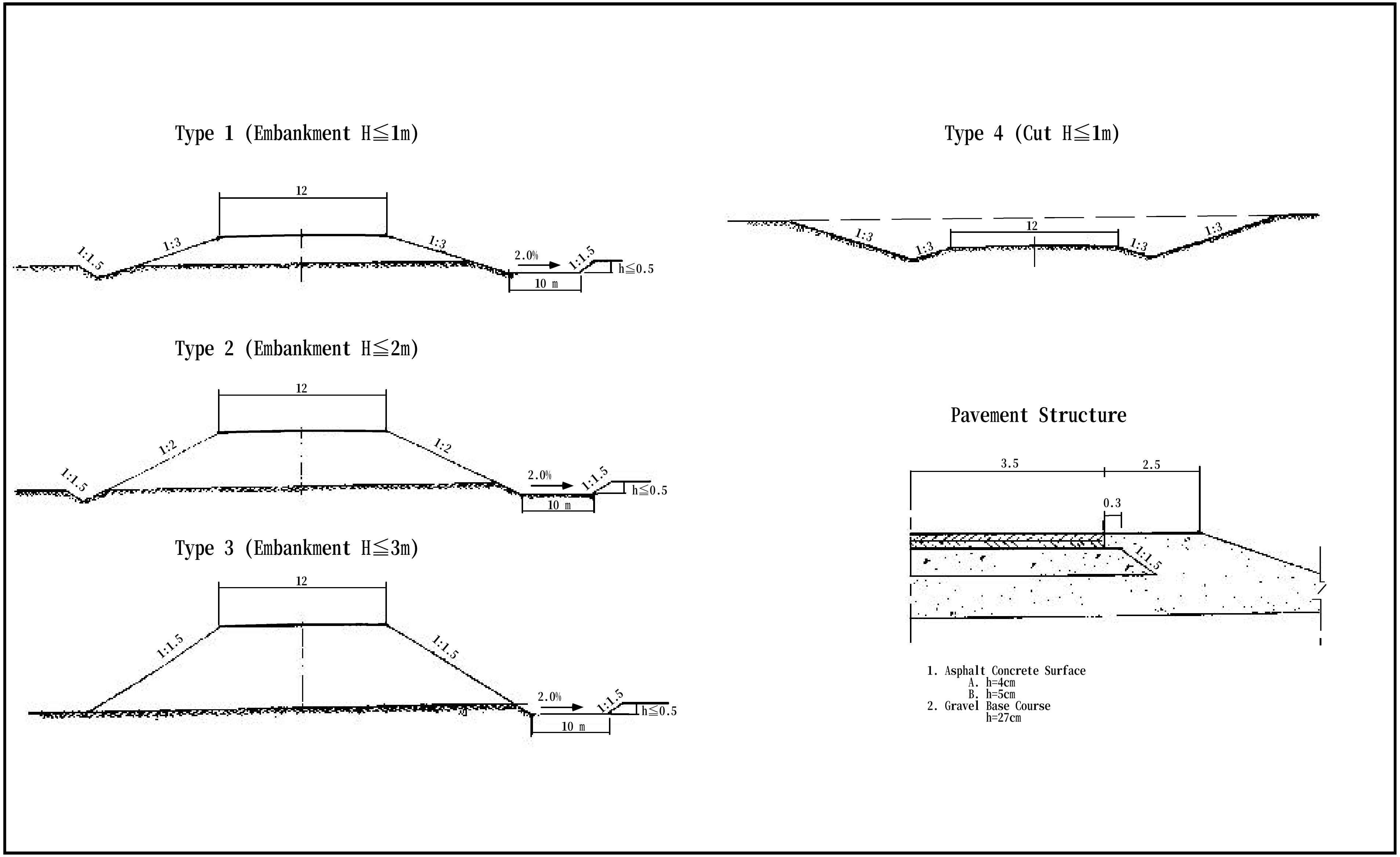


Figure 4-9-3 Typical Cross Section at Section 2

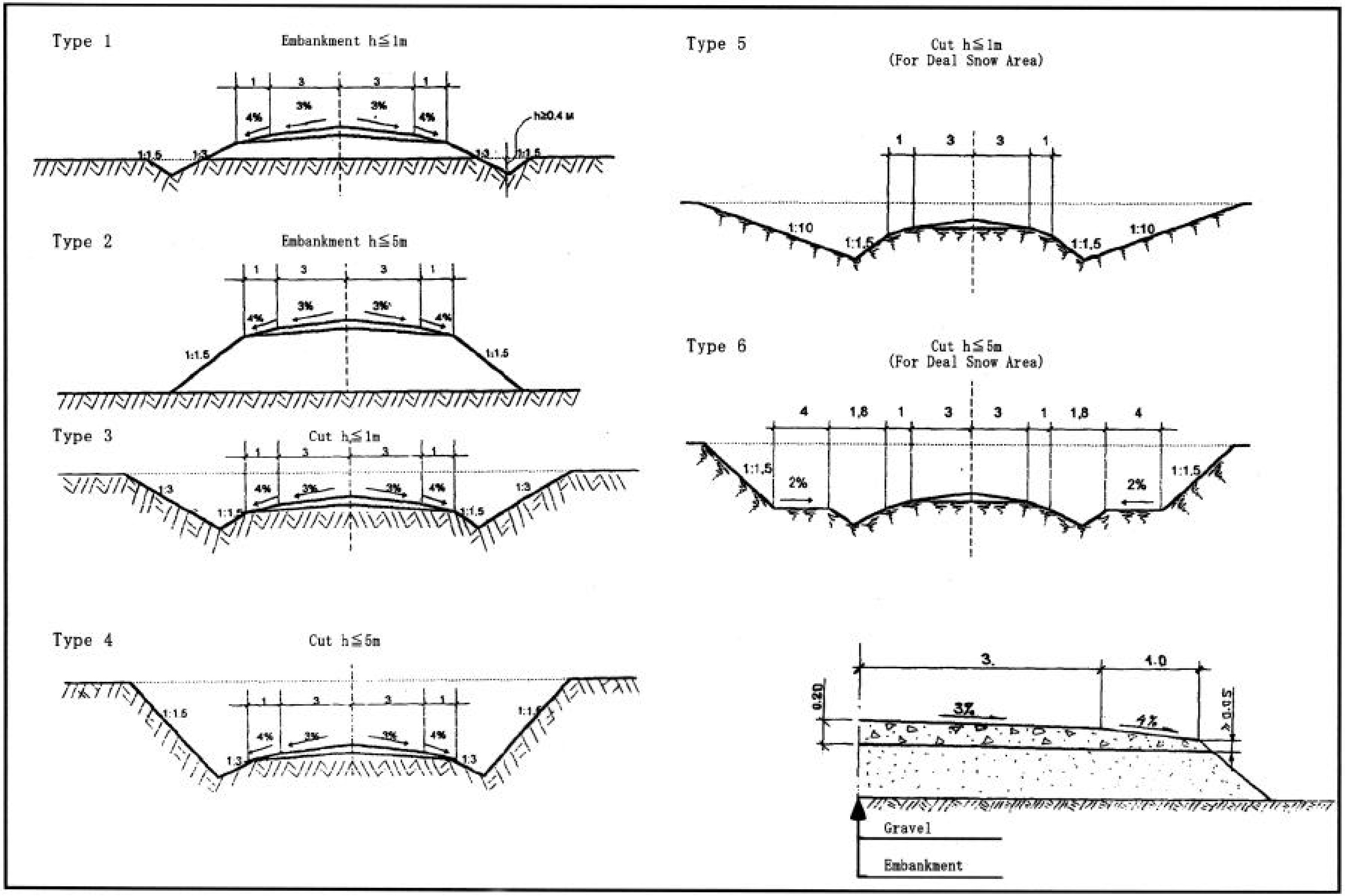


Figure 4-9-4 Typical Cross Section at Section 3-D

4.9.2 Planned Bridges for the Project Road

Bridges are designed at 31 locations as shown in Figure 4-9-5 and total length is 933 m as shown in Table 4-9-3. The bridge superstructures are of reinforcing concrete slab or T-girder. The slab type is applied to the bridge of less than 10 m span length and T- girder type is more than 12 m span length.

All the foundations (except that of the Kherlen River) apply a spread foundation because of high bearing stratum such as gravel more than 40 N-value. Caisson and cast in-situ pile are adopted to the bridge foundation of the Kherlen River.

The numbers and locations of planned bridges by Department of Roads, Infrastructure of Mongolian Government are listed in Table 4-9-3.

