Appendix–I

GEOTECHNICAL INVESTIGATIONS

1 Geotechnical Investigations

1.1 Preliminary Geotechnical investigation

In preparation of regional plan for the left bank of Indus delta and coastal zone,new drains are to be proposed and existing dhoras are to be addressed/improved. In these proposed drains are addressed drains, the hydraulic structure as well as the road aqueduct crossing structures will be required.

In order to design these structures geotechnical design parameter will be required and hence the geotechnical investigation is required at all the locations of these structures. Some of the selected/representativeareas/locations of the structures are proposed for investigations as per scope of the work. Table No.1/Map No.1 shows the provisional locations are proposed bore holes for geotechnical investigations. The process of geotechnical investigation has been started.

The provisional bill of quantities is prepared as per Table No.2. The provisional no. of bore holes proposed are 33,each one will be of 100ft depth from existing ground level.

1.1.1 Field testing and collection of samples

Following field testing and collection of samples are recommended.

i. Standard penetration test at5ft interval is recommended and disturb sample of the same will be collected.

ii. Undisturbed sample by Shelby tube / Denison sampler/Pitcher sampler will be collected in clayey strata.

iii. Water samples will be collected for chemical test (sulphate content, chloride content and pH value).

iv. At the location of siphon permeability test at about 20-25ft depth will be performed and at other locations F.P.T will be performed at each strata.

1.1.2 Lab Testing

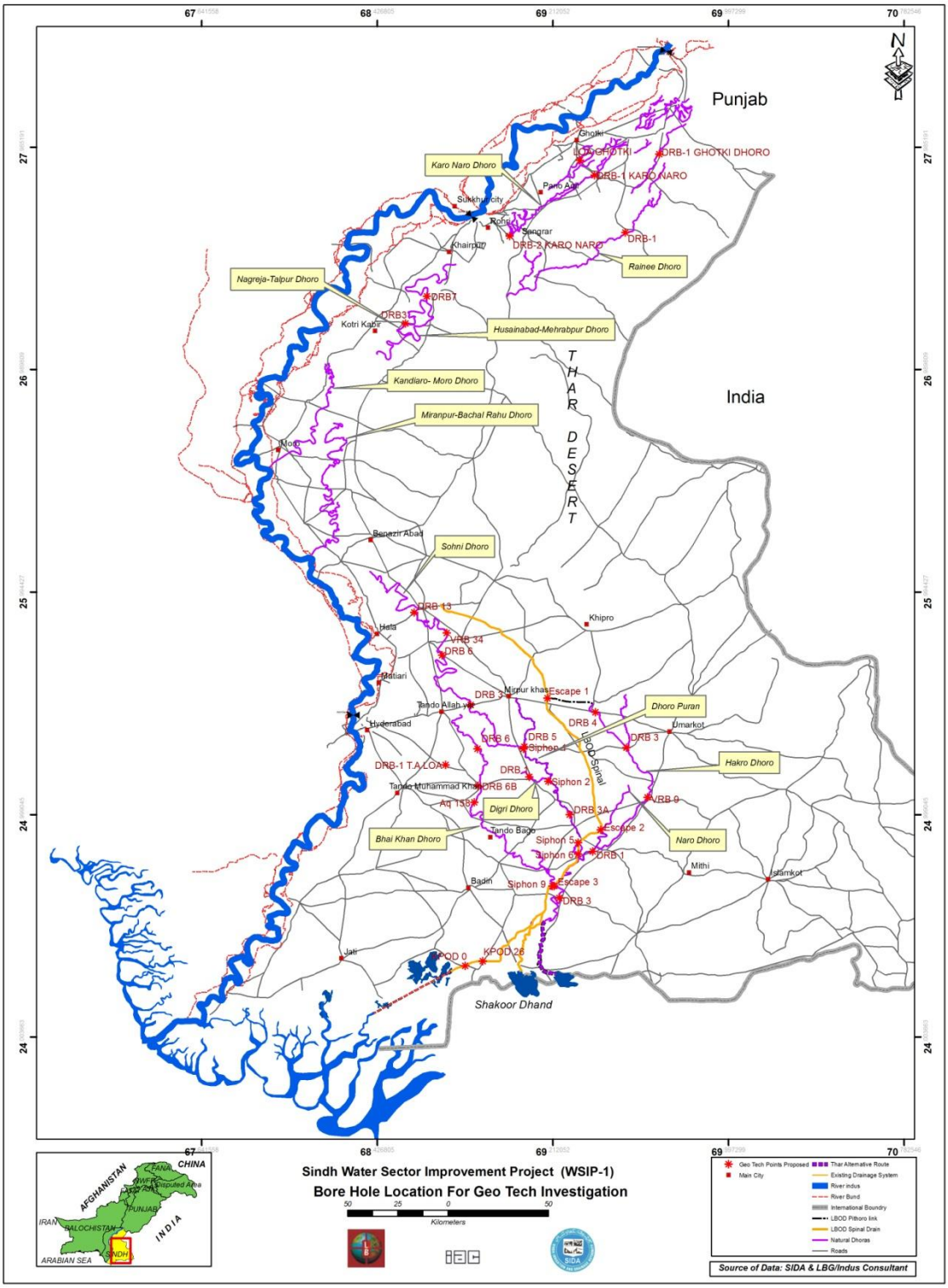
Selected samples of the representation strata's will be tested for natural moisture content, gradation analysis. Atter berg limits, unconfined compressive strength test, direct Shear box tests, consideration test, specific .Gravity, differential free swell test, pocket penetrometer test, lab permeability test, chemical test, etc as per strata encountered. The details are mentioned in Table 2. Showing provisional bill of quantities.

Depending upon the test results and experience, the geotechnical parameters will be selected /workout for design purpose and they will be again subjected to confirmation at the time of detailed design/execution.

Table 1: Location of Proposed Bore Holes

S. No	Structure	Lat	Long	Dhora/ Drain	Depth of Investigation Ft.	Field Permeability Test @ Ft.
1	Siphon-1	25°17'35.16"N	69° 4'50.58"E	MMD	100	25
2	Siphon-2	25° 8'49.85"N	69°11'34.72"E	MMD	100	25
3	Siphon-5	24°52'24.17"N	69°19'39.81"E	LBOD	100	25
4	Siphon-6	24°49'16.59"N	69°19'33.72"E	LBOD	100	25
5	Siphon-9	24°40'46.48"N	69°12'38.20"E	LBOD	100	25
6	Escape-1	25°31'10.07"N	69°11'18.56"E	LBOD	100	Each Strata
7	Escape-2	24°55'47.95"N	69°25'37.48"E	LBOD	100	Each Strata
8	Escape-3	24°40'46.06"N	69°13'8.91"E	LBOD	100	Each Strata
9	DRB-1	24°49'59.83"N	69°23'27.61"E	HD	100	Each Strata
10	VRB 9	25° 4'34.46"N	69°38'8.10"E	HD	100	Each Strata
11	DRB 3	25°17'53.74"N	69°32'31.18"E	HD	100	Each Strata
12	DRB 4	25°27'25.55"N	69°24'8.80"E	HD	100	Each Strata
13	DRB 3	24°37'33.54"N	69°14'33.90"E	PD	100	Each Strata
14	DRB 3A	24°59'55.32"N	69°17'18.42"E	PD	100	Each Strata
15	DRB 5	25°18'6.96"N	69° 5'7.56"E	PD	100	Each Strata
16	DRB 3	25°29'22.36"N	68°50'45.17"E	SD	100	Each Strata
17	DRB 6	25°42'42.48"N	68°43'1.85"E	SD	100	Each Strata
18	VRB 34	25°48'39.14"N	68°44'19.16"E	SD	100	Each Strata

19	DRB 13	25°54'9.79"N	68°35'36.96"E	SD	100	Each Strata
20	DRB 6	25°17'36.79"N	68°52'33.70"E	BKD	100	Each Strata
21	DRB 6B	25° 7'34.71"N	68°52'42.42"E	BKD	100	Each Strata
22	Aq 158	25° 3'13.73"N	68°51'40.89"E	BKD	100	Each Strata
23	DRB-1	25°10'2.25"N	69° 6'24.82"E	DD	100	Each Strata
24	DRB7	27°19'4.63"N	68°38'58.45"E	HMD	100	Each Strata
25	DRB3	27°11'43.90"N	68°33'11.97"E	TWND	100	Each Strata
26	DRB-1	27°51'33.31"N	69°23'56.49"E	KARO. N	100	Each Strata
27	DRB-2	27°35'15.24"N	69° 1'12.65"E	KARO. N	100	Each Strata
28	DRB-1	27°57'13.85"N	69°41'19.67"E	GD	100	Each Strata
29	DRB-1	25°13'16.84"N	68°43'59.52"E	LOA T.A	100	Each Strata
30	DRB-1	27°36'8.51"N	69°32'13.36"E	RD	100	Each Strata
31	LOA GHOTKI	27°55'34.47"N	69°19'59.60"E	GD	100	Each Strata
32	KPOD 26	24°20'35"N	68°53'43"E	KPOD	100	Each Strata
33	KPOD 0	24°19.21'20"N	68°49'13"E	KPOD	100	Each Strata



Map 1 Showing the location of proposed Bore Holes

2 Review of previous investigation reports and maps

2.1 Geology

From geological map of Pakistan prepared by Geological survey of Pakistan, the geological map of study area is prepared and attached as Map no.2.

The map reveals that the deposits belong to recent to sub-recent geological age, alluvial to eolin deposits consisting of deltaic flood plain deposits, tidal delta marsh deposits, tidal mud flat deposits, stream bed deposits and meander bed deposits, eolin sand deposits, and loes deposits.

2.2 Subsoil conditions

Previous reports of LBOD Stage-I executed by Drill Tech Corporation & MUET, Jamshoro under WAPDA shows that subsoil consists of ***stiff to very stiff silty clay/ clayey silt with trace of sand or medium dense to very dense silty fine sand or mixture of the same.***

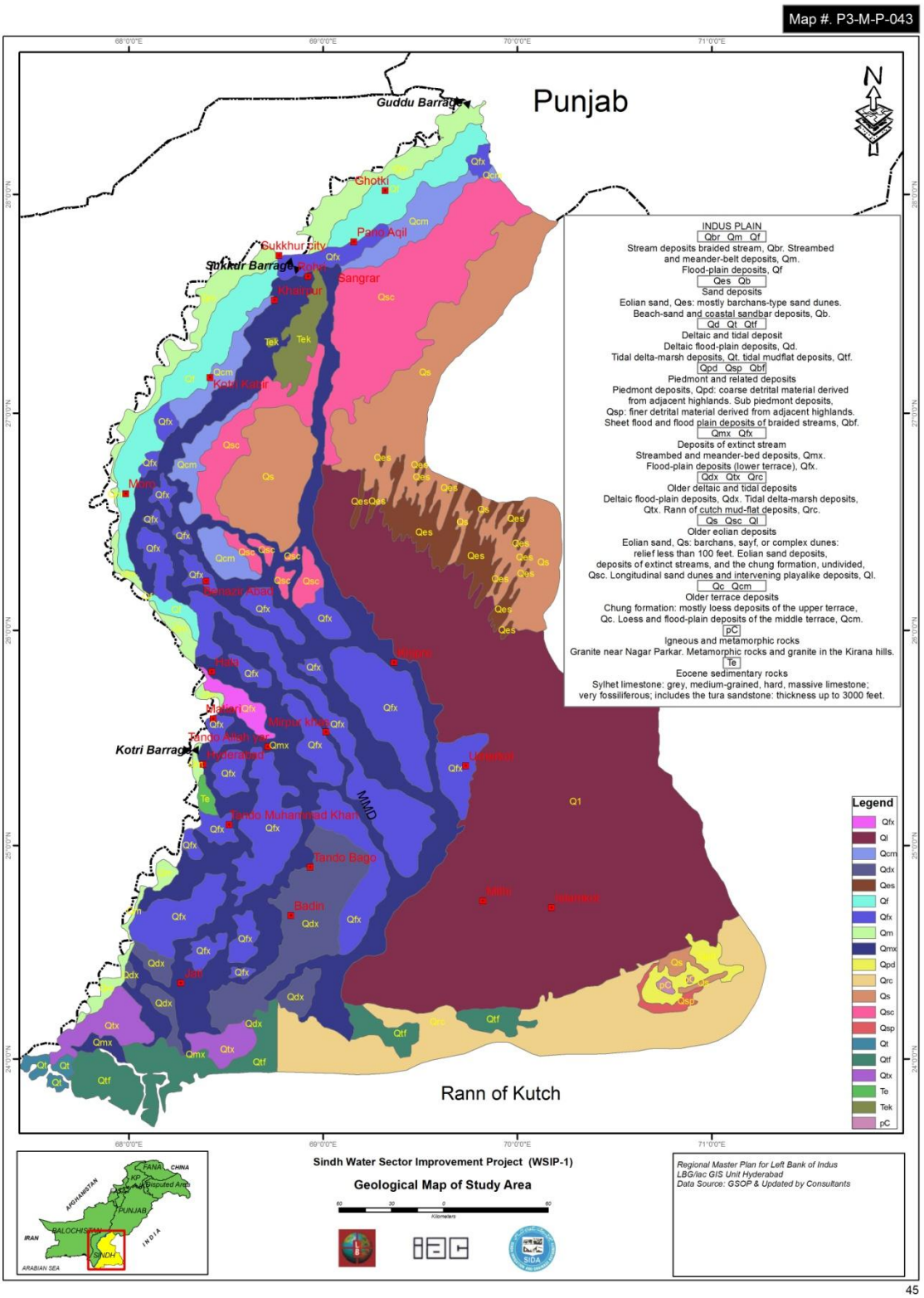
Bore holes logs & maps showing the locations of bore holes of MMD area(Drill Tech + Mirpurkhas (MUET)) are attached as Appendix A and detailed sub surface conditions are mentioned as observed at the time of investigation.

2.3 Ground Water

Ground water level in these reports shows that it varied between 3.75ft to 24ft depth and 2ft to 23.58 in MUET (Feb, 92) & Drill tech (Dec, 87 to Mar, 89) reports respectively.

2.4 Lab Test Results

Laboratory tests were conducted on the selected samples by the previous investigators. Following Table no. 3 and 4 shows the variation of lab. Test results of different tests conducted by DrillTechCorp.&MUET.



Map 2 Geological Map of Study Area

Table No. 2:Provisional Bill Of Quantities Of Sub-Soil Investigation

Sr. No	DESCRIPTION	UNIT	QUANTITIES
1	Mobilization & Demobilization	Lump Sum	Lump Sum
2	Shifting of Equipment & Main power from one bore hole to another .	No.	32
3	Drilling of bore hole in soil 00-30Ft.	Ft.	990
3.1	Drilling of bore hole in soil 31-70Ft.	Ft.	1320
3.2	Drilling of bore hole in soil 71-100Ft	Ft.	990
4	Carrying out SPT at 3-5 ft. interval 00-30ft.	No.	200
4.1	Carrying out SPT at 3-5 ft. interval. 31-70Ft.	No.	264
4.2	Carrying out SPT at 3-5 ft. interval. 71-100Ft	No.	200
5	Collection UDS sample in clayey strata	No.	170
6	Collection water Sample	No.	33
7	Test Pit in Soil 0-10 Ft. (No. Water Table)	Ft.	-
8	Test Pit in Soil 10-15 Ft. (No. Water Table)	Ft.	-
9	Field Permeability Test	No.	70
10	LABORATORY TESTING		
10.1	Gradation Analysis	No.	220
10.2	Hydrometer Analysis	No.	33
10.3	Atterberg Limits (L.L & P.L)	No.	220
10.4	Unconfined Compressive Strength of Clay/Rock	No.	165
10.5	Bulk Density in Soil/Rock	No.	660
10.6	Sulphate Content Soil/Water	No.	33
10.7	Chloride Content Soil/Water	No.	33
10.8	Ph Value	No.	33
10.9	Consolidation Test	No.	66
10.10	Specific Gravity	No.	-
10.11	Direct Shear Strength test	No.	66
10.12	Swelling Pressure	No.	-
10.13	Swelling Potential	No.	-
10.14	Natural Moisture Content	No.	660
10.15	Field Density test	No.	-
10.16	D. Free Swell test	No.	-
10.17	Modified Proctor Test	No.	-
10.18	Standard Proctor Test	No.	-
10.19	Pocket Pentrometer Test	No.	400
10.20	C.B.R Test	No.	
10.21	Permeability Test	No.	
11	Report Writing	Lump Sum	Lumpsum

Table 3: Summary of Field & Lab. Test Results (Report of DrillTech Corp. LBOD , MMD (Dec, 87 to Mar, 89))

Location	B.H No.	SPT N values	q_u Kg/cm²	Direct		N. Moisture %	Bulk density g/cc	pH	Chloride Content %	Sulphate Content %
				C_{kgkm^2}	Ø°					
MMD	1	5-29	0.99	0.19	12.2	13.03	1.972	-	-	-
	2	7-32	1.21-2.28	0.21-0.61	8.9-14.0	21.18-34.43	1.85-2.09	-	-	-
	3	7-47	0.77-3.86	0.22-0.63	4.0-16.7	21.51-34.56	1.86-1.99	-	-	-
	4	4->50	1.26-1.34	0.3-0.37	4.9-7.8	20.87-22.5	2.04-2.11	6.75	0.134	0.035
	5	9->50	1.39-1.70	0.40-0.48	5.8-9.3	18.34-21.84	2.06-2.14	7.00	0.398	0.081
	6	5->50	1.31-1.59	0.26-0.51	5.7-8.5	20.11-21.98	2.03-2.07	-	-	
	7	9->50	1.81-2.18	0.3-0.56	8.3-10.0	20.93-22.5	2.02-2.08	6.5	-	0.019
	8	9->50	0.89-3.18	0.14-0.66	7.0-13.6	21.93-22.93	2.00-2.04	7.5	0.448	0.074
	9	9->50	1.63-7.30	0.3-0.92	7.8-20.0	13.89-22.72	1.86-2.08	-		
	Over all variation	4->50	0.77-7.30	0.14-0.92	4.0-20.0	13.03-34.56	1.85-2.14	6.5-7.5	0.134-0.448	0.019-0.081

Table 4:SummaryofField & Lab. Test Results of MUET at Mirpurkhas Feb. 1992

B.H No.	SPT N values	q_u Kg/cm²	γb g/cc	N.M %	L.L %	P.I %
1	6-40	1.12-1.52	1.77-1.92	20-36.8	46-59	14-30
2	6-59	1.28-2.6	1.92-2.1	21.6-37.8	41-48	15-24
3	8-28	0.86-2.0	1.88-2.05	21.5-36.5	39-60	7-29
4	03-62	1.72	1.70-2.0	15.1-36.5	38-62	14-32
5	11-36	0.52-2.6	1.78-2.02	21.6-32.7	34-50	14-25
6	9-36	0.57-1.34	1.80-2.09	25.1-28.4	35-55	11-39
7	8-74	1.8-2.6	1.77-2.09	21.8-31.2	44-50	19-21
8	10-28	2.3-2.6	1.78-2.05	24.8-27.5	35-55	13-22
Over all variation	03-74	0.57-2.6	1.70-2.09	15.1-37.8	35-62	07-39

The detailed laboratory test results carried out by Drill Tech Corp. & MUET are appended in AppendixB.

3 Foundations

The proposed structures on these locations are aqueduct, village road bridges and Dist. Road bridges. The heavy loads will be coming up on the foundations from these structures. Considering the sub-soil conditions from previous reports it is decided that pile foundations will be used. Piles of 30 inch diameter are proposed with 60 ton safe working load capacity. Therefore, in order to get idea and to calculate provisional quantities it was required to design and recommend the length of piles of 30 inch dia for 60 ton safe working load capacity.

The safe load working capacity of piles is evaluated on the basis of following assumption/data.

i. As in operating conditions the water has to flow, therefore submerged conditions are considered while calculating the effective stresses.

ii. The shear strength parameter for silty CLAY/clayey SILT is taken as 0.045N, where N is SPT No. of below/ft. this is the average value of Stroud's (1974) co-relation between SPT and Cu. for clays of medium plasticity. in addition to that ourexperience also gives the value of Cu near to that.

iii. The adhesion factor is taken 0.45 as recommended by many authors (Tomlinson, NAVFAC DM-7.2 etc).

iv. Side resistance in clay as well as in sandy soils is restricted to 0.50 Tsf (NAVFAC DM-7.2).

v. The formula used for calculating the ultimate load carrying capacity in silty CLAY or clayey SILT is as follows:

Ultimate load on pile $=\frac{\pi}{4} d^2 \times Nc \times Cu + \pi d \times D \times \propto \overline{Cu}$

Where d = Dia. Of pile, D = Embedded length of pile.

Nc = Bearing capacity factor (6 when D = 0ft & 9 when D = 3d)

Cu = Un-drained shear strength cohesion at the tip of pile.

$\overline{Cu}$ = Av: ″ ″ ″ ″ ″ ″ along the shaft of pile.

$\propto$ = Adhesion factor.

i. The factor of safety in skin friction/ shaft resistance is assumed as 3.0.

ii. The factor of safety in base resistance is assumed as 4.0

iii. The Meyerhof's formula is used in calculating the ultimate load carrying capacity in silty SAND/Sandy non plastic SILT (Ref NAVFAC DM-7.2) based upon SPT corrected values.

iv. Pile penetrating multilayered soil profile, the base resistance is calculated by Meyerhof's formula (Ref. NAVFAC DM-7.2).

v. Scale Effect: For piles larger than 0.5m diameter, the reduction factors for pile base resistance as recommended by Meyerhof's are applied.

vi. Safe load carrying capacity of piles must be confirmed by performing full scale pile loading test.

vii. Following tables shows the calculated embedded length of Pile from previous reports.

Table No.5: Length of pile calculated as per Mayerhof (1976) (Data from Investigation by Drill Tech Dec.87-Mar.89 @ MMD)Assumed Dia. of Pile 30″,& safe working load of Pile 60 Tons

Location	B.H No.	E. Length of Pile below scouring depth ft.
MMD	01	90
	02 & 03	90
	04& 05	40
	06& 07	45
	08& 09	45
Over all variation	40-90ft below scouring depth	
Av.	62ft	

Table 6: Length of pile calculated as per Mayerhof (1976) (Data from Investigation byMUET @ Mirpurkhas Feb. 92)Assumed Dia. of Pile 30″,& safe working load of Pile 60 Tons

Location	B.H No.	E. Length of Pile ft (B. scouring depth)	Depth of cutting + Scour Depth ft
MMD	1	90	20
	2	75	20
	3	77	20
	4	80	20
	5	69	21
	6	73	17
	7	67	17.8
	8	70	17.0
Over all depth var.		67-90	17-21
Av.		75ft	19.1

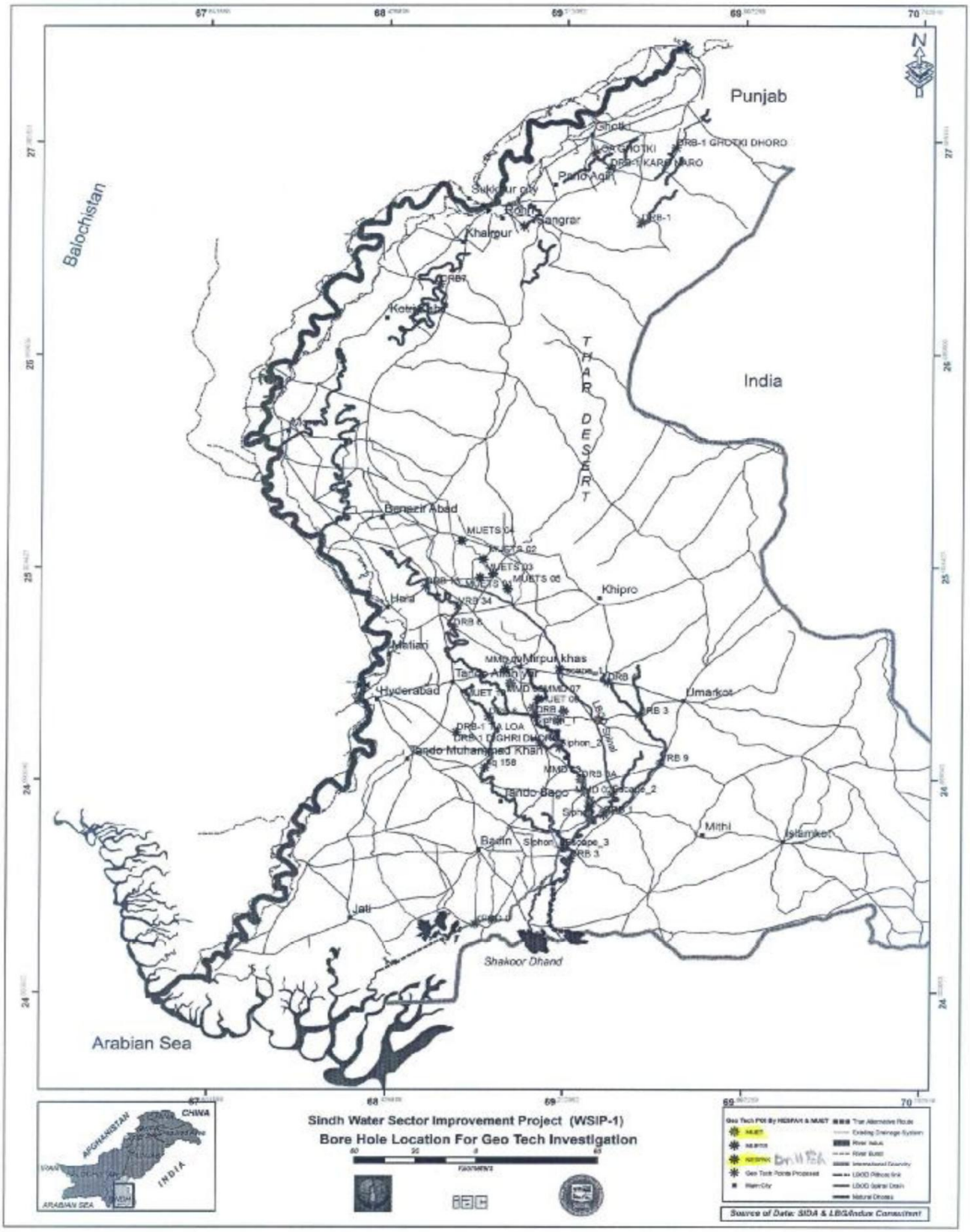
4 Conclusion

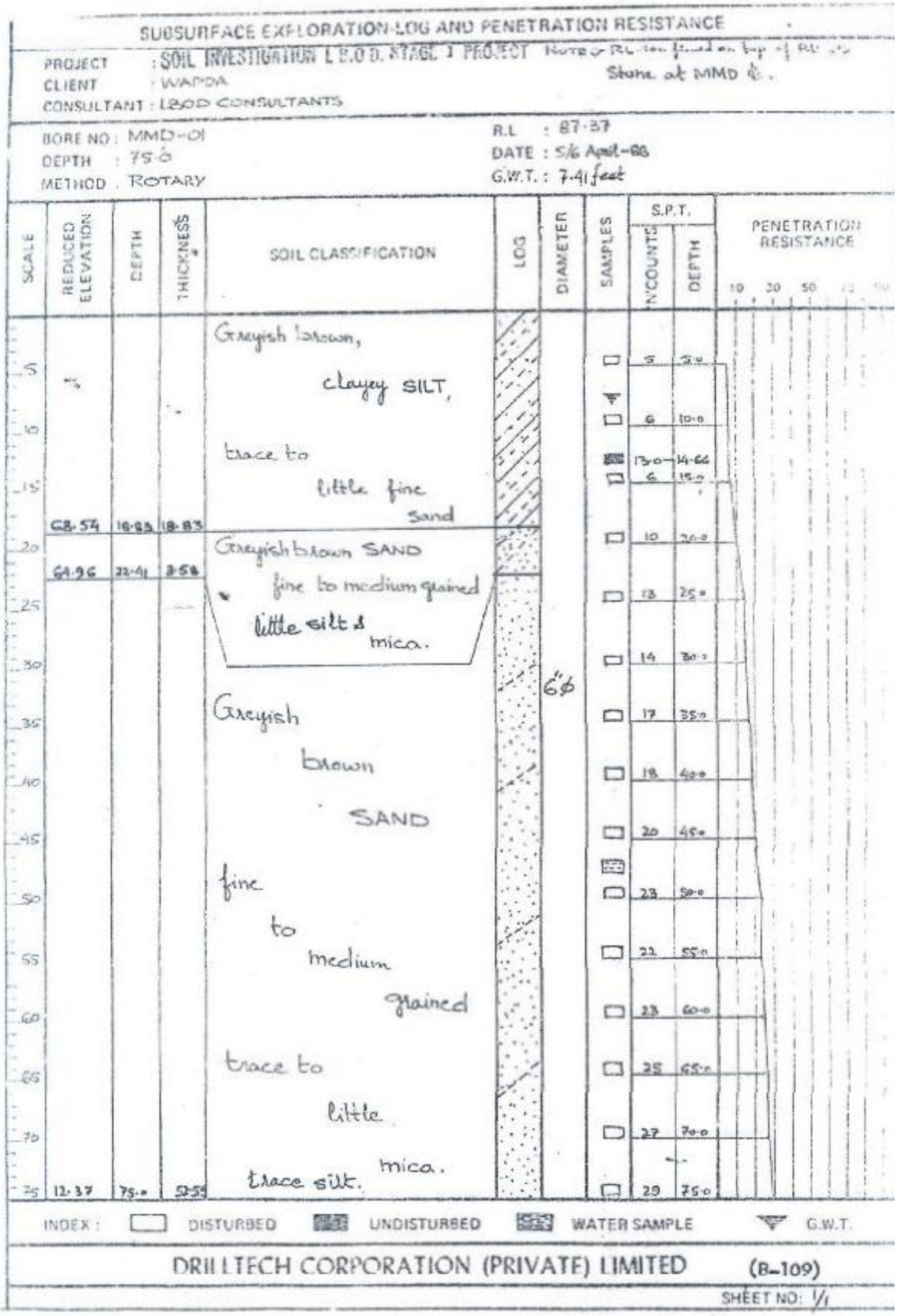
- Subsoil investigation of the selected project area will be carried out as per proposed programme.
- Previous reports shows that the subsoil conditions at MMD area consists of mostly medium stiff to very stiff silty clay/clayey silt and medium dense to very dense silty fine sand.
- As per reports of previous investigation the embedded length (effective length) of pile assuming 30″ dia and taking safe working load of 60 ton is calculated and comes in between 40ft -90ft length, and 67-90ft for Drill tech and MUET investigation reports respectively.
- SR cement is recommended for the piles.
- Actual length of piles will be calculated after the subsoil investigation is carried out at each location and again that will be subjected to confirmation by performing full pile load test at each location at the time of the execution of the work.

Annexure A

Bore Hole Logs

(MMD Drill Tech. Corp. & M. MUET)


Punjab
Balochistan
India
THAR DESERT
Arabian Sea
Shakoor Dhand
Sindh Water Sector Improvement Project (WSIP-1)
Bore Hole Location For Geo Tech Investigation
Source of Data: SIDA & LBI&Indus Consultant



SUBSURFACE EXPLORATION-LOG AND PENETRATION RESISTANCE

PROJECT : SOIL INVESTIGATION L.B.O.D. STAGE I PROJECT
CLIENT : WAPDA
CONSULTANT : LBOD CONSULTANTS

Note:- RL taken from top of RL Stone at MMD &.

BORE NO : MMD-01
DEPTH : 75.0
METHOD : ROTARY

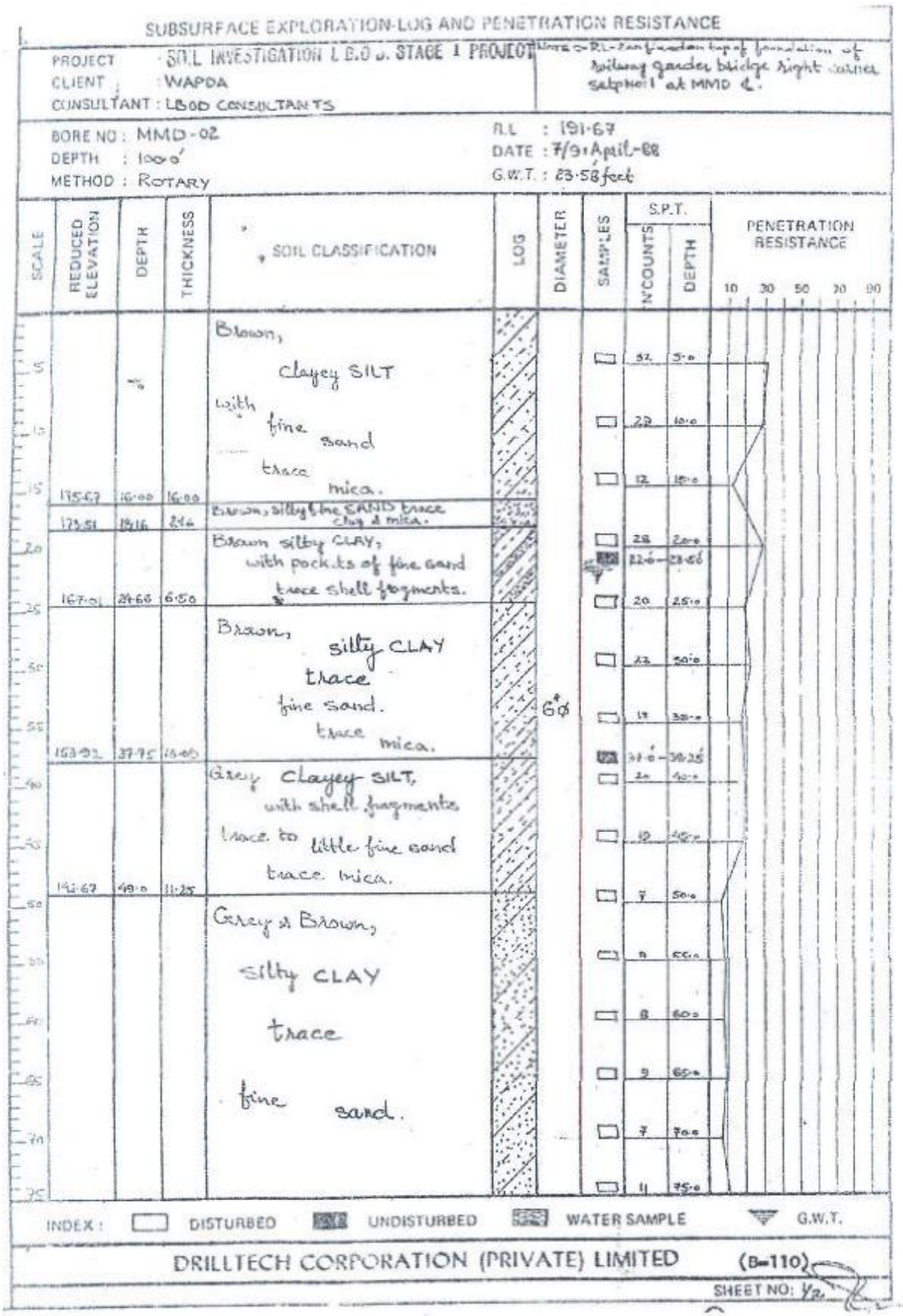
R.L : 87.37
DATE : 5/6 April-86
G.W.T. : 7.41 feet

SCALE	REDUCED ELEVATION	DEPTH	THICKNESS	SOIL CLASSIFICATION	LOG	DIAMETER	SAMPLES	S.P.T. N'COUNTS	S.P.T. DEPTH	PENETRATION RESISTANCE
				Greyish brown, clayey SILT, trace to little fine sand				5	5.0	
								6	10.0	
								13-0	14.66	
								6	15.0	
	68.54	18.83	18.83							
								10	20.0	
	64.96	22.41	3.58	Greyish brown SAND fine to medium grained little silt & mica.						
								18	25.0	
								14	30.0	
						6"ϕ		17	35.0	
				Greyish brown SAND fine to medium grained trace to little mica.				18	40.0	
								20	45.0	
								23	50.0	
								22	55.0	
								23	60.0	
								25	65.0	
								27	70.0	
	12.37	75.0	52.59	trace silt.				29	75.0	

INDEX : DISTURBED UNDISTURBED WATER SAMPLE G.W.T.

DRILLTECH CORPORATION (PRIVATE) LIMITED (B-109)

SHEET NO: 1/1



SUBSURFACE EXPLORATION-LOG AND PENETRATION RESISTANCE

PROJECT : SOIL INVESTIGATION L.B.O. STAGE I PROJECT
CLIENT : WAPDA
CONSULTANT : LBOD CONSULTANTS

Note:- R.L. of random top of foundation of railway garder bridge right channel satpur-I at MMD ℄.

BORE NO : MMD-02
DEPTH : 100.0'
METHOD : ROTARY

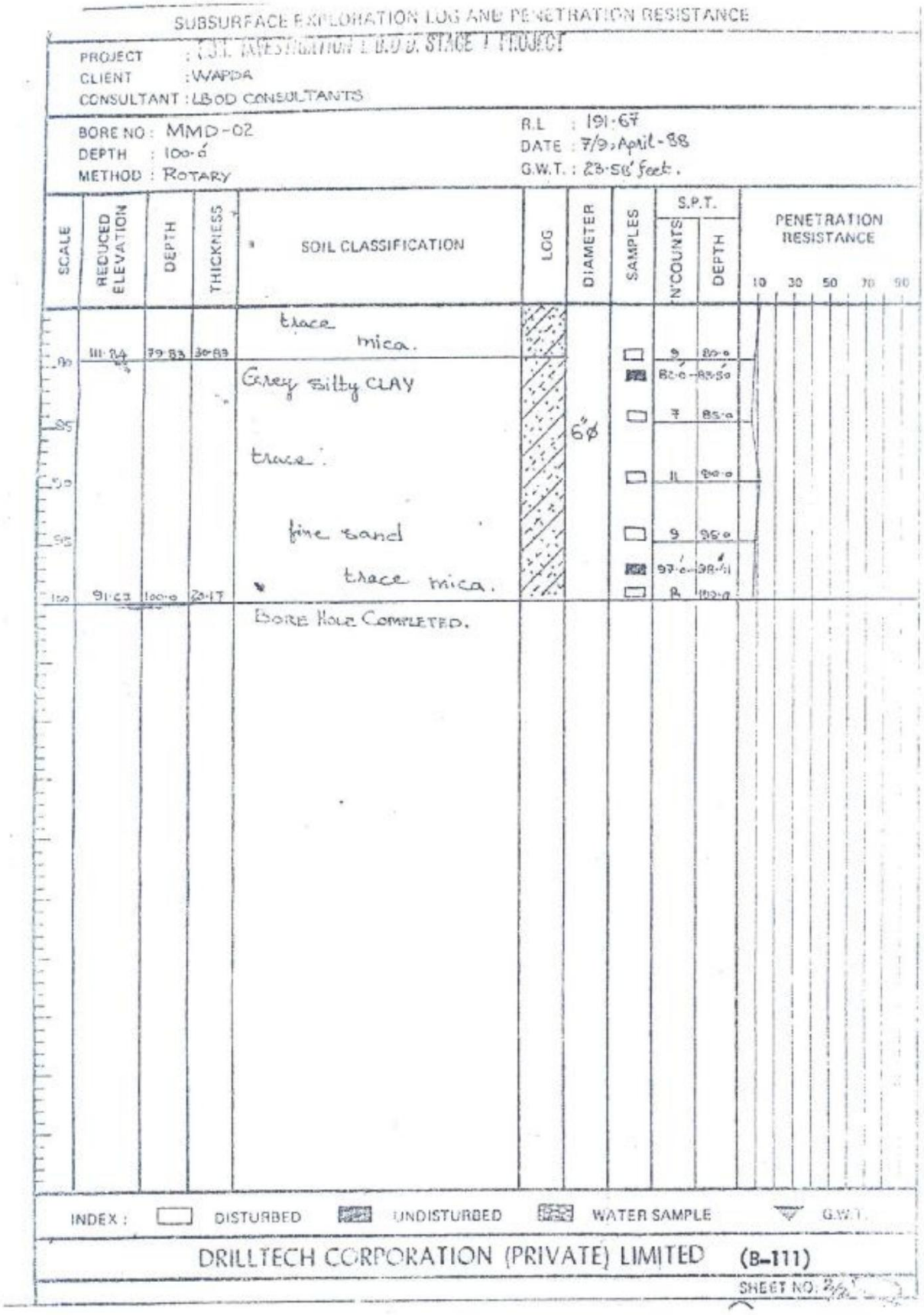
R.L : 191.67
DATE : 7/9 April-68
G.W.T. : 23.58 feet

SCALE	REDUCED ELEVATION	DEPTH	THICKNESS	SOIL CLASSIFICATION	LOG	DIAMETER	SAMPLES	S.P.T. N'COUNTS	S.P.T. DEPTH	PENETRATION RESISTANCE
	175.67	16.00	16.00	Brown, Clayey SILT with fine sand trace mica.				32	5.0	
								22	10.0	
								12	15.0	
	173.51	18.16	2.16	Brown, silty & fine SAND trace clay & mica.				28	20.0	
	167.01	24.66	6.50	Brown silty CLAY, with pockets of fine sand trace shell fragments.				22.6–23.66		
								20	25.0	
	153.92	37.75	13.09	Brown, silty CLAY trace fine sand. trace mica.		6" ϕ		23	30.0	
								19	35.0	
								31.0–38.25		
								20	40.0	
	142.67	49.0	11.25	Grey Clayey SILT, with shell fragments trace to little fine sand trace mica.				12	45.0	
								7	50.0	
								9	55.0	
								8	60.0	
				Grey & Brown, silty CLAY trace fine sand.				9	65.0	
								7	70.0	
								11	75.0	

INDEX : DISTURBED UNDISTURBED WATER SAMPLE G.W.T.

DRILLTECH CORPORATION (PRIVATE) LIMITED (B-110)

SHEET NO: 1/2



SUBSURFACE EXPLORATION LOG AND PENETRATION RESISTANCE

PROJECT : [illegible] INVESTIGATION L.B.O. STAGE I PROJECT
CLIENT : WAPDA
CONSULTANT : LBOD CONSULTANTS

BORE NO : MMD-02
DEPTH : 100.0
METHOD : ROTARY

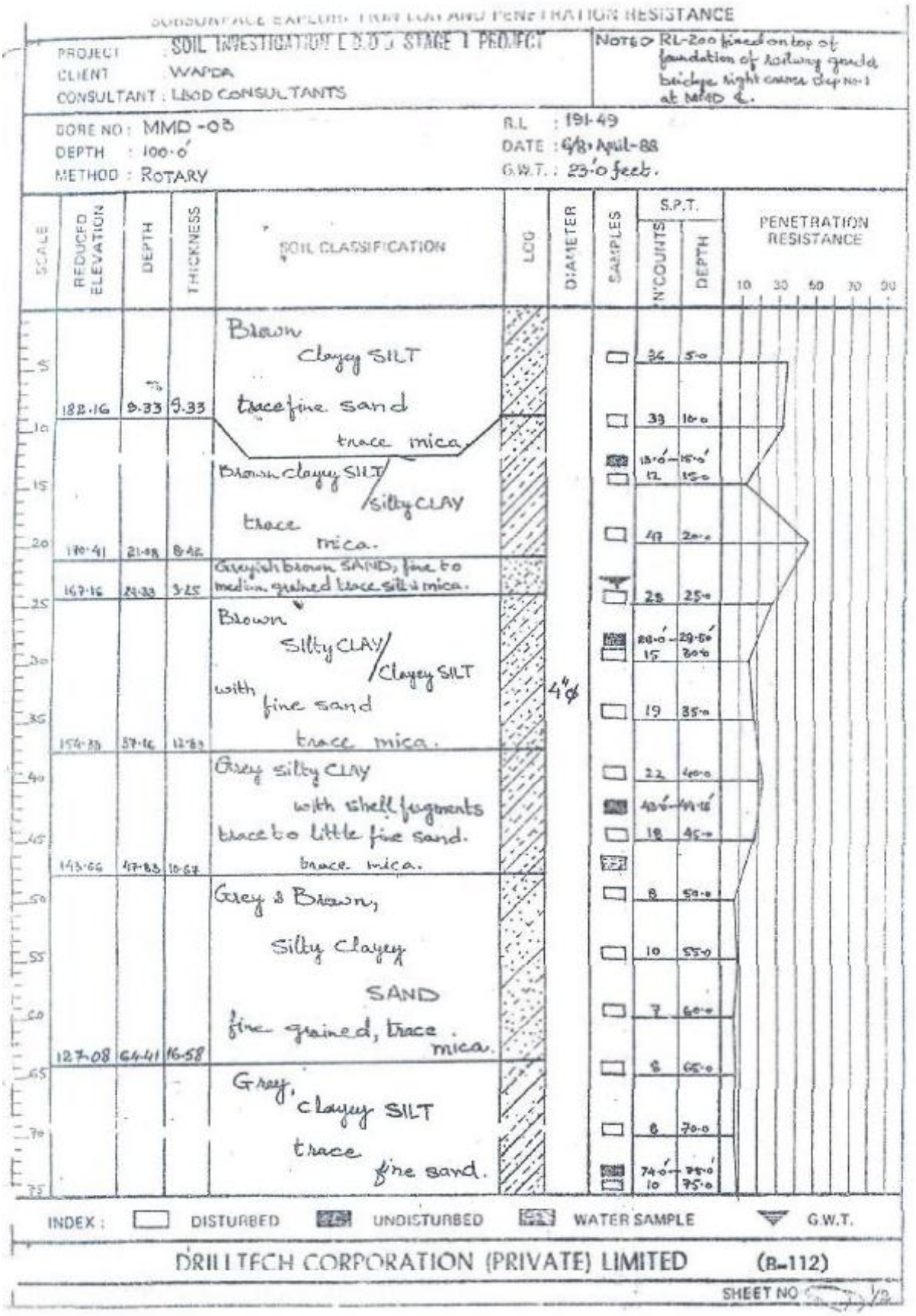
R.L : 191.67
DATE : 7/9, April-88
G.W.T. : 23.58' feet.

SCALE	RECUCED ELEVATION	DEPTH	THICKNESS	SOIL CLASSIFICATION	LOG	DIAMETER	SAMPLES	S.P.T. N'COUNTS	S.P.T. DEPTH	PENETRATION RESISTANCE
	111.84	79.83	30.83	trace mica.				9	80.0	
				Grey silty CLAY				82.0-82.50		
						6"		7	85.0	
				trace.				11	90.0	
				fine sand				9	95.0	
	91.67	100.0	20.17	trace mica.				97.0-98.41		
								R	100.0	
				BORE HOLE COMPLETED.						

INDEX : DISTURBED UNDISTURBED WATER SAMPLE G.W.T.

DRILLTECH CORPORATION (PRIVATE) LIMITED (B-111)

SHEET NO. 2/2



SUBSURFACE EXPLORATION AND PENETRATION RESISTANCE

PROJECT : SOIL INVESTIGATION (L.B.O.) STAGE I PROJECT
CLIENT : WAPDA
CONSULTANT : LBOD CONSULTANTS

NOTE: RL-200 fixed on top of foundation of railway guide bridge right canvas dip No-1 at MMD E.

BORE NO : MMD -03
DEPTH : 100·0'
METHOD : ROTARY

R.L : 191·49
DATE : 6/8 April-88
G.W.T. : 23·0 feet.

SCALE	REDUCED ELEVATION	DEPTH	THICKNESS	SOIL CLASSIFICATION	LOG	DIAMETER	SAMPLES	S.P.T. N'COUNTS	S.P.T. DEPTH	PENETRATION RESISTANCE
5				Brown Clayey SILT				36	5·0	
10	182·16	9·33	9·33	trace fine sand trace mica.				33	10·0	
15				Brown clayey SILT / silty CLAY trace mica.				13·0'–15·0' 12	15·0	
20	170·41	21·08	8·42					17	20·0	
25	167·16	24·33	3·25	Greyish brown SAND, fine to medium grained trace silt & mica.				25	25·0	
30				Brown Silty CLAY / Clayey SILT with fine sand trace mica.		4" ϕ		28·0'–29·50' 15	30·0	
35	154·33	37·16	12·83					19	35·0	
40				Grey silty CLAY with shell fragments trace to little fine sand. trace mica.				22	40·0	
45	143·66	47·83	10·67					40'–41·5' 18	45·0	
50				Grey & Brown, Silty Clayey SAND fine grained, trace mica.				8	50·0	
55								10	55·0	
60	127·08	64·41	16·58					7	60·0	
65								8	65·0	
70				Grey, Clayey SILT trace fine sand.				8	70·0	
75								74·0'–75·0' 10	75·0	

INDEX : DISTURBED UNDISTURBED WATER SAMPLE G.W.T.

DRILTECH CORPORATION (PRIVATE) LIMITED (B-112)

SHEET NO 1/2

SUBSURFACE EXPLORATION LOG AND PENETRATION RESISTANCE

PROJECT : [illegible]
CLIENT : WAPDA
CONSULTANT : LBOD CONSULTANTS

BORE NO : MMD-03
DEPTH : 100.0'
METHOD : ROTARY

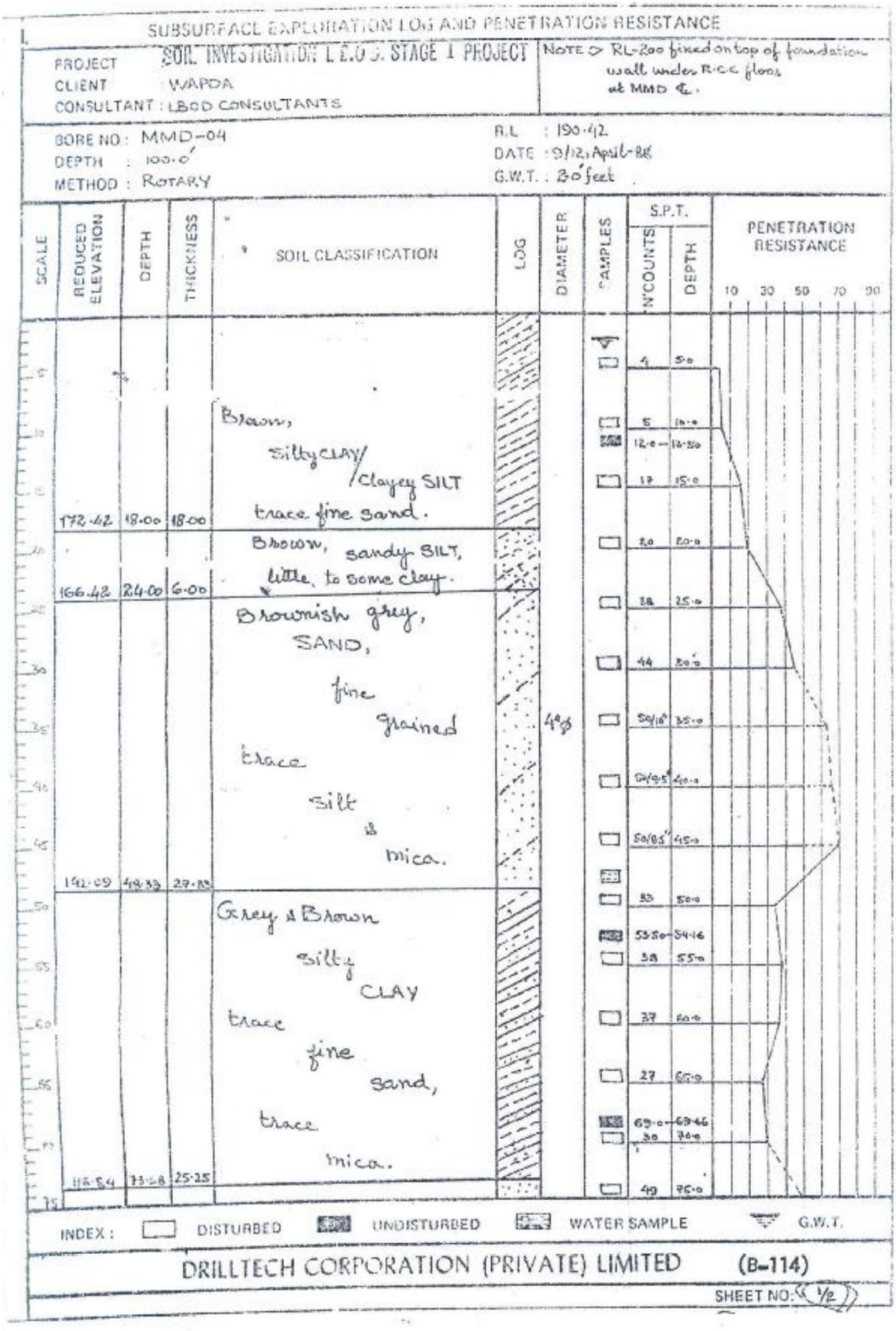
R.L : 191.49
DATE : 6/8 April-88
G.W.T. : 23.0' feet

SCALE	REDUCED ELEVATION	DEPTH	THICKNESS	SOIL CLASSIFICATION	LOG	DIAMETER	SAMPLES	S.P.T. 'N' COUNTS	S.P.T. DEPTH	PENETRATION RESISTANCE (10 30 50 70 90)
	114.49.	77.00	12.58	Clayey SILT.						
80				Grey, silty CLAY trace fine sand trace mica		4½		10	80.0	
85								8	85.0	
90								83.0'–83.85' 11	90.0	
95								8	95.0	
100	91.49	100.0	30.17					9	100.0	
				Bore Hole Completed.						

INDEX : DISTURBED UNDISTURBED WATER SAMPLE G.W.T.

DRILLTECH CORPORATION (PRIVATE) LIMITED (B-113)

SHEET NO: 5



SUBSURFACE EXPLORATION LOG AND PENETRATION RESISTANCE

PROJECT : SOIL INVESTIGATION L.B.O.D. STAGE I PROJECT
CLIENT : WAPDA
CONSULTANT : LBOD CONSULTANTS

NOTE :- RL-200 fixed on top of foundation wall under R.C.C floor at MMD ℄.

BORE NO : MMD-04
DEPTH : 100.0'
METHOD : ROTARY

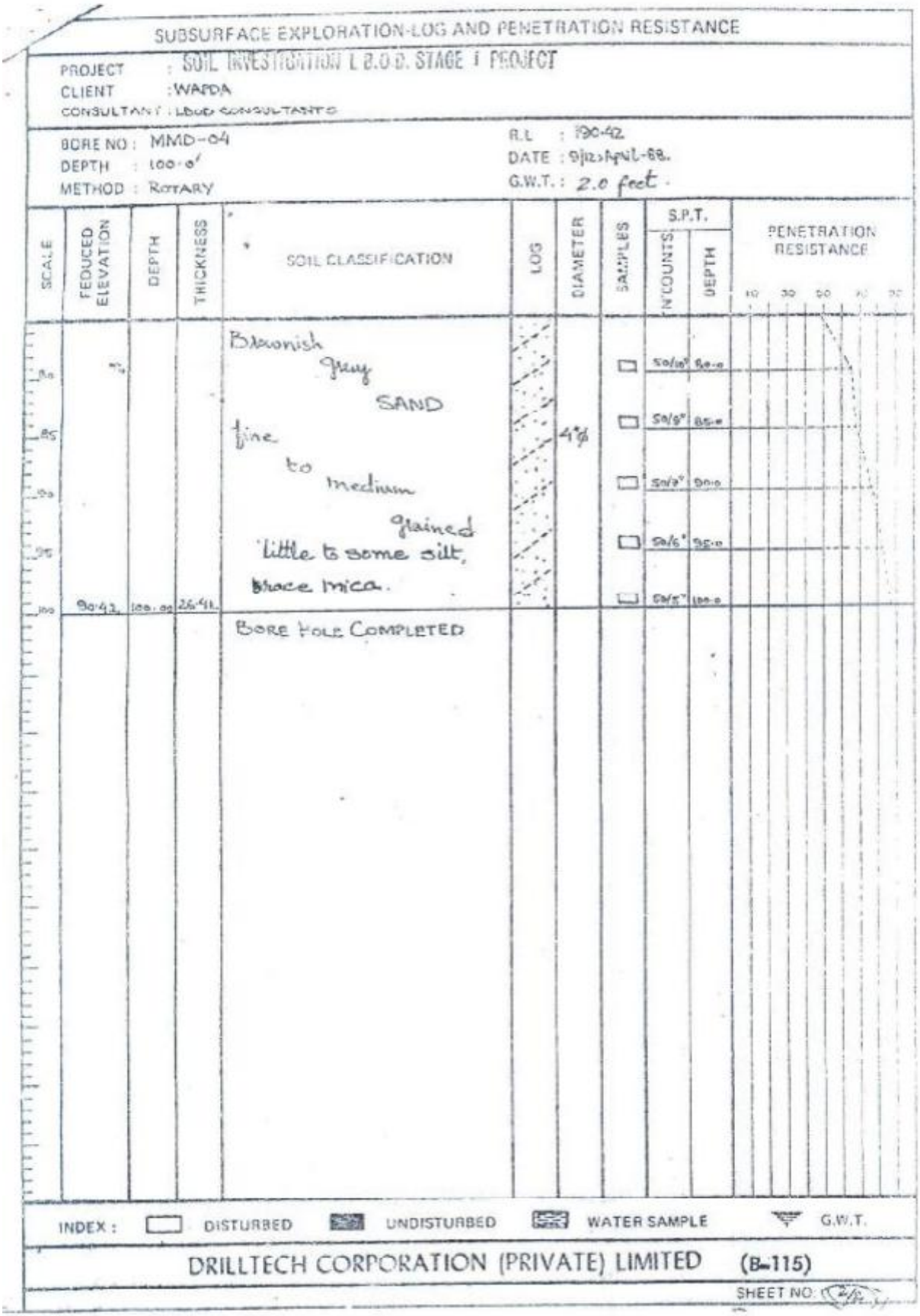
R.L : 190.42
DATE : 9/12, April-86
G.W.T. : 30 feet

SCALE	REDUCED ELEVATION	DEPTH	THICKNESS	SOIL CLASSIFICATION	LOG	DIAMETER	SAMPLES	S.P.T. N'COUNTS	S.P.T. DEPTH	PENETRATION RESISTANCE
								4	5.0	
				Brown, Silty CLAY / Clayey SILT trace fine sand.				5	10.0	
								12.0 – 13.50		
	172.42	18.00	18.00					17	15.0	
				Brown, sandy SILT, little to some clay.				20	20.0	
	166.42	24.00	6.00					38	25.0	
				Brownish grey, SAND, fine grained trace Silt & mica.		4" ϕ		44	30.0	
								50/10"	35.0	
								04/05"	40.0	
	141.09	49.33	27.33					50/05"	45.0	
								83	50.0	
				Grey & Brown silty CLAY trace fine sand, trace mica.				53.50 – 54.16		
								58	55.0	
								37	60.0	
								27	65.0	
								69.0 – 69.46		
								30	70.0	
	116.84	73.58	25.25					49	75.0	

INDEX : DISTURBED UNDISTURBED WATER SAMPLE G.W.T.

DRILLTECH CORPORATION (PRIVATE) LIMITED (B-114)

SHEET NO: 1/2



SUBSURFACE EXPLORATION-LOG AND PENETRATION RESISTANCE

PROJECT : SOIL INVESTIGATION L.B.O.D. STAGE I PROJECT
CLIENT : WAPDA
CONSULTANT : LBOD CONSULTANTS

BORE NO : MMD-04
DEPTH : 100·0'
METHOD : ROTARY

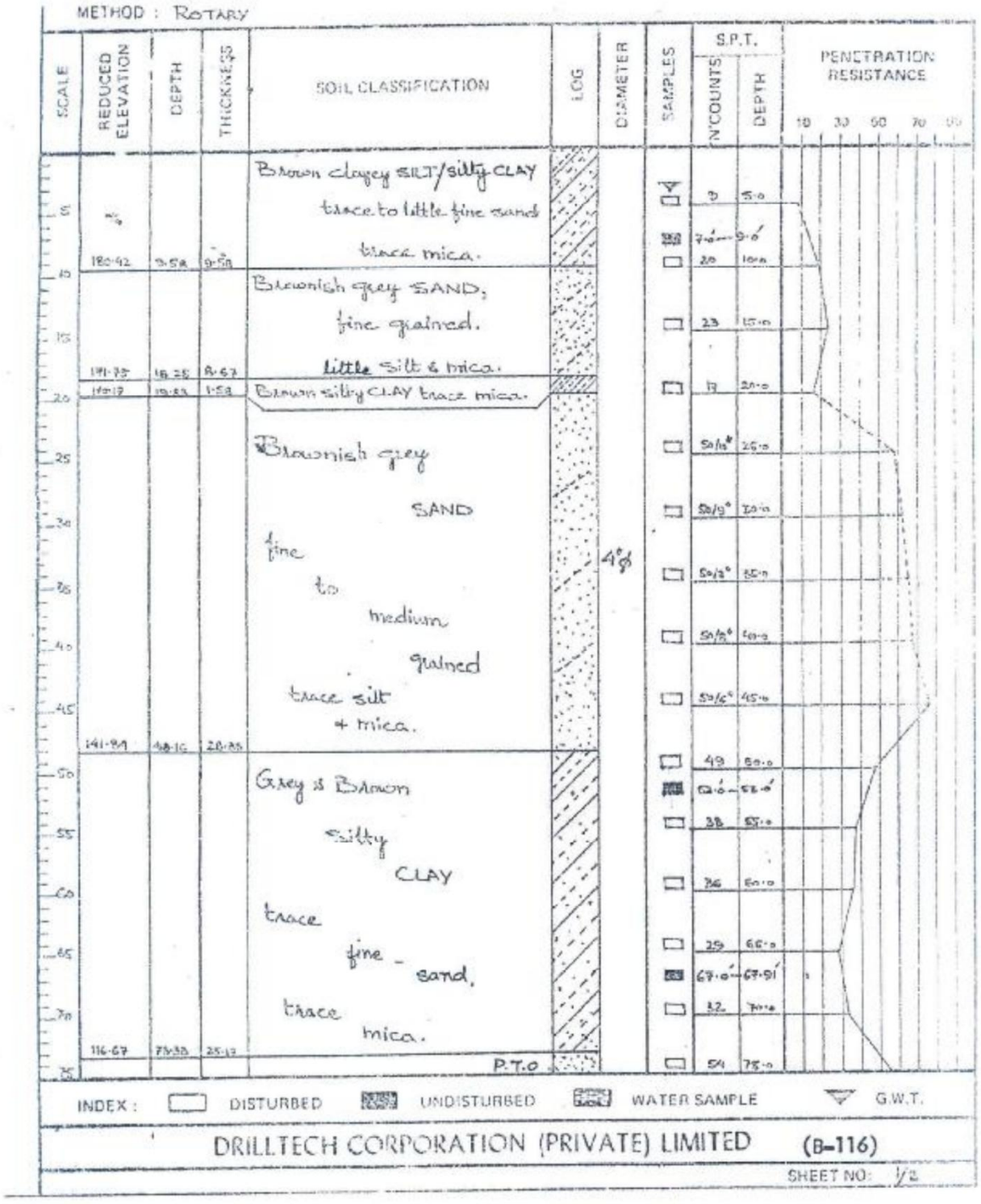
R.L : 190·42
DATE : 9/12/April-68.
G.W.T. : 2.0 feet.

SCALE	REDUCED ELEVATION	DEPTH	THICKNESS	SOIL CLASSIFICATION	LOG	DIAMETER	SAMPLES	S.P.T. N'COUNTS	S.P.T. DEPTH	PENETRATION RESISTANCE
				Brownish grey SAND fine to medium grained little to some silt, trace mica.		4"		50/10"	80·0	
								50/9"	85·0	
								50/8"	90·0	
								50/6"	95·0	
	90·42	100·00	26·41					50/5"	100·0	
				BORE HOLE COMPLETED						

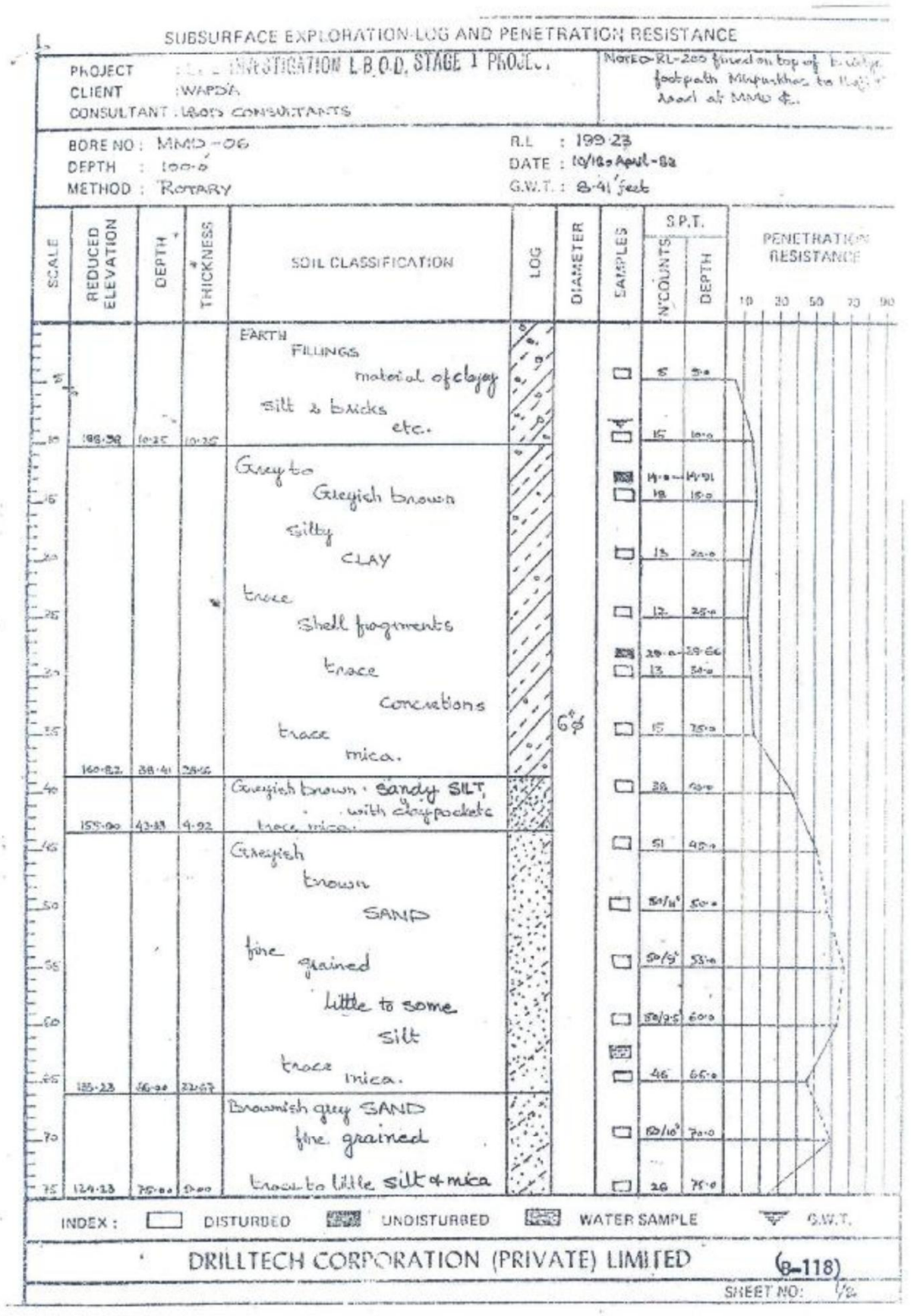
INDEX : DISTURBED UNDISTURBED WATER SAMPLE G.W.T.

DRILLTECH CORPORATION (PRIVATE) LIMITED (B-115)

SHEET NO: 2/2



DRILLTECH CORPORATION (PRIVATE) LIMITED (B-117)
SHEET NO: 2/2



SUBSURFACE EXPLORATION-LOG AND PENETRATION RESISTANCE

PROJECT : INVESTIGATION L.B.O.D. STAGE I PROJECT.
CLIENT : WAPDA
CONSULTANT : LBOD CONSULTANTS

Note:- RL-200 fixed on top of brick pillar footpath Mirpurkhas to Hyderabad at MMD &.

BORE NO : MMD-06
DEPTH : 100-0
METHOD : ROTARY

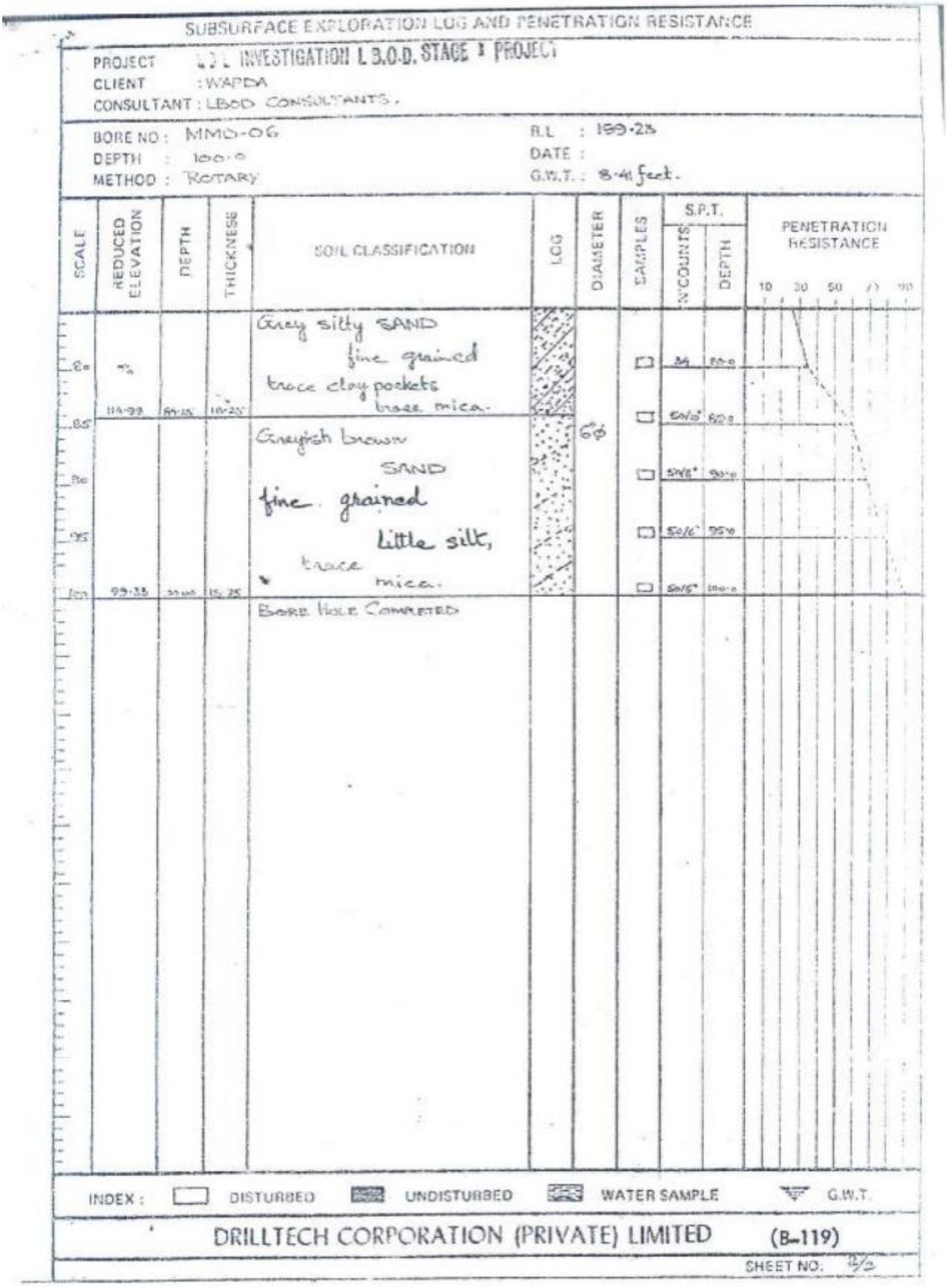
R.L : 199.23
DATE : 10/13 April-82
G.W.T. : 8.41 feet

SCALE	REDUCED ELEVATION	DEPTH	THICKNESS	SOIL CLASSIFICATION	LOG	DIAMETER	SAMPLES	S.P.T. N/COUNTS	S.P.T. DEPTH	PENETRATION RESISTANCE
				EARTH FILLINGS material of clayey silt & bricks etc.				5	5-0	
	188.98	10.25	10.25					15	10-0	
				Grey to Greyish brown silty CLAY trace Shell fragments trace Concretions trace mica.		6"ø		14-0 – 14-91		
								18	15-0	
								15	20-0	
								12	25-0	
								29-0 – 29-66		
								13	30-0	
	160.82	38.41	28.16					15	35-0	
				Greyish brown sandy SILT with clay pockets trace mica.				28	40-0	
	155.00	43.33	4.92							
				Greyish brown SAND fine grained little to some silt trace mica.				51	45-0	
								50/11"	50-0	
								50/5"	53-0	
								50/2.5	60-0	
	135.23	66.90	22.67					46	65-0	
				Brownish grey SAND fine grained trace to little silt & mica				50/10"	70-0	
	124.23	75.00	9.00					26	75-0	

INDEX : DISTURBED UNDISTURBED WATER SAMPLE G.W.T.

DRILLTECH CORPORATION (PRIVATE) LIMITED (B-118)

SHEET NO: 1/2



SUBSURFACE EXPLORATION LOG AND PENETRATION RESISTANCE

PROJECT : [illegible] INVESTIGATION L.B.O.D. STAGE I PROJECT
CLIENT : WAPDA
CONSULTANT : LBOD CONSULTANTS.

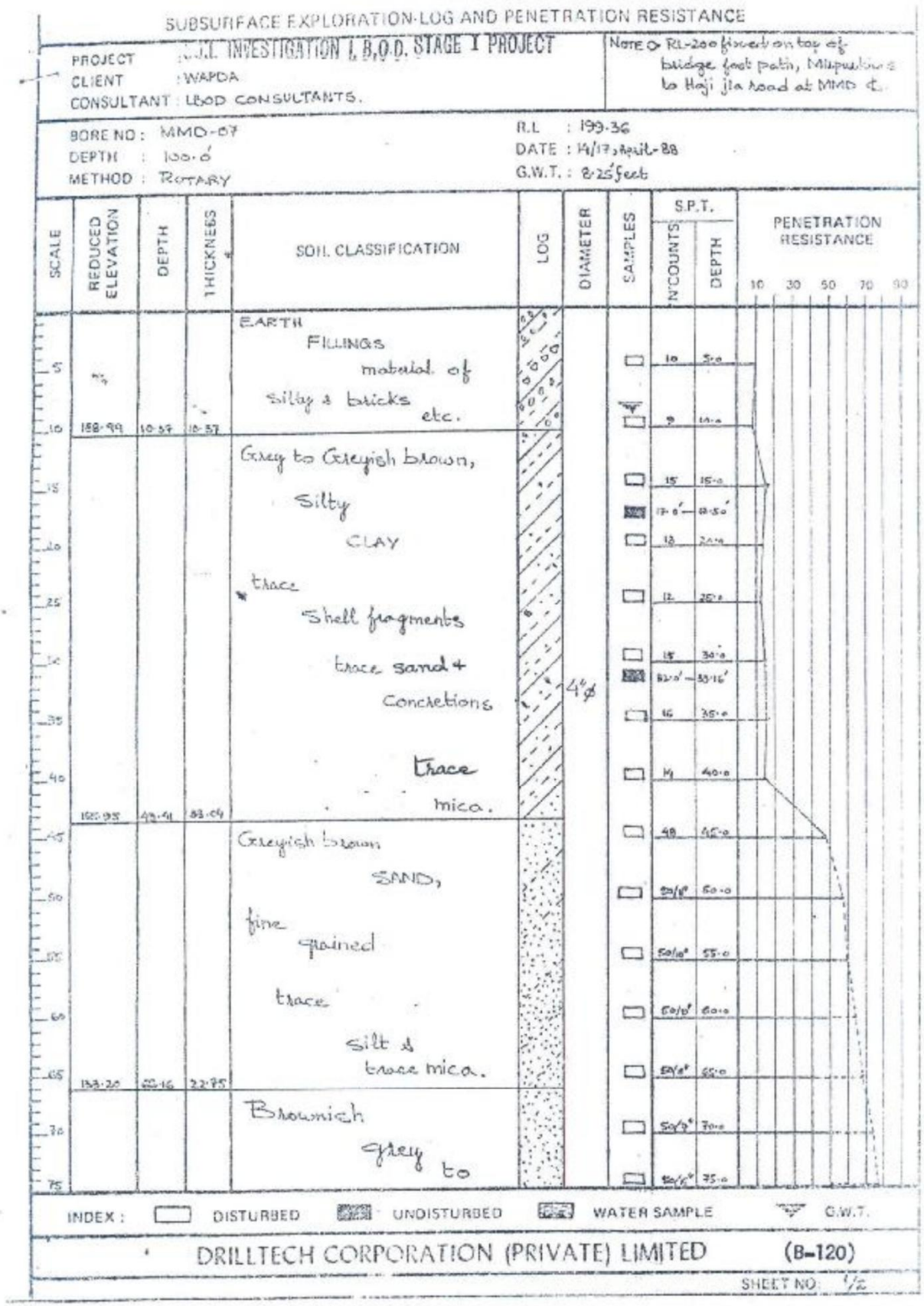
BORE NO : MMO-06 — R.L : 199.25
DEPTH : 100.0 — DATE :
METHOD : ROTARY — G.W.T. : 8.41 feet.

