46	8952.71	8046.76	8942.03	8036.08
10	2031		9	106.76	9320.87	9214.11	8282.03	9203.44	8271.35
11	2032		10	106.76	9582.27	9475.52	8517.29	9464.84	8506.62
12	2033		11	1212.15	9843.68	8631.53	7647.16	8510.31	7525.95
13	2034		12	106.76	10266.74	10159.99	9133.31	10149.31	9122.64
14	2035		13	106.76	10689.80	10583.05	9514.07	10572.37	9503.39
15	2036		14	106.76	11112.86	11006.11	9894.82	10995.43	9884.14
16	2037		15	106.76	11535.92	11429.16	10275.57	11418.49	10264.90
17	2038		16	106.76	11958.98	11852.22	10656.33	11841.55	10645.65
18	2039		17	106.76	12239.69	12132.93	10908.96	12122.26	10898.29
19	2040		18	106.76	12520.39	12413.64	11161.60	12402.96	11150.92
20	2041		19	106.76	12801.10	12694.35	11414.24	12683.67	11403.56
21	2042		20	106.76	13081.81	12975.05	11666.87	12964.38	11656.20
22	2043		21	106.76	13362.52	13255.76	11919.51	13245.08	11908.83
23	2044		22	106.76	13523.62	13416.87	12064.51	13406.19	12053.83
24	2045		23	106.76	13684.73	13577.98	12209.50	13567.30	12198.83
25	2046		24	106.76	13845.84	13739.09	12354.50	13728.41	12343.83
26	2047		25	106.76	14006.95	13900.20	12499.50	13889.52	12488.83
27	2048		26	106.76	14168.06	14061.31	12644.50	14050.63	12633.82
Total				14556.65	282192.47	267635.82	239416.57	266180.15	237960.91
Discount Rates				Present Worth		NPV (Base Case)	NPV (Sensitivity Tests)		
12%				9946.45	57472.29	47525.84	41778.61	46531.20	40783.97
15%				9381.31	43405.14	34023.83	29683.32	33085.70	28745.19
20%				8625.73	29183.70	20557.97	17639.60	19695.39	16777.02
25%				8019.67	20980.09	12960.42	10862.41	12158.45	10060.44
30%				7511.29	15829.08	8317.79	6734.88	7566.66	5983.75
						54.97	50.56	50.97	46.85
12%						5.78			
15%						4.63			
20%						3.38			
25%						2.62			
30%						2.11			

A- Base Case

B- Benefits Decreased by 10%

C- Costs Increased by 10%

D- Both Occurring Simultaneously

RESULTS OF THE ANALYSIS (VOC SAVINGS ONLY)

Economic Parameters	At 12% Discount rate
Present Worth of Benefit (Million Rs.)	57472.29
Present Worth of Costs (Million Rs.)	9946.45
Net Present Value (Million Rs.)	47525.84
B/C Ratio	5.78:1
EIRR (Percent)	54.97

The results given above indicate that the proposed road is economically viable as the calculated rate of return is well above 12 percent. The project should therefore be implemented as planned.

3.8.5 SENSITIVITY ANALYSIS

In order to examine the effect of a possible increase in project costs and or decrease in estimated economic benefits of the project, various alternative economic analyses have been undertaken by varying various assumptions.

The results of the sensitivity analysis under the various assumptions are given below:

RESULTS OF THE SENSITIVITY ANALYSIS

Description	EIRR(Percent)
a) Base Case	54.97
b) 10 percent decrease in project benefits	50.56
c) 10 percent increase in project costs	50.97
d) (both occurring simultaneously)	46.85
e) Base Case	54.97

The results of sensitivity analysis given above show that in all cases, the project is not sensitive to above assumptions as the calculated IRR is above 12 percent, the opportunity cost of capital in Pakistan.

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=67KM)