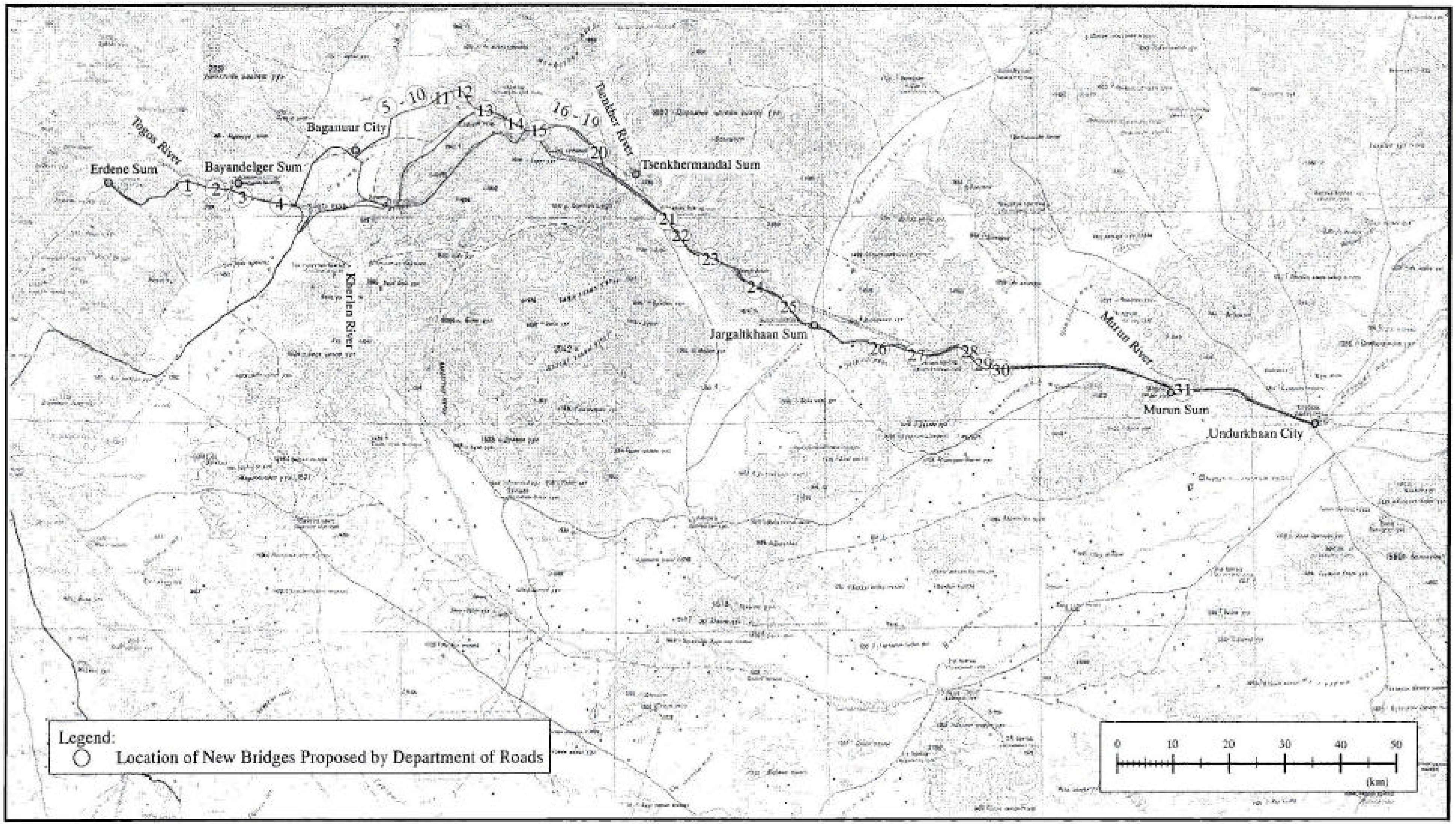


Figure 4-9-5 Location Map of New Bridges Proposed by Department of Roads

Table 4-9-3 Detailed Design for Bridges between Erdene and Undurkhaan

No.	Type	Length	Span	Station	m	Remarks	Location
1	RC-T	75.7	5@15.0	617	34.6	Togos	Togos River
2	RC-reU	9.0	8.73	642	46.0	Tal Bulag	↓
3	RC-reU	9.0	8.73	678	30.5	Delger	↓
4	RC-reU	9.0	8.73	745	55.5	Arshaant	↓
5	RC-T	343.5	19@18.0	35	67.75	Kh main	Baganuur
6	RC-T	36.7	3@12.0	44	3.0	Kh Trib	↓
7	RC-T	24.0	2@12.0	48	78.0	Kh Trib	Kherlen River
8	RC-T	24.0	3@18.0	69	6.0	Kh Trib	↓
9	RC-T	55.0	3@18.0	71	2.0	Kh Trib	↓
10	RC-T	91.0	5@18.0	73	70.0	Kh Trib	↓
11	RC-reU	6.5	6.0	132	54.0		↓
12	RC-reU	6.5	6.0	151	28.0		↓
13	RC-Slab	9.6	9.0	216	57.0		↓
14	RC-Slab	9.6	9.0	278	12.0		↓
15	RC-T	12.5	12.0	311	77.5		↓
16	RC-reU	6.5	6.0	322	80.0		↓
17	RC-Slab	9.6	9.0	330	35.0		↓
18	RC-reU	6.5	6.0	344	88.0		↓
19	RC-reU	6.5	6.0	349	9.0		↓
20	RC-Slab	9.6	9.0	446	82.0		Tsenkhermandal
21	RC-T	54.1	3@18.0	6	6.0	Tsenkher river	Tsenkher River
22	RC-T	15.0	15.0	26	60.5	Urugun Valley	↓
23	RC-Slab	6.0	6.0	100	97.0	Ar Khadagtay Valley	↓
24	RC-Slab	6.0	6.0	122	77.0	Zuulun Valley	↓
25	RC-T	15.1	15.0	275	29.79	Urt Valley	↓
26	RC-Slab	6.0	6.0	453	42.0	Ulaan Khudag Valley	Jargaltkhaan
27	RC-Slab	6.0	6.0	537	97.0	Gichgeny Valley	↓
28	RC-T	18.1	18.0	193	25.0	Duut river	↓
29	RC-Slab	5.0	5.0	175	0.0		↓
30	RC-Slab	5.0	5.0	141	26.0		↓
31	RC-Slab	36.25	4@9.0	1	60.1	Murun River	Murun
Total Length		**932.9** m					Undurkhaan

By Department of Roads, Ministry of Infrastructure

CHAPTER 5 NATURAL CONDITION EXAMINATION AND ENGINEERING SITE SURVEY

CHAPTER 5 NATURAL CONDITIONS EXAMINATION AND ENGINEERING SITE SURVEY

5.1 Physical Conditions of the Study Area

5.1.1 Topographic Conditions

Western half and northeast of Mongolia is classified as mountainous region. Remaining parts of the territory are covered by a wide plain including the Govi Desert. The Mongol Altai Mountains and the Khangai Mountains are the main mountains, and they have high peaks and ridges ranging in altitude from 3000m to 4000m. The former run along the western border of China, and the latter are situated to the east of them. The Khentii Mountains are situated in the northeast of the territory and are characterized by their very gentle relief in comparison with the above-mentioned mountains. The Khentii Mountains slope gently southward and eastward and contact with the plain area.

The study route runs in the boundary area between the Khentii Mountains and the plain area. The elevation of the route in the study area varies approximately from +1000m at Undurkhaan to +1600m at 1.5 km northeast of the Dutluur pass. More detailed topographic conditions along the study route are described below.

For the first 5 km from Erdene, the route runs along the northern edge of a 1.0 to 1.5 km wide valley. Then, the route crosses over the first and the steepest mountainous area. The 8 km long this stretch has the highest point in the route and has three crossings with shallow valleys. The next section is located in a relatively flat terrain situating to the west bank of the Kherlen River. In this section, the route run across a flood plain developed by the Togos river, the Narriin steppe and Nuga steppe where the Baganuur coal mine is located, and runs on the edge of gentle hilly areas and terraces.

The crossing point of the route with the Kherlen River selected by the Study team is located 30m downstream of the existing reinforced concrete bridge. There are mountains close to the both banks and the width of the river becomes narrowest around the bridge. The route planed by DOR crosses the river at approximately 15 km north, upstream, of the bridge. A very wide flood plain has been developed around the DOR's crossing point.

Next section of the route is located between the Kherlen river and a junction to Tsenkhermandal. In this section, the route again passes through the mountainous area. However, all of the alternative routes studied run along valleys such as Ust, Bor Khujirt, Jargalant and Khongor valleys, and defiles formed between small peaks. The route passes also steep slope sections such as Naran Pass and Khujirt Pass. The existing trails run along the edge of slopes and on terraces, in order to avoid soft ground mainly formed at the bottom of valley and locations susceptible of causing accumulation of water Locations of the soft ground appearing after winter may be identified by presence of earth hammocks covered by vegetation which has been formed by repeated freezing and thawing of fine grained soil. The earth hammocks are observed widely in this section, and small areas with the earth hammocks are also observed along the Tsenkher River, a valley, to the east of Khamur Pass, and the Murun river.

In the next 23 km long section covering the area between the junction and the west slope of Khamar pass, the route runs mainly flat terrain consisting of an alluvial plain and fans developed by the Tsenkher river and its tributaries. Before crossing the river, the existing trails pass along the toe of slope rather than in the flood plain developed along the Tsenkher River to avoid soft ground areas and erosion by the river. Tagyn Mountain rises sheer from the left bank of the Tsenkher River at the existing bridge.

After climbing a steep slope of Khamar pass with relative height of approximately 130m, the route runs over a gently undulated plateau, and goes gently down to the Urt valley, then runs across the 13 km wide Kherem steppe in which Tsagaan lake is situated. The proposed route is located to the north of the lake. Length of this section is approximately 24km.

Immediately after crossing the Kherem steppe, the route climbs the steep west slope of Oont pass and runs across a 16 km wide shallow depression named Ulaar Khadag valley and Northern valley. Baga khar and Ikh Khar lakes are situated at the center of this depression. The route passes by the Ikh Khar Lake. Then, the route crosses over Duut pass before entering the Chadgana steppe. Total length of the section is approximately 30km.

The last 60 km of the route to Undurkhaan is located in a flat terrain consisting of the Chandagna steppe, Dulaan steppe, terraces, very gentle slopes of cones and fans distributing around hills, and a flood plain formed by the Murun river. The earth hammocks are observed along the existing trail running along the Murn River near the existing Murun Bridge.

5.1.2 Geological Background along Study Route

Intrusive rocks such as granite, grano-diorite, diorite, and syenite are widely distributed along the study route. The intrusions into the area occurred in Proterozoic, Paleozoic, and Mesozoic. The intrusions in Paleozoic were very active. The intrusive rocks form ridges and peaks of mountains along the study route. The surface of the rocks has been weathered until it is extremely friable and crumbly, in general.

Proterozoic and Paleozoic sedimentary rocks such as shale, sandstone are sporadically distributed. Shale predominates among the sedimentary rocks along the study route. Due to the effect of the repeated intrusions and tectonic movements, shale has many fissures and planner schistosity structure. This kind of shale is typically observed on the east of the Duut pass. Following mountainous areas are made up mostly of the sedimentary rocks:

- South of the Togos river
- West bank of the Tsenkher river (between Mandal mountain and the existing Tsenkher river bridge
- Between Kherem steppe and Chandgana steppe

Cretaceous sedimentary rocks such as sandstone, shale, compacted sand and clay, and coal underlie the Nuga steppe and Nariin steppe in Baganuur, the Kherem steppe at Jargaltkhaan, Chandgana steppe, and a shallow basin situated between the Oont pass and the Duut pass. Small hills located in these flat areas are also formed by these rocks. Bagaunur and Chandgana coal deposits belong to this formation.

Cambrian volcanic rocks including tuff, porphyry, andecite and quartzite form mountains situated to the northeast of Murun and the northwest of Undurkhaan.

The Jargaltkhaan Mountain consists of basalt erupted in Cretaceous. Basalt hills are also scattered between Murun and Undurkhaan.

Low-lying areas including steppe and bottom of valleys are covered by Quaternary deposits. Terraces, taluses and fans developed along toe of slopes are also underlain by Quaternary deposits. The talus deposits cover even top of the gentle hills. Fluvial sand an gravelly soils have accumulated along rivers. These deposits mainly consist of coarse particles. Organic or silty fine soils are distributed along bottom of the valleys and backmarshes formed along existing rivers. As mentioned Section 5.1.1, the earth hammocks are formed at these fine soil areas with high groundwater table. Reddish brown to dark brown silty very fine sand to sandy silt with grassroots thinly mantled over the study area with 15 to 50cm in thickness. These soils are mainly aeolian deposits.

5.1.3 Climate

The weather information data such as Temperature, Number of Rainy days and Wind Velocity is shown in Tables 5-1-1 to 5-1-9.

These data are collected for ten years from 1991 to 2000. It shows the maximum, average and minimum value of each data. The data was collected in three cities, which are Ulaanbaatar, Baganuur, and Undurkhaan. The original data is in the Appendix.