SCALE	REDUCED ELEVATION	DEPTH	THICKNESS	SOIL CLASSIFICATION	LOG	DIAMETER	SAMPLES	S.P.T. N'COUNTS	S.P.T. DEPTH	PENETRATION RESISTANCE
80				Grey silty SAND fine grained trace clay pockets trace mica.				34	80.0	
85	114.93	84.15	15.25			6"		50/6"	85.0	
90				Greyish brown SAND fine grained little silt, trace mica.				50/6"	90.0	
95								50/6"	95.0	
100	99.33	99.15	15.25					50/5"	100.0	
				Bore Hole Completed						

INDEX : DISTURBED UNDISTURBED WATER SAMPLE G.W.T.

DRILLTECH CORPORATION (PRIVATE) LIMITED (B-119)

SHEET NO. 3/2



SUBSURFACE EXPLORATION-LOG AND PENETRATION RESISTANCE

PROJECT : G.I. INVESTIGATION L.B.O.D. STAGE I PROJECT
CLIENT : WAPDA
CONSULTANT : LBOD CONSULTANTS.

Note :- RL-200 fixed on top of bridge foot path, Mirpurbuthe to Haji jia road at MMD ct.

BORE NO : MMD-07
DEPTH : 100.0'
METHOD : ROTARY

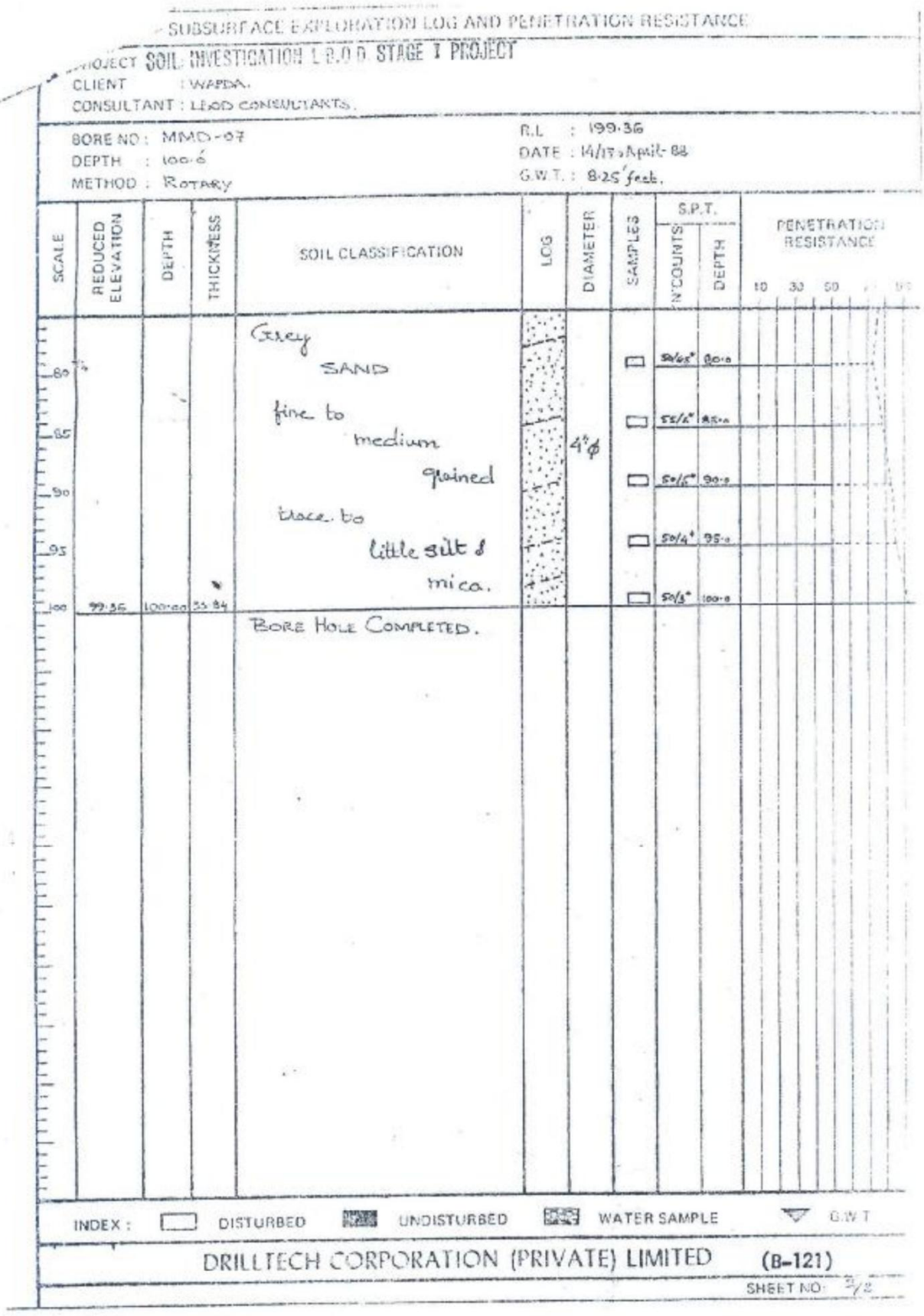
R.L : 199.36
DATE : 14/17, April-88
G.W.T. : 8.25 feet

SCALE	REDUCED ELEVATION	DEPTH	THICKNESS	SOIL CLASSIFICATION	LOG	DIAMETER	SAMPLES	S.P.T. N'COUNTS	S.P.T. DEPTH	PENETRATION RESISTANCE
5				EARTH FILLINGS material of silty & bricks etc.				10	5'-0	
10	188.99	10.37	10.37					9	10'-0	
15				Grey to Greyish brown, Silty CLAY trace Shell fragments trace sand & Concretions trace mica.		4"ϕ		15	15'-0	
								17'-0" – 18'-0"		
20								13	20'-0	
25								12	25'-0	
30								15	30'-0	
35								82'-0" – 83'-6"		
40	155.95	43.41	33.04					16	35'-0	
45								19	40'-0	
50				Greyish brown SAND, fine grained trace silt & trace mica.				48	45'-0	
55								50/6"	50'-0	
60								50/10"	55'-0	
65	133.20	66.16	22.75					50/8"	60'-0	
70								50/8"	65'-0	
75				Brownish grey to				50/3"	70'-0	
								50/6"	75'-0	

INDEX : DISTURBED UNDISTURBED WATER SAMPLE G.W.T.

DRILLTECH CORPORATION (PRIVATE) LIMITED (B-120)

SHEET NO: 1/2



SUBSURFACE EXPLORATION LOG AND PENETRATION RESISTANCE

PROJECT SOIL INVESTIGATION L.B.O.D. STAGE I PROJECT
CLIENT : WAPDA.
CONSULTANT : LEGO CONSULTANTS.

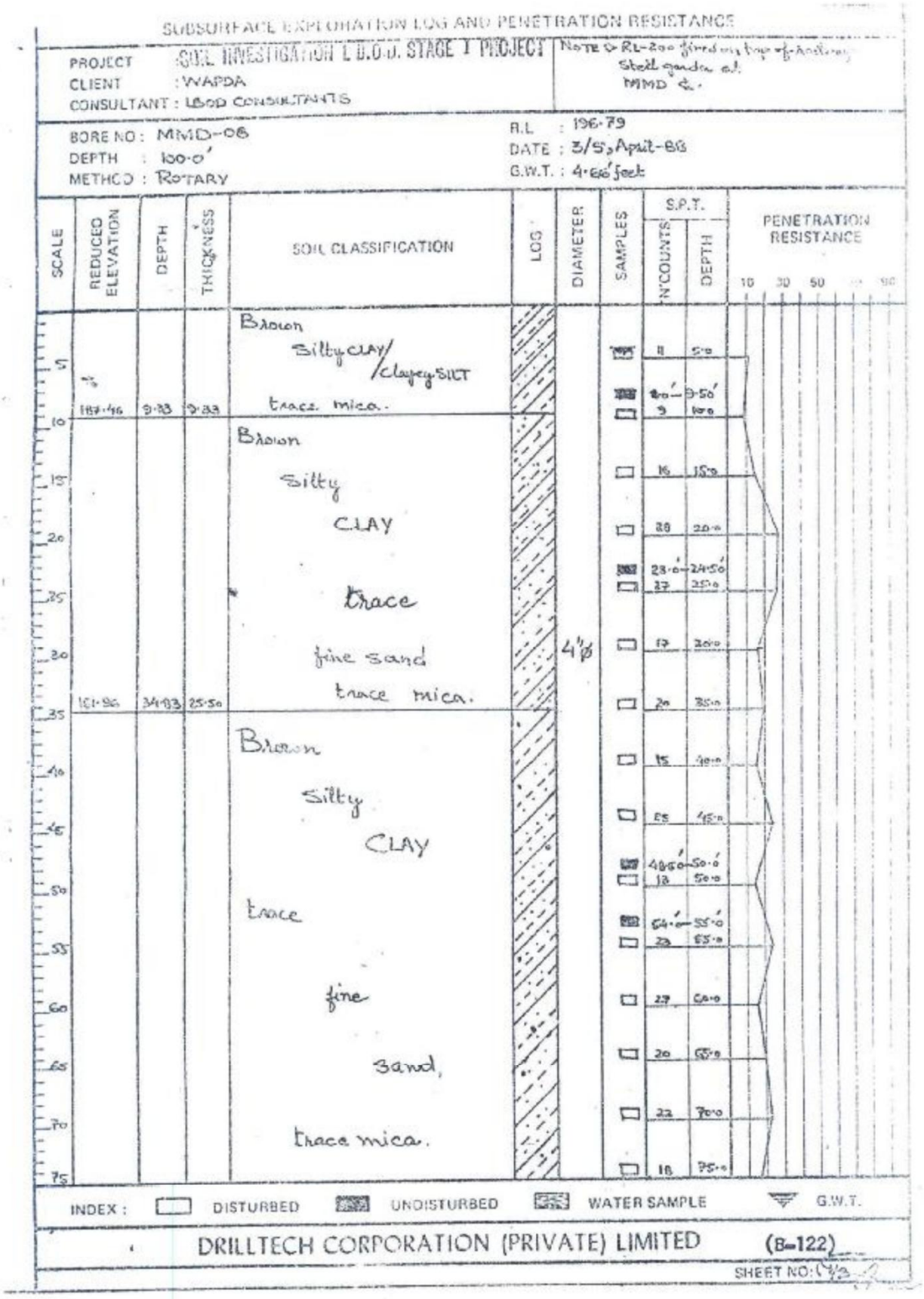
BORE NO : MMD-07
DEPTH : 100.6
METHOD : ROTARY

R.L : 199.36
DATE : 14/15 April-88
G.W.T. : 8.25' feet.

SCALE	REDUCED ELEVATION	DEPTH	THICKNESS	SOIL CLASSIFICATION	LOG	DIAMETER	SAMPLES	S.P.T. N'COUNTS	S.P.T. DEPTH	PENETRATION RESISTANCE
80				Grey SAND fine to medium grained trace to little silt & mica.		4"ϕ		50/6"	80.0	
85								55/5"	85.0	
90								50/5"	90.0	
95								50/4"	95.0	
100	99.36	100.60	35.84					50/3"	100.0	
				BORE HOLE COMPLETED.						

INDEX : DISTURBED UNDISTURBED WATER SAMPLE G.W.T

DRILLTECH CORPORATION (PRIVATE) LIMITED (B-121)
SHEET NO: 2/2



SUBSURFACE EXPLORATION LOG AND PENETRATION RESISTANCE

PROJECT : SOIL INVESTIGATION L.B.O.D. STAGE I PROJECT
CLIENT : WAPDA
CONSULTANT : LBOD CONSULTANTS

Note :- RL-200 fixed on top of Aluminum Steel garden el. MMD &.

BORE NO : MMD-08
DEPTH : 100-0'
METHOD : ROTARY

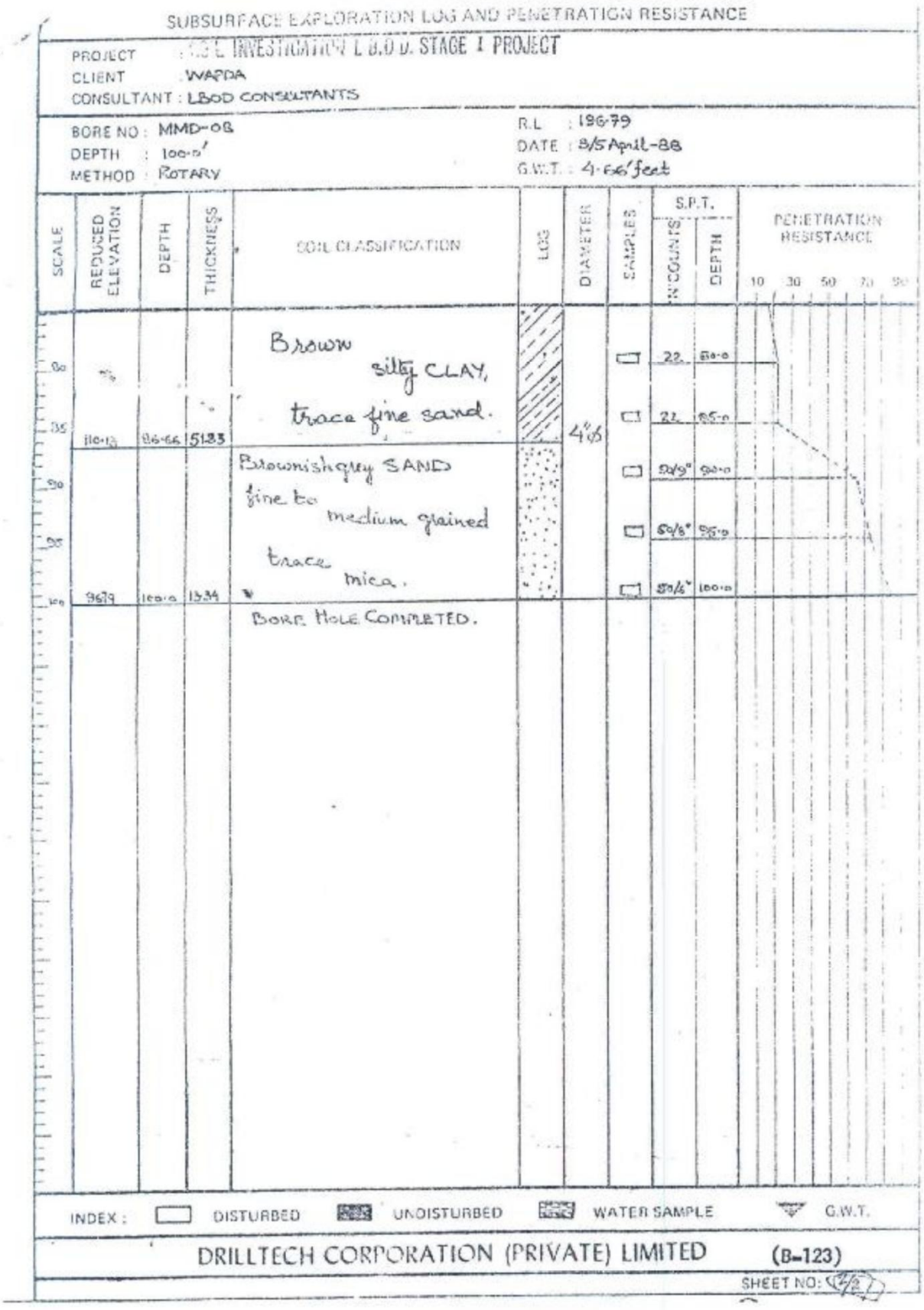
R.L : 196·79
DATE : 3/5, April-86
G.W.T. : 4·66 feet

SCALE	REDUCED ELEVATION	DEPTH	THICKNESS	SOIL CLASSIFICATION	LOG	DIAMETER	SAMPLES	S.P.T. N'COUNTS	S.P.T. DEPTH	PENETRATION RESISTANCE
5				Brown Silty CLAY / clayey SILT trace mica.				11	5·0	
10	187·46	9·33	9·33					8·0'–9·50' 9	10·0	
15				Brown Silty CLAY trace fine sand trace mica.		4"ϕ		16	15·0	
20								28	20·0	
25								23·0'–24·50' 27	25·0	
30								17	30·0	
35	161·96	34·83	25·50					20	35·0	
40				Brown Silty CLAY trace fine sand, trace mica.				15	40·0	
45								25	45·0	
50								48·50'–50·0' 18	50·0	
55								54·0'–55·0' 23	55·0	
60								27	60·0	
65								20	65·0	
70								22	70·0	
75								18	75·0	

INDEX : DISTURBED UNDISTURBED WATER SAMPLE G.W.T.

DRILLTECH CORPORATION (PRIVATE) LIMITED (B-122)

SHEET NO: 1/3



SUBSURFACE EXPLORATION LOG AND PENETRATION RESISTANCE

PROJECT : [illegible] INVESTIGATION L.B.O.D. STAGE I PROJECT
CLIENT : WAPDA
CONSULTANT : LBOD CONSULTANTS

BORE NO : MMD-08
DEPTH : 100-0'
METHOD : ROTARY

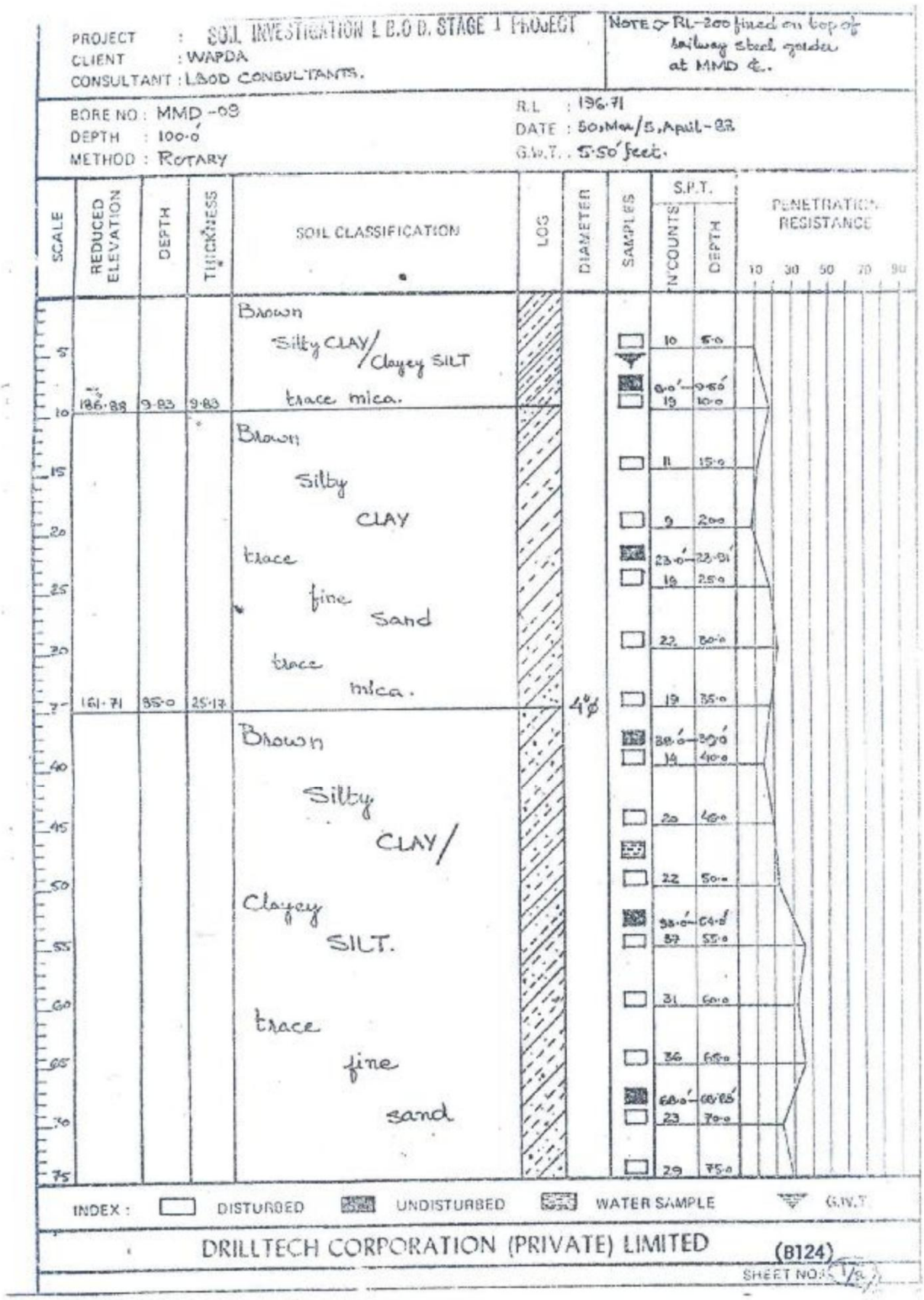
R.L : 196.79
DATE : 3/5 April-88
G.W.T. : 4.66' feet

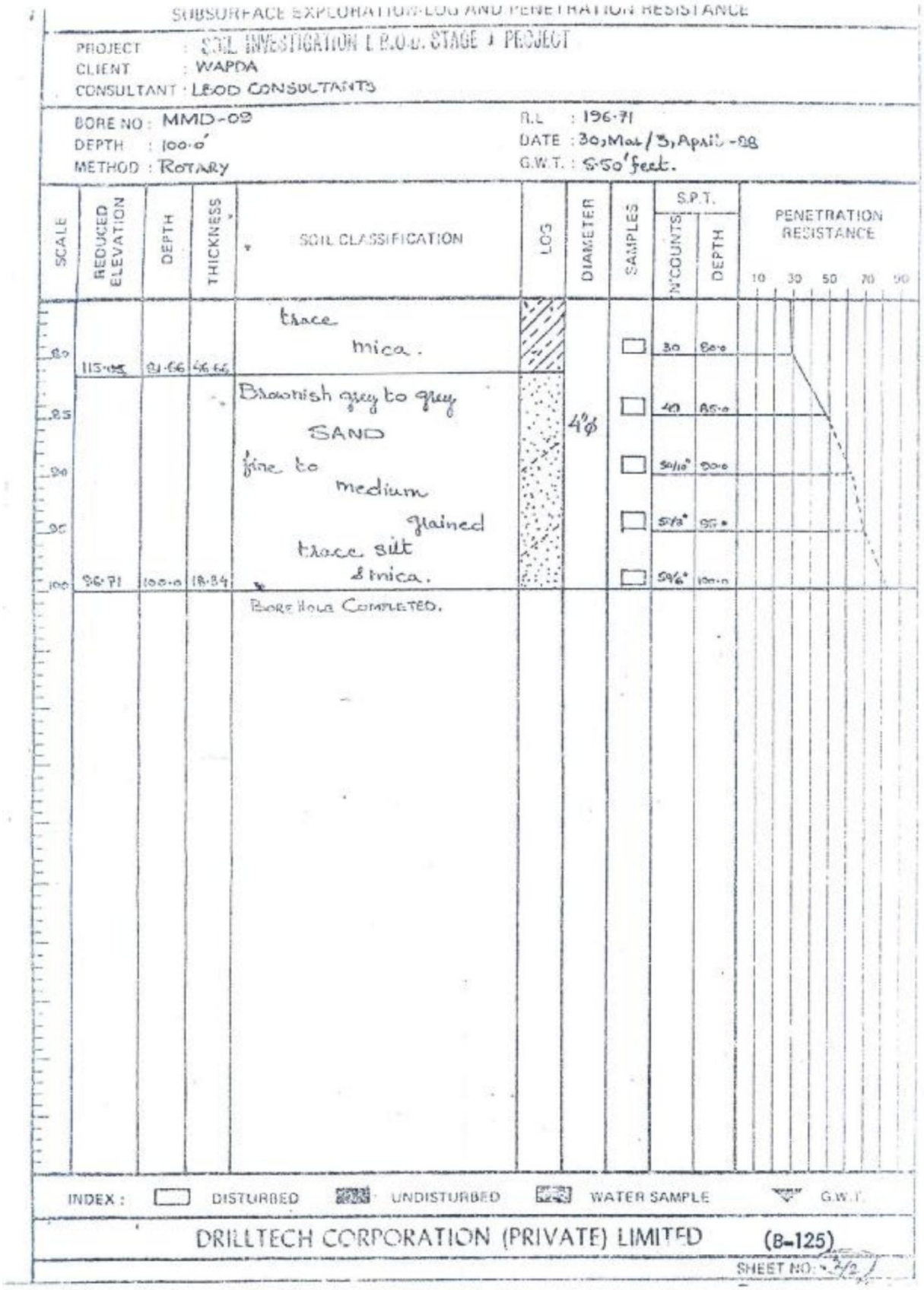
SCALE	REDUCED ELEVATION	DEPTH	THICKNESS	SOIL CLASSIFICATION	LOG	DIAMETER	SAMPLES	S.P.T. N-COUNTS	S.P.T. DEPTH	PENETRATION RESISTANCE
80				Brown silty CLAY, trace fine sand.		4"ø		22	80-0	
85	110.13	86.66	5.33					22	85-0	
90				Brownish grey SAND fine to medium grained trace mica.				50/9"	90-0	
95								50/8"	95-0	
100	96.79	100-0	13.34					50/6"	100-0	
				BORE HOLE COMPLETED.						

INDEX : DISTURBED UNDISTURBED WATER SAMPLE G.W.T.

DRILLTECH CORPORATION (PRIVATE) LIMITED (B-123)

SHEET NO: 2/2


PROJECT : SOIL INVESTIGATION L.B.O.D. STAGE I PROJECT
CLIENT : WAPDA
CONSULTANT : LBOD CONSULTANTS.
NOTE :- RL-200 fixed on top of railway steel girder at MMD &.
BORE NO : MMD-09
DEPTH : 100.0'
METHOD : ROTARY
R.L : 196.71
DATE : 30,Mar/5,April-93
G.W.T. : 5.50' feet.
SCALE
REDUCED ELEVATION
DEPTH
THICKNESS
SOIL CLASSIFICATION
LOG
DIAMETER
SAMPLES
S.P.T.
N'COUNTS
DEPTH
PENETRATION RESISTANCE
10 30 50 70 90
Brown Silty CLAY/Clayey SILT trace mica.
186.88
9.83
9.83
Brown Silty CLAY trace fine Sand trace mica.
161.71
35.0
25.17
4"ϕ
Brown Silty CLAY/ Clayey SILT. trace fine sand
INDEX : DISTURBED UNDISTURBED WATER SAMPLE G.W.T
DRILLTECH CORPORATION (PRIVATE) LIMITED
(B124)
SHEET NO.



SUBSURFACE EXPLORATION-LOG AND PENETRATION RESISTANCE

PROJECT : SOIL INVESTIGATION L.B.O.D. STAGE I PROJECT
CLIENT : WAPDA
CONSULTANT : LEOD CONSULTANTS

BORE NO : MMD-09
DEPTH : 100.0'
METHOD : ROTARY

R.L : 196.71
DATE : 30, Mar / 3, April-08
G.W.T. : 5.50' feet.

SCALE	REDUCED ELEVATION	DEPTH	THICKNESS	SOIL CLASSIFICATION	LOG	DIAMETER	SAMPLES	S.P.T. N'COUNTS	S.P.T. DEPTH	PENETRATION RESISTANCE (10 30 50 70 90)
80	115.05	81.66	46.66	trace mica.				30	80.0	
85				Brownish grey to grey SAND fine to medium grained trace silt & mica.		4" ϕ		40	85.0	
90								50/10"	90.0	
95								50/3"	95.0	
100	96.71	100.0	18.34					50/6"	100.0	
				Bore Hole Completed.						

INDEX : DISTURBED UNDISTURBED WATER SAMPLE G.W.T.

DRILLTECH CORPORATION (PRIVATE) LIMITED (B-125)

SHEET NO: 2/2

MEHRAN UNIVERSITY ADVISORY AND CONSULTANCY CENTRE
JAMSHORO.
Ph 71249

PROJECT: LBOD SURFACE DRAINAGE PROJECT, MIRPUR KHAS

CLIENT: WAPDA

CONSULIANT: MMP-ACE-NESPAK.

CONTRACTOR: CHINA GUANGXI CORPORATION.

SUBSURFACE EXPLORATION LOG AND PENETRATION RESISTANCE

METHOD OF DRILLING: ROTARY(MUD)
DEPTH OF EXPLORATION: 100 ft.
BORE HOLE NO: B.H. No.1
GROUND WATER TABLE: 13 ft. from Natural Ground.
DATE: 22-12-91 - 24-12-91

SCALE FEET	DEPTH FEET	THICKNESS FEET	SOIL DESCRIPTION	SYMBOL	SPT BLOWS / FT (0 10 30 50 70 90)	CORE RECOVERY (0 10 30 50 70 90)	RQD %	REMARKS
5			Stiff to hard Light Grey Clayey SILT. (MH)		.25			
10					.32			
13' W.L.								
15			" " "		.28			
20		35 ft.	" " "		.27			
25			" " "		.38			
30			" " "		40			
35			Trace Fine Sand		.21			

S.P.T = STANDARD PENETRATION TEST
R.Q.D = ROCK QUALITY DESIGNATION
W.L = WATER LOSS

-: 15 :-

GEOTECHNICAL ENGINEER

NAZIR AHMED

MEHRAN UNIVERSITY ADVISORY AND CONSULTANCY CENTRE
JAMSHORO.
Ph 71269

PROJECT: LBOD SURFACE DRAINAGE PROJECT, MIRPUR KHAS.
CLIENT: WAPDA
CONSULTANT:- MMP-ACE-NESPAK
CONTRACTOR CHINA GUANGXI CORP.

SUBSURFACE EXPLORATION LOG AND PENETRATION RESISTANCE

METHOD OF DRILLING: ROTARY (MUD)
DEPTH OF EXPLORATION: 100 ft.
BORE HOLE NO: B.H.No.1
GROUND WATER TABLE: —
DATE: 22-12-91 - 24-12-91

SCALE FEET	DEPTH FEET	THICKNESS FEET	SOIL DESCRIPTION	SYMBOL	S.P.T BLOWS / FT (0 10 30 50 70 90)	CORE RECOVERY (0 10 30 50 70 90)	R.Q.D %	REMARKS
	40		Stiff Gray Silty CLAY. (CH)		10			
	45	15 ft.	Stiff Blackish Grey Silty CLAY		13			
	50				11			
	55		Medium to loose Brownish Grey Silty Fine SAND. (SM)		8			
	60		" " "		10			
	65	25 ft.			06			
	70		" " Traces of Mica		11			

S.P.T = STANDARD PENETRATION TEST
R.Q.D= ROCK QUALITY DESIGNATION
W.L = WATER LOSS

-: 16 :-

GEOTECHNICAL ENGINEER

NAZIR AHMED

MEHRAN UNIVERSITY ADVISORY AND CONSULTANCY CENTRE
JAMSHORO.
Ph. 71269

PROJECT: LBOD SURFACE DRAINAGE PROJECT, MIRPUR KHAS.
CLIENT: WAPDA
CONSULTANT: MMP-ACE-NESPAK
CONTRACTOR: CHINA GUANGXI CORP.

SUBSURFACE EXPLORATION LOG AND PENETRATION RESISTANCE

METHOD OF DRILLING: ROTARY (MUD)
DEPTH OF EXPLORATION: 100 ft.
BORE HOLE NO: B.H.NO.1
GROUND WATER TABLE:
DATE: 22-12-91 - 24-12-91

SCALE FEET	DEPTH FEET	THICKNESS FEET	SOIL DESCRIPTION	SYMBOL	SPT BLOWS / FT (0 10 30 50 70 90)	CORE RECOVERY (0 10 30 50 70 90)	RQD %	REMARKS
					UDS I			
	75		Stiff to very stiff Grey silty CLAY.		14			
	80							
	85	25 ft.			UDS II			
	90				18			
	95		Loose Grey fine sandy SILT (M.L) (non plastic)		12			
	100		Bore Hole terminated at 100 ft. depth.		9			

S.P.T = STANDARD PENETRATION TEST
R.Q.D = ROCK QUALITY DESIGNATION
W.L = WATER LOSS

-: 17 :-

GEOTECHNICAL ENGINEER

MEHRAN UNIVERSITY ADVISORY AND CONSULTANCY CENTRE
JAMSHORO.

PROJECT: LBOD SURFACE DRAINAGE PROJECT, MIRPUR KHAS.
CLIENT: WAPDA
CONSULTANT:- MMP-ACE-NESPAK
CONTRACTOR: CHINA GUANGXI CORPORATION.

SUBSURFACE EXPLORATION LOG AND PENETRATION RESISTANCE

METHOD OF DRILLING: ROTARY (MUD)
DEPTH OF EXPLORATION: 100 ft.
BORE HOLE NO: B.H.NO.2
GROUND WATER TABLE: 24 ft. from Natural Ground surface.
DATE: 19-12-91 - 12-12-91

SCALE FEET	DEPTH FEET	THICKNESS FEET	SOIL DESCRIPTION	SYMBOL	SPT BLOWS / FT (0 10 30 50 70 90)	CORE RECOVERY (0 10 30 50 70 90)	RQD %	REMARKS
5		15 ft.	Hard to stiff Brownish Grey Silty CLAY. (CI)		52, 59, 34			
15		15 ft	Medium dense Brownish Grey non-plastic SILT. (M.L) " " " " Trace of Mica.		35, 19, 26			24ft. W.L
30			Very stiff to stiff, Brownish Grey Silty CLAY/ clayey SILT. (MI)		UDSI			

S.P.T = STANDARD PENETRATION TEST
R.Q.D = ROCK QUALITY DESIGNATION
W.L = WATER LOSS

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GEOTECHNICAL ENGINEER

NAZIR AHMED

MEHRAN UNIVERSITY ADVISORY AND CONSULTANCY CENTRE
JAMSHORO.
Ph 71269

PROJECT: LBOD SURFACE DRAINAGE PROJECT, MIRPUR KHAS.
CLIENT: WAPDA
CONSULTANT:- MMP-ACE-NESPAK
CONTRACTOR: CHINA GUANGXI CORPORATION.

SUBSURFACE EXPLORATION LOG AND PENETRATION RESISTANCE

METHOD OF DRILLING: ROTARY (MUD)
DEPTH OF EXPLORATION: 100 ft.
BORE HOLE NO: B.H.NO.2
GROUND WATER TABLE: —
DATE:- 19-12-91 - 21-12-91

SCALE FEET	DEPTH FEET	THICKNESS FEET	SOIL DESCRIPTION	SYMBOL	S.P.T BLOWS / F T (0 10 30 50 70 90)	CORE RECOVERY (0 10 30 50 70 90)	R.Q.D %	REMARKS
40			Very stiff to stiff Brownish Grey Silty CLAY/clayey SILT		17, 13, 14			
45								
50			Very stiff blackish grey silty CLAY / clayey SILT.		17, 9, 13, 11			
55								
60								
65								
70								

S.P.T = STANDARD PENETRATION TEST
R.Q.D= ROCK QUALITY DESIGNATION
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-: 19 :-

GEOTECHNICAL ENGINEER

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Ph. 71269

PROJECT: LBOD SURFACE DRAINAGE PROJECT, MIRPUR KHAS.
CLIENT: WAPDA
CONSULTANT:- MMP-ACE-NESPAK
CONTRACTOR: CHINA GUANGXI CORPORATION.

SUBSURFACE EXPLORATION LOG AND PENETRATION RESISTANCE

METHOD OF DRILLING: ROTARY (MUD)
DEPTH OF EXPLORATION: 100 ft.
BORE HOLE NO: B.H.NO.2
GROUND WATER TABLE:
DATE: 19-12-91 - 21-12-91

SCALE FEET / DEPTH FEET	THICKNESS FEET	SOIL DESCRIPTION	SYMBOL	S.P.T BLOWS / FT (0 10 30 50 70 90)	CORE RECOVERY (0 10 30 50 70 90)	R.Q.D %	REMARKS
75		Stiff to very stiff Blackish Grey Silty CLAY/ clayey SILT. (MI)		06			
80		" " " (CI)		15			
85		" " "		UDSII			
90		" " "		10			
95		" " "		UDSIII			
100		Bore hole terminated at 101.5 ft. depth		25			

S.P.T = STANDARD PENETRATION TEST
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W.L = WATER LOSS

-: 20 :-

GEOTECHNICAL ENGINEER
NAZIR AHMED

MEHRAN UNIVERSITY ADVISORY AND CONSULTANCY CENTRE JAMSHORO.

PROJECT: LBOD SURFACE DRAINAGE PROJECT, MIRPUR KHAS.

CLIENT: WAPDA

CONSULTANT:- MMP-ACE-NESPAK

CONTRACTOR: CHINA GUANGXI CORPORATION.

SUBSURFACE EXPLORATION LOG AND PENETRATION RESISTANCE

METHOD OF DRILLING: ROTARY (MUD)
DEPTH OF EXPLORATION: 100 ft.
BORE HOLE NO: B.H.NO.3
GROUND WATER TABLE: 15ft. from Natural Ground Level.
DATE:- 26-12-91 - 27-12-91

SCALE FEET	DEPTH FEET	THICKNESS FEET	SOIL DESCRIPTION	SYMBOL	S.P.T BLOWS / FT (0 10 30 50 70 90)	CORE RECOVERY (0 10 30 50 70 90)	R.Q.D %	REMARKS
5			Stiff to very stiff Light Grey Silty CLAY (CI)		16			
10			" " "		UDS, 15			
15		50 ft			20			∇ W.L 15ft.
20			" " "		10			
25			" " "		26			
30			" " "		28			
35			" Lenses of Sand		14			

S.P.T = STANDARD PENETRATION TEST
R.Q.D = ROCK QUALITY DESIGNATION
W.L = WATER LOSS

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GEOTECHNICAL ENGINEER

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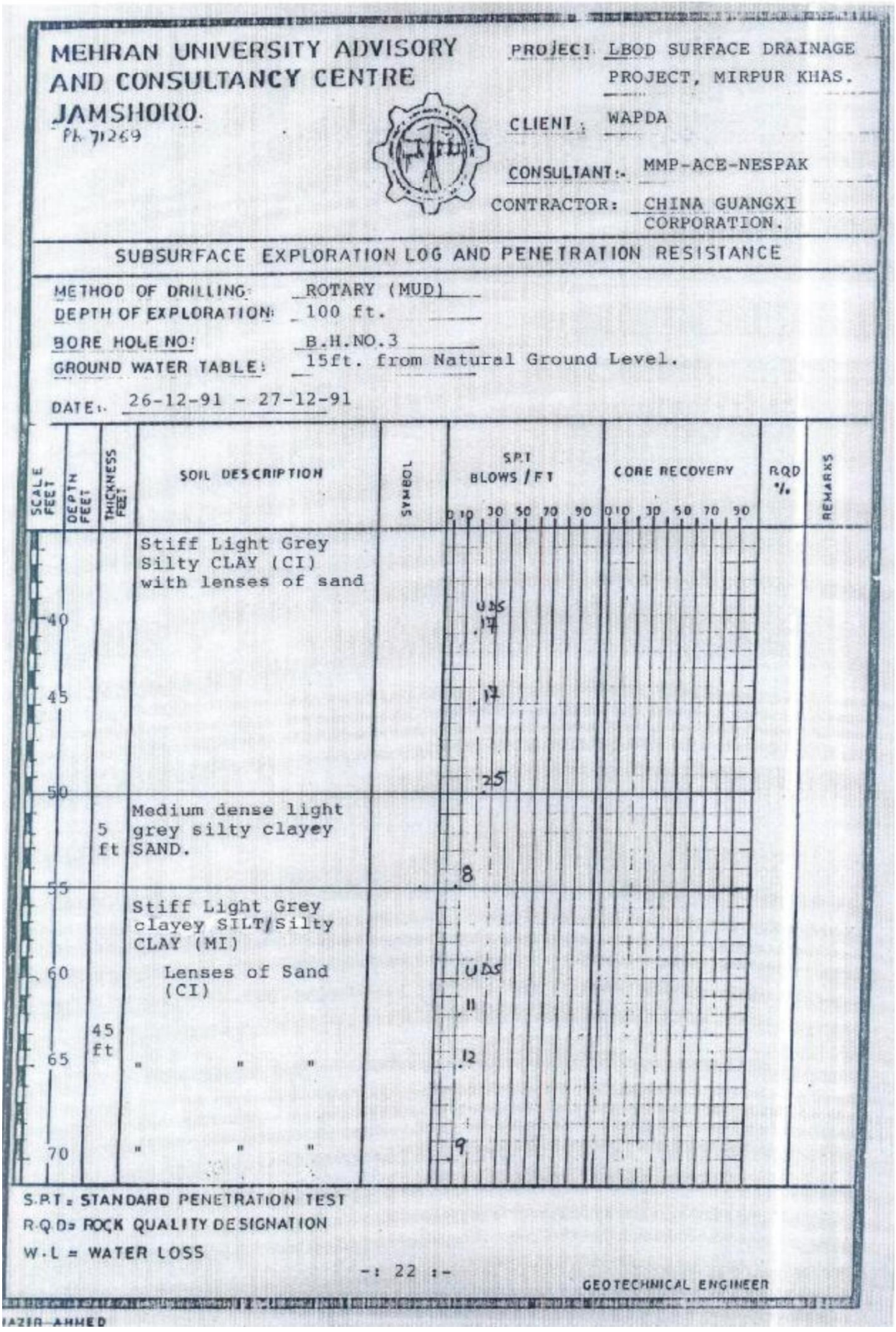

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JAMSHORO.
PK 71269

PROJECT: LBOD SURFACE DRAINAGE PROJECT, MIRPUR KHAS.
CLIENT: WAPDA
CONSULTANT: MMP-ACE-NESPAK
CONTRACTOR: CHINA GUANGXI CORPORATION.

SUBSURFACE EXPLORATION LOG AND PENETRATION RESISTANCE

METHOD OF DRILLING: ROTARY (MUD)
DEPTH OF EXPLORATION: 100 ft.
BORE HOLE NO: B.H.NO.3
GROUND WATER TABLE: 15ft. from Natural Ground Level.
DATE: 26-12-91 - 27-12-91

SCALE FEET	DEPTH FEET	THICKNESS FEET	SOIL DESCRIPTION	SYMBOL	S.P.T BLOWS / FT (0 10 30 50 70 90)	CORE RECOVERY (0 10 30 50 70 90)	RQD %	REMARKS
40			Stiff Light Grey Silty CLAY (CI) with lenses of sand		UDS 17			
45					17			
50					25			
		5 ft	Medium dense light grey silty clayey SAND.		8			
55			Stiff Light Grey clayey SILT/Silty CLAY (MI)					
60			Lenses of Sand (CI)		UDS 11			
		45 ft						
65			" " "		12			
70			" " "		9			

S.P.T = STANDARD PENETRATION TEST
R.Q.D = ROCK QUALITY DESIGNATION
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-: 22 :-

GEOTECHNICAL ENGINEER

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Ph. 71269

PROJECT: LBOD SURFACE DRAINAGE PROJECT, MIRPUR KHAS.
CLIENT: WAPDA
CONSULTANT:- MMP-ACE-NESPAK
CONTRACTOR: CHINA GUANGXI CORPORATION.

SUBSURFACE EXPLORATION LOG AND PENETRATION RESISTANCE

METHOD OF DRILLING: ROTARY (MUD)
DEPTH OF EXPLORATION: 100ft.
BORE HOLE NO: B.H.NO.3
GROUND WATER TABLE: 15ft. from Natural Ground Level.
DATE:- 26-12-91 - 27-12-91

SCALE FEET	DEPTH FEET	THICKNESS FEET	SOIL DESCRIPTION	SYMBOL	SPT BLOWS / FT (0 10 30 50 70 90)	CORE RECOVERY (0 10 30 50 70 90)	RQD %	REMARKS
75			Stiff Light Grey Silty CLAY / clayey SILT. (MH)		UDS 14 14 14 UDS 10			
80								
85								
90								
95			Lenses of Sand (MI)					
100			End of Bore hole at 100ft. depth.					

S.P.T = STANDARD PENETRATION TEST
R.Q.D= ROCK QUALITY DESIGNATION
W.L = WATER LOSS

-: 23 :-

GEOTECHNICAL ENGINEER

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PROJECT: LBOD SURFACE DRAINAGE PROJECT, MIRPUR KHAS.
CLIENT: WAPDA
CONSULTANT:- MMP-ACE-NESPAK
CONTRACTOR: CHINA GUANGXI CORPORATION.

SUBSURFACE EXPLORATION LOG AND PENETRATION RESISTANCE

METHOD OF DRILLING: ROTARY (MUD)
DEPTH OF EXPLORATION: 100 ft.
BORE HOLE NO: B.H.NO.4
GROUND WATER TABLE: 13 ft. from Natural Ground Level.
DATE:- 28-12-91 - 30-12-91

SCALE FEET	DEPTH FEET	THICKNESS FEET	SOIL DESCRIPTION	SYMBOL	SPT BLOWS / FT 0 10 30 50 70 90	CORE RECOVERY 0 10 30 50 70 90	RQD %	REMARKS
5		15 ft	Hard to very stiff Light Grey silty CLAY (CI)		62			
10					17			GWL 13'
15					29			
20		25 ft	M.dense to dense Light Grey Silty Fine SAND. (SM)		12			
25					29			
30					34			
35					47			

S.P.T = STANDARD PENETRATION TEST
R.Q.D= ROCK QUALITY DESIGNATION
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GEOTECHNICAL ENGINEER

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JAMSHORO.
PH 71269

PROJECT: LBOD SURFACE DRAINAGE PROJECT, MIRPUR KHAS.
CLIENT: WAPDA
CONSULTANT:- MMP-ACE-NESPAK
CONTRACTOR: CHINA GUANGXI CORPORATION.

SUBSURFACE EXPLORATION LOG AND PENETRATION RESISTANCE

METHOD OF DRILLING: ROTARY (MUD)
DEPTH OF EXPLORATION: 100 ft.
BORE HOLE NO: B.H.NO.4
GROUND WATER TABLE: 13 ft. From Natural Ground Level.
DATE:- 28-12-91 - 30-12-91

SCALE FEET	DEPTH FEET	THICKNESS FEET	SOIL DESCRIPTION	SYMBOL	S.P.T BLOWS / F T (0 10 30 50 70 90)	CORE RECOVERY (0 10 30 50 70 90)	R.Q.D %	REMARKS
			Medium dense to dense Light Grey Silty Fine SAND.		16			
40								
45			Medium dense Brownish Grey fine Sandy SILT (N.P.) (M.L)		23 32			
50								
55		30 ft			36			
60					39			
65					30			
70					13			

S.P.T. STANDARD PENETRATION TEST
R.Q.D. ROCK QUALITY DESIGNATION
W.L = WATER LOSS

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GEOTECHNICAL ENGINEER

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MEHRAN UNIVERSITY ADVISORY AND CONSULTANCY CENTRE
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PK 71269

PROJECT: LBOD SURFACE DRAINAGE PROJECT, MIRPUR KHAS.
CLIENT: WAPDA
CONSULTANT:- MMP-ACE-NESPAK
CONTRACTOR: CHINA GUANGXI CORPORATION.

SUBSURFACE EXPLORATION LOG AND PENETRATION RESISTANCE

METHOD OF DRILLING: ROTARY (MUD)
DEPTH OF EXPLORATION: 100 ft.
BORE HOLE NO: B.H.NO.4
GROUND WATER TABLE: 13 ft. from Natural Ground Level.
DATE:-

SCALE FEET	DEPTH FEET	THICKNESS FEET	SOIL DESCRIPTION	SYMBOL	SPT BLOWS / FT (0 10 30 50 70 90)	CORE RECOVERY (0 10 30 50 70 90)	RQD %	REMARKS
	75	30 ft	M.Stiff to very Stiff Blackish Grey Silty CLAY. (CH)		.13 UDS .20 .16 .20 UDS .06			
	80							
	85							
	90							
	95							
	100		(CI) Bore hole terminated at 100 ft. depth.					

S.P.T: STANDARD PENETRATION TEST
R.Q.D= ROCK QUALITY DESIGNATION
W.L = WATER LOSS

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JAMSHORO.

PROJECT: LBOD SURFACE DRAINAGE PROJECT, MIRPUR KHAS.

CLIENT: WAPDA

CONSULTANT:- MMP-ACE-NESPAK

CONTRACTOR: CHINA GUANGXI CORPORATION.

SUBSURFACE EXPLORATION LOG AND PENETRATION RESISTANCE

METHOD OF DRILLING: ROTARY (MUD)
DEPTH OF EXPLORATION: 100 ft.
BORE HOLE NO: B.H.NO.5
GROUND WATER TABLE: 12.5 ft.
DATE: 7-1-92 - 8-1-92

SCALE FEET	DEPTH FEET	THICKNESS FEET	SOIL DESCRIPTION	SYMBOL	S.P.T BLOWS / FT	CORE RECOVERY	RQD %	REMARKS
		20 ft	Very stiff Grey silty CLAY. (CI)		32, UDS, 23, 24, 18			G.W.L 126'
		5 ft	Medium dense Grey fine sandy SILT (N.P) (M.L)		29			
		5 ft	Very stiff Brownish Grey silty CLAY.		17			
		5 ft	Medium dense Brownish Grey sandy SILT (N.P.)		13			

S.P.T = STANDARD PENETRATION TEST
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-: 27 :-

GEOTECHNICAL ENGINEER

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Ph. 71259

PROJECT: LBOD SURFACE DRAINAGE PROJECT, MIRPUR KHAS.
CLIENT: WAPDA
CONSULTANT:- MMP-ACE-NESPAK
CONTRACTOR: CHINA GUANGXI CORPORATION

SUBSURFACE EXPLORATION LOG AND PENETRATION RESISTANCE

METHOD OF DRILLING: ROTARY (MUD)
DEPTH OF EXPLORATION: 100 ft.
BORE HOLE NO: B.H.NO.5
GROUND WATER TABLE: 12.5 ft.
DATE:- 7-1-92 - 8-1-92

SCALE FEET	DEPTH FEET	THICKNESS FEET	SOIL DESCRIPTION	SYMBOL	S.P.T BLOWS / FT	CORE RECOVERY	RQD %	REMARKS
	40		Stiff to very stiff Brownish Grey Silty CLAY/clayey SILT.		12			
	45		" " " (CI)		12			
	50		" " "		36			
	55	65 ft	" (MI) Traces of fine sand		21			
	60				12			
	65		Stiff to very stiff Blackish Grey Silty CLAY. (CI)		UDS			
	70				19			

S.P.T = STANDARD PENETRATION TEST
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-: 28 :-

GEOTECHNICAL ENGINEER

MEHRAN UNIVERSITY ADVISORY AND CONSULTANCY CENTRE
JAMSHORO.
Ph. 71269

PROJECT: LBOD SURFACE DRAINAGE PROJECT, MIRPUR KHAS.
CLIENT: WAPDA
CONSULTANT:- MMP-ACE-NESPAK
CONTRACTOR: CHINA GUANGXI CORPORATION.

SUBSURFACE EXPLORATION LOG AND PENETRATION RESISTANCE

METHOD OF DRILLING: ROTARY (MUD)
DEPTH OF EXPLORATION: 100 ft.
BORE HOLE NO: B.H.NO.5
GROUND WATER TABLE: 12.5 ft.
DATE:- 7-1-92 - 8-1-92

SCALE FEET	DEPTH FEET	THICKNESS FEET	SOIL DESCRIPTION	SYMBOL	SPT BLOWS / FT (0 10 30 50 70 90)	CORE RECOVERY (0 10 30 50 70 90)	RQD %	REMARKS
	75		Stiff to very stiff Blackish Grey Silty CLAY / clayey SILT.		21			
	80		" " "		11			
	85		" Traces of sand. (MI)		UDS			
	90		" " "		15			
	95		" " " (CI)		24			
	100				18			
			Bore hole terminated at 100 ft. depth.					

S.P.T. - STANDARD PENETRATION TEST
R.Q.D= ROCK QUALITY DESIGNATION
W.L = WATER LOSS

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GEOTECHNICAL ENGINEER

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JAMSHORO.

PROJECT: LBOD SURFACE DRAINAGE PROJECT, MIRPUR KHAS.
CLIENT: WAPDA
CONSULTANT:- MMP-ACE-NESPAK
CONTRACTOR: CHINA GUANGXI CORPORATION.

SUBSURFACE EXPLORATION LOG AND PENETRATION RESISTANCE

METHOD OF DRILLING: ROTARY (MUD)
DEPTH OF EXPLORATION: 100 ft.
BORE HOLE NO: B.H.NO.6
GROUND WATER TABLE: 5' - 7"

DATE: 9-1-92 - 10-1-92

SCALE FEET	DEPTH FEET	THICKNESS FEET	SOIL DESCRIPTION	SYMBOL	SPT BLOWS / FT (0 10 30 50 70 90)	CORE RECOVERY (0 10 30 50 70 90)	RQD %	REMARKS
5			Medium stiff to very stiff Brownish Grey Silty CLAY(CH)		14			G.W.L. at 5'-7"
10			" " " Lenses of sand (CI)		11			
15			" " "		12			
20		40 ft	" " "		20			
25			" " "		10			
30			" " "		09			
35			"(MI)" "		15			

S.P.T : STANDARD PENETRATION TEST
R.Q.D= ROCK QUALITY DESIGNATION
W.L = WATER LOSS

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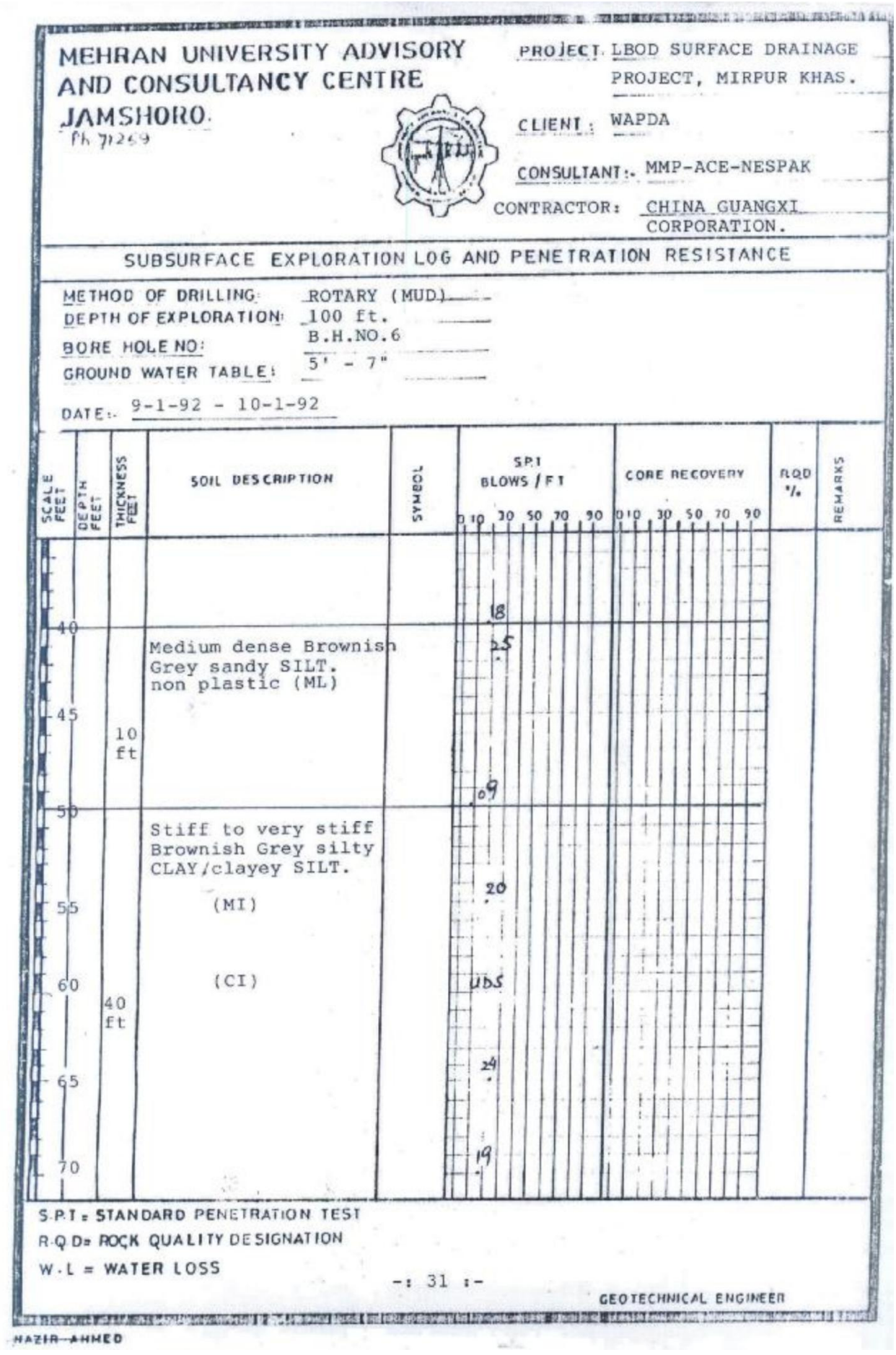

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PROJECT: LBOD SURFACE DRAINAGE PROJECT, MIRPUR KHAS.
CLIENT: WAPDA
CONSULTANT:- MMP-ACE-NESPAK
CONTRACTOR: CHINA GUANGXI CORPORATION.

SUBSURFACE EXPLORATION LOG AND PENETRATION RESISTANCE

METHOD OF DRILLING: ROTARY (MUD)
DEPTH OF EXPLORATION: 100 ft.
BORE HOLE NO: B.H.NO.6
GROUND WATER TABLE: 5' - 7"
DATE:- 9-1-92 - 10-1-92

SCALE FEET	DEPTH FEET	THICKNESS FEET	SOIL DESCRIPTION	SYMBOL	SPT BLOWS / FT (0 10 30 50 70 90)	CORE RECOVERY (0 10 30 50 70 90)	RQD %	REMARKS
40					18			
45		10 ft	Medium dense Brownish Grey sandy SILT. non plastic (ML)		25, 09			
50			Stiff to very stiff Brownish Grey silty CLAY/clayey SILT. (MI)		20			
55								
60		40 ft	(CI)		UDS			
65					24			
70					19			

S.P.T = STANDARD PENETRATION TEST
R.Q.D= ROCK QUALITY DESIGNATION
W.L = WATER LOSS

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GEOTECHNICAL ENGINEER

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MEHRAN UNIVERSITY ADVISORY AND CONSULTANCY CENTRE
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Ph. 71269

PROJECT: LBOD SURFACE DRAINAGE PROJECT, MIRPUR KHAS.
CLIENT: WAPDA
CONSULTANT: MMP-ACE-NESPAK
CONTRACTOR: CHINA GUANGXI CORPORATION.

SUBSURFACE EXPLORATION LOG AND PENETRATION RESISTANCE

METHOD OF DRILLING: ROTARY (MUD)
DEPTH OF EXPLORATION: 100 ft.
BORE HOLE NO: B.H.NO.6
GROUND WATER TABLE: 5' - 7"
DATE: 9-1-92 - 10-1-92

SCALE FEET	DEPTH FEET	THICKNESS FEET	SOIL DESCRIPTION	SYMBOL	SPT BLOWS / FT (0 10 30 50 70 90)	CORE RECOVERY (0 10 30 50 70 90)	RQD %	REMARKS
	75		Stiff to very stiff Blackish Grey Silty CLAY.		24			
	80		" "		13			
	85		" " " Small White Sea Shells		14 20			
	90		Very Stiff Grey Silty CLAY/clayey SILT.					
	95	8 ft.	" MI " some Sand.		UDS			
	100		Dense Grey Sandy SILT N.P. (ML)		36			
			Bore hole ended at 101.5 ft. depth					

S.P.T. STANDARD PENETRATION TEST
R.Q.D. ROCK QUALITY DESIGNATION
W.L = WATER LOSS

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GEOTECHNICAL ENGINEER

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JAMSHORO.

PROJECT: LBOD SURFACE DRAINAGE PROJECT, MIRPUR KHAS.
CLIENT: WAPDA
CONSULTANT: MMP-ACE-NESPAK
CONTRACTOR: CHINA GUANGXI CORP.

SUBSURFACE EXPLORATION LOG AND PENETRATION RESISTANCE

METHOD OF DRILLING: ROTARY (MUD)
DEPTH OF EXPLORATION: 100 ft.
BORE HOLE NO: B.H.NO.7
GROUND WATER TABLE: 5.5 feet
DATE: 1-1-92 - 2-1-92

SCALE FEET	DEPTH FEET	THICKNESS FEET	SOIL DESCRIPTION	SAMPLES	SPT BLOWS / FT (10 30 50 70 90)	CORE RECOVERY (10 30 50 70 90)	RQD %	REMARKS
5		5 ft	Stiff Brownish Grey Silty CLAY.		.08			G.W.L @ 3.5'
10		15 ft	Loose to medium dense light grey silty fine SAND. (SM)		.13 .21 .09			
20		55 ft	Stiff to very stiff Brown sandy silty CLAY/clayey SILT. (MI) " " Silty CLAY.		UDS .20 .15 .13			
25								
30								
35								

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MEHRAN UNIVERSITY ADVISORY AND CONSULTANCY CENTRE
JAMSHORO.
Ph. 71269

PROJECT: LBOD SURFACE DRAINAGE PROJECT, MIRPUR KHAS.
CLIENT: WAPDA
CONSULTANT: MMP-ACE-NESPAK
CONTRACTOR: CHINA GUANGXI CORP.

SUBSURFACE EXPLORATION LOG AND PENETRATION RESISTANCE

METHOD OF DRILLING: ROTARY (MUD)
DEPTH OF EXPLORATION: 100 ft.
BORE HOLE NO: B.H.NO.7
GROUND WATER TABLE: 5.5 feet.
DATE: 1-1-92 - 2-1-92

SCALE FEET	DEPTH FEET	THICKNESS FEET	SOIL DESCRIPTION	SYMBOL	S.P.T BLOWS / FT (0 10 30 50 70 90)	CORE RECOVERY (0 10 30 50 70 90)	RQD %	REMARKS
40			Stiff to very stiff Brown Silty CLAY/ clayey SILT.		12			
45			" "		13			
50					12			
55		55 ft	" "		UDS 28			
60								
65			" "		10			
70			" "		20			

S.P.T = STANDARD PENETRATION TEST
R.Q.D = ROCK QUALITY DESIGNATION
W.L = WATER LOSS

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GEOTECHNICAL ENGINEER

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MEHRAN UNIVERSITY ADVISORY AND CONSULTANCY CENTRE
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Ph 71269

PROJECT: LBOD SURFACE DRAINAGE PROJECT, MIRPUR KHAS.
CLIENT: WAPDA
CONSULTANT:- MMP-ACE-NESPAK
CONTRACTOR: CHINA GUANGXI CORP.

SUBSURFACE EXPLORATION LOG AND PENETRATION RESISTANCE

METHOD OF DRILLING: ROTARY (MUD)
DEPTH OF EXPLORATION: 100 ft.
BORE HOLE NO: B.H.NO.7
GROUND WATER TABLE: 5.5 feet.
DATE:- 1-1-92 - 2-1-92

SCALE FEET	DEPTH FEET	THICKNESS FEET	SOIL DESCRIPTION	SYMBOL	SPT BLOWS / FT (0 10 30 50 70 90)	CORE RECOVERY (0 10 30 50 70 90)	RQD %	REMARKS
					13			
75		5 ft	Stiff Blackish Grey silty CLAY/clayey SILT. (MI)		18			
80			Medium dense to dense Blackish Grey Sandy SILT (N.P) (ML)		29 28			
85		10 ft						
90			Dense Blackish Grey Silty fine SAND. (SM)		32			
95								
100			Bore hole terminated at 101.5 ft. depth from N.G.L.		74			

S.P.T = STANDARD PENETRATION TEST
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W.L = WATER LOSS

-: 35 :-

GEOTECHNICAL ENGINEER

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MEHRAN UNIVERSITY ADVISORY AND CONSULTANCY CENTRE
JAMSHORO.

PROJECT: LBOD SURFACE DRAINAGE PROJECT, MIRPUR KHAS.
CLIENT: WAPDA
CONSULTANT: MMP-ACE-NESPAK
CONTRACTOR: CHINA GUANGXI CORP.

SUBSURFACE EXPLORATION LOG AND PENETRATION RESISTANCE

METHOD OF DRILLING: ROTARY (MUD)
DEPTH OF EXPLORATION: 100 ft.
BORE HOLE NO: B.H.NO.8
GROUND WATER TABLE: 3.75 feet.
DATE: 11-1-92 - 12-1-92

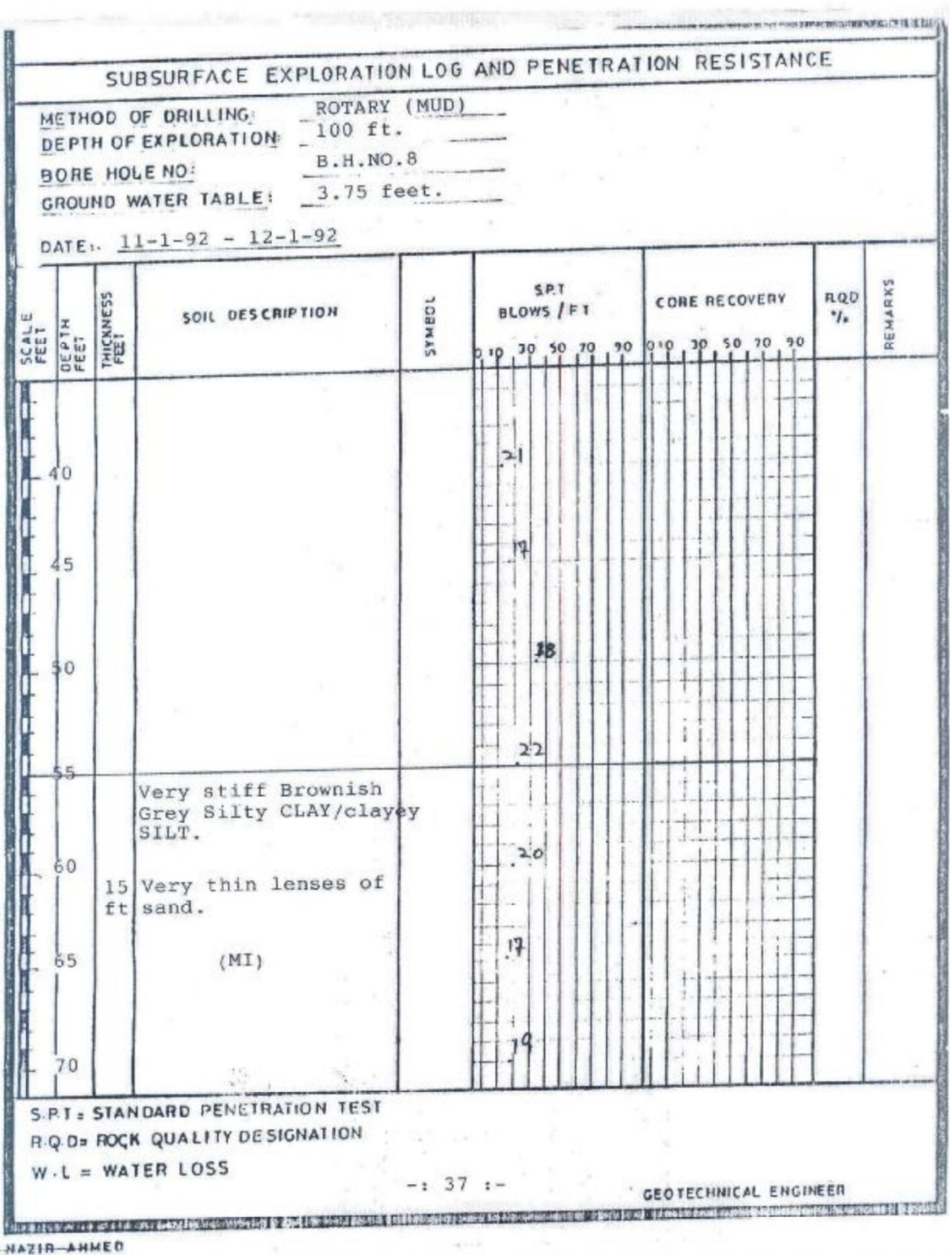
SCALE FEET	DEPTH FEET	THICKNESS FEET	SOIL DESCRIPTION	SYMBOL	S.P.T BLOWS / FT (0 10 30 50 70 90)	CORE RECOVERY (0 10 30 50 70 90)	RQD %	REMARKS
5		15 ft	Medium Dense Grey fine sandy SILT (N.P.) (ML)		10, 17, 24			3.75 ft W.L
15		40 ft	Medium dense Grey silty fine SAND. (SM)		25, 21, 25, 24			
20								
25								
30								
35								

S.P.T = STANDARD PENETRATION TEST
R.Q.D = ROCK QUALITY DESIGNATION
W.L = WATER LOSS

-: 36 :-

GEOTECHNICAL ENGINEER

HAZIR AHMED



SUBSURFACE EXPLORATION LOG AND PENETRATION RESISTANCE

METHOD OF DRILLING: ROTARY (MUD)
DEPTH OF EXPLORATION: 100 ft.
BORE HOLE NO: B.H.NO.8
GROUND WATER TABLE: 3.75 feet.

DATE: 11-1-92 - 12-1-92

SCALE FEET	DEPTH FEET	THICKNESS FEET	SOIL DESCRIPTION	SYMBOL	S.P.T BLOWS / FT (0 10 30 50 70 90)	CORE RECOVERY (0 10 30 50 70 90)	RQD %	REMARKS
	40				21			
	45				17			
	50				18			
	55				22			
	60	15 ft	Very stiff Brownish Grey Silty CLAY/clayey SILT. Very thin lenses of sand. (MI)		20			
	65				17			
	70				19			

S.P.T = STANDARD PENETRATION TEST
R.Q.D= ROCK QUALITY DESIGNATION
W.L = WATER LOSS

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GEOTECHNICAL ENGINEER

NAZIR AHMED

MEHRAN UNIVERSITY ADVISORY AND CONSULTANCY CENTRE
JAMSHORO.
Ph 71269

PROJECT: LBOD SURFACE DRAINAGE PROJECT, MIRPUR KHAS.
CLIENT: WAPDA
CONSULTANT:- MMP-ACE-NESPAK
CONTRACTOR: CHINA GUANGXI CORP.

SUBSURFACE EXPLORATION LOG AND PENETRATION RESISTANCE

METHOD OF DRILLING: ROTARY (MUD)
DEPTH OF EXPLORATION: 100 ft.
BORE HOLE NO: B.H.NO.8
GROUND WATER TABLE: 3.75 feet.
DATE:- 11-1-92 - 12-1-92

SCALE FEET	DEPTH FEET	THICKNESS FEET	SOIL DESCRIPTION	SYMBOL	SPT BLOWS / FT (0 10 30 50 70 90)	CORE RECOVERY (0 10 30 50 70 90)	RQD %	REMARKS
	75		Very stiff Blackish Grey Silty CLAY lenses of sand. (CI)		18			
	80		" "		UDS			
					21			
	85	27 ft						
	90		" "		20			
	95		" "		UDS			
	100		Very Stiff Brownish Grey silty CLAY.		28			
			End of Bore hole at 100 ft. depth from N.G.L.					

S.P.T = STANDARD PENETRATION TEST
R.Q.D= ROCK QUALITY DESIGNATION
W.L = WATER LOSS

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GEOTECHNICAL ENGINEER

NAZIR AHMED

Annexure B

Laboratory Test Results

(MMD Drill Tech. Corp. & M. MUET)

GEOTECHNICAL SERVICES
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Testing Laboratory

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Off Alamgir Road,
Karachi-5. Tele : 420613, 411361

B.E. (Civil) M. Engg. AIT. Bangkok

Date 29.6.88.

LR No. 003/10/88

CLIENT : M/S DRILLTECH CORPORATION (PVT) LIMITED
PROJECT : LBOD STAGE-1 PROJECT

UNCONFINED COMPRESSION TESTS

S.NO.	BORING NO	SAMPLE	DEPTH (ft.)	UNCONFINED q_u (kg/cm²)	COMPRESSION STRAIN (%)
1.	MMD-01	UDS-1	13.0-14.66	0.99	7.95
2.	MMD-02	UDS-1	22.0-23.5	1.21	8.45
3.	MMD-02	UDS-2	37.0-38.25	1.62	12.15
4.	MMD-02	UDS-3	82.0-83.5	2.28	14.47
5.	MMD-02	UDS-4	97.0-98.41	1.73	17.53
6.	MMD-03	UDS-1	13.0-15.0	3.86	7.02
7.	MMD-03	UDS-2	28.0-29.5	1.71	11.88
8.	MMD-03	UDS-3	43.0-44.16	2.61	4.68
9.	MMD-03	UDS-4	74.0-75.0	1.13	17.75
10.	MMD-03	UDS-5	89.0-89.83	0.77	8.19
11.	MMD-04	UDS-1	12.0-13.5	1.26	12.09
12.	MMD-04	UDS-2	53.0-54.16	1.34	16.19
13.	MMD-04	UDS-3	69.0-69.66	1.29	15.50
14.	MMD-05	UDS-1	7.0- 9.0	1.39	20.25
15.	MMD-05	UDS-2	52.0-53.0	1.70	13.01
16.	MMD-05	UDS-3	67.0-67.91	1.68	12.91
17.	MMD-06	UDS-1	14.0-14.91	1.59	15.49
18.	MMD-06	UDS-2	29.0-29.66	1.31	16.30

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(T-620)

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Date 29.6.88.

LR No. 003/10/88

SHEET 2 OF 2

CLIENT : M/S DRILLTECH CORPORATION (PVT) LIMITED
PROJECT : LBOD STAGE-1 PROJECT

UNCONFINED COMPRESSION TESTS

S.NO.	BORING NO	SAMPLE	DEPTH (ft.)	UNCONFINED q_u (kg/cm²)	COMPRESSION STRAIN (%)
19.	MMD-07	UDS-1	17.0-18.5	2.18	9.58
20.	MMD-07	UDS-2	32.0-33.16	1.81	14.12
21.	MMD-08	UDS-1	8.0- 9.5	0.89	8.43
22.	MMD-08	UDS-2	23.0-24.5	2.65	12.42
23.	MMD-08	UDS-3	48.5-50.0	2.28	11.33
24.	MMD-08	UDS-4	54.0-55.0	3.18	12.50
25.	MMD-09	UDS-1	8.0- 9.5	2.22	5.25
26.	MMD-09	UDS-2	23.0-23.91	1.82	13.17
27.	MMD-09	UDS-3	38.0-39.0	1.63	11.06
28.	MMD-09	UDS-4	53.0-54.0	2.01	12.87
29.	MMD-09	UDS-5	68.0-68.83	7.30	3.88

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Date 29.6.88.

LR No. 003/10/88

CLIENT : M/S DRILLTECH CORPORATION (PVT) LIMITED
PROJECT : LBOD STAGE-1 PROJECT

DIRECT SHEAR TESTS

S.NO.	BORING NO	SAMPLE	DEPTH (f't.)	DIRECT c (kg/cm²)	SHEAR Ø (deg)
19.	MMD-07	UDS-1	17.0-18.5	0.56	10.0
20.	MMD-07	UDS-2	32.0-33.16	0.30	8.3
21.	MMD-08	UDS-1	8.0- 9.5	0.14	7.0
22.	MMD-08	UDS-2	23.0-24.5	0.66	12.3
23.	MMD-08	UDS-3	48.5-50.0	0.59	10.4
24.	MMD-08	UDS-4	54.0-55.0	0.64	13.6
25.	MMD-09	UDS-1	8.0- 9.5	0.30	14.1
26.	MMD-09	UDS-2	23.0-23.91	0.46	10.8
27.	MMD-09	UDS-3	38.0-39.0	0.39	7.8
28.	MMD-09	UDS-4	53.0-54.0	0.47	11.0
29.	MMD-09	UDS-5	68.0-68.83	0.92	20.0

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Date 29.6.88.

LR No. 003/10/88

CLIENT : M/S DRILLTECH CORPORATION (PVT) LIMITED
PROJECT : LBOD STAGE-1 PROJECT

SHEET 1 OF

DIRECT SHEAR TESTS

S.NO.	BORING NO	SAMPLE	DEPTH (ft.)	DIRECT c (kg/cm²)	SHEA (c
1.	MMD-01	UDS-1	13.0-14.66	0.19	1
2.	MMD-02	UDS-1	22.0-23.5	0.21	1
3.	MMD-02	UDS-2	37.0-38.25	0.50	
4.	MMD-02	UDS-3	82.0-83.5	0.61	1
5.	MMD-02	UDS-4	97.0-98.41	0.54	
6.	MMD-03	UDS-1	13.0-15.0	0.63	1
7.	MMD-03	UDS-2	28.0-29.5	0.50	
8.	MMD-03	UDS-3	43.0-44.16	0.62	1
9.	MMD-03	UDS-4	74.0-75.0	0.35	
10.	MMD-03	UDS-5	89.0-89.83	0.22	
11.	MMD-04	UDS-1	12.0-13.5	0.37	
12.	MMD-04	UDS-2	53.0-54.16	0.33	
13.	MMD-04	UDS-3	69.0-69.66	0.30	
14.	MMD-05	UDS-1	7.0- 9.0	0.40	
15.	MMD-05	UDS-2	52.0-53.0	0.48	
16.	MMD-05	UDS-3	67.0-67.91	0.45	
17.	MMD-06	UDS-1	14.0-14.91	0.51	
18.	MMD-06	UDS-2	29.0-29.66	0.26	

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LR No. 003/10/88

CLIENT : M/S DRILLTECH CORPORATION (PVT) LIMITED
PROJECT : LBOD STAGE-1 PROJECT

DENSITY/MOISTURE TESTS

S.NO.	BORING NO	SAMPLE	DEPTH (ft.)	BULK DENSITY (gm/cc)	MOISTURE CONTENT (%)	DRY DENSITY (gm/cc)
1.	MMD-01	UDS-1	13.0-14.66	1.972	13.03	1.745
2.	MMD-02	UDS-1	22.0-23.5	2.082	21.18	1.718
3.	MMD-02	UDS-2	37.0-38.25	2.086	22.54	1.702
4.	MMD-02	UDS-3	82.0-83.5	2.009	23.60	1.625
5.	MMD-02	UDS-4	97.0-98.41	1.851	34.43	1.377
6.	MMD-03	UDS-1	13.0-15.0	1.943	21.51	1.599
7.	MMD-03	UDS-2	28.0-29.5	1.979	25.26	1.580
8.	MMD-03	UDS-3	43.0-44.16	1.994	26.64	1.575
9.	MMD-03	UDS-4	74.0-75.0	1.925	31.34	1.466
10.	MMD-03	UDS-5	89.0-89.83	1.864	34.56	1.385
11.	MMD-04	UDS-1	12.0-13.5	2.042	22.50	1.667
12.	MMD-04	UDS-2	53.0-54.16	2.045	21.33	1.685
13.	MMD-04	UDS-3	69.0-69.66	2.109	20.87	1.745
14.	MMD-05	UDS-1	7.0- 9.0	2.056	21.84	1.687
15.	MMD-05	UDS-2	52.0-53.0	2.139	18.34	1.808
16.	MMD-05	UDS-3	67.0-67.91	2.059	20.93	1.703
17.	MMD-06	UDS-1	14.0-14.91	2.031	21.98	1.665
18.	MMD-06	UDS-2	29.0-29.66	2.065	20.11	1.719

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Date 29.6.88.

LR No. 003/10/88

CLIENT : M/S DRILLTECH CORPORATION (PVT) LIMITED
PROJECT : LBOD STAGE-1 PROJECT

DENSITY/MOISTURE TESTS

S.NO.	BORING NO	SAMPLE	DEPTH (ft.)	BULK DENSITY (gm/cc)	MOISTURE CONTENT (%)	DRY DENSITY (gm/cc)
19.	MMD-07	UDS-1	17.0-18.5	2.018	22.50	1.647
20.	MMD-07	UDS-2	32.0-33.16	2.080	20.93	1.720
21.	MMD-08	UDS-1	8.0- 9.5	1.957	23.74	1.581
22.	MMD-08	UDS-2	23.0-24.5	2.015	22.93	1.639
23.	MMD-08	UDS-3	48.5-50.0	2.004	21.93	1.644
24.	MMD-08	UDS-4	54.0-55.0	1.750	06.02	1.651
25.	MMD-09	UDS-1	8.0- 9.5	2.036	22.55	1.662
26.	MMD-09	UDS-2	23.0-23.91	2.077	20.48	1.724
27.	MMD-09	UDS-3	38.0-39.0	2.001	22.72	1.631
28.	MMD-09	UDS-4	53.0-54.0	2.043	21.84	1.677
29.	MMD-09	UDS-5	68.0-68.83	1.863	13.89	1.636

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Date 21.9.88.
LR No. 135/88

CLIENT : M/S DRILLTECH CORPORATION (PVT) LIMITED
PROJECT : LBOD STAGE-1 PROJECT
LOCATION: MIR PUR KHAS

CHEMICAL ANALYSIS ON SOIL

S.NO.	BORING NO	SAMPLE	DEPTH (ft.)	TOTAL SOLUBLE SALTS (%)	SULPHATE CONTENT (%)	CHLORIDE CONTENT (%)	pH VALUE
1.	MMD-04	SPT-2	10.0-11.5	0.256	0.035	0.134	6.75
2.	MMD-05	SPT-1	5.0- 6.5	0.743	0.081	0.398	7.00
3.	MMD-07	SPT-7	35.0-36.5	0.161	0.019	N I L	6.50
4.	MMD-08	UDS-1	8.0- 9.5	0.741	0.074	0.448	7.50

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Date 21.9.88.
LR No. 135/88

CLIENT : M/S DRILLTECH CORPORATION (PVT) LIMITED
PROJECT : LBOD STAGE-1 PROJECT
LOCATION: MIR PUR KHAS

CHEMICAL ANALYSIS ON WATER

S.NO.	BORING NO	TOTAL DISSOLVED SOLIDS (ppm)	SULPHATE CONTENT (ppm)	CHLORIDE CONTENT (ppm)	pH VALU
1.	MMD-01	6780.3	689.34	2034.09	7.9
2.	MMD-03	5984.3	778.45	1895.36	7.7

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Date 29.6.88.
LR No. 003/10/88

CLIENT : M/S DRILLTECH CORPORATION (PVT) LIMITED
PROJECT : LBOD STAGE-1 PROJECT

CHEMICAL ANALYSIS OF WATER

S.NO.	BORING NO	TOTAL DISSOLVED SOLIDS (ppm)	SULPHATE CONTENT (ppm)	CHLORIDE CONTENT (ppm)	pH VALUE
1.	MMD-04	6,259.20	848.18	2,178.44	7.8
2.	MMD-06	4,650.00	517.17	1,595.45	7.6
3.	MMD-09	22,972.40	1,348.58	6,911.52	7.9

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For GEOTECHNICAL SERVICES

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MUACC
Feb., 1992

SUMMARY OF LABORATORY TEST RESULTS
LBOD SURFACE DRAINAGE PROJECT MIRPUR KHAS

1. GRADATION ANALYSIS

Sieve size % Passing.

S.NO.	B.H.NO.	SAMPLE	DEPTH (FT)	#4	#10	#40	#100	#200
1	1	SPT-1	5.0'-6.5'	100	100	99.86	99.3	98.1
2	"	SPT-8	40.0'-41.5'	100	100	100	100	99.7
3	"	SPT-10	50.0'-51.5'	100	100	99.1	34.9	5.51
4	"	SPT-18	100.0'-101.5'	100	99.8	97.2	70.8	59.6
5	"	UDS	75.0'-76.0'	100	100	100	100	99.7
6	2	SPT-1	5.0'-6.5'	100	100	100	100	98.1
7	"	SPT-3	15.0'-16.5'	100	100	99.8	93.4	63.5
8	"	SPT-10	55.0'-56.5'	100	98.4	97.4	96.7	95.7
9	"	SPT-13	70.0'-71.5'	100	100	100	98.2	85.4
10	"	SPT-15	80.0'-81.5'	100	100	100	100	98.8
11	3	SPT-2	12'-13.5'	99.3	97.9	95.4	93.1	86.6
12	"	SPT-5	25'-26.5'	100	100	100	100	96.9
13	"	SPT-7	35'-36.5'	100	100	100	100	99.1
14	"	SPT-11	55'-56.5'	100	100	100	100	99.7
15	"	SPT-12	62'-63.5'	100	99.8	99.4	95.9	74.0
16	"	SPT-14	70'-71.5'	100	100	100	100	99.8
17	"	UDS	97'-98'	100	100	100	100	99.6
18	4	SPT-1	5'-6.5'	100	100	100	100	96.2
19	"	SPT-3	15'-16.5'	100	100	99.7	23.9	1.1
20	"	SPT-8	40'-41.5'	100	100	100	97.1	79.5
21	"	SPT-11	55'-56.5'	100	100	99.9	87.0	58.6
22	"	SPT-14	70'-71.5'	100	100	100	100	99.3
23	"	SPT-19	99'-100.5'	100	100	100	100	98.2

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SUMMARY OF LABORATORY TEST RESULTS

LBOD SURFACE DRAINAGE PROJECT MIRPUR KHAS

1. Grain Size Analysis (Percent finer by weight)

S.NO.	B.H.NO.	SAMPLE	DEPTH (FT)	#4	#10	#40	#100	#200
24	5	SPT-1	5'-6.5'	100	99.9	99.7	99.5	98.5
25	"	SPT-4	20'-21.5'	100	100	98.5	97.6	96.3
26	"	SPT-9	45'-46.5'	100	100	99.9	99.7	98.0
27	"	SPT-11	55'-56.5'	100	100	99.7	98.9	88.9
28	"	SPT-12	60'-61.5'	100	100	100	100	99.1
29	"	SPT-16	87.5'-89.0'	100	100	100	98.8	80.6
30	"	SPT-17	95'-96.5'	100	100	100	100	99.8
31	6	SPT-1	5'-6.5'	100	99.9	99.7	99.2	97.2
32	"	SPT-2	10'-11.5'	100	100	100	100	97.11
33	"	SPT-7	35'-36.5'	100	100	100	100	98.2
34	"	SPT-8	42'-43.5'	100	100	99.9	96.5	51.1
35	"	SPT-10	55'-56.5'	100	100	100	99.7	95.9
36	"	SPT-16	90'-91.5'	100	100	100	100	99.8
37	"	SPT-17	99'-101.5'	100	100	99.9	96.0	56.4
38	7	SPT-1	5'-6.5'	100	100	99.9	46.5	10.6
39	"	SPT-4	20'-21.5'	100	100	100	98.7	55.8
40	"	SPT-11	57'-58.5'	99.9	99.7	99.5	98.8	97.5
41	"	SPT-14	75'-76.5'	100	100	100	99.7	96.6
42	"	SPT-16	85'-86.5'	100	100	100	100	98.4
43	"	SPT-19	100'-101.5'	100	99.6	99.5	83.7	35.7
44	8	SPT-1	5'-6.5'	100	100	99.8	99.3	54.2
45	"	SPT-5	25'-26.5'	100	100	99.8	67.4	11.7
46	"	SPT-11	55'-56.5'	100	97.2	93.3	80.9	78.0
47	"	SPT-15	75'-76.5'	100	100	100	100	98.3

MUACC
Feb., 1992

SUMMARY OF LABORATORY TEST RESULTS
LBOD SURFACE DRAINAGE PROJECT MIRPURKHAS

2. Result of Atterberg Limits.

S.NO.	B.H.NO.	SAMPLE	DEPTH (FT)	L.L	P.L	P.I
1	1	SPT-1	5'-6.5'	54	40	14
2	"	SPT-8	40'-41.5'	59	29	30
3	"	UDS	75'-76'	46	22	24
4	2	SPT-1	5'-6.5'	47	23	24
5	"	SPT-10	55'-56.5'	46	31	15
6	"	SPT-13	70'-71.5'	48	30	18
7	"	SPT-15	80'-81.5'	41	19	22
8	3	SPT-2	12'-13.5'	47	23	24
9	"	SPT-5	25'-26.5'	50	25	25
10	"	SPT-7	35'-36.5'	39	11	28
11	"	SPT-11	55'-56.5'	46	33	13
12	"	SPT-12	62'-63.5'	44	15	29
13	"	SPT-14	70'-71.5'	60	38	22
14	"	UDS	97'-98'	43	36	7
15	4	SPT-1	5'-6.5'	45	18	27
16	"	SPT-14	70'-71.5'	62	30	32
17	"	SPT-19	99'-101.5'	38	24	14
18	"	SPT-8	40'-41.5'	-	N.P	-
19	5	SPT-1	5'-6.5'	46	25	21
20	"	SPT-9	45'-46.5'	36	18	18
21	"	SPT-11	55'-56.5'	50	29	21
22	"	SPT-12	60'-61.5'	49	25	24
23	"	SPT-16	87.5'-89'	34	20	14
24	"	SPT-17	95'-96.5'	44	19	25
25	6	SPT-1	5'-6.5'	55	16	39
26	"	SPT-2	10'-11.5'	35	20	15

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SUMMARY OF LABORATORY TEST RESULTS
LBOD SURFACE DRAINAGE PROJECT MIRPURKHAS

2/8. Results of Atterberg limits.

S.NO.	B.H.NO.	SAMPLE	DEPTH (FT)	L.L	P.L	P.I
27	6	SPT-7	35'-36.5'	42	31	11
28	"	SPT-10	55'-56.5'	41	29	12
29	"	UDS-II	61'-63'	43	20	23
30	"	SPT-16	90'-91.5'	53	32	21
31	7	SPT-4	20'-21.5'	44	25	19
32	"	SPT-11	57'-58.5'	50	29	21
33	"	SPT-14	75'-76.5'	50	30	20
34	8	SPT-11	55'-56.5'	55	33	22
35	"	SPT-15	75'-76.5'	35	22	13

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SUMMARY OF LABORATORY TEST RESULTS
LBOD SURFACE DRAINAGE PROJECT MIRPUR KHAS

3. Results of Bulk density and natural moisture content.

S.NO.	B.H.NO.	SAMPLE	DEPTH (FT)	BULK DENSITY PCF	NATURAL MOISTURE CONTENT %
1.	1	SPT-1	5.0'-6.5'	119.8	20.03
2	"	SPT-3	15'-16.5'	116.7	
3	"	SPT-5	25'-26.5'	119.7	
4	"	SPT-7	35'-36.5'	118.5	
5	"	SPT-8	40'-41.5'	112.3	36.8
6	"	SPT-10	50'-51.5'	112.3	31.4
7	"	SPT-12	60'-61.5'	111.0	
8	"	SPT-14	70'-71.5'	111.7	
9	"	UDS-I	75'-76'	122.3	28.8
10	"	UDS-II	85'-87'	117.3	28.8
11	"	SPT-17	95'-96.5'	118.5	
12	"	SPT-18	100'-101.5'		25.1
13	2	SPT-1	5'-6.5'		25.5
14	"	SPT-2	10'-11.5'	131.0	
15	"	SPT-3	15'-16.5'		21.6
16	"	SPT-4	20'-21.5'	126.0	
17	"	SPT-6	30'-31.5'	124.0	
18	"	UDS-I	35'-36.0'	125.0	28.3
19	"	SPT-8	45'-46'	126.0	
20	"	SPT-9	50'-51.5'	119.0	
21	"	SPT-10	55'-56.5'		35.1
22	"	SPT-11	60'-61.5'	126.0	
23	"	SPT-13	70'-71.5'	118.0	33.6
24	"	SPT-15	80'-81.5'	131.0	30.8
25	"	UDS-II	85'-87'	121.0	28.8

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SUMMARY OF LABORATORY TEST RESULTS
LBOD SURFACE DRAINAGE PROJECT MIRPURKHAS

3. Results of Bulk density and natural moisture content.

S.NO.	B.H.NO.	SAMPLE	DEPTH (FT)	BULK DENSITY PCF	NATURAL MOISTURE CONTENT %
26	2	UDS-III	90'-91.5'	120.	37.8
27	"	SPT-17	100'-101.5'	128.	
28	3	SPT-1	5'-6.5'	122.05	
29	"	UDS-I	10'-12'	127.92	21.51
30	"	SPT-3	15'-16.5'	127.29	
31	"	SPT-6	30'-31.5'	118.68	23.0
32	"	UDS-II	40'-41'	121.06	27.67
33	"	SPT-9	50'-51.5'	124.18	
34	"	UDS-III	60'-62'	117.31	34.32
35	"	SPT-14	70'-71.5'	121.06	36.5
36	"	UDS	75'-77'	121.68	30.44
37	"	SPT-16	85'-86.5'	117.31	
38	"	UDS-IV	97'-98'	121.06	29.57
39	4	SPT-1	5'-6.5'	107.96	15.1
40	"	SPT-3	15'-16.5'	114.19	21.9
41	"	SPT-4	20'-21.5'	118.56	
42	"	SPT-6	30'-31.5'	126.05	
43	"	SPT-8	40'-41.5'	124.8	30.97
44	"	SPT-9	45'-46.5'	109.2	
45	"	SPT-12	60'-61.5'	106.08	
46	"	SPT-14	70'-71.5'	117.31	36.5
47	"	UDS-I	80'-82'	114.82	34.5
48	"	SPT-18	92'-93.5'	122.93	

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SUMMARY OF LABORATORY TEST RESULTS
LBOD SURFACE DRAINAGE PROJECT MIRPURKHAS

3. Results of Bulk density and natural moisture content.

S.NO.	B.H.NO.	SAMPLE	DEPTH (FT)	BULK DENSITY PCF	NATURAL MOISTURE CONTENT %
49	4	SPT-19	99'-101.5'	124.80	29.7
50	5	SPT-1	5'-6.5'	120.56	21.65
51	"	SPT-3	15'-16.5'	115.44	
52	"	SPT-4	20'-21.5'	111.07	24.4
53	"	SPT-5	25'-26.5'	119.18	
54	"	SPT-9	45'-46.5'		31.8
55	"	SPT-10	50'-51.5'	124.8	
56	"	SPT-11	55'-56.5'		32.7
57	"	SPT-12	60'-61.5'	113.59	29.2
58	"	UDS	66'-68'	119.81	29.6
59	"	SPT-14	75'-76.5'	123.55	
60	"	UDS-II	86'-87.5'	126.05	29.83
61	"	SPT-16	87.5'-89'		29.3
62	"	SPT-17	95'-96.5'		29.5
63	"	SPT-18	100'-101.5'	126.05	
64	6	SPT-1	5'-6.5'	121.68	26.8
65	"	SPT-3	15'-16.5'	127.92	
66	"	SPT-5	25'-26.5'	121.05	
67	"	SPT-7	35'-36.5'	122.93	25.1
68	"	SPT-9	50'-51.5'	125.42	
69	"	UDS	6'-63'	120.43	28.4
70	"	SPT-11	64'-64.5	112.32	
71	"	SPT-13	75'-76.5'	130.42	
72	"	SPT-15	85'-86.5'	115.44	

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SUMMARY OF LABORATORY TEST RESULTS
LBOD SURFACE DRAINAGE PROJECT MIRPURKHAS

3. Results Bulk density and natural moisture content.

S.NO.	B.H.NO.	SAMPLE	DEPTH (FT)	BULK DENSITY PCF	NATURAL MOISTURE CONTENT %
73	6	SPT-16	90'-91.5'		28.1
74	"	UDS	97'-98'	128.54	
75	"	SPT-17	99'-101.5'		27.0
76	7	SPT-1	5'-6.5'		24.76
77	"	SPT-3	15'-16.5'	110.45	
78	"	SPT-4	20'-21.5'		31.2
79	"	UDS-I	25'-27'	122.93	24.7
80	"	SPT-6	30'-31.5'	123.55	
81	"	SPT-9	45'-46.5'	130.42	
82	"	UDS-II	55'-56.5'	124.41	25.8
83	"	SPT-14	75'-76.5'	119.81	28.6
84	"	SPT-17	90'-91.6'	112.32	22.7
85	"	SPT-19	100'-101.5'		21.8
86	8	SPT-1	5'-6.5'		23.6
87	"	SPT-3	15'-16.5'	111.07	
88	"	SPT-5	25'-26.5'		27.5
89	"	SPT-6	30'-31.5'	112.9	
90	"	SPT-9	45'-46.5'	111.69	
91	"	SPT-11	55'-56.5'	124.8	25.1
92	"	SPT-13	65'-66.5'	125.42	
93	"	SPT-15	75'-76.5'	120.43	24.8
94	"	UDS-I	81'-83'	122.3	27.06
95	"	UDS-II	97'-99'	127.92	25.7

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Appendix – II

SOCIAL IMPACT STUDIES

Social Impact Studies

Executive Summary

Report Objectives

The purpose of this report is to present the findings of the household surveys and consultations with stakeholders and village communities the Consultant conducted in communities residing along dhoras suggested for revival. The consultations were conducted according to the requirements set out in the Terms of Reference for the following tasks:

21. Carry out environmental and social assessments in each sub area, and propose clustering of sub-s where these assessments are not cost effective to carry out separately. Undertaking environmental and social assessment in batches of sub-s may also form the basis for broader assessments for the whole study/ area;

23. Review the social conditions in the subs, and undertake social assessment of the Project;

24. Have consultations with the beneficiaries to develop appropriate methodology and levels of cost sharing/recovery for the Project works;

Community consultations- approach and methodology

The social impact study is related to the area that is traversed by the major dhoras on the Left Bank of Indus. The study includes the following dhoras and drains: DhoroPuran, SonhiDhoro, DhoroNaro, HakroDhoro, DhoroPithoro, BhaikhanDhoro and D4 Drain. The total length of dhoraand the proposed D4 drain is more than 700 km.

The main objective of this phase of community consultations was todiscuss with communities proposed revival of dhoras and possible constructions of drains in the leftover areas. The major outcome expected was communities' views and opinions, their perceptions of possible impact of the proposed interventions as well as the mitigation measures as perceived by the communities.

In accordance with the main objective of the study, the following sample selection criteria were determined:

i. Major dhoras which have inactive parts considered for revival
ii. Dhoras which are running but are partially encroached or blocked
iii. Drains proposed for constructions
iv. Districts which are traversed by the sampled dhoras/proposed drains
v. Talukas in each district traversed by dhoras/proposed drains
vi. Villages situated within 200m from the dhora/proposed drain

Following the sample selection criteria, a multilevel sampling method has been adopted. The sample included six major dhoras and the longest proposed drain in the area. These dhoras traverse seven districts and 33 talukas. Two to three villages from each taluka(in total 91 villages) were randomly chosen for community consultations and data collections on village profile and household surveys. In each sampled village, the team conducted:

- Open community consultations (separate for men and women)
- Household survey with six respondents (3 men and 3 women) randomly chosen and
- One Key Informant interview on village profile

Overall, open community consultations were conducted in **91 sample villages in seven districts**. In total, **2,815 persons(1,333 men and 1,482 women)** participated in the community consultations. In addition, data on the socioeconomic profile of local population were collected by semi-structured household questionnaires. In each village, six household questionnaires were completed. Overall, **543 persons(271 women and 272 men)**were interviewed.

Main Findings

The following is the summary of views and opinions brought up at the community consultations:

Perceived positive impact

Surveyed communities reported 9,573flood affected households, which makes 91% of all surveyed households. There are 9,373 households with some structures affected by the 2011 flood and 1,306 with the agriculture land affected. The most stated positive impacts which revival of dhoras would bring were as follows:

- Water will drain out fast
- Water logging and salinity will decrease
- Agriculture production will increase
- Houses and land will be safe
- Livestock will get sufficient drinking water
- Diseases will decrease
- Necessary drainage system will be developed
- Paid local labour will rise

Generally, local communities were satisfied with the proposal. They expect to be saved from flooding, damages and constant relocation during rainy seasons. People expect only rain water to flow in dhoras as they would use it for livestock and domestic purposes. The most cited benefits were that dhoro will enable fast draining of water and that land, houses and livestock will be saved from floods. The most of people's concerns were related to bunds which should be elevated and additionally straightened. In addition, people want to see dhoras revived along the entire length. Communities expect Government's seriousness and honesty throughout the planning, implementation and the monitoring of the Project and post-Project operation and maintenance.

*'Puran is our mother; our descendants were always looking at Puran as mother; they saw it running. And that was the time when nearby lands were all green. Now, since many years we see it as our mother has passed away because all nearby lands are facing drought condition day by day.'*Ghulam Mohammad Khoso village, DhoroPuran, Tharparkar

Perceived negative impact

A great majority of consulted population (78.1%) think that revival of dhoras will not have any negative impacts at all. The rest of the respondents think that the Project would be successful if it is done honestly and timely. In addition, consulted communities think that, once work is completed, operation and maintenance will be of utmost importance for the project.

Some of the agriculture communities inMirpurkhas area were reluctant to discuss the revival of dhoro as their villages are almost entirely built in the dhoro and the proposed interventions would affect their structuresand crops planted inside the dhoro. People think that it would be a very challenging task but with Government seriousness and dedication, the Project could be accomplished successfully.

Some of the perceived negative impacts of the proposed interventions are summarized below:

- Crops and structures inside the dhoro will be affected
- Access to other sides will be hard if bridges are not constructed
- Possible damage or cut of bunds would harm local communities
- Improper monitoring, maintenance and management will damage the whole area
- Potential overflowing will damage houses and livestock
- Any backflow will affect the area
- It may involve relocation of people

Perceived mitigation measures

More than 85% of consulted persons gave their vision of the mitigation measures which should minimize potential negative impact of the Project. The most common suggestions were:

- Ensure proper deep de-silting of dhoras by advanced machinery
- Make bunds stronger and ensure that villages are not easily flooded
- Build safety bunds around villages
- Have safe place for people if they have to move during the flood
- Ensure proper access from one to the other bank of a dhoro
- Prevent backflow by installation of gates
- Ensure timely and proper compensation for lost crops, structures and other affected assets
- Implement the Project and establish operation and maintenance of dhoras with honesty, sincerity and without corruption
- Involve local communities in every stage of the Project

Communities' readiness to participate in the project implementation

Almost without exception, respondents expressed their support for the proposed dhoras revival as well as the readiness to participate. **95.6%** stated that they are ready to cooperate with Government in every way they could. Most of ordinary people are poor and cannot contribute money, but they suggested paid daily labour, collecting donations, giving information to the working team, looking after construction material etc. Also, if local labour hired on daily wages, villagers would be able to contribute a day or two of work on a voluntary basis.Consulted communities expect the Government to involve them in operation and maintenance activities. *'Each time we have been ignored in development schemes; it is our basic right to get work in all schemes because our youngsters are jobless and they need work.'* Village DhanoKolhi, Bhai khan Dhoro, Badin. People insist that, before any work, the Government should present them the work plan, consult with affected communities again and fully compensate those who would lose crops and structures due to dhoras revival.

1 INRODUCTION

1.1 Description of the project

Sindh Province has a vast irrigation and drainage network and it is one of the primary beneficiaries of the Indus Basin Irrigation System of Pakistan (IBIS). The IBIS is considered as one of the largest contiguous irrigation systems in the world. Of the total 14 barrages of the IBIS, Sindh has three major barrages on the Indus River that divert approximately 48 million acre feet MAF (59.0 billion cubic meters- BCM) of water annually to the 14 main canal commands in Sindh Province. These canal systems have an aggregate length of 13,325 miles (21,445 Km), which serve a gross command area (GCA) of 14.391 million acres (5.8 million ha). There are also about 42,000 watercourses (tertiary channels), which have an aggregate length of about 75,000 miles (120,000 Km).

The government of Sindh assigned the of preparation of regional master plan on drainage to Louis Berger Group & Indus Associated Consultants on 5th March 2010 covering a period of 36 months. The beneficiaries of the Regional master Plan are the populations on the Left Bank of the Indus River; and the population in the Delta and Coastal Zone of Sindh province. The particular interest was to be directed to the assessment of deficiencies in the Left Bank Outfall Drain System (LBOD).

The area is experiencing prevailing issues associated with drainage, salinity and flooding, hampering continued efforts towards economic development and poverty reduction within the province. The region has very limited drainage capacity because there are no well defined rivers or streams in Sindh to convey these flood waters away from the main channel of the Indus River itself. As a consequence, flooding typically lasts a long time, destroying the crop and bringing the water table rapidly to the surface.

Due to these problems, the Government of Sindh with support from the World Bank, initiated the Water Sector Improvement Project Phase I (WSIP). The overreaching objective of WSIP is to

improve the efficiency and effectiveness of distribution of irrigated water in three AWBs (Ghotki, Nara and Left Bank).

The assignment was designed to be performed in four phased studies as defined below:

***Phase-I*:** Inventory and assessment of existing conditions and identification of issues and problems, preparation of a report that will form the basis of consultations with all stakeholders to reach an agreement on definitions of issues and problems.

***Phase-II*:** Identification of solutions covering structural and non-structural options, and institutional and management measures and their technical, environmental and social feasibility, approximate cost, workability and ranking based on pre-feasibility level studies and analysis.

***Phase-III*:** Preparation of detailed feasibility including technical, economic, environmental and social viability and implementation/institutional arrangements for the solutions identified under Phase II as high priority. This phase will also result in consultations based on the feasibility studies, and identification and prioritization of structural and non-structural solutions and their ranking for which detailed designs will be prepared.

***Phase-IV*:** Preparation of detailed designs and bidding documents for the most preferred solution for implementation according to international standards and implementation manuals, and institutional arrangements for non-structural solutions.

1.2 Scope of the assignment

The consultants were required to conduct community consultations to identify the issues and problems in phase-I of the Project. The Project phase II was focused on solutions for identified problems. During these two phases, the Consultants have met with over 9,500 people, visited around 231 villages, conducted 34 workshops at district, area water board and regional/national levels. Identified and community prioritized solutions have resulted into structural and non-structural interventions. Some of the proposed interventions such as proposed revival of dhoras and construction of some new drainage needed to be discussed with the affected communities and the impact perceived by communities assessed. The social impact assessment is related to the task 21, 23 and 24:

Task 21: Carry out environmental and social assessments in each sub area, and propose clustering of sub-s where these assessments are not cost effective to carry out separately. Undertaking environmental and social assessment in batches of sub-s may also form the basis for broader assessments for the whole study/ area;

Task 23: Review the social conditions in the subs, and undertake social assessment of the Project;

Task 24: Have consultations with the beneficiaries to develop appropriate methodology and levels of cost sharing/recovery for the Project works;

1.3 Project area

The Project study area includes all areas in Sindh Province lying on the Left Bank of Indus River, including the river delta, associated wet lands, and adjacent coastal zone. In particular, it covers the irrigation areas served by the Indus River canals off-taking from the left bank of Guddu, Sukkur and Kotri barrages; the area covered by the Left Bank Outfall Drain (LBOD), and its catchment and backwash areas.

2 Socioeconomic Profile Of The Area

2.1 Overview

Sindh is geographically the third largest province of Pakistan, stretching about 579 km from north to south and 442 km (extreme) or 281 km (average) from east to west, with an area of 140,915 km² of

Pakistani territory. Sindh is bounded by the Thar Desert to the east, the Kirthar Mountains to the west, and the Arabian Sea in the south. In the centre is a fertile plain around the Indus River.

Sindh is an arid region with some hilly and desert areas and depends largely on irrigation for agriculture. Its major crops are wheat, rice, cotton and sugarcane. Sheep, cattle and poultry are raised, and fishing is important in the coastal area along the Arabian Sea. It is estimated that 62% of the geographical area of Sindh is arid, comprising Thar, Nara and Kohistan, beside a large area under the coastal belt (350 Km) and Katcha area.

2.2 Economy

Agriculture plays a fundamental role in Pakistan's economy and is one of the main drivers of poverty reduction objectives in the country. Agriculture contributes to 25% of the Pakistan Gross Domestic Product (GDP), 50% of employment and 60-70% of exports. Irrigation along the Indus River is the backbone of the agricultural sector and uses 95% of the water available in the country. *(PID, Project 2004, Report No.: AB1145)*. In Sindh, out of total geographical area of 140,915 km², 5.7 million hectares of land are cultivated. *(Sindh vision 2030)*

67.5% of the country's population living in rural areas is directly or indirectly linked with agriculture for their livelihood. The economic development of Sindh is largely dependent on the development and growth of the agriculture sector.The province contributes significantly to theoverall national agriculture production in rice, sugarcane, cotton and wheat. *(Sindh vision 2030)*

2.3 Demography

The Project area is comprised of fifteen districts with an estimated population of over 20 million in year 2010. **(Table 2.1)**Khaipur and Hyderabad are the most populated districts with over 2 million inhabitants in each district. In Pakistan 32.52 percent of the total population live in urban localities. Sindh is most urbanized province where 48.75 per cent of the population lives in towns and cities. The 1998 Census data shows 10,983,000 inhabitants live in rural and 39,408,000 in urban areas on the left bank of Indus River. It is estimated that 20,413,000 inhabitants lived in the Project area in year 2010.

Table 2.1
Study area population by districts

SINDH 2008 TO 2010 - PROJECTED POPULATION BY SURVEYED DISTRICTS

Province/ District	Population census 1998 (in numbers)	Projected population (in numbers)		
		2008	2009	2010
SINDH	**30,439,893**	**40,119,000**	**41,246,000**	**42,400,000**
Left Bank Canal	**14,654,788**	**19,313,000**	**19,858,000**	**20,413,000**
TandoAllahyar	468,373	617,000	635,000	652,000
Matiari	515,398	679,000	698,000	718,000
Badin	1,103,857	1,455,000	1,496,000	1,538,000
Sanghar	1,324,726	1,746,000	1,795,000	1,845,000
Mirpurkhas	1,001,484	1,320,000	1,357,000	1,395,000
Umerkot	664,797	876,000	901,000	926,000
Tharparkar	914,291	1,205,000	1,239,000	1,273,000
Total	**5,992,926**	**7,898,000**	**8,121,000**	**8,347,000**

Source: Population census 1998

2.4 Local context

Out of fifteen districts in the Project area, the studied dhoras and the sample drain traverse seven districts: TanduAllahyar, Matiari, Mirpurkhas, Sanghar, Badin, Umerkot and Tarparkar. More than eight million inhabitants living in these districts will be affected by the proposed interventions. Sanghar, Badin and Mirpurkhas are the most populated districts in the researched area with over one million inhabitants in each district.

3 Community Consultations – Approach And Methodology

3.1 Overview

The social impact study is related to the area that is traversed by the major dhoras on the Left Bank of Indus. In addition, a sample drain proposed for the leftover area is included in the sample. The study includes the following dhoras and drains:

1. DhoroPuran (185km) running through Mirpurkhas, Badin and Tarparkar
2. SonhiDhoro (205km) running through Matiari, Tandu Allah Yar, Mirpurkhas, and Sangar
3. DhoroNaro (29km) running through Umerkot, Mirpurkhas and Tarparkar
4. HakroDhoro (109km) running through Umerkot, Mirpurkhas and Tarparkar
5. DhoroPithoro (22km), running through Umerkot
6. BhaikhanDhoro (147km) running through Tandu Allah Yar and Badin districts
7. D4 Drain (67km), which goes through Tandu Allah Yar and Sangar

The total length of dhora studied is more than 700 km.

3.2 Conceptual approach

The main objective of this phase of community consultations was todiscuss with communities proposed revival of dhoras and possible constructions of drains in the leftover areas. The major outcome expected was communities' views and opinions as well as their perceptions of possible impact of the proposed interventions as well as the mitigation measures as perceived by the communities.

3.3 Sampling and methodology

In accordance with the main objective of the study, the following sample selection criteria were determined:

- Major dhoras which have inactive parts considered for revival
- Dhoras which are running but are partially encroached or blocked
- Drains proposed for constructions
- Districts which are traversed by the sampled dhoras/proposed drains
- Talukas in each district traversed by dhoras/proposed drains
- Villages situated within 200m from the dhora/proposed drain

Following the sample selection criteria and in order to cover a very large geographical area, a multilevel sampling method has been adopted. This type of sampling is very practical for studies on a large area, such as a country or a region. However, the usual rationale for multilevel methodological approach resides in the fact that the phenomena under study have a multilevel structure. The main advantages of this method are convenience, effectiveness and cost efficiency.

The sampling universe in our study is divided into Districts, Talukas, Union Councils, Deh and at the end villages and individual households. The following are the steps taken in the sampling process:

1. Out of eight dhoras in the area, six major dhoras and the longest proposed drain in the area comprised the sample.
2. Seven (7) districts and thirty-three (32) Talukas traversed by these dhoras/drains were identified.
3. A list of villages situated within 200 meters from each dhora is made.

4. The villages which have planted crops or built dwellings in dhoras were marked.
5. Two to three villages from each Taluka were randomly chosen for community consultations and data collections on village profile and household surveys. If there were no enough encroaching villages or dhora was operational, the sample is completed by a random choice of other villages situated within the determined parameters.
6. In each sampled village, six persons (3 men and 3 women) are randomly chosen for households' survey.
7. In each village, one Key Informant interview on village profile is completed.

In order to get a representative sample for the household data collection, the 1998 Census data on local population **(Table 2.1)** were taken for the districts and Talukas concerned. According to the projected population number for seven studied districts, the population in 2010 was a bit over 8,000,000 people. For such a number of potentially affected people, a sample of 384 respondents **(Table 3.1),**with a confidence level of 95% and a margin error of 5%,would give a fair picture of the socio-economic situation of population residing around the dhoras proposed for revival.

Table 3.1
Required sample size

Required sample size				
Confidence =95%				
Population size	**Margin of error**			
	5.00%	**3.50%**	**2.50%**	**10%**
10	10	10	10	10
100	80	89	94	99
1,000	278	440	606	906
5,000	357	678	1,176	3,288
10,000	370	727	1,332	4,899
100,000	383	778	1,513	8,762
1,000,000	384	783	1,534	9,512
10,000,000	384	784	1,536	9,594
100,000,000	384	784	1,537	9,603

Source: The research advisors (2006)
http://research-advisors.com/tools/SampleSize.htm

Nevertheless, considering a very large area sampled dhoras and drains traverse, the adopted approach was expanded beyond the necessary size of the sample (384) with an aim to cover each district and each Talukawith the potential Project impact. In addition, in order to distribute fairly the chances for people to voice their opinions, 2-3 villages from each Taluka are considered for the sample and six household interviews taken from each village. **(Table 3.2)**This approach gave a larger sample size than required for the sample statistical representativeness and ensured a qualitative dimension to the approach. In total, 91 villages from 33 talukas were covered by the study. Additionally, 91 key informant interviews and 543 household interviews were completed. **(Table 3.5)**

Table 3.2
Social impact assessment sample size

Dhoro	District	No of talukasdhoro traverses	No of villages surveyed	No of household surveys	No of participants at open consultations
DhoroPuran	Badin, Mirpurkhas, Tarparkar	5	15	87	445
Bhai Khan Dhoro	Badin	2	6	36	172
DhoroNaro	Umerkot, Tarparkar, Mirpurkhas	4	12	72	414
HakroDhoro	Umerkot, Tarparkar, Mirpurkhas	6	18	108	615
PithoroDhoro	Umerkot	3	10	60	305
SohniDhoro	Mirpurkhas, TanduAllahyar, Sangar, Matiyari	8	21	126	572
D4 drain	TanduAllahyar, Sangar	5	9	54	292
Total	**7**	**33**	**91**	**543**	**2,815**

A special consideration was given to the gender representation in the consultations and data collection. Women participation at village level consultations and household data collection was higher than men's participation. **(Tables 3.3 and 3.4)**

Table 3.3
Participation at community consultations

District	Villages	Men	Women	Total
Badin	8	90	119	209
Tarparkar	13	164	201	365
Mirpurkhas	21	341	383	724
Umerkot	25	400	450	850
TanduAllahYar	6	66	93	159
Matiari	3	24	21	45
Sangar	15	248	215	463
Total	**91**	**1333**	**1482**	**2815**

Table 3.4
Participation at household level

Dhoro	No of female respondents	No of male respondents	Total
DhoroPuran	44	43	87
Bhai Khan	18	18	36
DhoroNaro	36	36	72
HakroDhoro	54	54	108
PithoroDhoro	29	31	60
SohniDhoro	63	63	126
D4 drain	27	27	54
Total	**271**	**272**	**543**

Table 3.5
Sample village consultations

VILLAGE LEVEL PARTICIPATION					
Number	Village	District	Participants		
			Male	Female	Total
1	Ali Hassan Khoso	Badin	2	2	4
2	BudhoUner	Badin	12	21	33
3	Aulia Khan Shah	Badin	13	14	27
4	KhaliphoFaizMohd	Badin	8	12	20
5	M. QasimAhmadani	Badin	10	10	20

VILLAGE LEVEL PARTICIPATION

Numbe	Village	District	Participants		
6	DhanoKolhi	Badin	17	25	42
7	MohdBuxKhaskheli	Badin	12	14	26
8	BachalAraser	Badin	16	21	37
9	Allah Dino Mallah	Tharparkar	8	10	18
10	Kaloiabad	Tharparkar	38	13	51
11	Ghulam Mohammad Khoso	Tharparkar	13	22	35
12	Mir Mohammad Lund	Tharparkar	7	12	19
13	Allah Dino Khokher	Tharparkar	11	10	21
14	Photo Bheel	Tharparkar	11	7	18
15	Janhan	Tharparkar	13	25	38
16	Haji ObhayoChandio	Tharparkar	9	16	25
17	Noor Shah	Tharparkar	7	11	18
18	ArbabZakaullah	Tharparkar	9	12	21
19	Mir Shezad Khan Talpur	Mirpurkhas	8	19	27
20	Mir Ghulam Ali Talpur	Mirpurkhas	10	15	25
21	ArbabKhaskheli	Mirpurkhas	7	16	23
22	RanoRamdan	Mirpurkhas	11	17	28
23	QaimRamdan	Mirpurkhas	14	7	21
24	FaqirGhulam Ali Leghari	Mirpurkhas	17	20	37
25	Bahram Khan Gorchani	Mirpurkhas	19	17	36
26	MisriKhaskheli	Mirpurkhas	21	27	48
27	GulsherGorchani	Mirpurkhas	23	17	40
28	Hayat Tangri	Mirpurkhas	7	10	17
29	KarimabadKhawaja	Mirpurkhas	19	38	57
30	Haji Lund Khan Chandio	Mirpurkhas	19	21	40
31	FaqeerFaiz Mohammad Bilalani	Mirpurkhas	16	18	34
32	Bacho Khan Tangri	Mirpurkhas	38	21	59
33	Haji Sultan Tangri	Mirpurkhas	19	16	35
34	Abdul LatifGori	Mirpurkhas	13	16	29
35	Bhai Khan Kaloi (Hafiz Miro Khan Kaloi)	Mirpurkhas	24	21	45
36	Mir Allah Bachayo (Ghalpur)	Mirpurkhas	18	15	33
37	Seth Goband Ram (Sehri Farm)	Mirpurkhas	8	20	28
38	ShaganBhagat	Mirpurkhas	19	18	37
39	Pinjal Khan Nondani	Mirpurkhas	11	14	25
40	M MoosaJaeser	Umerkot	12	11	23
41	Haji Mohammad RamzanKalro	Umerkot	33	12	45
42	Haji SiddiqHalepoto	Umerkot	13	10	23
43	AmeerBuxHalepoto	Umerkot	18	8	26
44	Haji Ghulam Mohammad Mangrio	Umerkot	29	21	50
45	Haji Mohammad Daim	Umerkot	18	14	32
46	Haji ManjhiMangrio	Umerkot	10	11	21
47	Haji Wali Mohammad Dars	Umerkot	11	6	17
48	Haji Mohammad Ismail Mahar	Umerkot	19	15	34
49	Haji BachoMangrio	Umerkot	19	15	34
50	KamilKalar	Umerkot	9	21	30
51	Haji Ahmed Ali Memon	Umerkot	19	19	38
52	Saeed Khan Jamali	Umerkot	19	28	47
53	Khan Sahab Major AzharPali	Umerkot	19	19	38
54	MureedHalepota	Umerkot	22	19	41
55	Khan Sahab Atta Mohammad Pali	Umerkot	8	38	46
56	Ahmed Ali Pali	Umerkot	5	20	25
57	Abdul Hakim Mahar	Umerkot	19	13	32
58	NangodarMangrio	Umerkot	18	9	27
59	Bashir Ahmed Chandio	Umerkot	23	19	42

VILLAGE LEVEL PARTICIPATION					
Numbe	**Village**	**District**	**Participants**		
60	Haji Irshad Ahmed Bajwa	Umerkot	5	26	31
61	RaisGajyan Khan Chandio	Umerkot	8	19	27
62	RahmorePirBachal Shah	Umerkot	14	20	34
63	ChoudhryGhulam Ali (Shah Ali Wah)	Umerkot	11	28	39
64	BhoroKolhi	Umerkot	19	29	48
65	RamdanGurgez	Umerkot	8	19	27
66	Long Khan Gurgez	Umerkot	19	20	39
67	Mohammad IshaqChandio	Umerkot	11	24	35
68	Sultanabad	TandoAllahyar	11	23	34
69	Mir Jo Goth	TandoAllahyar	9	17	26
70	Haji JaffarHakro	TandoAllahyar	12	16	28
71	MohsinDhago	TandoAllahyar	12	12	24
72	GhulamQadir Dago	TandoAllahyar	6	13	19
73	Aliabad Farm	TandoAllahyar	16	12	28
74	KhudaBux Dal	Matyari	10	6	16
75	Khan Mohammad Sand	Matyari	9	7	16
76	Essa Sand	Matyari	5	8	13
77	Khan Mir Mari	Sanghar	16	10	26
78	Major Nasir Ali	Sanghar	8	9	17
79	Jan Mohammad Panhwar	Sanghar	19	15	34
80	PiruFaqirShoro	Sanghar	18	19	37
81	Sehra Mari	Sanghar	19	8	27
82	Shah Baig Mari	Sanghar	20	23	43
83	Duran Khan Brohi (Now in Tando Adam Taluka)	Sanghar	9	14	23
84	Haji Fateh Mohammad Brohi	Sanghar	7	10	17
85	ChoudryInayat Ali	Sanghar	16	19	35
86	Haji Sher Mohammad Khaskheli	Sanghar	16	12	28
87	BhobharWa (DaaithMalokani)	Sanghar	16	13	29
88	Khan Mohammad Mari	Sanghar	32	18	50
89	Haji Ghanwar Khan	Sanghar	27	13	40
90	ManikThaeem	Sanghar	19	19	38
91	Allah DitoThaeem	Sanghar	6	13	19
	Total		**1333**	**1482**	**2815**

3.4 Primary data collection

The major area of interests covered by consultations was people's perceptions on positive and negative aspects of revival of natural dhoras, construction of drains in the leftover area, community readiness to contribute and be involved in the Project as well as identification of mitigation measures as seen by communities. The consultations and data collections were conducted from May to July 2012. In each district, our partner NGO played a vital role in guiding the Consultant's social team, getting access to the villages and ensuring community participation. The role of the partner NGOs during the fieldwork was indispensible. Villagers were informed about intended community consultations a minimum of 1 day prior to consultations.

Household survey, men, Ghulam Mohammad Khoso, Tarparkar

Consultations with women, Kaloy Abad, DhoroPuran, Tarparkar

The community consultations involved the collection of primarily qualitative data from primary sources at sample village level. The quantitative data were collected from the Key Informants at village level as well as by the socioeconomic survey at household level. The Consultant used a combination of the following methodological tools for collection of information:

- Consultations with men in sampled villages
- Consultations with women in sampled villages
- Semi-structured household interviews
- Key informant interviews
- Observation

In addition to the key informant questionnaire and household surveys data, the collected information was complemented with relevant information obtained from the government population censuses and relevant studies and reports. Combined methodological tools enabled appropriate insight into communities' perceptions of the Project and possible impact by the proposed interventions.

Women of Umerkot

Open community consultations were conducted in **91 sample villages in seven districts** through which studied dhoras and proposed drains traverse. The participants were verbally informed about the Project interventions and the objectives of the consultations with them. Overall, 91 open community consultations with men and 91 with women were conducted. In total, **2,815 persons** participated in the community consultations. Women's participation was greater than men's participation. There were **1,333 men and 1,482 women**participating at consultations. On average, 31 persons per village were consulted. **(Table 3.5)**

Additional information on the village population, existence of basic services in the villages, distance and access to services outside the villages, information on the village poor, landless, education, health etc, was collected from the key informants. The Consultant conducted 91 such interviews; one in each of the sampled villages. The matrix for village data collection was prepared in advance. Usually, a key person was a wadera, a local teacher or any other educated and/or well-informed person.

Data on the socioeconomic profile of local population were collected by semi-structured household questionnaires. In each village, six household questionnaires were completed. Overall, **543 persons** were interviewed. A special consideration was given to inclusion of women respondents in data collection. In this regard, the Consultant's social team conducted almost an equal number of interviews with men and women **(271 women and 272 men).** Consultations and data collections were conducted separately for men and women. To avoid duplication of data collection, it was ensured that only one person from a household is interviewed. The social team would ensure three male respondents for the household survey and made sure that in the separate consultations, their wives or other female household members were not interviewed for the same purpose.

4 Presentation And Discussion Of Findings

4.1 Sample village profile

The main quantitative data on sample villages were gathered through the key informant interviews and household surveys. The analysis of the interviews is presented in the following paragraphs.

Table 4.1
Village profile

No of villages	Population/ self reported	No of households/ self reported	No of poor households /self reported	No of landowners/ self reported	No of landless/self reported
91	87,606	10,562	9,162 (86.74%)	973	9,571 (90.63%)

Sample village population amounts to 87,606 inhabitants living in 10,562 households as reported by the Key Informants. Population in the surveyed villages ranges from 20 to 9,500 inhabitants. Majority of the surveyed villages, (almost 44%) have between 100 and 500 inhabitants, while a quarter of villages have between 1,000 and 5,000 inhabitants. Only a few villages have population greater than 5,000 and around 10% have population less than 100.

Roads through the villages are mostly kacha roads. Only 18% of surveyed villages has pacca road through the village. Houses in surveyed villages are mostly kacha (63%) and jopra (20%) while 34 (6%) does not have a house at all:

'*No house. My house is drowned by last flood. I am living under a tree.House is destroyed in flood 2011. Living under sky.No home, leaving under tree',* Villagers from Umerkot, Mirpurkhas and Badin.

Proper sanitation facilities are not common in villages. Out of 543 surveyed households, only five have latrines while the rest of the sample villages use open space for these purposes. Drinking water is generally available in surveyed villages (93.4%) and almost half (49.45%) of the key informants think that water is not safe to drink. The main sources of drinking water are hand pumps (78%), followed by canals (6%) and ponds or combination of all three sources.

Around two thirds (68%) of the surveyed villages have electricity. However, a bit less percentage of individual households (64%) has electricity connected. During the community consultations, villagers stated that many households could not afford to have electricity connected. Mobile phones are found in every of the surveyed village. Nevertheless, only 31.5% of all households have a mobile phone.

Other facilities available in villages are usually mosques (83%). Pharmacy or a medical store is available only in one village (KhalifioFaiz Muhammad) in Badin and majority of villages have to travel up to 10 km to the nearest pharmacy. Only Kaloi village in Tarparkar has a market in the village while 75% of villages have a market available at the distance of up to 10 km from the villages.

Overwhelming majority of villages (92%) reported agriculture and general labour as the main occupations of villagers. Beside agriculture labour, farming, casual labour, woodcutters and fisheries were reported as some of the most common occupation of surveyed villagers. Majority of surveyed villages have irrigation water from canal, wah or tube wells. However, 62% of landowners have some uncultivated land. The main reasons stated are: the land is still flooded, shortage of water and lack of finances to invest in agriculture. *'In last flood, our whole crops destroyed. Just two months ago we have started cultivation. Due to water shortage we cannot cultivate whole land'.*Aulia Khan Shah village, Badin

89% of surveyed villages plant sugarcane, cotton and chilies in rabi season and rice in karif season. Only 9% of surveyed population has some land while 91% are landless. Landlessness nearly corresponds to the percentage of poor households (87%). **(Table 4.1)**

Common livestock in villages are buffalo, sheep or goats, caw, donkeys and mules. Most of the households have some chicken too. The most common problems in animals, reported in each surveyed village, are diseases, shortage of fodder and lack of veterinary facilities.

Only one village has a basic health unit in the village and two villages have a dispensary unit. Usually, they have to travel long distance to reach medical help in Taluka, district hospitals or some private clinics in the cities. The most common diseases reported are malaria, hepatitis, skin problem, diarrhea, respiratory problems and tuberculosis.

Educational facilities in almost half of the surveyed villages are usually mixed boys and girls primary school. Separate girls and boys primary schools are available in more than a quarter of villages. Other villages send their children to primary school in the close-by neighboring villages. The distance to the school varies between 2 and 6 km. Secondary schools are not available in any of the surveyed villages. In some cases, boy's secondary schools are from 10 to 20 km away from the village. Children from Haji Mohammed RamzanKalu village in Umerkot have to travel 10km to get to school and children from KhalifioFaiz Muhammad village in Badin travel 20km to reach school.

Almost all villages use rickshaw, public transport, a motorbike or private car to access market and hospitals while most of villagers walk to the field. A quarter of villages pay from PRs 100-500 to access market while access to hospitals could cost up to PRS 1,500 especially is the sick person cannot sit while travelling. Those who stated travelling problems, on the first place put lack of or inadequate public transport. Bad road was also one of the problems stated.

Only 8 out of 91 villages have some projects in villages such as installing hand pumps, construction of latrines and microcredit projects. The projects are being implemented by NGOs such as SAWFCO, Save the children, Oxfam and RDF. All villages were heavily affected by the recent (2011) flood. The key informants reported all households being affected by the recent flood while 1,306 households have affected agriculture land.

When asked to state the major issues in their villages, over 75% stated poverty, 56% included water as one of the main issues, while 45% stated road, school and a health unit as the major concerns in their villages. *'We sit on the mud floor, we make mud, we are made of mud, so, no problem for us',* KamilKalar village, DhoroPithoro, Umerkot

4.2 Population and family profile

The total (self-reported) population of the sample villages is 87,606 persons living in 10,561 households. The number of inhabitants ranges from 20 in Ali Hassan Khoso village in Badin to 9,500 in ManikThaeem in Sangar district. 56% of villages have population up to 500 inhabitants, while around 10% of villages have population larger than 2,000. The number of households ranges from 5 to 1,000 with Ali Hassan Khoso (Badin) having the smallest and Mohsin Dago in TandoAllahyar, the largest number of households. Family size ranges from 2 to 18 family members. A small percentage of sample villages (3.68%) have 11-18 family members. A bit over a half of the surveyed households (52.13%) has 6 to 10 people in the household while 44% has from two to five family members in the household. Average surveyed family size is eight persons. 9,162 households (86.75%) were reported by the village key person as being poor.*'We are very poor, one person earns and eight are dependant. How can we buy new clothes and new shoes? Even we cannot afford food properly. And you are here to ask for luxuries?'* AmeerBuxHalepoto village, DhoroPithoro, Umerkot.

In 91 sampled villages, 543 household questionnaires were completed. These 543 households have 3,277 family members (1,520 males and 1,757 females). The age of family members were almost equally distributed in the categories 0 to 5 years of age, 6-10 and 11-18 years of age, where the percentage of children up to 5 years of age is the highest of all categories (20%). The number of people starts declining in the age bracket 31-40 years while 40+ age brackets indicates a rapid declination of number of people. It seems that very few villagers live beyond 50 years of age.

Only 22% of households reported some household assets. **(Table 4.2)**

Table 4.2
Family assets

Asset	No and % of HH	
TV	26	(4.79%)
Electric fan	53	(9.76%)
Washing machine	1	(0.18%)
Bicycle	5	(0.92%)
Sawing machine	10	(1.84%)
Fridge	9	(1.66%)
Motorbike	18	(3.31%)
Buffalo	100	(18.42%)
Caw	37	(6.81%)
Sheep/goat	106	(19.52%)
Donkey/mule	17	(3.13%)

The most common family assets found are electric fans, TV sets and motorbikes. However, livestock as a family asset is more significant than inside-the-house assets. 100 families reported having some buffalos and 106 some sheep or goats.

Literacy in the surveyed area is generally very low. The sample households data based on the household questionnaires, indicate zero years of schooling for 63 % of the households' members of school age and older.

Income distribution data shows that 816 (25%) out of 3,277 persons earns some money. A majority of villagers work in agriculture. A small number of persons (55) have government jobs, some private work or a small business.

A self-reported monthly family income ranges from RS 2,000 to Rs 45,000 **(Table 4.3)**. Almost the same number of surveyed households has income from six to ten thousands and from ten to twenty thousand rupees per month (214 and 221). Numbers of households having income below five or above twenty thousand per month are relatively small in the sampled households. A few households from Umerkot stated that they do not have any income at all as their landlords take care of their needs by giving them food, clothing and other necessity:

'Since two years, we have not received any money or crop share from landowner due to continuous floods. Landowner is giving us food. We are taking everything from landowner and he is charging debts that we don't know how much it is'. Wali Mohammad Darsvillage village,Umerkot.

Table 4.3
Household monthly income

Monthly income	
PRs	**No of households with income**
2,000-5,000	41
6,000 - 10,000	214
11,000-20,000	221
20,000 - 30,000	52
31,000-45,000	11

A few kitchen items

Fireplace

When asked about food consumption and monthly expenses on different food items, the respondents from 543 surveyed households stated that wheat, wedgies, legumes, rice, meet, gee etc consume once a month. None of these food items they can afford on a regular daily basis. Meat and rice are rarely consumed; 486 households never eat meet except when they get it from wealthy people during Eid or for Zakat. Also, 345 household do not have rice in their diet. Milk and eggs are almost nonexistent in people's food consumption. Over 500 surveyed households stated that they never eat milk (501) and eggs (535). More than half of the households reported expenses on each stated food item up to RS 1,000 per month. The most common villagers' daily food is boiled chilies with chapatti. *'We don't have money for food, cannot afford to go to doctor. We don't have enough money to buy vegetable. We are eating chapattis with chilies. We have not seen ghee for years'.* Photo Bheel village, Hakrodhoro, Taraparkar

Poverty is a widespread in most of the surveyed villages. It is very visible, almost tangible. The condition of clothing women and men wear, the appearance of children, few items in houses, type and condition of houses, poor or lack of basic services, all speak loudly of extreme poorness:

*'We are not using ghee but taking chapatti with chilies; this is our food for years day and night and some time even we don't have this; we and our children have to sleep empty stomach'.*Haji Ahmed Ali Memon village, Hakrodhoro, Umerkot

'*We are very poor, we can't afford washing material, we use to wash with simple water, and take bath with mud and water, how can we afford those luxuries for which you are asking? We don't have house; we are living under tree, what type of jokes you are asking?'* Women fromAli Hassan village, DhoroPuran, Badin

Surveyed families purchase clothing and footwear mostly once per year, 86.4% and 91% respectively. When the cost is spread on monthly basis, on average, a family spends Rs300-500 on clothing and the same amount on footwear for the whole family:

'*We have not purchased anything since two years. We are very poor, we have no money, we cannot afford. Usually we wear old clothes for years.I am walking bare feet; I don't have money to buy*

*shoes. I don't know since how many years I have not purchased shoes. Even these shoes I have found from somewhere and you can see different shoes on my feet.We don't have money to afford the luxuries you are asking about'.*Women from Haji SiddiqHalepoto, KamilKalar and RamzanKalro villages from Umerkot.

Social obligation expenses range from Rs50 to Rs1, 000 per month. Usually people spend nothing or a smaller amount on such occasions as they cannot afford such expenses: '*We are participating without giving any amount because we cannot afford.We cannot afford to go to social activities'.* PiruFaqirShoro village, Sanghar.Two thirds of households spend monthly up to Rs 500 for medical help. Some households (7) in Tarparkar, Umerkot and Sangharstated that they cannot afford doctor's fees and medicine at all. A great majority of sample households did not have any expenses for education, communication or electricity.

When income and expenses are compared, most of families have higher expenses than incomes. People live in constant debts. The answers on loans taken last year revealed that 59% of surveyed families have taken a loan in the past year. Overwhelming majority took the loan to repair the house, to invest in agriculture or both. Only 2 families stated that they took the loan for their business. The amount borrowed ranges from Rs 10,000 to Rs 700,000. However, over half took the loan up to Rs 50,000, while almost 40% borrowed between Rs 50,000 and 100,000. Less than 8% borrowed over Rs 100,000 during the last year. All borrowers have to repay the borrowed sum by a lump sum.

4.3 Women's participation and decision making role

Organizing and conducting consultations with women was a remarkable experience. The team mostly gained the access to women without any problem. The access was granted due to the WSIP local NGO partners who were usually well known and trusted in the local communities.

Wango village,DhoroPuran, Badin

At first, men would be concerned (mostly because we insisted to consult women without male presence) and usually asked questions about consultations such as, why we need to ask women, what we will talk to them, could one man sit with women and watch them, will we try to take photos without permission etc. After sincere explanations, the team was granted unsupervised access to women. Only in one of the villages in Umerkot, a man was present during the entire consultations, shouted at younger girls when they giggled and allowed only a few photos with young girls to be taken.

Generally, as soon as the team entered the village, women were coming in great numbers. Sometimes they mistaken the team for an NGO giving some aid; nevertheless, when women learned the purpose of our visit, they wanted to stay and talk to our team. During the consultations, 1,482 women came to participate as compared with 1,333 men. The household survey was controlled by the adopted methodology which envisaged the same number of male and female respondent (271 female and 272 male respondents). There was no problem in getting women to answer our questions. On many occasions, the whole group helped answering questions for one particular household. They knew exactly how often someone eat meat, or ghee, how often someone buys new clothing, footwear, how much it cost and so on. The community knows all and everything about any of their members.

The consultations with women were outstanding. The atmosphere created at each consultation was informal, spontaneous, non-threatening, friendly and full of giggle, laughter and jokes. It seemed that women had their time and they appreciated the chance to talk about their problems and their visions. In a few villages men came to call some of their women to give them lunch or to attend other of their needs, but women just waved the hand telling the men to wait until they finish.

Women proved to be a rich source of information, knowledgeable about community problems and creative in seeking the solutions. They gave their insight into dhora's revival and the jobs themselves and their men can do during the Project implementation.

According to women, their primary tasks are house chores, children rearing and social obligations. Nevertheless, work on farms and taking care of livestock are responsibilities of many surveyed women. The only field that women's role is almost negligible is selling and purchasing properties. Only 15 women stated that their husbands would consult with them on these issues and that they have the decision making power too. **(Table 4.3)**When household chores are in question, every women and men interviewed stated that it is a woman's role and a primary responsibility. With this, almost all of them stated that women have in this matter the decision power too. Child rearing is almost exclusively women's responsibility and almost all have their say when decisions about children are made. Crops, farm work, livestock is a primary responsibility for many women.

The data indicate that primary responsibility entails inclusion in the decision making process. However, in each category, decision making incidence is always a bit smaller than the incidence of primary role and responsibility.

Table 4.3
Women's decision making power

Type of chores	Primary responsibility		Decision making	
	Yes	No	Yes	No
House chores	542		519	23
Child rearing	522	4	494	32
Crops/farm work	159	373	134	298
Livestock	207	228	183	250
Sale/purchase property	15	525	15	525
Social obligations	541	1	460	82
Total	**1,986**	**1,131**	**1,805**	**1,210**

5 PERCIEVED IMPACT OF THE PROPOSED INTERVENTIONS

5.1 Perceived positive impact

Historic monsoon flood from the year 2011, affected a huge number of Sindh people. Surveyed communities reported 9,573flood affected households, which make 91% of all surveyed households. There are 9,373 households with some structures affected by flood and 1,306 with the agriculture land affected. Villagers at open consultations and during the household surveys underlined all positive impacts which the revival of dhoras would bring. The most stated positive impacts were as follows:

- Water will drain out fast
- Water logging and salinity will decrease
- Agriculture production will increase
- Houses and land will be safe
- Livestock will get sufficient drinking water
- Diseases will decrease
- Necessary drainage system will be developed
- Paid local labour will rise

Generally, people were satisfied with the proposal and listed all positive effects the Project may bring. They expect to be saved from flooding, damages and constant relocation during rainy seasons. People expect only rain water to flow in dhoras as they would use it for livestock. The most cited benefits

were that dhoro will enable fast draining of water and that land, houses and livestock will be saved from floods.

The most of people's concerns were related to bunds which should be elevated and additionally straightened. Furthermore, people were concerned with potential 'partial' solutions, which, in their opinions will be worse than not having Project at all. They request full revival of dhoras (entire dhoro's length) and the Government's seriousness and honesty throughout the planning, implementation and the monitoring of the Project and the post-Project maintenance. The following are some examples of villagers' comments on the proposed interventions:

*'We will get sweet water for drinking. Now we are going two km away for drinking water. We were displaced for one to two months due to last flood. If you revive dhoro, we will benefit',*RahmorePirBachal Shah village, Umerkot.

'We will be safe from upcoming floods. Our houses and lands will be safe from flood water', KarimabadKhawaja village, Mirpurkhas.

'*It is good. People can be saved from floods and water will go to end point of Dhoro. Even agriculture land can be saved that was destroyed in last year if dhoro*is *revived.*'Haji Mohammad village, Umerkot.

'Please try to do proper work. Don't allow ***them*** *to do corruption. Otherwise, bunds will break up'.* Mohammad MoosaJaeser village, Umerkot

*'Water shortage will be reduced and our land will be able to cultivate. Our homes and crops will be saved from upcoming floods. From last five years, during every rain and flood we had to go to roads for three to four months. After revival of dhoro we will be safe from flood and will not need to go'.*Aulia Khan Shah village, Badin

'We have suffered a lot in last flood. It will save us from flood and rain water'. Mohammad BachalKhaskheli village, Badin

*'This project is best. People will benefit',*KamilKalar village, Umerkot

5.2 Perceived negative impact

Overwhelming majority of consulted people think that if the Project is implemented correctly, they will be better off in many ways. A great majority (78.1%) think that revival of dhoras will not have any negative impacts at all. The rest of the respondents see the success of the Project conditionally. Apart from the most cited perceptions, people are concerned about quality of work, management and regular maintenance, access to other bank of dhoras and the possibility to relocate. There is a certain mistrust that work would be done properly.

The biggest reservation towards the Project has been recorded in Mirpurkhas area. Some landlords were reluctant to allow consultations with people and especially with women. Also, in some cases villagers at first were unwilling to discuss the revival of dhoro as their villages are almost entirely built in the dhoro. For example, people of ShaganBhagat village, Sonhidhoro, Mirpurkhas, claim that dhoro did not flow for years and due to that, they built structures in its bed. RanoRamdan, Bahram Khan Gorchani and ShaganBhagat villages along DhoroPuran in Mirpurkhas as well as Mir Jo Goth and Haji JaffarHakro villages along proposed Drain 4 in TanduAllahyar, were not as pleased with the proposed interventions as it would affect their structures built and crops planted in the bed of the dhoro.

According to people from MohsinDhago village, Sohnidhoro, TanduAllahyar, *' It will be a very difficult task because people have structures and cultivation in dhoro, but nothing is impossible if the Government is serious'.*

Perceived negative impacts of the proposed interventions are summarized below:

- Crops planted in dhoro will be affected
- Houses and other structures inside the dhoro will be affected
- Access to other sides will be hard if bridges are not constructed
- Possible damage or cut of bunds would harm the whole village and the surrounding area
- Improper monitoring, maintenance and Project management will damage the whole area
- Potential overflowing will damage houses and livestock
- Any backflow will affect the area
- It may involve relocation of people

'Overflow of Puran will drown us', FaqirGhulam Ali Leghari village, Mirpurkhas

*'We need water and dhoro is best source which government also knows since years. Therefore, you cannot revive dhoro; you will fail because government has never been serious as usual',*Kaloiabad village, DhoroPuran, Tharparkar

'If still water will not drain out, then lands and village will be drowned. Livestock will also die and graveyard will also be drowned', Mir Ghulam Ali Talpur village, Mirpurkhas

*'Nothing will be worse. There is no any bridge on dhoro, therefore our children cannot go to school'.*MisriKhaskheli village, Mirpurkhas

We will be worse because we will have to migrate to other places that we don't want even if we get compensation. So many villages will migrate and nobody wants to migrate to other places.' KhalifioFaiz Muhammad village, Bhai Khan dhoro, Badin

*'We don't know about negative effects. If water will come towards our village, then again we will take everything on our shoulders like during this flood and go out from our houses again'.*RamzanKalro village, dhoroPithoro, Umerkot

*'It will be worse for those who have agriculture land in dhoro. They should be compensated. If cuts will occur, then it will damage our village'.*KhalifoFaiz Mohammad village, Bhai Khan dhoro, Badin

*'If water starts running back then it will drown us'.*FaqirFaiz Mohammad Bilalani village, DhoroNaro, Mirpurkhas

5.3 Perceived mitigation measures

More than 85% of consulted persons gave their vision of the mitigation measures which should minimize potential negative impact of the Project. Nevertheless, 16.7% did not know how the negative effects could be managed or they think that professionals should take care of it.

Consulted people underlined the importance of a proper execution of the Project. People think that a proper deep de-silting of dhoras should be done by advanced machinery which will ensure satisfactory work. The most important in people's opinion is to make bunds stronger and to ensure that villages are not flooded. There were some suggestions to build safety bunds around villages and have safe place for people if they have to move during the flood.

Many of the respondents were concerned with access to other sides of revived dhoras. Access from one to the other bank of a dhoro should be ensured by construction of bridges. Some respondents think that simnalas which will drain out village water into dhoro, should be constructed. In order to prevent backflow, people suggest installation of gates. Above all, consulted people expect timely and proper compensation for lost crops, structures and other affected assets. In addition, they underline the

need for implementation of the Project and management of dhoras in post-construction period with honesty, sincerity and without corruption.

Some of the most mentioned suggestions on mitigation measures are presented below:

*'It should have gates at its end points so that it cannot get back. Bridge should be made for crossing of people. If there is encroachment of land into dhoras then it should be removed.Bunds should be strengthened. Encroachments should be removed because landlords have developed their lands into dhoras'.*FaqirFaiz Mohammad Bilalani, DhoroNaro, Mirpurkhas

'Bridge should be made so that peoplecan cross easily. People should also be compensated against damages of their lands or houses due to this project or they should be shifted at safe places'. Haji Ludan Khan Chandio village, Hakrodhoro, Mirpurkhas

*'Channels should be established from our land into dhoros'.*Long Khan Gurgez village, DhoroNaro, Tarparkar

*'Compensation for cultivation of lands within dhoro should be given to local people. Bridge should be made on dhoro for crossing to access graveyard.'*Haji ObhayoChandio village, Tarparkar

*'Advanced machines should be used in the Project and bunds should be strengthened.'*RamzanKalro village, dhoroPithoro, Umerkot

*'Safety bunds should be developed round the village so that if it gets cuts, then water cannot come inside the village.Work should be started with honesty and without corruption. Arrangements for our safety can be made if it breaks out or get cuts. Bridge should be established so that we can cross dhoro easily by walk or by transport'.*AmeerBuxHalepoto and Haji SiddiqHalepoto villages, DhoroPithoro, Umerkot

*'There should be tree plantation on the banks of Puran. Water flow into dhoro should not be stopped.'*FaqirGhulam Ali Leghari village, DhoroPuran, Mirpurkhas

5.4 Community perception of their involvement in the project implementation

Almost without exception, respondents expressed their support for the proposed dhoras revival as well as the readiness to participate. **95.6%** stated that they are ready to cooperate with Government in every way they could. Most of ordinary people are poor and cannot contribute money, but they suggested paid daily labour, collecting donations, giving information to the working team, looking after construction material etc. Also, if local labouris hired on daily wages, villagers would be able to contribute a day or two of work on a voluntary basis. Otherwise, as some women pointed out, there would be nobody to earn for their families if men work for free*: 'We can do only labour work with wages. We don't have enough money to buy food and you are asking about contribution for revival'.*Mohammad IshaqChandio, DhoroNaro, Tarparkar. *'We are poor and we will do labour work on wages. If we offer volunteer work, then, who will feed our families?'* Noor Shah village, DhoroNaro, Tarparkar.

Farmers and farming laborers claim to be very busy with work in agriculture and there will not be time to work on a voluntary basis. In addition, many of them had taken loans to invest in agriculture but two consecutive years of flooding impoverished the entire communities as the loans have to be repaid regardless of the flood damage in agriculture.

Consulted communities also think that the Government should involve them in monitoring and maintenance activities. They suggested that each village should have a committee which will do monitoring and some maintenance. Villagers are hopeful that such post-construction tasks will be distributed to locals on a paid basis. People will do voluntary work in case of emergencies.

People insist that before any work, the government should present them the work plan, consult with affected communities again and fully compensate those who would lose crops and structures due to dhoras revival.

Some of the chosen responses presented below illustrate people's readiness to be fully involved in the Project planning, implementation and maintenance phases.

*'Labour work should be given to local people by offering the daily wages. Monitoring should be given to local people.We will support official teams. Any information will be given to them like the identification of the routes of Puran. For financial support, we will try to collect donation collectively.'*Ghulam Mohammed Khoso village, DhoroPuran, Mirpurkhas

*'We will support working teams and take care of the material. We will do labour work. We will also guide them. For financial support, we will request to landowners to help project financially.We will cooperate fully. We will help government. For financial help, we will try to donate collectively some amount but we are very poor.'*FaqirGhulam Ali Leghari, DhoroPuran, Mirpurkhas

*'Committees should be formed in villages and work should be distributed to committees so that they can properly look after dhoro'.*KamilKalar village, HakroDhoro, Umerkot

*'We will provide every possible help. We will do labour work on daily wages and on voluntarily basis. We can only provide physical help like cutting trees, labour work or desilting work. We cannot provide financial help'.*Khan Sahib Major AzharPali village, Hakrodhoro, Umerkot

*'We will do labour work on wages and we will provide every possible help to the official working teams. We are very poor, though we will try for donation collectively to provide financial help to the project'.*Allah DitoThaeem village, Drain 4, Sangar

*'We already busy in agriculture labour and having taken big loans, so we don't have time. If we got some time then we can provide labour work on wages'.*Ahmed Ali Palivillage, Hakrodhoro, Umerkot

*'Our males are busy in land cultivation and other labour work. They cannot do anything, so please you do yourself everything.'*Wali Mohammad Darsvillage, PithoroDhoro, Umerkot

5.5 Recommendations

The following is the summary of the key recommendations the Consultant has formulated on the basis of the data analysis and suggestions expressed at consultations with potentially affected communities living along major dhoras proposed for revival. In the opinion of the Consultant, these recommendations must be considered at all stages (planning, construction and operation and maintenance phases) of the interventions.

Recommendation 1 Review and consider people's suggestions in the course of planning dhoras revival or new drains construction.

Recommendation 2 Ensure transparency at all stages of the proposed interventions. Share the detailed project plan with communities by conducting another wave of consultations with potentially affected villagers.

Recommendation 3 Ensure **consistent** and **meaningful** inclusion of local communities and other stakeholders at all stages of the project through continuous consultations and by providing proper feedback about any action taken.

Recommendation 4 Compensate fully all affected persons before any works.

Recommendation 5 As per people's suggestions, establish people's committees at a village level and ensure local labor on daily wages whenever practicable.

Recommendation 6 Involve local communities in the dhoras maintenance on paid basis whenever practicable.

Appendix – III

TECHNICAL SPECIFICATIONS

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1 General

1.1 Abbreviations

The following abbreviations are used in this Specification:

Ft, ft	foot	
RD	reduced distance (thousands of feet); 1 RD = 1000 ft; 5 RD = 1 canal mile	
RD_c	reduced distance along the Canal channel measured from head regulator	
RD_i	reduced distance along the Canal inspection path measured from theCanal head regulator	
mm	millimeter	
m	meter	
km	kilometer	
Area	sq.ft,	
ft^2	square foot	
sq.mm, mm^2	square millimetre	
sq.cm, cm^2	square centimetre	
Volume	cu.ft, ft_3	cubic foot
cu.mm, mm_3	cubic millimetre	
cu.m, m^3	cubic metre	
Discharge	cusec	cubic feet per second (ft_3/s)
Mass	lb	pound
kg	kilogram	
T	ton = 1000 kg	
Force	Kn	kiloNewton
Time	d	day
Hr, hr	hour	
Sec, s	second	
Other	dia	diameter
nr	number	
°C	degree Celsius	
°F	degree Fahrenheit	
%	per cent	
±	plus or minus	
GC	General Conditions of Contract	
PC	Particular Conditions of Contract	
ICB	International Competitive Bidding	
WSIP	Sindh Water Sector Improvement Project	

1.2 Brief Description of Works

This general specification is prepared for use on the ICB contracts for rehabilitation and improvement of the main and branch canals for Sindh Water Sector Improvement Project. The rehabilitation and improvement of the main and branch canals shall include inter alia the following:

a) Remodeling of feeder, main and branch canals.

b) (b) Re-forming canal sections including silt clearance and removal, strengthening of banks including stone pitching in vulnerable canal prism and inspection paths.

c) Rehabilitation and / or reconstruction of regulating structures and falls.

d) (d) Repair and / or replacement including providing, installation and motor station, of gates and embedded parts.

e) (e) Installation of gauges and control structures to measure flows in the main and branch canals and at the distributaries canal off-take points.

f) (f) Repairs and / or reconstruction of operational buildings near the regulators, field offices, operators quarter and guest houses;

g) (g) Rehabilitation and / or replacement of foot and road bridges.

h) (h) Construction of escape structures to avoid overtopping

i) Planting of trees in the right-of-way beyond the inspection and non inspection paths; and after care for one year.

j) (j) Restoration and / or replacement of markers showing distance from the head of the canal (RD markers)

k) Other crucial rehabilitation and improvement works identified during the design preparation.