(1) Temperature (°C)

Table 5-1-1 Temperature in Undurkhaan

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.
Ex.Max.T	-3.0	7.4	19.0	27.5	34.2	35.9
Ave.MaxT.	-8.7	-3.8	11.1	22.5	30.7	33.7
Ave.Min.T.	-36.0	-32.6	-27.7	-14.8	-5.7	1.8
Ex.Min.T.	-39.5	-37.0	-35.3	-19.3	-10.4	-1.5
Month	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Ex.Max.T	38.6	38.1	32.3	24.8	13.5	0.7
Ave.MaxT.	33.7	31.4	28.1	19.8	8.2	-3.2
Ave.Min.T.	6.8	4.9	-4.6	-17.8	-29.8	-33.6
Ex.Min.T.	3.1	2.5	-8.9	-25.4	-38.1	-37.6

Table 5-1-2 Temperature in Baganuur

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.
Ex.Max.T	-3.2	8.3	15.5	24.5	31.6	35.3
Ave.MaxT.	-9.5	-0.25	8.8	19.6	28.1	30.2
Ave.Min.T.	-38.3	-33.2	-28.2	-15.6	-7.9	-1.3
Ex.Min.T.	-43.7	-39.6	-37.0	-20.0	-11.5	-6.1
Month	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Ex.Max.T	35.6	33.6	26.2	21.2	8.8	-0.7
Ave.MaxT.	30.7	27.8	24.0	17.6	5.2	-5.3
Ave.Min.T.	4.4	1.6	-6.9	-19.2	-31.1	-34.6
Ex.Min.T.	1.6	-0.5	-10.6	-25.5	-35.8	-40.3

Table 5-1-3 Temperature in Ulaanbaatar

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.
Ex.Max.T	-2.6	8.5	15.5	23.6	30.8	34.5
Ave.MaxT.	-7.4	-1.2	9.7	20.6	29.3	30.6
Ave.Min.T.	-33.3	-27.7	-23.0	-12.3	-4.7	1.9
Ex.Min.T.	-38.8	-31.4	-26.6	-15.6	-8.2	-2.7
Month	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Ex.Max.T	38.1	34.6	28.8	21.7	10.6	-2.4
Ave.MaxT.	32.1	29.1	25.3	16.5	6.01	-5.2
Ave.Min.T.	6.5	4.9	-3.6	-15.4	-25.9	-31.0
Ex.Min.T.	4.0	2.2	-6.5	-17.5	-29.7	-34.5

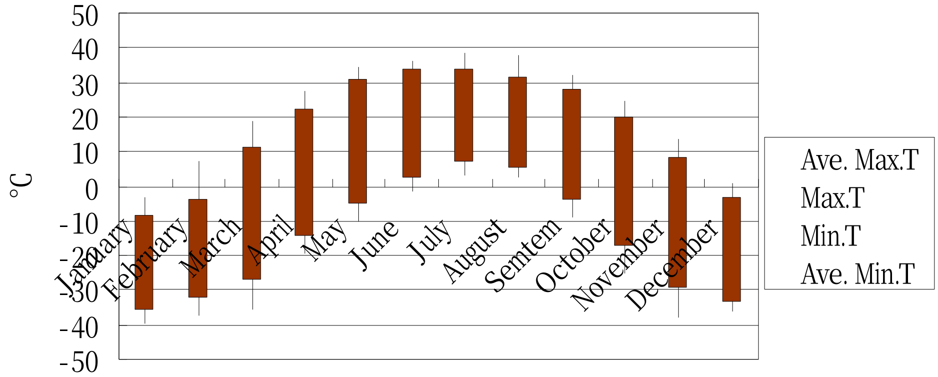


Figure 5-1-1 Temperature in Undurkhaan

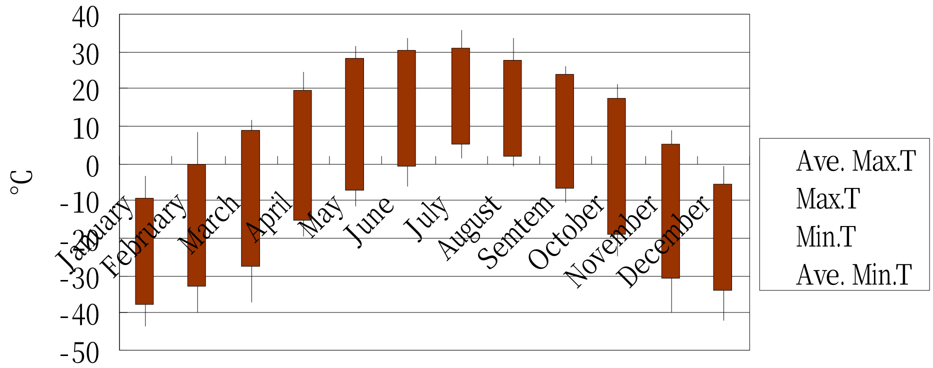


Figure 5-1-2 Temperature in Baganuur

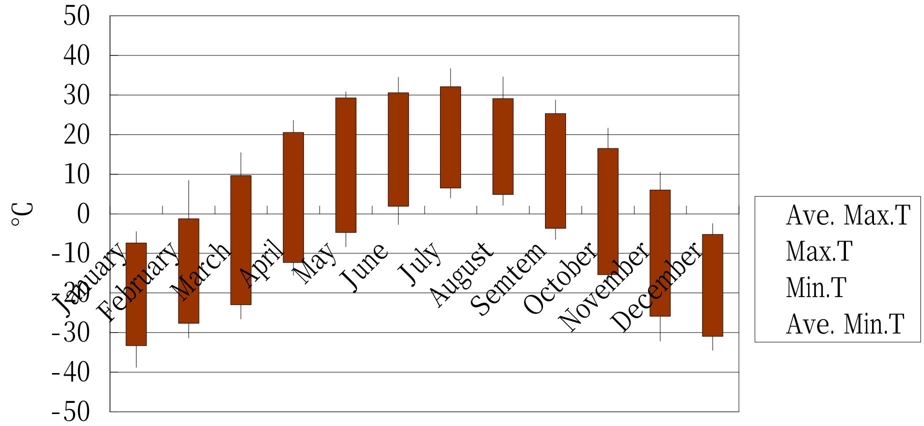


Figure 5-1-3 Temperature in Ulaanbaatar

(2) The number of rainy days (days)

Table 5-1-4 The Number of Rainy Days in Undurkhaan

	Jan.		Feb.		Mar.		Apr.		May		Jun.	
	0<	10<	0<	10<	0<	10<	0<	10<	0<	10<	0<	10<
Max.	5	0	4	0	10	0	11	1	11	1	15	2
Ave.	3.4	0	2.9	0	5.0	0	5.2	0.1	6.4	0.1	12.6	0.9
Min.	1	0	1	0	1	0	1	0	3	0	7	1
	Jul.		Aug.		Sep.		Oct.		Nov.		Dec.	
	0<	10<	0<	10<	0<	10<	0<	10<	0<	10<	0<	10<
Max.	18	7	19	6	12	2	10	0	10	0	7	0
Ave.	15.7	1.9	14.2	2.1	7.7	0.6	6.1	0	5.4	0	4.8	0
Min.	13	0	12	1	4	0	2	0	2	0	1	0

Table 5-1-5 The Number of Rainy Days in Baganuur

	Jan.		Feb.		Mar.		Apr.		May		Jun.	
	0<	10<	0<	10<	0<	10<	0<	10<	0<	10<	0<	10<
Max.	7	0	4	0	11	0	14	0	16	1	16	2
Ave.	4.4	0	2.3	0	5.6	0	6.9	0	7.7	0.2	12.4	0.7
Min.	1	0	1	0	2	0	3	0	3	0	8	0
	Jul.		Aug.		Sep.		Oct.		Nov.		Dec.	
	0<	10<	0<	10<	0<	10<	0<	10<	0<	10<	0<	10<
Max.	19	3	20	4	9	1	5	0	8	0	8	0
Ave.	15.7	1.7	15.0	1.6	6.5	0.1	3.9	0	4.5	0	3.2	0
Min.	13	0	8	0	2	0	2	0	1	0	2	0

Table 5-1-6 The Number of Rainy Days in Ulaanbaatar

	Jan.		Feb.		Mar.		Apr.		May		Jun.	
	0<	10<	0<	10<	0<	10<	0<	10<	0<	10<	0<	10<
Max.	10	0	7	0	12	0	13	1	11	1	16	3
Ave.	6.2	0	5.1	0	6.2	0	7.7	0.1	8.3	0.2	12.8	1.1
Min.	4	0	3	0	2	0	4	0	6	0	11	0
	Jul.		Aug.		Sep.		Oct.		Nov.		Dec.	
	0<	10<	0<	10<	0<	10<	0<	10<	0<	10<	0<	10<
Max.	17	4	23	7	14	2	10	1	15	0	13	0
Ave.	14.9	2.4	14.1	2.7	9.3	0.9	6.5	0.1	8.8	0	9.2	0
Min.	12	1	8	1	6	0	3	0	4	0	6	0

(3) Maximum Wind Velocity (m/s)

Table 5-1-7 Maximum Wind Velocity in Undurkhaan

	Jan.	Feb.	Mar.	Apr.	May	Jun.
Max.	18	18	26	32	34	34
Ave.	13.4	14.3	17.4	23.4	20.8	20.2
	Jul	Aug.	Sep.	Oct.	Nov.	Dec.
Max.	28	20	20	20	22	20
Ave.	18.8	16.4	17.4	16.2	17.4	14.2

Table 5-1-8 Maximum Wind Velocity in Baganuur

	Jan.	Feb.	Mar.	Apr.	May	Jun.
Max.	16	18	22	20	24	16
Ave.	11.0	12.5	15.8	17.5	16.1	13.5
	Jul	Aug.	Sep.	Oct.	Nov.	Dec.
Max.	16	16	16	16	15	14
Ave.	10.3	10.3	13.0	13.9	11.8	10.3

Table 5-1-9 Maximum Wind Velocity in Ulaanbaatar

	Jan.	Feb.	Mar.	Apr.	May	Jun.
Max.	15	16	22	24	24	24
Ave.	11.8	12.4	15.4	19.1	20.6	19.0
	Jul	Aug.	Sep.	Oct.	Nov.	Dec.
Max.	19	18	18	22	18	15
Ave.	15.7	14.7	15.4	15.8	13.9	10.8

The annual rainfall distribution in the Mongolia is shown in figure 5-1-4. The study area is in the range of 200-300mm.

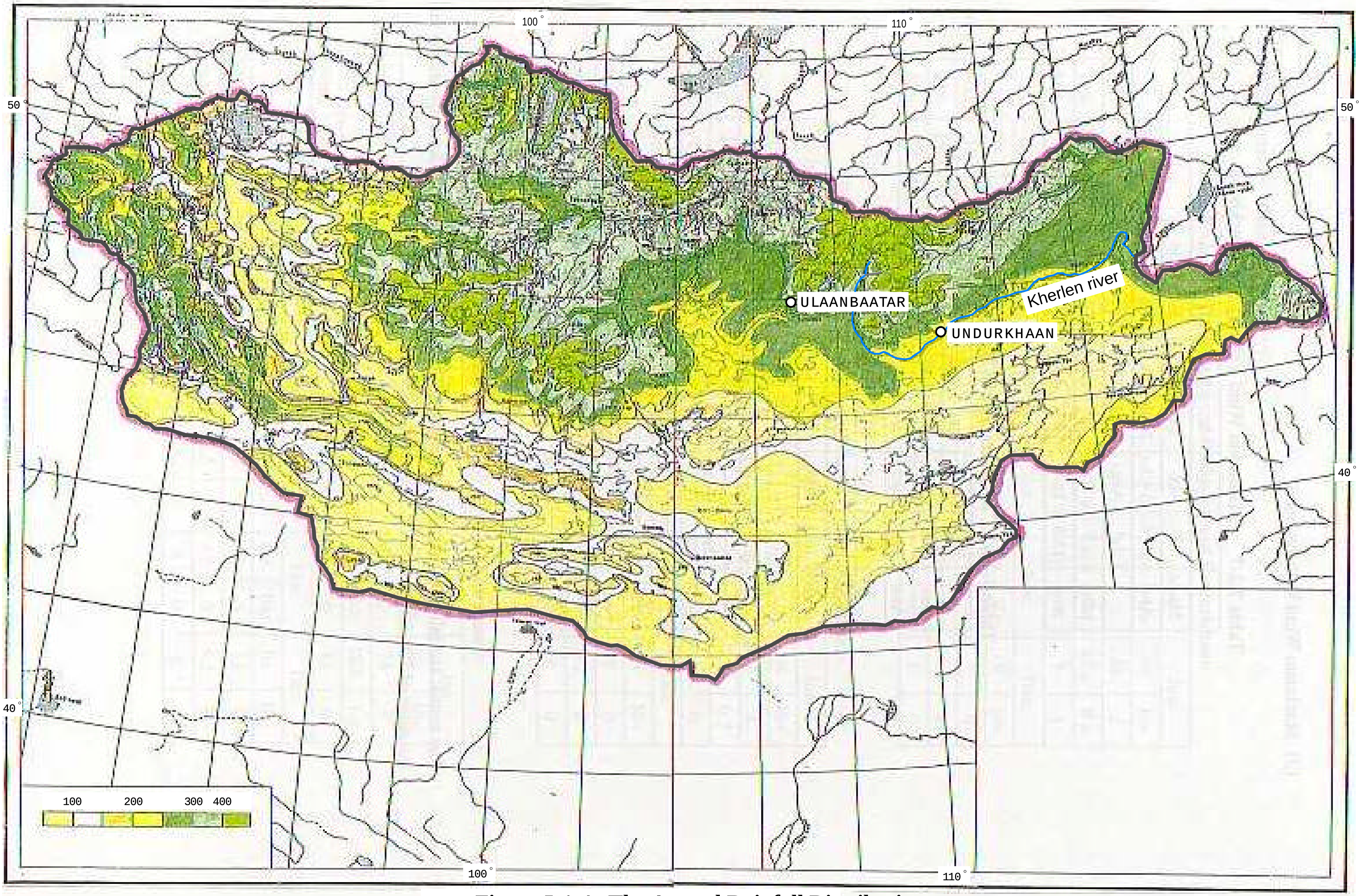


Figure 5-1-4 The Annual Rainfall Distribution

5.1.4 Earthquake

(1) Earthquake in Mongolia

Earthquakes in Mongolia have occurred mostly along mountain ranges situated in west, southwest and northwest of her territory as shown in Figure 5-1-5. The figure shows locations of epicenter of earthquakes with magnitude of equal to or greater than 5.0. The magnitude is expressed on the Richter scale.