Details of the works are given in the Drawings.

1.3 Mobilization for Construction of the Works

The Contractor shall mobilize all resources as required for construction of Works according to the ContractProvisions. The major items of mobilization are, but not limited to listed and described hereof. The

Contractor shall make his own assessment for provision and maintenance of mobilization and demobilization requirements and shall ensure their availability.

a) Mobilization of Contractor’s Equipment to the Site

b) Mobilization of Contractor’s personnel and labour at the Site

c) Provision of camps.

d) Provision of such administrative and field offices, as the Contractor considers necessary for his organization.

e) Provision of workshops, warehouses, sheds, and storage yards required by the Contractor for the proper and sufficient execution of the works.

f) Arrangements for supply of water for use in construction, including installation of the necessary wells, pumps, pipes, storage tanks, and suitable arrangements for the delivery of water at the various points of requirement.

g) Maintenance of temporary site facilities provided by the Contractor for performance in connection with the works.

h) Demobilization at the end of the defects notification period.

1.4 Shipment of Contractor's Equipment and Equipment to Site

The Contractor shall be responsible for shipment of plant, equipment and machinery required for the execution of the Work to the specified Site within the specified time.

1.5 Provision of Camps

The Contractor shall provide such camps as are required for the proper and efficient progress of the worktop house his own employees and to provide such Site office facilities for use of the Engineer and Employer in accordance with Chapter 23. The Contractor shall provide for a cold food storage area, food preparation and associated waste facilities as well as refectory for all employees. On the completion of the Works, the Contractor shall remove the said camps and facilities and reinstate the camp area. The Contractor shall be responsible for any damage caused by his lab our to trees and other utilities.

The Contractor's camps shall comply with the rules of the Pakistan Labour Camp Rules, 1960, issued bythe Pakistan Health, Welfare and local Government Department and the requirements therein set forth.

1.6 Provision of Contractor's Workshops and Warehouses

The Contractor shall provide workshops, warehouses, shades, and storage yards required by the Contractor for the proper and sufficient execution of the Works.

The Contractor shall provide, maintain, operate such temporary buildings as his staff quarters, stores, workshops, labour camps and other temporary buildings necessary for the execution of the Works at the place the Employer will provide. The Contractor shall submit site plans and general particulars of the prescribed buildings to the Engineer for his approval. The construction of the buildings shall not be started until his proposals have been approved by the engineer.

The Contractor's staff quarters and labour camps shall be provided with all necessary services for drainage, lighting, roads, and paths, parking places, fencing, sanitation, cook-houses, fire prevention and firefighting equipment. All labour camps, workshops and storage area shall be built on hard compacted ground with sufficient bunding and spill kits so as to prevent the loss or infiltration of leaked or spilt fluids into surrounding soils, ground water or water courses.

1.7 Latrines

The Contractor shall provide, maintain and cleanse sufficient latrines for the use by his employees. He shall ensure that his employees do not foul the Site but make use of the latrines.

1.8 Contractor's Power Supply

The Contractor shall make his own arrangements for electricity supply to the Contractor's office, his quarters, labour camp, workshop and stores and other temporary buildings.

1.9 Water Supply

The Contractor shall make his own arrangements for the supply of water for the purposes of the Works. The quality of the water shall be to the approval of the Engineer and suitable for the purpose for which it is intended. Waste water shall be disposed of clear of the Site so as to cause no damage or complaint.

1.10 Maintenance of Site Facilities of Contractor

The Contractor shall arrange service for all of his mobilization works, fixtures and equipment including provision of all water, electricity and sewerage and refuse disposal services, until the end of the Defects

Notification Period. The Contractor shall replenish consumable items as and when required. At the end of Defects Notification Period, the Contractor shall remove his camp and facilities and reinstate the camparea.

1.11 Drawings and Specification

The Drawings at the date of the Letter of Acceptance show the Works to be carried out in sufficient detail for the Contractor to fully plan his activities. However, the Drawings issued with the Contract shall not beused to construct the Works, as revised versions of these Drawings will be issued to be used for the construction of the Works.

The Contractor shall check the Drawings and Specification carefully and advise the Engineer, in writing, of any ambiguities, discrepancies, errors or omissions and a full instruction will be furnished to the Contractor should any ambiguities, discrepancies, errors or omissions be found. Although the Drawings are prepared to scale, work shall be based upon dimensions shown on the Drawings and not on dimensions scaled from the Drawings. Drawings when read in conjunction with the Specification and instructions that may be issued from time to time by the Engineer, will show sufficient dimensions, specific details and typical details to define the various features of the work, but the details necessary for the construction of any part of the Works may have to the deduced from several Drawings. Any additional drawings, which the Contractor requires to interpret how to construct the Works, shall be prepared by the Contractor. The Engineer may, from time to time, issue additional or revised Drawings to modify the Works.

1.12 Contractor's Working Drawings and Shop Drawings

The Contractor shall prepare and submit to the Engineer such working drawings and shop drawings asmay be necessary to illustrate his proposed designs and method of working.

The Contractor shall note that during the course of the contract information will be given by the Engineer in respect of individual structures to be constructed in accordance with issued drawings which show typical structures of the same form. The Contractor shall prepare from this information such working drawing as required for the proper setting out and construction of such structures. Work shall not commence on an individual structure until the relevant working drawing has been approved by the Engineer.

These working drawings and shop drawings shall:

Be prepared to appropriate scales and include plans, elevations and sections;

a) Consist of an electronic copy of the drawing (if available) in AutoCAD and PDF format, one print and one copy of design calculations, specification and parts catalogues;

b) Be signed by a qualified engineer responsible for the design, checked and approved by the Contractor prior to submission;

c) Bear the title of the contract package.

Within 60 days of receiving such working drawing and shop drawings the Engineer shall signify his approval or request modifications. The Contractor shall modify the designs and drawings, as may be required by the Engineer.

The Works shall be constructed in accordance with the approved working drawings and shop drawings, and a copy of such drawings shall be kept on the Site at all times until the completion of the Works. All drawings, on which changes are made, shall have the revisions clearly marked and dated.

Construction, fabrication or manufacture of any portion of the Works shall not commence until the design and drawings have been approved in writing by the Engineer and thereafter no change shall be made toany drawings so approved without the permission of the Engineer. Permission to make such changes shall be treated as a new submission under this Clause 1.12, and the requirements (a) through (d) above shall be met.

The approval of the working drawings and shop drawings by the Engineer shall not in any way relieve theContractor of his responsibilities under the Contract.

1.13 As Built Drawings

The Contractor shall prepare as built drawings as the works proceed. These drawing shall for the permanent record of the Employer and shall be in the form of soft and hard copies (black line/monochrome). Total number of prints shall be 10 (five on A1 size and five on A3 size) along with one soft copy on DVD in AutoCAD and PDF format. The drawings shall be readable on both A1 and A3 size for each drawing produced. The quality and format of these drawings shall be subject to the approval of the Engineer.

1.14 Right to Change

When additional information regarding the geological formations, or other conditions becomes available as a result of excavation, testing, model studies, or exploratory work, the Engineer may revise the Works to accommodate the newly disclosed conditions. The Contractor's Equipment shall be laid out and his operations shall be conducted so as to accommodate any such reasonable changes in the Works with no increase in cost to the Employer other than that due to changes in the measured quantities of the Works.

1.15 Datum of Levels

The levels shown on the Drawings refer to a system of bench marks previously established by the Irrigation Department based on a fixed datum level at Sukkur Barrage. For the purpose of these Works the datum to be used shall be a bench mark for which the Engineer will ascribe a value prior to the commencement of the Works.

1.16 Survey

From the bench mark specified in Clause 1.15 hereof, the Contractor shall check the levels of any existing temporary bench marks he proposes to use in setting-out the Works and shall establish additional benchmarks such that no level is transferred more than 3000 feet without being transferred to a bench mark. Bench marks shall be numbered and their construction shall be to the approval of the Engineer. The Contractor shall supply to the Engineer, in duplicate, maps and records in an approved form, giving details of the location (including coordinates) and level of each bench mark used or established by the Contractor. Levels shall be transferred and ascribed to the bench mark within an accuracy of 0.25 inches, where m is the length in miles of the leveling circuit. Bench mark coordinates shall be determined to within an accuracy of 1 in 4000 of the length of the levelingcircuit. Where required, the Contractor shall submit to the Engineer lists of original ground surface levels for the purpose of measurement of earthwork operations.

The method of surveying shall be to the approval of the Engineer. Field books and tabulated data shall he well maintained and made available to the Engineer for inspection when ordered.

1.17 Program

Before commencing the Works the Contractor shall submit to the Engineer for his approval a program including the Gantt chart prepared in MS Project software, showing the order in which he proposes to carry out the Works. The Contractor shall revise this program as necessary to ensure completion of the Works within the time periods stated in the Contract. The Contractor shall submit three hard copies, an electronic copy and one copy as a pdf file. The programme shall include the following details:

i. Details of the Contractor's methods of working for all operations;

ii. Narrative statement giving the numbers and categories of supervisory and technical staff and skilled and unskilled labour to be employed on the Works;

iii. A list and type details of major Contractor's Equipment (including vehicles) which the Contractor

iv. Proposes to employ on the Works;

v. A statement giving the proposals for location or locations and sizes of base camps, accommodation, offices, workshops, stores and working areas.

Each Gant chart shall:

- Be prepared using the critical path method
- Show the assumed or actual commencement date
- Show the start and finish date and float (if applicable) for each activity
- Show the interdependencies between activities
- Have each activity 'resource loaded' with labour, materials, equipment and be accompanied by print outs of planned and actual resource usage
- show the progress achieved on each activity
- show a clear critical path

The Contractor shall prepare and submit method statements for approval by the Engineer prior to starting any new activity or section of the Works, or at such other time that the Engineer may reasonably require.

1.18 Notice of Operations

The Contractor shall give full and complete written notice, of all important operations to the Engineer, sufficiently in advance to enable the Engineer to make such arrangements as the Engineer may consider necessary for inspection and for any other purpose. The Contractor shall not start any important operation without the written approval of the Engineer.

1.19 Working Hours

The Contractor shall plan his work on the basis of a six-day working week, and within the hours of 6:00 am and 6:00 pm. Should the Contractor require additional working hours, or weekend working, he shall submit a request to the Engineer for permission to work extended hours, giving full reasons for the requests.

Approval to such requests will not be granted on a regular basis, but only in exceptional circumstances.

1.20 Staffing

The Contractor shall employ a full time, qualified Environmental Coordinator for the project who is conversant with national legislation related to the environment and with the World Bank's environmental safeguard policies.

The Contractor shall employ a full time, qualified Human Resource Officer for the project who is conversant with the Ministry of Labour and Manpower laws and their objectives related to:

a) Formulation of a progressive and dynamic Labour and Manpower Policy;

b) Human Resource Development, focus on education, training and skill development;

c) Respect for human rights, gender balance, eradication of child and bonded labour;

d) Promotion of dignity of labour;

e) Promotion of social dialogue among the stake holders;

f) (f) Coordination with the Provincial Governments, International LabourOrganization (ILO) and other international agencies.

The Contractor shall employ a full time, qualified Community Liaison Officer for the project who is conversant with the World Bank's social safeguard policies and can address resettlement, consultation and stakeholder communication, grievances and other community liaison issues that arise according to the project action plans.

The Contractor shall employ a full time, qualified Health and Safety Office for the project who is conversant with national legislation on occupational safety and work environments, and with the Ministry of Labour and Manpower and other ministry requirements and can manage and mitigate health and safety issues according to the Health and Safety Plan and the project action plans.

The Contractor shall provide sufficient staff with appropriate skills who are regularly available in SindhProvince for adequate management of environmental, social and community liaison issues. The Contractor shall agree to not use any child labour or exploitative or forced labour. The Contractor shall not allow anyone under 18 years of age to carry out dangerous occupational tasks.

1.21 Training

The Contractor shall prepare a training plan within three months of the Commencement Date which provides all personnel with adequate information, instruction and training on environmental and social awareness and skills to implement the method statements. Training activities shall be recorded and reported on monthly. The Contractor shall update the training planning annually.

The Contractor shall organize induction training for all staff. The Contractor shall not allow staff on site without having undergone induction training.

The Contractor shall ensure employees are trained in the proper use of equipment in their care to minimize the risk of accidents.

1.22 Code of Conduct

The Contractor shall develop a Code of Conduct within three months of the Commencement Date which outlines expectations regarding staff and:

a) Proper use of Personal Protective Equipment (PPE) that has been provided;

b) No poaching of illicit use of local natural resources;

c) Discreet sexual behavior that takes into consideration HIV / AIDS messages;

d) Respect for the local community and its cultural norms;

e) Presentation of professional behavior and integrity when dealing with the public.

The Contractor shall ensure that each member of staff signs the Code of Conduct or provides a written explanation of why they have elected not to sign it.

1.23 Communication Strategy and Stakeholder Management

The Contractor shall establish a Communication Strategy within one month of the Commencement Date. The Communication Strategy shall detail stakeholders and their information, disclosure, consultation and

participation requirements. The Communication Strategy shall include the use of various media for providing information (for instance face to face meetings, leaflets, website and radio) and receiving comments (for instance telephone, fax, face to face meetings, text and email).

The Contractor shall establish a database for recording and tracking stakeholder complaints, accolades and comments. The database shall begin functioning within two months of the Commencement Date and a summary of the stakeholder comments shall be provided to the Engineer on a monthly basis. The Contractor shall prepare a progress report on an annual basis which summarizesproject achievements and performance information for SIDA.

The Contractor shall provide key stakeholders with contact details for liaison regarding their own activities which interface with the project activities.

1.24 Suppliers of Materials

Before ordering a material of any description intended for the Permanent Works, the Contractor shall submit for the approval of the Engineer the name of the maker or supplier proposed and details of the place of origin and specification of the material. If requested by the Engineer, the Contractor shall supply to the Engineer for his retention a copy of any such order placed.

1.25 Natural Materials

The Contractor shall make all arrangements for the location, selection and processing of natural materials to comply with the Specification. The Contractor shall obtain any specific approvals and permission for the excavation/abstraction of all materials. Before commencement of any works or request for approval from the appropriate authority the Contractor shall submit to the Engineer full set of material and source information regarding the proposed location for approval. This information should be submitted to the Engineer, well-in advance of commencement of working of the material. Approval of a source shall not imply that all the material in that source is approved.

1.26 Disruption of Local Communities and Maintenance of Existing Irrigation Flows

The Contractor shall take all measures necessary to avoid nuisance and disruption to local communities. In particular the Contractor shall ensure no damage is done to crops, pasture or woodland and outside the area for which the Engineer's approval for bush clearance has been given, that all irrigation supplies to such areas are maintained and that the Contractor's operations do not cause flooding or pollution hazards.

The Contractor shall note that the inspection and non-inspection paths along the canal are used by the Employer’s staff for canal operation, inspection and maintenance purposes. The contactor shall allow for continued use of the inspection and non-inspection paths by the Employer during the construction of the Works.

The Employer permits public access to parts of the inspection and non-inspection paths along the canals. The Contractor shall allow for the continued public use of these paths where permitted by the Employer. Irrigation is carried out in parts of the project area. In the course of construction of the Works the Contractor shall not interrupt the water supply to an existing irrigation consumer or reduce it below the flow normal for the growing crops, taking into account the time of year, without the recorded and witnessed consent of the consumer.

Before commencing any work which could cause interruption to the existing irrigation supplies the Contractor shall submit, in accordance with Clause 1.17 hereof, full details of his proposed methods of maintaining such supplies.

The canal system is closed for a two to three week maintenance period each year. The Contractor shall program the work to utilize the closure period for works which require interruptions in the irrigation supplies. The dates of the closure period are provided in the Particular Specification.

The Contractor shall ensure that road and pedestrian access across the canal is maintained at all locations where existing crossings are present or in a reasonable location close to the existing crossing.

1.27 Archaeological Findings

The Contractor shall not trespass, excavate in or otherwise disturb graveyards whether shown on Drawings or not. In the case of unidentified graveyards or burial sites, the Contractor shall notify the Engineer in writing and the Engineer shall makes such design changes as required.

1.28 Landscape Preservation

The Contractor shall exercise care to preserve the natural landscape and shall conduct his construction operations so as to prevent any unnecessary destruction, scarring or defacing of the natural surroundings in the vicinity of the work. Except where clearing is required for permanent works, for approved construction roads and for excavation operations, all trees, native shrubbery, vegetation, fences and walls shall be preserved and protected from damage which may be caused by the Contractor's construction and restoration operations and equipment. Movement of crews and equipment within the canal reservation and over routes provided for access to the work shall be performed in a manner to minimize damage to grazing land, crops or property.

1.29 Water Pollution

a) The Contractor shall comply with applicable regulations concerning the control and abatement of water pollution as follows:

b) The Contractor's construction activities shall be performed by methods that will prevent entrance or accidental spillage, of solid matter, contaminants, debris and other objectionable pollutants and wastes into flowing streams, flowing or dry watercourses, lakes and underground water sources.

c) Sanitary wastes shall be disposed of in the soil by burial at approved sites or by other approved methods.

d) The Contractor will provide suitable sanitary facilities for the use of his personnel.

1.30 Disposal of Waste

Waste materials including, but not restricted to, refuse, garbage, sanitary wastes, industrial wastes, and oil and other petroleum products shall be disposed of by the Contractor. Disposal of waste materials shall be by burying, where burial of such materials is approved by the Engineer; by burning where burning of such materials is permitted in accordance with local laws; or by removal from the construction area.

The Contractor shall comply with air quality requirements as set by law and shall not burn any materials which may lead to the release of toxic or hazardous substances. All waste materials shall be handled, stored and disposed of in compliance with the Site Environmental Management Plan and with all relevant legislation.

All materials to be burned shall be piled in designated burning areas in such a manner as will cause the least fire hazards. Burning shall be thorough and complete and all charred pieces remaining after burning, except for scattered small pieces, shall be removed from the construction area and disposed of. The Contractor shall, at all times, take special precautions to prevent fire from spreading beyond the piles being burned and shall be liable for any damage caused by his burning operations.

Disposal of material by removal from the construction area shall be accomplished prior to the completion of any section of the Works. All materials removed except trees, shall become the property of the Contractor. Materials to be disposed of by dumping shall be hauled to an approved dump.

Trees and bushes cleared from the construction area shall be placed at the edge of the construction area or canal reservation. The Employer shall arrange the use and disposal of the wood. Where large trees are

tobe removed then the Engineer will determine how the trees are to be cut and removed and at the sometime try not to impede the progress of the Works. All trees, tree roots and bushes not required by the Employer will be burned or removed from the construction area by the Contractor.

1.31 Site Environmental Management Plan

All work executed by or on behalf of the Contractor in the performance of the Works shall be in accordance with a Site Environmental Management Plan (SEMP). The Contractor shall provide a draft copy of the SEMP for the approval of the Engineer prior to the commencement of works on site.

The SEMP shall address the specific issues contained below in Appendix B.

The Contractor shall ensure that the work of all sub-contractors is subject to the requirements of the Contractor's SEMP.

The supervision of the SEMP of the Contractor shall be subject to audits undertaken by the Employer and the Engineer. Such audits will include a review of the Contractor's internal audit records including identified non-conformities and the effectiveness of the corrective action. The Contractor shall be provided with ten working days' notice prior to an audit being carried out.

On a day-to-day basis, the Contractor shall afford reasonable availability of staff and documentation for the Engineer to assess implementation of the SEMP.

1.32 Grazing of Livestock

The Contractor shall provide reasonable care by hiring watchmen to ensure that livestock are not allowed within the canal reservation during the operations.

1.33 Wildlife

The Contractor shall take all necessary precautions to prevent danger to wildlife. The Contractor shall fully cooperate and assist as necessary with any protection plans developed by state authorities to avoid damage to or disturbance of wildlife.

1.34 Safety

All work executed by or on behalf of the Contractor in the performance of the Works shall be in accordance with the approved Health and Safety Plan, the contents of which shall include the topics set out in Appendix C. The Contractor shall observe high standards of safety for men and machines at all times and with regard to safety shall, inter alia, comply with local laws and ensure strict adherence to the following:

a) The Contractor shall take appropriate precautions where personnel are required to work in confined spaces and other hazardous areas, and to only permit employees to work in confined spaces or other hazardous areas when there are adequate and continuous communication links with colleagues equipped to provide emergency assistance.

b) The Contractor shall protect men working in trenches from cave-ins by the proper shoring or sloping of trenches, and shall take special care of persons working in the trenches, and prohibit individual employees from working alone in trenches.

c) The Contractor shall protect personnel from the moving parts of the machines by installing and maintaining proper guards.

d) The Contractor shall not permit casual observers close to excavating operations.

e) The Contractor shall provide adequate fencing around the working areas.

1.35 Utilities

The Contractor shall locate on the site all utilities whether or not they are indicated on the Drawings and to make the necessary arrangements with the utilities authorities for any work in the vicinity of the utilities and or diversions of the utilities.

1.36 Medical Facilities

A qualified doctor / paramedic shall be appointed on site and adequately equipped and properly staffed portable first aid stations or dispensaries shall be provided by the Contractor at camps and other strategic locations, to administer first aid treatment at any time required and free of charge to all persons on the Site, including personnel of the Engineer and the Employer. The nature, number and location of facilities furnished and the Contractor's staff for administering first-aid treatment shall, as a minimum, meet the requirements of the Health Service of the Government of Pakistan.

1.37 Radio, Use of

If the Contractor wishes to employ air wave radio transmitting equipment for communications he shall submit details of the power and frequency of transmission proposed and shall obtain prior written consent to such use from the Engineer.

1.38 Operation and Maintenance Instructions

The Contractor shall provide operation and maintenance instructions for Plant, including instrumentation, to be supplied and installed for the Works, it is intended that these instructions will be incorporated in the operator's maintenance manuals for the Works to be compiled by the Engineer and to this end they shall be in loose leaf form on A4 paper. All operating and maintenance instructions shall be in English.

Operation and maintenance instructions shall be submitted as drafts for examination and approved by the Engineer prior to final issue and shall be ready for issue prior to taking over of the Works by the Employer.

Five copies of the operation and maintenance instructions shall be supplied by the Contractor to the Engineer. Completion will not be certified until the instructions are supplied.

Manufacture's advertising literature and advertising catalogues will not be acceptable for operation and maintenance instructions, but may be included for information.

Operation and maintenance instructions shall generally take the following form and shall contain the following information:

a) Step-by-step procedures for any operation likely to be carried out during the life of the Plant;

b) Maintenance and troubleshooting information, including charts showing lubrication, checking, testing and replacement procedures to be carried out daily, weekly, monthly and at longer intervals;

c) Technical details;

d) Description of the installation;

e) Complete parts list.

The instructions shall have a hard cover bound with the name and title of the installation clearly marked on it. The instructions shall be properly indexed and contain dividers with tabs between each section. All data must be organized in a neat and concise manner. All data must also be supplied in electronic form to a format approved by the Engineer.

1.39 Taking over of Contractor's Equipment

The Employer reserves the right to either take over major items of equipment used by the Contractor, or assign operation and maintenance-tasks to the Contractor for a renewable two year period. If the Employer wishes to exercise his right to either take over equipment or to assign operation and maintenance tasks to the Contractor, he shall give notice to the Contractor not later than 84 days before the Completion Date of the Contract.

After giving notice to takeover equipment, the Employer shall request the Engineer to commission condition and valuation surveys of all Contractor's Equipment. The appointed surveyor shall be an independent specialist surveyor of construction plant.

The survey shall establish the condition of the Contractor's Equipment in general, any necessary repairs to bring it in to a condition commensurate with its age and the cost thereof and the replacement costs on an 'as is' (before repair) basis. The survey shall also give an indicative price for the sale value of the Contractor's Equipment on an 'as and where laying' basis.

This survey shall be completed by not later than 63 days before the end of the Time for Completion. In the event that the Employer takes over Contractor's Equipment, the Contractor shall arrange to supply such spare parts as shall reasonably be expected to be required during the two years following take over. The requirement for, and value of, such spare parts shall be audited by the surveyor engaged as described above.

In the event that the Employer exercises his right to take over equipment or assign operation and maintenance tasks to the Contractor for, a renewable two year period a separate agreement between Employer and Contractor shall be drawn up to cover the means and terms of measurement and payment therefore and such other terms as may be agreed. The basis of this agreement shall be the obligations and rights as set out in this Contract, the valuation of Contractor's Equipment and spares as determined by the independent surveyor engaged as described herein and, for operation and maintenance tasks, the equivalent rates as applicable under this Contract adjusted for reallocation of overheads and other on-costs and for changes in costs and prices as applicable to the tasks undertaken.

1.40 Tests on Completion

1.40.1 Requirement Preparatory to Final Inspection

The Contractor shall request the Engineer to perform a preliminary final inspection for the purposes of determining the state of completion. He shall notify the Engineer at least seven (7) days in advance of when this inspection is to be performed. From the information gathered from this inspection, the Engineer will prepare a "punch list" of work to be performed, corrected, or completed before the Works will be accepted. All work on the "punch list" shall be completed by the Contractor prior to final inspection. The following are also required for the Works to be considered complete:

1. All temporary facilities shall be removed from site, unless directed otherwise by the Engineer.
2. All operating instructions for equipment shall be properly mounted and posted as specified or required.
3. All guarantees and warranties shall be submitted to the Employer in care of the Engineer, as specified in the various sections of the Specifications, along with required or printed maintenance instructions and manuals.
4. Tests on gates as detailed in Chapter 17 and Chapter 18.

1.40.2 Final Inspection

After all requirements preparatory to the final inspection have been completed, the Contractor shall notify the Engineer and Employer to perform the final inspections.

The Contractor shall accompany the Engineer on the final inspection, together with any subcontractors that the Engineer may request to be present, If the works have been completed in accordance with the Contract, and no further corrective measures are required the Engineer will issue a Taking-Over certificate.

2 The Site

2.1 Site Location

The Sindh Water Sector Improvement Project comprises of various components for the improvement and rehabilitation of irrigation in Sindh province of Pakistan. The Site Location is stated in the Particular Specification.

2.2 The Site

The Site shall be that area as defined in Clause 1.1.6.7 of the Conditions of Contract and stated in the Particular Specification the site of work and as may be required to commence and proceed with the works, when the Engineer's order to commence work is given.

The Contractor shall maintain the Site in a neat, tidy and healthy condition and free from accumulation of waste or rubbish. The site should comply with good health and safety standards at all times and as per the minimum conditions set out in the Site Environmental Management Plan (EMP).

2.3 Cooperation with other Contractors

The Contractor shall note the following stipulation with regard to multiple uses of the Site.

i) It is in the nature of the Works that parts of the site may be required from time to time by contractor for other contracts. It will also be necessary for there to be access across the site byothercontractors. The boundary of parts of the site coincides with or is near to the boundaries of the sites of one or more of the said other contracts and work on them may be concurrent with that of the Contractor. Notwithstanding the provisions of Clause 4.6 of the General Conditions of Contract, the Contractor shall not be entitled to a Variation in respect of such circumstance as are described above and provided for in this Clause.

ii) In the event of another contractor wishing to make use of or occupy a part of the site for the purpose of his contract the Engineer will inform the Contractor.

iii) Similarly, in the event of the Contractor wishing to use or occupy from a certain date land in the possession of another contractor carrying works for the Employer, he shall not less than 30 days and not more than 60 days before the said certain date, request in writing to the Engineer that he inform the other contractor accordingly.

iv) In either of the events described in (ii) an (iii) above the Contractor and the other contractor shall confer and reach agreement on a mutual adjustment of programs and inform the Engineer so that the possession of the relevant part of the site may be transferred from one to the other for an agreed period or failing such agreement the mattered shall be referred to the Engineer whose decision shall be accepted by both parties.

v) In the event of the possession of part of another contractor's land being transferred as aforesaid to the Contactor, the Contractor's obligations in respect thereof shall be as if that part were a portion of the Site.

vi) The provisions in sub-paragraph (i) to (v) above have been and shall be incorporated in the terms of the other relevant contracts.

2.4 Other Contracts Affecting the Contract

Other contracts affecting the Contract are as stated in the Particular Specification.

2.5 Access to the Works

Right of way for access to the Works from existing roads shall be provided by the Contractor through his own arrangements. The Contractor shall make his own investigations of the condition of available public or private roads and of clearance, restrictions, bridge load limits and other limitation that affect or may affect transportation and ingress and egress at the job sites, and shall bear all responsibilities in that respect.

Before the commencement of any part of the Works the Contractor shall make temporary access tracks including all necessary temporary diversions and bridge works to the part of the Site concerned, both for the Contractor's own access and for the maintenance of public access, all to the approval of the Engineer.

The Contractor shall maintain such access tracks in a condition suitable for the safe and easy passage of Contractor's Equipment, vehicles, and pedestrians until these tracks are no longer required for the purposes of the Works. Other contractors may use such access. The Contractor shall also provide and maintain temporary drainage and shall divert and reinstate permanent drainage systems.

The Contractor shall make a record to be agreed by the Engineer of the condition of the surfaces of any private lands or any public cultivated or maintained lands over which access for the Site lies before use for access and he shall keep such surfaces in a reasonable state of cleanliness and repair. On the termination of the Contractor's use of such access he shall restore the surfaces to a condition at least equal to that found before his first entry on them.

2.6 Haul Routes

The hauling of materials and other hauling and transportation over public highways, roads and bridges shall be in compliance with local regulations. Where haul routes cross public highways or roads, the Contractor shall provide barricades, flagmen and other necessary precautions for safety.

2.7 Damage to Canal and Drain Banks and Operating Roads

The Contractor shall limit his loads, speeds, and hauling operations over the existing roads so as to minimize damage to other existing facilities. Ruts and scars resulting from the Contractor's operations shall be repaired and any damage to drain and canal embankments shall be promptly corrected.

2.8 Reservation Width

The land lying wholly within the reservation width shall be construed to be the area available to the Contractor for the construction of the individual Works indicated on the Drawings, otherwise known as the Site. The Contractor shall not have a right of access to such land ahead of undertaking construction in that part of the Works but permission to use the land for access may be granted by the Employer through the Engineer.

The reservation width is measured from the outer toe of the embankment on either side of the canals. The reservation widths are shown in Table 2.1 below:

Table 2-1**: Reservation Width**

Canal	**Reservation Width(ft)**
Main Canals	20
Branch Canals	20
Distributaries Canals	20
Minor Canals	20

The Contractor shall not borrow nor place spoil outside the reservation width without the Engineer's written permission.

2.9 Restoration of Disturbed Lands within Reservation Width

The Contractor shall restore the surface of the lands disturbed by the Work within the reservation width as close as possible to its condition as the Commencement Date. Upon the Contractor's application the Engineer will agree a schedule of conditions before the Contractor's entry.

2.10 Clearance of Site

The Contractor shall clear the Site to the extent required by the Engineer for checking setting-out. The Contractor shall also clear the parts of the Site to be occupied by the Works of all vegetation and artificial obstructions.

The Contractor shall fill and make good with appropriate material those cavities and losses of soil which result from clearing for setting-out as specified in this Clause. The material arising from such clearance shall be removed from the Site and disposed of by the Contractor.

The Contractor shall make periodic clearance of vegetation as is necessary to preserve the amenity and appearance of the neighborhood of the Site.

3 Material and Workmanship

3.1 Sampling and Testing

i) The Contractor shall keep records of all the tests he conducts in compliance with the Specification or as required by the Engineer and shall submit copies of the results of such tests to the Engineer.

ii) The Contractor shall not use for his own purpose any testing equipment supplied for the Engineer's laboratory unless expressly permitted to do so by the Engineer.

iii) Samples required for tests in the Engineer's laboratory, or in a laboratory approved by the Engineer, shall be supplied and delivered by the Contractor in appropriate containers, suitably packed and labeled.

iv) The Contractor shall supply, install and service the equipment specified in the Contract for use in the Engineer's laboratory to the extent order by the Engineer.

v) Tests in the Engineer's laboratory shall be carried out by the staff of the Engineer or the laboratory technician supplied by the Contractor in accordance with Clause 23.15 hereof under the direction of the Engineer.

vi) Tests required by the Engineer may be carried out at the Engineer's laboratory or a laboratory approved by the Engineer. Tests carried out in the Engineer's laboratory will be made using the equipment supplied under the Contract and no additional payment will be made for carrying out the tests. Where specified or ordered by the Engineer, the Contractor will arrange for additional tests to be carried out at a laboratory approved by the Engineer. If at any time a test cannot be carried out in the Engineer's laboratory due to a malfunction of the laboratory equipment maintained by the Contractor the test shall be carried out in an approved laboratory at the Contractor's expense. The Contractor shall maintain the equipment supplied under the Contract in full working order and shall hand over the same in this condition to the Employer at the end of the Defects Notification Period or at such earlier time as the Employer may require. The Contractor shall also supply and maintain such number of sample containers for the tests as is necessary to meet the requirements of the Engineer's testing program.

3.2 Testing Plan

Before the commencement of work at site the Contractor shall submit a testing plan indicating methods, standards, frequency of tests for the approval of the Engineer. The testing plan may be revised with the permission of the Engineer when required.

The testing plan shall also include all tests to be performed as specified in all the chapters of the specification unless otherwise stated.

3.3 Equipment for the Engineer's Laboratory

If ordered, the Contractor shall provide and maintain all the equipment and materials required to carry outthe following tests. ASTM and AASHTO Standards may also be used by the Contractor with the approval of the Engineer.

(a) Soil Testing (the numbers given in brackets refer to the tests as specified in BS 1377:1990):

i) Determination of moisture comment (IA)

ii) Determination of liquid limit (2A)

iii) Determination of plastic limit (3)

iv) Determination of plasticity index (4)

v) Determination of linear shrinkage (5)

vi) Determination of specific gravity of soil particles (6A or 6B)

vii) Determination of particle size distribution (down to sieve size 200) (7A)

viii) Determination of particle size distribution (fine grained soils) (7D)

ix) Determination of sulphate content of soil and groundwater (9) and (10)

x) Determination of dry density/moisture content relationship (12)

xi) Determination of dry density of soil on the Site (I5B), ASTM D1556, and D 1558.

xii) Modified Proctor Test ASTM D1557 T-180.

(b) Concrete Testing (the part number refers to the tests or procedures specified in BS 1881):

i) Slump test - Part 102: 1983

ii) Making and curing test cubes -Parts 108:1983 and 111:1983

iii) Compressive strength test – Part 116:1983

(c) Fine and Coarse Aggregate Testing (the part, section and paragraph numbers refer to the tests specified in BS 812):

i) Flakiness Index -Part 105: Section 105.J:1989

ii) Elongation Index - Part 105: Section 105.2: 1990

iii) Particle size and grading - Part 103: Section 103.1: 1'985

iv) Silt content by field settling test - Part 103: Section 103.2: 1989

v) Chloride content - Part 117:1988

vi) Aggregate moisture Content - Part 109:1990.

3.4 Concrete Sampling and Testing

The Contractor shall provide samples of concrete and its constituent materials either for testing by himself or on behalf of the Engineer or for testing at the Engineer's or a laboratory approved by the Engineer. Samples may also be taken by the Engineer for testing at the Engineer's laboratory or a laboratory approved by the Engineer. Concrete test cubes, which shall be made in accordance with BS 1881, shall be deemed to be samples for the purpose of this Clause. All sampling of constituent materials shall be carried out in accordance with the provisions of the appropriate British Standard, and all sampling of fresh and hardened concrete shall be carried out in accordance with the Provisions of BS 1881 unless such provision is at variance with the Specification hereof.

Details of such samples shall be recorded by the Contractor and passed to the Engineer. The Engineer will make available to the Contractor the results of each test carried out on the samples provided. The tests which the Contractor is required to undertake himself, on behalf of the Engineer, are those to be carried out on fresh concrete at the place of final deposit, or elsewhere in the Site as directed by the Engineer.

The Contractor shall also test aggregates for moisture content and so determine the water / cement ratio of the fresh concrete. Determinations of water / cement ratio shall be carried out as required by the Engineer and the results and calculations submitted to him.

The Contractor shall until the end of the Defects Notification Period (or such earlier date as directed by the Engineer) supply, service and operate the necessary apparatus for sampling concrete and its constituent materials in accordance with the requirements and for slump tests on fresh concrete as described above.

Sampling of fresh concrete for concrete test cubes shall be carried out, whenever possible, at the place of deposition in the Works. From each such sample three (3) such cubes shall be made. Each cube shall be marked indelibly for identification when it is in the mould. After retention at the place where they are made for 24 hours, the cubes shall be delivered to the Engineer's laboratory for removal from their moulds, curing and testing. Moulds shall be returned to the Contractor for re-use. Sampling fresh concrete for such cubes shall be carried out by the Contractor in accordance with a sampling plan approved by the Engineer in accordance with the following principles.

The frequency of sampling for each class of concrete from each batching centre in each active day to be at a rate of:

(a) one sample from one batch of every 10 batches: or

(b) one sample per-350 cubic feet of concrete; or

(c) one sample,

Whichever involves the greatest number of samples.

When more than 700 cubic feet from one batching centre is placed in one location in one day, the rate of sampling may be decreased, with the approval of the Engineer, to one sample from one batch of every 20batches or one sample per 700 cubic feet of concrete, whichever involves the greatest number of samples.

The actual rate of sampling may vary to the approval of the Engineer according to the random selection of batches to be sampled and shall be increased when ordered by the Engineer in appropriate circumstances.

In addition to his other duties in connection with the sampling and testing of concrete, the Contractor shall provide the instruments for, and record the temperatures of the concrete and concrete materials, as required by the Engineer, and copies of such records shall be supplied to the Engineer.

3.5 Sampling

The Contractor shall provide for the approval of the Engineer samples of all construction materials and manufactured items required for the Permanent Works specified herein and in all chapters of these Technical Specifications, if ordered. All samples rejected by the Engineer shall be removed forthwith from the Site. All approved items shall be stored on the Site by the Engineer with assistance of Contractor for the duration of the Works under conditions which will prevent deterioration of the approved sample. Any materials or manufactured items subsequently delivered to the Site for incorporation in the Permanent Works shall be at least equal to the approved sample.

3.6 Records

The Contractor shall keep full and proper weekly records of the operation, production and progress of each item of Contractor's Equipment, including details of the ground and conditions of working and shall copy such records to the Engineer on a regular basis.

3.7 Quality of Materials

All materials, fixtures, fittings, and supplies furnished by the Contractor shall be new and unused, of standard first-grade quality and of the best workmanship and design. No inferior or low grade materials, supplies or articles will be either approved or accepted, and all work of assembly and construction shall be done in a first class and workmanlike manner.

Prior to procurement, the Contractor shall furnish to the Engineer, for his approval, the names of the manufacturers of all equipment and materials which he contemplates incorporating in the Works. With this information the Contractor shall also furnish such pertinent information as to capacities, efficiencies and sizes, and such other information as may be required by the Engineer. Samples of materials shall be submitted to the Engineer for approval when so directed. Equipment, materials, supplies and articles installed or used without the Engineer's approval shall be at the risk of subsequent rejection.

3.8 Standards and Specifications

Except where otherwise specified all materials and workmanship shall conform with the requirements of the relevant British Standards and British Standard Codes of Practice hereinafter referred to as latest BS or CP) issued by the British Standards Institution. Other equivalent National or International Standard Specifications may be substituted at the sole discretion of the Engineer or as may have been agreed in the Contract. A list of the relevant standards is included as Appendix A to this specification.

Where relevant British Standards and Codes of Practice now quote metric units only, these are to be interpreted, if so required, as the nearest equivalent imperial (foot / pound) unit.

The Contractor shall obtain and keep on Site at least one copy of each BS, CP or other approved Standard and reference work which is referred to in these Specifications, and of each other Standard which applies to materials which are being supplied to, or workmanship executed on, the Works, save that if the Engineer is in possession of any Standard, further copies may not be required, as the Engineer shall determine.

These Standards and reference works shall be supplied to the Engineer within 40 days of the Engineer's instruction.

If the Contractor, at any time and for any reason, wishes to deviate from the above standards or desires to use material or equipment not covered by the above standards, he shall state the exact nature of the changes, the reason for making the change and shall submit complete specifications of the materials and equipment to the Engineer for approval as a proposal under Clause 13.2 of the Conditions of Contract(Value Engineering).

3.9 Inspection and Tests

All equipment and materials furnished under these Specification and all work performed in connection therewith will be subject to rigid inspection by the Engineer. Inspection at the manufacturer's plant willsbeamed to determine that the equipment and materials meet the requirements of these Specifications. The Contractor shall notify the Engineer not less than 14 days in advance of the date and place that the equipment or materials will be available for inspection. No equipment or material shall be transported until inspection by the Engineer at the manufacturer's plant has been made and final drawings have been furnished by the Contractor and accepted by the Engineer. Acceptance of equipment and materials or the waiving of inspection thereof shall in no way relieve the Contractor of the responsibility for furnishing equipment and materials meeting the requirements of the Specification.

4 Site Investigations

4.1 General

4.1.1 Equipment

The Contractor shall make available the following items of equipment until the end of the Defects Notification Period:

(a) 6 inch diameter auger. 30 ft length of extension rods, auger hole casing and spare auger bit:

(b) 6 inch minimum diameter percussion borehole rig with sufficient equipment to penetrate 70 ft

(c) Equipment for taking both disturbed and undisturbed soil samples, and water samples; and

(d) Sample containers.

Where specified or ordered by the Engineer, the Contractor shall investigate and take samples of the material and water in and about the earthworks and structures. Investigation will be by auger, borehole or trial pit. The precise location and method of investigation and sampling will be ordered by the Engineer in each case. The Contractor shall employ staff experienced in site investigation to undertake the site work.

4.1.2 Method of Work

The investigations will be undertaken in accordance with BS 5930: 1999 and BS 1377: 1990.All containers holding samples shall be securely and indelibly labeled with a reference number, trial hole number, and depth of sampling. Samples shall be delivered to the Engineer's laboratory or the laboratory approved by the Engineer, as appropriate; those for the Engineer's laboratory shall be delivered not later than 24 hours after sampling.

The trial pits shall be excavated as directed by the Engineer and shall be kept open for as long a period as the Engineer may direct during this time adequate safety precautions are to be taken and the pits are to be cleared of standing water when required

Auger holes and boreholes may be required from original ground, in the bottom of trial pits, or in any excavation, as directed by the Engineer. Auger holes will generally be required to penetrate 15 ftdepth which will usually be below the existing water table.

4.1.3 Records

The Contractor shall make a detailed record in the field at the time of each Investigation in a form approved by the Engineer, of all sub-soil investigations made by the Contractor. These records shall include a description of the materials encountered and their depth. A copy of each record shall be submitted to the Engineer not later than the day following that to which the records refer. The descriptive record should accord with the recommendations of BS 5930: 1981.

Each record shall show the level of the ground at the commencement of the investigation referred to the datum specified in the Clause 1.15. It shall also record the level where water was first encountered, other relevant water levels, the depths at which samples were taken, and the reference numbers of the samples.

Upon completion of each investigation, the Contractor shall prepare and submit five hard copies and softcopy in PDF format of the investigation record in a form agreed with the Engineer, which shall include the results of the tests undertaken at the Engineer's laboratory and laboratories approved by the Engineer as notified to the Contractor by the Engineer.

4.2 Purpose of Investigations

The purpose of the soil investigations specified herein is to determine the extent and nature of the principal soil strata, their arrangement, thickness and texture, and obtain samples of various soils for identification and testing at specified locations. This investigation shall be achieved by rotary or percussion drilling, augur boring and the excavation of soil test pits and the testing of soil and water samples.

4.3 Locations of Exploratory Holes and Test Pits

The location, total number and the depths to which holes are to be drilled and the test pits are to be excavated shall be shown on the Drawings.

4.4 Order of Work

The order in which the work is to be accomplished will be determined by the Engineer.

4.5 Drillers and Supervisory Staff

The Contractor shall have at the site, during drilling operations, only qualified, experienced, orderly and thoroughly competent persons including Engineer / geologist who shall conduct and supervise drilling operations, sampling, logging and in-situ testing.

4.6 Boreholes and Samples

4.6.1 Location of Boreholes

The actual location of Boreholes shall be established in the field by the Contractor on the basis of the Drawings. The Contractor shall locate the holes accurately in the field. The Contractor shall carry out leveling surveys and provide accurate ground elevation and co-ordinates for each hole. The elevations shall be given with respect to the bench marks established at site by the Employer.

4.6.2 Diameter and Depth of Boreholes

The boreholes shall not be smaller than four inches (100 mm) size and as instructed by the Engineer at their deepest point of penetration. Borings shall be made by the Contractor at least to the elevation directed by the Engineer. The Engineer may direct that the position, the number, and the depths of boreholes, are changed during the progress of the work.

4.7 Containers

The Contractor shall furnish jars, tubes, boxes, bags and crates meeting the requirements as required. All such containers shall become the property of the Employer.

4.8 Care and Delivery of Samples

The Contractor shall preserve all samples in good conditions. He shall keep samples from under exposure to the weather, and shall keep descriptive labels and designations on sample jars and boxes clean and legible until final delivery of samples to the Engineer or to the designated laboratories. All samples shall be submitted to the Engineer for approval before they are transported to the testinglaboratory.The Contractor shall arrange for all such samples to be safely packed and for careful transportation to

laboratory or laboratories. The Contractor shall also deliver the samples, as the Engineer may order, to a place of storage designated by the Engineer near the site.

4.9 Method of Drilling

4.9.1 General

Drilling shall be done by the rotary or percussion method. Before using an alternate method of advancing the boring, the Contractor must obtain the written permission of the Engineer. Drilling of holes by percussion method shall be permitted only if boulders and gravel are encountered.

4.9.2 Rotary Drilling

4.9.2.1 Definition of Method

The method of drilling may be any approved standard and accepted method of rotary drilling by means of which a hole of specified diameter is continuously extended to the required depth.

4.9.2.2 Equipment and Supplies

Equipment for rotary drilling shall include a rotary drilling machine of a hydraulic feed type most suitable for the site conditions. Complete with all accessories for extending the hole to required depths, taking samples and performing the necessary tests in accordance with the specifications. Supplies shall include all casings, drill rods, core barrels, sampler and bits most suitable for sampling the material encountered at site, piping, pumps, power tools and containers required for protecting and transporting recover samples.

4.9.2.3 Procedure

In the method of rotary drilling a hole of specified diameter is continuously extended to required depth. The method shall provide and allow the specified sampling and testing to be undertaken at designated depth. After the in-situ testing and sampling have been performed at the prescribed depth, the Contractor may employ rotary drilling to deepen the hole to the next layer of testing, or, in advancing the boring. The casing shall be driven down without washing to depths as directed by the Engineer, after which the material shall be cleaned out to the bottom of casing by using a cutting or chopping bit. Drilling fluid may be forced down through the drilling rod and out through the ports in the chopping bit to carry the cutting up and out of the boring. It is imperative that water ports in the cutting bit be so arranged that there is no jetting action of the drilling fluid ahead of the chopping bit. In no case shall the cleaning operation proceed beyond the lower limit of the casing unless specified by the Engineer. The minimum amount of drilling fluid necessary to carry away the cuttings shall be used. During drilling the Contractor shall regulate the drilling at such speeds and control the drilling fluid at such pressures which will ensure minimum disturbance in the underline material in which the in-situ testing and sampling is to be carried out.

4.9.3 Percussion Drilling

4.9.3.1 General

If the drill hole must be advanced through exceptional hard strata of soil or through rock where other methods cannot be used, the percussion method shall be permitted.

4.9.3.2 Definition of Method

In the percussion drilling method the advance of a borehole is accomplished by alternately raising and dropping a heavy drilling bit which is attached to a drill stem. The material chopped off by the bit is then bailed out with a bailer.

4.9.3.3 Equipment and Supply

The Equipment for percussion drilling includes but not limited to a power driven drilling rig provided with suitable winch to raise and drop the bit through a wire, complete with a bailer and all accessories for extending the hole for required depths. The percussion bit (or churn bit) shall not exceed six feet in length and its weight shall be 1000 to 2000 lbs or as approved by the Engineer. Supplies shall include all casings, drill rods, wire ropes, piping, pumps, and all necessary tools for the execution of drilling.

4.9.3.4 Procedure

The borehole shall be advanced alternately raising and dropping of a heavy drilling bit attached to drill stem. Enough water shall be added into the borehole, if required to form a slurry of the chopped off material. When the carrying capacity of the slurry removed by means of bailer or sand pump is exceeded, the Engineer may allow the drilling in a borehole to proceed without casing if in his opinion there is no apprehension of caving in of the material or collapsing of borehole. The hole shall always be kept full of water to check the boiling of subsoil material.

4.10 Drilling Fluid

The Drilling fluid used for rotary drilling or wash boring shall be clean water, free from suspended sediments, except that the Contractor may use Bentonite slurry as the drilling fluid with the approval of the Engineer.

4.11 Casing of boreholes

A casing of the required to allow entry of sampling tools shall be used in conjunction with drilling to wash the boring to bottom hole elevation, the casing shall be made of cylindrical steel pipes and shall have sufficient strength so as to maintain its position and shape during drilling operations. The casing may be omitted only where it can be shown that sampling operations without the casing will not allow the entry of soils from an elevation higher than the depth at which field testing or sampling is to be made. The Contractor shall pull out the casing from the boreholes on completion of investigatory work, following receipt of the Engineer's written approval to do so.

4.12 Field Testing and Sampling

4.12.1 Standard Penetration Tests

4.12.1.1 Definition

Standard penetration testing (SPT) shall conform to United States Bureau of Reclamation (USBR) designation E-21. This designation describes a procedure to obtain a record of the resistance of sub-soils to the penetration of a standard sampler and to obtain representative disturbed samples to the material for identification purpose and laboratory testing. The penetration resistance shall be expressed as the number of blows of a 140 pound hammer freely dropping 30 inches required to force the standard sampler 12 inches into the soil. The blow count shall be taken for 18 inches penetration. The blow count for the last 12 inches shall be taken as that required for the test.

4.12.1.2 Equipment and Supplies

Equipment to be furnished by the Contractor for making standard penetration tests shall be based onUSBR Designation E-21 test equipment which shall include but not limited to: standard diameter "B" rods,140 pound drop weight, manila rope and tackle, guide pipe and driving head. Alternative equivalent standard equipment based on ASTM designation may be used. Supplies shall include all casing, piping, pump and power for sampling and containers required for sampling. The pulleys and tackle shall be kept as frictionless as practicable.

4.12.1.3 Methodology

Standard penetration test shall be conducted in the boreholes at five ft intervals up to the specified depth for the boreholes unless otherwise directed by the Engineer. Using prescribed equipment, the hole shall be cleaned to the testing elevation by means of drills bits or washing ensuring that the material to be tested is not disturbed by the drilling and clean out operation. The hole shall be clean of all sand and sludge before the sampler is placed in the hole. The standard split-tube sampler attached to drill rods shall be lowered to the bottom of hole. The drive weight shall then be allowed to fall on the jar coupling until the sampler is penetrated six inches into the soil. The penetration test shall then be started and the number of blows recorded as specified above. Immediately after each penetration test, the sampler shall be carefully disassembled and the soil classified according to visual identification.

A representative portion of the soil core from the bottom 12 inches drive shall be placed in a suitable container and properly labeled. The leveled edge of the drive shoe shall be maintained in good condition and if excessively worn, shall be re-sharpened. The drive shoe of the sampler shall be replaced if damaged in such a manner as to cause projections within the interior surface of the shoe. Each drill rig shall be equipped with a minimum of two drive shoes in good condition. The casing shall not be driven into the layer to be tested (and sampled) in advance of penetration and sampling operation.

4.12.2 Field permeability Test

i) Seepage test shall be carried out to determine the permeability of soil wherever directed by the Engineer. The seepage tests shall be conducted by the constant head or falling head method as approved by the Engineer. When so determined by the Engineer, the Contractor shall place quantity of approved gravel or sand filter material in the hole sufficient to fill the hole to 3 ftabove the bottom of the hole and to raise the casing of the hole a small distance prior to starting the test. The permeability tests shall be carried out in accordance with the methodology set out for field permeability tests in boreholes (designation E-18) of the USBR Earth Manual. Constant Head Method The constant head permeability test shall be carried out as follows:

   a. Clean the borehole with water ensuring that no disturbance is caused to the subsoil during the cleaning operation.

   b. Fill the casing with water. The casing shall project at least two feet above the ground surface.

   c. Add water from a calibrated water container into the casing at such a rate so as to maintain constant water level near the top of the casing.

   d. Record the amount of water added to the cased hole at 1, 2 and 5 minutes after the start of the test and at 5 minute intervals thereafter until sufficient records are gathered to determine the field permeability.

ii) Falling Head Method. The falling test permeability test shall be carried out as follows:
   a) Clean the hole carefully.

   b) Fill the casing with water.

   c) Observe the rate of fall of water from the top of casing at 1, 2 and 5 minutes after the start of test and 5 minute intervals thereafter. Continue to take observations until the rate of fall becomes negligible or sufficient readings are obtained for the determination of field permeability.

4.13 Undisturbed Soil Samples

4.13.1 Definition

An "undisturbed" sample boring shall be any mechanically driven boring made to obtain samples which on testing will show properties as close to the in-situ (in place) properties as possible.

4.13.2 Equipment and Samples

The equipment to be used for undisturbed sampling shall include the prescribed rotary drilling rig, or other drilling equipment as specified elsewhere along with all accessories required to perform sampling operations. Sampling apparatus shall consist of Denison tube core barrel or pitcher sampler or other suitable double core barrel provided with proper liner of 28 gauge with steel inner walled sampler (Shelby Tubes) for extraction of the undisturbed samples using the prescribed procedure if the strata is not very hard. The thin walled sampler shall have an internal diameter of at least three inches. The ratio of maximum outer diameter of sampling portion of the spoon to the minimum internal diameter shall not exceed 1.01. The thin walled sampler shall be formed from seamless steel tubing of 16 or 18 gauge metals having a clear length of 33 inches and adequate means, such as a check valve, shall be provided to prevent loss of samples. The thin walled sampler shall also have a suitable cutting edge.

Supplies shall include all casings, piping, pumps, power for boring and sampling, and all boxes, labels and containers required for samples.

4.13.3 Procedure

The undisturbed samples will be extracted at the locations and intervals as directed by the Engineer. Using the equipment described above, the Contractor shall clean the hole to the prescribed sampling elevation by means of rotary drilling or washing ensuring that the material to be sampled is not disturbed by the drilling and clean out operations. To minimize the compacting effect of casing driving, the bottom of the casing shall be kept as high above the soil zone to be sampled as the conditions permit. Above the water table, samples shall be obtained from a dry hole. Below the water table, water shall be maintained within the hole at or above ground water level. Sampling with a Denison sampler, pitcher sampler or equivalent double tube core barrel will consist of lowering the tool to the bottom of the hole and rotation coring in the normal manner. After completion of the drive, the sampler shall be withdrawn from the hole, extreme care being taken to avoid disturbance. The soil core and the liner tube shall be separated from the core barrel without jarring the sample. The length of undisturbed sample thus obtained shall not be less than 24 inches.

The soil in the liner at the ends shall be trimmed to a depth of about two inches, to a smooth flat surface which shall be painted with warm liquid wax. A wooden filler block previously waxed, shall be placed inside the liner tube at each end and covered with melted wax. The soil retained in the inner barrel shoe and that removed from the top of the core shall be used for field inspection. The top and bottom of the sample, hole number, contract reference, location features and elevations or depths between which the sample was taken should be clearly marked on the before transporting to the laboratory.

Sampling with the thin walled sampler (Shelby tube) will consist of lowering the sampler to the bottom of the hole and forcing the thin walled cylindrical tube into the soil at as approved by the engineer in one continuous stroke, without rotation, using the hydraulic feed and weight of the drilling. The sampler tube shall not hammer into the being sampled unless permitted by the Engineer. The sampler with its contained soil sample shall remain in place for from 5 to 30 minutes, depending upon the nature of nature of material being sampled at which time the Contractor shall rotate the drill rods through two complete revolutions or until the soil immediately below the sample has sheared. The tube containing the sample shall then be carefully removed from the boring and detached from the diving head and the sample shall not be extruded from the tube. The length of undisturbed sample thus obtained shall not be less than 24 inches. The undisturbed samples obtained by the thin walled sampler shall be cleaned out to a depth of about three inches and provided with a seal of micro crystalline wax. A metal disc having a diameter

slightly less than the inner diameter of tube shall be inserted into the wax at a distance of one inch from the ends of the tube and a final seal consisting of a metal cap or tap shall be over the end.

4.13.4 Labeling of Samples

Tubes and crates for undisturbed samples shall be labeled "Do not jar or vibrate" and "Handle, haul and transport in a horizontal position". The tubes and crates shall contain a printed or type written label giving the following information:

- Project
- Location
- Hole nr
- Sample nr
- Top elevation of hole (with reference to Bench Mark)
- Date
- Depth of sample
- Length of sample
- Description of material
- Remarks (if any)

4.14 Groundwater Samples

Ground water samples shall be collected at the locations and intervals as directed by the Engineer. The sampled water should be free from any contamination from drilling fluid. Water should be preserved in galas bottle and should be properly sealed and labeled.

4.15 Deposition of Samples

4.15.1 Disturbed Soil Samples

Disturbed samples shall be placed in moisture proof containers or plastic bags. Each sample shall have identification tags giving all the information outlined in Clause 23.16 of this Specification. The selected disturbed samples shall be transported by the Contractor to the approved laboratory for testing.

4.15.2 Undisturbed Soil Samples

Every precaution shall be taken to avoid damage to the undisturbed samples as a result of careless handling and undue delay in transportation. Samples shall be transported in wooden boxes made from 1/8 inch or heavier timer, and with a capacity for holding six sample containing tubes. The sample tube shall be well packed in suitable material to protect the samples against vibration. The Contractor shall avoid exposing sealed and crated samples to extremes of temperatures. Sample partially damaged due to weather action or careless handling shall be replaced by the Contractor at his expense. In general, no undisturbed sample shall remain at the site of sampling for more than one week before transportation. Samples shall be transported with the tube in a horizontal position in order to prevent consolidation and segregation of water content.

4.15.3 Groundwater Samples

The bottles containing groundwater samples shall be transported in wooden or plastic crates. Every precaution shall be taken to avoid damage of bottles containing water samples. The Contractor shall avoid exposing water to extremes of temperatures. Samples wasted due to weather action or careless handling shall be replaced by the Contractor at his expense.

4.16 Groundwater Observation

4.16.1 Record of Groundwater Level

Groundwater, when encountered, shall be recorded for all boreholes. If completing a hole takes more than one day, the groundwater level shall be measured each day before starting work and also 24 hours after completing the borehole. All unusual water conditions and elevations at which such conditions are encountered shall be carefully recorded by the Contractor. The borehole elevation, groundwater elevation, casing tip and time measurement shall be recorded. If water under artesian conditions is encountered, the casing shall be extended above the ground surface to contain the rise in groundwater level. After the flow has stabilized, the height of water above ground level shall be recorded.

The groundwater depth in bore holes shall be determined by one of the following methods as directed by the Engineer.

After drilling the borehole to the required depth, the borehole shall be bailed out to a depth lower than theexpected groundwater level as directed by the Engineer. The level of groundwater shall be determined 24hours later. The level thus determined shall be recorded as the "groundwater level".

Clean water shall be added in the borehole so as to raise the water level in the borehole, as directed by the Engineer. The water level shall be determined 24 hours after the addition of water. The level thus determined shall be recorded as the "groundwater level".

When the borings are advance by using natural or commercial drilling mud to stabilize the hole, the hole shall be flushed thoroughly with clean water at the completion of boring for the purpose of observing groundwater level.

4.17 Laboratory Tests

4.17.1 General

The laboratories in which the samples are tested shall be approved by the Engineer. Generally the Contractor'slaboratory or a laboratory approved by the Engineer shall be used unless ordered otherwise. The Engineer shall have access to the laboratories to supervise and check the laboratory testing of the samples. The testing shall be carried out in accordance with British Standards, or equivalent ASTMprocedures, or as directed by the Engineer.

4.17.2 Tests

The Contractor shall arrange to carry out all or some of the following laboratory tests on the specified samples of water and soil; the samples to be tested and the test carried out on each sample shall be asdirected by the Engineer.

i) test as specified in Clause 3.3, sub-section (a) of these specifications;
ii) Direct shear test;
iii) Unconfined compression test.

Testing as required under sub-paragraphs (ii) and (iii) shall be undertaken using the method given in "Soil Testing for Engineers" by Lamb, 1951, or as otherwise approved by the Engineer.

4.18 Records and Reports

4.18.1 Records

The Contractor shall keep accurate logs and records of all the site investigation work. All such records shall be preserved in good condition and order by the Contractor until they are delivered and accepted by the Engineer. The Engineer shall have the right to examine such records at any time prior to their delivery

to him. Accurate logs shall be made for each borehole. The following information shall be included on the logs or in the record for each borehole:

i) Whole number or designation, coordinates and elevation of top of the hole (with reference to Benchmark) or mean sea level as instructed by Engineer.

ii) Type of drilling operation.

iii) Dates and times by depths when drilling operation were performed.

iv) Depths at which samples or cores were recovered or attempts made to sample or core including top and bottom depths of each run.

v) The classification or description by depth of the materials sampled, cored or penetrated including description of condition of compactness or stiffness of soil materials encountered and moisture conditions.

The description of each soil layer should include the following information.

- Typical name (according to standard engineering classification)
- Approximate percentage of gravel and sand (if present)
- Maximum size of particles
- Color (in moist condition)
- Moisture (dry, moist, wet, saturated)
- Organic content (if present)
- Plasticity degree (non-plastic, low, medium, high) and dilatancy, dry and toughness for fine-grained soils and of fine grained fraction in coarse grained soils
- Structure (stratification, lenses and seams, lamination, honeycomb, flocculent, root, holes,etc)
- Cementation type (if present)
- Degree of compactness
- Loose or dense (excepting clays)
- Consistency in undisturbed and remolded states (clays only)
- Group symbol

i. Indication of penetration resistance as determined from standard penetration tests.

ii. Elevation at which groundwater was observed (with reference to benchmark)

iii. Elevation of bottom of hole (with reference to benchmark).

The presence of the Engineer or the Employer, or the keeping of separate drilling records by such parties shall not relieve the Contractor of the responsibility for the work specified in this Clause. Payment will not be made for any work for which complete records have not been furnished by the Contractor.

4.18.2 Reporting

i. Reports of the results of the site investigation carried out shall be communicated to the Engineer as follows:

i. Daily reports as the work proceeds;

ii. The drilling records as specified in Clause 4.18.1 hereof, in duplicate not later than 48 hours after completion of each borehole.

iii. Five copies of a Final Report of the work at each site within fifteen days of the completion of the last borehole.

iv. The Final Report shall include:

v. A site plan showing the position of the borings, and giving their map reference, with coordinates.

vi. The borehole logs.

vii. Result of field and laboratory tests, observations and analysis including soil profile (cross sections).

viii. The Contractor's appreciation of the general subsoil conditions in the area together with comments on any points which the Engineer has put to him for enquiry and investigation during the works.

ix. The work shall not be regarded as complete until the full report has been submitted in a satisfactory form to the Engineer.

5 Earth Works

5.1 Scope of Work

Earth works consists of all necessary work for excavation and placing in embankment or back fill or disposal by dumping of earth or other material from or to the canal or adjacent thereto or from borrow areas, including excavation from structures, trenches and backfilling, removal of unsuitable material, formation of canal banks, widening, desalting of canal, clearing, grubbing, selective removal of trees, removal of existing obstructions within the reservation width in accordance with these specifications and in conformity with lines, grades, sections and dimensions shown in the Drawings or as instructed by the Engineer.

5.2 Jungle Clearance

5.2.1 General

Jungle is defined as any weeds, reeds, long grass, pann grass, bushes, hedges, trees, undergrowth or the like which may affect the visibility and access along the berms, inspection and non-inspection paths. Jungle wherever it occurs along the length of irrigation channel will be cleared only where ordered by the Engineer.

The trees shall not be felled without prior written authorization of the Engineer. The Work includes the clearance and disposal of jungle from the berms, inspection and non-inspection paths and side slopes. The Contractor shall generally remove the same, which is visible above the ground including roots.

5.2.2 Scarifying Ground Surface

Where fill in embankments is to be compacted, the surface of the ground under the embankment shall be scarified to a depth of 6 inches so as to provide a satisfactory bond between grounds and fill. The moisture content of the scarified surface shall be carefully controlled either by natural drying or by wetting with a fine spray. If for any reason, progress in compacting the fill is interrupted for a significant time, the surface of the fill material shall be scarified before compaction continues.

5.2.3 Removal of Trees

The work consists of removal of trees and stumps along with their roots to a depth to ensure complete removal of roots and stumps and their disposal as instructed by the Engineer.

5.3 Earthworks

The Contractor shall make excavations in any material and any conditions for the Works and shall dispose of the excavated materials all as specified, shown on the Drawings, and instructed by the Engineer. The earthworks specification is divided into three sub-divisions, as follows:

A. General

B. Channels and Embankment

C. Structures and Pipelines

Clauses in "A. General" shall apply to all types of earthworks.

A- GENERAL

5.4 Notice to be given before Commencing Earthworks

The Contractor shall give the Engineer at least seven days written notice of his intention to commence earthworks on any part of the Site. The earthworks shall not be commenced until the Contractor has received written approval from the Engineer.

5.5 Earthworks to Lines and Levels

The whole of the earthworks for the several parts of the Works shall be carried out to the dimensions and the levels shown on the Drawings or to such other dimensions and levels as may be ordered by the Engineer. Dimensions, which are based on, or related to, ground levels or chain ages, shall be referred tothe Engineer before commencing earthworks at any locations

For the purpose of the Specification the term ground level shall refer to the original profile before the startof earthwork operations.

5.6 Extent of Excavations

The extent of excavations shall be the minimum practicable in the opinion of the Engineer for theconstruction of the Works.

The excavation in the irrigation channel shall at any one time be limited to lengths previously approved bythe Engineer in writing. Except with the written approval of the Engineer, work on each approved lengthshall be completed before work on any new length is commenced.

5.7 Excavation of Unsound Material

i) If any unsound material occurs in the bed or sides of a channel, in foundations, or below embankments, the Contractor shall remove and dispose of it. Unsound material shall include roots, organic matter, mud, gypsum, surface layers of boulders, cobbles and gravel, and deleterious substances. Unless otherwise specified or ordered by the Engineer, the Contractor shall fill the voids so formed, with concrete class D for structures, with compacted fill, not less than 95% of dry density as determined by AASHTO T180 or equivalent, for channels and embankments, and with approved granular material for embankment pitching.

ii) If the Contractor encounters any material, which in his opinion may be unsound, he shall immediately inform the Engineer who will instruct the Contractor in writing as to whether or not the material is to be treated as unsound.

iii) The above notwithstanding, where the Drawings show the placing of earthworks on vegetation existing prior to commencement of earthwork operations at any location, such vegetation shall notbe considered to be unsound material except to the extent that the vegetation, or its roots etc, is deemed by the Engineer to be unsuitable.

iv) The provisions of Sub-Clause (i) hereof, notwithstanding, where the Drawings show excavation below the line of future embankments in order to remove roots of reeds, etc. the material so excavated shall be classed as unsound if comprising roots, organic matter or mud.

5.8 Slips and Falls

The Contractor shall exercise the greatest possible care and take all necessary precautions to prevent slips and falls of material from the sides of the excavation and embankments In the event of slips and falls accrue, the Contractor shall make good all earthworks and associated works and execute any requisite modifications of the Works.

5.9 Fill

Fill means selected suitable material placed in embankment above original ground level. Selection shall, interlay, be such as to exclude material of particle size specified or approved by the Engineer.Notwithstanding other provisions of the specifications all suitable sandy, salty and clayey earth material will be accepted in the fill. Where the channel excavation at any section does not furnish sufficient suitable material for embankments, the material shall be taken from designated borrow areas as approved by the Engineer.

5.10 Borrow Areas

5.10.1 Approved Borrow Areas

Where specified or ordered by the Engineer, fill material for incorporation in the Works shall be obtained from approved borrow areas after the completion of any tests to confirm the suitability of the material. On completion of excavation the Contractor shall, where applicable, trim, grade and leave the borrow area in a tidy condition and shall carry out any further earthworks necessary to prevent accumulation of water in the area.

5.10.2 Borrow Area of Private Owners

Borrow areas located in cultivable land shall be as shallow as is practicable in order that the land so used may be subsequently ploughed over and brought under cultivation. In such cases where land has been temporarily acquired the Contractor shall remove top soil prior to excavation in the borrow area and shall replace it on completion of excavation and, following reinstatement, the maximum depth of excavation shall not exceed one foot as specified and as approved by the Engineer.

5.10.3 Strip of Borrow Area

The borrow areas shall not be continuous. For every 200 feet, ten feet wide strip shall remain unexcavated, to avoid the formation of a continuous channel. Material within the irrigation channel reservation width which is in excess of the requirements of the inspection path and non-inspection path shall be considered as borrow material, if so directed by the Engineer.

5.10.4 Arrangement of Land for Borrow Areas outside the Reservation Width

The Contractor shall make his own arrangements with the landowners for procurement of borrow material from their lands.

5.11 Approved Material for Compacted Fill and Backfill

The material for compacted fill shall comply with the following requirements or as approved by the Engineer.

a) Sandy material with greater than 20% passing on a sieve nr. 200 is unsuitable;

b) The borrow areas to be outside of the inspection path but, wherever possible, within the reservation width;

c) Material excavated from borrows areas more than 2 feet in depth or from areas near standing crops or with vegetation will generally not be approved.

d) Suitable material from irrigation channel excavation shall be dry and free of vegetation.

5.12 Special Compaction of Fill or Backfill

Specially compacted fill or backfill shall consist of approved material spread and compacted in layers approximately horizontal and of uniform thickness with a slight outward slope and of a compacted depth not exceeding 6 inches. The moisture content of the soil shall be carefully controlled either by natural drying or wetting with a fine spray.

The compaction shall be carried out by mechanical rollers, rammers, vibrators or other approved Contractor's Equipment so as to produce a dry density not less than 90 percent of the maximum dry density as determined by ASTM D-1557 for canal embankments and material placed above structural foundation level, and not less than 95% of the maximum dry density for material placed below structural foundation level, as determined by ASTM D-1557.

The Contractor shall exercise careful control of the moisture content of the fill material prior to and during compaction such that it lies within a range of values established to the approval of the Engineer during the trials specified in Clause 5.13 herein and is suitable for the fill material and the method of compaction adopted.

5.13 Preliminary Trials for Specially Compacted Fill

At least one month before commencing special compaction of the fill in the Works, the Contractor shall submit to the Engineer details of the method and Contractor's Equipment proposed to be used, and shall make trials on Site. The Contractor shall make such tests of the materials before and after compaction as the Engineer considers necessary, both of the trials and of the Works, to ascertain that the degree of compaction specified is attained.

Any approval given by the Engineer to the Contractor's method of working will not relieve the Contractor of his responsibility to meet the requirements of Clause 5.12 hereof.

5.14 Allowances for Settlement

The Contractor shall make due allowance for the effects of consolidation, including the settlement of fill and compacted fill, such that the levels, widths and dimensions of the finished surfaces at the end of the Defects Notification Period are in accordance with the Specification.

B- Channels And Embankment

5.15 Construction Methods

i) Improvement and rehabilitation of canals shall be carried out as outlined below or by a similar method subject to the approval of the Engineer. Full details of the Contractor's proposed method of working and earth moving equipment shall be provided. Improvement and rehabilitation of canals will be executed by excavation through mechanical means. The inspection paths shall be generally formed with material excavated from bed and from borrow areas in accordance with Clauses 5.9and 5.10 hereof.

ii) The Contractor shall make arrangements as are necessary for the inspection and non-inspection "path" embankments to be formed simultaneously over the same advance of completion of design level with one bank being no more than 10 RD in advance of completion to the design level on the other bank. The embankments shall be constructed so as to be continuous, without breaks or gaps, to the full height required, except where the Engineer permits otherwise.

5.16 Excavation / Silt Clearance and Disposal

i) The excavation in the channel bed and side slopes includes the stripping of grass, uprootingbush stumps, weeds, reeds etc. The Contractor shall undertake excavation using the equipment and methods to the approval of the Engineer. The excavation shall be to the lines and levels specified in Clause 5.5 hereof except that the Contractor is not required to replace material in the channel section of that bed eroded, unless so ordered by the Engineer. In particular the bed width should be limited to that as shown on the Drawings and instructed by the Engineer.

ii) Suitable material excavated from a channel shall generally be placed alongside of fill to form maintenanceberms, inspection paths and free board embankments as shown on the Drawings and instructed by the Engineer. Excavated material containing stumps, roots, vegetable matter another objectionable material that are otherwise unsuitable or not required for backfill, compacted fill for channel or in any other permanent construction required under these Specifications, shall be placed in the designated spoil banks as directed by the Engineer. All spoil banks shall be leveled and sloped to channel and trimmed to reasonably regular line as directed by the Engineer.

iii) The Contractor shall prepare a plan of earthworks operation for each particular part of the Works to be constructed at any one time, detailing the location and programme of excavation in channels and structures and of placing the fill in embankments, etc. The Contractor shall submit his proposed plan of operation at least twenty-eight days before his intended date to commence earthworks on each particular part of the system for the Engineer's approval.

5.17 Embankments

Embankments for drains, canals, roads and ramps shall unless otherwise specified be formed with spoil excavated from the drains and canals, if available. Where material for embankments additional to that available from excavation of the drains and canals is required, or where so specified, it shall be obtained from borrow areas under the terms of Clause 5.10.

The material obtained from excavation may be too wet for direct placement in fill and the Contractor shall stockpile the materials within a lead as specified in the reservation width of canal or as approved by the Engineer for drying and shall have to rework it before placing in the fill.

Embankments of canals and drains, with bank top level above ground level, shall not exhibit any signs of incipient seepage after prolonged retention at the maximum level. These embankments and embankments which carry roads shall be formed as subsequently described or in such other manner as may be approved by the Engineer. The spoil shall be spread in approximately level layers of 6 inch loose thickness by mechanical means including leveling; dressing and watering for compaction. Embankment fill shall be compacted by at least four passes either with 12 ton sheep's foot roller or vibrator of equivalent capacity to achieve maximum dry density not less than 90% of dry density as determined by ASTM D 1557 or as instructed by the Engineer. The spreading and compacting of spoil in this manner will not be considered as compaction under the terms of Clause 5.12. The moisture of the soil shall be controlled either by natural drying or by wetting with a fine spray to ensure optimum moisture content for compaction.

Where shown on the Drawings or ordered by the Engineer, prior to construction of embankments, the topsoil shall be removed to the depth given and disposed of as spoil. Embankments that do not have a water retaining function will not generally have the top soil removed prior to their formation.

Embankments which carry un-surfaced roads shall be aligned and graded on the top surface so as to permit the safe and easy passage of a light vehicle at a speed of 25 mph and shall be maintained in this condition to the end of the Defects Notification Period.

5.18 Carriage of material

When the suitable material in accordance with Clause 5.9 is not available within the range of haulage distance, the borrow area shall be selected as per clause 5.10 within specified lead in the reservationwidth

or other areas arranged by the Contractor with the approval of the Engineer. The material shall becarted by approved methods.

5.19 Tolerances on Earthworks for Channels and Embankments

Tolerances on levels and dimensions of channels and embankments will be permitted as stated below instable 5.1.

Notwithstanding the tolerances stated in Table 5.1, the Contractor shall also achieve the tolerances for finished canal lining stated in Table 13.1.

Table 5-1: Tolerances on Earthworks

Description	Channels	Embankment
Bed width	± 6 inches	Not applicable
Bed width	± 2 inches	Not applicable
Formation level for geo-membrane	± 1 inches	Not applicable
Side slopes	± 6 inches	Not applicable
Bank top level and berm	Not less than specified minimum in fill	Not less than specified minimum
Centerline of channels, embankments and roads	± 6 inches	± 6 inches

All surfaces shall be finished off neatly and cleanly.

5.20 Transitions

Except where otherwise shown, at all changes in cross section necessitated by design or any other reason, transitions shall be formed in the bed and side slopes of the channel such that the horizontal or vertical change in direction does not exceed a deviation of 1 in 10.

5.21 Gaps in Embankments

Where necessary at the sites of structures and, where ordered by the Engineer, the Contractor shall leave gaps in the embankments. On completion of the Works for which gaps have been left or as otherwise ordered by the Engineer the Contractor shall make good the gaps to the approval of the Engineer.

5.22 Over Excavation

Should any channel be excavated or any embankment or any berm be formed beyond the tolerance specified, the Contractor shall form the specified cross section or such other section as the Engineer may direct.

5.23 Single Groynes

Single groynes shall be constructed from suitable timber and brushwood. The vertical stake shall be 18inches apart; the girth of each stake shall be between 10 inches and 12 inches. The vertical stakes shall extend 1 ft above proposed berm level and 3 feet below bed level, and shall be intertwined with brushwood. Horizontal stakes with girths between 5 inches and 7 inches shall be placed 2 feet intervals fixed to vertical stakes up to berm level by galvanized nails and approved twine. The space between the vertical stakes shall be filled thoroughly with brushwood up to berm level.

C- Structures and Pipelines

5.24 Method of Excavation

The Contractor shall submit his proposed method of excavation, including details of necessary supports for the excavations, to the Engineer for his written approval.

5.25 Working Space

Excavation shall be carried out to such minimum dimensions as will permit, proper support of the sides of the excavation, the erection of shuttering, placing of concrete and fill, including compaction, and any other construction operation.

5.26 Excavation for Pipelines

Excavations for pipelines shall follow the lines and levels shown on the Drawings and instructed by the Engineer. Curves, where necessary, shall not involve angular deviations at any pipe joint greater than those recommended by the manufacturer and approved by the Engineer.

Properly painted sight rails and boning rods of predetermined measurement shall be supplied and shall be used to ensure the excavation is to true and even gradient.

Whether excavations for pipelines are constructed with vertical, sloping, or stepped sides, that portion of the excavation which extends from the formation to a level not less than 1 foot above the pipe when laid in its correct position shall be formed with vertical sides unless otherwise specified or ordered by the Engineer.

5.27 Backfill and Fill

Backfill means selected material obtained from that excavated for the structure and replaced below original ground level. Selection shall be as for fill as specified in Clauses 5.9 and 5.10. All backfill and fill above original ground level at or adjacent to structures shall be compacted in accordance with Clause 5.12 or as directed by the Engineer.

5.28 Test on Formation Level

On reaching the level for hand trimming specified in Clause 5.31, the Engineer may order in-situ or other tests as specified to determine the nature and strength of the soil.

5.29 Structure Foundations

For structures, where the underside of part of the foundation lies between 4 inches and 18 inches below the existing ground level, the plan area of such section of the structure that is to be repaired shall be excavated in foundation to 18 inches below existing ground level and the space between the foundation and the under slab or blinding layer and the surface so exposed shall be made up with fill compacted not less than 95% of maximum dry density as determined ASTM D1557 in accordance with Clause 5.12.Where the underside of any repair to part of a structure foundation is higher than 4 inches below the existing ground level, the ground shall be excavated in foundation to 12 inches below ground level and the volume between the surface so exposed and the underside of the foundation slab shall be filled with Class ‘D’ concrete.

For structures, where the underside of any repair is found less than 12 inches below existing ground level, the ground shall be excavated in foundation to 12 inches below ground level and the space between foundation slab or blinding layer and the surface so exposed shall be made up with backfill and specially compacted fill as necessary.

5.30 Over-excavation

Any excavation for structures beyond the limits specified or ordered, other than specified in Clause 5.29,shall be filled by the Contractor at his own expense with concrete of the same class as the concrete in the foundation or with gravel backing material or with specially compacted fill as the Engineer may require. Hand Trimming at Formation Level

Where the formation level of any excavation is to receive concrete or backfill, the final 6 inches of the excavation shall be trimmed by hand, or such other method as may be approved or ordered by the Engineer, after removal of any slurry and immediately before the placing of concrete or backfill.

5.31 Protection of the Works

The Contractor's proposals for protecting the Works from damage by flooding or otherwise shall be submitted to the Engineer, but such submission shall not in any way absolve the Contractor from responsibility for any damage, which may be incurred subsequently.

5.32 Minor Repairs to Earthworks around Structures

A structure may be damaged by erosion or piping of the fill material around it as a result of poor quality backfill. Three potential problems may be recognized:

i) Swallow holes appearing at the surface, possibly indicating that material is being washed through the structure;

ii) Erosion runnels around the sides of the structure, possibly leading to an undermining of a part of the structure;

iii) Pounding due to a shallow depression close to the structure, possibly leading to a weakening of the foundations, and the development of deep ruts if traversed by vehicles. In order to remedy these problems the Contractor shall undertake any excavation as ordered by the Engineer to investigate the cause and severity of the problem. As a result of such investigation, or otherwise the Engineer shall order the Contractor to undertake such backfilling or local re-profiling as he considers necessary.

6 Care and Handling of Water including Dewatering

6.1 General

The Employer does not guarantee or describe completely the conditions which may be encountered in performing the specified work. Ground water, surface runoff and sub-surface water may be encountered during construction of the Works.

6.2 Scope of Work

The work to be done under care and handling of water, including dewatering for construction of the Works, consists of, but will not be limited to the following:

a) Protecting the Works from damage by rains, surface runoff and sub-surface water.

b) Dewatering foundations of structures including other areas required for the Works and care of water to maintain all foundations, excavations and surfaces dry and free of water as required for proper construction of the works.

6.3 Protection of Works

The Contractor shall construct and maintain all required temporary diversion and protective works as maybe required to protect the Works from rains, surface runoff, sub-surface water, if any, as is necessary for their proper construction in accordance with the Specifications. After having served their purpose, all

cofferdams or other temporary protection works shall be removed or leveled and graded so as not to interfere in any way with the operation and usefulness of the completed Works.

6.4 Plans to be Approved by the Engineer

Prior to the beginning of construction of any protection or diversion work, the Contractor shall submit for the approval of the Engineer his proposed plan for such protection and diversion works. The plan may be placed in operation upon its approval. Nothing in the Contract shall relieve the Contractor from full responsibility for the adequacy of the protection and diversion works. The Contractor shall repair any damage to the foundations, or any other part of the works caused by flood water / sub-surface water or failure of any part of the protection works undertaken by him.

6.5 Handling Water and Dewatering Foundations

The Contractor shall maintain the areas and the foundations of structures and embankment and other structures, where ever applicable, free from water. The Contractor's methods of dewatering the foundations shall always be subject to the approval of the Engineer. The dewatering shall be accomplished in a manner that will;

a) Maintain stability of excavated slopes;

b) Keep foundations dry for proper construction by lowering sub-soil water 3 feet lower than the lowest excavated levels;

c) Ensure proper compaction and bonding of earth fill material when placed; and

d) Facilitate placing of concrete.

e) Establish water table before the start of work and maintain the below the foundation level and record the levels of water table during the construction and inspection period.

7 Dismantling, Demolition, Repair and Re-fixing

7.1 General

The work includes dismantling stated in Clause 7.2 herein. The work also includes the repair and re-fixingas instructed by the Engineer.

7.2 Works included in Dismantling

Dismantling shall include, but will not be limited to, the following:

- Demolition of structures to be completely removed;
- Removing cement or lime plaster;
- Demolition of protection works to be completely removed;
- Dismantling carefully a part of a structure without causing damage to the part of the structure to be retained as a part of the new structure;
- Protecting structures or parts of the same structure from damage during dismantling operations;
- Disposing of the waste materials to the approved waste pile;
- Dismantling of steel gates and accessories including embedded parts etc.

7.3 Masonry and Concrete Works

Dismantling of masonry and concrete as required to be carried out to existing structures which are to be partially preserved shall be undertaken using pickaxes and crowbars by manual labour and mechanical

hammers, equipment or any other methods up to the lines and levels, as shown on the Drawings and as instructed by the Engineer. Any damage caused to the Works during the dismantling operations shall be repaired or replaced by the Contractor. Dismantled material shall be stacked or disposed of within reservation width and as instructed by the Engineer.

7.4 Removal and Reuse

Pre-cast concrete blocks, stone, bricks and other materials which the Engineer instructs for reuse shall be removed safely using mechanical equipment, if necessary, and stored in a nearby place as directed by the Engineer. The removed material shall be cleaned and reused at locations as directed. Steel and wood shall be stacked item-wise in Employer's stores (within reservation width) irrespective of whether it will be reused or not, as instructed by the Engineer.

7.5 Dismantling of Steel Gate and Accessories

Dismantling of gates and accessories includes but not limited to gate leaf, supporting structures, hoisting machinery, hoisting decks, embedded parts, lifting gears, nut and bolts, cast steel, steel axles and hubs, shafts, wire rope and steel pipe etc as required to be carried out to existing structures by using man power, equipment as shown on the Drawings and as instructed by the Engineer. Any damage caused to the works during the dismantling operations shall be repaired or replaced at the expense of the Contractor. Dismantled material shall be stacked or disposed of within reservation width and as instructed by the Engineer.

The Contractor shall submit the condition of each gate and accessories and other works along with color photos with identification as in clause 23.19.2 with proposal for repairs for the Engineer's approval. The proposed gate repair approved by the Engineer shall be repaired, rectified and placed in position complete and ready for operation.

8 Concrete

8.1 Scope of Work

The work shall consist of furnishing, placing, curing, finishing, including transport of cement, concrete, various type of cement, water, fine and coarse aggregate in accordance with requirements in these specifications, and conforming to lines, grades and typical sections shown on the Drawings or as instructed by the Engineer.

8.2 Cement

The cement used in the Works shall be Ordinary Portland Cement (OPC) complying with BS EN 197-1:2000, or Sulphate Resisting Cement (SRC) complying with BS 4027.

The Contractor shall supply samples of cement, when requested by the Engineer, both from the Contractor's store on Site and from the place of manufacture.

The Contractor shall supply the manufacturer's test certificate for each consignment of cement received at the Site. He shall maintain a record available for inspection by the Engineer of the locations of concrete made from each consignment.

8.3 Aggregates

Aggregates for concrete shall comply with BS 882 at the time of use. Aggregates which are likely to cause alkali aggregate reaction in the concrete shall not be used. Fine aggregate shall consist of natural sand. The Engineer will permit the addition of suitable crushed rock fine aggregate, as necessary, to the natural sand where in his opinion it is impracticable to obtain the required grading of the combined aggregates other than by such addition. The maximum quantities of clay, silt and fine dust shall, in any event, not exceed 3 percent by weight as determined by the test given in Clause 7.2.4 of BS 812, Part 1:1975.

Coarse aggregate shall comply with the requirements in Table 4 of BS 882:1983 for graded aggregate to the nominal maximum size specified for the appropriate class of concrete.

The aggregate shall be such that concrete, when made and tested in accordance with Building Research Station Digest 35 (2nd series), shall not show a drying shrinkage greater than 0.065 percent. Immediately after commencement of the Works the Contractor shall supply and deliver samples of proposed aggregates for testing at a laboratory approved by the Engineer. If the material in the samples passes the specified tests for quality the Engineer will give approval to the source of aggregates proposed by the Contractor.

Alternatively, and subject to the approval of the circumstances by the Engineer, the Contractor may submit test certificates in respect of the proposed aggregates from an independent laboratory. Unless otherwise specified, separate fine aggregate and 0.78" nominal maximum size coarse aggregate shall be used. When 1.57" nominal maximum size coarse aggregate is specified or approved it shall be separate grading additional to the 0.78" aggregate added at the time of batching the concrete ingredients. The Contractor shall supply samples of aggregates when required by the Engineer (the samples shall betaken in accordance with BS 812) at a frequency at least once every six months at each source of each grading approved by the Engineer.

8.4 Water

The water used for making and curing concrete shall be from a source approved by the Engineer and at the time of use shall be free from objectionable quantities of silt, organic matter, alkali salts or other polluting matter in any quantity which:

Affects the initial setting time of the cement by more than 30 minutes or reduces the compressive strength of test cubes by more than 20% when tested in accordance with BS 3148;

Prevents the achievements of the specified test cube strengths at 28 days for the appropriate class of concrete;

a) produces discoloration or efflorescence on the surface of the hardened concrete;

b) Aggravates or promotes an "alkali-aggregate" reaction.

Inorganic matter in solution shall not exceed 500 parts per million by weight and in suspension shall not exceed 30 parts per million by weight.

The Contractor shall make regular tests of the water taken from the points of delivery into the other ingredients of concrete and mortar in a pattern and at a frequency approved by the Engineer and shall furnish the Engineer with two copies of each test result.

8.5 Additives

Concrete shall be made from cement, aggregates and water as specified. No other ingredient shall bemire with the concrete or mortar without the Engineer's approval.

If the Engineer approves the use of retarding or workability agents this use shall be subject to the following conditions:

a) No reduction of testing plan mean strength compared with additive-free concrete of the same class;

b) No reduction of cement content prescribed;

c) No corrosive effect on reinforcement steel;

d) No alkali-aggregate reaction promoted; and

(e) Dosage and admixture strictly in accordance with the manufacturer's instructions in respect of the specific conditions obtaining. Dosage to be by approved dispenser. The Contractor may use a retarder to facilitate the preparation of construction joints, subject to the approval of the Engineer to the composition of the retarder and its method of application.

8.6 Chemicals in Materials

The total sulphate content, whether as gypsum or more soluble salts, of concrete ingredients when measured as SO_3 shall together not exceed 4.0 percent of the weight of cement in the concrete. The chloride content of concrete ingredients when measured as Cl shall together not exceed 0.2 percent of the weight of cement in the concrete.

8.7 Storage of Materials

The Contractor's arrangements for storing and handling the materials for concrete shall be to the approval of the Engineer. Such arrangements shall be directed towards preventing the deterioration, adulteration or segregation of the various materials and ingredients thereof and shall ensure the ready identification and orderly use of consignments of cement.

8.8 Formwork

Formwork shall be constructed to obtain the required profiles and surface textures of the structures and be such that it remains rigid during the placing and setting of the concrete.

It shall be fixed in accurate alignment and to the true shape and dimensions of the Works shown on the Drawings or ordered by the Engineer.

A method of support which would result in holes extending the whole width from face to face of concrete which forms part of the Works shall not be permitted.

No plugs, bolts, wire ties, holdfasts or any other appliance whatsoever, for the purpose of supporting the formwork or reinforcement, shall be fixed permanently into the structure so that they have less cover than the reinforcement or in any way impair the strength or appearance of the work, nor shall they be placed in such a manner that damage to work would result in the removal of the same at the time of striking the formwork.

Unless otherwise approved, top formwork shall be provided for concrete upper surfaces where the slope exceeds one vertical in three horizontal.

Except where otherwise specified, formwork for concrete faces which will remain exposed in the Works, shall be "face formwork", which is to say that it shall be such as will prevent the loss of any ingredients from the concrete and will produce a dense smooth concrete surface without discontinuities of line, texture or appearance. Face formwork shall be prepared from suitably thick portal.

Except where otherwise specified, formwork for concrete faces which will remain hidden in the Works, shall be "back formwork", which is to say that it shall be such as will prevent the loss of any ingredient from the concrete and will produce a dense concrete surface.

Unless otherwise shown on the Drawings, exposed concrete edges shall be formed with a chamfer measuring 1 inch by 1 inch.

Before each concreting operation is commenced, formwork shall be carefully examined and cleaned. All formwork in contact with concrete shall be treated with an approved composition before each usage to prevent adhesion of the concrete. Such composition shall be carefully applied in such a manner that there is no contamination of the reinforcement or previously placed concrete by the composition. When so instructed the Contractor shall submit his proposed design and details of formwork for theEngineer's approval.

Formwork shall only be removed with the permission of the Engineer, and the work of removing it after the receipt of such permission shall be carried out under the personal supervision of a competent foreman, Great care shall be exercised during the removal to avoid shocks to, or reversal of stress, in the concrete.

8.9 Classes of Concrete

The concrete used in the Permanent Works shall be of the class shown on the Drawings or ordered by the Engineer. Characteristics of the classes of concrete which may be used are given in Table 8.1 and Table8.2.

Except where otherwise specified, the concrete ingredients, manufacture, testing and workmanship shall conform with the requirements of BS 8110 : 1997 and BS 5328 : 1997.

The water : cement ratios referred to in the Specification are the ratios by weight of free water to cement in the mix and are based on the aggregates being in a saturated surface-dry condition.

The Contractor shall not commence concreting in the Permanent Works until a trial mix design for the class of concrete required has been approved by the Engineer pursuant to Clause 8.10 hereof. Adjustments to the concrete mix proportions will only be made if, in the opinion of the Engineer, such adjustments are necessary.

The Contractor shall not alter the mix proportions nor the source of supply of any of the ingredients without having previously obtained the approval of the Engineer.

Table 8-1: Concrete Classification

Class	Grade	Cement Type	Maximum Aggregate Size(mm)	workability	Mean strength (N/mm2)	Mean strength (N/mm2)
A	35	OPC	40	Medium	38	32
B	30	OPC	20	Medium	33	27
C	25	OPC	20	High	28	22
C1	25	OPC	40	Medium	28	22
Aa	45	OPC	20	Medium	48	42
D	17.5	OPC	40	Medium	17	13
E	8	OPC	40	High	8	7
BS	25	SRC	20	High	28	22
CS	25	SRC	40	Medium	28	22

Note: High workability: slump 100 to 150 mm (4 to 6 inches).

Medium workability: slump 50 to 100 mm (2 to 4 inches).

Concrete classes shall be as shown on the Drawings and generally used as indicated below:

AA Pre-stressed concrete

A Reinforced concrete – hydraulic structure

B Reinforced concrete - thin sections

C Reinforced concrete – general use

C1 Reinforced concrete - general use

D Mass concrete

E Blinding, infill

BS Reinforced concrete – thin sections in contact with the ground or drainage water

CS Reinforced concrete _ general use and mass concrete in contact with the ground or drainage water.

8.10 Designed Mix Concrete

Some characteristics required of concrete produced to design mixes are given in Table 8.2.The Contractor shall determine to the approval of the Engineer the actual proportions of ingredients foreach class of concrete. Unless otherwise agreed by the Engineer and except where not consistent with this Specification, such determination shall be in accordance with the recommendations of BS 5328: 1997 and BS 8110:1997 : Part 1.

Table 8-2: Designed Mix Concrete

Class	Minimum cement content (kg/m3 of concrete)	Maximum water :cement ratio	Trial mean strength (n/mm2)
AA	500	0.45	57.5
A	410	0.45	46.5
B	320	0.55	41.5
C	290	0.50	36.5
C1	275	0.50	36.5
D	220	0.55	21.5
E	170	-	10.0
BS	330	0.45	36.5
CS	330	0.45	36.5

The Contractor shall make trial mixes for each class of concrete using the same type of Contractor's Equipment and the same materials as are proposed for the Permanent Works. The Contractor shall give 24 hours' notice of such trials to enable the Engineer to attend. For each trial mix, three separate batches of concrete shall be made. From each batch of concrete, three 6 inch (150 mm) concrete cubes shall bemade by the Contractor and will be tested by the Engineer at 28 days all in accordance with BS 1881:1983. A trial mix design will be approved by the Engineer. The specified characteristic compressive strength for the minimum individual and the minimum mean of specified consecutive test results are derived from BS 8500-1:2002, BS 8500-2:2002, BS EN 206-1:2000.

8.11 Compliance with Strength Requirements

Of the three cubes made from each sample of fresh concrete in accordance with Clause 8.10, of the specification one will be crushed at 7 days and the other two at 28 days. The average of the 28 days strengths will be taken as the test result. Compliance with the specified strength requirements shall always be judged on the results of tests taken at 28 days.

Concrete shall be considered to have failed to comply with the Specifications;

(a) if a test result is less than the testing plan minimum specified for that class of concrete, in which case the concrete which it represents shall be broken out and removed by the Contractor when ordered(b) if the average of four consecutive test results for that class / grade of concrete shall have failed to exceed the testing plan mean strength as specified in which case no further concrete of that class shall be placed in the Works until the Contractor shall have discovered the cause of such failure and rectified it.

8.12 Control and Mixing Ingredients

The Contractor shall proportion the ingredients of each batch of concrete accurately by weight. The water shall be added to the aggregates and cement in a mechanical batch mixer; it shall not exceed the amount specified in Table 8.2 hereof and shall otherwise be the minimum amount necessary consistent with complete compaction. The device for measuring the water shall show accurately the weight required having regard to the moisture content of the aggregate and shall be so designed that the water supply will be stopped automatically when the correct quantity has been discharged into the mix. The concrete ingredients shall then be mixed thoroughly.

8.13 Truck Mixed Concrete

Truck mixed concrete may be used with the prior approval of the Engineer provided that it complies with the Specification and with BS 5328, and that the water for the mix is added at the Site adjacent to the point of final deposit. Truck mixers shall comply with BS 4251. The manufacturer's data listed in Appendix B of BS 4251 shall be submitted to the Engineer for approval if requested.

8.14 Preparation of Surfaces for Concreting

Concrete surfaces in construction joints shall be treated carefully to expose the aggregate over the full section and to leave a sound irregular clean surface free from laitance by scrabbling, wire-brushing, washing with water and air under pressure or other approved means. Immediately before the fresh concrete is to be placed, the set concrete shall be dampened, without excessive water remaining.

8.15 Transportation, Placing and Compaction of the Concrete

The concrete shall be handled so that at the point of deposition it is of the specified quality and consistency, nothing having been added to it or lost from it since leaving the mixer, and segregation of the concrete ingredients is avoided. Any concrete which has stiffened to a degree where proper placement cannot be assured should be wasted and no payment will be made to the Contractor for such wastage. The Contractor shall obtain the approval of the Engineer to his proposed arrangements before commencing concreting. Concrete shall only be placed in the presence of the Engineer.

The Contractor shall regard the compaction of the concrete as a work of fundamental importance and shall produce a watertight concrete of maximum density compatible with the approved mix. Compaction shall be assisted by the use of mechanical vibrators of the immersion type but shall not involve the vibration of reinforcement or formwork except that vibration of formwork may be allowed in the case of pre-cast concrete with the approval of the Engineer.

The number and type of vibrators available for use during each period of concreting shall be to the approval of the Engineer, which will not be given if sufficient standby vibrators are not readily available in good working order.

8.16 Construction Joints

Construction joints shall be watertight. They shall be formed in straight lines with rigid shuttering perpendicular to the principal line of stress and as far as practicable at points of least shear. They shall bethe plain butt type unless otherwise specified or approved.

Before placing new concrete against that which has already set, the latter shall be treated carefully to exposé the aggregate over the full section and to leave a sound irregular clean surface free from laitance. Where not shown on the Drawings, the details and positions of construction joints shall be submitted to

the Engineer for approval before any concreting takes place. They shall be located so that, in conjunction with the programme for concreting, the effects of shrinkage and temperature are minimized. Where long lengths or large areas of work are to be concreted and where in the opinion of the Engineer it is practicable, the Contractor shall so arrange his programme of construction that concrete is two weeks old before new concrete is placed against it.

8.17 Surface Finishes

The classes of finish required for concrete surfaces, both those formed against formwork and those unformed (i.e. horizontal or sloping surface finished without the use of formwork) and the maximum tolerances on true position, dimension and shape of the completed work which will normally be permitted and accepted by the Engineer are described in the following Clauses 8.18 to 8.20.

No treatment to the finished concrete other than that specified in the class of finish shall be carried out unless an instruction to do so is given by the Engineer.

The faces of all concrete shall be left sound, solid and to the class of finish specified. If the Engineer should decide to allow minor defects to be rectified rather than have the whole lift removed then voids shall be properly opened out and repaired with cement sand mortar and projections shall be ground off. The finish of the surface of blinding concrete shall be matched to the requirement to bond with or to be free from the subsequently placed concrete.

8.18 Classes of Formed Surfaces

Unless shown otherwise on the Drawings formed concrete surfaces shall comply with one of the classes of finish described below.

Class F1

This finish is for surfaces against which backfill or further concrete will be placed or which will remain hidden. Formwork shall be such as will prevent the loss of any ingredients from the concrete and will produce a dense concrete surface.

Class F2

This finish is for all surfaces that will remain exposed in the Works unless otherwise shown on the Drawings. Formwork shall be such as will prevent the loss of any ingredients from the concrete and will produce a dense smooth concrete surface without discontinuities of line, texture or appearance. The surface shall be free from surface pitting but other minor defects shall be remedied by methods approved by the Engineer.

Class F3

This finish is for all surfaces in contact with flowing water. Formwork shall be such as will produce surface that is smooth, true and accurately formed to the required lines and levels and free from all lips, pitting, excrescences, etc. If considered necessary by the Engineer, the hardened faces shall be ground down to produce the desired finish.

Where a surface is partly hidden and partly exposed the finish appropriate to the exposed surface shall extend 1.5 ft (500 mm) below the level of exposure.

8.19 Classes of Unformed Surfaces

Unless shown otherwise on the Drawings unformed concrete surfaces shall comply with one of the classes of finish described below.

Class U1

This finish is for surfaces of roads or of foundations, beds, slabs, and structural members to be covered by backfill, and for exposed surfaces of paving where a superior finish is not required. It is also the first stage

for finishes U2 and U3. The finish shall be similar to that left by a vibrated hardwood board, 2 inches (50mm thick), when used for screening concrete to its proper level and profile immediately after deposition.

Class U2

This finish is for all exposed unformed (or un-shuttered) surfaces in the Works unless otherwise shown on the Drawings and as an intermediate stage for a U3 finish. The surface shall be floated with a wood float to a smooth finish free from screed marks. The floating shall be executed so as not to bring excess laitance of the material to the surface.

Class U3

This finish is for all unformed (or un-shuttered) surfaces in contact with flowing water and shall be achieved by floating with a steel trowel to a fine open surface finish. The fine open surface shall be obtained by first screening and floating the concrete to a Class U2 finish then leaving it until the concrete has stiffened and the film of moisture has disappeared. Floating shall then be applied with a steel float to produce a 'glossy' surface without bringing excess laitance of fine material to the surface. Whenever necessary a properly constructed overhead cover shall be erected before the work is commenced to prevent the finished surface from being marred by raindrops or dripping water.

Except at movement joints, concrete surfaces which are to be covered by further concrete or mortar shall be prepared in accordance with Clause 8.14.

8.20 Tolerances in Finished Work

The irregularities in formed and unformed surface for the various classes of finish shall be within the target limits shown in Table 8.3.

Tolerances for concrete canal lining shall be in accordance with Clause 13.2.

Table 8-3: Maximum Irregularities in Formed and Unformed Surfaces

Type of irregularity	Tolerance (Inches)±					
	Type of Finish					
	Formed			Unformed		
	F1	F2	F3	U1	U2	U3
Departure from alignment and grade shown on the Drawings	+1 +1/2	±1/2	±1/2	±1/2	±1/4	±1/4
Variations in cross-sectional dimension (1)	=1/2 -1/4	=1/2 -1/4	=1/2 -1/4	-	-	-
Deviation from template in long dimension(2)	±1/2	±1/2	±1/4	±1/2	±1/4	±1/4
Abrupt (3)	±1/2	±1/4	±1/8	±1/2	±1/4	±1/

In Table 8.3 the numbers in brackets under the type of irregularity are defined below.

1) The cross-sectional dimensions of structural members such as walls, columns, beams, etc, where, for structural reasons it is necessary to keep the tolerances within closer limits than those for alignment and grade.

2) Gradual irregularities caused by misalignment of formwork from the dimensions shown on the Drawings and measured from a 10 ft (3 m) long template.

3) Offsets and fins caused by displaced or misplaced formwork sheathing, lining or supports, by loose knots in forms or by otherwise defective form material, and abrupt surface irregularities in unformed surfaces. If irregularities exceed the target the Contractor shall take the necessary steps to bring subsequent work within the target. If, however, the irregularities exceed the maximum allowable shown in the table, the structure, member or section of a member of the structure may be rejected by the Engineer. The Contractor should note that the tolerances are for the completed work and the formwork, etc. used should be constructed and erected to a considerably higher standard of accuracy.

8.21 Concreting in Unfavorable Weather

The Contractor shall not place concrete:

(a) During heavy rain or dust storms; or
(b) When the air temperature is more than 43 degrees C.

When the air temperature exceeds 30 degrees C the Contractor shall not place concrete without the approval of the Engineer and without taking such precautions as may be required to keep the temperature of the concrete during mixing and setting below 38 degrees C, for example, by keeping the concrete materials and formwork shaded from the sun and the aggregates and shutters sprayed with water. Concrete shall not be poured against formwork, which is hotter than 30 degrees C without the approval of the Engineer.

8.22 Curing Concrete

Until it has thoroughly hardened, concrete shall be protected from the harmful effect of wind, sun, temperature and variations of temperature, premature loading or deflection or impact, and aggressivegroundwater.Unless otherwise approved by the Engineer, all concrete shall be cured by water curing. Concrete curedwith water shall be kept wet for at least 7 consecutive days immediately following placement of the concrete, by covering with water saturated material, or by a system of perforated pipes, mechanical sprinklers, or porous hose, or by any other approved method which will keep all surfaces to be cured continuously (not periodically) wet. Water used for curing shall meet the requirements of these specifications for water used for mixing concrete.

8.23 Precast Concrete

Unless otherwise specified or approved all precast work shall be of Class ‘C’ concrete. Each mould for concrete work, which is specified or approved by the Engineer to be precast shall have different embossed or recessed identification mark in a position to the approval of the Engineer.

Each precast unit shall be indelibly marked with the date of casting and after the mould is removed shallot be disturbed for 28 days thereafter.

Each precast unit shall, where required, be provided with lifting eyes and holes located to the approval of the Engineer so as to avoid unsafe stresses during handling.

If the Contractor proposes pre-casting concrete which is not specified or described as precast work, the Contractor shall provide such additional reinforcement as may be necessary, that handling will not give rise to unsafe stresses.

9 Reinforcement

9.1 General

The work consists of furnishing transportation, storage, cutting, fabrication, bending and placing steel reinforcement and welded wire fabric in concrete structures or elsewhere at any elevation as shown on the drawing or/land as directed by the Engineer for a complete job.

9.2 Materials

Reinforcing bars, shall conform to the requirements of ASTM A-615 Gr. 60 for deformed hot rolled new stock billet steel bars and shall have a minimum yield strength of not less than 60,000 psi (414 Map) Reinforcement shall be free from all loose or flaky rust and mill scale, or coating including ice, and another substance that would reduce or destroy the bond. Reduced section steel reinforcement shall not bemuse.

The Engineer shall have the right to witness routine testing of steel reinforcing bars at the manufacturer's workshop. When required by the Engineer, the Contractor shall take samples from the reinforcing steel bars delivered to the site and shall arrange for the samples to be tested by an approved testing agency. Test certificates from the agency shall be submitted to the Engineer.

The Contractor shall submit certificates of compliance from the manufacturer stating that the supplied reinforcement conforms to the specifications. In addition, wherever and as directed by the Engineer, conformance of the supplied reinforcing bars with the specifications shall be demonstrated by the Contractor through laboratory tests, in accordance with the relevant standards.

9.3 Storage of Reinforcing Bars

The Contractor shall stack separately and label different types of reinforcement for positive identification of the manufacturer, size and productive run or other number, which relates to the last certificates furnished by the manufacturer. All reinforcement shall be stored under cover on wooden or concrete supports at least 6 inches above the ground.

9.4 Placing Reinforcing Bars

The reinforcing bars shall conform to the requirements shown on the reinforcement Drawings. The steel bars shall be securely and accurately fixed in position as shown on the drawings using approved spacer blocks or chairs. All interconnection of bars shall be secured with soft wire, the ends turned into the body of the concrete.

Splices shall be located where shown on the Drawings. The location of splices may be altered subject to the written approval of the Engineer.

Splice lengths shall be according to ACI 318 requirements or as shown on the Drawings. All additional splices allowed for the convenience of the Contractor shall be at the expense of the Contractor and with prior written approval of the Engineer.

Bars shall be cut and bent in accordance with ACI 315, bending shall be carried out slowly at a steady even pressure without jerking or heating.

Unless otherwise prescribed, placement dimensions shall be to the centerline of the bars. Reinforcement will be inspected for compliance with requirements as to size, shape, length, splicing, position, and amount after it has been placed.

Reinforcement shall be accurately placed to meet the following tolerances:

A. The amount of concrete covering reinforcement shall not deviate from that specified by more than1/4 inch if the cover specified is more than 2½ inches, nor by more than 1/8 inch if the cover specified is 2½ inches or less.

B. The spacing of reinforcing bars shall not deviate from the required spacing by more than 1/2 inchand the total number of bars shall be as shown on the Drawings.

Reinforcement shall be secured in position so that it will not be displaced during the placing of the concrete, and special care shall be exercised to prevent any disturbance of the reinforcement in concrete that has already been placed. Bars shall not be field bent to the extent of permanent set, nor straightened, except as approved by the Engineer or shown on the Drawings. Bars bent without approval shall be replaced to conform to the Drawings. Welding or tack welding of reinforcing bars will not be permitted except where approved by the Engineer. Chairs, hangers, spacers, and other supports for reinforcement shall be of concrete, metal or other approved material. Where portions of such supports will be exposed on finished concrete surfaces, the exposed portion of the supports shall be galvanized or made of corrosion-resistant material. Unless otherwise shown on the Drawings, reinforcement in structures shall be so placed that there will be a clear distance of at least 1inch between the reinforcement and any anchor bolts, form ties, or other embedded metalwork.

The Contractor shall provide for the immediate availability of competent steel fixers and carpenters during the whole period of any concrete placement.

9.5 Reinforcement Drawings to be prepared by the Contractor

The Contractor shall prepare and submit reinforcement detail drawings for review and approval, including bar-placing drawings, bar bending diagrams, and bar bending schedules, in accordance with the following provisions:

The Contractor's reinforcement detail drawings shall be prepared from reinforcement design drawings issued by the Engineer. These shall be submitted, in one (1) soft and four (4) A1 size, at least 60 days before scheduled concrete placement for all structures.

The Contractor's reinforcement detail drawings shall be prepared following the recommendations established by the American Concrete Institute's "Manual of Standard Practice for Detailing Reinforced Concrete Structures" (ACI 318-latest) unless otherwise shown on the reinforcement design drawings. The Contractor's detailed reinforcement drawings shall clearly show necessary details such as quantities, shapes, lengths, sizes, and weights of the bars and laps, for checking the bars during placement and for use in establishing payment quantities.

The Contractor's reinforcement detail drawings shall be clean, legible, and accurate and checked by the Contractor before submittal. Acceptable reinforcement detail drawings will be reviewed by the Engineer for adequacy of general design and controlling dimensions. Errors, omissions, or corrections will be marked on the print, and one print of each drawing will be returned to the Contractor for correction. The Contractor shall make all necessary corrections shown on the returned prints, and resubmit the corrected drawings as before. Such review and approval shall not relieve the Contractor of his responsibility for the correctness of details or for conformance with the requirements of these Specifications.

10 Movement Joints

10.1 Water stops

The Contractor shall supply and fix water stops in all contraction and expansion joints in members which are to be water-retaining and where shown on the Drawings. Such joints shall be watertight. Water stops built into joints shall be made of rubber and shall be of the hollow centre bulb type. They shall be obtained from manufacturers approved by the Engineer and shall be stored, fixed and jointed in accordance with the manufacturer's instructions. They shall be fabricated into the longest practicable units complete with angles and junctions at the manufacturer's works and shall be made continuous throughout the structure below highest water level and where shown on the Drawings. The number of joints in the water stop made on Site shall be kept to a minimum and these shall be jointed by approved means. The edge bulb section shall be circular. The webs shall be plain without serrations. Thewater stop shall be

carefully maintained in the position shown on the Drawings and properly protected from damage and the harmful effects of light and heat during all stages of construction. The stop-boards on each side of the water stop shall be accurately wrought to match the profile of the water stop. The concrete shall be carefully compacted under and around the water stop so as to leave no cavities. The Contractor shall supply the manufacturer's test certificates for each consignment of waterstopdelivered to Site and shall, in addition, supply to the Engineer sufficient of each type and consignment for confirmatory tests to be carried out in accordance with the appropriate standard test procedure, if ordered.

The rubber for rubber water stop shall satisfy the following requirements when tested as molded sheet in accordance with BS 903 : 1990.

Table 10-1: Requirements of Water stops

Material property	**Requirement**
Minimum tensile strength	20 N/mm2 (204 kg/cm2)
Minimum elongation at break	500%
BS Hardness (BS 903/Part A7:1990/1957)	60 to 65 degrees
Maximum compression set by constant deflection method	20% of original deflection
Maximum water absorption after 2 days at 20°C 5%	20% of original deflection
After accelerated ageing (48 hours at 70°C in oxygen at 2.0 N/mm_2	(0.22 kg/mm_2) 5%
(i) minimum tensile strength	80% of initial value
(ii) minimum elongation at break	80% of initial value

10.2 Joint Fillers

The Contractor shall supply and fix pre-molded joint filers in all expansion joints and where shown on the Drawings. Unless otherwise specified, the joint filler shall be of resin or bituminous bonded cork. The filler shall be obtained from a manufacturer approved by the Engineer and shall be stored and fixed in accordance with the manufacturer's instructions. The joint filler of the thickness specified shall be cut to shape and fixed to fill the whole space between the concrete faces of the joint which is not otherwise filled bywater stop and joint sealer. Abutting pieces shall be placed in close contact and the joints covered on each side to prevent the passage of cement grout.

The Contractor shall supply the manufacturer's test certificate for each consignment of joint filler delivered to Site and shall, in addition, supply to the Engineer sufficient numbers of each consignment for confirmatory tests to be carried out in accordance with the appropriate standard test procedure, if ordered.

The filler shall comply with United States Federal Specification HH-F-341e Type II Class B for the resin bonded cork and HH-F-341e Type I Class B for the bituminous bonded cork.

The filler shall also comply with the American Society for Testing and Materials Specification as follows:

(a) For resin bonded cork - specification ASTM D 1752 - 67 Type ll

(b) For bituminous bonded cork - specification ASTM D 1751 -73

10.3 Dowel Bars

Where dowel bars are to be provided through movement joints they shall be of mild steel plain round bars with sawn cut ends and complying with BS 4449.

In expansion joints the part of the bar to be free to move shall be encased in a rigid PVC or metal sleeve and fitted with a compressible cap of joint filler material or other material approved by the Engineer. The free end of the dowel bar shall be coated with an approved bitumen bond breaking compound. The diameter of the sleeve shall be the minimum necessary to allow free sliding movement of the bar after concreting.

In expansion joints care shall be taken during fixing and subsequent paving of concrete to ensure that the bars are correctly aligned with the direction of movement of the completed structure.

10.4 Joint Sealers – General

The Contractor shall construct recesses at expansion and contraction joints on both faces of the concrete work except on the underside of continuously supported work and on faces backfilled with earth. The recesses shall be accurately formed to the lines and dimensions shown on the Drawings or where not shown on the drawings or specified elsewhere shall be to minimum dimensions recommended by the manufacturer.

The Contractor shall prepare the surfaces of the recess and shall supply a joint sealer and fill or caulk the recess completely with it. Unless otherwise shown on the Drawings or ordered by the Engineer, the joint sealer shall be a hot poured rubber/bitumen compound for horizontal joints, and bituminous putty for sloping, vertical and soffit joints.

Where shown on the Drawings, or ordered by the Engineer, an elastomeric two-part polysulphide sealer shall be used. Joint sealers and the requisite priming materials shall be obtained from manufacturers approved by the Engineer and shall be used in accordance with the manufacturer's instructions. The application of joint sealer shall not be commenced without the Contractor having first obtained the approval of the Engineer.

The Contractor shall supply the manufacturer's test certificate for each consignment of each type of joint sealer delivered to Site and shall, in addition, supply to the Engineer sufficient numbers of each type and consignment for confirmatory tests to be carried out in accordance with the appropriate test procedure, if ordered.

10.5 Bituminous Sealer

The hot poured rubber/bitumen compound for sealing horizontal joints shall comply with BS 2499: 1993 for type Al. For sloping, vertical and soffit joints, bituminous putty shall be supplied which shall not slump in a vertical joint 25mm wide and 25mm deep at a temperature of 80°C.

10.6 Polysulphide Sealer

The elastomeric two-part polysulphide sealer shall comply with BS 4254 : 1983.In conjunction with this type of sealer an approved bond breaker such as a self-adhesive polyethylene strip shall be positioned against the exposed edge of the joint filler prior to application of the joint sealer. The bond breaker shall be resistant to attack from any primer used to bond the polysulphide sealer to the concrete.

10.7 Bitumen Coated Joints

Where the Drawings show a layer of bituminous paint between concrete faces, the Contractor shall clean and dry the face to which the bitumen is to be applied and shall then paint the bitumen on in two separate applications. The bitumen shall be a straight run bitumen, grade 40/50 penetration, or other approved by the Engineer.

11 Bored Cast-in-Situ Reinforced Concrete Piles

11.1 Scope of Work

This work shall consist of performing all operations for bored cast-in-situ reinforced concrete piles including but not limited to transportation of equipment, plant, to site of work staff, setting, survey work,

excavation of pit, disposal of material within the reservation width (leveling, finishing etc), drilling to be design depth, diameter as shown on the drawing and as instructed by Engineer, use of material (Bentonite etc), water power, lubricants, shifting of equipment, lowering of cage (concrete and reinforcement will be paid separately in respective chapters of 'Concrete' and 'Reinforcement'), testing, production of record strictly in accordance with these specifications stated herein under, complete in all respect as shown on the Drawings and as instructed by the Engineer.

All works to be performed under these specifications shall be carried out at the proposed locations shown on the Drawings and shall include but not be limited to the following:

- Construction of bored cast in-situ reinforced concrete test piles for pile load tests.
- Performance of load tests on piles.
- Construction of bored cast in-situ reinforced concrete piles for various structures under thisContract.
- Performance of proof load tests on working piles selected by the Engineer.
- Keeping complete record of all operations performed during construction, boring and load testing of the above piles.

11.2 General Requirements

The general requirements for reinforced concrete piles shall be as follows:

a) Type, Diameter and Length of Piles:

b) Bored cast in-situ reinforced concrete piles using sulphate resisting cement (if required under the codes and standards) according to soil report shall be constructed as shown on the Drawings.

c) All piles shall have specified diameter and length as shown in the Drawings.

d) The Engineer may direct the positions, the number, diameter and length of piles to be changed and accordingly the design requirements during the progress of the work(s).

e) Tolerances in location and plumpness:

Each pile shall be placed with its top being within 2 inches of the correct position as shown on theDrawings.Piles shall be cast as accurately as possible to the vertical. The maximum allowable deviation from the vertical shall not exceed 0.5 degree (1:114) on any section of the length of the pile.

11.2.1 Cutting of Pile Heads

The pile heads shall be cut to the levels shown on the Drawings and the cut shall be level, smooth, and horizontal. Due care shall be taken to protect the edges and reinforcement. Pile cut off levels shall be shown on the shop drawings to be submitted by the Contractor for approval of the Engineer.

11.2.2 Order of Work

The Engineer shall decide the order in which construction and load testing of piles shall be carried out.

11.2.3 Supervisory Staff

The Contractor shall have at site at all times, only qualified, experienced and thoroughly competent persons, who shall conduct and supervise drilling, pile construction and load testing operations. Since the construction of piles requires special knowledge and utmost care. The Contractor shall have at least one qualified and experienced engineer specialized in this field of work that shall be present full time during execution. The Contractor shall remove from the site any employee who does not in the opinion of the Engineer meet these requirements.

11.2.4 Site Conditions

The Contractor is responsible for any damage to the existing superstructures and sub-structure caused due to piling work. The Contractor shall ensure that pile construction works shall not interfere with the work of any other contractors working in the area. Where approval has been given to the Contractor for carrying out concreting operations at night, the Contractor shall provide adequate lighting at all points where mixing, transporting, placing of concrete is in progress. When concrete is to be manufactured, transported and placed in hot weather, specific precautions as required by the Specification shall be observed and the entire relevant standard applicable in this connection shall be adhered to.

11.3 Submittals

The Contractor shall be required to make following submittals:

11.3.1 Method Statement

The Contractor shall submit to the Engineer before start of piling work a detailed description of the equipment, materials and procedures that will be used. The description shall include equipment specifications, loading capacities, protective devices, test apparatus, detailed installation procedures, test procedures and other documents ordered by the Engineer. Contractor's construction procedures shall be type-written and shall include charts and diagrams as applicable and necessary, to allow effective review by the Engineer.

11.3.2 Survey and Location

The Contractor shall carry out a leveling survey and provide excavated ground elevations for each pile location. The elevations shall be given with respect to a permanent Bench Mark. The locations of piles shall be established by the Contractor as per shop drawings as approved by the Engineer. The Contractor shall establish the pile locations accurately in the field.

11.3.3 Protective Measures

The Contractor shall submit to the Engineer procedures for the following:

i) Hot weather concreting procedures shall be submitted to the Engineer by the Contractor regardless of the need for the immediate implementation of such procedures. Procedures shall include insulating procedures, finishing procedures. Timing and duration of curing shall also be described.

ii) Protection of concrete against damage due to mechanical contact and construction operations.

iii) Proposal regarding necessary facilities for drainage of the excavated areas. The Contractor shall keep the site free of ponding water during rain and during boring and construction of piles.

11.3.4 Placement Schedule

The Contractor shall submit a placement schedule for review prior to start of concrete placement operations. Daily concrete pour schedules shall be submitted 24 hours in advance of planned pours.

11.3.5 Testing Programme

The Contractor shall submit test programme for all specified requirements along with the test plan.

11.3.6 Test Reports

The Contractor shall submit test reports showing the results of required tests and compliance with specified standards and codes. The Contractor at the testing agency approved by the Engineer who shall certify test reports.

11.3.7 Sample

The Contractor shall submit to the Engineer for acceptance prior to purchase, fabrication or delivery samples of materials or products where required by the Engineer.

11.4 Products

The products and materials shall meet the following requirements.

11.4.1 General

All materials used in the Works shall be subjected to inspection and testing as and when directed by the Engineer. Should the Engineer decide not to carry out tests on a material or materials himself or under his direction, the Contractor shall, whenever required, obtain from the Manufacturer and submit to the Engineer the certificates, showing that tests of materials having been carried out in accordance with the requirements of this Specification. Before ordering any materials proposed to be used in the execution of the Works, the Contractor shall submit to the Engineer for his written approval the name(s) and address (es) of the firm from which he proposes to order the material(s). If the Engineer is in doubt about the quality of the delivered materials, the Contractor shall demonstrate through the relevant tests that the quality of the materials fully satisfies the requirements of this Specification.

11.4.2 Concrete

Concrete for bored, cast-in-situ piles shall be in accordance with the requirements specified in the Chapter "Concrete". Sulphate Resisting Cement shall be used for all concrete in reinforced concrete piles and their caps. In addition to meeting the strength requirements, the concrete for bored cast in-situ piles shall have adequate workability for the method of placing employed in the casting of piles and the consistency will meet the requirement as stipulated in the Chapter - "Concrete". The concrete shall be of the concrete class shown on the Drawings.

11.4.3 Sand and Aggregate

All coarse and fine aggregates used for concrete under these specifications shall be furnished by the Contractor in accordance with the provisions of and in complete conformity with the requirements of the specification in Chapter "Concrete".

11.4.4 Reinforcing Steel

Reinforcing steel shall conform to the requirements set forth in the Chapter – "Reinforcement". All placing shall be in accordance with the Drawings furnished or as approved by the Engineer.

11.4.5 Drilling Fluid

The drilling fluid used for all types of drilling shall be clean water, free from suspended sediments. The Contractor may be allowed to use Bentonite slurry as drilling fluid with the prior approval of the Engineer.

11.4.6 Casing of Holes

Casing of holes shall be according to the provisions given below:

1. The holes shall be cased down to the bottom.
2. The Casing shall be made of cylindrical steel pipes of inside diameter equal to the pile diameter and shall have sufficient strength so as to maintain position and shape during drilling operations. Casing used during concreting should be free from internal projections and encrusted concrete, which might prevent the proper formation of piles. It shall also be free from distortion and shall be of uniform cross-section throughout.

3. The casing maybe omitted only where it can be shown that lowering of reinforcement cage and concreting operations will not cause caving of the borehole.
4. The Contractor shall pull out the casing from the holes at the time of concreting of piles.

11.5 Execution

11.5.1 General

(1) Before starting the piling work, the Contractor shall complete clearing, levelling and setting out of the site. Any obstacles shall be removed, as directed by the Engineer. If the presence of existing underground utilities is known or suspected, the Contractor shall carry out such diversion or protection of these as directed by the Engineer.

(2) All excavation shall be carried out as nearly as possible to the exact dimensions of the pile foundations to minimize backfilling.

(3) All surplus excavated material from excavations not required for back filling shall, if considered unsuitable by the Engineer, be disposed of as directed.

(4) All installation procedures shall be subject to the Engineer's approval. No pile boring shall take place within 48 hours of the concreting of any pile, which is within a radius of 10 ft.

(5) The Engineer shall decide the sequence of work. The test piles shall be constructed and loadtestedprior to the start of the main piling. Additionally, proof load tests shall also be carried out onworking piles during construction of piles. The Engineer shall select the piles for proof load tests.

11.5.2 Method of Drilling

The drilling of holes for piling shall be done by straight or reverse rotary rig or any other suitable method proposed by the Contractor, subject to approval of the Engineer. Regardless of the method used for drilling holes:

(1) After completion of drilling operations the borehole length shall be checked and recorded.

(2) The deviation from the vertical shall not exceed 0.5 degree (1 in 114) on any section of the length for the holes.

(3) Drilling operations shall be carried out in such a way as to avoid any disturbance of the soil especially at the bottom of the hole.

11.5.3 Stabilizing the Holes

The Contractor shall ensure at all times that the hole does not collapse during and after boring. The Contractor may use Bentonite slurry or any other drilling method with written approval of the Engineer. When Bentonite slurry is used strict compliance with sub-section herein below shall be ensured. The nominal diameter of pile is defined as the minimum cross-section of unlined portion of borehole. The possible enlargement of the pile shaft during boring, placement and compaction of the concrete shall not be taken for measurement and for increase in the admissible load.

11.5.4 Removal of Mud

The excavated material from boreholes shall be disposed of by the Contractor.

11.5.5 Clean out and Control at the Bottom of the Piles

After the bore has reached its final penetration as stipulated on the Drawings and as may be additionally ordered by the Engineer, on the basis of data obtained in the field, and after it has been completely cleaned of all earth and otherwise made ready to receive the reinforcement and thereafter the concrete, the Contractor shall so inform the Engineer. All disturbed soil and loose materials shall be pumped out in

such a manner that after cleanout operation, the bottom of borehole remains horizontal and in undisturbed condition. The clean out pumping arrangement shall be such that the lower end of the pump can be moved all over the cross-section by a routine operation. The suction of pump shall be adjustable. At the end of cleanout operations, a break shall be made for a period of at least five minutes, and then pumping shall be resumed and shall continue until the bottom of hole is cleaned.

The Engineer shall check the actual bore penetration achieved, the cleanliness of the boreholes and the amounts and directions, if any, by which the borehole is out of position and/or out of plumb and having satisfied himself on these and on any other points which he may consider relevant, shall sign pour slip for the borehole authorizing the Contractor to proceed with the placing of reinforcement. The Contractor shall under no circumstances proceed with the placing of reinforcement in the boreholes or with subsequent concreting without having first obtained the written authority signed separately for each and every borehole.

11.5.6 Bentonite Slurry

Where the use of Bentonite slurry is approved for the purpose of maintaining the stability of the walls and base of bore, these shall include inter-alia.

- The source of the Bentonite
- The constitution of the slurry.
- Specific gravity, viscosity, shears strength and pH value of slurry.
- The methods of mixing, storing, placing, removal and re circulating the slurry.
- Tests shall be carried out to ensure that the proposed constitution of the slurry is compatible with the ground water: Proposals for the constitution and physical properties of the slurry shall include average, minimum and maximum values. The specific gravity of the slurry shall not be less than one and one tenth in any case at any time. The Contractor shall use additives where necessary toensure the satisfactory functioning of the slurry.
- A manufacturer's certificate showing the properties of the Bentonite Powder shall be delivered to the Engineer for each consignment delivered to Site. Independent tests shall be carried out at laboratory approved by the Engineer on samples of Bentonite frequently.
- The Contractor shall carry out tests at site during the course of the pilling to check the physical properties of the Bentonite slurry in the works. These tests shall include, inter-alia, density, viscosity, shear strength and pH tests. The test apparatus and test methods shall be those givenin "Recommended Practice" Standard by American Petroleum Institute, New York City, 1957Reference API RP 29, Section I, II and VI.
- The frequency of tests shall be that which the Contractor considers necessary to ensure that theBentonite slurry is in accordance with his proposals and as such other times as the Engineer may direct.
- Should the physical properties of any Bentonite slurry deviate outside the agreed limits, such slurry shall be replaced, irrespective of the number of times it has been used by new Bentonites lorry of correct physical properties. Adequate time shall be allowed for proper hydration to take place consistent with the method of mixing, before using slurry in the works.

11.5.7 Concreting

Concreting of piles shall be done as given herein below:

11.5.7.1 Placing of Steel Reinforcement

The cage of reinforcement shall be assembled on the ground and securely tied by means of binding wire in such a manner as to form a rigid cage. It shall be lowered in the borehole carefully keeping the cage concentric with the borehole. Adequate concrete spacers shall be provided around the cage to ensure the required concrete cover to be available on all sides of the cage. Concrete spacer blocks specially pre-castor this purpose shall be securely attached to the reinforcement at a suitable spacing and each quarter point so as to ensure that the concrete cover stipulated on the Drawings is maintained throughout and that the reinforcement cage is not displaced in the casing during the course of subsequent concrete operations. In addition concrete spacer blocks shall be located immediately below and immediately above the lap at 4 points spaced around the cage.

Particular care shall be taken to ensure that none of the spacer blocks move out of position to the inside of the reinforcement cage due to spacer blocks or lapped reinforcement or any other reasons which might interfere with concrete placement. Depth of the hole shall be measured just before and after the lowering of cage. In case it is found that the soil has caved into the hole during the lowering of the cage, the Contractor shall be required to adequately clean the hole before the start of concreting.

11.5.7.2 Composition of Concrete

Composition of concrete shall be according to the relevant clause of the Chapter "Concrete".

11.5.7.3 Batching of Concrete

Batching of concrete shall be as per requirements of the relevant clause of the Chapter "Concrete".

11.5.7.4 Mixing of Concrete

Mixing of concrete shall be done in accordance with the relevant clause of the Chapter "Concrete".

11.5.7.5 Conveying

Concrete shall be conveyed from mixer to piles as rapidly as practicable by methods, which will prevent segregation or loss of ingredients. Any wet batch hopper through which the concrete passes shall be conical in shape. There shall be no vertical drop greater than 5 feet. Belt conveyers, chutes, or other similar equipment will not be permitted for conveying concrete except where the use of such equipment disapproved in written by the Engineer, in advance of any use.

11.5.7.6 Placing

1. General

And the reinforcement cage properly installed, and such depth has been checked and recorded concreting operations shall be carried out. Approval of the Engineer shall be obtained before starting any concrete pour. Concrete pouring will not be permitted when in the opinion of the Engineer weather conditions prevent proper placement. Unless otherwise approved concrete pouring shall be performed only in the presence of the Engineer.

2. Mixing-Placing Interval

Concrete shall be placed within thirty minutes, after it has been mixed.

3. Placing Temperature

Concrete shall be delivered to the piles at the coolest temperature, which is practicable to produce under current conditions but in no case at a temperature in excess of 32°C or lower than 5°C.

4. Placing Method

Pouring of concrete shall be done by an efficient termite technique. The method and equipment used shall be subject to the prior approval of the Engineer. The tremie pipes shall have to be large enough with dueregard to the size of the aggregate. For ¾ inch aggregate, the tremie pipe shall be of diameter not less

than 6 inches and for larger aggregate, larger diameter tremie pipes shall be used. The hopper and tremie pipe shall have to be a closed system embedded in the placed concrete, through which water will not pass. When concrete is deposited by tremie, the tremie seal shall be affected in a manner, which will not produce undue turbulence in the water around the pipe. The discharge end shall be kept submerged continuously in the concrete and the shaft kept full of concrete to a point well above the water surface. The tremie shall not be moved horizontally during a placing operation. The rate of placing concrete in the borehole shall be nether less than 30 feet per hour and no more than 50 feet per hour. When a casing is used, it shall be lifted up to a height less than the height of casing already filled in with concrete. The bottom of casing shall stop to an elevation of 5 feet lower than the top of the concrete. Particular care shall be taken in order to avoid earth slide the hole. During the progress of pouring, the Contractor will ensure that standby equipment is available in order to cope with equipment break down if encountered.The Contractor shall not be permitted to place concrete while it is raining. The Contractor shall carry on with proper and sufficient precautions, the concrete placement operation until the pile is completed and shall cover the concrete already placed and under setting condition with polythene or similar impervious sheets. No additional payment shall be made for any such emergency and protection works. All tremietubes shall be scrupulously cleaned after use for subsequent concreting. Concrete in piles shall be continued up to two feet above cut off levels as shown on Drawings and shall be broken down to cut-off levels prior to placement of pile caps.

The Contractor shall break back the concrete in the top portion of the piles to the final elevation which will be 3 inch above the bottom of the pile cap and the same time exposing the length of pile reinforcement required for lapping and binding with the pile cap.

The Contractor shall also establish and record the actual co-ordinates of the centers of the broken-off pile tops with respect to theoretical centre line of each pile cap as shown on the Drawings and the tolerance in this respect shall not exceed 2” in any direction. No separate payment will be made for manufacturing, placing and breaking of this part of concrete.

5. Protection and Curing

As each pile cap is completed, the projected length shall be immediately and carefully protected from any condition that will damage or adversely affect the hardening of concrete. Concrete shall be cured for 28continuous days by an approved method.

6. Stripping and Finishing

Any cracked or defective concrete in the head of the completed pile shall be cut away and made good with new concrete well bonded into the old. The reinforcement in the pile shall be exposed for a sufficient distance to permit it to be adequately bonded to the pile cap. This shall be done carefully to avoid shattering or otherwise damaging the rest of the pile. The reinforcement shall then be cleaned and bent to form an anchorage into the concrete of the super-structure as directed by the Engineer. Where a temporary casing is used, the top of the pile shall be brought up sufficiently above the required finished level to allow for slumping on withdrawal of the casing and to permit all laitance and weak concrete to be removed. Particular attention shall be paid to the compaction of the concrete in the top 3 feet or so of the pile.

7. Damaged Piles

For any pile damaged or not conforming to the requirements of this Specification the Contractor shall be responsible for repair or replacement.

If the Engineer doubts the efficiency of any pile so repaired, he may order the Contractor to construct additional piles, at points selected by him. The Engineer may direct the Contractor to proof load test the

Doubtful pile. Any piles that are damaged or imperfect and thus rejected by the Engineer shall be removed and discarded. When the rejected pile is withdrawn, the space shall be filled solid with gravel or broken

Stone without extra payment therefore. Debris from pile cut-offs and damaged piles shall not be buried in required fill under slabs at grade or in required embankments but shall be disposed of by the Contractor off the site of the work. Piles, which, in the opinion of the Engineer, are defective in any way, shall be rejected and replaced by the Contractor.

11.6 Loading Tests on Piles

The procedure for loading test on piles shall be as given below:

(1) Pile load tests shall be conducted to failure on test piles prior to commencement of actual piling work. The Engineer in the field shall give the number and location of test piles. Test piles shall be constructed first, cured 21 days and then load tested for load carrying capacity by the procedure specified in ASTM D 1143.Proof load tests shall also be conducted on selected working piles during and after Execution of piling work of the constructed piles. The number of proof load tests to be carried out shall be decided by the Engineer and the proof load test piles bed selected by him.

(2) The Contractor shall bring all equipment and supplies to the site for satisfactory performance of the test according to ASTM D 1143, or any other method approved by the Engineer.

(3) The Contractor shall submit to the Engineer an up-to-date calibration certificate from a laboratory established by the Contractor or a laboratory approved by the Engineer as indicated in chapter of Materials and Workmanship herein, showing correctness of the gauge and or load cell to be used with the hydraulic jacks.

(4) The apparatus shall be calibrated as per requirements of ASTM D1143 or equivalent. The Contractor shall submit to the Engineer details of calibration within 7 days prior to commencing testing for his review and approval.

(5) The pile head shall be cut-off or built up to the necessary elevation and shall be capped appropriately to produce a horizontal bearing surface.

(6) Care shall be taken to ensure that the centre of gravity of the ken ledge is on the axis of the pile and that the load applied by the jack is coaxial with the pile.

(7) Maximum load on test shall be 2 to 3 times the design load of the pile as specified by the Engineer or to failure. In any case, the pile shall be considered to have failed during testing if the settlement exceeds 0.5 inches. If any test pile fails, more piles of redesigned length shall be constructed and load tested.

(8) Maximum proof load test on working pile shall be limited to 150 percent of the pile design load oras specified by the Engineer. In case of failure of a working pile it shall be considered as damaged pile to be replaced by another pile.

(9) The record of pile load test shall be kept on an approved format. The Contractor shall prepare load time settlement curves for each such load test. Two copies of the relevant field data and the graphs shall be supplied to the Engineer within 48 hours of the completion of the test.

11.7 Record and Reports

The Contractor shall prepare the following tests, records and reports:

a) Records

The Contractor shall keep accurate records of all the works accomplished. The Contractor shall preserve all such records in good condition and order until they are delivered and accepted by the Engineer. The Engineer shall have the right to examine such records at any time prior to their delivery to him. The following information shall be included in the records for each pile:

- Pile number and elevation of top of bore hole and top of pile
- Type of drilling operations
- Type of soil encountered in the hole with values of cohesion and angle of internal friction
- SPT resistance values (N-values)
- Date and depth of bore when drilling operations were performed and piles constructed
- Total depth of each bore hole
- Size and length of casing, if used
- Quantity of concrete and steel used for the construction of each pile
- Quantity of constituents of each batch of mix, water cement ratio and the result of all quality control tests
- Date and time of load testing of piles, load and settlements readings during the loading and unloading of the test piles (for test piles only)
- Graph of time-load-settlement relationship for test (for test piles only)
- Remarks concerning any unusual occurrence during drilling, concreting and load testing of piles
- Report:
- Reports of each pile construction and pile load test shall be communicated to the Engineer as follows:
- Verbal reports as the work proceeds.
- A report in duplicate no later than 48 hours after the completion of each hole, concreting of piles and load testing of piles.
- Daily record for bored piles.
- Five copies of the final report of the works within one month of completion of the last pile.
- The final report shall include:
- Layout showing the “As built” arrangement of piles, their exact locations, dimensions, length, reinforcement, cut off elevation and the location of test piles.
- A tabulation of the loads and settlement readings during the loading and unloading of the test piles.
- A graphic representation of the test results in the form of time-load-settlement curves.

12 Pre-stressed Concrete Girders

12.1 Description

The work shall consist of providing and pre-stressing pre-cast or cast-in-place concrete members by furnishing, placing and tensioning steel in accordance with details shown on the Drawings and specified herein or as instructed by the Engineer.

12.2 Material Requirements

12.2.1 Anchorage Cones

Male and female anchorage cones shall be standard size Freyssinet or other cones which are equivalent and approved by the Engineer. Anchoring cones showing any damage or any appreciable rusting of inner or outer wire spirals shall be rejected. Cleaning of female cones having a rusted inner wire spiral will not bellowed.

The Contractor is advised in his own interest to procure at his own expense spare male and female cones so that spares are immediately available in case cones are rejected due to damage/rusting. Since the reinforcing bars in the end region of post-tensioned girders are congested, it may be difficult to place and vibrate the concrete. For the convenience of concreting the Contractor has the option to cast the 5 ft. end regions (end blocks) separately preferably in flat position. The end block after 3 days curing period may be erected in position to receive the form work and lapping bars, sheaths etc. of the main body of the girder. The female cones shall be securely, wired to the shuttering and the cable sheath slopped on to the protruding part of the female cones. The junction shall be well wrapped with plastic tape to ensure water tightness.

12.2.2 Sheathing

1) The assembled cable shall be sheathed, as recommended for use with Freyssinet cables or in an approved metal sheath and shall be hydro-rigid and strong enough to withstand handling and placing of concrete without sagging between its supports. Rusted sheathing shall not be used under any circumstances. Sheathing showing holes, openings or slits at seams shall be rejected and immediately removed form Site.

2) Unless self-joining sheath is used, all joints between shuttering and anchorages shall be made with approved couplers specially designed for this purpose. The sheath shall be laid to the lines indicated on the Drawing and shall be securely fixed in position with mild steel strip and binding wires. Absolute conformity in respect of the positioning of the sheathing with the locations shown on the Drawings and as instructed by the Engineer is essential in the end blocks, at the construction joints, if any, between the end blocks and the body of the girders and at all the points in the body of the girder where cable ordinates are given. In the intervening zones, and important consideration is to achieve smooth curves as shown on the Drawings and to avoid interference between the cables and/or between the cables and the reinforcement. Additional (support) reinforcement is permissible for this purpose provided that stipulated cover is maintained throughout and that such additional reinforcement does not result in difficulties with concreting and the possibility of honeycombing of the concrete.

(4) All joints between sheath and anchorages shall be adequately and securely taped to prevent the ingress of grout from the concrete. All sheathing shall be carefully inspected immediately prior to concreting in order to ensure that the alignment is correct, the joints secure, and the sheath undamaged and unblocked. The cable shall be moved free by hand pull or by light hammering after concreting to ensure that leakage of concrete, if any, does not bond the cable to the sheath. The Contractor shall submit to the Engineer for approval his proposed method for fixing the sheathing.

12.2.3 Helical Core

The steel helix used in the centre of the Freyssinet cable is manufactured and supplied as closely wound helix which must be draw-out to an extension of approximately 10:1 before placing in the cable, in order tonsure that the wires of the cable are all in contact and bearing against the central helix core. The use of a helix core with a Freyssinet 12 ½ cable is not necessary. However, if used, the inner diameter of the sheath must be 70 mm instead of 62mm.

12.2.4 Pre-stressing Reinforcement Steel

Uncoated, stress-relieved or low-relaxation, seven-wire strand, or uncoated plain or deformed, high strength bars, shall conform to the following materials standards.

1) ASTM A 416 – Uncoated, Seven-Wire, Stress-Relieved Strand for Pre-stressed Concrete, or
2) ASTM A 421 – Uncoated, Stress-Relieved Wire for Pre-stressing Concrete.

Tensile and yield strengths for these steels may be taken as specified in Table 12.1 below:

Table 12-1: Properties of Pre-stressing Strand and Bar

Material	Grade of Type	Diameter in inch	Tensile strength Fpu(ksi)	Yield Strength fy(ksi)
Strand	(Grade250) (Grade 270)	0.25" to o.60" 0.375" to 0.60"	250 270	85% of fpu except 90% of fpu for low-relaxation strand
Bar	Type 1.smooth	0.192.0 . 276	235-250	85% of fpu

If the Drawings indicate only the pre-stressing forces and locations of application, the choice of size and type of steel shall be left to the Contractor, subject to the Engineer's approval.
If more precise data are not available, the modulus of elasticity for pre-stressing steels, based on nominal cross-sectional area, may be taken as:

For strand: Ep = 27,000 ksi

For Bar: Ep = 29,000 ksi

12.3 Method of Pre-stressing

Stressing shall take place within 4 weeks of the concrete attaining the required strength otherwise the Engineer will require one or more tendons in each element to be post tensioned , to be withdrawn and checked (if necessary by testing) for corrosion. Tendon removal, testing, replacement (if considered necessary by the Engineer), re-threading etc. shall be the Contractor's responsibility. Grouting shall take place within 4 weeks of post-tensioning. Where the Contractor fails to meet this criterion the Engineer may require de-stressing of the post-tensioned member.

Where a member has, for any reason, been de-stressed the post-tensioning tendons shall not be re-used and new tendons shall be provided. All costs associated with de-stressing, including tendon replacement shall be responsibility of the Contractor. No part-payment for post tensioned member shall be made until the member is stressed and grouted in accordance with the Specification.

12.4 Launching

The Contractor shall choose his own method of launching to suit the site condition. However, the method should be compatible to the loading imposed on the girder and its strength. A detailed methodology of launching including description of the mechanism should be presented to the Engineer seven (7) days in advance of the operation for approval. Approval by the Engineer shall not relieve the Contractor from liabilities arising from the operation.

13 Canal Lining

13.1 Preparation of Substrate for Canal Lining

The canal profile shall be built and compacted in accordance with Clause 5.16 and 5.17 to the following levels:

- Over the full width of the concrete lining to a level at least 6 inches (150 mm) above the required final level; and
- For the remainder of the width of the two bank tops, approximately up to the level of the top of the concrete lining. Not more than 7 Days before the geo-membrane is to be placed, the soil shall be trimmed to the final line and level within the tolerances given in Clause 5.19 and also to a standard of straightness and flatness such that the local variations away from flat planes shall not exceed 10 inches (0.25 m) in any distance of30 inches (0.75 m) measured across the surface. Any stones, roots, hard clods or other objects that protrude above the surface, or that are likely to do so during the process of installing the lining system, shall be removed and replaced with suitable material compacted to as required by Clause 5.17 if this is necessary.

Immediately before the placing of the geo-membrane the surface of the sub-grade shall be inspected and any defects remedied.

All suitable material from the trimmings shall be used as fill in the final section of the embankment. The canal banks shall be built up and compacted and trimmed to their final dimensions, care being taken to avoid the use of heavy compacting equipment within 1 ft (0.3 m) of the edge of the concrete lining.

13.2 Tolerances for Concrete Canal Lining

All concrete canal lining shall be finished to Class U3 finish as defined in Clause 8.19. The allowable tolerances shall be as defined in Table 13.1.

Table 13-1: Tolerances for Irregularities in Canal Lining

	Tolerance (inch)
Type of irregularity	Maximum allowed
Departure from centerline alignment shown on the Drawings	±6
Departure from vertical alignment and grade shown on the Drawings (1)	±2
Reduction in concrete cross-sectional thickness	¼
Deviation from template in long dimensions (2)	±1/4
Abrupt (3)	±1/8

.In Table 13.1 the numbers in brackets under the type of irregularity are defined below

1. The cross-sectional area of the channel must not be less than shown on the Drawings.
2. Gradual irregularities from the dimensions shown on the Drawings and measured from a 10ft (3 m)long template.
3. Offsets and fins caused by displaced or misplaced formwork or failure to achieve required U3finish.

13.3 In-situ Concrete Canal Lining

13.3.1 Preparation

Preparatory work for concreting in the canal bed shall not begin until the geo-synthetics have been placed and jointed and approved, in compliance with the requirements of Clause 13.4.The precautions taken when placing the concrete lining over the geo-synthetics shall be as defined in Clause 13.4.5(a). As far as possible, people working in the canal profile before concrete is placed shall walk on planks laid carefully on the geo-synthetics to spread the loads and prevent damage. These planks, and all shutters, props and

other devices used to secure shutters, shall be free of sharp or jagged edges and splinters. No fixing devices may be driven into the surface of the underlying geo-synthetics.

13.3.2 Joints in Concrete Canal Lining

The in-situ concrete lining shall be divided into panels by construction joints. Concrete shall be placed in alternate panels, at least 3 days and not more than 14 days elapsing between the placing of the first set of panels and the placing of any panels abutting the first set, these being referred to as the second set. The maximum dimension of any panel along the canal shall be 12 ft (4 m). Panels shall be separated by transverse construction joints, each extending across the canal in a straight line at right angles to the canal axis with a tolerance of 1 inch (25 mm).

In canals with a bed width of less than 3ft (1.0 m) there shall be no longitudinal construction joints and each panel shall extend across the full width of the canal.

In canals with a bed width of more than 3ft (1.0 m) there shall be two longitudinal construction joints and the full width of the canal shall have three concrete panels between any two transverse construction joints.

These shall be referred to respectively as one bed panel, located entirely on the bed, and two side panels, which shall comprise the outer few inches of the bed, the canal side slopes, and the horizontal concrete on the berms. The longitudinal construction joints shall be located in the bed of the canal, distant 2 to 4 inches (50 mm to 100 mm) from the nominal line where the canal bed surface meets the side slope surface. In such canals, unless explicitly agreed otherwise by the Engineer, every panel in the bed shall be placed, and cured for at least 3 days, before any of the side slope panels adjacent to that bed panel or to the two panels adjoining it are placed. By this means the Contractor shall, in canals of this size, entirely avoid moving persons or Equipment on the geo-synthetics surface of the bed while concreting the sides. In the case of canals without longitudinal construction joints, the edges of the first set of panels shall be formed by means of shutters along the sides of the canal and across the width of the canal. Beyond the sides of the canal lining these shutters may be fixed in place by means of pegs driven into the embankments but within the canal profile they may only be fixed by means of sandbags. In the case of canals with longitudinal construction joints, the shutters for the first set of bed panels shall be held in place only with sandbags and/or with struts joining the shutter of one panel to the shutter of another. The side shutters for the second set of bed panels may also be secured to the sides of the first set of bed panels. The transverse shutters of the first set of side slope panels shall be secured to the concrete panels already placed in the bed, and to pegs in the embankment beyond the sides of the completed lining, and may also be secured by sandbags on the berms, but no devices for securing these shutters shall be located on the side slopes.

With the exception of the expansion joints as defined in Clause 13.5, all construction joints shall be left open, or filled immediately with silt or fine sand available locally to prevent any malicious damage to thegeo-membrane.

13.3.3 Placing the Concrete

Any ramps, chutes or other devices used for the transport of materials shall be approved by the Engineer. Concrete shall be placed in canal beds without touching the exposed geo-synthetics on the side slopes and without dropping significant quantities of wet concrete onto those surfaces. Concrete may be transported along the bed of the canal across bed panels already concreted, provided that the concrete is at least 3 days old, and that no wheeled device with a wheel load of more than 1 kN shall be used, and that planks are used as far as possible to spread the load on the concrete.

Concrete in the canal lining shall be placed to line and level by means of a beam or roller spanning the width of a panel, its ends resting on, and sliding or rolling along, shutters or the concrete surface of adjacent panels already concreted. The concrete shall be vibrated either with immersion type vibrators (which shall at no time touch the underlying geo-synthetics) or by vibration of the said beam or roller.

Within 30 minutes of the placing of the concrete by this means, its surface shall be smoothed with a suitable trowel to give a smooth surface free of irregularities or honeycombing more than 1/16th inch (1 mm) deep.

The surface finish for the concrete lining shall confirm to the Class U3 finish, as defined in Clause 8.19, and the construction tolerances shall be as defined in Clause 13.2.

13.4 Geo-synthetic Canal Lining

13.4.1 Elements of the Geo-synthetic Lining System

The geo-synthetic canal lining shall consist of a geo-membrane laid against the soil surface, covered by age textile, which in turn is covered by a concrete layer or a layer of soil. In some places the geo-membrane may be placed over rigid materials, such as brickwork or concrete, instead of soil. The following definitions shall apply.

A geo-membrane is essentially an impermeable flexible membrane of synthetic material whose purpose isto prevent loss of water from a lined canal.

A geotextile is a permeable textile whose purposes are to protect the geo-membrane from puncturing and to prevent sliding of concrete or soil.

A geo-synthetic is a geo-membrane or a geotextile.

A concrete layer is a layer of in-situ Class C concrete whose purpose is to protect the underlie inggeosyn the tics from mechanical damage, heat, and radiation.

The substrate is the layer immediately under the geo-membrane lining.

The letters ASTM refer to standards issued by the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103-1187, USA.

The letters BS refer to standards issued by the British Standards Institute, 389 Cheswick High Road, London W4 4AL, UK.

The letters DIN refers to German standards issued by the DitchesInstitutefurNorman,Berlin, Germany.

The letters ISO refer to standards issued by the International Standards Institute, 1 ruedVariable, Case Postal 56, CH 1211 Genève, Switzerland.

The reference GRI/GM3 means the Large Scale Hydrostatic Puncture Test, designated Test Method GM3, defined by Geo-synthetic Research Institute, 475 Kedron Avenue, Folsom, PA 19033-1208 USA.

The letters GRI refer to the Geo-synthetic Research Institute, Drexel University, 475 Kedron Avenue,

Folstom, PA 19033-1208 USA

Where a published standard test or specification is referred to in this Clause 13.4:

i. any parameter value defined in this Clause 13.4 shall replace the value of the same parameter in the published document, while any parameter not defined in this Clause 13.4 shall have the value defined in the published document;

ii. any stated restrictions on the applicability of that test to particular types or thicknesses ofgeo-synthetic shall be ignored; and

iii. the applicable version or revision of the standard shall be the latest one in force 28 Days prior to the bid submission date.