According to "On the Seismicity of Territory of Mongolia" edited by T. Bayaraan et al in 1974, Mongolia is divided into 6 active earthquake zones. The zoning was made based on information of earthquakes occurred between 1900 and 1972. The area of the active zones covers 2/3 of Mongolia and 98% of the quakes in Mongolia occurred in these zones. Earthquake characteristics in the active zones are as follows:

a) Mongol Altai Zone

The zone includes the Mongol Altai mountain range. The largest quake in this zone occurred near the Munkhkhairkhan Mountain in August 1931. Its magnitude exceeds 8.0. Since then, no quake with Magnitude 7.0 or greater has been recorded in this zone.

b) Govi Altai Zone

The zone is covered the Govi Altai mountain range and is one of the most active earthquake zones in Mongolia. 20 to 25% of the whole earthquakes recorded between 1900 and 1972 occurred in this zone. The largest quake in this zone rocked at Gurvan Bogd in December 4, 1957. Its magnitude was 8.3.

c) Central Khangai Zone

The zone is covered the Khangai mountain range and a half of the Orkhon-Selenge catchment area. No quake was recorded in the Khangai mountain range in the last century. While the Orkhon-Selenge catchment area has been active. The largest shock occurred at Mogod in January 5, 1967. Its magnitude was 7.25. The Mogod earthquake was followed by many after shocks lasting for almost one year. The magnitude of the strongest after shock was 6.8 to 7.2 recorded in January 20, 1967.

d) Khan Khukhii and Bulnai Zone

The zone is covered a strip of land running in west-east direction from Uvs lake through Khan Khukhii and Bulnai mountain ranges to the end of Erchmiin mountain. The zone is also one of the active earthquake zones. The largest earthquake in Mongolia occurred along an active fault near Bayantes in July 9 and 23, 1905.

e) Khuvsgul zone

The zone is covered the Darkhad depression, Khuvsgul mountains, Khuvsgul lake and its surrounding area. Only weak quakes have been recorded in this zone.

(f) Buren and Buteel Zone

The zone is covered the northern part of Bulgan province and the Buren and Buteel; mountain ranges. The quakes recorded in this zone were weaker than those in other zones.

(2) Earthquake around Study Area

The study area is not included in the above mentioned active earthquake zones. But this does not mean that no earthquake has hit the study area. According to Figure 5-1-5 and information provided by Astronomic and Geophysical Research Center (AGRC), quakes have occurred at the Kherlen river basin and a southeast branch of the Khentii niybtain range. Based on the information by AGRC, details of earthquakes around the study area are summarized below.

The Erdenekhaan earthquake is the strongest quake and occurred at Erdenekhaan Mountain in January 1, 1951. Its magnitude is 5.8 on the Richter scale. Reported seismic intensities on EMS scale at villages and town are as follows:

- Epicenter..8
- Chandgana coal mine (40km to the southeast)......................7
- Murun, Undurkhaan (70km to the southeast),
  Jargaltkhaan, and Tsenkhermandal ....6 to 7
- Ulaanbaatar (240km to the west)...3

The earth quake caused damage to chimneys and roof of houses in Undurkhaan. As shown in Table 5-1-10, three more earthquakes, but smaller magnitude, occurred around the study area. The quakes measured greater than 3.5 on the Richter scale are extracted from a database owned by AGRC and are presented in this table. The searched area is an area encompassed by the latitudeN47o and N48o and the longitude E107o30' and E108o.

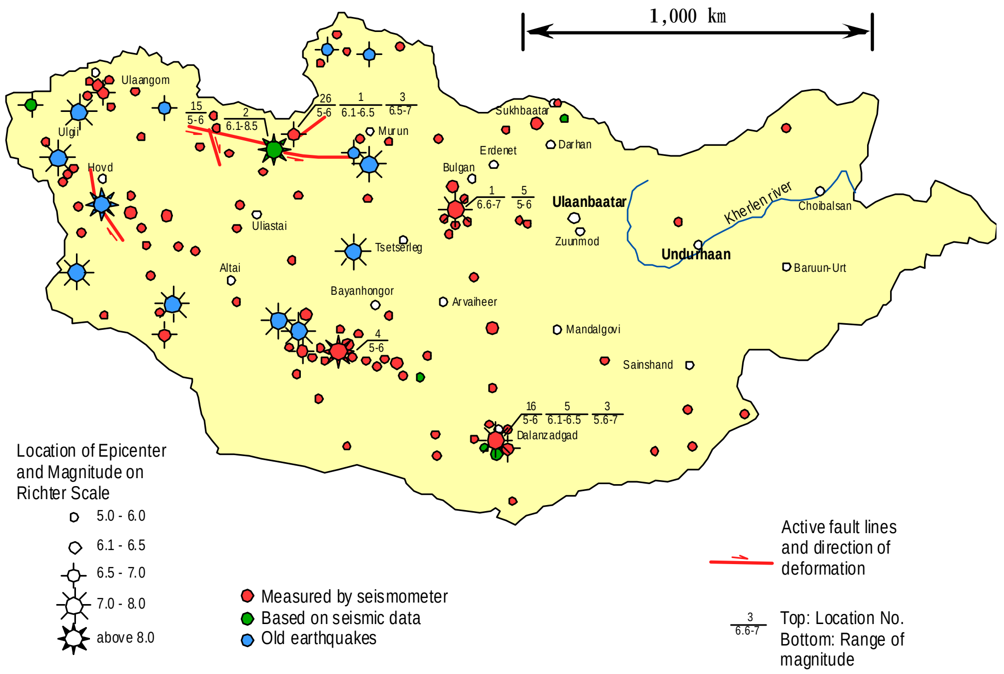


Figure 5-1-5 Epicenter of Major Earthquake in Mongolia (Mongolian Atlas, 1990)

Table 5-1-10 List of Earthquake around Study Area, M>3.5

Date	Coordinates		Magnitude	Remarks
	N	E		
Jan. 1, 1951	47.70°	109.90°	5.8	70km to the northwest of Undurkhaan
Sep. 4, 1983	47.40°	110.70°	3.5	10km to the north of Undurkhaan
Apr. 10, 1986	47.15°	108.70°	4.0	65km to the southeast of Kherlen river RC bridge
Jul. 7, 1995	47.15°	108.83°	3.9	65km to the southeast of Kherlen river RC bridge

(3) Norms and Regulations for Construction in Seismic Regions

Design norms for construction of buildings and facilities in seismic regions are stipulated in the National Standard SNIP II-7-81 M87. In this standard, the seismic intensity on the EMS scale for each town or village is given for design purpose. Khentii province is classified to Intensity 6 and 7, while the area along the study road in Tuv province is classified to Intensity 7. Ulaanbaatar is classified to Intensity 6, 7, and 8 depending on areas.

5.2 Topographic Survey

5.2.1 List of Maps and Aerial Photographs

The satellite, aerial photographs and maps collected through this Study are as follows:

(1) Satellite Photograph

1) Satellite Photographs

- Based on the State Administration of Geodesy & Cartography from September 1978 to September 1980.
- Scale: 1:200,000
- 3 Sheets

(2) Aerial Photographs

1) Aerial Photographs

- Based on the State Administration of Geodesy & Cartography from July 1963 to September 1964.
- Scale: 1:100,000
- 15 Sheets

2) Aerial Photographs of Baganuur

- Based on the State Administration of Geodesy & Cartography in May 1986.
- Scale: 1:80,000
- 1 Sheet

3) Aerial Photographs of Baganuur

- Based on the State Administration of Geodesy & Cartography in May 1986.
- Scale: 1:32,000
- 1 Sheet

4) Aerial Photographs of Baganuur

- Based on the State Administration of Geodesy & Cartography in May 1986.
- Scale: 1:18,000
- 122 Sheets

Since these aerial photographs are original of aerial photograph, they are almost duplicated.

(3) Topographic Maps

1) Topographic Maps

- Based on the State Administration of Geodesy & Cartography in 1992, maps were modified from a scale of 1 to 100,000.
- Scale: 1:500,000
- 6 Sheets

2) Topographic Maps

- Based on the State Administration of Geodesy & Cartography in 1983.
- Scale: 1:100,000
- 11 Sheets

3) Topographic Maps

- Based on the State Administration of Geodesy & Cartography from 1974 to 1997.
- Scale: 1:25,000
- 46 Sheets

4) Topographic Maps

- Based on the Baganuur District in May 2001.
- Scale: 1:2,000
- 25 Sheets

5) Undurkhaan City Maps

- Based on the Khentii Province in November 1997.
- Scale: 1:3,400
- 1 Sheet

Topographic maps for the scale bigger than 1 to 500,000 and the scale smaller than 1 to 5,000 were available. However, topographic maps of scale between 500,000 and 5,000 were needed an official submit by "State Administration of Geodesy & Cartography". Therefore, it was prohibited due to the government's restriction to utilize the maps for attachment on reports.

5.2.2 Topographic Survey

(1) Route Survey

The following measurements were carried out:

- Geographical features measurement
- Height measurement
- Center line survey
- Vertical crossing survey

Using the state standard point along the measuring line and the level point, measurement was carried out. The benchmarks were installed along the measuring line when needed. The topographical map, site exploration and materials were taken into account to set the points for the new benchmarks.

(2) River Cross-section Survey

River cross-section survey was carried out in the following 4 rivers.

- The Togos River
- The Kherlen River
- The Tsenkher River
- The Murun River

Topographic survey and river crossing measurement was put into practice. Details are as below.

1) Topographic survey

Survey area is defined as listed below:

- Longitudinal length: Planned bridge length + 200m (100m towards starting point and 100m towards end point).
- Sectional length: Total is 100m. The road centerline is set to the middle.

2) River crossing measurement

3 crossing measurement was conducted. First survey line is on the road centerline and the other two are placed on 30m upstream and downstream from road centerline.

(3) The Kherlen River Plan Survey

Geographical features measurement was carried out at the basin of the River. Total are is about 60 square kilometers. The main purpose is to examine the river crossing point.

5.3 Soil Investigation and Material Test

5.3.1 Soil Investigation

(1) Method

Exploratory drillings with penetration test at 1m intervals were carried out at the selected 7 bridge locations. A truck mounted hydraulic feed drilling rig was mobilized to the site. Dry core method was used to advance the borehole and to recover disturbed soils.