The term "piece" shall have the meaning given to it by Clause 13.4.2.4 for geo-membrane and Clause13.4.3 for geotextile, except where the context refers to something else such as a test piece or an offcut.A berm is a horizontal surface at the side of a canal, adjacent to the top edge of the side slope.

13.4.2 Geo-membranes

13.4.2.1 General

The geo-membranes shall be made of material complying with Clause 13.4.2.2, and shall consist of flexible sheets complying with Clause 13.4.2.3. Joints within the sheets shall comply with Clause 13.4.2.4, and the attachment of the sheets to rigid structures shall comply with Clause 13.4.2.6 and Clause 13.4.2.7. Up to three different geo-membranes may be used for different parts of the Works, provided that each of them complies with this Clause 13.4.2.

13.4.2.2 Material

The material from which each geo-membrane is made shall comply with all the requirements of the standard specifications for geo-membranes issued by the Geo-synthetic Research Institute for either:

- High Density Polyethylene (HDPE), complying with GRI Test Method GM13, Standard Specification for Test Properties, Testing Frequency and Recommended Warranty for High-density Polyethylene (HDPE) Smooth and Textured Geo-membranes under Table 1(b) for smoothgeo-membranes; or
- Low Density Polyethylene (LDPE), complying with GRI Test Method GM17, Standard Specification for Test Properties, Testing Frequency and Recommended Warranty for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geo-membranes under Table 1(b)for smooth geo-membranes.

13.4.2.3 Sheet Properties

The geo-membrane as installed, when tested at a temperature of 21 to 25 °C and a relative humidity of 45%to 60% after conditioning under the same conditions for at least 40 hours, shall comply with all the following requirements.

a. The geo-membrane shall be at least 1.00 mm thick when measured to ASTM D 5199 for smoothgeo-membrane and ASTM D 374 for textured geo-membrane (though in the absence of disputeASTM D 374 Method C, ASTM D 1593 para 8.1.3, ASTM D 412 or ISO 4648 may be used instead).

b. In the Stiffness Test ASTM D 1388, the geo-membrane shall be at least flexible enough that the overhang length (2c in the standard) shall be less than 400 mm (16 inches). For this purpose the sample length given in the standard shall be ignored.

c. In the puncture resistance test ASTM D 4833 the geo-membrane shall have a puncture resistance of at least 250 N.

d. In the pyramid puncture test ASTM D 5494 Method A (pyramid over water), the puncture resistance load (average of ten samples), conducted on aged samples after artificial heat ageing ina hot-air oven for either 1 week at 100 °C or 4 weeks at 85 °C or 15 weeks at 70 °C, shall exceed70% of its value without such ageing; ageing shall be in an air oven with forced air circulation toASTM D 573 or ISO 188, the tolerances being +/- 2 °C on temperature and +/- 1% on duration.

e. In the pyramid puncture test ASTM D 5494 Method B (pyramid over aluminum), the puncture resistance load (average of ten samples), shall exceed 80 N.

f. The geo-membrane shall have a tear resistance of at least 70 N in the Graves test to ASTM D 1004or ASTM D 624 Die C.

(a) The geo-membrane shall be free from holes, pinholes, blisters, and contaminants.

The geo-membrane shall be manufactured under quality control arrangements with the minimum testing frequencies as defined in Table 13.2 carried out at the factory laboratory or an independent laboratory.

Table 13-2: Geo-membrane Factory Testing Requirements

Property	Test method	Minimum test frequency
Thickness	ASTM D 5199	Every roll
Density	ASTM D 1505 / D792	Every 50 roll
Tensile properties: yield Strength break strength yield elongation break elongation	ASTM D 6693	Every 8 roll
Tear resistance	ASTM D1004	Every 15 roll
Puncture resistance	ASTM D 4833	Every 15 roll
Carbon black content	ASTM D 1603	Every 8 roll
Carbon black dispersion	ASTM D 5596	Every 15 roll
Oven aging at 85% standard OIT or High pressure OIT	ASTM D 5721 / D 3895	Every 120 roll
UV resistance standard OIT or High pressure OIT	ASTM D 3895 / ASTM D 5885	Every 120 roll

13.4.2.4 Geo-membrane Joints

All seams or joints joining formerly separate pieces of geo-membrane shall be classified as either factory seams or field seams. For this purpose:

- A factory seam is a joint or seam made in an enclosed space such as a factory, with controlled environment to protect the materials and equipment from excessive dust, wind, moisture or radiation (windows, doors and other wall or roof openings shall not exceed 5% of floor area);
- Any other seam is a field seam.

The geo-membrane shall be made into large pieces under factory conditions; using factory seams unless the piece has no seams. These pieces, whether rolled or folded, shall be brought to Site with sufficient protection during transport and storage to avoid damage to the geo-membrane, and spread in the canal before being joined to each other or to rigid structures. To minimize the extent of field seams each single piece placed in the canal shall have an area of at least 800 m_2 (8600 sq.ft) except where this is impracticable because of canal bends or the location of structures. Field seams shall be double fusion seams (dual hot wedge seams or double track seams defined in GRI Test Method GM19) which can be tested using air pressure testing. Within canals, field seams shall only be used approximately at right angles (within 10°) to the canal centerline, never longitudinally, except for short local seams near structures with the Engineer's written approval. No longitudinal field seams shall be permitted where the total width of the material required is less than the width of the rolls of geo-membrane material supplied. Where the total width of the material required for a canal section is greater than the width of the rolls of geo-membrane material provided, a single field longitudinal seam shall be permitted.

Apart from exceptions approved in advance by the Engineer, longitudinal factory seams shall not be permitted in canal reaches with a geo-membrane width of less than 6.0 m (20ft), and shall not number more than one longitudinal seam in any canal reach. Any geo-membrane whose manufacturing and fabrication method requires a greater number of longitudinal seams shall be unacceptable in the sense of Clause 13.4.6. Any factory seams within a piece shall be continuous and shall extend to the edges of the piece.

Each piece of geo-membrane as defined here shall have a unique reference number, which shall be used for marking the pieces for transport and storage, and also for reporting tests. In destructive tensile testing to ASTM D 882 of samples cut across a seam at right angles, all factory seams shall have a strength of at least 95% of the tensile strength of the plain geo-membrane as measured by the same test in the same direction (machine or cross direction), and all field seams shall have a strength of at least 90% of that strength. In these tests the strip width shall be 25 mm (1 inch), the initial jaw separation 50 mm (2 inches), and the jaw separation rate 50 mm/min (2 inches / min).Methods of making and testing field seams shall be demonstrated to the Engineer before seaming begins, and seaming in the canals shall not begin until the Engineer has approved these methods in writing. Any subsequent change in method shall also be approved by the Engineer in writing before the Contractor begins to use it. Different methods for different situations or types of field seam shall be permissible, provided each method meets the requirements of this Clause 13.4.2.4.

The full length of all finished field seams shall be visually inspected and also tested by the Contractor using any one of the non-destructive test methods defined in ASTM D 4437 or D 4545 or D 5641, or by means of a special test technique approved by the Engineer, such as an air pressure test in the case of a double seam or a vacuum box test. Any defects shall be patched or remedied, or else the whole field seam shall be cut out and replaced. The test equipment provided by the Contractor shall be regularly inspected and tested for accuracy.

13.4.2.5 Joint Testing Equipment

For the Vacuum Box Test the equipment for testing the extrusion seams shall comprise the following:

- a vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft rubber gasket attached to the base of the box, and a vacuum gauge;
- Suitable soap solution for use with the vacuum box.
- For the air pressure test, the equipment for testing double fusion seams shall comprise the following:
- An air pump equipped with pressure gauge capable of generating and sustaining a pressure between 25 and 30 psi;
- A pressure gauge equipped with a sharp hollow needle.
- The contractor shall specify and agree with the engineer the procedure to be followed for the testing of all seams.

13.4.2.6 Joints with New Structures

Where the geo-membrane is to be joined to a new rigid structure which is included in the Works, the Contractor shall during construction install an embedded channel section of the same material as used for lining the channel appropriately into the structure so that the geo-membrane can be joined, and the seam on-destructively tested to confirm a completely waterproof joint.

Prior to commencing such installation the Contractor shall submit to the Engineer for approval a method statement (including drawings) along with samples of all materials to be used and appropriate test results to demonstrate compliance with this Clause 13.4.2.6.

13.4.2.7 Joints with Existing Structures

Where the geo-membrane is to be joined to an existing rigid structure, stainless steel metal battens or banding strips (or an approved alternative procedure) shall first be fixed to the structure with a short length ofgeo-membrane attached to the batten with stainless steel grips or pins, and this shall be welded to the main geo-membrane lining material. Gasket materials shall be neoprene, closed cell, minimum 50 mm (2 inch) wide and 8 mm (5/16th inch) thick. The geo-membrane shall be fixed to the structure over a width of at least 50 mm. Tucks or folds in the geo-membrane where it is fixed to the structure shall be minimized, and any that are inevitable shall be sealed with polysulphide sealer (Clause 10.6).

13.4.3 Geotextiles

Up to three different geotextiles can be used for different situations or different parts of the canal lining Works, provided each of them meets all the following requirements for normal geotextiles:

(a) it shall be capable of preventing slipping of the fresh in-situ concrete on canal side slopes;

(b) it shall comprise a continuous-fiber needle-punched non-woven geotextile of unit mass at least 250g/m2 to ASTM D 5261 or ASTM D 3776, made of polypropylene or polyester fiber;

(c) its thickness shall be at least 3 mm, measured to ASTM D 5199 or ASTM D 1777 with a pressure of 2 kPa;

(d) its slow puncture resistance must either exceed 3 000 N in a CBR-type puncture test to BS 6906:Part 4: 1989 or to DIN 54307 or exceed 530 N in a puncture test with a 8-mm diameter probe toASTM D 4833;in a cone drop puncture test to BS 6906: Part 6: 1990 or NT Build 243, the hole size shall not be more than 11 mm.

The geotextile layer shall comprise pieces as large as practicable, preferably with the long dimension of each piece lying along the canal. Junctions between adjacent pieces shall be plain overlaps of not less than 150 mm (6 inches). Any such junction on the canal side slope shall run approximately (within 10°) at right angles to the canal axis. Unless the agreement of the Engineer is obtained in advance, each piece of geotextile as defined here shall have a unique reference number, which shall be used for marking the pieces for transport and storage, and also for reporting tests.

13.4.4 Packaging, Transport and Storage

The pieces of geo-membrane mentioned in Clause 13.4.2.3 shall each be packaged as a roll or accordion folded, and each piece shall be wrapped with at least one layer of strong paper or other disposable wrapping capable of preventing damage during normal handling, transport and storage. Each piece or roll shall be clearly marked with the contract number and its unique piece number. The wrapped pieces shall be transported to the Site in adequate containers, and any wooden containers, crates or pallets used shall be designed to prevent damage to the geo-membrane by nails, screws or other fasteners.

If the pieces of geo-membrane are fabricated in the factory for particular reaches of canal, they shall be at least 0.3 m (12 inches) longer than the necessary final dimension to allow for trimming and taking samples for testing at one or both ends.

The pieces of geotextile defined in Clause 13.4.3 shall be packaged so as to prevent damage during normal handling, transport and storage. Each piece or roll shall be clearly marked with the contract number and, unless the Engineer has agreed that numbering of such pieces is unnecessary, also its unique piece number.

Neither geo-membranes nor geotextiles shall be stored or exposed in direct sunlight for more than a total of 14 Days before being installed and covered with concrete or soil.

Any pieces of geo-synthetic that are damaged, or exposed to more than the permissible sunlight, shall be removed from the Site and replaced, unless the Engineer agrees, explicitly for that piece, that the damage

can be removed by cutting off part of the piece or (in the case of geo-membrane) repaired by patching, using field seams complying with Clause 13.4.2.4.

13.4.5 Installation

Before the making of field seams begins on any day, a test seam at least 1.5 m (5 ft) long shall be made in off cut or scrap pieces of geo-membrane, to ensure that Equipment is in good order and appropriately adjusted. For each section of canal corresponding to a piece of geo-membrane as described in Clause13.4.2.3, the installation procedure shall be as stated below, unless a different procedure has been agreed with the Engineer.

a) After the substrate has been prepared in compliance with Clause 13.1, the piece of geomembraneshall be unrolled or unfolded and placed approximately in position with the minimum disturbance of the substrate. During the unrolling or unfolding and placing of the geo-membrane piece, samples shall be cut from its sides and ends and its thickness shall be measured, as specified in Clauses13.4.9(a) and 13.4.9

b) As far as practicable, workers shall not walk on the geo-membrane, and where this is unavoidable they shall not wear any footwear unless it is wrapped in two layers ofgeotextile or similar padding to prevent damage to the geo-membrane. No sharp implements shall be used or carried on or over the exposed geo-membrane, except in places where earth nails are permitted under Clause 13.4.5 (f) or at the edges or ends of a geo-membrane piece where trimming or the cutting of test samples is necessary. No mechanical Equipment shall be used in the canal profile, except approved devices specifically designed for the purpose, such as Equipment for making field seams.

c) The geo-membrane shall be temporarily held in place by appropriate clips or grips anchored onto the berm, and on the loose end.

d) Unless it has to be removed under the provisions of Clause 13.4.9, the piece shall then be joined to the previously laid piece with a field seam, and the seam shall be inspected and tested as specified in Clause 13.4.2.4 and any defects remedied. If the piece abuts a rigid structure, it shall be jointed to the structure in accordance with Clause 13.4.2.6 or Clause 13.4.2.7, as appropriate.

e) The position of the piece of geo-membrane shall be adjusted so as to leave its whole area, and the new field seam, without significant stress but to avoid folds, and to ensure that the extent of thegeo-membrane is in accordance with the Drawings.

f) The condition and positioning of the whole surface of the piece, and the parts of adjacent pieces near any field seam, and any joints to structures, shall be visually inspected from the top of both canal banks. Any visible defects shall be remedied by patching or replacement.

g) Within four hours of the placing of the geo-membrane, the geotextile layer shall be placed on top of thegeo-membrane, leaving uncovered only the minimum strip necessary for making the next field seam. The geotextile shall be held in place by similar clips or grips as used for the geo-membrane. If necessary sandbags may be placed in the bed of the canal to avoid the geotextile being moved by the wind. There shall be no folds or loose areas on the slopes of the canal, since the geo If tolerances will need to act in tension to prevent the slipping of fresh concrete (or soil), but folds are permissible in the geotextile on the canal bed. To help hold the geo-synthetics in place the Contractor may, at his own risk and expense, use earth nails not more than 150 mm (6 inches) long, driven through the geo-synthetics into the substrate, but only on the berm and at least 150 mm(6 inches) away from the edge of the sloping canal side.

h) The concrete lining, or at least the first set of alternate panels in the case of in-situ concrete, shall be placed within 2 Days of the placing of the geotextile. Care shall be taken during placing of the soil or concrete to avoid damaging the geo-synthetics, and the specified overlap at any junctions between geotextile strips shall be maintained. If any damage does occur, it shall be reported to the

i) Engineer and made good before work proceeds or any geo-synthetic is covered with soil or concrete. Any sandbags used to hold the geotextile in place on the canal bed shall not be removed until immediately prior to the placing of the concrete or soil. The Contractor shall, at all times, ensure that no members of the public or animals are allowed to trespass on the geo-synthetic linings.

13.4.6 Acceptance Testing

Before any geo-synthetics are dispatched to the Site the following sampling and testing shall be carried out.

a. The geo-synthetic supplier shall declare which sections of Clause 13.4.2.2 apply to thegeo-membrane or geo-membranes to be used (the maximum number of different geo-membranespermitted is fixed by Clause 13.4.2.1), and which of the alternative combinations of time and temperature are to be used for the ageing tests of Clause 13.4.2.3(d), for each geo-membrane.

b. The Contractor shall arrange to undertake tests at an independent laboratory with at least 5 years 'experience of geo-synthetic testing and having the necessary equipment for the tests required under this Specification. The laboratory shall comply with the appropriate national standards of Pakistan, and the force measuring devices of any tension/compression machines used shall be accurate to +/- 0.5% or better, to ASTM E 94. If the Engineer is not satisfied with the independence or capacity of this laboratory, giving his reasons, the Contractor shall suggest another, continuing until agreement is reached. A testing programme shall be agreed between the Contractor and the Engineer, giving the Engineer at least 3 weeks' notice of the beginning of testing(except that the artificial heat ageing under Clause 13.4.2.3(d) may begin before the end of this notice period).

c. The supplier shall send to the chosen laboratory two clearly marked samples of each of thegeo-membranes and geotextiles to be used in the Works, each sample extending fully across thestrip or roll of the material as manufactured and extending at least 2 m (6 ft) along the material, andalso being large enough for all the acceptance tests required by this 13.4.6. The laboratoryshall, at random, choose one of each pair of samples for testing, and store the other in a cool dry place away from direct sunlight, for possible later use in comparisons. These reserve samples shall subsequently be handed over to the Engineer.

d. The laboratory shall cut the necessary test pieces from the samples of geo-synthetic, ensuring a representative distribution of samples across the roll or strip width, and conduct the tests mentioned in the appropriate tables defined by Clause 13.4.2.2 (according to the declaration of Clause 13.4.5(a) and in each section of Clauses 13.4.2.3 and Clause 13.4.3 except Clause13.4.2.3 (g) and Clause 13.4.3(a)). The Engineer may witness any of the tests. Each test shall be done on ten samples and the geo-synthetic shall be deemed to pass the test only if all ten samples pass individually, except for Clause 13.4.2.3(c) where each of three samples must pass, and Clause 13.4.2.3(d) where averages are used. The Contractor shall provide to the Engineer are port on all the tests done, including any that fail, giving all parameter values.

e. If all the specified tests on a particular geo-synthetic are passed, and in the case of a geo-membrane its manufacturing and fabrication method enables it to meet the seam spacing requirements ofClause 13.4.2.4, the Engineer shall declare that geo-synthetic, as submitted for testing, to be acceptable. If any of the geo-synthetics fail, the Contractor may submit an alternative geo synthetic and the whole acceptance testing procedure, for geo-membrane or geotextile as appropriate, shall be repeated on that geo-synthetic. This can continue until a number of different geo-synthetics, up to the maximum numbers defined in Clauses 13.4.2.3 and 13.4.3, have been declared acceptable.

f. No geo-synthetic shall be dispatched to Site from the place of manufacture or fabrication until it has-been declared acceptable under this Clause 13.4.6, and any geo-synthetic then dispatched shall be of the same nature and thickness as the samples submitted under Clause 13.4.6(c), apart from minor variations that are likely to be accepted under Clauses 13.4.8 and 13.4.9.

g. For each geo-membrane declared acceptable, the Engineer shall determine four parameters for use in site testing:

i) The Required Thickness, which shall be 90% of the average thickness as determined on ten samples for Clause 13.4.2.3(a);

ii) The Required Overhang Length (parameter 2c) in the stiffness test ASTM D 1388, which shall be115% of the average value determined on ten samples for Clause 13.4.2.3(b);

iii) The Required Puncture Load, which shall be 90% of the average puncture resistance load of tenant-aged samples tested under Clause 13.4.2.3(d);

iv) The Required Tensile Strength, which shall be the maximum force, as an average from ten samples, in tensile testing to ASTM D 882. If the geo-membrane shows significant differences intensive strength in the machine and cross directions, four of the ten samples shall be taken in the stronger direction and six in the weaker direction. Unless the Contractor obtains the Engineer's agreement to use different values to suit his site testing equipment for application of Clause13.4.9 (f), the strip width shall be 25 mm (1 inch), the initial jaw separation 50 mm (2 inches), and the jaw separation rate 50 mm/min (2 inches / min). If the necessary tensile tests have not already been done in connection with Clause 13.4.2.4, the Contractor shall cause the laboratory to conduct them at the Contractor's expense.

13.4.7 Testing at the Geo-synthetics Manufacture and Fabrication Locations

There shall be a clearly defined programme of routine testing at the places of manufacture of geo-synthetic pieces, with the objective of minimizing the likelihood of transporting to the Site any geo-synthetics which then fail the site tests under Clauses 13.4.8 and 13.4.9. The Contractor and/or the geo-synthetics supplier shall, before fabrication of the geo-synthetics begins, define the routine testing procedures for both manufacture and fabrication in the senses of NSF 54 1993 Section 6 for approval by the Engineer.

For geo-membranes this shall include at least the following tests or aspects:

- Thickness;
- Freedom from pinholes and other local defects;
- Tensile strength and elongation at break by any official test;
- puncture resistance to ftms 101c 2065.1 or ftms 101c 2031 or astm d 4833 or astm d 5494 or bs 6906: part 4 or din 54307 or another officially defined test similar to one of
- These, using any defined penetration speed;
- integrity and continuity of factory seams;
- Shear or peal strength of factory seams. For geotextiles the routine testing shall include at least:
- Thickness;
- Unit mass or weight.

In addition to these minimum tests the supplier may include other tests appropriate to the proposedgeo-synthetics and methods. The sampling frequency should be no less than the minimum provided underClause 13.4.2.3, though the puncture tests may be applied at a lower frequency than the tensile tests.

The routine testing programme shall be discussed with the Engineer and modified if necessary until an agreed programme is defined. The Engineer shall bear in mind the objective of this testing, as stated above, and shall not unreasonably withhold approval.

Any pieces or rolls of geo-synthetics that do not pass this routine testing shall not be dispatched to the Site. Those that do pass shall each be clearly labeled, both on the exposed end or edge and on the wrapping, with the unique identification number mentioned in Clauses 13.4.2.4 and 13.4.3. During manufacture and fabrication of the geo-synthetics the supplier shall, at intervals not exceeding 1 month, submit to the Engineer copies of summaries of his routine testing results in accordance with the agreed testing programme, identifying the rolls or pieces by their numbers.

Such factory tests shall be on the basis of a frequency of at least every 240 rolls. The Contractor shall

Submit to the Engineer a report on the testing methods, accuracy and the test results.

13.4.8 Testing on Site before Placing in a Canal

13.4.8.1 General

Before pieces of geo-synthetic are taken from the Site storage area to the canals where they are to be installed, the Contractor shall, using the Site laboratory or a laboratory approved by the Engineer and under the supervision of the Engineer, carry out the tests defined in this Clause 13.4.8 in order to demonstrate that the geo-synthetics brought to the Site are as good as the ones that passed the acceptance testing under Clause 13.4.6. For geo-membranes this shall be done by reference to the parameters established for each acceptable geo-membrane under Clause 13.4.6(g). For geotextiles it shall be done by reference to the relevant requirements of Clause 13.4.3.

All test results shall be labeled with the unique number of the roll or piece of geo-synthetic they refer to, except for geotextiles for which the Engineer has agreed to the dispatch of unnumbered pieces under Clause 13.4.2.3.

In the absence of test failures the Engineer shall, for this routine site testing only, allow relaxation of the temperature and humidity restrictions contained in or implied by Clauses 13.4.2.4, 13.4.2.5 or 13.4.3, but if any test failures then result in pieces being marked as unacceptable the relevant tests shall be repeated with strict adherence to those limits.

13.4.8.2 Geo-membranes

The wrapping of each roll or piece of geo-membrane shall be opened (without removing the labeling) and a strip shall be cut from the exposed edge or end, the area of the strip being at least 0.5 m_2 (5.4 sq.ft) and its least dimension at least 150 mm (6 inches). The thickness of the strip shall be measured with micrometer, using a pressure between 20 kPa and 27 kPa, in ten places so as to reflect the whole width of the geo-membrane piece. Each measurement shall be compared with the Required Thickness for the particulargeo-membrane, defined in Clause 13.4.6(g).

a. The whole geo-membrane piece from which the strip was taken shall be marked as unacceptable, unless, either:
    1. all ten micrometer measurements exceed the Required Thickness; or
    2. nine of the ten micrometer measurements reach the Required Thickness, and the tenth one fails to reach it by less than 5%; or
    3. the ten thickness measurements are repeated to ASTM D 751 instead of using micrometer, and then either all ten measurements reach the Required Thickness, or nine of the ten do so and the tenth one fails to reach it by less than 5%.

b. If the geo-membrane piece has not been marked as unacceptable under Clause 13.4.8.2(a), two sets of three test pieces shall then be cut from the strip, so as to be representative of the full width

of the piece. Three shall be subjected to the stiffness test of Clause 13.4.2.3(b) and three to the pyramid puncture test ASTM D 4833. In the stiffness test a sample shall pass if its overhang length is less than the Required Overhang Length defined in Clause 13.4.6(g), while in the puncture test a sample shall pass if its puncture resistance load exceeds the Required Puncture Load of the same clause.

c. The whole geo-membrane piece from which the strip was taken shall be marked as unacceptable unless either:

   i) all three tests of each kind pass; or

   ii) one of the three stiffness tests or one of the three puncture tests fails, the other five tests all passing, and the Contractor then takes further test pieces from the strip and/or from the piece of geo-membrane, in a manner which in the Engineer's opinion is representative of the whole piece, and conducts ten new tests of the same kind as the one that failed, and then either the ten tests all pass, or nine of the ten pass and the tenth misses the requirement by less than 5%.

d. If the strip cut from the exposed end of the roll or piece of geo-membrane includes one or more factory seams, two test pieces shall be cut at right angles to such seams and subjected to tensile testing to ASTM D 882. If either of them fails to meet the tensile seam strength requirement defined in Clause 13.4.2.4, the whole roll or piece shall be marked as unacceptable. For this routine testing the Engineer may agree to modifications of the initial jaw separation and the jaw separation rate, for speed and convenience of site testing, but he may also at any time require are turn to the parameters defined in Clause 13.4.2.4.

13.4.8.3 Geotextiles

The wrapping of each roll or piece of geotextile, as defined in Clause 13.4.3, shall be opened (without removing any labeling) and a strip shall be cut from the exposed edge or end, the area of the strip being at least 0.2 m_2 (2.2 sq.ft) and its least dimension at least 75 mm (3 inches). The thickness of the strip shall be measured with a micrometer or to ASTM D 1777 or D 5199, using a pressure of 2 kPa in five places so as to reflect the whole width of the geotextile piece. From the strip two test pieces shall then be cut, so as to be representative of the full width. The unit mass of these shall be measured using one of the tests mentioned in Clause 13.4.3(b). If the thickness in any one place or the unit mass of any one test piecedoes not conforms to the relevant requirements of Clause 13.4.3, the whole geotextile piece from which the strip was taken shall be marked as unacceptable.

For one in ten rolls or pieces of geotextile, chosen by the Engineer, further test pieces shall be taken from the exposed end or edge and subjected to the tests of Clauses 13.4.3(d) and 13.4.3(e), with two tests of each kind. If any one of the four tests fails to meet the requirement, the whole geotextile roll or piece shall be marked as unacceptable.

If more than one out of any twenty rolls or pieces of geotextile is found to be unacceptable, the frequency of puncture testing as specified in this Clause 13.4.8.3 may be increased by the Engineer, up to a frequency of one roll in three instead of one in ten.

13.4.8.4 Procedures Following Tests on Site

a. Any roll or piece of geo-synthetic marked as unacceptable under Clause 13.4.8.2 or Clause13.4.8.3 shall be removed from the Site within 2 Days, and no part of it shall be brought back into the Site.

b. Every roll or piece of geo-synthetic that has been tested under the appropriate parts of this Clause13.4.8, and has not been marked as unacceptable, shall be clearly marked as acceptable. Its testing and marking shall be recorded, using the unique number applied to it at the time of fabrication according to Clause 13.4.7, and a copy of all such records shall be submitted to the Engineer.

c. If more than two of any ten successive pieces of any one geo-membrane tested under this Clause13.4.8 are marked as unacceptable, the Engineer may declare that in his opinion some of thegeo-membrane materials delivered to Site are not effectively similar to the samples submitted for acceptance tests under Clause 13.4.6. The Engineer may then order the Contractor to arrange foray tests from among those specified in Clause 13.4.2.3 and the applicable tables of Clause13.4.2.2. These tests shall be carried out, at the Contractor's expense, on samples taken as directed by the Engineer from any rolls or pieces of geo-membrane stored on the Site. For purposes of comparison the Engineer may cut test pieces from the samples handed to him at the time of acceptance testing under Clause 13.4.6(c) and stored by him, and require the Contractor totest them similarly. Each of these tests shall be carried out either on the Site under the Engineer's supervision at an independent laboratory acceptable to the Engineer as under Clause 13.4.6.While these tests are being carried out, none of the pieces of geo-membrane from which thesamples were taken may be used in the Works. If any of the samples fail to reach the relevant requirements of Clauses 13.4.2.2 and 13.4.2.3, the Engineer may mark the geo-membranepieces from which those samples were taken as unacceptable, in which case they shall be dealt with asunder Clause 13.4.8.4(a), and the Engineer may then order similar tests on samples from other pieces stored on the Site, which can similarly lead to rejection of those pieces if the tests fail. In making decisions under this Clause 13.4.8.4 the Engineer shall be guided by comparisons between the geo-synthetic delivered to the Site for inclusion in the Works and the appropriate samples stored by the Contractor from the time of acceptance testing, as provided for in Clause13.4.6(c).

d. Where, because of canal bends or structures, a piece of geo-membrane is significantly smaller than the normal size specified in Clause 13.4.2.4, the Engineer shall determine what reduction can bemade in the number of samples and measurement places required under this Clause 13.4.8.

13.4.9 Sampling at the Place of Installation, and Corresponding Tests

While a roll or piece of geo-membrane is being placed in the canal, the following sampling and tests shall be carried out.

a. During the unrolling or unfolding of the piece, and while it is still possible to make a loose fold in it without stretching or kinking it, the Engineer may measure its thickness at a place remote from it sedges by temporarily making a small fold (not bending the geo-membrane to a radius of curvature of less than 150 mm (6inches)), measuring the thickness of the resulting two layers ofgeo-membrane with a micrometer (using a pressure between 20 kPa and 27 kPa), and halving that measurement. If the resulting figure is less than 95% of the Required Thickness defined in Clause13.4.6 (g), a further ten such local measurements shall be made; if then any two of the ten figures isles than 95% of the Required Thickness, or if one of the ten is less than 90% thereof, the whole roll or piece of geo-membrane shall be marked as unacceptable and removed from the Site within 2Days, and no part of it shall be brought back onto the Site.

b. Unless the geo-membrane piece has been rejected under Clause 13.4.9(a), four samples shall be cut from its sides. The places from which these samples are cut shall be agreed with the Engineer, but shall be places that will not adversely affect the performance of the lining, for instance places wheregeo-membrane needs to be trimmed on the berm or at the canal bank under Clause 3.4.5 (d). If any factory seams intersect the sides of the canal reach, two of the four samples shall include such seams. The thickness of the plain (unsealed) geo-membrane in each sample shall

immediately be measured with a micrometer using a pressure between 20 kPa and 27 kPa. If all of the four samples meet the Required Thickness defined in Clause 13.4.6(g), sampling and installation shall continue according to the remaining sections of this Clause 13.4.9.

c. If two or more of the four samples fail to meet the said Required Thickness, the whole roll or piece ofgeo-membrane shall be marked as unacceptable and removed from the Site within 2 Days, and no part of it shall be brought back onto the Site. If one of the four samples fails to meet the said Required Thickness, a further six such thickness measurements shall be made, approximately uniformly spaced along both sides of the geo-membrane piece, and a further four such measurements shall be made on its two ends. If all these ten new measurements reach the said RequiredThickness or if nine of them do so and the tenth one fails to reach it by less than 5%,then the failure of one of the four samples shall be disregarded. Otherwise the whole roll or piece ofgeo-membrane shall be marked as unacceptable and removed from the Site within 2 Days, and no part of it shall be brought back onto the Site.

d. The four samples mentioned in Clause 13.4.9(b) shall be marked to identify precisely where they were cut, and shall be taken to the Site laboratory or a laboratory approved by the Engineer where they shall be tested as follows: any samples which contain a factory seam shall be tested intension to ASTM D 882 (the seam being in shear and the test strip cut at right angles to the seam),while any other samples shall be subjected to the pyramid puncture test ASTM D 5494 Method A. In the tensile test a sample shall pass if it meets the seam strength requirement of Clause 13.4.2.4(for this routine testing the Engineer may agree to modifications of the initial jaw separation and the jaw separation rate, for speed and convenience of site testing, but he may also at any time require return to the parameters defined in Clause 13.4.2.4). In the puncture test a sample shall pass if its puncture resistance load exceeds the Required Puncture Load defined in Clause 13.4.6(g). In the absence of test failures the Engineer shall, for this routine site testing only, allow relaxation of the temperature and humidity restrictions implied by Clauses 13.4.2.3 and 13.4.2.4, but if any test failures then result in pieces being marked as unacceptable the relevant tests shall be repeated with strict adherence to those limits.

e. If any of the four samples fails its test, further samples, seamed or plain to match the one that failed, shall be cut from the piece of geo-membrane in the canal (at places directed by the Engineer) and tested in the laboratory so as to make ten tests of the type concerned (seam strength or puncture resistance). If then two or more of the ten samples have failed, or if any one sample has failed by a margin of more than 5%, the whole roll or piece of geo-membrane shall be marked as unacceptable and removed from the Site within 2 Days, and no part of it shall be brought back onto the Site.

f. To save time the Contractor may replace the laboratory tests under Clause 13.4.9(d) by a more rapid canal-side testing procedure, provided that the details thereof have been previously agreed in writing by the Engineer. The testing shall comprise measurement by a portable testing machine of the tensile strength of both plain and seamed strip samples; a sample of either kind shall pass if its strength exceeds the Required Tensile Strength defined in Clause 13.4.6(g), using the test parameters defined or agreed under that clause. If any of the four samples fails, four fresh samples shall be cut and laboratory tests under Clause 13.4.9(d) shall be used to determine the outcome.

g. The Engineer may require that, for up to one in ten geo-membrane pieces, a second set of samples be sent to the laboratory and tested under Clause 13.4.9(d), though the remaining stages of the installation of the geo-membrane piece shall not need to await the outcome of such testing. If in his opinion such tests indicate that pieces are being accepted under this Clause 13.4.9(f) which would not be accepted under Clause 13.4.9(d), the Engineer may suspend his agreement to the Contractor’s canal-side testing procedure until it has been modified.

h. The piece of geo-membrane may not be joined to another piece nor covered with the geotextilelayer until the satisfactory conclusion of the thickness testing under Clauses 13.4.9(a) and13.4.9 (b). While awaiting the completion of the laboratory tests under Clause 13.4.9(d) or the canal-side tests under Clause 13.4.9(f), the Contractor may, at his own risk, continue with the placement of the geotextile and the preparations for placing the concrete (or soil) layer. Placement of concrete (or soil) may not, however, begin until the satisfactory conclusion of the said laboratory or canal-side tests, and if they result in the geo-membrane piece being marked as unacceptable there shall be no payment for the placing and removing of the geotextile nor for the work done in preparation for concreting (or placing soil).

13.4.10 Recording of Test Results

The Contractor shall maintain a neat and complete record of all testing carried out under Clauses 13.4.7 to 13.4.9 inclusive, identifying each test by the unique mark applied at the place of fabrication under Clause 13.4.8 and, in the case of tests under Clause 13.4.9, also by the precise location in the canal.

13.4.11 Ponding Tests

13.4.11.1 General

The Contractor shall undertake random Ponding Tests for separate 100-metre (330ft) sections of the lined canal selected by the Engineer to establish that the geo-membrane lining has been correctly installed. For all Ponding Tests the test shall be considered successful if the amount of water measured as passing through the geo-membrane lining (Loss) satisfies the following:

Loss < 0.02 x A m^3/day

Where: A = plan area of geo-membrane below the ponded water level (m^2)

Prior to undertaking any such tests the Contractor shall submit to the Engineer for approval his proposed method of testing, and repair to the lining if this is necessary.

13.4.11.2 Ponding Tests for Canals

Prior to undertaking the test the Contractor shall allow a period of at least 5 Days without any water being added to the upstream reach, in order to determine what flow (if any) is arising as a result of the natural drainage from the ground in the vicinity of the reach to be tested. If the flow is not steady, the Contractor shall continue to measure the flow for a further 5 Days. This process to be repeated until a steady state is reached. The Contractor shall then fill the canal reach being tested to a point where the concrete lining freeboard at the downstream end is 100 mm (4 inches) (the Required Ponding Level). The reach shall be left for a period of 48 hrs, after which time the pond shall be topped up to the Required Ponding Level. Once the Required Ponding Level has been achieved the Contractor shall measure the water level in the canal every 6 hrs for a period of 48 hrs. Adjacent to the canal the Contractor shall install a USBR Type A Measuring Pan, to establish the evaporation over the period of the Ponding Test. The Loss shall be calculated on the basis of the drop in level in the canal after taking evaporation losses or rainfall into account. If there is more that 5 mm (1/4 inch) of rainfall in the period of the Ponding Test the Ponding Test shall be repeated. The test shall be used to verify the quality of the Contractor's work. Should the losses be less than the criterion set in Clause 13.4.11.1 the test may be considered successfully passed. In the event of failure the Engineer shall review the methodology of the Contractor and may order the section of lining to be replaced or repaired. The Engineer may instruct the Contractor to undertake additional tests on other lined reaches of the canal.

13.5 Expansion Joints in Canal Lining

At intervals of not less than 50ft (16 m) along the canal, a transverse joint shall be constructed as an expansion joint, as shown on the Drawings.

14 Reinforced Concrete Pipes and Pipe Culverts

14.1 General

This work shall consist of the construction, reconstruction or repair of culverts and hydraulic structures in accordance with these specifications, and in conformity with the line, grades and dimensions shown on the Drawings or ordered by the Engineer.

The work shall include the furnishing and laying of the pipe, and the construction of such joints and connection to other pipes, catch basins, or other structures as may be required to complete the work as shown on the Drawings or as required by the Engineer.

The work shall also include the removal and disposal of existing culverts and structures except such portions as may be required or permitted by the Engineer to be left in place.

The Engineer reserves the right to inspect and test the pipe after its delivery to work. Injurious defects revealed subsequent to acceptance of pipe and prior to its installation in the work shall be cause for rejection.

The Contractor shall not order and deliver the pipes for any work until the Engineer has approved a list of sizes and lengths.

The pipelines referred to in this Chapter are those having a maximum working pressure of less than 10 fathead of water and shall include all pipe formed culverts, conduits, underpasses etc.

14.2 Materials and Design Criteria

Low pressure pipelines in structures have been designed assuming that pre-cast concrete pipes and precast reinforced concrete pipes are used as shown in the Drawings or as instructed by the Engineer. However the Engineer may approve alternative systems, the details of which shall be submitted to the Engineer well in advance of any intended use. Such alternatives might include cast in-situ pipe culverts using inflatable moulds. No alternative system, which is likely to have a shorter useful life than pre-cast concretepipes, will be permitted. Unless otherwise specified on the Drawings, joints in low pressure or gravity pipelines shall be flexible.

14.3 Reinforcement

Each line of reinforcement shall be assembled into a cage, which shall contain sufficient longitudinal bars or members extending through the barrel of the pipe to maintain the reinforcement rigidly in exact shape and correct position within the form. If the splices are not welded, the reinforcement shall be lapped not less than 30 diameter for bars and 40 diameter for cold-drawn wire. If welded, the member at either a welded splice or intersection shall develop a tensile strength of not less than 60,000 psi or as approved by the Engineer. The spacing centers of adjacent rings of the circumferential reinforcement (pitch) shall not exceed 4 inches. The circumferential reinforcement shall be located midway between the inner and outer surfaces of the pipe within a tolerance of + 2 inches.

14.4 Concrete Pipes and Fittings

1. Concrete pipes and fittings shall comply with BS 5911.
2. The cement used in the manufacture of the pipes shall be Sulphate Resisting Cement unless otherwise stated in the Drawings or ordered by the Engineer.
3. (3)No admixtures shall be included in the concrete without the written approval of the Engineer.
4. If the pipes are to be supplied by a manufacturer, the Contractor shall produce to the Engineer for his approval, prior to any order for such pipes being made, confirmation from such proposed manufacturer that he can supply pipes of the required sizes, which will conform to the Specification.

5. During the course of manufacture, the Contractor shall supply the Engineer with certificates from the manufacturer as required under Clause 24 of BS 5911. Tests shall be made, for witness by the Engineer, unless otherwise ordered by him, all in accordance with BS 5911.

6. If the pipes are to be manufactured by the Contractor himself he shall obtain the equipment for pipe making from a reputable manufacturer whom he will have made aware of the requirements of this Specification and who will have undertaken that his plant, if his instructions are followed, will provide pipes which will comply with this Specification. The Contractor shall have satisfied himself that he will be able to comply with the instructions of the manufacturer with the materials available and under the conditions prevailing at the Site. The Contractor shall provide all details in respect of manufacturer of pies to the Engineer for his approval prior to commencement of casting and these details shall include his proposals for the fabrication and placing in position of reinforcement cages where these are to be used. The Contactor shall provide the equipment for testing and test samples in accordance with BS 5911, and the Engineer will apply the rules in respect of acceptance or rejection as set out therein.

14.5 Joints for Concrete Pipes and Fittings

1) Unless otherwise specified or ordered, joints for concrete pipes, bends and junctions shall be of the flexible spigot and socket type as specified in Clause 17 of BS 5911 incorporating rubber gaskets complying with BS 2494 all to the approval of the Engineer. Unless otherwise shown on the Drawings or approved by the Engineer, joints shall be at not less frequent intervals than 6 feet. In the event of substitution of standards for the manufacture of pipes, the Contractor shall satisfy himself, inter alia, that the rubber gaskets he proposes to use fit the spigots and sockets he has been permitted to adopt and that the physical properties of the gaskets are suitable for their installation and use under the conditions prevailing on the Site.

2) Where ordinary ogee or rebated-type joints for concrete pipes, bends and junctions are specified or ordered by the Engineer, they shall comply with BS 5911, Part 3. Except where such pipes are shown on the Drawings as open jointed, cement mortar shall be used to seal the joints.

3) Where it is made up into cages, they shall be sufficiently rigid to enable them to be handled without damage. Bends cast in-situ shall be formed in a continuous operation; joints other than with adjacent sections of pipeline shall not be permitted. The concrete dimensions, reinforcement and internal surface finish shall be such as will give a bend of strength and internal dimensions, shape and smoothness at least equal to that required for pipe bends in BS 5911.

14.6 Bends in Pipelines

Where it is required to form a bend in a pipeline of more than 11 degrees, either a pre-cast pipe bend which meets the requirements of BS 5911 : 2002 shall be placed, or the bend shall be cast in situ in reinforced concrete forming rigid, watertight junctions with the adjacent straight pipes. If the bend is cast in situ, the concrete dimensions, reinforcement and internal surface finish shall be such as will give a bend of strength and internal dimensions, shape and smoothness at least equal to that required for pipe bends in BS 5911 : 2002.

14.7 Transportation and Handling of Pipes and Fittings

Any vehicle on which pipes are to be transported shall have a body of such length that the pipes do not overhang. Large pipes are to be placed on cradles and the loads properly secured during transport. The pipes are to be handled in accordance with the manufacturer's recommendations. Wide non-abrasive or other approved slings shall be used and all hooks and dogs and other metal devices shall be well padded and steadying ropes used. Any equipment which in the opinion of the Engineer may damage the pipes or their coating shall not be used. Hooks engaging on the inner wall surfaces at pipe ends shall not be used.

Under no circumstances are pipes to be dropped or allowed to strike one another, rolled freely or dragged along the ground.

Pipe ends shall be protected during transport to and around the Site and during handling. The timber or skids used to support the pipe prior to lowering into the trench shall be properly padded with sufficient bags stuffed with sand or straw for the purpose of protecting any coating. Alternatively, the pipe may be supported alongside the trench on mounds of sand. Any injury to protective coating, from any cause, must be repaired before the pipes are tested. Every precaution shall be taken to prevent foreign material from entering the pipes or fittings. During laying operations, no debris, tools, cloth or other material shall be placed in the pipe. Pipes and fittings shall be lowered into the trench with equipment suitable for the weight of the pipes and fittings, and shall be carefully cleaned before jointing.

14.8 Inspection of Pipes and Fittings

Each pipe and fitting shall be carefully brushed out and examined for soundness, before incorporation in the Works. Damaged pipes which in the opinion of the Engineer cannot be satisfactorily repaired shall be rejected.

14.9 Bedding

Pipes including bends shall be laid in standard bedding or in reinforced concrete, mass concrete or granular bedding as shown on the Drawings or as ordered by the Engineer in accordance with the Specification and at least to the minimum dimensions shown on the Drawings.

Standard bedding shall be used where no other bedding is specified and where there is no risk of rock, boulders and irregular hard spots occurring beneath the pipe barrel. Standard bedding shall consist of careful hand preparation and compaction of the trench bottom to the level of the underside of the pipe barrel to a smooth and regular surface free from all rocks and stones greater than 1 inch size.

Where pipes are to be laid in a bedding of granular material, the granular material shall be evenly spread over the full width of the formation and carefully compacted up to the level of the underside of the pipe barrel to a minimum thickness of 6 inches, or one sixth of the external diameter of the pipe barrel, whichever is the larger. In rock or mixed soils containing rock bands, boulders or other irregular hard spots, the thickness of granular material beneath the pipe barrel shall be not less than 8 inches or one quarter of the external diameter of the pipe barrel, whichever is the larger. The thickness of granular material generally shall be such that in no case does a pipe socket or sleeve rest on the excavated formation.

14.10 Concrete Blinding

Where pipes are to be laid in a concrete bedding, a blinding layer of concrete Class D shall be laid evenly over the full width of the formation to a minimum thickness as shown on the Drawings and accurately to the required gradient of the finished pipeline.

The layer of blinding concrete shall be allowed to set for at least 12 hours before pipe laying commences.

14.11 Pipe laying – General

Each pipe immediately before being laid shall be carefully brushed out and examined for soundness. Unless otherwise shown on the Drawings pipelines shall be straight and each pipe shall be laid accurately within the following tolerances to the lines and levels shown on the Drawings or ordered by the Engineer:

Table 14-1: Pipe laying Tolerances

Nominal Internal Diameter	Tolerance in line or Level(inches
Up to 30 inches	0.5
Over 30 inches	1.0

Provided always that there shall be no reverse gradient on any pipe or on the line as a whole. Properly painted sight rails shall be supplied and erected and used with boning rods of predetermined measurement for the boning in of individual pipes to the correct alignment. The sight rails shall be situated vertically above the line or pipe or immediately adjacent thereto, and there shall at no time be less than three sight rails in position on each length of pipe under construction to any one gradient.

14.12 Pipe laying in Standard Bedding

Sufficient space shall be made in the trench bed to allow each pipe joint to be made, tested and inspected.

The pipe shall then be laid and covered to a depth of 1 ft above the crown of the pipe, leaving the joints exposed. Selected excavated material shall be used with particle size not exceeding 1 inch. The material shall be evenly placed and compacted in layers not exceeding 4 inch thickness after compaction. Hand controlled vibrators or such other means as approved by the Engineer shall be used. Special care shall be taken to fill under the sides of pipes to ensure full contact with the barrel of the pipe.

After the pipeline has passed the test before completion of backfilling, the holes left at exposed joints shall be carefully filled and compacted with material as specified above. The remainder of the pipe trench shall then be filled in with the excavated material with particle size not exceeding 4 inches. Trenches must be overfilled to allow for settlement.

14.13 Pipe laying in Granular Material

Where pipes are to be laid in a bedding of granular material, they shall be laid on the bed prepared as specified in Clause 14.9. Sufficient space shall be made in the granular material to enable the joints to be made, tested and inspected, but the Contractor shall ensure that at least three-quarters of each pipe length is fully supported at all times.

The pipe joints shall be protected to prevent granular material or fill entering the space between the pipe spigot and the socket. Such protection may take the form of a twist of yarn lightly pressed into the annular space or other equal protection approved by the Engineer.

After the pipeline has been approved by the Engineer, the trench shall be carefully filled to the level of the horizontal diameter of the pipe barrel with granular material. This filling shall be carefully compacted by method approved by the Engineer so as not to disturb the pipes or joints.

Special care shall be taken to fill under the sides of pipes to ensure full contact with the barrel of the pipe. After the pipeline has passed the preliminary test the joint holes shall be carefully filled with granular material and then backfilling shall proceed with selected excavated material with particle-size not exceeding 4 inches and as specified in Clause 5.12 of the Specification.

The pipe shall then be covered to a depth of 12 inches above the crown of the pipe, using selected excavated material with particle-size not exceeding 1 inch. The material shall be evenly placed and compacted in layers not exceeding 4 inch thickness after compaction. Hand controlled vibrators or other such means as approved by the Engineer shall be used.

Trenches must be overfilled to allow for settlement.

Where ordered by the Engineer, the granular bedding and fill to the excavation shall be interrupted by clay or other approved impermeable barrier.

14.14 Pipe laying in Concrete Bed

Where pipes are to be laid in a concrete bed, the concrete blinding layer specified in Clause 14.10 shall first be washed clean. The pipe to be laid shall be firmly supported to true line and gradient on pre-cast concrete blocks and separated from them by a 1 inch thick saturated softwood or other approved flexible packing. The blinding concrete shall then be thoroughly washed down and reinforcement, if any,and concrete shall be carefully placed and compacted thereon until the appropriate profile shown on the Drawings for the required concrete bed has been obtained in such manner as not to disturb the pipes or joints. The concrete shall be placed against vertical shutters or to the full width of the trench. The concrete class shall be Class A for all reinforced concrete bedding and for pipe diameters less than 30 inches on mass concrete bedding. Class B concrete shall be used for all other pipe diameters on mass concrete bedding.

Before placing the concrete bed, a thickness of bituminous joint filler as specified, or other approved filler, shall be shaped and placed at every pipe joint to prevent concrete entering the pipe joint and to interrupt the concrete bed across its full section. The thickness of the joint filler shall be:

a) 0.5 inch for pipes up to and including 3 ft nominal diameter; and

b) 0.75 inch for pipes over 3 ft nominal diameter

After placing and fixing the reinforcement, if any, the concrete shall be placed and compacted evenly to within 1 inch of the underside of the pipe barrel over the full width of the excavation or between rigid shutters to the required minimum width of the bedding. The concrete shall then be placed on one side of the pipe only and carefully worked under the pipe until all voids are filled and the pipe is firmly supported on the concrete. The remainder of the concrete shall then be placed to bring up the level of the concrete equally on each side of the pipe.

After the pipeline has satisfied the preliminary test as specified in Clause 14.15 and after the concrete has been cured as specified for not less than 24 hours, the remainder of the excavation shall be refilled. The pipe shall be covered to a depth of 1 ft above the crown of the pipe, using selected excavated material with particle size not exceeding 1 inch. The material shall be evenly placed and compacted in layers note exceeding 4 inch thickness after compaction. Hand controlled vibrators or other such means as approved by the Engineer shall be used. Backfilling shall then continue with selected excavated material with particle size not exceeding 4 inches and as specified in Clause 5.12 herein.

Trenches must be overfilled to allow for settlement.

14.15 Drainage pipe in Bridge Deck

The measurement and payment for the pipes shall be the number of linear of pipes provided and fixed in position. The accepted quantity measured as provided shall be paid for at the contract unit price as listed below and shown in the bill of quantities, for which price and payment shall constitute full compensation for labour, equipment and incidentals necessary to complete the item in all respects.

ITEM	DESCRIPTION	UNIT
1	Providing and fixing drainage pipe in bridge deck	
	1. 50 mm diameter galvanized iron pipe	m
	2. 100 mm diameter galvanized iron pipe	m

14.16 Testing Pipelines

Pipelines shall be subjected to preliminary tests and tests on completion. The preliminary test shall be an air water test as specified below. The test on completion shall be a water test as specified below. The preliminary test shall be made after the pipeline length to be tested has been laid and jointed, but before completing the filling of the excavation or placing the concrete surround or bed, as the case may be. The test on completion shall be made after the pipeline excavation for the length under test has been filled. All fittings required for temporarily closing the openings in pipelines to be tested shall be properly designed for the purpose and shall be adequately strutted to withstand the pressure specified. All apparatus required by the Engineer for measuring and maintaining pressures and levels shall be supplied, fixed and maintained by the Contractor to the approval of the Engineer. A record shall be kept to the approval of the Engineer of all tests made and of their results.

Any length of pipeline for which the Engineer requires test shall not be considered complete until it has satisfied the test on completion in the presence of the Engineer.

a) The air test shall be conducted as follows: The pipelines shall be thoroughly wetted for the length under test. Air or smoke shall be pumped into the pipeline under test until a pressure equal to 4 inches of water is indicated in a graduated 'U' type gauge. After a period of 5 minutes without any further pumping, this pressure shall not have fallen below 3 inches. The water test shall be conducted as follows:

b) The pipeline under test shall be filled with water from a header tank at the lower end, air being released through a valve at the upper end until the pipeline is completely full of water. After a period approved by the Engineer for absorption by the pipe material, water shall be added until the head over the soffit of the pipeline is 4 ft at its highest point, but not more than 20 ft at its lowest point. The water level in the head rank shall be marked. At the end of thirty minutes the amount of water necessary to bring the level in the header tank up to the original mark shall not exceed 0.07 gallons per hour per 100 ft of pipeline per half inch of nominal internal diameter of pipe.

For pipelines of nominal internal diameter more than 2 ft, subject to the agreement of the Engineer (which will not be unreasonably withheld) the test on completion as specified may be substituted by a visual inspection by the Engineer of the internal surfaces of the pipeline for apparent defects together with hydraulic test of the joints. The hydraulic test of the joints shall be performed using apparatus approved by the Engineer. The test pressure shall be twice the maximum pressure specified above for the test on completion, and the duration of the test shall be not less than 5 minutes. The test will be considered satisfactory if the loss of water is not greater than 0.0006 gallons per hour per inch of internal diameter per joint.

15 Channel and Structure Protection Works

15.1 Preparation of Formation

The Contractor shall prepare the formation for channel and structure protection works by trimming the

Excavation accurately to the specified dimensions. Where over-excavation occurs it shall be backfilled with specially compacted fill or, if a gravel backing is used, with the gravel backing material, all to the approval of the Engineer.

Where a filter cloth is to be laid on the formation, all sharp projections caused by rocks, roots, etc. shall be removed and the voids so formed shall be filled with specially compacted fill material. The surface of the formation shall be smooth and even.

15.2 Stone Pitching

15.2.1 Scope of Work

The work to be done under stone pitching consists of furnishing and transporting materials and placing them in bed and slopes of canal at locations shown on the Drawings and as instructed by the Engineer.

15.2.2 Materials

The materials under this chapter are stone, geotextile and filter layers as specified herein.

15.2.3 Geotextile

1) The work to be done under geotextile shall include providing and placing geotextile under filter layer in accordance with the Specifications hereof and the Drawings and shall be approved by the Engineer.
2) All material procurement and installation, field and laboratory testing shall be done according to the procedure specified herein below.
3) If the formulation of Geotextile changes during the work, the Contractor shall provide the Certificate of Analysis (COA) every change of formulation / product to the Engineer.
4) The COA will assure that the material meets the minimum property values of ASTM parameters as follows:
    a) It shall comprise a continuous fiber needle-punched non-woven geotextile of unit mass of at least 7.37 ounces per square yard (250 g/m2) conforming to ASTM D 5261 or ASTM D3776, made of polypropylene or polyester fibre.
    b) Its thickness shall be at least 2.28 mm measured conforming to ASTM D 5199.

15.2.4 Packaging, Transport and Storage

The geotextile layer shall comprise pieces as large as practicable, preferably with the long dimension of each piece lying along the canal. Junctions between adjacent pieces shall be plain overlaps of not less than 6 inches. Each piece of geotextile as defined here shall have a unique reference number which shall be used for marking the piece for transport and storage, and also for reporting tests.

The pieces of geotextile shall be packaged so as to prevent damage during normal handling, transport and storage. Each piece or roll shall be clearly marked with the contract number unless the Engineer has agreed that such numbering is not necessary.

Geotextiles shall not be stored or exposed in direct sunlight for more than a total of fourteen days before being installed and covered with stone pitching.

Any pieces of geotextile that are damaged, or exposed to more than the permissible sunlight, shall be removed from the site and replaced, unless the Engineer agrees, explicitly for that the damage can be removed by cutting off part of the piece and repaired by patching, using field seams.

15.2.5 Placement

The Contractor shall submit his plan and method for placement of geotextile in detail to the Engineer prior to material being delivered to the job site. Geotextile shall be placed after approval of the proposed panel layout diagram and all applicable certificates / field checklists by the Engineer. If the material does not meet the specifications it shall be removed from the site by the Contractor. The geotextile panels shall be placed using a spreader bar assembly attached to a loader bucket or by other approved method. Adequate loading of sand bags or equivalent ballast shall be used as necessary to temporarily hold the geotextile in position. Damaged panels/portions which have been rejected shall be marked and their removal from the work area recorded. All persons walking or working on the geotextile shall wear shoes that will not damage the product. No vehicles, other than those approved by the Engineer, shall be allowed on the geotextile.

When the geotextile is in place and its placing approved by the Engineer, anchor trenches on each side shall be backfilled in accordance with the Drawings, the sand bags in the trench being removed as the backfilling proceeds. The backfill shall be compacted as per specification.

15.2.6 Base Filter layer

Base layer for the stone pitching shall consist of a mixture of 20% medium to coarse sand with 80% graded material. The graded material shall consist of gravel well graded to a maximum size of less than 1-1/2 inches.

15.2.7 Stone for Pitching

Stone for pitching shall consist of rock fragments or boulders/pebbles which are dense, sound, angular and resistant to abrasion. The stones shall be generally cubical in shape with the largest dimensions not exceeding twice the smallest dimensions. The stones individually shall weigh between 40-120 lbs and 80percent shall be 80 lbs or larger and not more than 5 percent shall weigh less than 40 lbs.

15.2.8 Rock Spalls

All interstices in stone pitching shall be well filled with rock spalls. The rock spalls shall be rock fragments size between 2 inches and 4 inches.

15.2.9 Testing of Materials

Stone and rock spalls may be rejected if they fail to meet the following test requirements:

i. Los Angeles abrasion test (large size Coarse Aggregate ASTM Designation: C535) - If the loss exceeds ten percent, by weight, at 200 revolutions, or 40 per cent, by weight, at 1000 revolutions.
ii. Los Angeles abrasion test (small size Coarse Aggregate ASTM C131) - If the loss exceeds ten percent by weight at 100 revolutions or 40 percent by weight at 500 revolutions.
iii. Specific gravity (ASTM Designation: C127) - If the specific gravity (saturated surface-dry basis) isles than 2.60.

15.2.10 Material Sources

The Contractor shall propose the sources of base filter layer, stone pitching and rock spalls for approval of the Engineer. The use of the materials shall always be subject to approval of the Engineer. All the requisite tests will be carried out by the Contractor under supervision of the Engineer either at Contractor's Laboratory or at an approved laboratory at the expense of the Contractor.

15.2.11 Placement

The base filter layer shall be placed to a uniform thickness and finished to a reasonably smooth and even surface as shown on the Drawings or as directed by the Engineer. Before placement of the base filter, the surface over which the base filter is to be placed shall be trimmed to the proper lines and grades and shall be moistened with water and tamped or rolled with suitable tools or equipment for the purpose of forming a firm foundation.

Stone used in the stone pitching shall be hand packed and placed and bedded in such a manner that the completed stone pitching is stable and without tendency to slide. Large open spaces between the stone shall be avoided. Care shall be taken to ensure that all stone is well-bedded on its flattest surface. The stone shall be placed so as not to project above the neat lines shown on the Drawings or as directed by the Engineer. All interstices in the stone pitching shall be well-filled with rock spalls. The amount of rock spalls used shall not be in excess of that required to fill the voids in the revetment stone.

15.3 Pre-cast Concrete Blocks

15.3.1 General

Concrete blocks for pitching or for any other purposes shall be pre-cast or cast in-situ, to the sizes shown on the Drawings using concrete Class 'B' as shown in chapter of "Concrete" of the Specification, shall be prepared. Sample blocks for each size shall be approved by the Engineer before construction of all the blocks.

A recessed lifting eye shall be incorporated in each block during pre-casting to enable the block to be lifted and accurately placed.

The blocks shall be placed on prepared gravel backing of the specified thickness to a true and even surface with a gap as specified in the drawing.

Gravel backing for block pitching shall consist of approved clean, broken stone or washed natural gravel, shall be well graded from 2 inches to 0.5 inches, and shall be laid to the thickness shown on the Drawings to give an even horizontal surface.

The gravel backing shall be underlain by geotextile as specified in Chapter -"Stone Pitching" of these Specifications.

16 Brickwork and Plasterwork

16.1 General

All bricks shall be new and of the best quality of their respective kinds. They shall be clean, hard, sound and well burnt, equal in size, straight and sharp in the arises and shall be obtained from manufacturers approved by the Engineer. Samples of ten bricks from each consignment of 20,000 bricks or less are to be submitted to the Engineer for his approval and every consignment delivered to the Works shall be equal in quality to the approved samples retained by the Engineer. Bricks delivered to and within the Site, shall be unloaded by hand and not tipped.

16.2 Cement Mortar for Brickwork

Unless otherwise ordered cement mortar for brickwork shall consist of one part of Cement to four parts of sand by volume mixed with just sufficient water to make it workable.

16.3 Sand

Sand shall be as specified in the Chapter of 'Concrete'.

16.4 Cement

Cement shall be as specified in the chapter of 'Concrete'.

16.5 Laying

Brickwork shall be laid in English Bond unless otherwise specified. Bricks shall be laid to true line and level courses and to the dimensions shown on the Drawings or instructed by the Engineer. The bricks shall be thoroughly soaked in clean water for at least one hour before use and before continuing partly completed work. The exposed bed joint shall be likewise soaked. The new work should be kept wet during construction and for ten days after completion. The joints shall generally be not more than 0.25 inch in the beds and 0.50 inch at the ends or such other dimensions as may be agreed by the Engineer and the whole joint shall be completely filled with the same mortar.

Brickwork shall be carried up in a uniform manner and no one portion carried more than 3 ft above another, the ends being racked not toothed.

For roads, where indicated on the Drawings the bricks on the edge shall be laid with their width parallel and joints at right angle to the centre line of the road, the soil beneath the bricks should be well rammed

and brought to proper level. The edging shall be made with bricks laid on either side of the carriage way. The dimensions of the brick to be provided for road and brick work (masonry) shall be 4.5" (thick), 3" (wide) and 9" (long) and 9 inches x 4 3/8 inches x 2 11/16 inches or 228.6 mm x 111.12 mm x 68.26 mm respectively.

16.5.1 Compressive Strength

The compressive strength of brick shall not be less than 2000 lbs per square inch.

16.5.2 Water Absorption

This test shall be carried out in the following manner:

The weights of samples of bricks are taken:

(i) when dry at room temperature

(ii) after immersion in water at room temperature for 24 hours and

(iii) After boiling in water for 5 hours and cooling in water overnight. In each case the weight of water absorbed is expressed as percentage of the corresponding weight of dry bricks. Water absorption by dry weight of an average first class brick varies from 10 to 15 per cent and that of a second class brick varies from 15 to 25 per cent.

16.6 Cement Plaster

The cement plaster shall consist of one part cement to three parts of sand by volume. Cement plaster shall be applied in two coats to give a total thickness of 19 mm and 12.5 mm (0.75 and 0.5 inches), as instructed by the Engineer. The undercoat shall be thoroughly scratched and brought to a true surface before application of the topcoat.

The top coat shall be finished to a true and even surface with a wood float. Corners shall be finished true, vertical, even and carried out at the same time as adjacent wall surfaces. All brickwork shall be cured as it is constructed and for not less than 10 days.

17 Repair and Renovation of Steel Gates

17.1 Mechanical Maintenance of Regulator Gates

The contractor shall provide the necessary arrangements for oiling and greasing including washing with degreasing to remove the dust accumulated over the moving parts. All gearing systems viz.opinion gear, crown gear and wheel driving shaft spur gearing shall be properly lubricated with suitable gear oil. All damaged greasing nipples shall be replaced. Greasing must be done with the specified quality of grease with the help of grease gun. The operation of each vertical gate shall be checked by the Engineer to ensure that these regulator gates are in fully serviceable and operational conditions.

17.2 Standard Specifications

Except where otherwise specified all materials and workmanship shall conform to the requirements of the relevant British Standard Codes of Practice issued by the British Standards Institution. Other equivalent Standard Specifications may be substituted for the British Standards or British Standard Codes of Practice (hereinafter referred to as BS or BSCP) at the sole discretion of the Engineer.

All materials not herein fully specified or covered by BS or BSCP shall be of such kind as is used in first class work. The Engineer shall determine whether all or any of the materials offered for use in the Works are suitable for the purpose and the Engineer's decisions in this respect shall be final. If the Contractor proposes to use materials complying with standards other than those specified herein, shall submit details of such Standards for the approval of the Engineer.

17.3 Seals

Seals shall be in accordance with requirements given in Chapter 18 of this Specification.

17.4 Welding

Welding shall be in accordance with requirements given in Chapter 18 of this Specification.

17.5 Galvanizing

Where steel or wrought iron is specified to be galvanized the galvanizing shall be executed after all fabrications have been completed. The articles shall be cleaned and pickled in dilute sulphuric or hydrochloric acid followed by rinsing in water and pickling in phosphoric acid.

They shall be thoroughly washed, stoved and dipped in molten zinc and brushed so that the whole of the metal shall be evenly covered and the additional weight thereof after dipping shall be not less than 2 ounces per square foot of surface galvanized, except in the case of tubes to British Standard 1387 when it shall be 1.5 ounces per square foot. Edges shall be clean and surfaces bright.

17.6 Nuts and Bolts

External bolts and fixing rag bolts, nuts and washers shall be sheradised steel. Assembly nuts, bolts and washers on galvanized fittings or equipment shall be either galvanized or sheradised.

17.7 Bolted Joints

The Contractor shall supply all the necessary bolts, nuts, washers, etc for fixing the steelwork, together with a suitable number of spare bolts, nuts and washers.

Friction grip bolts, nuts and washers shall comply with BS 4395, Part 1, and shall be used in accordance with BS 4604, Part 1. They shall be used on all bolted joints, which are liable to vibrate and elsewhere to the approval of the Engineer.

17.8 Field Connections

Field connections shall wherever possible be bolted connections. Welded field connections will be permitted where it is considered by the Engineer impractical to form bolted connections, in which case the weld preparation shall be carried out in the manufacturer's works before dispatch and the prepared surfaces shall be fully protected for transport to and storage on the Site.

17.9 Standardization and Maintenance

Where possible, corresponding parts shall be finished with sufficient accuracy to ensure that they are interchangeable and where required by the Engineer interchangeability shall be proved by actually changing the various parts.

17.10 Protective Treatment

17.10.1 General

This section covers the surface treatment required for all new metalwork and existing metal works, which is to be retained.

The surface preparation and painting of each item will depend upon the working of the item and whether the item is new or existing.

17.10.2 Anti-Corrosion Paint and Guarantees

The Contractor is required to apply anti corrosion paint and furnish guarantee for a period of one year following the issue of the taking over certificate for regulator gates. The guarantee shall not be applicable to embedded metalwork in the regulators and sluiceways. The guarantee shall bound the Contractor to take all necessary measures to fully restore any area of protective coating which becomes defective within

the guarantee period, except where such defectiveness is the result of fair wear and tear. During the closure period prior to the expiry an inspection of each gate shall be undertaken by the Engineer. The Contractor may if they so wish be present during this inspection. Areas, which in the opinion of the Engineer require restoration, shall be clearly marked, by the Contractor.

Principal defects which will be required to be restored are:-

- Corrosion of metal substrate, e.g. rusting
- Blistering of protective coatings.
- Cracking of protective coatings.
- Flaking of protective coating
- Pinpoint rusting through protective coating

Discoloration will not of itself be sufficient grounds for the need for remedial measures. If so instructed by the Engineer the Contractor shall immediately undertake all necessary restoration work provided that such work can be completed before the end of the closure period during which the inspection took place. Such work shall be carried out in close liaison with the Engineer. All restoration work shall be carried out with minimum interference to the operational function of the regulator and in the shortest possible time.

If following the inspection by the Engineer no remedial work is found to be necessary the Engineer will issue a certificate for the inspected gates and the guarantee for these gates will be discharged. If restoration work is required, a certificate will be issued by the Engineer upon satisfactory completion of all notified remedial work.

All the restoration work shall be carried out in a manner approved by the Engineer. Where appropriate, such clauses of the Specification as may be reasonably applied shall apply to all restoration work.

17.11 Record

The Contractor shall prepare a photographic record before repair including locations, date of time and name of structure. After remedy of defects the photographic record shall be repeated by the Contractor. A complete report thereof shall be prepared and submitted to the Engineer.

17.12 Surface Preparation

17.12.1 General

All surface defects, including cracks, surface laminations, shelling and deep pitting, likely to be detrimental to the protective painting system shall be removed as laid down in BS EN 10 025. All fins at saw cuts; burrs and sharp edges shall be similarly removed.

Where the protective treatment requires blast cleaning, and extensive grinding has been necessary to remove defects, the dressed areas shall be re-blasted to restore the required standards of cleanness and roughness.

17.12.2 Blast Cleaning

1) All new steelwork and all existing steelwork which is returned to the workshop shall be blast cleaned in accordance with BS 7079 to second quality of surface cleanliness. Visually the blast cleaned surface shall be equal to Swedish Standard S.I.S. 05.5900 Preparation Grade Sa. 2.5. Where existing steelwork is excessively corroded a lesser standard of Sa 2 may be accepted subject to the written approval of the Engineer. The level of such corrosion should be brought to the knowledge of the Engineer as soon as possible so that the use of the steel can be reassessed and its possible replacement with new steel can be considered.

2) Blast cleaning shall generally be carried out in accordance with the appropriate section of BS 5493 and BS 7079.. The use of sand shall be subject to local requirements or the provision of satisfactory safeguards as directed, all to the approval of the Engineer.

3) The blast cleaning shall remove all oil, grease, salts and contaminants and rust and mill scale to the level set by the quality required. The items shall be tested by the Contractor to show that this has been achieved. The amplitude, from peak to trough, of the surface after blast-cleaning shall not exceed 100 microns.

4) Where fabrications are made from steel which has been coated with pre-fabrication primer all traces of the primer shall be removed by the blast cleaning process.

5) Following blast cleaning the surfaces shall be cleaned by air blast, vacuum or other approved method to free the surface of all residual abrasive or dust.

6) The application of the protective system for the steel shall be commenced as soon as possible following blast cleaning. Any deterioration in surface finish resulting from delay will need to be rectified by further blast cleaning.

7) Only where blast cleaning is not practical or appropriate may an approved form of mechanical cleaning be accepted. The written approval of the Engineer shall be obtained before such a system may be adopted.

8) A sample blast cleaned steel panel not less than 150 millimeters square and 6 millimeters thick, shall be submitted for the approval of the Engineer before any blast cleaning is commenced. The approved sample be retained by the for comparison with the work as carried out on the permanent steel work, which work shall be at least equal to the approved sample.

17.12.3 Mechanical Cleaning

Mechanical cleaning shall be carried out by means of power driven tools, such as carborundum grinding discs, chipping hammers, needle guns, etc., followed by steel wire brushing and dusting with stiff bristle brushes to remove all loosened material. Excessive burnishing of the metal through prolonged application of rotary wire brushes will not be permitted.

The surface finish after mechanical cleaning shall correspond to Grade St3 of Swedish standard SIS 055900 or other finish as directed.

17.12.4 Hand Cleaning

Hand cleaning using a combination of power driven tools and manual brushing shall be carried out on the existing painted metal work both above and below water level, e.g. gate counterweights support trestles, and the retained built-in metal part in the sluiceway. The purpose of hand cleaning is to remove loose, flaking and otherwise defective paintwork together with all rust and other foreign matter. The surface of sound existing paintwork shall be washed with a detergent solution rinsed with clean water, then lightly abraded to provide a keying surface for subsequent painting. The preparation of all existing paintwork shall be to the approval of the Engineer and repainting shall not commence without the approval of the Engineer. Before repainting is started all surfaces shall be completely dry and shall be brushed to remove loose particles. Surface preparation and painting of existing metalwork shall be carried out in a planned manner such that a minimum interval between preparation and priming is achieved. Care shall also be taken to ensure that newly painted work is not contaminated as a result of cleaning of adjacent areas.

17.13 Paints

Paints shall be in accordance with requirements given in Chapter 18 of this Specification.

17.14 Painting of Steel Surfaces

17.14.1 General

All painting shall be executed in accordance with the principles and practices recommended in BS 5493 and BS 6150 and the workmanship shall be of the highest quality in all respects throughout. All painting shall be carried out by skilled painters under competent supervision and it shall be the responsibility of the Contractor to ensure that each coat of paint is compatible with the preceding coat.

17.14.2 Application of Paint

All paint shall be applied to dry surface that have been prepared and cleaned in accordance with the provisions of Clause 17.12. The interval between the preparation of the base metal and the application of the first priming coat shall in no case exceed 4 hours. In the case of acid-pickling, the priming coat shall be applied as soon as the surface has dried and while the metal is still warm.

Paint shall not be applied in the open during sandstorms, rain hail, fog or mist, except where full protection from the elements is provided, nor when the relative humidity exceeds 90 per cent. It shall not be applied when condensation has occurred or is liable to occur on the surface nor when moisture is present on the surface of the previous coating. Where paint is applied in the open air the work shall be protected from direct sunlight as far as is possible and from windblown dust and dirt. The waste from blast cleaning operations shall be kept clear of the painted surfaces. Adequate ventilation shall be provided where paint is applied in confined spaces. Two pack paints of the epoxy resin shall not be applied when the temperature is outside the ranges specified by the paint manufacturer.

All paint shall be applied by airless spray in workshop conditions wherever possible and in accordance with the manufacturer's recommendation or as directed by the Engineer to produce a continuous film of paint of uniform texture and thickness. As soon as the first priming coat has dried a further coat of paint of similar composition to the priming coat but of contrasting shade shall be applied to all edges, corners, crevices, rivet heads, bolt heads and nuts and welds. Whenever two or more coats of paint of the same color are specified the undercoat shall be tinted with a different shade, as a means of identification and each coat shall be thoroughly dry before the next coat is applied.

17.14.3 Examination before Over-Coating

Before over-coating, paintwork shall first be examined and all dirt, grease, oil and other contamination shall be removed using a suitable cleaning solution followed by thoroughly rinsing with clean water. Paintwork that has been exposed in the open for any length of time shall be similarly treated prior to the application of further coats of paint.

17.14.4 Paint Inspection Equipment

The Contractor shall make available for the use of the Engineer sufficient equipment to check both wet and dry film thickness. He shall check all items that will be subject to immersion for final dry film thickness and for any pinholes or holiday using an approved instrument at the appropriate voltage.

17.14.5 Contractor's Programme

The Contractor shall establish a programme for each blast cleaning and painting operation, which shall include for checks or inspections as required. Once approved by the Engineer, this procedure shall be followed unless otherwise agreed with the Engineer.

17.14.6 Repairs to Paintwork

The Contractor shall follow what is considered to be good practice in handling and storing steel items to minimize damage to paint coatings. Any damage sustained shall be drawn to the attention of the Engineer and remedial work shall be carried out. All loose paint and rust shall be removed and cleaned down to

bare metal where required by the Engineer and the area around the damage shall be abraded and feathered back for approximately 4 inches.

After the damaged surfaces have been treated in the aforesaid manner the full specified painting system shall then be re-applied and the new paint shall overlap the existing paint by at least 2 inches all around the affected area.

17.14.7 Surfaces inaccessible after Fabrication

Surfaces to be painted which will be inaccessible for painting after fabrication or assembly shall be cleaned in accordance with the provisions of Clause 17.12 and painted with the priming coat as specified, before being fabricated or assembled.

17.14.8 Meeting Surfaces at In-Situ Bolted Connections

The regulator gates are to be erected in the sluiceway by bolting together of separately fabricated gate sections. The meeting surfaces of the bolted connections shall be prepared and painted with primer as specified before trial erection in the Contractor's workshop.

After transportation of the gates sections to the sluiceway, and immediately prior to bolting up, the meeting faces shall receive the minimum specified paint application. A 'wet-painted' joint will then be made by immediately offering up the meeting faces for bolting.

17.14.9 Unpainted Meeting Surfaces for H.S.F.G. Bolts

The meeting surfaces of all joints made with high strength friction grip bolts shall not be painted.

17.14.10 Multiple Coats

Where more than one coat is to be applied each shall show a clear change of color from the preceding coat. The intervals between coats shall normally be as recommended by the manufacturer and agreed by the Engineer taking into account the conditions of application. No further coat shall be applied until the previous coating has dried or cured to the correct degree.

17.15 Preparation and Storage of Bolts

Before they are dispatched to the site, the Contractor shall protect all bolts (other than rag-bolts, Lewis bolts and galvanized bolts) by heating them and dipping them while hot into boiled linseed oil, or shall provide such other protection as may be approved by the Engineer. The Contractor shall pack the bolts carefully so that the threads do not become damaged or dirty during delivery, storage and transport to Site.

17.16 Inspection and Tests

a) All equipment and materials furnished and all work performed in connection herewith will be subject to rigid inspection by the Engineer at the manufacturer's plant to determine that the gate/equipment meets the requirements of the Contract. The Engineer shall be permitted to inspect all materials and equipment during the manufacture and fabrication and prior to its preparation for shipment and to inspect like packing, boxing and crating. The Engineer shall have access to witness all factory tests of finished products and to witness any or all tests for which results are required under this specification.

b) The Contractor shall notify the Engineer not less than 7 days in advance of the date and place that the materials and equipment, or any portion thereof, will be available for each inspection or test. Acceptance of materials and equipment, including packing, boxing and crating or the waiving of any inspection or test or witness thereof, shall in no way relieve the Contractor of the responsibility of furnishing materials and equipment meeting the requirement of this Specification.

c) The Contractor shall furnish the Engineer with four certified copies of reports of tests of control and accessory equipment. The results of these tests shall be in such from as to show compliance with the applicable specifications for the materials used. All costs of tests and reports for materials shall be borne by the Contractor.

17.17 Operation and Maintenance Instructions

The Contractor shall provide instructions in English for operating and maintaining the various items of Plant. The Contractor shall prepare a draft of the instructions for approval of the Engineer and thereafter shall supply five sets of the instructions, together with any relevant reduced-scale drawings, catalogues, parts list etc on stout paper bound into durable covers for use at the various sites. The issue of a certificate of completion for the whole or a section of the Works shall be conditional upon the Contractor having supplied the relevant approved documents required under this clause.

17.18 Correct Assembly and Erection

The Contractor will be responsible through his supervisors for ensuring that the Plant is correctly assembled and erected in accordance with the Drawings.

17.19 Outlet Lock Plate

The Contractor will provide and fix M.S frame in the outlet and also provide steel plate (6 mm thick), lock along with handle and the locking arrangement to stop the flow as shown in the drawing and as directed by Engineer. Painting to the frame and plate will be as per specification in Clause 17.13 herein

18 Gate and Gate Equipment

18.1 Scope of Work

This chapter specifies technical requirements for the manufacture, site delivery, installation, testing and commissioning of gate equipment in accordance with the provisions of the Contract. The Contractor shall provide all labour, material, equipment, transportation for the satisfactory completion of work. The gate equipment specified hereinafter shall be installed at regulators as shown on the Drawings.

18.2 Work to Be Done

The Contractor shall:

1) Detail, manufacture, furnish, deliver to the Site, install, test, and commission the following equipment in accordance with the specifications and as shown on the Drawings:
   a) Fixed wheel gate equipment:
   b) Gate leaf assemblies
   c) Hoisting machinery
   d) Hoisting decks
   e) Embedded parts
   f) Stoplog equipment:
   g) Stoplogs
   h) Embedded parts
   i) Lifting gear
   j) Slide gate equipment:
   k) Slide gate assembly

l) Embedded parts

m) Electric Motor

2) Furnish a complete set of maintenance tools needed for the lubrication, adjustment and normal maintenance of each item of the equipment. These tools shall be neatly mounted in heavy duty steel cabinets provided with locks, suitable for wall mounting. The price for each set of maintenance tools shall be included in the quoted price of the respective equipment to which it belongs.
3) Furnish the basic spare parts for gate equipment. The cost of the spare parts shall be included in the corresponding equipment cost.
   All spare parts shall be interchangeable and of the same material and quality as the original parts. All spare parts shall be treated and boxed as required to prevent deterioration during storage. Boxes shall be clearly marked for identification of the parts they contain.
4) Submit equipment drawings, installation drawings, equipment data, O&M manuals with preventive and predictive maintenance schedules and perform all other work specified hereinafter.

18.3 Drawings Furnished By the Engineer

The general arrangement of the equipment shall conform to the Drawings included in the Contract. The Drawings included in the Contract are not intended to define the detailed design of the equipment to be furnished and installed but are merely illustrative to show the general layout of the equipment except where limiting or mandatory dimensions, elevations, tolerances and similar features are indicated. Alternative details and arrangements will be considered if, in the judgment of the Engineer, they are not inferior to the details and arrangement shown on the Drawings included in the Contract.

18.4 Contractor's Drawings and Data

18.4.1 General

The Contractor shall submit drawings and instructions as outlined herein. The sequence of submission to the Engineer for review shall be such that information is available for review of each drawing when it is received. Before submitting any drawings for review, the Contractor shall submit a list of proposed drawings, showing sequence and dates of submittal to meet the requirements of the Contract.

18.4.2 Outline Drawings

The Contractor shall submit outline drawings of the equipment together with data, to permit final design of the structures into which the equipment is to be incorporated. Outline drawings and/or data shall be submitted in accordance with a schedule mutually agreed upon between the Contractor and the Engineer.

18.4.3 Detail Drawings and Data

Before proceeding with manufacture of the equipment, the Contractor shall submit, for the Engineer's approval, general assembly drawings, subassembly drawings, detail drawings, catalogue leaflets, specifications and similar engineering documents required to demonstrate fully that all parts will conform to the provisions and intent of the Drawings in the Contract. These drawings shall show all necessary dimensions and fabrication details, including the design of welded and bolted joint connections, tolerances on fits and clearances, and all field flints and subassemblies in which the Contractor proposes to transport the equipment. The detail drawings shall include the following where applicable: General arrangement drawings of gates: These drawings shall show all final dimensions and tolerances, surface finishes, details of field connections and final weights. General arrangement drawings of the hoists: These drawings shall show all final dimensions and tolerances, details of field connections, final weights and loads on foundation bolts. General arrangement drawings of embedded parts: These drawings shall show all final dimensions, tolerances, and details of field connections. Slot and sill beam details showing seal contact with the embedded sealing faces. Typical seal details Seal splice and seal corner details Structural detail drawings of each gate Hoisting deck and access ladder details of the hoist gear box, drum and

couplings Assembly match mark sheets Other drawings not specifically listed but required to be developed as detail drawings

18.4.4 Review of Drawings

a. Three (3) hard copies and one soft copy of each drawing shall be furnished. All drawings submitted shall be on A1 size. Printed catalogues and data shall be submitted in five (5) copies.
b. One copy will be returned to the Contractor marked "Approved", "Approved Except as Noted", "Revise and Resubmit" or "Not Approved". Review will not relieve the Contractor of responsibility for conformity to the Contract and correct detail and fit of parts when installed. No major revision affecting the design shall be made after a drawing has been "Approved" without resubmitting the drawing.
c. When copies of drawings have been marked "Approved Except as Noted", or "Revise and Resubmit", or "Not Approved", the Contractor shall make the necessary corrections and resubmit three (3) hard copies and one soft copy. Every revision shall be shown by number and date.
d. Should an error be found in a Contractor's drawing during the installation or field testing of equipment, the correction, including any field changes found necessary, shall be noted on the drawing, and it shall be resubmitted for review and record.

18.4.5 Record Drawings

Prior to completion of the work under the Contract, the Contractor shall furnish record drawings as one softcopy and six hard copies (three on A1 size and three on A2 size both readable)

18.4.6 Installation Instructions

a. General: The installation instructions shall be prepared in one volume (one in soft copy and one in hard copy), divided into two sections as referred below, and shall cover instructions for installation, (hereinafter referred to as the installation section), testing and setting to work (hereinafter referred to as the site testing section). The volume (hard copy) shall be strongly bound in a durable cover with approved legend.
b. Installation section: This section shall include full and detailed instructions as to all procedures and precautions to be observed in installing, assembling and adjusting the equipment and as to the use of the erection and maintenance tools. It shall include or be accompanied by drawings clearly showing installation marking and particularly any match-marking and shall embody in particular a full statement as to installation tolerances to be observed.
c. Site testing section: This section shall include full detailed directions as to the methods and procedures to be followed and the quantities to be observed and recorded in checking the accuracy of installation, and the carrying out of Site tests as required by the Specification. It shall also include a schedule of the tests and a description of all instruments provided for these tests and of their use.
d. Number of copies: The Contractor shall submit two (2) hard copies (draft) copies and one soft copy to the Engineer for approval prior to producing the final volumes. The Contractor shall provide six (6) hard copies and one soft copy to the Engineer.

18.4.7 Operating and Maintenance Manuals

The Contractor shall submit for Engineer's review two (2) trial copies of detailed operating and maintenance manuals for the equipment. After the Engineer's review, six (6) complete, durable bounded copies of the manuals shall be furnished. The operating and maintenance manuals, shall include reduced size copies of applicable drawings, applicable parts lists and catalogues covering all equipment furnished and which may be needed in operation, maintenance, repairs, dismantling or assembling, and for repair and identification of parts for ordering replacements.

18.5 Technical Designations

Whenever the following technical terms occur in the Specification, these shall be understood to have the following meanings:

"GATE EQUIPMENT": All equipment to be furnished under the Contract which includes gates and all accessories, including embedded parts, hoisting/operating system arrangement, decks, access ladders, spare parts, erection and maintenance tools and all appurtenances including supplementary equipment. The word "equipment" wherever used instead of "gate equipment" shall mean gate equipment.

"GATE UNIT": The completely operational group of equipment parts that are required and sufficient to close toe opening. A gate unit will normally include one gate, one hoist with hoisting deck, one set of embedded parts, access ladders and all required appurtenances.

"GATE": The movable or moving parts of a gate serving to close one opening.

"HOIST": A device serving to move (open and close) a gate, including all related equipment necessary to assure safety.

"Electric Motor with Actuator"

The motor shall be specifically designed for radial gate service and shall be for high torque having 25% more lifting capacity than the designed load of the gate and gate equipment, totally enclosed, no ventilated construction, with motor leads brought into the limit switch compartment. The electric motor drive shall be self contained, complete with a weatherproof motor having Class B insulation, limit and torque switches integral reversing controls and controls as specified. The gear reducer shall be of the worm gear type directly coupled to the electric motor drive. Worm gears will be self-locking to hold the gate in position. The motor duty rating shall be sufficient for one complete open to close to open (or reverse) cycle.

Emergency hand-wheel shall be provided for manual operation. The hand-wheel shall not rotate during motor operation nor shall a fused motor prevent manual operation. When in manual operating position the unit will remain in this position until motor is energized at which time the gate operator will automatically return to electric operation and shall remain in motor position until hand-wheel operation is desired.

"EMBEDDED PARTS": The group of parts of a gate which is to be embedded in concrete or otherwise permanently attached to the civil work, such as frames, sea-plates, sill beams, bearing plates and rails. All welding pads, erection studs and anchorages to be furnished by the Contractor are also considered embedded parts except if otherwise advised.

"HOISTING/OPERATING DECK": A steel structure consisting of beams, chequered plates, required to install the hoists/operating system and related equipment. Or Equal: For convenience in designation in the Specification, certain equipment, articles, materials, or processes are designated by trade name or catalogue name and number. Such designation shall be deemed to be followed by the words "or equal".

18.6 Materials

18.6.1 General

Materials shall be new and of first-class quality, suitable for the purpose, free from defects and imperfections, and of the grades, classes and types listed herein, or their equivalents.

18.6.2 Material Specifications

Sr.no	*Material*	*Specification*
1	1 Structural Steel a) For skin plate, main components of gate leaf.	ASTM-A36, "Specification for Structural Steel". ASTM-A36, "Specification for

	b) For embedded parts and supports etc. (except seal bearing "Specification for plates, guide plates Structural Steel". and-rails which will be of CRES1).	Structural Steel
2	2 Corrosion Resistant bars, bolts, nuts, and washers, etc.	ASTM-A276. "Specification for Stainless and Heat Resisting Steel Bars and Shapes." Type: Series 316L
3	Corrosion Resistant Steel pins and rods	ASTM-A276. "Specification for Stainless and Heat Resisting Steel Bars and Shapes." Type: Series 316L
4	Stainless Steel plate, Sheet, and Strip	ASTM-A240, "Specifications for sheet and strip for Heat Resisting Chromium and Chromium-Nickel Stainless Steel Plate Sheet, and Strip for Fusion Welded Unfired Pressure Vessels."
5	Corrosion-Resisting Steel Castings	ASTM-A743, "Specification for Corrosion Resistant Iron-Chromium, Iron-Chromium-Nickel and Nickel-Base Alloy Casting for General Application"
6	Stainless Steel Axles and Hubs	ASTM A564, Type 630
7	7Steel Shafting	ASTM-A29, "Specification for Steel Bars, Carbon and Alloy, Hot-Wrought and Cold Finished".
8	Steel Bolts and Nuts	Carbon Steel Externally Threaded Standard Fasteners," and AS'fM-A325, "Specification for High-Strength B, ASTM-A307,"Specification for olts for Structural Steel Joints."
9	Locked Washers	Spring steel, SAE proportions, regular series.

10	Forged Steel	ASTM-A668, "Specification for Steel Forgings, Carbon and Alloy for General Industrial Use."
11	Cast Steel	ASTM-A27, "Specification for Mild-to-Medium-Strength Carbon Steel Castings for General Application," Grade 65-63
12	Round Wire Rope	ASTM-A492 ".Specification for Stainless and Heat Resisting Steel Rope Wire" and U.S. Fed. Spec. RR-W-410b. "Wire Rope and Strand".
13	Wire Rope Fittings	Contractor's standard fittings for the type of rope used
14	Permanent self- lubricating bearings and washers with rated coefficient of friction less than 0.15	''Lubrite'' A cast bronze alloy (ASTM-B22, "Specification for Bronze Castings for Bridges and Turntables." Alloy E) with sell-lubricating inserts.
15	Lubricating Fittings	According to manufacturer's published data
16	Bronze Bushings, Sleeve type Bearings and other Lubricated Wearing Parts	Bronze ASTM B22 / B271
17	Anti-Friction Bearings	According to manufacturer's published data B10 life shall be>5000 hours
18	Steel Pipe	Dipped, Zinc-ASTM-A53, "Specification for Pipe, Steel Black and Hot-Coated Welded and Seamless".
19	Steel Pipe Flanges and Flanged Fittings	ANSI-816.5, "Steel and Flanged Fittings Pipe Flanges

20	Expansion Anchors	According to manufacturer's published data.
21	Gears and Speed Reducers	AGMA Standard
22	Rubber Seals	The rubber seals shall be moulded and the material shall be compound of natural rubber or copolymer of butadiene and styrene or a blend of both. The compound shall contain not less than 70% by volume of the basic polymer and the remainder shall consist of reinforcing carbon black, zinc oxide, accelerators, anti-oxidants, vulcanizing agents, and plasticizers.
23	Fluoro-Carbon Clad Rubber Seals	Rubber seals shall be as specified above. A fluoro-carbon sheath shall be bonded to the rubber on the sealing surface. The sheath shall be abrasion resistant. The outside surface of the fluoro-carbon shall be free of adhering or bonded rubber
24	Concrete Anchor Studs	According to manufacturer's published data.
25	Metal contact surface for seals	Stainless Steel
26	Cast Steel Wheels	ASTM-583 "Specification for Cast Steel Wheels for Railway Service."
27	Carbon Steel Axels	ASTM-21 "Specification for Carbon Steel Axels, Non-Hear –Treated for Railway use."

18.7 Test of Material

18.7.1 General

All materials or parts used in the gate equipment shall be tested, unless otherwise directed, in conformity with applicable methods prescribed by the ASTM, or such other organisation as may be specifically required, and in general accordance with the best commercial methods. When requested, tests shall be made in the presence of the Engineer. Stocked material may be used, provided evidence is furnished to the Engineer to show that such material meets the requirements specified herein, in which case tests on stocked materials may be waived.

18.7.2 Test Certificates

Certified material test reports shall be furnished in triplicate to the Engineer as soon as possible after the tests are made. The test certificate shall identify the component for which the material is to be used and shall contain all information necessary to verify compliance with the Specifications.

18.7.3 Rubber Seals

All rubber seals shall be tested for and shall have the following physical properties:

Physical Properties	**Tests**
Tensile Strength min. 210 Kg/cm (3000 lbs/sq. in.)	ASTM-D412, "Tests for Rubber Properties in Tension."
Elongation at Break min. 450%	ASTM-D412
300% Modulus, min. 60 Kg/cm_2 (850 lbf/sq.in).	ASTM-D412
Shore Durometer (Type A) 60 to 70	ASTM-132240, "Test for Rubber Properly-Durometer Hardness".
Specific Gravity	1.15 + or - .03
Absorption of Water by Weight, max 5%	ASTM-13471, "'rest for Rubber Property-Effect of Liquids,"
Compression Set (constant deflection) or Original Deflection max. 30%.	ASTM-13395, "'rest for Rubber Property-Compression Set.
Tensile Strength after Oxygen Bomb Aging (48 hr, 158" F, 300 lbs/sq.in.),percentage of Tensile Strength before Aging min. 80	ASTM-13572, "'Test for Rubber Deterioration by Heat and Oxygen Pressure".

On rubber seals with fluoro-carbon cladding, the rubber shall be tested as specified above. The fluorocarbon shall be tested for and shall possess the following physical properties:

Tensile strength:	2000 lbs/sq.in (min.)
Elongation:	250% (min.)

The fluoro-carbon cladding on rubber seals shall be tested for adhesion in accordance with ASTM-D413, "Tests for Rubber Property Adhesion to Flexible Substrate," using either the machine method or the deadweight method.

18.8 Operating Conditions

All fixed wheel gate and slide gate shall be able to regulate the flow from minimum water level to full supply level as shown on the Drawings.

18.9 Minimum Dimensions

Minimum dimensions, without regard to stress considerations, shall not be less than the following, unless otherwise specified.

Plate thickness on any structural member except webs of rolled shapes.	3/8 in
Webs of rolled shapes.	5/16 in
Embedded metal with exposed surfaces	1/2 in.
Completely embedded metal	7/16 in
Diameter of bolts or screws on gate structures	3/8 in.
Diameter of adjusting bolts between frame or embedded part and welding pad	5/8 in.

18.10 Workmanship

18.10.1 General

Like parts and spare parts shall be interchangeable wherever possible. Surface finish of machined parts shall be adequate for their functional requirements. Machining of fits on renewable parts shall be accurate and to specified dimensions so that replacements made to the size shown on the drawings may be readily installed.

18.10.2 Electric Welding

a. General: All welds shall be made continuous and watertight. All butt welds shall be full/partial penetration welds as required.
b. Preparation of Base Material: Members to be joined by welding shall be cut to shape and size by mechanical means such as shearing, machining, grinding, by gas or by cutting, to suit the conditions. The edges of surfaces to be welded shall be sound metal free of visible defects, such as laminations or defects caused by cutting operations and free from rust, oil, grease, and other foreign matter.
c. Welding qualifications: The qualification of welding procedures and welders for all welding including weld repairs shall conform to the AWS "Structural Welding Code-Steel". The Contractor shall furnish the facilities, till equipment, materials and other articles required to perform qualification tests of his welders.
d. Weld Finish: Welds shall in general display good appearance and a surface suitable for painting. Structural welds shall be ground and blended to avoid stress raisers. All welds which require nondestructive examinations shall be dressed by chipping and grinding as required for good interpretation by the selected weld examination methods.

18.10.3 Steel Castings

Castings shall be free from injurious defects and shall be satisfactorily cleaned for their intended use. Surfaces of castings which do not undergo machining shall be dressed for good appearance and for painting. The location of existing defects shall be determined, and all defects which impair the strength or utility of the casting shall be removed. The structure of the castings stroll be homogeneous and free front

excessive nonmetallic inclusions. An excessive concentration of impurities or separation of alloying elements at critical points in the casting shall be cause for its rejection.

18.10.4 Nondestructive Testing

a. General: Unless otherwise indicated, the nondestructive tests shall be in accordance with ASTM Standards.

b. Examination of welds: All butt welds on skin plates and beam flanges, and all welds on other main components shall be given complete nondestructive examination by ultrasonic; dye penetrate, or magnetic particle method, supplemented by radiographic examination if required. The Engineer shall have the right to request random spot-check examination of welds as part of the equipment inspection.

c. Examination of welds shall be in accordance with the technique and acceptance standards of Section VIII, Division I, of the ASME "Boiler and Pressure Vessel Code".

d. Examination of castings: All castings shall be given a complete ultrasonic examination and a radiographic examination insofar as practicable. Where radiographic examination is not practicable due to configuration or accessibility, the castings shall be examined by the penetrate or magnetic particle methods in addition to the ultrasonic method.

e. Examination of forgings: All forgings shall be given ultrasonic examination with liberal overlap and other applicable nondestructive tests, to determine that they are sound. The structure of forgings shall be homogeneous and free from excessive nonmetallic inclusions. An excessive concentration of impurities and separation of alloying elements at critical points while forging will be cause for its rejection.

f. Structural work: Design and fabrication of structural parts shall conform to the applicable provisions of file AISC "Specification for the Design, Fabrication, and Erection of Structural Steel for, Buildings" of the AISC "Code of Standard Practice for Steel Buildings and Bridges."

18.10.5 Machine Work

a. General: All tolerances, allowances, and gauges for metal pits between plain (non-threaded) cylindrical parts shall conform to ANSI-B4.1. "Preferred Limits and Pits for Cylindrical Parts" for the class of fit shown or as otherwise required. All drilled holes for bolts which are intended to match other drilled lodes shall be accurately located and drilled from templates. No machining shall be done on working surfaces of "Lubrite" bushings or washers.

b. Finished Surfaces: All surfaces that requite machining for their intended function, of those that are usually machined according to good shop practice shall be machined. Surface finish qualities shall be adequate for the intended use and shall be indicated in the Contractor's drawings and shall be in accordance with ANSI-B46.1. "Surface Texture" Compliance with specified surface will be determined by sense of feel and by visual inspection of the work compared to standard roughness specimens, in accordance with the provisions of ANSI-B46.1.

c. Unfinished Surfaces: So far as practicable all work shall be laid out to secure proper snatching of adjoining unfinished surfaces. Where there is a large discrepancy between adjoining unfinished surfaces they shall be chipped and ground smooth, or machined to secure proper alignment. Unfinished surfaces shall be true to the lines and dimensions shown in the drawings and shall be chipped or ground free of all projections and rough spots. Depressions or holes not affecting the strength or usefulness of the parts may be filled in as per approved manner. Corrosion resistant steel seal plates shall have all surfaces thoroughly cleaned and those in contact with seals shall have a surface finish of 63 RMS or finer.

d. Pins and pin holes: Pin holes shall be bored in to gauges, straight, and at right angles to the axis of the member. Pin holes shall have a surface finish of 125 RMS or finer. The boring shall be done after the member is securely fastened in position.

e. Protection of machined surfaces: Machine-finished surfaces shall be thoroughly cleaned of foreign matter. Finished surfaces of large parts and other delicate surfaces shall be protected with wooden pads or other suitable means. Unassembled pins and bolts shall be oiled and wrapped with moisture- resistant paper or protected by other approved means. Finished surfaces of ferrous metals to be in bolted contact shall be washed with a rust inhibitor and given one thin coat of white or blue lead and lung oil.

18.10.6 Lubrication

Before assembly all bearing surfaces, journals, and grease and oil grooves shall be carefully cleaned and lubricated with an approved oil or grease. After assembly, each lubricating system shall be filled with an approved lubricant. "Lubrite" bearings shall not be greased and shall be assembled dry according to the manufacturer's instructions. Solvents shall not be used on "Lubrite" bearings.

18.10.7 Tolerances

a) General: All tolerances shall be selected by the Contractor to correspond to the accuracy required for the proper operation of the equipment considering the nature and function of the part. All tolerances shall be indicated on the Contractor's drawings and submitted for review. The tolerances specified herein are maximum tolerances applicable to the equipment when it is installed. The Contractor shall establish finer tolerances if necessary to meet the specified design or operational requirements or for interchangeability of spare parts. All tolerances shall be selected with due consideration to the nature and function of the parts and to the corresponding accuracy required to secure proper operation, but shall not exceed the tolerances specified in the Specification.

b) Gates
   i. Skin plate: The bottom and top edge of each skin plate shall be parallel within + or - 0.002 in. per 10 in. height. The length of the two diagonals connecting the skin plate corners shall be within 0.125 in. maximum.
   ii. Sealing surfaces: The plane formed by side and top seals shall be true within + or - 0.060 in.
   iii. Sill seal hacking bars: Sill seal hacking bars shall be within + or - 0.060 in. of a plane surface formed by the top of sill seals.

c) Embedded parts
   i. Seal bearing plates for gates and stoplogs: Each bearing plate shall be within + or - 0.060 in. of the design plane along its length and + or - 0.008 in. along its width. All bearing plates shall be checked by means of 10 ft. and 5 ft. straight edges and feeler gauges. The maximum deviation from 10 ft. straight edge shall not exceed 0.080 in. and 0.02 in. from the 5 ft. straight edge.
   ii. Rails: Rails for fixed wheel gates shall be within + or - 0.040 in. of design plane along their entire length and 0.004 in. across their width. Rails shall be checked by means of 10 ft. and 5 ft. straight edges and feeler gauges and shall be straight within + or - 0.020 in. over any 10 ft. length or + or - 0.l05 in over any 5 ft. length.
   iii. Sealing surfaces side and top seal bearing plates shall be in the same plane within + or - 0.030 in. Sill beams shall be square with the centerline of the side seal bearing plates and shall have a maximum camber of not more than 0.060 in. top of the entire length.
   iv. Guides: All guiding surfaces of each guide shall be straight within + or - 0.04 in. over any 10 ft. length. All guides shall be parallel with their opposite guide across the opening within + or - 0.060 in.

18.11 Structures and Embedded Parts

18.11.1 Structures

The structure of each item of the equipment and embedded parts shall be of welded steel construction. All welding shall be done in the shop, excepting welded field splices.

Field Splices

i. Field splices (or field connections) shall be provided wherever required for compliance with the size or weight limits for transportation.

ii. Permanent field splices shall be nettle either with fitted bulls or with high-strength bolts, or by field welding. Temporary field connections shall be made with pills or hulls. Fitted pins or bolts shall be used if exact positioning is required.

iii. The location and arrangement of field splices shall be such that they do not affect integrity, rigidity, function or alignment of the structure. Field splices shall be located as far as possible away from highly stressed areas and shall not be made in main girders.

iv. Field welded splices shall not be used where distortions due to welding might affect finished tolerance requirements. Chamfering and other preparation for field welding shall be completed in the shop. Backing cover plates shall be provided for temporary connection during shop assembly and field welding.

v. Exact relative position and alignment of members to be connected by field splicing shall be established by shop-reamed dowels, fitted polls or closely fitted shear lugs, so that field alignment work is required at the connection. The strength, quality and arrangement of such dowels, bolts or lugs shall be proportional to the member size and adequate for their purpose.

Stress relieving: The Contractor shall stress relieve all parts which are to be heat treated. Drain holes: Drain holes or other openings of suitable size, quantity and location shall be provided to ensure effective drainage of all water accumulated from submergence or weather conditions.

18.11.2 Sealing System

a. General: Each gate unit shall be provided with a sealing system consisting of seals mounted on the gate and seal plates embedded in the concrete structures. Seals shall not be mounted on embedded parts. The sealing system for fixed wheel gates shall consist of side, bottom and top seals. The scaling system shall be continuous providing a tight closed scaling line without gaps when the gate is closed.
b. Seal plates: The scaling surface on the seal plates shall be arranged as shown on the Drawings included in the Contract.

Seal plates shall be of adequate width to ensure the seals remain on seal plates under all possible working conditions. These working conditions shall consider the most unfavorable combinations of all factors causing relative position change including the following:

The contact width of the expanded rubber seal when compressed by maximum load.

The extreme lateral positions of the gate as limited by actual clearances.

The most unfavorable manufacturing and erection tolerances

Deformation or deflection of structures

Thermal expansion effects

Seal Profiles: Seals shall be of the following profiles, as specified:

i. Wedge type seals: Wedge type seals shall be without cladding and shall have a rectangular profile with chamfers as required.

- J-Type Seals: J-type (music note type) seals shall be with fluro-carbon cladding.
- Gaskets: Gaskets shall be flat or of some other profile suitable for their function.
- Seal Arrangement and Mounting
- J-Type Seals:

J-type seals shall be arranged to have a positive initial pre compression when the gate is closed. Mountings shall provide adequate freedom of movement for seal deflection.

Seals shall be seated on seal sealing bars and held in place by clamp bars bolted to the gate Seal seating bars shall be continuous within each section. Clamp bars shall be arranged in sections ending at corners. Clamp bars shall be fastened with CRES bolts, nuts and washers. The splices of clamp bars shall overlap all seal splices by at least 4 in.

ii. Wedge Type Seals

Wedge type seals shall seal by expansion of the edge of their profile when the seal is compressed due to the gate weight or water load.

Wedge type seals shall be seated on the gate skin plates or seal scaling bars, and clamped as specified for J-type seals.

Corners where seals of the same type of profile are connected shall be moulded with one piece. Corners where wedge type seals are connected to J-type seals shall be overlapped and cemented.

iii. Seal Splices

- Seal lengths: Seals shall be furnished in sections as long as feasible. Each section shall have minimum 6 in. of excess length of field splices for final trimming of the seal end in the field.
- Shop splices: All splices other than those specified herein as field splices shall be connected in Contractor's shop.
- Field splices: Connections between it lower corner block and either side seal or a bottom seal, shall be field spliced.

18.11.3 Guiding System

General: The guiding system shall perform one or more of the following:-

- When the gate is handled above the working area, the guiding system shall ensure that the gate is in the required position and shall correctly engage the frame when lowered.
- When the gate is handled in its working area the guiding system shall ensure that the gate remains engaged with the frame.

Guide plates and guide rails

- Guide plates shall be used for restricting the gate in one or two directions per plate. Guide rails shall be used for restricting the gate in two or three directions per rail. Guide rails and guide plates shall be part of the embedded parts.
- Geometry, clearances and contact areas in the guiding system shall be established according to the requirements shown on the Drawings included in the Contract.

- When defining the extreme positions of the gate for geometric layouts, the most unfavorable combination of all possible effects, such as shills to clearances, tolerances, deformations and expansions shall be considered.

18.11.4 Gate Accessories

a) Lifting lugs: Two lifting lugs shall be provided on each gate for hoist connection.

b) Handling eyes: permanent handling eyes shall be provided on gates for attachments to lift the gates vertically for handling during manufacture, erection and maintenance.

c) Dogging devices: Gates shall be provided with dogging devices to hold them in maintenance position at the top of the slots.

d) Ballast: Ballast, if necessary, shall be confined within the structure, without protrusions.

e) Access ladders, hoisting deck and railing: Access ladders, hoisting deck and railing shall be provided for each gate.

f) Frame: A complete frame shall include one sill beam, two side seal plates (including side seal bearing plates and guide rails). One lintel shall be included in the frame for fixed wheel gate. Each set of embedded parts supplied and installed by the Contractor in first and second stage concrete are explained herein.

18.11.5 System for Alignment and Anchorage of Embedded Parts

All embedded parts shall be set in blackouts and aligned with studs field welded to welding pads embedded in first stage concrete.

The embedded parts shall be reasonably smooth, true to form and free from twists, warps and kinks, so that they may readily be brought within erection tolerance and straightness requirements.

The system for alignment and anchorage shall include the following:

a) Alignment studs with two nuts and two oversized washers.

b) Erection brackets shall be shop welded to the embedded parts or frames wherever required. The brackets shall be arranged to provide the following:

- Ease of placing the embedded part of the studs already welded to welding pads.
- Convenient access for adjusting and tightening of all nuts.
- Strong and rigid holding in position during placement of second stage concrete.

Welding pads embedded in first stage concrete shall be located so as to provide a minimum 4 in. distance between the construction joint and the nearest edge of the welding pad.

18.11.6 Hoisting Machinery

Electrically operated wire rope and drum type hoists with provision of manual operation shall be installed at fixed wheel gates.

18.11.7 Embedded Parts for Gate Equipment

a. General: Embedded parts of the equipment shall include all the metal parts which are to be embedded in first stage or second stage concrete or otherwise permanently attached to the civil structure frame shall also include slot corner protection angles.

Appurtenances: Appurtenances shall include embedded bearing plates, seating plates for installing hoisting machinery, platforms, dogging devices etc.

(b) Side seal bearing plates, guide plates and rails: The side seal bearing plates, guide plates and rails shall be of CRES. Splices shall be avoided on side seal bearing plates if possible. If splices cannot be avoided because of transportation limitations, the seal bearing plates shall be spliced by field welding and grinding. Field splices on corners between different seal bearing plates shall also be spliced by field welding and grinding.

The side seal bearing plates shall extend from the sill heart to the top of the gate. The top of the side seal bearing plates, guide plates and rails shall be tapered to ensure safe and correct engagement of the seals and guide rollers when the gate is lowered.

18.12 Nameplate

The equipment items shall be provided with nameplates, written in English, suitably engraved, weather resistant, containing operating instructions, warnings, or other information essential to the proper use of the equipment. Information on these nameplates shall include rated capacity of fitting hooks and lifting lugs or pins, required for lowering and raising the gate.

All nameplates shall be permanently attached to the respective parts, components or equipment items in clearly visible locations.

18.13 Miscellaneous Equipment Details

The following stipulations referring to miscellaneous design details shall be applied to all equipment covered by these documents.

18.13.1 Locking of Bolted connections

All screws bolts and nuts shall be provided with a locking device.

18.13.2 Handling Provision

All parts components and assemblies which are heavier than 33 lbs or as approved by the Engineer, shall be provided with suitable provisions for handling, such as eyebolts lugs, hooks, tapped holes fur eyebolts or holes with rounded corners fur passing slings.

18.14 Gate Equipment Details

18.14.1 Skin-plate Structure

For fixed wheel, the gate shall be of welded construction and consist of downstream skin plate strengthened by horizontal and vertical stiffener plates all of ASTM-A36. Wheel axles shall be attached to end vertical stiffener plates by means of locking plates. Wheels shall move on downstream stainless steel/CRES rails. Special care shall be exercised in the fabrication of all parts affecting the strength, rigidity and water tightness of the gate. Unless otherwise specified herein or shown on the Drawings, all connections shall be welded.

Each gate leaf shall be completely assembled in the shop and be free of twists, bends and open joints. Pockets or depressions that may hold water shall be provided with effective drains. Connections between structural members for the gate leaf shall have continuous welds designed to develop full strength of the members. Sections of skin-plate shall be connected by continuous welding all around.

18.14.2 Wheels and Axles

Each gate shall be provided with fixed wheels of material conforming to ASTM-A743. The wheel rims shall be heat treated to a minimum BHN of 225. Wheel shafts shall conform to the material of ASTM A564, Type 630.

Holes in the wheel axles shall be bored and counter bored in pairs to common axis after the gate's leaf is fully fabricated. The accuracy of locating and boring holes shall be such that the axis of the completed

hole will be perpendicular to the vertical centerline of the gate and lie into common plane which shall be parallel to the skin-plate surface of the gate within a tolerance of plus or minus 0.060 in. Wheels on the same side of the gate shall be in a common plane through the laid-point of the wheel treads within a tolerance of + or -0.006 in. and such plane shall be parallel to the corresponding plane through the wheels on the other side of the gale.

The bushings of the gate wheels shall be self-lubricating / Laborite bushings, suitable for use in canal water.

18.14.3 Seals

J-type side and top rubber seals with fluoro-carbon cladding shall be attached to gate skin plate on downstream side with CRES holding plates and CRES bolts, nuts and washers. Sill seal shall be compression type attached to bottom of gate with CRES holding plates and CRES bolts, nuts and washers. Side and sill seals shall bear against stainless steel/CRES bearing surfaces. Sill beam steel strip and side and top seal bearing plates shall have hardness not less than 150 BHN. Joints in rubber seal shall be kept to a minimum in number. Holes in seals and gate skin plates will be drilled in the workshop. After match marking, the seals will be attached to gates in the field. Complete leak proof seal corner blocks shall be provided.

18.14.4 Embedded Parts

a. Fixed wheel gates: The fixed wheel gate shall be provided with one set of embedded parts which shall include sill beam, stainless steel/CRES seal bearing plates, guide rails, welding pads embedded in first stage concrete and alignment studs with nuts and washers. The guide rail material shall conform to ASTM-A240 and will have hardness not less than 275 BHN. The guide rails shall extend from sill beam to top of the piers and side seal bearing plates shall extend from sill beam to 1 ft. above the top of fixed wheel gate. The top edge of guide rails and side seal bearing plates shall be tapered.

Fixed wheel gate side slots will act as guides for the gate. The width of the slots shall be such that it will provide ample clearance for gate movement and at the same time it will not allow the wheel collars to come out of rails. The rails shall also act as guides for gate wheels and will restrict the lateral movement of the gate.

a) Stop logs: Each set of embedded parts for stop logs shall consist of two side seal bearing and guide plates and one sill beam, all of corrosion resisting steel. The guide plates shall extend from the sill beam to the top of the waterway. The side seal bearing plates shall extend from sill beam to 1 ft above the top of stop log (with all the stop log sections lowered in position) and their top edges shall be tapered to avoid damage to side seals when stop logs are lowered. The embedded parts shall be installed in the block outs and adjusted by means of alignment studs attached to welding pads embedded in first stage concrete. After the alignment of the embedded parts, the block outs shall be filled with concrete.

18.14.5 Electric Motor Operated Hoist

The electric hoist actuator shall include the motor, operator unit gearing, limit switch gearing, limit switches, torque switches, declutch lever or knob, mechanical dial position indicator and auxiliary hand wheel as a self-contained unit, shall be provided for the gate operation. Each gate shall have independent local control panel. The hoisting arrangement shown on the Drawings is indicative only. The Contractor shall start fabrication alter approval of the Engineer. The hoist shall consist of the following equipment:

a. Worm-gear reducers: The worm-gear reducers shall be standard, high-grade reduction units suitable for the service intended, and the proportioning of all parts therein shall be in accordance with the best engineering practice. Either cylindrical or double envelope-

type worm-gear reducers will be acceptable. The reducers shall be standard, regularly produced commercial units, manufactured in accordance with standard practice for heavy duty worm-gear, speed reducers. The worm-gear shaft shall extend through the housing on one end for the attachment of flexible coupling and on other end for fixing of motor assembly and also handle for manual operation of the gate. Keyways shall be cut to suit all flexible couplings. Worm shaft and gear shaft openings shall be provided with seals or packing glands. The gear reduction ratio shall be selected such that one man effort will be required to lift the gate manually. The minimum output torque rating shall be less than the torque required to lift the gate at a speed of 0.060 in. per revolution of handle.

b. Drums and ropes: Drums shall be of fabricated construction or cast steel. Drum diameter shall not be less than 20 times the rope diameter. When assembled, the shafts and drums shall have a common horizontal axis. Each drum shall be supported by grease lubricated, self-aligning, roller bearings and pillow blocks mounted from a common base plate. Drums shall be accurately machined and keyed properly to the shafts. Drums shall have sufficient grooves to provide two dead-wraps of the rope on them when the gate is fully closed. Drums shall be equipped with integral cable clamps. Rope shall be standard hoisting wire rope made of plow steel, galvanized, non-preformed and regular lay. Rope size shall be selected according to the loading. Provision for adjusting the length of one of the two ropes in each hoist shall be made. The ends of the wire rope shall be hoisted with wire role fittings for connection to the gate. Dust covers shall be constructed of 16 gauge sheets steel. One intermediate shaft support containing a split habited bearing shall be provided between each drums and gear reduction unit.

c. Drive shafts: The lengths of the drive shafts will depend upon the length of the worm-gear output shall and shall be such that when the hoist is completely assembled with proper clearances between the faces of the halves of the flexible couplings, the distance between the drums shall be according to manufacturer's instructions or as approved by Engineer.

d. Flexible couplings: The flexible couplings shall be fully enclosed, dustproof, geared type, all shall be bored for tight fits of the shafts and shall be fitted accurately to the shafts, shall be of the size rated for the shafts they connect and shall have torque ratings suitable for the load transmitted. The flexible couplings shall be designed for oil or grease lubrication, and shall be all metallic except that oil or grease seals may be of suitable non-metallic material.

e. Lubricating fittings: Lubricating fittings shall be provided for parts needing lubrication.

f. Bearings and bearing blocks: Bearings and bearing blocks shall be of standard well known manufacturer like SKF or other equivalent known make.

g. Shafting: Shafting shall have provision for longitudinal movement. Lateral shaft deflections shall not be more than 0.01 in. per foot length of shaft and angular shaft deflection shall not exceed 0.08 deg. per foot.

18.14.6 Hoisting/Operating Deck

Hoisting/operating deck shall be furnished for the gate to support the gate and all hoist loads. The hoisting deck shall consist of structural steel framework and chequered plate flooring. Before being laid out, all structural steel components shall be straight and free from kinks and bends. All working surfaces shall be finished neatly. Connections between adjoining members shall be welded or bolted. Holes for bolts shall be accurately located and drilled 0.060 in. larger than the nominal size of the bolts. When placed in the structure, the length of bolt shall extend at least 0.25 in. beyond the nuts. Washers shall be used with all bolts. Beveled washers shall be used on sloping member.

18.14.7 Gate Position Indicator and Gate Locking Arrangement

A gate position indicator shall be provided and installed with the gate so that operator while working on the hoist can easily see and read the position of the gate. Gate position shall be indicated by a pointer on a 12 in. diameter circular graduated scale. The Contractor shall design and provide required mechanism of speed reduction so that total travel of the gate can be calibrated on the scale. The Contractor shall also be required to provide a device to lock the gate at any position.

18.15 Painting

18.15.1 Scope

The Contractor shall furnish and apply all paint as specified herein, before packing and transportation, with the exception of those parts or surfaces that are expressly designated as unpainted. Surfaces to be painted shall receive the preparatory treatment and number of coats prescribed. The applicable provisions of the SSPC shall apply unless specifically covered otherwise in this clause.

18.15.2 Standard products

All materials, supplies, and articles furnished shall be the standard products of recognized and reputable manufacturers.

18.15.3 Surface Preparation

a. Cleaning and preparation of surfaces shall be as specified herein in Clause 17.12.

b. Surfaces to be painted shall be cleaned before applying paint or surface treatment in accordance with SSPC SP10. "Near White Blast Cleaning".

c. Surface preparation and paint application shall be done after the parts are completely finished and checked in shop assembly.

18.15.4 Colors

Colors shall be as directed. Alternate coats of paints having the same color shall be tinted in order to ensure that all surfaces are properly coated with the specified number of paint coats. Unless otherwise specified, the color of all undercoats shall be different to the color of the finish paint.

18.15.5 Equipment, submerged

All equipment that is regularly submerged, for example the upstream side of gates will be coated as follows:

Corrosion resistant materials, for example stainless steel and wood, will not be coated All other parts will be coated as follows;

One coat of zinc rich epoxy primer, dry film thickness (DFT) > 60 µm

Two coats of high build epoxy paint of a coal tar replacement type, formulated for marine applications, each coat to have a DFT > 150 µm

18.15.6 Equipment, exposed to sunlight

Equipment that is exposed to sunlight and weather, for example the downstream side of gates will be protected as follows:

Corrosion resistant materials, for example stainless steel and wood, will not be coated

All other parts will be coated as follows;

One coat of zinc rich epoxy primer, dry films thickness (DFT) > 60 µm

One coats of high build epoxy paint of a coal tar replacement type suitable for marine applications, with a DFT > 150 µm

One finish coat of acrylic polyurethane based paint, formulated for marine applications, with a DFT > 60 µm.

18.15.7 Equipment, not wetted

Corrosion resistant materials, for example stainless steel and wood, will not be coated Non-wetted equipment such as hoists, walkways and so on will be coated as follows; One coat of micaceous iron oxide primer, dry film thickness (DFT) > 40 µm

18.16 Shop Assembly and Tests

18.16.1 General

All shop assemblies and tests specified below for the various items of equipment will be witnessed by the Engineer and the completed shop inspection reports shall be signed by him. Copies of all shop inspection records shall be furnished to the Engineer. No equipment shall be transported to Site until it has been inspected. Prior to major shop assemblies and tests, the Contractor shall submit an outline of the procedures and tests he plans to perform to demonstrate fulfillment of the requirements of the Drawings. While assembled, each item of equipment shall be checked for dimensions, tolerances and accuracy of alignment. Any errors and misalignments discovered shall be corrected. Before disassembling and after installation of dowels and fitted bolts between bolted subassemblies, all parts shall be clearly match marked.

18.16.2 Gates

Each finished and painted gate including seals, wheels, hoists and all other applicable accessories shall be completely shop assembled. All field splices shall be assembled. Welded field splices shall be temporarily bolted for shop assembly.

All seals shall be fitted to their supports during the shop assembly and proper allowances shall be made for shrinkage after aging. Seal sections which are furnished in excess lengths for field splicing shall be mounted successively.

18.17 Installation

18.17.1 Installation of Embedded Parts

Each set of embedded parts shall be assembled in its blackout, brought to line and grade within the applicable tolerances and firmly secured in place on the alignment studs. The alignment studs shall be located with care so that no subsequent bending or forcing is required to match them with the corresponding holes in the frame and guide members. The alignment studs shall then be welded to the embedded welding pads. Alignment studs shall be adjusted and firmly tightened to hold the frames and guides securely in position while concrete is being placed in the blackouts. Additional bracing shall be provided where necessary to ensure the required alignment. Extreme care shall be taken to ensure that the guiding, bearing and sealing surfaces are within the tolerances specified throughout their entire length.

Placement of concrete in blackouts shall proceed until the frames and guides have been completely assembled, cleaned of dirt, aligned, and secured at least throughout the height of the openings. The use of the gates as a support or brace for the guides during placement of concrete shall not be permitted. Caution shall be exercised in placing the concrete to avoid distortion and displacement of the frames and guides. Before placing the concrete in any one lift and between placements of successive fills alignment tolerances shall be checked and remedial action shall be taken. Suitable windows shall be provided in the concrete forms to facilitate concrete placement and inspection. After all blackout concrete has been placed and forms removed, the blackout concrete will be inspected and the embedded parts will be

sounded to detect any voids. All voids shall be filled by pressure grouting. No grout holes shall be drilled in the sealing or bearing surfaces.

The tolerances specified in Clause 18.11.7 shall be met during installation of embedded parts for gates and stop logs.

18.17.2 Installation of Fixed Wheel Gates

The fixed wheel gates shall be installed as shown on the Drawings. The bottom of the gate when erected shall be in true alignment to ensure a tight even bearing of the rubber seal on the embedded sill beams. The sides and top of the gate shall be in true alignment so that the seal when installed shall have a tight and even bearing on the embedded sealing surfaces. The rubber seals shall be installed after the gate has been painted. The wheels on fixed wheel gates shall be properly and truly aligned keeping in view the proper deflection of the side seals.

1) Installation of gate hoists: Each gate hoist equipment complete with all accessories shall be assembled and installed as shown in the Drawings.

2) Installation or deck and access ladder: All hoisting/operating decks, and access ladder parts shall be accurately assembled and erected as shown on the Drawings, and all snatch marks shall be accurately followed.

18.18 Inspection and Testing

18.18.1 General

a. All equipment, apparatus, material and supplies forming part of the equipment shall be subjected to inspection and tests at the plant of the Contractor in conformity to the requirements of the specifications. For site testing of the equipment, the method and procedure of the inspection and tests shall be as specified for the particular items or in conformity with one of the applicable recognized standards for making such inspections and tests or as approved by the Engineer. After being assembled by the Contractor in place at Site, each complete machine or structural unit shall be operated through a sufficient number of complete cycles to demonstrate to the satisfaction of the Engineer that it meets the requirements of the Specification in all respects and is suitable for performing the work intended. Site tests shall be conducted under the supervision of the Engineer. The Contractor shall submit a schedule of the specified testing program to the Engineer for approval. Testing of related equipment shall be coordinated so that testing may proceed with a minimum of delay. Site tests shall start, proceed, stop and be resumed in accordance with the approved schedule and as directed by the Engineer.

b. Remedy of defects: Defects disclosed during trial operations and tests shall be remedied. The Contractor shall stop work and shall notify the Engineer immediately when any defect is disclosed so that alternate assessment may be made as to where the responsibility for the defect lies, and so as to permit the recording of necessary data as to the extent of delay and the additional costs of work, labour and material required for remedy of the defect. After defects in equipment have been remedied, the equipment shall be subjected to such retesting as may be necessary to demonstrate satisfactory operation.

c. Tests: After the installation of each system or item of the equipment and the system in which it operates, including testing and adjusting as outlined above, has been completed, the equipment and system shall be given commissioning tests as specified for the respective item of the equipment. During the final acceptance test, the equipment shall he placed in service under normal operating conditions, and fully loaded where possible. Commissioning and final acceptance tests will be witnessed by the Engineer.

d. Records and reports: Records of all tests shall be kept by the Contractor. All test reports shall be signed by the Contractor and shall be in the format approved by the Engineer. When approved by

the Engineer, five (5) copies of the test reports shall he submitted by the Contractor to the Engineer. All site test reports will be combined into one comprehensive report to he prepared by the Contractor.

e. Test equipment, materials and labour: Except as otherwise specified, all plant, test equipment, materials and labour required for the performance of tests shall be furnished by the Contractor.

18.18.2 Site Stage Tests

From time to time at various stages of installation, tests of sub-assemblies of' the equipment as instructed by the Engineer will be carried out by the Contractor. The Contractor will conduct such tests, make records of all measurements, as instructed and advised by the Engineer and make good corrections or adjustments. A record of all stage tests shall be embodied in a report.

18.18.3 Performance Tests

a. Commissioning tests: Once equipment has been installed and checked for normal operation, commissioning tests shall be conducted to prove that all parts have been accurately assembled and are operating correctly to meet the requirement of the Contract.

b. Testing of fixed wheel gates: Each fixed wheel gate shall be operated in its respective slot through a sufficient number of complete cycles to ensure that it is suitable for performing its intended function. Minor adjustments necessary to achieve the above shall he made where required. All joints and connections in the gate and sealing surfaces, which are field welded and where leakage may occur, shall be tested for water tightness prior to field painting. The gates and their embedded parts shall be thoroughly cleaned of all foreign material, with particular attention being paid to bearing and sealing surfaces, and the paint repaired where necessary.

c. Testing of gate hoists: After installation, the hoisting equipment shall be tested for proper operation and adjusted if required. Each gate shall be operated through a number of complete cycles and gate position indicators shall be tested for proper operation. Any defects and improper operation discovered during the tests shall be corrected by the Contractor and the same tests repeated. All instrumentation and test equipment required for tests shall he furnished by the Contractor.

d. Final acceptance tests: After the entire equipment of a project feature has been completely assembled at the Site and placed in satisfactory operation, it shall be tested at or near full head by the Contractor to determine whether or not the requirements of the Contract have been fulfilled.

18.19 Equipment Parameters

The dimensions of all gate equipment’s shall be according to the parameters specified in the Drawings included in the Contract.

19 Instrumentation

19.1 General

The Contractor shall provide, install, test and commission the following instrumentation equipment as specified and shown on the Drawings:

a) Water level meter;

b) Flow measuring weirs and flumes; and

c) Water level boards.

19.2 Design

The Drawings indicate generally the layout of equipment required. The equipment shall be designed for a minimum useful life of twenty years.

The Contractor shall be responsible for the satisfactory quality, design and workmanship of all equipment whether manufactured by him or supplied to him by other manufacturers.

19.3 Installation

The Contractor shall install the instrumentation equipment strictly in accordance with the manufacturer's instructions. Installation of the instrumentation shall be carried out by a technician well experienced in such work. Details of this experience shall be submitted to the Engineer for his approval.

At least 60 days prior to planned installation, the Contractor shall submit to the Engineer for approval six copies of instructions detailing the proposed method of installation and site testing for each item of instrumentation equipment to be supplied under the Contract. Once the equipment has been installed and tested and the trenches have been backfilled and the embankment placing continued, connecting tubes and cables cannot be attended to again.

19.4 Operation and Maintenance Instructions

Instructions in English for operating and maintaining the equipment shall be provided by the Contractor. The Contractor shall prepare a draft of the instructions for the approval of the Engineer and, after approval, shall supply complete sets in accordance with Clause 1.38.

19.5 Water Level Meter

Water level meters shall be installed at the locations shown on the Drawings.

19.6 Flow Measuring Weirs and Flumes

Flow measuring devices shall be installed at the locations shown on the Drawings.

19.7 Water Level Boards

Water level boards shall be fabricated and fixed in accordance with the Drawings. Generally water level boards shall be installed upstream of any location where water measurement is required including:

- Fall structures, head regulators and cross regulators on the main and branch canals;
- Measuring weirs and flumes on the distributary and minor canals; and
- Elsewhere as shown on the drawings.

20 Steel Sheet Piling

20.1 Scope of Work

The item shall consist of furnishing, transport, driving, cutting off, steel sheet piles including but not limited to all material, labour, equipment, tools, plants, bolts, bracings and incidental necessary to complete the item in accordance with the Drawings, or as instructed by the Engineer for cofferdams in connection with foundations for structures.

20.2 Sheet Pile Cut off

The layout of the mild steel sheet piled cut-offs under the structures is given on the Drawings. Piles shall be driven with their clutches engaged for the full length and any indication that a pile has become bent or a clutch has become disengaged shall require the immediate withdrawal of the piles concerned. Junction piles shall be provided at all points shown on the Drawings or where rows of piles meet and shall be the same length as the longer of the rows joined. Taper piles shall be used where necessary, but their use shall be kept to a minimum; and if used they shall be of a steel which is suitable for welding or riveting. Piles shall normally be driven in pairs.

20.3 Steel Sheet Piles

If the piles shown on the Drawings are not easily available the Engineer may allow to use piles of other varieties, with similar cross-sections, moments of inertia and the quality of the steel is in accordance with the Specification, and that the nominal thickness of the metal is nowhere less than 0.50 inch, and that the interlocks can be made watertight. The minus tolerance on pile thickness shall not exceed 2½ %.

20.4 Coating of Interlocks

Prior to being driven the piles shall receive two coats of "Noah's Pitch" or filled with an approved no setting cold applied bituminous material of such a consistency that it does not run or flow and it can be easily applied into the interlocks. Steel plates shall be welded at the bottom of female interlocks of piles to prevent soil from pushing out the "Noah's Pitch", etc., during driving; also over handling holes after driving to prevent leakage.

20.5 Driving of Piles

The piles shall be driven vertically to the alignment shown on the Drawings to true lines and even planes and to the levels indicated. Deviations shall not be greater than 3 inches from the alignment shown on the Drawings and one degree (1°) from the vertical plane but junction piles shall be correctly located to within 1 inch. Should there be any defect in the horizontal or vertical alignment of the piling, or should a break through any cause whatsoever occur or be suspected to have occurred in the continuity of the piling, the Contractor shall withdraw such pile or piles, whether defective or otherwise and drive such further piles as may be necessary to remedy the defect or suspected defect. Should any distortion, creep, or fanning occur in the line of the piling, the Contractor shall take steps to rectify the defect and shall where necessary supply and drive suitably tapered piles.

20.6 Permission for Jetting

The Contractor shall be at liberty to jet the piles if he wishes, but care shall be taken to ensure that the jetting does not loosen the soil below the feet of the piles, and for the last 3 ft the piles shall be driven without jetting.

20.7 Bitumastic Coating and Protective Cover

Piles, walling, etc., embedded in or adjoining concrete, which may settle differentially to the piles, shall be coated with approved bitumen over the area embedded, and shall have a 2 inches thick pad of expanded polystyrene on top to permit movement of the concrete, a suitable protective cover being provided over it to prevent it being crushed by the first lift of concrete and handling holes shall be plugged to prevent hind.

21 Roads

21.1 Surfacing of Roads

21.1.1 Scope of Work

The work to be done under Surfacing of Roads consists of constructing asphaltic wearing course for metalling such roadways as shown on the Drawings or as directed by the Engineer. The asphaltic wearing course shall consist of a 2-inch thick bituminous mat of mineral aggregates and asphaltic material. The operations in constructing the asphaltic wearing course shall include but not be limited to supply of material, transport, mixing, placing, spreading and compacting the bituminous mat of mineral aggregates and asphaltic material on the designated areas and all incidental work required for surfacing of roadways in accordance with the Contract Documents and the Engineer's instructions.

21.1.2 Materials

The Contractor shall furnish all materials for the complete construction of the asphaltic wearing coat including liquid asphaltic materials for prime coat, bituminous mat and mineral aggregates. The materials to be used in surfacing of roadways shall conform to the following requirements:

1) Liquid asphaltic materials shall be cut-back asphalt, medium curing type (MC), and shall be provided in the proper grades for its intended use.

2) Mineral aggregates used for metalling of roadways shall consist of sand and aggregates furnished by the Contractor in accordance with the provisions of, and in complete conformity with the stipulations and requirements for sand and aggregates specified in Chapter "Concrete". The Contractor will be required to blend the required quantity of sand and aggregates to produce mineral aggregates with the following gradation properties:

Table 21-1: Mineral Aggregates Grading for Roads

Screen size designation	Percent by weight passin sieve
1 inch	100
3/4 inch	95 to 100
3/8 inch	60 to 80
No. 4	50 to 60
No 8	25 to 45
No 50	5 to 25
No 200	2 to 10

All screens used for gradation test shall be woven wire cloth sieves conforming to the requirements of BS 812, with respect to permissible variations in average openings.

21.1.3 Construction Methods

After having been cleaned of any foreign material and prepared, prime coats shall be applied prior to the placement of the bituminous mat as approved by the Engineer. The prime coat shall be applied over the areas designated on the Drawings or directed by the Engineer. The application temperature shall be in conformity with the application range for the grade of asphaltic material being used. The prime coat shall be applied in one application at the approximate rate of 1.06 lbs of kerosene oil mixed with 0.10 lbs of binder per square foot of the surface area.

After the liquid asphalt has penetrated the surface, the treated area shall be covered where necessary with sand or other granular material in sufficient quantity to absorb any excess of asphalt remaining on the surface. The bituminous mat shall not be placed on tap of the primed base until authorized by the Engineer. Prior to the placement of the mat, the primed base shall be broomed and thoroughly cleaned of all extraneous material.

After the completion of the prime coat and when the quantity of asphaltic material to be mixed with the mineral aggregates (as per design submitted by Contractor and approved by the Engineer), the bituminous mat shall be prepared by mixing the mineral aggregate with the required quantity of asphaltic material on the primed base course or by other means and methods approved by the Engineer. The Contractor shall mix the mineral aggregates and asphaltic material until a product of uniform colour and consistency is produced. The asphaltic material shall be applied uniformly and under pressure and at the specified temperature. The bituminous mat materials, with or without additive, shall have a moisture content of two percent or less by weight at time of laying. After the asphaltic material and mineral aggregates have been prepared as described above, the bituminous mat shall be spread to a uniform thickness at the required locations and be compacted until the surface is smooth, firm and of the density specified by the Engineer.

Rolling shall proceed longitudinally starting at the edges of the material and progressing toward the centre and shall be performed immediately after the material has been spread. On completion of the rolling

operation the bituminous mat shall be true to the section shown on the Drawings, smooth, and free from humps, depressions or irregularities. When a straight edge 10 feet long is laid on the finished surface of the bituminous mat, the surface shall not vary more than one quarter inch from the lower edge of the straight edge in any place. Should the bituminous mat show an excess or deficiency of asphaltic material or uneven distribution thereof due to insufficient mixing or other causes, after the mat is laid, the condition shall be corrected by thorough scarifying of the mixed material; adding surfacing or asphalt as required; and spreading and compacting until a bituminous mat satisfactory to the Engineer has been produced.

21.2 Construction of Metal led Roads

21.2.1 Granular Sub base and Sub grade

This item shall consist of furnishing, spreading on prepared Sub grade in one or more layers and compacting granular sub base according to the specifications and Drawings and/or as directed by the Engineer. Before laying of sub base the sub grade shall be prepared and compacted to the density not less than 95% of laboratory dry density as determined by AASHTO T-180.

21.2.2 Material Requirements

Granular sub base material shall consist of natural or processed aggregates such as gravel, sand or stone fragment and shall be clean and free from dirt, organic matter and other deleterious substances, and shall be of such nature that it can be compacted readily under watering and rolling to form a firm stable sub base.

The material shall comply with the following grading and quality equipment:

a) The sub base material shall have a gradation curve within the limits for grading A, B and C given below. However grading A may be allowed by the Engineer in special circumstances.

Table 21-2: Grading Requirements for Sub base Material

Sieve Designation	Alternate	Percent Passing by Mass		
		A	B	C
60.0	2 ½ inch	100	-	-
50.0	2 inch	90-100	100	-
25.0	1 inch	50-80	55-85	100
9.5	3/8 inch	-	40-70	50-85
4.75	No. 4	35-70	30-60	35-65
2.0	No. 10	-	20-50	25-50
0.425	No 40	-	10-30	15-30
0.075	No 200	5-15	5-15	5-15

The Coefficient of Uniformity D60/D10 shall be not less than 3, where D60 and D10 are the particle diameters corresponding to 60% and 10% respectively, passing (by weight) in a grain size analysis, curve.

a) The Material shall have a CBR value of at least 30%, determined according to AASHTO T-193. The CBR value shall be obtained at a density corresponding to Ninety eight (98) percent of the maximum dry density determined according to AASHTO T-180 Method-D.

b) The coarse aggregate material retained on sieve No.4 shall have a percentage of wear by the Los Angeles Abrasion (AASHTO T-96) <d' not more than fifty (50) percent.

c) In order to avoid intrusion of silty and clayey material from the sub grade in sub base, the ratio D_{15} (Sub base)/D_{85} (Sub grade) should be less than 5.

d) Where D_{85} and D_{15} are the particle diameters corresponding to eighty five (85)% and fifteen (15)%, respectively, passing (by weight) in a grain size analysis, curve.

e) The fraction passing the 0.002 inch or 0.075mm (No.200) sieve shall not be greater than two third of the fraction passing the 0.425mm (No.40) sieve. The fraction passing the 0.017 inch or 0.425mm sieve shall have a liquid limit of not greater than 25 and a plasticity index of 6 or less.

21.2.3 Construction Requirements

Granular sub base shall be spread on approved sub grade layer as a uniform mixture. Segregation shall be avoided during spreading and the final compacted layer shall be free from concentration of course or lime materials.

Granular sub base shall be deposited on the roadbed or shoulders in a quantity which will provide the required compacted thickness without resorting to spotting, picking up or otherwise shilling the sub base material.

When the required thickness is 6 inches or less, the aggregates may be spread and compacted as one layer, but in no case shall a layer be less than 3 inches thick. Where the required thickness is more than 6 inches, the aggregates shall be spread and compacted in 2 or more layers of approximately equal thickness, but in any case the maximum compacted thickness of one layer shall not exceed 6 inches. All subsequent layers shall be spread and compacted in a similar manner.

Granular sub base shall be spread with equipment that will provide a uniform layer conforming to the specified item both transversely and longitudinally within the tolerances as specified in Standards or as approved by the Engineer. No hauling or placement of material will be permitted when, in the judgment of the Engineer, the weather or road conditions are such that the hauling operation will cause cutting or rutting of sub grade or contamination of sub base material.

21.2.4 Compaction

The moisture content of sub base material shall be adjusted prior to compaction by watering with approved sprinklers mounted on trucks or by drying out, as required, in order to obtain the specified compaction.

The sub base material shall be compacted by means of approved vibrating rollers or steel wheel rollers (rubber tired rollers may be used as a supplement), progressing gradually from the outside towards the center, except on super-elevated curves, where the rolling shall begin at the low side and progress to the high side. Each succeeding pass shall overlap the previous pass by at least one third of the roller width. While the rolling progresses, the entire surface- of each layer shall be properly shaped.

21.3 Aggregate Base Course

This item shall consist of furnishing, spreading and compacting one or more layers of aggregate base on a prepared, sub base, or existing road surface, in accordance with the Specification and the Drawings and/or as directed by the Engineer.

21.3.1 Material Requirements

Material for aggregate base course shall consist of crushed hard durable, gravel, rock or stone fragments. It shall be clean and free from organic matters, lumps of clay and other deleterious substances. The material shall be of such a nature that it can be compacted readily under watering and rolling to form a firm, stable base-for both flexible and rigid pavements.

The aggregate base shall comply with the following grading and quality requirements:

a. The gradation curve of the material shall be smooth and within the envelope limits for Grading A or B given below.

Table 21-3: Grading Requirements for Aggregate Base Material

Sieve Designation	Alternate	Percent Passing by Mass		
		A	B	C
50.0	2 ½ inch	100	-	-
25.0	1 inch	70-95	100	-
9.5	13/8 inch	30-65	55-85	100
4.75	No. 4	25-55	40-70	50-85
2.0	No. 10	15-40	30-60	35-65
0.425	No 40	8-20	20-50	25-50
0.075	No 200	2-8	10-30	15-30

The material shall be well graded such that the coefficient of Uniformity D_{60}/D_{10} shall be greater than four (4).

b. Crushed Aggregate (material retained on sieve No.4) shall consist of material of which at least ninety (90) percent by weight shall be crushed particles, having a minimum of two (2) fractured faces.

c. The Coarse aggregate shall have a percentage of wear by the Loss Angeles Abrasion test (AASHTO T-96) of not more than forty (40); if overplayed by triple surface treatment (TST) and forty five (45) if overplayed by Asphaltic concrete.

d. The material shall have a loss of less than twelve (12) percent when subjected to five cycles of the Sodium Sulphate Soundness test according to AASHTO T-104.

e. The sand equivalent determined according to AASHTO T-176 shall not be less than 50 or the material shall have a Liquid limit of not more than twenty five (25) and a plasticity Index of not more than 6 as determined by AASHTO T-89 and T-90.

f. The material passing the 19 mm sieve shall have a CBR value of a minimum eighty (80) percent, tested according to the AASHTO T-193. The CBR value shall be obtained at the maximum dry density determined according to AASHTO T-180, Method D.

g. (g)Laminated material shall not be allowed.

21.3.2 Filler for Blending

If filler, in addition to that naturally present in the aggregate base material is necessary for meeting the grading requirement or for satisfactory bonding of the material, it shall be uniformly blended with the base course material at the crushing plant or in a pug mill unless otherwise approved. The material for such purpose shall be obtained from sources approved by the Engineer. The material shall be free from organic matter, dirt, shale, clay and clay lump or other deleterious matter and shall conform to the following requirements:

Table 21-4: Filler for Blending

Criteria	Requirement
3/8 inch AASHTO	Sieve Percent Passing = 100
No 4 AASHTO Sieve	Percent passing = 85-100
Plasticity Index (AASHITO t-90)	6 maximum
Sand Equivalent (AASHTO t-176)	30 minimum

21.3.3 Construction Requirements

In case crushed aggregate base is to be laid over prepared sub base course, the sub base course shall not have loose material or moisture in excess of the optimum moisture content.

21.3.4 Compaction Requirement

The relative compaction of each layer of the compacted base shall not be less than 100 percent to the maximum dry density determined according to AASHTO T-180, Method D (Modified). The field density shall be determined according to AASHTO T-191 or other approved method. For all materials, the field density thus obtained shall be adjusted to account for oversize particles (retained on 19 mm sieve) as directed by the Engineer. Also for adjustment of any material retained on 4.75mm sieve, AASHTO Method T-224 shall be used.

Moisture content for calculation of field density shall be observed on material passing 4.75 mm sieve.

Completed base course shall be maintained inacceptable conditions at all times until prime coat is applied. When base course is to carry traffic for an indefinite length of time before receiving surfacing, the Contractor shall maintain the surface until final acceptance and shall prevent reveling by wetting, balding, rolling and addition of fines, which may be required to keep the base tightly hound and have a slight excess of material over the entire surface which must be removed and the surface finish restored before application of prime coat.

21.3.5 Tolerance

The completed base course shall be tested for required thickness and smoothness before acceptance. Any area having waves; irregularities in excess of 0.4 inches in 10 feet or 0.8 inches in 50 feet shall be corrected by scarifying the surface, adding approved material, reshaping, re-compacting and finishing as specified. Skin patching of an area without scarifying the surface to permit proper bonding of added material shall not be permitted. The allowable tolerances shall be according to the "Table for Allowable Tolerances" in these specifications.

21.3.6 Acceptance, Sampling and Testing

Acceptance of sampling and testing with respect to materials and construction requirements shall be governed by the relevant international standards or as approved by the Engineer.

21.4 Bituminous Surface Treatment and Seal Coat

This work shall consist of one or more applications of asphaltic material with sub grade covers of the aggregates or an application of asphaltic material applied in accordance to the specifications and in conformity with the lines shown on the Drawings or established by the Engineer.

21.4.1 Material Requirements

Aggregate shall consist of clean, dry, hard, durable, tough, angular, sound crushed stone or crushed gravel of uniform quality, and free from dirt, clay and other objectionable matter. The percentage of wear by the Los Angeles Abrasion test (AASHTO T-96) shall not be more than forty (40). When subjected to five (5) cycles of sodium-sulphate soundness testing as determined by AASHTO T-104, it shall have a weight

loss not greater than ten (10) percent. The moisture content in the aggregate applied directly to the surface of the bituminous material shall not exceed three (3) percent by weight plus one-half (1/2) the water absorption of the aggregate at the time of delivery to the Works.

The portion of aggregate retained on the 3/8 inch sieve shall not contain more than fifteen percent of particles by weight so flat or elongated, or both, that the ratio between the maximum and the minimum dimensions exceeds 5:1.

The nominal sizes of aggregates used for surface treatment; shown in the drawing shall be as under:

Size No.1 - Nominal size 18mm

Size No.2 - Nominal size 12mm

Size No.3 - Nominal size 9mm

Size No.4 - Nominal size 6mm

The percentage composition by weight of aggregate shall conform to the following gradations:

Table 21-5: Aggregates for Surface Treatment

Percent Passing Weight US Standard Sileve	Size No 1	Size No. 2	Size No. 3	Size No. 4
1	100	-	-	-
3/4" (19 mm)	90-100	100	-	-
1/2" (12.5 mm)	20-55	90-100	100	
3/8" (9.5 mm)	0-15	40-70	85-100	100
No.4 (4.75 mm)	0-5	0-15	10-30	85-100
No.8 (2.38 mm)	0	0-5	0-10	10-40
No.16 (1.18mm)	-	0	0-5	0-10
No.200 (0.075 mm)	-	-	0	0

21.4.2 Asphaltic Material

The type of asphaltic material shall be one of the following or as ordered by the Engineer.

Single surface treatment: AC 80-100, RC-250, RC-70, RS-1 or RS-2.

Double surface treatment: AC 80-100, RC-250, RS-1 or RS-2.

Triple surface treatment: AC 80-100, RC-250, RS-1 or RS-2

Seal Coat: RC-250, RS- 1 or RS-2

21.4.3 Construction Requirements

At the time of the application, the weather shall be warm and dry, and the road surface shall be clean and dry. Spraying shall not be done unless the road temperature is above twenty 20ºC during the spraying. Prior to applying the asphaltic material, dirt and other objectionable materials shall be removed from the

surface and surface shall be primed. If so directed by the Engineer, the surface shall be cleaned by power booming or wire brush until all loose and foreign material are removed.

21.4.4 Application of Asphaltic Materials

Asphalt cement, liquid asphalt and emulsified asphalts shall be applied by means of pressure distributor manual or automatic at the temperature specified for the type and grade of asphalt being used. The rates of application shall be within the ranges given herein clause 21.4.2.

The spread of bituminous materials shall not be more than 4 inches greater than the width covered by the aggregate from the spreading device. The distributor shall be moving at the proper application speed at the time the spray bar is opened. Any skipped areas or deficiencies shall be corrected in an approved manner. Junctions of spreads shall be carefully made to assure a smooth riding surface. The length of spread of bituminous material shall not exceed that which trucks loaded with cover coat material can immediately cover. Under no circumstances shall operations proceed to otherwise impair retention of the cover coat.

The distributor when not spreading shall be so designed that the spray bar or mechanism will nut drip bituminous material on the surface of the travelled way. Distribution of the bituminous material shall be so regulated and sufficient bituminous material left in the distributor at the end of each application so that there will be uniform distribution of bituminous material. In no case shall the distributor be allowed to expel air with the bituminous material thereby causing uneven coverage. The angle of the spray nozzles and the height of the spray bar shall be so adjusted and frequently checked that uniform distribution is assured. The distribution shall cease immediately upon any clogging or interference of any nozzle and corrective measures shall be taken before distribution is resumed.

21.4.5 Spreading of Aggregate

Immediately after applying the asphaltic material, dry aggregate shall be uniformly. and evenly distributed over the treated surface from an approved mechanical aggregate spreader or any other means approved by the Engineer. The truck carrying the aggregate shall move backward as it spreads same so as to prevent the tyres of the truck and the mechanical aggregate spreader from driving directly on the newly sprayed asphalt. No portion of the hinder shall remain uncovered for a period in excess of twenty (20) minutes after spraying.

Immediately after spreading of the aggregate, the treated surface shall be rolled with a self-propelled pneumatic-tyred roller having a minimum contact pressure of 2.8 kg/square centimeter. A steel-wheeled roller weighing, between six (6) to eight (8) tons may be used as a second roller. Rolling shall continue only until a smooth, thoroughly compacted surface is obtained. Procedures of starting, stopping, or turning of any piece of equipment which results in displacement of the cover material or damage to the seal courses shall be prohibited.

Any place where hinder shows on the surface shall be covered with additional aggregate and further rolled and broom dragged until an even surface results, and does not adhere to wheels of vehicles. Overlapping the applications of cover material shall be avoided and all spillage shall be removed from the surface.

The quantity of aggregates to be applied shall be within the ranges specified herein in the table and as shown in the Drawings.

21.4.6 Maintenance of Traffic

Diversion of highway traffic for this work will not be provided for or permitted; except when authorized by the Engineer. All construction operations shall be coordinated to result in the least practicable delay of traffic. One way traffic shall be maintained and traffic speeds restricted to 10 miles per hour. The Contractor shall provide flagmen, warning signs and barricades.

One (1) flagman shall be stationed immediately ahead of the application of the bituminous material and one (1) flagman immediately behind the section being rolled. Suitable speed limit signs shall be displayed, and the signs shall be moved forward with the flagman as the work progresses.

21.4.7 Working Period

All work shall be so conducted that the work of applying asphalt and aggregate and of all rolling shall be completed during the time from sunrise to sunset and under favorable weather conditions as determined by the Engineer.

21.4.8 Maintenance of Completed Work

When directed by the Engineer, the Contractor will be required to add bituminous material or aggregate or both to a portion of the Works. Furnishing additional bituminous material and furnishing, spreading, dragging and rolling of additional aggregate will not be paid for separately but will be considered as subsidiary work pertaining to the relevant item of "Bituminous Surface Treatment".

21.4.9 Quantities of Material for Bituminous Surface Treatment

The quantities for application of various layers of surface treatment are shown below in Table 21.6. The Contractor shall execute the work according to the specifications and the quantities stated in the table below.

Table 21-6: Quantities of Material for Bituminous Surface Treatment

Surface Treatment		**Aggregate**		**Bituminous Material**	
Type	Application	Size No.	Quantity (lbs/sq.ft)	Quantity l/sq.ft	Type
Triple	First	1	4.91	20.45	(a)
				23.03	(b)
	Second	2	2.45	12.80	(a)
				17.54	(b)
	Third	3	1.33	7.31	(c)
Seal caot/ pad coat with Aggregate		4	0.81	5.4	(c)

Note:

i. Bituminous material types are (a) asphalt cement, (b) cut-back or emulsified and (c) asphalt cement, cut-back and emulsified

ii. Quantities of bituminous material may be varied by the Engineer by ± 15% depending on site conditions.

iii. Prime coat shall be applied prior to the surface treatment as instructed by Engineer and included in the item of (TST).

22 Miscellaneous

22.1 Items of Miscellaneous Work

These specifications cover the following items:

- Elastomeric bearing pads
- PVC drain pipes
- Canal distance markers and boundary pillars
- Ladder rung
- Hand rail
- Direct outlet structures

22.2 Elastomeric Bearing Pad

22.2.1 Scope of Work

The work to be done under elastomeric bearing pads consists of providing all materials for elastomeric bearing pads of required size and shape and placing in position as shown on the Drawings, in accordance with the stipulations stated herein or as directed by the Engineer.

22.2.2 Elastomeric Bearing Pads

Elastomeric bearings pads as specified herein shall include plain bearings (consisting of elastomer only) and laminated bearings (consisting of layers of elastomer restrained at their interfaces by bonded laminates). The elastomer portion of the elastomeric compound shall be 100 percent Virgin Chloroprene (neoprene) meeting the requirements of the AASHTO Standard Specifications (1983) for Highway Bridges.

Laminates shall be rolled mild steel sheets conforming to ASTM A36/A36M unless otherwise specified. Neoprene bearing pads shall be furnished by the Contractor and installed at the locations shown on the Drawings. All operations of the Contractor in storing and installing the neoprene bearing pads, shall be in strict accordance with the manufacturer's instructions and as directed by the Engineer.