Dynamic cone penetration tests were carried out as a substitute for the originally planed standard penetration test (SPT) because the specified split barrel sampler was not available in Mongolia. A solid cone with apex angle 60° and 50.5mm in diameter was used. Falling height and weight of hammer, and penetration length of probe are the same as the SPT. Based on results of a comparison test conducted in Japan, N-value obtained by the dynamic cone penetration test were judged to be equivalent to the SPT N-values.

One undisturbed soil sample was taken from BH-3 sunk at the Kherlen river. A 49cm long Shellby tube sampler was pushed into the ground with hydraulic pressure to recover the undisturbed soil sample.

All findings during drilling are summarized in drilling logs and are shown in Appendix H.

(2) Soil Conditions at Selected Bridge Locations

1) 1.3Km Northeast of Dutluur Pass (N47°42'809, E107°57'017)

A 10m deep borehole was drilled at beside the existing road. The drilling point is located 14.5m away toward east from the center of an existing pipe culvert. Highly weathered rock crops out up and down stream of the culvert. No surface water was observed at the culvert during the investigation.

A 2.1m thick rock fill covers the drilling point. The fill materials are imported from an adjacent road cut section at which mélange of sedimentary rock crops out. Fill thickness at the existing culvert locations is approximately 10m. Following the fill is a silty sand and gravel layer consisting of rock fragments. N-values of this layer exceed 50. A boundary between the talus deposits and the weathered rock zone could not be identified from the boring samples. No ground water or a frozen layer was encountered within the drilling depth.

The weathered rock formation provides a competent bearing layer for the foundation. The weathered rock formation and the talus deposits can be differentiated easily by a qualified geotechnical engineer during excavation of foundation pit.

2) The Togos River

The site is located in a huge flood plain developed by the Togos River. A total of two boreholes, 11 and 15m deep each, were sunk along the proposed alignment. Drilling locations are indicated in the topographic map.

Very dense fluvial gravely soil underlies the site and can be divided into 2 layers based on the content of fine particles such as silt and clay fractions. The topmost 4 to 4.5m layers have less fine content and forms a permeable layer. Estimated coefficient of permeability of the upper layer is 4.5 x 10^{-2} cm/s. The estimation was made based on the grading analysis on a soil sample. While, gravely soil deeper than this depth contain more fine particles. A 50cm thick silty clay lens was encountered in the lower layer of BH-1. During drilling operation, no water is present at the Togos River. Groundwater table and frosted soil zone observed are shown in Table 5-3-1.

Table 5-3-1Groundwater Table and Frosted Soil Depth

BH Number	Ground water Table GL-m	Frosted Soil Depth GL-m
BH-1	7.5	No frosted soil
BH-2	6.6	2.0 to 2.5m

Both gravely soil layers provide competent bearing strata for bridge foundation. Dewatering should be taken into account to prevent sudden floods and seepage of surface water after heavy rain into the excavation pit during foundation works if the shallow foundation is applied.

Frost of the soil should be taken into account for the foundation design. No liquefaction of soils is anticipated.

3) The Kherlen River

Two granite mountains rise sheer from the west bank at the proposed bridge location. Khutsaa river flows into the Kherlen river from the west side through a narrow valley formed between the two mountains. A high river terrace has been formed along the east bank of the river.

A total of 4 boreholes with varying depths from 3 to 15m were sunk along the proposed alignment. However the alignment was shifted toward north, upstream of the Kherlen River after the investigation, was completed. Two of them, BH-1 and BH-2, were sunk at a gravelly river beach. BH-3 was sunk at the junction of two rivers and the last borehole was located about 40m upstream of the Khutsaa River from BH-3. The latter two boreholes are allocated in a small delta formed by the Khutsaa River. Southern half of the delta where the boreholes were sunk is covered by vegetation and forms a swampy ground, while the rest is covered by coarse deposits with poor vegetation. The finally selected alignment is located at the latter poor vegetation area. The location of boreholes is shown in the topographic map.

Very dense fluvial sandy or gravelly soils underlie the river bed of the Kherlen River. Similar to the Togos River, the coarse deposits can be divided in to two layers based on the content of silt and clay. A boundary between these two layers is present at 5 to 6m below the ground surface. The upper layer has less fine content and an estimated coefficient of permeability is 4.5 x 10^{-2}cm/s. The lower layer extends to farther west, from the Kherlen River to the Khutsaa River.

A 3 m thick heterogeneous silty clay with seams and lenses of sand and gravel cover the delta. At the area of the selected alignment, composition of the heterogeneous layer may become coarser and this layer may be changed to sandy or gravely soil with thin beds of silty clay. Except the topmost 1m, the layer was frosted at the drilling. One undisturbed soil sample was taken from the unfrosted zone, however the sample was very sandy. Laboratory tests results are tabulated in Table 5-3-2. Estimated consolidation settlement is 20cm and will be ceased practically within 2 years after completion of the filling work and the fill is placed safely assuming that height of the fill is 5m. These estimations should be certified by a detailed soil investigation which should be carried out when the full depth of this layer is thawed.

Table 5-3-2 Laboratory Soil Tests Results

Compression Index	Initial Void Ratio	Coefficient of Consolidation (cm^2/min)	Undrained Shear Strength (kPa)	West Density (g/cm^3)	Moisture Content (%)	Silt and Clay Content (%)
0.18	0.88	0.28 to 0.43	60	1.76 and 1.79	29	50

Underlining this silty clay layer is a 3m thick very dense sand and gravel layer belonging to the upper layer. As mentioned before, the very dense lower layer follows this layer. Groundwater table and frosted soil zone encountered are shown in Table 5-3-3. Water level measured in the boreholes is same as the level of river water.

Table 5-3-3 Groundwater Table and Frosted Soil Depth

BH Number	Ground Water Table GL-m	Frosted Soil Depth GL-m
BH-1	1.0	2.0 to 2.5
BH-2	1.0	2.0 to 2.5
Bh-3	0.55	1.0 to 3.0
BH-4	0.40	1.0 to 2.8

Both coarse soil layers provide competent bearing strata for bridge foundation. Frost of the soil should be taken into account for the foundation design. No liquefaction of soils is anticipated.

4) The Tsenkher River

The proposed route crosses the Tsenkher river at the northern edge of the Tag mountain. The route passes a flood plain developed by the river at the site.

A 9m deep borehole was sunk at the right bank of the river. The borehole is located on the center line proposed by DOR and 8.3m away from the edge of the river.

Very dense to dense, N-value exceeding 40, fluvial sandy and gravelly soils underlie the site. A 50cm thick silty clay layer was encountered between 3.5 and 4.0m below the ground surface. Estimated permeability of a sandy soil at 3.0m is 2.2 x 10^{-2}cm/s.

Groundwater table and frosted soil zone observed are shown in Table 5-3-4. The level of the groundwater is equal to the river water level.

Table 5-3-4 Groundwater Table and Frosted Soil Depth

BH Number	Groundwater Table GL-m	Frosted Soil Depth GL-m
BH-1	1.0	2.0 to 2.5m

Very dense sandy or gravelly soils distributing below 4m from the ground surface provide a competent bearing layer for the bridge foundation.

Frost of the soil should be taken into account for the foundation design. No liquefaction of soils is anticipated.

5) Urgun Valley (N 47° 38'666, E 109° 8'977)

A 19m deep borehole was sunk at the dry river situated at Urgun valley formed between Tag Mountain and Barchin Mountain. The proposed road alignment is located to the north of the drilling point.

A 30cm thick black silty sand covers the site. The materials underlying the surface black soil can be divided into 3 layers. A 7.7m thick dense to very dense sandy soil underlies the black surface soil followed by a 6.5m thick stiff to very stiff silty or clayey soil layer. Average N-value of this cohesive soil layer is 16. Very dense silty sand with N-value exceeding 50 underlies the cohesive layer. A confirmed thickness of the very dense sand layer is 4.9m. Groundwater table and frosted soil zone observed are shown in Table 5-3-5.

Table 5-3-5 Groundwater Table and Frosted Soil Depth

BH Number	Groundwater Table GL-m	Frosted Soil Depth GL-m
BH-1	8.0	2.0 to 2.5

The first and second dense to very dense sandy soil layers provide competent bearing strata for the bridge foundation. Dewatering should be taken into account to prevent sudden flood and seepage of surface water after heavy rain into the excavation pit during foundation works if the shallow foundation is applied. Frost of the soil should be taken into account for the foundation design. No liquefaction of soils is anticipated.

6) Urt Valley (N 47° 31'228, E 109° 24'872)

A 19m deep borehole was sunk at a dry river located at Urt valley. The proposed road runs 140m northeast of the drilling point.

A 40cm thick dark grey silty sand covers the site followed by 2.3m thick very dense fluvial gravelly soils. Reddish brown stiff to very stiff silty clay and sandy clay is thickly deposited below the fluvial gravelly deposit. The thickness of the cohesive soil is 11.8m and an average N-value is 13. Very dense clayey sandy or gravelly layers with N-value exceeding 50 underlie the cohesive layer.

Groundwater table and frosted soil zone observed are shown in Table 5-3-6.

Table 5-3-6 Groundwater Table and Frosted Soil Depth

BH Number	Groundwater Table GL-m	Frosted Soil Depth GL-m
BH-1	8.6	2.3 to 3.0

A deep foundation system will be required to support the bridge. The first very dense sand layer is too thin to support the shallow foundation in consideration of the embedment depth. The strength of the stiff to very stiff cohesive soil layer may not be enough to support the shallow foundation.

Frost of the soil should be taken into account for the foundation design. No liquefaction of soils is anticipated.

7) The Murun River

A 15m deep borehole was sunk the right bank of the Murun River. The drilling location is indicated in the topographic map.

A flood plain has been developed the right bank of the river. A river terrace is close to the left bank. The earth hammocks are observed along the existing trail and around the existing wooden bridge.

A 40 cm thick black sandy silt with organic fragments was encountered under a 40 cm thick surface soil. This layer is very heterogeneous. Some portions are very clayey with high moisture content while some are very sandy. The earth hammocks are formed by this soil. A layer of sand and gravel with boulder underlies this layer. N-value of this layer is not known as the layer was frosted at the investigation.

Dense to very dense coarse materials consisting of sandy and gravelly soils underlie the frosted soil. Thickness of this layer is 7.8m. A 50cm thick silty clay lens was encountered in this layer. N-value of this layer exceeds 40. Next encounter is a 70cm thick hard silty clay layer followed by medium to dense sandy and gravelly soils. Groundwater table and frosted soil zone observed are shown in Table 5-3-7 Groundwater level in the borehole fluctuated corresponding to the water level of the river.

Table 5-3-7 Groundwater Table and Frosted Soil Depth

BH Number	Groundwater Table GL-m	Frost soil Depth GL-m
BH-1	0.35	0.40 to 2.50

The dense to very dense sandy and gravelly soil layer provide a good bearing layer for the bridge foundation.

Frost of the soil should be taken into account for the foundation design. No liquefactions of soils are anticipated.

5.3.2 Material Investigation

(1) Method

A total of 26 bulk soil samples were taken from 1 m deep of pits dug in approximately 10 km intervals along the route to evaluate subgrade conditions. A total of 27-bulk soil samples were also taken from possible borrows pit locations to evaluate material properties. The locations for borrow materials were decided after a series of field reconnaissance, and most of the locations are selected from abandoned borrow pits scattered around the route. The samplings were made for the southwest alternative route. The samples were subjected to the laboratory material tests. All the test results together with sampling locations and soil logs of test pits and borrow pits are tabulated in Appendix H. The sampling locations are expressed in coordinates.
Rock and sand samples were also collected and were subjected to the aggregate tests.

(2) Surface Soil Conditions, within 1 m from the Ground Surface

Reddish brown to dark brown silty very fine sand to sandy silt covers the entire stretch of the study route. The materials are mostly aeolian deposits in origin. The thickness of this zone varies from 15 to 50 cm, and 30 to 40 cm in general. The topmost 15 to 20 cm forms a top soil layer rich in roots. CBR-value of this layer varies from 4 to 19% with representative values of 4 to5% when compacted to 98% of the maximum dry density determined by the modified Proctor test. This zone provides a smooth road surface condition to earth trails once the surface soil is compacted by repeated traffic load, but resistance against rutting is lower than a gravel road. This is one of the reasons why the existing earth road has been shifted its trail one after another.

Clayey to gravelly soils underlie the abovementioned zone. They are mostly Quaternary deposits. Among the soils, sandy or gravelly soils with varying percentage of silt and clay are predominant. Weathered rock was encountered at a few sections such as Khamar pass and Duut pass. CBR-values of the Quaternary deposits and weathered rock are higher than the surface soil. CBR-value of 10% or higher will be expected for sandy or gravelly soils and weathered rock when compacted to 98% of the maximum dry density determined by the modified Proctor test. Silty or clayey soils in this zone have medium stiff consistency except swampy area. CBR-value for the cohesive soils varies from 4 to 20%. Major distribution areas of the cohesive soils are;

Shallow basin situated between the Oont pass and the Duut pass

- Flat area situated between Suul hill and Ovoot hill

Soft and swampy areas, most of which may be appeared only in thawing season, were confirmed. In the design of this road alignment, crossing over the such areas was minimized to prevent problems to be caused by frost heaving in winter and softening of the ground during the thawing season. When the road passes such soft areas, a part or full depth of soft and frost susceptible soils should be replaced with coarse materials. The soft and swampy areas are formed along the bottom of valleys, toe of the slopes and along the rivers where groundwater is present at shallow depth just before the frost season, frost susceptible fine soils underlie the ground, and vegetation covers the ground. Presence of earth hammocks, small heaves of soil covered by vegetation, is very distinct feature at the soft and swampy ground. The major distribution areas of the soft and swampy ground are as follows;

- Valleys and toe of the slopes situated between the Kherlen and the Tsenkher rivers
- Along the Tsenkher and the Murun rivers
- Valley on the southwest of the Khamar pass

The southern most alternative route at the Section C passes across one of the weakest swampy grounds situated on the east of Mandal Mountain. Very soft soil with organic fragments distributes at this location. The thickness of the very soft soil may be more than 1.2 m. This depth of 1.2 m was measured by a penetration of iron rod into the ground. The soil may be frosted in further deep. Characteristics of this soil should be investigated at the detailed design stage when this alternative route is implemented. The soil investigation should be carried out after throwing of the full depth of this layer is completed.

(3) Subbase Material

Among the 27 tested borrow pits, only 8 of them will be able to supply suitable subbase material in respect of CBR-value and plasticity index. Expected CBR-values of the materials from these sources vary from 20 to 30% at the 98% of the maximum dry density determined by the modified Proctor test.

The material test results show that possible sources of the subbase material are as follows;

- Weathered granitic rocks
- Gravelly soils of fluvial deposits
- Gravelly soils of terrace deposits
- Talus deposits originated from granitic rocks

It should be noted that materials from these sources do not always satisfy the requirements of the subbase material. The material tests should be carried out for each candidate locations of the borrow at the detailed design stage and before opening of borrow pits.

At sedimentary rock areas, only one source of subbase material consisting of weathered shale, BPD-1, was found at the Oont pass. In the remaining areas, no suitable source was found. Because shale is too flaky as the subbase material. Some of shale is also susceptible to deterioration under sever weather conditions. Sandy soils, silty or clayey soils, and talus deposit originated from sedimentary rocks are not suited to the subbase material.

Based on the laboratory tests and the field reconnaissance, average distances between borrow pits for the subbases are as follows:

Erdene to Kherlen river	:	11 km
Kherlen to Tsenkhermandal	:	12 km
Tsenkhermandal to Oont pass	:	25 km
Oont pass to North of Khavtagai mountain	:	50 km
Khavtagai mountain to Undurkhaan	:	15 km

Volume of the suitable material from the possible borrow pits identified in the present investigation is not enough to construct a full stretch of the proposed road. Detailed material investigation is required at the detailed design stage.

Usage of crusher-run and /or cement stabilized materials should be considered if volume of suitable materials is not enough or hauling of the suitable materials is too costly. CBR-value of the sandy soils and weathered granitic rocks will be improved by adding cement. According to the preliminary test on cement stabilized sandy soils collected from BP9-2 at Murun and a sand pit near the existing Kheren River Bridge, required content of cement is approximately 8% of dry mass of the soil.

(4) Subgrade Material

Imported subgrade materials are extracted from borrow pits opened at steppe, terraces, flood plains, and slope of mountains and hills. The materials may be also obtained from the stock piles of tailings at Tsenkhermandal.

At the flat terrain except the beforementioned swampy areas, a design CBR-value of subgrade will be controlled by that of the fill material. CBR-value of 7% or more, with typical value of more than 10%, is expected for the design purpose. The magnitude of CBR-value depends on borrow pit to be used.

When the road runs along a slope of a hill, the height of embankment may be low and CBR-value of the surface silty sand at sandy silty layer with CBR-value of 4 to 5% will control the subgrade strength in terms of design CBR-value.

Placement of an anti-frost layer consisting of gravelly material with very low fine content is required where the road passes over the abovementioned seasonal swampy and soft areas. Subgrade replacement with the anti-frosted material will not be required at the remaining sections. Because precipitation along the project site is very low and/or subsoils are very permeable. Thickness of the anti-frost layer will be 2.5 m from the bottom of base course assuming that a frost penetration depth is 3.5 m. CBR-value of the subgrade is equal to the anti-frost layer.

(5) Quarry

Results of the aggregate tests are presented in Appendix E-25.

1) Granitic Rocks

Granitic rocks are widely distributed along the study route. Fresh to moderately weathered portions of these rocks can be used as sources of aggregate. However rocks rich in silica may not be used for asphalt cement or bituminous surface dressing, because resistance of bitumen film coating aggregates against stripping is doubtful.

In general, the granitic rocks has been weathered deeply, outcrops of fresh to moderately weathered rocks suits to the source of aggregate are very few. Detailed quarry investigation is necessary to open quarries in highly weathered rock area.

Granitic rocks have been quarried at two quarries at a hill on the north of Erdene and Tumur Mountain situating 3 km to the northeast of the Kherlen

Bridge. The former quarry provided aggregate for the rock asphalt project granted by Japan. The latter was used for the construction of the existing Kherlen Bridge. Rock sample is taken from the quarry at Tumur Mountain for the aggregate tests.

2) Other Types of Rocks

Fresh to moderately weathered tuff and andecite distributed the north of Murun can be used as the source of aggregate. Boulders of weathered tuff scattered on a slope of Delger Mountain were sampled for the aggregate tests. No fresh or moderately weathered rock crops out at this mountain.

Basalt forming the Jargaltkhaan Mountains is suited to aggregate, but the rock cannot be quarried as the local people worship the mountains.

Sedimentary rocks mainly consisting of shale have many fissures and are flaky, and are judged to be unsuitable for the aggregate source. However the mélange of sedimentary rocks cropping out 1.3km northeast of Durluur pass can be used as aggregate source.

Boulders in stock piles, gravel tailings, at the former Tsenkhermandal tin mine can be used. However screening is required to collect the boulders and content of the boulders in the stockpiles is very low. Boulders were collected from one of the stockpiles of gravelly tailing and were subjected to the aggregate tests.

3) Possible Quarry Locations

Possible quarry locations identified at the present investigation are tabulated in Table 5-3-8.

Table 5-3-8 Locations of Possible Quarry

No	Location	Coordinates		Type of Rock	Notes
		N	E		
1	Erdene	47°44’110	107°47’471	Granite	Operating
2	Northeast of Dutluur pass	47°42’829	107°57’017	Melenge /Intrusive rock	No quarry
3	Tumur Ulgii mt.	47°42’932	108°25’846	Granodiorite	Quarried occasionally
4	East of the Kherlen bridge	47°41’712	108°31’618	Diorite	No quarry
5	4km east of Zayat mt.	47°47’229	108°39’724	Diorite	No quarry
6	Tag mt. (Tsenkher)	47°40’520	109°08’203	Granitic rock rich in quartz	Abandoned quarry For concrete and base course one only
7	4km southwest of Khamar pass	47°34’074	109°13’994	Granodiorite	Only highly weathered rock crops out.
8	Salbar mt. (East of Chadgna steppe)	47°23’232	110°07’240	Granite	Only highly weathered rock crops out.
9	East of Ikh Del mt. (Murun)	47°23’391	110°16’840	Granodiorite	No quarry
10	Northeast of Ikh Del mt. (Murun)	47°23’805	110°17’442	Diorite	No quarry
11	Delger mt. (Murun)	47°23’308	110°23’202	Tuff	No quarry
12	Bayanmunkh mt. (Undurkhaan)	47°24’391	110°35’890	Tuff	Operating in the nineteen seventieth
13	Stockpile at Tin mine Ex-Tsenkhermandal tin mine	47°40’640	109°07’966	Boulder (Tailings)	Small reserve (Need screening)

(6) Fine Aggregate

Figure 7-4-2 shows the grading curves of sand collected from existing sand pits, stock piles of sand tailing, and two sand deposits at Murun.

Sand pits at Zoomond, near Kherlen bridge and Undurkhaan are currently used by local contractors. Zoomond is a main source of fine aggregate to Ulaanbaatar and supplied fine aggregate to the rock asphalt road project granted by Japan. Sand collected from the sand pints and Murun are finer than the fine aggregate generally used for concrete. Fineness modulus of these sands is judged to be low and varies from 1.6 to 2.1. If such fine sand is used for concrete, more water and cement are required to keep same workability as the concrete mixed with coarser fine aggregate. The material from these sources also contains silt and clay particles excessively which should be reduced by washing if it is used for the concrete work.

The stock piles of sand tailing are located at the former Tsenkhermandal tin mine and a gold mine operating at the Barchingyn Mountain. Reserve of material at the former tin min is small. The materials from these stock piles can be used as the fine aggregate for concrete. Same to the above-mentioned sources, washing of the material is required before use for the concrete work. In comparison with naturally deposited sand mined at the sand pits, less effort for the washing is required. Because silt and clay particles originally contained in deposit were largely washed off in the process of extraction of tin or gold.

Usage of crushed sand processed from rock or gravel will be required for the construction of some of the bridges.

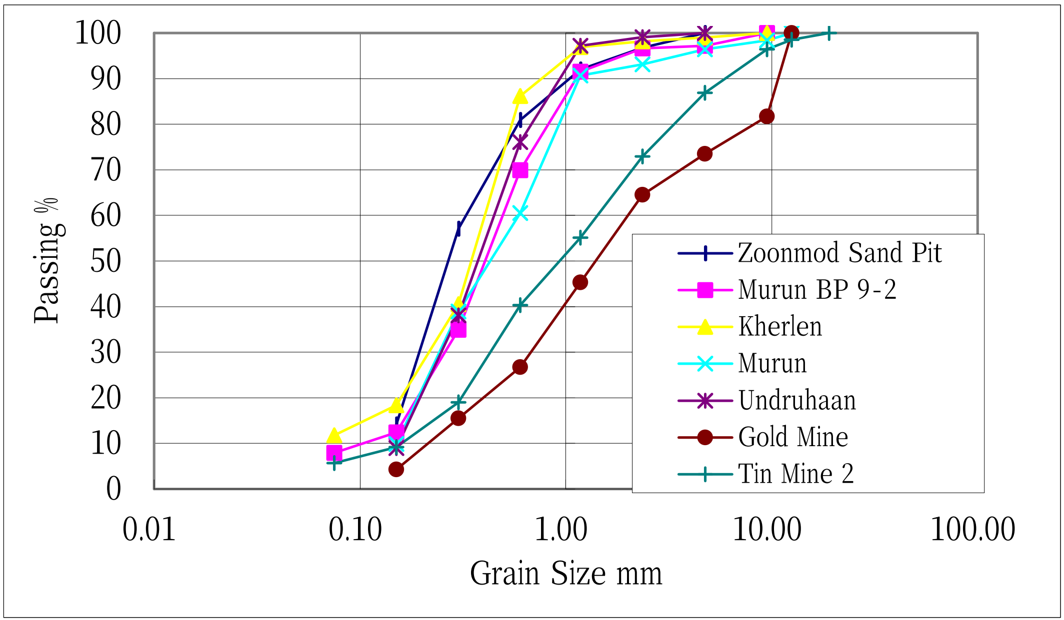


Figure 5-3-1 Grading Curves of Sand

5.4 Rivers and Hydrological Survey

5.4.1 Outline of River Conditions in the Study Area

Within the project area there are four rivers, the Togos, the Kherlen, the Tsenkher and the Murun. Although not in the project area, the Tuul River has also been considered since there is comparatively more hydrological data available. This data has been used as reference material in discharge analysis for the Project Rivers.

A common feature of the rivers is that their flood has two sources: one originating from melting snow in April-May and the other from rainfall in July-August. The rainfall flood accounts for more than 80% of the annual runoff, and the peak runoff also occurs during the rainy season. Locals say that there is no experience of damage due to runoff of ice blocks.

The following is a brief description of each river and of their nature upstream of the proposed river-crossing points:

(1) The Togos River

This is a tributary on western bank of the Kherlen River. It rises in a mountain range which rises to over 2000m, and which forms a watershed between the Tuul and the Kherlen river basins. The catchment zone is part unvegetated and part grassland. The form of the river is a wadi and is heavily meandered, about 4-5m wide and less than 0.5m deep. According to local inhabitants, the width of the river reaches more than 100m during floods, although its depth remains less than 1m. There is no other recorded hydrological data on this drainage basin.

(2) The Kherlen River

The study covers the upstream of the Kherlen River from the river crossing point.. The source is at an altitude of 2450m. The catchment area is unvegetated or grassland. In its middle reaches the flood plain of the river is several kilometers wide and forms reservoir during floods. The river width narrows to about 500m at the existing river crossing points. At this point there is an existing reinforced concrete bridge about 270m long with embankment. There is very wide flood plain at the upstream of this point, which reaches 3 to 5 km with 5 or 6 flow channels. To cross the river at this point, it is needed to fix and stabilize the stream by big river training works.

The discharge of the existing crossing point will be reduced due to the attenuating effect of the flood plain upstream. However, it is necessary to consider the possibility of an increase in riverbed level.

According to interviews with local inhabitants a wooden bridge was washed away by the flood in 1961. The existing concrete bridge was constructed in 1974. The highest water level of flood since reached up to 2 to 3m deep in 1990.

Available hydrological data includes water levels and discharge data at the present bridge and at Mungun Morit in the middle reaches, and precipitation data at Baganuur and Mungun Morit.

(3) The Tsenkher River

This is a northern tributary of the Kherlen River. Its catchment area is formed by a mountain range of altitude 1800 to 2000m, and adjoins the Kherlen, Murun and other river basins. Of this area, 10% is forested and the remainder is unvegetated or grassland. The river from its middle reaches is heavily meandered with section around 10m wide and less than 0.5m deep. Small flow was visible at the beginning of May 2001.

There are written records of the highest observed flood water level at the existing wooden bridge, which describe the depth as reaching 1.5m. This depth of water would result in a river width of 100m. According to interviews with local inhabitants, the highest water level at the proposed bridge location is just under the beams of the existing timber bridge. There is no other hydrological data on this river basin.

(4) The Murun River

This is a northern tributary of the Kherlen River. Its catchment area is a mountain range with altitude 1600 to 1800m. The river's catchment area is mostly unvegetated or grassland, with limited forested area. The river has wide flood plain with a resulting high flood storage capacity. The river regularly has very limited flows and has a highly meandered course.

According to local inhabitants, the highest observed water level in the last 20 years is 0.2m below the beams of the wooden bridge at the proposed bridge site. This river seems to have higher attenuating effect of the flood plain than the Tsenkher River. There is no hydrological data on this river basin, however precipitation data is available for Undurkhaan, which is just outside its river basin.

(5) The Tuul River

This river runs through the Mongolian capital city, Ulaanbaatar. The catchment area is a mountain range of altitude 2000 to 2800m. Half of the mountainous area of the catchment area is forested and the rest of the basin is unvegetated or grassland. This river should have a lower storage capacity than the four rivers described above, due to its smaller flood plain area.

A few reinforced concrete bridges and flood control measures (levees etc.) have been constructed. According to an interview with engineer of Ulaanbaatar City Authorities, a flood of 1580m^3/s occurred in 1966 causing substantial damage. The flood control measures have been designed for the 100 year return discharge of 1880m^3/s. It was designed by Russian engineers, but details were not available.

Hydrological data including water level, discharge, and precipitation is available for Ulaanbaatar, Bosgo Bridge and Terelj (located upstream), and also precipitation data for several locations within Ulaanbaatar City.

Table 5-4-1 shows summary of hydrological data.

Table 5-4-1 Summary of Hydrological Data
(Upstream of Proposed Bridge Point)

Name of River	Togos	Kherlen	Tsenkher	Murun	Tuul
Catchment Area	$460km^2$	$7350km^2$	$790km^2$	$3160km^2$	$6300km^2$
Channel Length	45km	150km	55km	100km	160km
Elevation difference from Source	600m	1150m	550m	700m	1200m
Average incline	1/75	1/130	1/100	1/140	1/130
Riverbed slope near the bridge	0.5%	0.2%	0.1%	0.1%	
Width of river near the bridge	10m	400m	30m	20m	300m
Average particle size of riverbed	1-2mm	2-3cm	0.5－1cm	1-2mm	2-3cm

Values shown are approximate, in particular the riverbed particle size which was by visual estimate.

5.4.2 Hydrological Data and Analysis

(1) Hydrological data

A summary of the collected hydrological data is shown in Table 5-4-2.

Table 5-4-2 Summary of Collected Hydrological Data

Name of River	Water level, Discharge (points)	Period (years)	Precipitation (points)	Period (years)
Togos	—	—	—	—
Kherlen	1	30	2	12
Tsenkher	—	—	—	—
Murun	—	—	1	30
Tuul	3	30	4	30

Locations of the data points are shown in Figure 5-4-1.

The collected data is shown in the Appendix. Maximum water levels and discharge are included, however, they cannot be considered to be the true maximum value due to the lack of automatic water level recorder.

For reference, data relating discharge and historic rainfall events is given in Table 5-4-3.

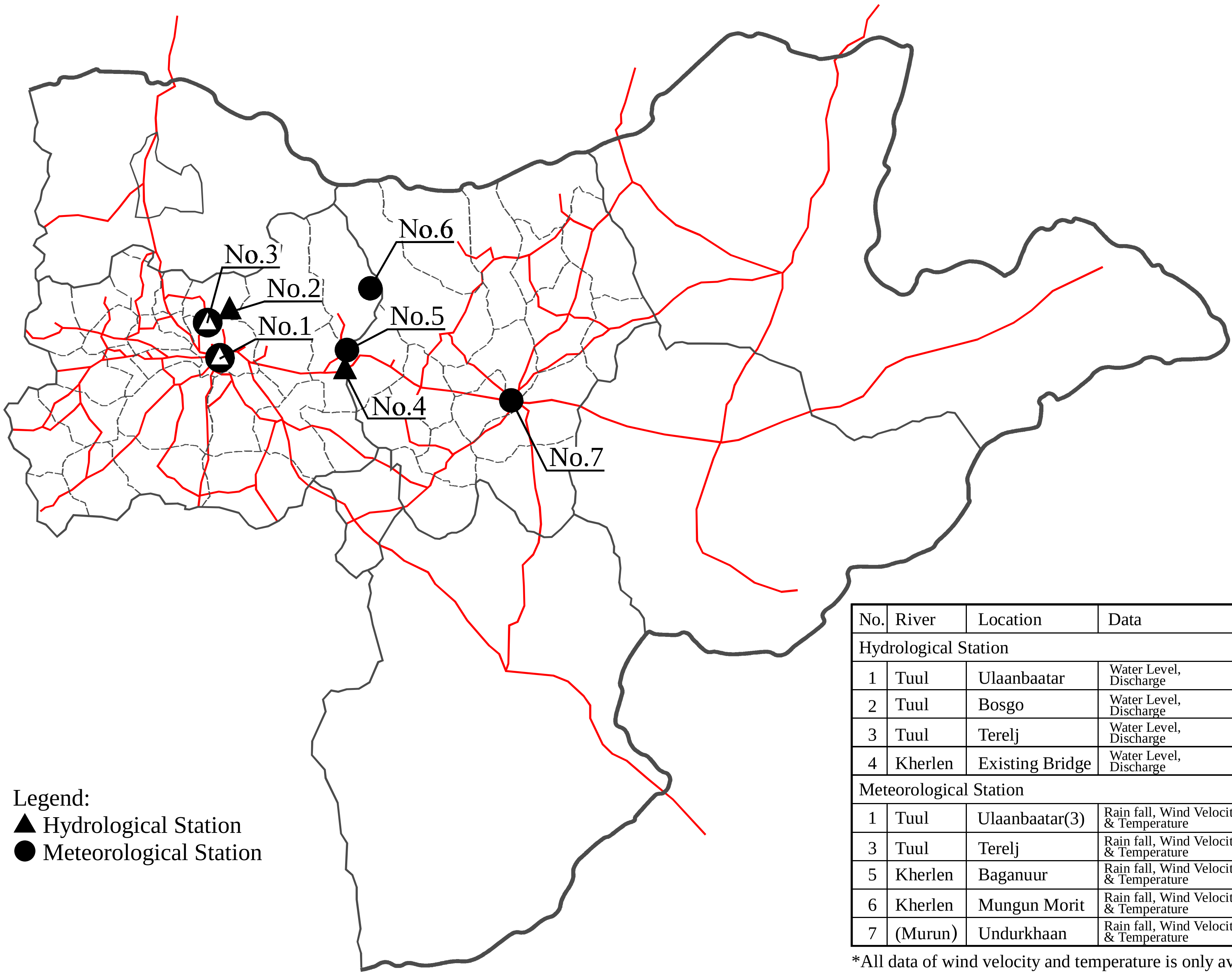
Table 5-4-3 Discharge and Rainfall Data for Selected Flood Events

River	Location	Discharge	Precipitation	Date
Tuul	Ulaanbaatar	795	68.6	1966.7.11
		717	20	1973.7.1
			18	1973.7.2
		917	2.1	1983.6.25
			7.7	1983.6.26
		507	7.0	1990.8.21
			1.3	1990.8.21
		678	4.6	1993.7.9.
	Bosgo	340	13.2	1933.7.23
			11.0	1933.7.24
	Terelj	166	13.5	1990.7.16
			2.3	1990.7.17
Kherlen	Kherlen Br.	632	9.4	1990.8.8
			4.3	1990.8.9
		214	7.9	1991.8.29
			25.6	1991.8.30
		418	0.3	1999.7.23
			2.5	1999.7.24

The data in the table shows no clear relation between discharge and precipitation. This is due to the localized nature of the rainfall in the upper reaches which may not be reflected at the gauge locations.

(2) Precipitation Analysis

Precipitation data is needed to calculate design discharge. Analysis was carried out using probability analysis for the seven points shown in and near the study area.. The graph of analysis and other terms' tables are is in the appendix. The return period precipitations are shown in Tables 5-4-4.



No.	River	Location	Data	Year
Hydrological Station				
1	Tuul	Ulaanbaatar	Water Level, Discharge	1970～2000
2	Tuul	Bosgo	Water Level, Discharge	1970～2000
3	Tuul	Terelj	Water Level, Discharge	1970～2000
4	Kherlen	Existing Bridge	Water Level, Discharge	1970～2000
Meteorological Station				
1	Tuul	Ulaanbaatar(3)	Rain fall, Wind Velocity & Temperature	1970～2000
3	Tuul	Terelj	Rain fall, Wind Velocity & Temperature	1986～2000
5	Kherlen	Baganuur	Rain fall, Wind Velocity & Temperature	1991～2000
6	Kherlen	Mungun Morit	Rain fall, Wind Velocity & Temperature	1989～2000
7	(Murun)	Undurkhaan	Rain fall, Wind Velocity & Temperature	1970～2000

*All data of wind velocity and temperature is only available during 1991～2000

Figure 5-4-1 Location of Hydrological and Meteorological Station

Table 5-4-4 Design Daily Precipitation

No.	Location	Altitude (m)	Number of data	1/100 (mm)	1/50 (mm)	1/20 (mm)	1/10 (mm)	Max. (mm)	Ave. (mm)	Note
1	Ulaanbaatar-A	1350	31	65	60	51	45	51.7	26.6	1970-2000
2	Ulaanbaatar-B	1350	18	80	65	51	42	56.3	26.6	1983-2000
3	Ulaanbaatar-C	1350	26	80	70	56	50	60.1	25.8	1975-2000
	Max.for A,B,C	1350		80	70	56	50	60.1	26.6	
4	Terelj	1800	15	80	70	61	54	55.5	38.8	1986-2000
5	Baganuur	1350	10	85	75	65	57	62.5	31.4	1991-2000
6	Mungun Morit	1450	12	60	52	43	40	38.3	28.9	1989-2000
7	Undurkhaan	1050	29	135	115	82	64	97.8	30.7	1970-1998

Data for hourly precipitation was not available. The only available data is the graph and equation of 100 year return 24 hours rainfall intensity in Ulaanbaatar City. This data was obtained from the Mongolian Meteorological Observatory and is shown in Figure 5-4-2.

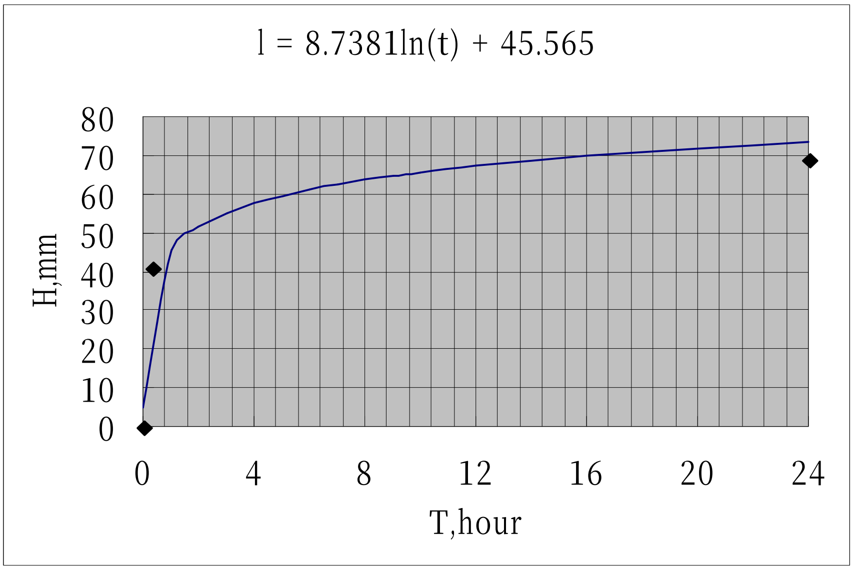


Figure 5-4-2 Design Daily Rainfall Intensity

(3) Analysis of flood discharge

Design discharge is analyzed and designed from the data listed below:

- Existing discharge data analysis
- Calculation of water levels based on information obtained from interviews with local inhabitants
- Calculation from precipitation data using the Mongolian formula
- Calculation from precipitation data using the Russian formula
- Calculation using the Rational formula

1) Analysis of Discharge Data - ①

Probability analysis of discharge data of each monitoring station was carried out. The calculation is by the same method as for precipitation analysis. The graphic results are given in the Appendix, and results are in Table 5-4-5. Specific Discharge is also calculated and shown in Table 5-4-6.

Table 5-4-5 Design Discharge of Main Rivers (m^3/s)

Observatory	Catchment Area (km^2)	Return Period			
		1/100	1/50	1/20	1/10
Ulaanbaatar	6300	2100	1350	1050	800
Bosgo B.	2160	600	400	270	200
Terelj	1220	850	610	410	300
Kherlen B.	7350	1100	790	520	400

Table 5-4-6 Specific Discharge of Main Rivers ($m^3/s\ km^2$)

Observatory	Catchment Area (km^2)	Return Period			
		1/100	1/50	1/20	1/10
Ulaanbaatar	6300	0.33	0.21	0.17	0.13
Bosgo B.	2160	0.28	0.19	0.125	0.09
Terelj	1220	0.70	0.50	0.34	0.25
Kherlen B.	7350	0.15	0.11	0.07	0.05

The calculation is based on data from the past 30 years. The data, however, does not show the true maximum discharge, as it is based on data with an observation frequency of 2 hours.

2) Discharge Calculation of water levels based on information obtained from interviews with local inhabitants - ②

The highest water levels at the proposed bridge construction sites were obtained through interviews with local inhabitants at the site. Rough surveys of longitudinal and cross sections were also carried out. The discharge was calculated by Manning's formula. The results are listed in Table 5-4-7.

Table 5-4-7 Discharge Based on Recorded Water Levels of Main Rivers

Name of River	Catchment Area (km^2)	Flow Section Area (m^2)	Manning's Roughness Coefficient	Hydraulic Mean Depth (m)	Riverbed Slope (%)	Flow Velocity (m/s)	Discharge (m^3/s)	Location
Togos	460	87	0.025	0.28	0.5	1.2	100	Proposed Bridge by DOM
Kherlen	7350	270	0.03	1.16	0.2	2.1	500	Existing Reinforced Concrete Bridge
		80		0.7		1.2		
Kherlen	7350	356	0.03	2.54	0.2	2.8	1130	Wooden Bridge washed away in 1961
		112		0.8	0.15	1.3		
Tsenkher	790	54	0.025	0.36	0.3	1.1	60	Existing Wooden Bridge 4 km Upstream to proposed river crossing point
Tsenkher	790	41	0.025	1.25	0.1	1.5	60	Existing Wooden Bridge on the rote
Murun	3160	51	0.025	0.64	0.1	1.0	50	Existing Wooden Bridge

This discharge data is for the 10 year return period except for Kherlen River flood which includes data for the flood in 1961.

Ratios to convert the discharges of Table 5-4-10 to 20, 50 and 100 year return periods are shown in Table 5-4-8.

Table 5-4-8 Probability Ratio of Discharge

Observatory	Catchment Area (km^2)	1/100: 1/10	1/50 : 1/10	1/20 : 1/10
Ulaanbaatar	6300	2.63 : 1 (2100 : 800)	1.69: 1 (1350 : 800)	1.28 : 1 (1020 : 800)
Togos B.	2160	3 : 1 (600 : 200)	2 : 1 (400 : 200)	1.35 : 1 (270 : 200)
Terelj	1220	2.83 : 1 (850 : 300)	2.03 : 1 (610 : 300	1.37 : 1 (410 : 300)
Kherlen B.	7350	2.75 : 1 (1100 : 400)	1.98 : 1 (790 : 400	1.30 : 1 (520 : 400)

3) Discharge Analysis (Mongolian Formula) - ③

The Mongolian formula is appropriate up to 200 km^2 of river basin area and tends to overestimate discharge values. To give an approximation of the discharge, this method has been applied for areas up to 1000 km^2 (Togos, Tsenkher). For details of the analysis refer to the Appendix.

4) Discharge Analysis (Russian Formula) - ④

The Russian formula has approximately similar character to the Mongolian formula. To give an approximation of the discharge, this method has also been applied for areas up to 1000 km^2 (Togos, Tsenkher). For details of the analysis refer to the Appendix.

5) Discharge Analysis (Rational Formula) - ⑤

The Rational formula method is appropriate for river basins up to 200 km^2 and tends to overestimate relative to observed data, or predictions made by the Mongolian or Russian formula. As an indicative method only, the method can be used on basin areas up to 1000 km^2 (Togos, Tsenkher).

The value of Runoff Coefficient, “f” is taken as “0.48” for in this study considering the high infiltration capacity and evaporation of Mongolia.

5.4.3 Discharge and Water Level of Proposed River Crossing Points

(1) Design Discharge

Design discharge for the Kherlen River is 100 year floods considering its wide river basin and large cross section. The other rivers use the 50 year return period. The calculated values are shown in Table 5-4-9. Details are shown in the Appendix.

Table 5-4-9 Design Discharge of Main Rivers by Various Methods

Name of River	Catchment Area (km^2)	① (m^3/s)	② (m^3/s)	③ (m^3/s)	④ (m^3/s)	⑤ (m^3/s)	Proposed Value	Note
Togos	460	160	200	(320)	(240)	(370)	250	1/50
Kherlen	7350	1100	1380	—	—	—	1100	1/100
Tsenkher	790	270	120	(330)	(300)	(470)	300	1/50
Murun	3160	350	100	((430))	((330))	—	350	1/50

( ), (( )) : indicator due to the catchment area is over 200 km^2

The processes of setting the proposed discharge are as follows.

1) The Togos River:

The result of discharge analysis based on recorded flood levels (②) is the most reliable value due to the lack of hydrological data. Considering the possibility of error, 25% is added to the value as a safety factor.

2) The Kherlen River:

The result of analysis of discharge data (①) is selected, due to the existence of sufficient hydrological data.

3) The Tsenkher River:

Result of Russian formula (④) is selected for the following reasons:

- Lack of hydrological data (①)
- Lack of reliability of historical data obtained by interview (②)
- Other data tends to overestimate flood flows (③,④,⑤)
- The lowest value of the remaining data can be considered as safe discharge. (④)

4) The Murun River

Result of analysis of discharge data (①) is selected for the following reasons:

- Lack of reliability of historical data obtained by interview (②)
- Other data is only indicators. (③,④)
- The result of analysis of discharge data can be considered as safe discharge since its value is larger than the result of Russian formula. (①)

(2) Design Water Level

Manning's formula is used to calculate design river depth. The results are shown in Table 5-4-10.

Table 5-4-10 Design River Depth of Main Rivers

Name of River	Design Discharge (m^3/s)	Proposed Bridge Length (m)	Passing Discharge (m^3/s)	Design River Depth (m)	Bridge No.
Togos	250	35	297	2.0	A1
Kherlen (*)	1100	350 (268.8)	1164 (784)	2.0	B2
Tsenkher	300	52.5	362	1.8	B3
Murun	350	52.5	394	1.9	B5

Design Riverbed slope is set to 0.15% for Kherlen River and 1.0% for the others. Manning's roughness coefficient is set to 0.03 for the natural riverbed and checked in site investigation. Topographic survey and close investigation of riverbed material should be made to design in details.

(*) Design river section for The Kherlen River is not sufficient in first stage. 3 spans should be added in future to obtain sufficient section. Total bridge length and passing discharge will be 369.6m and 1285m^3/s respectively.