22.3 PVC Drain Pipe

22.3.1 Scope of Work

The work to be done under this item consists of providing and placing PVC plain pipes of specified diameter as shown on the Drawings or directed by the Engineer.

22.3.2 PVC Pipe

The PVC pipes shall conform to following standards and specifications.

Table 22-1:Requirements for PVC Pipes

Standard	Item
ASTM D1785	Polyvinyl chloride (PVC) pipe, Schedules 40, 80 and 120.
ASTM D2466	Polyvinyl chloride (PVC) pipe fittings, schedule 40.
ASTM D2467	Socket type polyvinyl chloride (PVC) pipe fittings schedule 80.

In addition:

a. The pipe should be homogenous throughout and free of visible cracks, holes or other defects. The pipe shall be as uniform as commercially practicable in colour, opacity, density and other physical properties.

b. The pipes should meet all the necessary requirements of dimensions and tolerances, sustained pressure, burst pressure, workmanship and appearance as outlined in the above referred standards to ensure quality.

c. The Contractor shall carry out all the tests required to confirm that the material/product meets the prescribed requirements as outlined in the above referred specifications.

22.4 Canal Distance Marker and Boundary Pillar

22.4.1 Scope of Work

The work to be done under Canal Distance Markers, and Boundary Pillars consists of furnishing and installing permanent canal distance markers at intervals shown on Drawings along left side and boundary pillars at intervals shown on the Drawings on both sides of the Main Canal in accordance with the Drawings and these Specifications, and of furnishing, installing and maintaining temporary canal distance markers and boundary pillars at the same intervals until placement of the permanent one.

22.4.2 Materials and Workmanship

All concrete materials production, and curing of concrete class ‘C’ for canal distance markers shall be in accordance with the provisions of, and in complete conformity with, the stipulations and requirement for concrete specified in the Chapter - "Concrete". Cast iron mounts shall be manufactured in accordance with ASTM Designation: A48, Class 20A, for grey iron castings.

22.4.3 Permanent Markers and Boundary Pillars

Permanent canal distance markers shall consist of cast iron mounts with concrete bases. Boundary pillars shall be concrete buries and shall be in accordance with the dimensions shown on the Drawings. The finished surface of the cast iron mounts shall be free of adhering sand and shall be reasonably smooth. Mounts shall have all figures and features cast integrally with the markers on both sides. All markers shall be identical except the numbers indicating the canal RD shall be one, two and three-digit numbers as required for the appropriate canal distance. Surfaces to be embedded in concrete shall be thoroughly cleaned of all rust, dirt, grease, loose scale and other foreign substances immediately before the concrete is placed. Boundary pillars and bases of distance markers may be pre-cast or cast-in-situ of concrete class C in accordance with chapter “Concrete” of these specifications, but in either case, these shall be accurately placed in accordance with the Drawings and the Engineer's instructions. When approved by the Engineer, the cast iron mounts shall be painted as shown on the Drawings and as directed by the Engineer.

22.4.4 Temporary Markers

On commencement of work on the main and branch canals, the Contractor shall furnish and install temporary canal distance markers and boundary pillars at or near the locations designated for the permanent one and maintain each temporary marker/pillars in good condition until such time as it is replaced by a permanent one. The temporary markers may be of any type and material suitable for the intended purpose provided the size and design are such as to be clearly visible and are acceptable to the Engineer. The temporary marker/pillars for a designated location shall be removed from the site after the permanent marker/pillars for the position have been accepted by the Engineer.

22.5 Ladder Rung

22.5.1 Scope of Work

The work to be done under ladder rungs will consist of mild steel deformed bars embedded in structures at the specified locations and in a manner as shown on the Drawings or as directed by the Engineer and in accordance with the Specification.

22.5.2 Materials and Construction

The rungs shall be of mild steel of minimum yield strength of 6,000 psi and shall be fabricated to the shape and dimensions as shown on the Drawings and conforming to the standards and specification set forth in Chapter - "Reinforcement".

22.6 Hand Rails

22.6.1 Scope of Work

The work to be done under hand rails consists of fabrication of hand rails of approved type as shown on the drawings or as directed by the Engineer. The work to be done by the contractor shall include the embedding of structural steel of the required size in the retaining wall/curbs and providing the galvanized hand railings of 4" diameter pipe.

22.6.2 Galvanizing

All steel and iron work of whatever kind described to be galvanized is to be pickled in dilute hydrochloric acid and then washed, fluxed and stove and coated with zinc by means of dipping in a bath of molten zinc. All articles are to be immersed in the bath only for the time sufficient for them to attain the temperature of the bath and they are to be withdrawn at such speed that a coating of 90 micron thickness on each face is achieved. Every article is to be covered evenly on all sides. Where applicable the galvanizing shall be such as to conform with the tests given in ASTM A123 "Hot dip galvanized coatings on iron and steel articles".

22.6.3 Galvanized Hand railing

1) Handrail tubes are to be supplied galvanized in accordance with hereof and are to be 4 inches bore tubing to BS 1487 "Specification for screwed and socket steel tubes and tabular and for plain end steel tubes suitable for welding or for screwing to BS 21 pipe threads" Class A except that the hydraulic test is not required. The top and bottom rails are to be 2 ft and 9 inches respectively above the deck level. The ends of the tubes are to be cut truly square, and all buried edges are to be removed.
2) Handrail standards are to be supplied galvanized in accordance with galvanizing hereof and are to be two inch bore tubing as for hand railing standard. The dimensions of handrail standards shall be as shown on the Drawings or directed by the Engineer. All holes shall be drilled in true alignment with each other as shown on the drawings.

22.7 Direct Outlets

22.7.1 Scope of Work

Direct outlets shall include the following:

a) Adjustable Orifice Semi Modules (AOSM) / Adjustable Proportionate Module (APM);

b) Open Flume;

c) Pipe or Barrel Outlets.

22.7.2 Materials and Construction

Direct outlets shall be as shown on the Drawings including concrete, reinforcement, formwork, excavation, earthworks, backfill, stone pitching, care and handling of water including dewatering if required and to the designed dimensions of outlet (dismantling will be paid separately in Bill of Quantities).

23 Engineer's Requirements

23.1 Meetings and Reports

Approved representatives of the Contractor shall attend formal meetings at the office of the Engineer on Site or in Hyderabad and Karachi, when called upon, for the purposes of contract administration. Such meetings, unless otherwise agreed, shall not be more frequent than once per month or as instructed by Engineer. Daily and weekly meetings shall also be conducted at site when called upon by the Engineer.

23.2 Office-cum Residential Accommodation (Furnished)

The Contractor, if ordered, shall provide furnished office accommodation with floor area as shown in the Bill of Quantities at the nearest city or as directed by the Engineer for the Engineer, his staff and the Farmer Organization (FO). The office shall be provided with air conditioners, ceiling fans, utilities including water supply, electricity, sanitary facilities, gas and telephone facility. These facilities shall be made available and maintained for the duration up to the end of the Defects Notification Period. The following specifications shall be adopted for the construction of offices.

Table 23-1: Requirements for Offices

Description	Specification	Reference & Chapter
Lean concrete	1:3:6	Concrete
Plain cement Concrete	Class C	Concrete
RCC	Class C	Concrete
Masonry (Brick Work 9" thick for wall) except foundation	1:4 (cement, sand)	Brick Work
Damp proof course (Horizontal and Vertical 2 and 1 inchesthick respectively)	Class C	Concrete
Glass for windows	5 mm	--
Rain water spouse	C.I pipe	--
Bathroom water supply pipes 3/4 , ¾ ,1 inch	P.V.C (Suitable for hot and cold)	
Sewerage Pipes 4 inches (in Bathroom)	C.I or P.V.C	--
Bathroom tiles on floors and up-to 6 feet on wall	As approved	--
Earthenware in bathrooms (local made)	First Class	--
Floors tiles size (12 x 12 x ¾ inch)	Approved, Chemical Polish Marble	
Floor (4 inches compacted sand, 4 inches lean tiles concrete class 'E', 2 inches	-	Concrete

Description	Specification	Reference & Chapter
Class C'' Concrete than marble tiles))		
Paint (distemper under roof, plastic emulsion on walls surface, weather shield paint on outer faces)	First class (branded known manufactures)	Prepared
Electric fitting and fixtures (three phase)	As approved	--
Roof Fan	As approved	--
Air Conditions split type (1.5 ton) paid separately	As approved	--
Kitchen with concrete shelf covered with leaf, floor and wall tiles (5 feet height) marble top steel sink, hot and cold water connection, drainsetc	As approved	--
Plinth protection (30 inches wide) 4 inches thick concrete	Class C	Concrete
Man holes separate tanks, waste well	As approved	--
Overhead tanks for building	As approved	--
Termite Treatment, to foundation, floor, wall and wood	As approved	--
Underground tanks for building	As approved	--
Tube well (suitable capacity) with motor pumps electrical installation in operation conditions	As approved	--
Fire extinguishers (suitable Nr)	As approved	--
External Power Supply from main source and metering	As approved	--
External Lighting system		
Blinds for Windows	As approved	--
Steal cages for protection of Air condition	As approved	--

1) The Contractor shall submit design for the foundation with bearing capacity of 0.5 tons /sqft or some other value confirming to the parameters substantiated by the Contractor and approved by the Engineer.

2) The specification for the construction stated herein is guidance for the Contractor for developing design drawings. The Engineer will change, modify alter the above specifications during approval or during Construction if required.

3) 'As approved' refers to approval accorded by the Engineer to the 1st class products of recognized and reputable manufacturer where applicable.

4) The elevation of the floor of the buildings shall be minimum 18 inches above the natural ground level or road level, whichever is higher.

5) Measurement for payment of the buildings shall be made in sqft of the plinth area constructed as specified herein the Table 23.1.

6) The term 'Plinth Area' refers to the entire carpet area along with the thickness of the external walls of the building. It also includes the thickness of the internal walls and the columns, if any, lying within the four walls of a building.

23.3 Transport for the Engineer

1) The Contractor shall, if ordered, provide within 60 days from signing of the Agreement vehicles (including cars, vans, trucks and boats) latest model including registration, tracker and comprehensive insurance, yearly taxes etc, as listed in the Bills of Quantities for the use of the Engineer and his staff, comprising:
    a) Toyota Prado – 5 doors,
    b) Toyota double cabin pickups
    c) Suzuki Jimny jeeps
    d) Toyota Diesel cars 1600 cc or above
    e) 125 cc motor cycles; and
    f) Motor boats, complete with trailer suitable for road and track use.
    g) Bicycles

Kerb weight and tyre pressures shall be stated on each vehicle and the vehicles shall conform in all respects to the regulations of the appropriate registration authority.

The maximum number of persons which can be safely transported under normal usage (as may be expected in the conditions prevailing on the Canal and its distributaries) must be permanently marked on each motor boat.

The 4WD-motors and motor cycles are to be registered in the name of the Employer who will arrange for the registration and insurance. The cost of registration and insurance shall be borne by the Contractor and the Contractor shall promptly advise the Employer of all vehicle details necessary to complete these formalities. The Contractor must arrange for the vehicles to be in an on the road" condition and must advise the Employer where and when in Pakistan the vehicles are to be collected. The vehicles must be ready for collection within 30 days of the Engineer's order to supply them.

2) (2) All 4WD-motors shall be petrol / diesel-engine unless the Engineer approves otherwise. All 4WD-motors shall be equipped with spare water and fuel containers and be suitable for use in the prevailing climate on the Site. The station wagons shall be equipped with roof rack. All 4WD-motors shall be equipped with inertial reel seat belts to front and rear main seating.

3) (3) The Contractor shall provide competent English speaking drivers to the approval of the Engineer. The Contractor shall provide all fuel, lubricants, etc and shall license, insure (as detailed below), service and maintain the vehicles in a safe state suitable for road or waterway use as appropriate. Vehicles shall be serviced so as to minimize avoidable pollution from exhausts, leaking oils and other fluids etc. The Contractor shall be obliged to have ready access to spare parts appropriate to the number, type and duty of the vehicles supplied. If in the opinion of the Engineer the Contractor should default in this respect and deprive the Engineer of use of vehicle made unserviceable by normal use. In the conditions and demands of the Site, the Contractor shall provide suitable alternative transport to the approval of the Engineer. If the Contractor fails

to provide this service the Engineer shall be entitled to withhold the issue of a Payment Certificate until the service is resumed.

4) Motor cycles shall be supplied complete with three safety helmets, which meet internationally recognized standards and approved by the Engineer, for every two motor cycles provided. Each boat shall be supplied complete with sufficient life jackets, conforming to internationally recognized standards, to provide such a jacket to all conveyed at any one time.

5) Insurance for the vehicles must be 'comprehensive' and include:

   i. cover for the Engineer and his staff driving the vehicle;

   ii. (ii) usage on the business of the Engineer and his staff and for social, domestic and pleasure purposes; and

   iii. Liability to third parties (including passengers whether the Engineer, his staff or others) for an unlimited indemnity in respect of death or personal injury and for the maximum indemnity reasonable obtainable in respect of, loss, destruction or damage to property.

6) The vehicles shall be handed over to the Employer at the end of the Defects Notification Period or earlier if ordered by the Engineer.

23.4 Deadlines and Penalties

The Contractor shall supply vehicles within 60 days as stated Clause 23.3 herein. If the Contractor fails to supply the vehicles stated in Bill of Quantities within the period stated herein, the Contractor shall provide alternate vehicles (with drivers) on rent at his own cost.

23.5 Permanent Site Office for the Engineer

1) The Contractor shall, if ordered, supply, construct and erect, service and insure until the end of the Defects Notification Period or such other shorter time as may be directed, for the sole use of the Engineer's site supervisory staff, air conditioned office block with car port, all as specified below. Office space provided herein for the Employer's and Engineer's personnel shall be made available for the duration of the Works, serviced and maintained as specified. For the purpose of this Chapter, the office space so provided shall be known as the Engineer's site office.

2) The Contractor shall site the office at, locations approved by the Engineer. The building shall be enclosed within a compound having security wall with lockable double entrance gates in an opening 12 feet wide and with a personnel gate 3 feet wide. The compound shall be illuminated with electric lighting. The Contractor shall submit the design of the site office for the approval of the Engineer. All weather access roads shall be provided to serve the buildings. Surface water drainage facilities shall be provided to protect the buildings from surface run-off and to convey it from the compounds.

3) The design of the office block shall be suitable for the climate and shall be provided with foundations appropriate to the selected design, all to the approval of the Engineer. The roof shall be of an approved construction of a type generally used in first class work special attention being paid to the weatherproofing, insulation and expansion. At the front of the building the roof shall be extended and supported so as to form a veranda not less than 6 ftwide. The building shall be complete with electrical, water and sewage installations and with a complete inventory of furniture and equipment as listed in the appropriate schedules of the Bill of Quantities, or as otherwise agreed with the Engineer.

4) The minimum plinth area of the office block shall be as specified in BoQ excluding the veranda areas.

5) The Contractor shall arrange, operate, suitable generators for Engineer’s Site office in addition to the power supply from public source if available.

6) The Contractor shall, supply, construct and erect, service and insure until the end of the Defects Notification Period or such other shorter time as may be directed, a laboratory block with car port, all as specified herein.

7) The laboratory block shall be provided to the same standard and on the same basis as for the Engineer's office and the terms of Clauses 23.2 and 23.5 and applicable sub clause shall apply as though the term "office", implied or otherwise, is substituted by the term "laboratory".

8) The minimum plinth area of the laboratory block shall be as specified in BoQ excluding the veranda areas.

9) Unless ordered otherwise, the laboratory block shall form in a compound with the Engineer's site office.

10) Chain link fencing for security purposes, comprising of 7 ft height, mesh size (55 inches x 55 inches x 8 SWG) tight to angle iron frame (1.5 x 1.5 x 0.19) inches fixe to GI pipe 3 inch (10 SWG) diameter in mounted on reinforced cement concrete class C with base plates (0.5 inch thick) anchors, shuttering for foundation (1.5 x 1.5) ft, reinforcement and lean concrete as shown in the drawing. The gate in the fence for vehicles will be of the same specification with addition of cross bars as approved. There will be a separate gate (4 ft) wide for pedestrians.

23.6 Moveable Offices

(1) The Contractor shall, if ordered, provide moveable air conditioned offices, minimum 400 sft floor area each as specified in BoQ. The movable offices shall be provided and placed on foundation at suitable elevation with utilities like water supplies for washing, lavatory , internal, external lighting, drainage and arrangements for sewage and refuse disposal, and be equipped with ample fly-proof doors and windows, as ordered by the Engineer. Furniture and equipment as listed in the appropriate schedules of the Bill of Quantities, or as otherwise agreed with the Engineer shall be provided. Ceiling fans and air conditioners shall be provided as ordered by the Engineer and in accordance with the Schedules. Movable offices shall be placed in accordance with the Engineer's instructions as may be advised from time to time.

(2) The Contractor shall site the offices at locations approved by the Engineer. The offices shall be enclosed within a compound having a chain link security fence with lockable personnel gate 3 feet wide. The fencing shall be at least 10 ft from the external movable office walls at its nearest point. The compound shall be illuminated with electric lighting.

(3) All weather access roads shall be provided to serve the buildings in each and every location sited. Surface water drainage facilities shall be provided to protect the buildings from surface run-off and to convey it from the compounds at all times.

(4) The design of the moveable offices shall be suitable for the climate and shall be provided with foundations appropriate to the selected design, all to the approval of the Engineer. The roofs shall be of an approved construction of a type generally used in first class work, special attention being paid to the weatherproofing, insulation and expansion approved by Engineer.

(5) The Contractor shall arrange, operate, suitable generators for Engineer’s Site office in addition to the power supply from public source if available.

23.7 Car Ports

Car ports shall be constructed of concrete columns on mass concrete footings with a roof of corrugated sheets supported on a steel frame or a similar equivalent construction approved by the Engineer. The floor, which shall be of the same area as the roof, shall be of well-compacted granular material. The design drawings submitted to the Engineer for approval.

23.8 Materials and Workmanship

The materials used and workmanship employed in the construction of the buildings, including permanent and movable offices, laboratory and car ports, shall be in accordance with the other requirements stated in various chapter of these Technical Specifications,

23.9 Deadlines and Penalties

The office blocks for Engineer, Farmer Organization and laboratory shall be furnished and ready for occupation within five months and moveable offices shall be ready within two months, of the order to commence or as instructed by the Engineer.

The Contractor shall provide alternative accommodation at his own cost, and if Contractor fails to complete, or provide as appropriate, the buildings within the above stated time.

23.10 Water, Electricity, Gas and Communication

The Contractor shall provide continuous supplies of utility and drinking water (WHO standards), electricity, gas, internet and telephone to the Engineer's laboratories, offices, residential accommodation and mobile offices up to Defect Notification Period.

23.11 Servicing

The Contractor shall service all ancillary works, the Engineer's site and movable offices, laboratory, furniture, fixtures and equipment including provision of all utility and drinking water, electricity, gas, internet, telephone and sewerage and refuse disposal services, until the end of the Defects Notification Period. The Contractor shall replenish consumable items as and when required. In addition, at the end of the Defects Notification Period the furniture, fittings and equipment shall be cleaned, repaired or replaced, as necessary, to bring them into good condition, and they shall remain, together with all fencing, walling, gates, roads and paths the property of the Employer at the conclusion of the Works.

23.12 Furniture, Fitting and Equipment, etc

23.12.1 Furniture, Fitting and Equipment etc

The Contractor shall supply the furniture, fittings and equipment listed in the Schedule S1 to the Bill of Quantities and shall install them in the laboratory, movable offices or the Engineer's site office as ordered by the Engineer. They shall be for the sole use of the Engineer and his staff and employees of the Employer. All furniture, fixtures and equipment shall be supplied new, and a manufacturer's description or sample shall have been approved by the Engineer before any item is ordered. The Contractor shall keep insured all furniture, fittings and equipment supplied to the Engineer to their full local value (including duty) until the end of the Defects Notification Period or such shorter period as the Engineer may decide.

23.12.2 Replacement

All electrical equipment shall be of a suitable rating for the power supply and shall be capable of sustained use. It shall be installed with due care for safety and shall be replaced if it becomes damaged.

23.12.3 Revolving Chair with Lumber and Neck Support

Revolving chair with lockable revolving and synchrony-tilt mechanism pivoted at front for stability with fixed angle control system, adjustable seal height-gas lift and swivel seat and back rest with lumbar and neck support, arms, upholstery fabric, 5-prong pressure die-cast aluminum / nylon with reinforced fiber glass base and twin wheel castors.

23.12.4 Visitor Chairs with Lumbar Support

Visitor chair with foam seat and back rest with low lumbar support, arms, upholstery fabric, 5-prong pressure die-cast aluminum / nylon with reinforced fiber glass base.

23.12.5 Office Chairs Shisham Wood

Shisham wood office chairs, two inches dia arms and legs, lacquer polish seat and back, single bamboo caning.

23.12.6 Microwave Oven

Microwave Oven 27 liters, inverter controlled, multi stage cooking type, auto defrost, tactile programme panel, turntable diameter 340 mm, LED display type, power output 901 – 1500 Watts, minimum clearance (sides, rear and top) two inches and with child safety lock.

23.12.7 Dispenser

Dispenser for 18.9 liter bottle, power 220 V, frequency 50 Hz, rated heating 500 W, rated cooling 81 W, high efficiency compressor cooling, refrigerant / pour R:134a/37g, On Off buttons, indicators, plastic body, 12 Liter storage cabinet.

23.12.8 UPS

Three (3) KVA UPS, input plug 16A, Voltage 220 to 240, frequency 50 to 60 Hz, input current 10 to 13A, power output 1.9 to 2.7 KW with terminals, breakers, other accessories etc, with four batteries each of 12 VDC and 120 A.

23.13 Computers, Accessories and Photocopier etc

The Contractor shall, if ordered, provide laptop and desktops computers, software, photocopier machine, printers, uninterruptible power supply (UPS), mobile telephone and camera as approved by the Engineer, ancillary equipment and software as listed in Schedule S1 of the Bills of Quantities for the use of the Engineer and his staff.

All software provided shall be suitable for use with all hardware components provided and shall be furnished with all drivers, peripherals and other components necessary for use without additional provision. The software shall be suitable for use with the operating systems provided.

All software shall be licensed for use by the Engineer and customer support facility. The Contractor shall maintain computers, printers, accessories and photocopy machines up to the end of the Defect Notification Period.

23.14 Assistance to the Engineer

The Contractor shall supply such labour, either continuously or from time to time, as may be required by the Engineer to assist him in checking the setting out of the Works, in measuring the works, as messengers in connection with the Works, general labour in connection with the operation and maintenance of the Engineer's office and laboratory, and as watchman over the Engineer's offices, laboratory and equipment.

23.15 Technicians

If ordered by the Engineer, the Contractor shall provide technicians and staff to carry out the tests required for the Works or any further tests which may be ordered by the Engineer. The technicians shall be fully qualified and shall each have had a minimum of five years' experience of this type of work. The qualifications and experience of the technicians shall be subject to the approval of the Engineer before the technicians are employed upon the Works.

23.16 Surveying Instruments and Equipment's

23.16.1 General

The Contractor shall supply and insure, for the sole use of the Engineer, surveying and other instruments and equipment, as detailed in Schedule S2 to the Bill of Quantities or otherwise approved by the

Engineer. The instruments and equipment shall be new and shall be maintained in a good state of repair and shall be replaced in the event of loss or damage. On completion of the Contractor, the equipment shall become the property of the Employer.

All equipment's shall be provided with carrying cases suitable to prevent damage when carried about the Site. The Contractor shall maintain and service the equipment up-to the Defect Notification Period.

23.16.2 Instruments

The equipment shall be provided within six weeks of the Engineer's order for its provision, and shall include some or all of:

23.16.2.1 Electronic Total Station

Electronic Total Station Model GTS-239N (30X, 1 sec, display reading, alphanumeric keypad, 45 hrs battery life, accuracy +_ (2mm+2ppmxD) m.s.a complete with battery charger, lens cap, tool data and operated manual battery CD Automatic level shall be with set of Tribach set with adapter and optical plummet and hard carrying box and three sets of tilting range pole prism complete as [prism (-30) SOUTH], single tilting mount with coaxial target SOUTH, soft bag with prism SOUTH including services facility.

23.16.2.2 GPS

Hand held global positioning system (GPS) equipment as approved by the Engineer.

23.16.2.3 Leveling Instrument

Leveling instrument (CST / Berger model SAL32N) magnification 32x, leveling accuracy 1/16" @ 250', Working range 400ft, angular accuracy 1o / 1 gon, clear objective Aperture 40mm, Compensator setting accuracy ± 0.3", standard deviation for 1km double-run leveling 1.0mm, along with aluminum staff (meter and ft)

23.16.2.4 Camera

Cameras (Sony), the key features are 12.1 megapixel Intelligent auto mode Double anti-Blur technology, 28mm wide Angle Lens, 2.7 inch clear photo LCD screen, 5x optical Zoom (with date and time programmed on production) with carrying case.

23.16.2.5 Projector

Hitachi LCD Projector CP-RX80, 2200 ANSI Lumens, Native 1024 x 768 XGA resolution, 6000 Hrs lamp life including servicing facility up-to the issuance of Completion certificate.

23.17 Correspondence

All correspondence to the Employer and to the Engineer originating from the Contractor shall be in English.

23.18 Progress Reports

The following requirements are additional to the requirements of Clause 4.21 of the General Conditions of Contract.

1) The Contractor shall submit an electronic copy as a pdf file.2. The Contractor shall submit a Gantt chart on MS Project, narrative summary, explanation of changes, current status, delay and remedies to improve the progress.
2) The Gantt chart shall be prepared using the critical path method, include the following:

- Work Breakdown Structure (WBS)
- Assumed or actual commencement date
- Start and finished dates, including float (if applicable) for each activity
- Interdependencies between activities
- Activities will be 'resource loaded' with labour, materials, equipment and be accompanied by print outs of planned and actual resource usage
- Progress achieved on each activity
- Showing Critical path

The progress report shall include the programme prepared in accordance with Clause 1.17.

23.19 Progress Photographs

23.19.1 General

The following requirements relate to the photographs required to be included in the progress report. Photographs shall be taken using a high quality digital camera as approved by the Engineer, of the construction activities including all structures and at the following stages of work:

a) Before the start of construction, during construction and after completion of each activity of work.

b) Monthly during construction or at shorter intervals as instructed by the Engineer.

c) Upon completion of the project.

23.19.2 Identification of Photographs

The caption shall be typed on each photograph

a) Title of Project.

b) Identification of subject shown.

c) Station point of camera and direction of view.

d) Date & time (automatically displayed on the photos)

e) Name of Employer / Engineer and Contractor.

All these photographs (color copies) shall be included in the hard and soft copies of Progress Reports.

23.20 Lab Equipment

23.20.1 Apparatus for Sieve Analysis (Coarse Aggregate)

Sieves for sieve analysis of coarse aggregate (12" dia, 4-¼" full height), 3", 2.5", 2", 1.5", 1.25", 3/4" 1/2", 3/8", stainless steel mesh with pan and cover (complete set). The frame of sieves shall be seamless spun brass with rigid rolled edges and extended bottom (skirts). The apparatus shall comply with ASTM E11 and AASHTO M92. Each sieve shall include a certificate of conformity to the applicable specifications which bears a serial number.

23.20.2 Apparatus for Sieve Analysis (Fine Aggregate)

Sieves for sieve analysis of fine aggregate (8" dia, 2-5/8" full height), # 4, # 8, # 16, # 30, # 50, # 100, # 200, stainless steel mesh with pan and cover (complete set). The frame of sieves shall be seamless spun brass with rigid rolled edges and extended bottom (skirts). The apparatus shall comply with ASTM E11

and AASHTO M92. Each sieve shall include a certificate of conformity to the applicable specifications which bears a serial number.

23.20.3 Sieve, Wet Washing

Wet washing sieve with No. 200 stainless steel cloth; size: 8"x 4" (203 x 102mm). Sieves shall be constructed of brass frames and permanently installed stainless steel cloth. The sieve shall include a certificate of conformity to the applicable specifications which bears a serial number.

23.20.4 Liquid Limit Device

The liquid limit device consists of a brass cup held on an adjustable bracket.

The cup can be adjusted for a height of 1 cm and can be lifted and dropped on a rubber base of standard hardness by cam action.

Complete device consists of one Casagrande grooving tool, one ASTM grooving tool and a height gauge Block.

23.20.5 Sand Cone Apparatus

Sand cone apparatus (6 ½ inches) for testing field density of soil consists of two spun steel cones with a brass valve, a gallon plastic container, detachable metal cone with valve (open or completely closed position), a cast aluminum alloy Density Base Plate (12 x 12 inches), Small round bottom scoop, 2 D x 5 L, Rubber mallet, Stainless Steel Sampling Spoon and Field scale 36 lb and 25 kg standard sand. The apparatus shall be for testing in accordance with ASTM D 1556, AASHTO T 191.

23.20.6 Speedy Soil Moisture Tester

The Speedy Moisture Tester shall be of gravimetric moisture content in soil, includes pressure gauge, electronic balance, beaker, cleaning cloth, cap, washer, scoop, steel pulverizing balls and cleaning brush in a heavy-duty plastic carrying case for field use, meets ASTM D4994 and AASHTO T217.

23.20.7 Field Test Balance, 16 kg x 5 g

Field test beam balances 16 kilogram capacity with 5 gram precision. Slotted weights fit in base of scale, epoxy coated, readings up to 500g are taken from a single, sliding-weight beam, while a set of slotted weights, stored in the base, can extend the capacity up to 16kg and large stainless steel platform.

23.20.8 Speedy Moisture Testers for Aggregate and Soils and Reagent

The system consists of a low pressure vessel fitted with a pressure gauge and an electronic scale and test accessories for measuring the moisture content of a wide range of materials Moisture measurements are made by mixing a weighed sample of the material with a calcium carbide reagent in the sealed pressure vessel.

Accuracy shall be within 0.5% on most materials, test Speed: 45 sec. to 3 min., Gauge: Calibrated from 0-20% moisture based on wet weight with, Electronic balance: 0-7 oz (0-200g) range; battery operated and Moisture Tester Reagent Calcium carbide (2 kg) for Speedy Moisture Testers.

The tester shall be supplied complete with heavy-duty plastic carrying case, electronic balance, beaker, cleaning cloth, cap, washer, scoop, steel pulverizing balls and cleaning brushes. Meets ASTM D4944 and AASHTO T217.

23.20.9 Modified Proctor Compaction Test Apparatus

Proctor mould with a detachable collar assembly and base plate, Manual rammer, sample extruder, straight edge, squeeze bottle mixing tools such as mixing pan, spoon, trowel, spatula etc and moisture can for testing compaction of soil in accordance with ASTM D1557 and AASHTO T-180, Specification is as under:

Mould - Mould shall be cylindrical, made of metal and having the dimensions [4.584 inches height, 4 and 6 inches dia (set)]. It shall include a detachable collar (2 inches height) and a base plate to which the mould can be fastened.

Rammer - Rammer manually operated rammer diameter (2 inches), mass (10 lbs), drop (18 inches). The manually operated rammer shall be equipped with a guide-sleeve to control the path and height of drop. The guide-sleeve shall have at least four vent holes no smaller than 9.5 mm (3/8 in.) diameter, spaced approximately 90 degrees apart and approximately 19 mm (3/4 in.) from each end.

Sample Extruder – A jack, lever frame, or other device for extruding compacted specimens from the mold quickly and with little disturbance.

One beveled edge and at least one surface, used for final trimming, plane within 0.1 percent of its length. Containers - Container (stainless steel) with close-fitting lids to prevent gain or loss of moisture in the sample.

23.21 Heavy Duty Balance 20 kg triple beam

Heavy-Duty n Balance 20kg triple beam, readability 1.0g, tare capacity 2270g, stainless steel platform 11"dia with weight set.

23.21.1 Mechanical Balances 2610gm.

Mechanical Balance capacity 2610g triple beam, readability 0.1g, 6" dia stainless steel pan with weight set.

23.21.2 Mechanical balances 311gm.

Mechanical Balance capacity 311g triple beam, readability 0.01g, 3.5" dia. x 0.5" deep stainless steel pan.

23.21.3 Calibration Weights (masses) up to 10kg (Set)

Calibration masses shall be ASTM class 1, consist of set of 200g, 300g, 400g, 500g, 1000g, 2kg, 4kg, 5kg, 10kg, cylindrical style carrying case (except 10 kg unit).

23.21.4 Apparatus for Slump Test (set)

The Apparatus consists of one slump cone complying with EN 12350-2, ASTM C143 and AASHTOO T119, Tamping Rod steel, 600 mm long x 16 mm dia hemispherical at both ends, Steel Rule, Base Plate, Funnel and scoop.

23.21.5 Concrete Compression Machine

Concrete compression machine load from 2,500–250,000 lbs (11–1,112 kN), with accuracy of ±0.5% .iD digital load-indicating systems, continuous-duty hydraulic pump and pressure-compensated loading-control valve manufactured to ISO 9001 international quality standards. The machine shall conform to ASTM C39, E4 and AASHTO T22 specifications.

Machine shall be supplied with platen set for 6" (150 mm) cylinders and 6 in. cube set (platen and pedestal).

23.21.6 Hydrometer, Field Use Specific Gravity (Set)

Instruments for testing specific gravity in liquids with graduated divisions of 0.0005 and a range of 1.000° to 1.070° and the Buoyoucos scale hydrometer to determine specific gravity of soil, with a range of -5 to 60 grams/liter in 1.0 increments, including hydrometer clear plastic cylindrical 500 ml capacity jar with a broad base (approximate weight 0.5 lbs) for testing solids.

23.21.7 Heavy Duty Forced-Air, Convection Oven

Heavy duty forced-air, convection ovens 2.3 cubic feet (65 Liters) thermostatically controlled fast heat-up rates, power in alloy sheathed tubular heating elements 50Hz, single phase, 240V 15 amps, 1.2KW heater, with digital controls to deliver precise temperature and a large LED panel. The oven shall operate at temperatures up to 400°F (204°C) and use forced convection airflow for uniform temperatures throughout the oven chamber. The motor shall be 1/3 HP with a 400 CFM blower located on the top of oven. Two nickel plated wire shelves (which can be placed on any of the 10 support channels, which are located on 3" centers) shall handle up to 22.7 kg each.

The oven shall have 2 inches 6 lb/cf industrial Rockwool insulation with in built-in baffle to prevent radiant heat and explosion venting latches.

The oven features shall meet the requirements of National Fire Prevention Association Standard 86, Industrial Risk Insurers, Factory Mutual and OSHA standards. Motor starter and heating element contactors are electrically interlocked to shut off heaters if power to the blower is interrupted, and, permit operation of the blower without heat for cooling.

23.21.8 Shelving

The shelving shall be of depth 300 mm, width 2000 mm with a shelf height of 400 mm.

23.21.9 Chest of Drawers

Chest of drawer shall be of 5 ft wide x 3 ft x 3 ft with 8 drawers fabricated from 20 gauges (minimum) steel sheet, hammer enamel painted.

23.22 Laboratory Bench

Laboratory bench with 9 ft x 3 ft x 1.5 inches resin bonded chipboard, faced and edge in best resistant laminate complete with fitted laboratory sink with fitting and fixture, pipe lines, drains, disposal system, cabinet and all other accessories complete in operation condition.

23.22.1 Concrete Cube Mould

Concrete cube mould shall comply with BS 1881 & EN2930-1 standard of cast iron for making concrete cubes with the dimension 15 x 15 x 15 cm approximate weight: around 19 Kg, the faces are machined flat to +/-0.2mm accuracy and finished to within 0.2mm. For the inch size moulds, the faces are machined flat to +/-0.01 inches and finished to within 0.01in. All moulds shall be supplied with base plate.

23.22.2 Schmidt Concrete Test Hammer

Schmidt concrete test hammer for measuring concrete strengths of: 10 to 70 N/mm2 (100 to 700 kgf/cm) with carrying case complete with grinding carborundum stone. Approximate Weight 1.7kg.

23.22.3 Thermometer Pocket Type

5" long stem. Large-bore, tempered glass with non-toxic liquid, includes plastic pocket case and clip with the division of 20F.

23.22.4 Thermometer Dial Type

Direct-reading, all-metal dial thermometers for general use include °F and °C scales. Units have bi-metal element in 8" long x 0.15" dial (203 x 4mm) stainless steel stem that actuate pointer over graduated dial. Dial face is 1-3/4" (45mm) dia with external adjustment for recalibration, 0 to 260°C (50 to 500°F), and division of 2°C.

23.22.5 Thermometer Dual Scale

Dual-scale thermometer has U-shaped capillary mounted in plastic 8" x 2-5/8" x 1" (203 x 67 x 25mm) with guard and mounting tab. Ranges: -40°F to 120°F in 2°F div. and -40°C to 50°C in 1°C div.

Thermometer shall indicate present, highest and lowest temperature since last indices setting. Indices shall easily reset after each reading.

23.22.6 Heat-Resistant Gloves

Made with large thumb, fingers and loose-fitting palm with wide gauntlet, gloves feature one-piece full length palm and finger portions, keeping seams to a minimum.

23.22.7 Rubber Gloves

For use in compaction, concrete and general lab work, medium thickness short-form gloves without gauntlets are chemical and abrasion resistant and feature.

23.22.8 Nitride Coated Hot Mill Glove, Size 9 and 10

Non-woven, felt insulation and a full-length heat barrier protect hands. Nitride coating prevents cuts and abrasions. For use in handling hot objects up to 400°F.

23.22.9 Clear Safety Goggles

Clear safety goggles shall be soft vinyl frame and replaceable lens.

23.23 Square-Point Shovel

Square point shovel shall be heat-treated high-carbon steel 9-3/8x11-1/2” (24x29cm) square-pointed blade with 48” (122cm) handle.

23.23.1 Vernier Caliper (Standard Model)

Vernier caliper shall be double scale (metric/inch) vernier Caliper stainless steel range 0 - 200mm, total length 288mm, depth of lower jaw 50mm, depth of upper jaw 24.5mm, width of blade 16mm,carbide tipped upper and lower jaws, clamping screw atop the slider with accuracy ±0.03mm (≤200mm) and graduation accuracy 0.02mm (.001”).

23.23.2 The Phunque Flasks (Set)

The Phunque Flasks are for measuring moisture content and specific gravity of fine and coarse aggregate shall have a neck approximately 1" inch and 2” inch diameter respectively. The scale on both items is readable to 0.1 grams; both shall include an excel calculation sheet and a swabbing utensil to keep the neck of the flask dry during loading.

23.24 Metrological Observatory, Instrument for

23.24.1 Rain Gauge with Measuring Jug

Rain gauge with 31 square inches (200 cm²) circular collecting area (WMO Standard), made of stainless steel, dimensions: height 453 mm, diameter 190 mm, weight 3.1 kg with accessories as, i) deposit collector, ii) container, iii) collection container made of plastic volume approx. 1.2 l, iv) holder made of galvanized steel, v) graduated cylinder made of polystyrene clear as glass in accordance to DIN 58667B for 0 to 10 mm of precipitation, graduation 0.1 mm. vi) Measuring jug: a measuring jug 5” rain gauges marked in inches & mm, material: polyethylene Full scale: 0.2.. 30mm or 0.05”.1.2” of rain.

23.24.2 Maximum and Minimum Thermometer with Weather Screen

Maximum thermometer measuring range -30..+60 °C: 0,2 Total length 360 x 17 mm and Minimum thermometer measuring range -30..+60 °C: 0,2 Total length 360 x 17 mm with standard weather screen in conformity with British Met Office in the UK Synoptic Station Network. Weather screens shall be for operating temperature range -50..80°C, powder coated aluminum frame with high chrome content, upper/lower deck UPVC, louvers acrylic with UV stabilizers, door polyamide with RVS screws, large model MET 01, internal dimensions HxBxD 406x492x313 mm approximate weight 21 kg.

23.24.3 Wet and Dry Bulb Hygrometers

The two thermometers are mounted on body dark gray plastic 4 inches wide and 10 inches high, 1-1/8 inches deep, physically identical, with black numbers on a white background. The thermometer scales read from -12°C to 60°C and are actually graduated from -20°C to 60°C in increments of 2°C. The Hygrometer is spirit-filled, metal relative humidity table on front of unit cross-references Dry Bulb Temperature with Degrees difference between Wet & Dry Bulb to indicate humidity.

23.24.4 Open Pan Evaporimeter

The evaporation pan set consist of stainless steel, inner diameter: 120.7 cm, height: 25.4 cm, thickness material: 1.5 mm, with i) Stilling well (Height: 25.4 cm, Thickness: 0.8 mm, Diameter: 7.5 cm – 10 cm, height and tripod adjustable) ii) Hook gauge iii) Floating thermometer (Measuring range: 0 up to +80°C, Graduation: 1/2°C, Weight: 0.5 kg, Dimensions: 140 x 340 x 40 mm).

23.24.5 Wind Recorder

Wind recorder having technical data viz.i) Recorded Values: wind run, wind direction (velocity with the aid of the evaluation ruler) ii) Form of recording: on wax paper, iii) Recording length: 31 days, iv) Recording speed: 10 mm/h, v) Graduation of recorder: 1 km or resp. 300 vi) Width of writing: wind run 50 mm = 10 km, wind direction 36 mm = 3600 vii) Admissible: max. 60 m/s, viii) Responsiveness Anemometer less than m/s, Wind vane less than 1.3 m/s (bei 900 Auslenkung), ix) Accuracy 5… 15 m/s less than plus minus 2% of meas. Value x) Paper transport: Band Recorder, hand winding Accuracy: less than plus minus 60 s/d bei 200C (nach DIN 1620) xi) Admissible temperature range: -350… + 450C xii) Recomm. Mast dimensions: threaded pipe 1 ½ acc. to DIN 2440 (Ø50) xiii) Approximate Weight: 10.5 kg.

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Appendix A. Standards

The Contractor shall supply standards, the publications, stated herein, but not limited to the list when ordered by the Engineer. All amendments to each Standard (Published by the British Standards Institution) shall be included.

A.1. British Standards

BS 4: Part 1: Structural steel sections, Specification for rolled sections.

BS 21 Specification for pipe threads for tubes and fittings where pressure-tight joints are made on the treads.

BS 302: Parts 1 & 5: Standard steel wire ropes.

BS410 Specification for test sieves.

BS 443 Specification for testing zinc coatings on steel wire and for quality requirements.

BS 486 Specification for asbestos-cement pressure pipes and joints.

BS 534 Specification for steel pipes, joints and specials for water and sewage.

BS 709 Methods of destructive testing fusion welded joints and weld metal in steel.

BS 812 Testing aggregates.

BS 882 Specification for aggregates from natural sources for concrete.

BS 903 Physical testing of rubber. Parts A1, A, A3, A4, A5, A6, A19 & A6.

BS 1052 Specification for mild steel wire for general engineering purposes

BS 1199&1200 Specification for building sands from natural sources.

BS 1377 Methods of test for soils for civil engineering purposes

BS 1387 Specification for screwed and socketed steel tubes and tubular and for plan end steel tubes suitable for welding or for screwing to BS 21 pipe threads

BS 1471 Specification for wrought aluminum and aluminum alloys for general engineering purposes; place, sheet and strip

BS 1722: Part 1: Specification for chain-link fences.

BS 1853 Tubular fluorescent lamps for general lighting service

BS 1881 Testing Concrete

BS 2494 Specification for elastomeric seals for joints in pipe-work and pipelines

BS 2499 Hot applied joint sealant systems for concrete pavements.

BS 3083 Specification for hot-dip zinc coated and hot-dip aluminum / zinc corrugated steel sheets for general purposes.

BS 3100 Specification for cast steel for general engineering purposes

BS 3148 Methods of test for water for making concrete (including notes on the suitability of the water)

BS 3382 Specification for electroplated coating on threaded components.

BS 3416 Specification for bitumen-based coatings for cold application, suitable for use in contact with potable water

BS 3505 Specification for un-plasticized polyvinyl chloride (PVC-U) pressure pipes for cold potable water.

BS 3680 Measurement of liquid flow in open channels, Parts 1, 3A, 3C, 3D, 8A, 8B, 10B, 10C and 10D.

BS 4027 Specification for sulphate-resisting Portland cement

BS 4072 Wood preservation by means of copper/chromium/arsenic compositions

BS 4254 Specification for two parts polysulphide-based sealants

BS 4395 Specification for high strength friction grip bolts and associated nut and washers for structural engineering

BS 4449 Specification for carbon steel bars for the reinforcement of concrete

BS 4466 Specification for scheduling, dimensioning, bending and cutting of steel reinforcement for concrete

BS 4482 Specification for cold reduced steel wire for the reinforcement of concrete.

BS 4483 Specification for steel fabric for the reinforcement of concrete

BS 4504 Circular flanges for pipes, valves and fittings (PN designated)

BS 4550 Methods of testing cement

BS 4604 Specification for the use of high strength friction grip bolts in structural steel work, Metric series.

BS 4660 Specification for plasticized polyvinyl chloride (PVC-U) Pipes and fittings of nominal sizes 110 and 160 for below ground gravity drainage and sewerage

BS 4251 Truck mixed Concrete

BS 2494 Rubber Gasket

BS 4848: Parts 1 & 4: Hot-rolled structural steel sections.

BS 4872: Part 1: Specification for approval testing of welders when welding procedure approval is not required.

BS 4987 Coated macadam for roads and other paved areas.

BS 5135 Specification for arc-welding of carbon and carbon manganese steels.

BS 5328 Concrete

BS 5390 Code of practice for stone masonry.

BS 5400: Part 6: Steel, concrete and composite bridges. Specification for materials and workmanship, steel

BS 5481 Specification for plasticized PVC Pipe and fittings for gravity sewers

BS 5493 Code of practice for protective coating of iron and steel structures against corrosion.

BS 5628 Code of practice for use of masonry.

BS 5911: Part 100: Precast concrete pipes, fittings and ancillary products, Specification for unreinforced and reinforced pipes and fittings with flexible joints.

BS 5930 Code of practice for site investigations

BS 6073 Precast concrete masonry units.

BS 6150 Code of practice for painting of buildings

BS 6323 Specification for seamless and welded steel tubes for automobile, mechanical and general engineering purposes

BS 7079 Preparation of steel substrates before application of paints and related products Part 0, A1, A1 Supplement 1, C1, C2, C3, C4, E3 & E4.

BS 7613 Specification for hot rolled quenched and tempered weld-able structural steel plates

BS 7668 Specification for weld-able structural steels. Hot finished structural below sections in weather resistant steels

BS 5911 Concrete pipes and filling

BS 8004 Code of practice for foundations

BS 8110: Part 1: Structural use of concrete. Code of practice for design and construction

A.2. BS European Standards

(Published by the British Standards Institution)

BS EN 197 Specification for Ordinary Portland Cement

BS EN 499 welding consumables, Covered electrodes for manual metal are welding of non alloy and fire grained steels. Classification

BS EN 10029 Specification for tolerances on dimensions, shape and mass for hot rolled steel plates 3 mm thick and above

BS EN 10113 Hot rolled products in weld-able fine grain structural steels, Part 1 to 3

BS EN 10155 Structural steel with improved atmospheric corrosion resistance Technical delivery Conditions

BS EN 10210-I Hot finished structural below sections of non-alloy and fine grained steels. Technical delivery requirements

A.3. American Standards

ASTM D-412 Test for rubber properties in tension

ASTM D-1117 Tear Strength of Fabrics

ASTM D-1600-81 Abbreviations of terms relating to plastics

ASTM D-1682 Tensile Strength/Elongation of Fabrics

ASTM D-1751 Preformed Expansion joint filters for concrete paving and structural construction (non-extruding and resilient bituminous types)

ASTM D-1752 Preformed sponge rubber and cork expansion joint filters for concrete paving and structural constructions

ASTM D-1777 Thickness of Yarn and Fabrics

ASTM D-1784 Right Polyvinyl Chloride compounds

A.4. United States Federal Specification

HH-F 341e Joints Filters

A.5. Miscellaneous

Building Research Station, UK Digest 357: Shrinkage of natural aggregates in concrete (January 1991)

US Bureau Reclamation Earth manual Department of Environment, UK Analysis of raw, portable and waste waters, 1972 T.M AckroydLaboratory testing in soil machine

Appendix B. Site Environmental PLAN

B.1. General

The general objectives of the environmental management for the implementation of improvement and rehabilitation of the main and branch canals for Sindh Water Sector Improvement Project are:

(a) Implementation of measures to prevent or reduce negative impacts to acceptable levels or to enhance environmental conditions.

(b) Implementation of measures to deal with risks that arise during implementation and Defects Notification Period: occupational health and safety, accidents.

(c) Implementation of measures that ensure that the environmental actions are in phase with engineering and other project activities throughout implementation.

(d) Supervising and monitoring significant issues during installation and operation. Wherever it is stated within this document that any information or documentation shall be provided or submitted by the Contractor to the Employer or others that he may so nominate, such provision or submission shall be via the Engineer.

The Employer and the Engineer may nominate representatives to act on behalf of them for the provisions of this document. In such case, the Contractor shall liaise and make the necessary coordination with such nominated representatives for the fulfillment of his requirements under this document.

B.2. Site Environmental Management Plan

The Contractor shall prepare and implement a Site Environmental Management Plan (SEMP) setting out clear statement of environmental policy to be adopted for the Works, and incorporating the following Principles

a. Details of the Contractor's organizational framework, in particular the designation of a senior manager to take overall responsibility and an engineer, nominated as the Environmental Monitor, to manage environmental control facilities on a day-to-day basis and liaise with the Engineer and the Employer.

b. Details of the principal pollution control facilities proposed, including procedures for the collection and disposal of wastes, and of contingency plans in the event of failure of these facilities.

c. Details of the Contractor's proposed environmental monitoring procedures, to ensure the construction site is operating satisfactorily and that problems are being dealt with promptly.

d. The format of a monthly report to the Employer, comprising a checklist of environmental issues at work site, and covering the specific problems of the Works. Forms will be developed by the Contractor to demonstrate compliance with the environmental requirements of the contract and to identify any problems. The forms will be copied to the Engineer for information and action where required.

e. Details of the Contractor's environmental awareness training programme proposed for the workforce.

f. Environmental impact assessments of work camps, borrow areas (if any), and fire control, etc and mitigating measures.

g. A requirement that all method statements include a section on environmental impacts and mitigation.

    a. Details of the records to be kept to demonstrate compliance with the SEMP.
    b. A formalized mechanism to audit the effectiveness of the SEMP.

B.3. Identification of Environmental Risks

The construction risks which should be addressed through the SEMP and to be monitored will include, but not limited to, the following issues:

a) handling of hazardous material as far as part of construction activities;

b) movement of machinery;

c) management of quarries and borrow areas;

d) collection and safe disposal of hazardous residues and dismantled material;

e) occupational safety and health; (safety and health requirements shall be covered under a separate plan prepared by the Contractor)

f) avoidance and management of pollution incidents.

g) disturbance of wildlife

h) disturbance of archaeology

B.4. Contractor's Responsibilities

The Contractor shall:

a) Produce and implement the SEMP;

b) Co-operate with the Engineer and the Employer or their nominated representatives;

c) Provide the Engineer and Employer with access to records of the environmental management programme for the purposes of an audit, every six months.

d) Produce a monthly report to the Employer, copied to the Engineer, comprising a checklist of environmental issues at each work site, and covering the specific problems of the Works. Forms will be developed by the Contractor to demonstrate compliance with the environmental requirements and to identify any problems

Appendix C. Health and Safety Plan

The site specific health and safety plan should include or address the following topics, where they are relevant to the work proposed.

C.1. Description of Project

a) Project description and programme details;

b) Details of the employer, designers, the engineer, the contractor and other contractors;

c) Extent and location of existing records and plans.

C.2. Communication and Management of the Work

a) Management structure, responsibilities (to include sub-contractors), supervision and reporting scheme;

b) Health and safety goals for the project and arrangements for monitoring and review of health and safety performance;

c) arrangements for:

- Appointment of a qualified safety officer;
- Provision of personal protective equipment;
- Regular liaison between parties on site including meetings of the safety committee;
- Consultation with the workforce; the exchange of design information between the employer, designers, the engineer, the contractor and other contractors on site.
- Handling design changes during the project;
- The selection and control of sub-contractors;
- The exchange of health and safety information between parties;
- Security, site induction and onsite training for workers and supervisors;
- Medical examinations, welfare facilities, first aid and emergency facilities;
- The reporting and investigation of accidents and incidents including near misses.
- The production and approval of risk assessments and method statements;

d) Site rules;

e) Fire and emergency procedures.

C.3. Arrangements for Controlling Significant Site Risks

a) safety risks:

- services, including temporary electrical installations;
- working in confined spaces;
- preventing falls;
- working near water;
- work with or near fragile materials;
- control of lifting operations;

- dealing with services (water, electricity and gas);
- the maintenance of Contractor's Equipment;
- poor ground conditions;
- traffic routes and segregation of vehicles and pedestrians;
- storage of hazardous materials;
- dealing with existing unstable structures;
- accommodating adjacent land use;
- other significant safety risks.

b) health risks:

- Removal of asbestos;
- Dealing with contaminated land;
- Manual handling;
- Use of hazardous substances;
- Reducing noise and vibration; and
- Other significant health risks.

C.4. Health and Safety File

a) Layout and format;
b) Arrangements for collection and gathering of information;
c) Storage of information.

Appendix-IV

ENVIRONMENTAL IMPACT ASSESSMENT AND ENVIRONMENTAL MANAGEMENT

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1 Introduction

1.1 General Background

The province of Sindh is one of the primary beneficiaries of the Idus Basin Irrigation System (IBIS). It has three major barrages on the Indus River that divert approximately 59.0 billion cubic meters of water annually to the 14 main canal commands in Sindh. These canal systems have an aggregate length of 21,445 Km, which serve a gross command area (GCA) 5.8 million ha. In addition, there are 13 existing surface drainage systems in Sindh, which serve a total area of over 2.5 million hectares and have an aggregate length of about 6,133 Km and there are two sub-surface drainage systems, which serve an area of 0.04 million ha. Key features of the project area are presented in Figure 1.

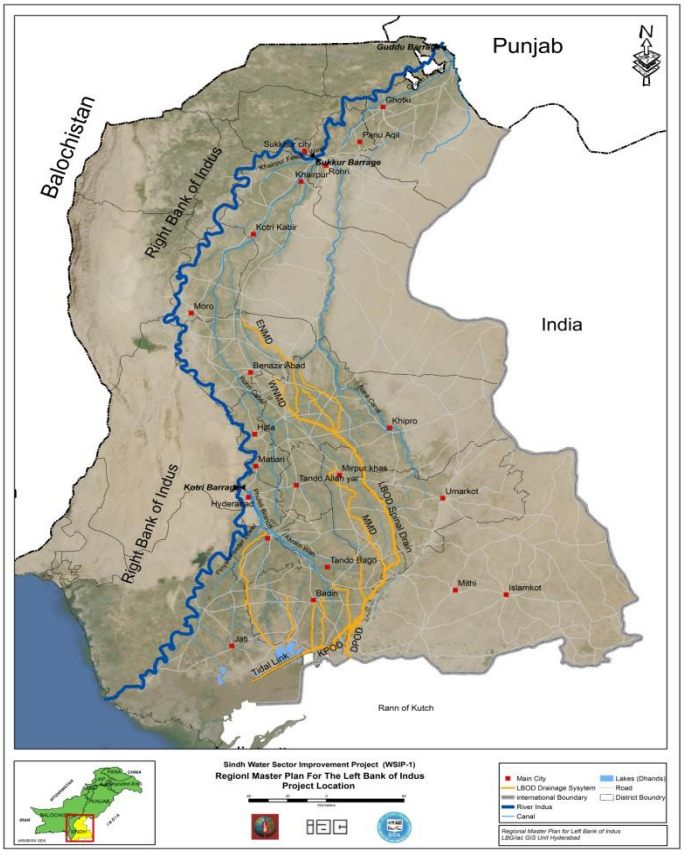


Figure-1 Project / Study Area for the Preparation of Regional Plan for the Left Bank of the Indus, Delta and Coastal Zone

1.2 Irrigation and Drainage Infrastructure

The irrigation and drainage infrastructure, however, has deteriorated over the years and is in need of rehabilitation. The irrigated agriculture from this extensive system accounts for approximately a quarter of Pakistan's GDP, two thirds of employment and about 80% of exports and is thus considered critical for the economic and social well being of the country and Sindh province in particular. Sindh however is experiencing prevailing issues associated with water logging and salinity together with drainage and flooding, hampering continued efforts towards economic

development and poverty reduction. Sindh occupies the southern portion of the Indus valley, a wide, flat plain that slopes gently toward the Arabian Sea. In southern Sindh, the Indus River flows along the western edge of this valley, and the plain slopes gently southeastwards away from the river toward the coastal zone and the sea. The proximity of this valley to the sea exposes it to frequent natural disasters including monsoon cyclones and intense rainfall and floods in addition to the droughts and earthquakes.

Sindh has very limited drainage capacity because there are no well defined rivers or streams in Sindh to convey these flood waters away from the main channel of the Indus River itself. As a consequence, flooding typically lasts a long time, destroying the crop and bringing the water table rapidly to the surface.

1.3 Waterlogging and Salinity

Nearly 30% of irrigated lands in Sindh are threatened by salinity and water logging that depress crop yields and in some cases lead to the abandonment of formerly productive land. Most of the Sindh (about 80%) is underlain by saline groundwater. Thus, water lost through seepage from canals and fields, unlike fresh groundwater areas, is wasted, and cannot be re-used by groundwater pumping. This results in shallow groundwater levels and water logging. With high evaporation rates in arid climate, salts are mobilized from lower soil profile upwards resulting in severe soil salinity. The high soil salinity in turn requires high application of irrigation water to dilute and leach the salts from soil profile to make cropping possible. This vicious cycle of "high irrigation application high seepage-shallow groundwater levels, "water logging and salinity" can only be broken by improving the drainage and irrigation management whilst significant efforts have been made to improve the drainage in Sindh (e.g construction of Left Bank Outfall Drain and tidal link), the overall drainage infrastructure for the province is inadequate with nearly 43% of the irrigated land being waterlogged, about 32% affected by salinity, and about 70% of groundwater is considered unusable for irrigation because of high salinity. This latter condition also severely constrains drinking water sources forcing people to use polluted canal water where it is available.

1.4 Institutional weakness

In addition, the institutional weaknesses in the management of the irrigation and drainage systems also compound the above mentioned problems. Institutional weaknesses manifest in the form of: (i) low surface water delivery efficiency (only about 35 - 40% from the canal head to crop root zone); (ii) water distribution inequities; (iii) wasteful on farm water use; (iv) water logging and salinity; (v) poor operation and maintenance (OM) and low cost recovery; and (v) constrained investment climate. The prevailing drainage and flooding issues in Sindh province, as briefly discussed above are complex and multi-dimensional having a direct and indirect effect on agricultural productivity, economic development and social well being. These issues combined with development demands within the region have led to the need for the preparation of a comprehensive regional plan for handling flood and drainage problems through both structural and non-structural interventions.

It is against this background and within this context that, the Government of Sindh, with support from the World Bank, initiated the Water Sector Improvement Project Phase-I (WSIP-I). The overarching objective of WSIP is to improve the efficiency and effectiveness of distribution of irrigation water in three AWBs (Ghotki, Nara and Left Bank), particularly with respect to measures of reliability, equity and user satisfaction. This would be achieved by: (a) deepening and broadening the institutional reforms that are already underway in Sindh; (b)

improving the irrigation system in a systematic way covering key hydraulic infrastructure, main and branch canals, and distributaries and minors; and (c) enhancing long term sustainability of irrigation system through participatory irrigation management and developing institutions for improving operation and maintenance (O&M) of the system and cost recovery.

1.5 Regional Plan Preparation

Preparation of Regional Plan for the Left Bank of Indus, Delta and Coastal Zone has the following key objective: "*to prepare for the Government of Sindh (GoSindh) a regional master plan for addressing the flooding issues and providing proper drainage to the area on the left bank of the Indus River through appropriate structural and non-structural measures, including remedial measures for any outstanding deficiencies in the Left Bank Outfall Drainage system, measures for retention and/or safe disposal of drainage, storm and flood water, improvement of wetlands in the delta area and in the coastal zone recognizing their environmental importance and considerable economic potential for the local communities*".

1.6 Project Location

The project is located on the left bank of River Indus, Delta of the river, and associated wetlands and adjacent coastal zone. In particular, it would cover the irrigated areas served by Indus River canals offtaking from Guddu, Sukkur and Kotri barrages, area covered by Left Bank Outfall Drain (LBOD) its catchment and backwash areas.

1.7 Issues and constraints

The water resource management issues in the Sindh province (including delta and coastal zone) are complex and multi- dimensional and require a full and comprehensive understanding / analysis of the existing issues in order to develop appropriate, feasible and publically accepted solutions towards the development objectives. Drainage systems are still inadequate and issues associated with flooding and saline soils still exist impeding the economic development process. Many of the on-going water management issues in Sindh are compounded through institutional weaknesses and a lack of capacity particularly with regards to the operation and management of the existing system often leading to inefficiencies and unreliable service delivery. In general, negative public perceptions of previous investments still remain and subsequently fostering the feeling of ownership and engaging the community / stakeholders to fully participate and support the project developments will be a key challenge.

Technical aspects:

Following points provide a summary of key technical issues for consideration for the comprehensive analysis of the problems and identification and development of solutions during the preparation of the regional plan.

a) Flat Topography and Lack of Natural Drainage.
b) Water Logging and Salinity
c) Lack of Storage Capacity and Control Structures
d) Mixed Use Water Supply for irrigation, domestic and industrial use
e) Water Losses and Water Balance
f) Low Irrigation Delivery and Application Efficiencies
g) Use of Hydrological and Hydraulic Modeling in flood / drainage planning and management
h) Rainwater Harvesting and Water Sensitive Design
i) Seawater Intrusion
j) Impacts of Hazards and Climate Change

k) Performance, Safety / Reliability of Existing Systems

Environmental aspects:

The project / study area is vast covering a range of physical environments including a number of sensitive and fragile ecosystems. The planned structural interventions will be significant in scale and have the potential for adverse environmental impacts. Accordingly, it is critically important to consider environmental issues throughout the planning and design process. Some noteworthy points are given below.

a) Water Quality Considerations
b) Environmentally Sensitive and Protected Areas
c) Impacts Upon the Mangrove Forests
d) Impacts Upon the Wetlands
e) Impacts upon the Thar Desert Ecosystem
f) Wastewater Management
g) Establishment of Baseline Data and Implementation of Monitoring Systems

Socio-economic considerations

Previous drainage investments in the project area have not received full support of the local communities. Unfortunately, during the implementation of the LBOD project, efforts to meet with local people and explain the project and its functioning, and to make adjustments and changes that people felt necessary did not begin in earnest until after construction was completed, and as a consequence the controversies have continued up to the present.

a) Participatory Approach
b) Stakeholder Engagement
c) Community Consultation
d) Communications and Education
e) Social Inclusion
f) Livelihoods
g) Transparency and Accountability
h) Resettlement and Land Acquisition
i) Establishment of Baseline Data and Implementation of Monitoring Systems

Economic aspects:

Economic considerations are essential to the long success of the project interventions. The feasibility of various structural and non-structural elements for drainage and flood management will to a large extent be determined based on economic factors. The main objective of the assignment is to improve drainage and flood management within the project area, which in turn will lead to improved water management, increased agricultural production and economic development and employment. Some key points for economic consideration are given below:

a) Capital Cost Recovery Mechanisms
b) Water and Service Charges
c) Agricultural Considerations
d) Operation and Maintenance
e) Small Grants and Community Credit Schemes
f) Associated Infrastructure to Facilitate Production and Delivery to Market
g) Creating a Reliable System and Secure Investment Climate

Institutional Aspects:

Institutional weaknesses are at the heart of many of the prevailing water management issues in the project area as given in the Project Appraisal Document. Some important points are given below.

a) Early Flood Detection, Warning and Preparedness
b) Institutional Structure of the SIDA, AWBs and FOs.
c) Human Resource Capacity of the SIDA, AWBs and FOs
d) Compliance and Enforcement
e) Clear Definition of Roles and Responsibilities
f) New Technologies and Systems

1.8 Summary of Key Issues

The water resource management issues in the Sindh province are complex and multi-dimensional and require a comprehensive analysis and consideration of various factors to identify the existing issues and develop feasible and publically accepted solutions which will improve water management and increase agricultural productivity.

a) **Phase-I:** Inventory and assessment of existing conditions and identification of issues and problems through extensive consultations with the stakeholders
b) **Phase-II:** Identification of solutions covering structural and non-structural options, and institutional and management measures and their technical environmental and social feasibility, approximate cost, workability and ranking based on pre-feasibility level studies and analysis.
c) **Phase-III:** Preparation of detailed feasibility including technical, economic, environmental and social viability and implementation/institutional arrangement for the solutions identified under Phase II as high priority; and
d) Phase-IV: Preparation of detailed designs and bidding documents for the most preferred solutions

2 Requirement for Environmental Impact Assessment

As per the provisions of Environmental Protection Act, 1997 it is mandatory to conduct the environmental assessment before executing the projects. Environmental Impact Assessment (EIA) is the process of identifying, predicting, evaluating and mitigation of the biophysical, social and the relevant effects of development project prior to major decisions to be taken and commitments made. EIA provides assessment of possible positive or negative impacts that a proposed project may have on the environment. Hence, EIA is used as a decision aiding tool rather than decision making tool.

For selected and prioritized feasibility proposals, environmental impact assessment in essentially required before their execution which will be accomplished as per World Bank guidelines and as per the EPA rules. While conducting environmental assessment of the proposed projects the potential impact of the activities in each sub project on the flora, fauna, physical environment, water and other associated issues is to be determined. The impact on the fauna and flora are more important as they affect the habitat, soil, water, physical environment and social and economic dynamics for the communities. This report pertains to the fauna of the area for which the regional plan is being prepared and the projects being executed on different fields.

2.1 Objectives of EIA & EMP

Objective of the Environmental Impact Assessment (EIA) study is to understand the prevailing physical and biological environment and prepare an EIA report including Environment Management Plan (EMP) in accordance with the guidelines issued by the World Bank and Ministry of environment government of Pakistan as a necessary requirement for obtaining environmental clearance.

The major objectives of the EIA study are listed below:

a) To establish the present environmental setting
b) To anticipate the impacts of the proposed project on the environment
c) To suggest preventive and mitigation measures to minimize adverse impacts alongside maximizing the beneficial impacts anticipated from the project
d) To prepare a detailed action plan for the implementation of mitigation measures
e) To prepare a suitable monitoring plan

2.2 Scope of Environment Impact Assessment

The study envisages characterization of the existing status of physical environment such as air, water, soil, land use, meteorology, socio-economic and heritage etc. as well as biological environment such as flora and fauna of the study area quantifying impacts on the environmental parameters. Based on the study, the EIA evaluates the proposed control measures by the project and prepares an environment management plan, outlining additional proposed activities and delineates the requirements of environmental monitoring program. EIA study shall cover the following aspects:

a) Evaluation of present environmental factors through analysis of generated and collected baseline data
b) Assess the probable impact on the environmental factors due to implementation of the project with respect to existing scenario.
c) Analyze the predicted impacts with respect to the regulatory environmental standards.
d) Assess the probable risk in the project area.

e) Develop an Environmental Management Plan and on site Disaster Management Plan for the proposed project to mitigate the negative significant impacts that would arise from the proposed project.

Baseline data on parameters of the above-mentioned aspects provides means for identifying possible impacts, positive as well as adverse. An environmental impact assessment and environment management plan comprising an overall assessment of the impact due to project activity over baseline condition of the existing environment and a mitigating action plan to counter the adverse impact as defined. An environmental monitoring program is also prepared to provide scientific support to future actions of environmental protection.

2.3 EIA Methodology and Fieldwork

Methodology adopted for accomplishment of baseline and impacts of interventions

Collection of primary data

Detailed field visits of the project area for which master plan is being proposed was conducted to assess the floral composition through best professional judgment and focused groups meetings with local village communities to get basic information with respect to existing fauna, impact of proposed activities of the sub-projects and mitigation measures required for the adverse impacts if any. The information collected from the field was processed analyzed and incorporated in the report.

A detailed program of field visits of Talukas Tando Allahyar, Chambar, Digiri, Kot Ghulam Muhammad, Samaro, Umarkot, Pithoro, Dhoro Naro, Mirpur Khas, Tando Bago, Jati, Golarchi, Badin, Sujawal, Matli, Matiari, Hala, Saeedabad, Sanghar, Shahdadpur, Tando Adam, Nawabshah, Sakrand and others were undertaken. A survey questionnaire with specific and objective type questions was prepared and tested.

During the field visits 40 villages were visited and consultations were made with about 1000 village inhabitants throughout the study area.

Predominantly the project area can be divided into following belts/zones

1. Coastal zone located in left bank of River Indus in Thatta and Badin districts.
2. Area from where old natural water ways used to flow. Major water ways identified by the drainage consultants of LBG are: (1)Dhoro puran (2) Dhoro Naro (3) Hakro dhoro (4) Sarfaraz dhoro (5) Sohni dhoro and other minor Dhoras.
3. Areas covered under vertical drainage. These areas were undertaken under SCARP. Tube wells, both saline and fresh water in the LBOD command area, Ghotki saline zone, Khairpur Tile Drainage and Rohri north and south tube well projects.

Surface /subsurface drainage through LBOD system includes 3 components i.e Nawabshah component, Sanghar component and Mirpurkhas component. There is a network of drainage system covering main drains, lateral drains, sub drains, LBOD spinal drain, KPOD in district of Benazirabad, Sanghar, Mirpurkhas and Badin.

Project Area:

The project area for the left bank of Indus, delta and coastal zone consists of irrigated areas of three Area Water Boards (AWBs), namely Ghotki Feeder, Nara Canal and Left Bank Canals (Akram Wah and Fulleli Canal commands) that have been already established and functioning.

Scope of Assignment:

As per the TORs, the scope of the assignment is as under:

a) Prepare an overall Environmental Assessment (EA) including and Environmental Management Plan (EMPs) which will be prepared in compliance with the Pakistan, Government of Sindh and World Bank Guidelines and Operational Polices (OP 4.01).
b) Collect necessary data and information and prepare all the environment related documents for all works to be implemented under the project that may be necessary for getting location, construction and other permits for constructing works and carrying out activities.
c) Assist with the operationalization of the findings of the EAs and EIAs and implementation of Environment Management Plan (EMP) plans for any adverse impact of the construction activities, and operation of the project may have on the environment. EMP would consist of mitigation measures, monitoring program and institutional development/strengthening program for implementation of EMP.
d) Prepare implementation of EMP, scope of work, terms of reference and a plan of how various mitigating measures would be implemented either through modification of construction contracts for project facilities or through additional works for which consultants would prepare designs or through technical assistance and training which the consultants would carry out for operation of the project facilities. Also, include the cost of enhancement measures for the anticipated positive impacts of the project proposed interventions.

2.4 Physiography of the Study Area

Sindh lies largely in the delta of the lower Indus basin, connected on three sides with areas of marked geographical contrasts. On the west, it rests against the slopes of Kirthar mountains bordering the Iranian tableland. Towards the east, it passes into the great desert of Thar, beyond which lie the Aravalli Range. At the base of the deltaic triangle it has the Arabian Sea-bed. In the North, narrow apex of Sindh penetrates into the plains of the Five rivers of Punjab. Sindh is about 360 miles long from North to South and nearly 275 miles in its extreme breadth (175 miles average). It covers an area of about 53,000 sq. miles.

Sindh is essentially a gift of the River Indus. Its flowing length in Sindh is about 580 miles. It bisects Sindh, overflowing on both east and west valley regions to form the rich alluvial areas with forests and agricultural lands. The Indus delta region has been continuously growing reclaiming lands during historic times. Sindh has a flat low-level country topography with some hills in the distance (i.e. Halar and Sulaiman ranges of Kirthar) in the west and Aravalli in the east. Some isolated limestone rock formations are also evident near Sukker, Hyderabad and other areas. Its soils are deltaic valley soils; with sands more and more prominent as one goes towards the sea-board. Its rock are marine, with plenty of proofs of the presence of a sea which once lay between the two hilly regions of geologically different formations and age, viz., the Khirthar and the Aravallis (also called as Karonjhar). Phisiographically, Sindh can be divided in three vertical almost parallel sections:

a) Western highlands- comprising of the Kirthar Mountains and Sindh Kohistan extending from Sulaiman range in the North all the way to sea-board in the South.
b) Lower Indus valley- consisting of western and eastern valley sections and the deltaic area.
c) Eastern Desert- including Pat section and the Thar area.

The Landscape: From north to south, Sind assumes a pattern of three parallel belts. A central stretch of rich alluvial plain bisected by the long, winding, silvery line of the Indus, flanked on the west by the rocky range of the Khirthar Range and bounded on the east by a sandy desert

belt. The Khirthar Range consists of three parallel tiers of ridges. The easternmost section is steep on the west but has a long gradient to the east. The central ridge has flat tops and rounded sides broken by deep ravines and fissures, whereas the westernmost tier consists of a vast plateau or tableland with some peaks rising above 7,000 feet. This mountainous belt has little soil and is mostly dry and barren. The easterly desert region first appears in the north as low dunes and vast flats. Continuing southward, the Achhrro Thar (White Sand Desert) occurs in the middle of the belt and is followed by the Thar Desert in the southeast.

The central riverine belt - 360 miles long and about 20,000 sqare miles in area - constitutes the Valley of the Indus. The fertile plain, gradually sloping down from north to south, in its long gradient forms the three flat regious known as siro (the upper), vichole (the middle), and larr (the lower). The variety of soils includes pakki, or patt, the flat level land of old alluvial forming the northern strips of the Sukkur, Jacobabad, and Larkana districts; reti-wari, the soft reddish rocky soil of the belt skirting the northwesterly rocky range; kacho, the fertile silt alluvial in the narrow inundated belt of the Indus; wariasi, an admixture of soft clay and sand; chiki, the composite fine clay and soft sand on both sides of the inundated belt; and kalar, or alkaline soil, found mostly in the larr region.

2.5 Climate of the StudyArea

Sind is hot in the summer and cold in winter. Temperatures frequently rise above 115 F (46 C) between May and August, and the minimum average temperature of 36 F (2 C) occurs during December and January. The annual rainfall averages about seven inches, falling mainly during July and August. The southwesterly monsoon wind begins to blow in mid-February and continues until the end of September, whereas the cool northerly wind blows during the winter months from October to January. Sindh is said to be between the two monsoons - the southwest from the Indian Ocean and the Northeast or the retreating monsoon, deflected towards it by Himalayan mountains- and escapes the influence of both. The average rainfall in Sindh is only 6 to 7 inches per year. But what is lost by the region during the two seasons is, however, regained for it by the Indus, in the form of inundation, caused twice a year, by the spring and summer melting of Himalyan snow and by rainfall in the monsoon season. It should be noted that these natural patterns have since been somewhat changed due to man-made dams and barrages that have been constructed on river Indus.

Climatically, Sindh is divided in three sections - Siro (Upper section centered at Jacobabad), Wicholo (Middle section centered at Hyderabad), and Lar (Lower section centered at Karachi). In Upper Sindh, the thermal equator passes through Sindh. The highest temperature recorded was 127 Degrees F in 1919. The air is generally very dry. In winter frost is common. In middle Sindh, average monsoon wind speed is 11 miles/hour in June. Temperature is lower than Upper Sindh but higher than the Lower Sindh. Dry hot days and cool nights are summer characteristics. Maximum temperature reaches 110-112 Degrees F. The Lower Sindh is effected by the coastline and is damper, humid, SW winds in summer and NE winds in winter and generally the climate is maritime with rainfall little less than the Middle Sindh. The maximum temperature reaches 95-100 Degrees F. In the Kirthar range at 6,000 ft and higher on the Gorakhnath and other peaks in Dadu district, temperatures near freezing have been recorded and brief snow fall is received in winters.

2.6 Topography of the Study Area

The general slope of study area is flat and is considered as level to nearly level with an average gradient 0.75 ft per mile. The contours are almost at right angles to the river from Guddu Barrage to Nawabshah, and this has been the zone of the most persistent movement of the river course in the past. In Guddu barrage left command there are number of drainage lines, especially in the desert fringe, running south-west wards, towards the head reaches of Nara Canal. South of Nawabshah the valley broadens and general slope is to the south-east, towards Nara and eastern flanking trough of the valley. Likewise the old river courses fan out in this direction with several drainage lines between them, the most important drainage line is the Dhoro Puran, which runs south-east of from Mirpur Khas to the old Nara bed (Dhoro Nara), and eventually into Rann of Kutch. However, the Nara itself does not run along the lowest line for its entire length, as the ground level continues to fall eastwards, towards the Thar Desert, resulting in several lakes between the sand hills. On the left bank the old bed of Nara was utilized as a canal as early as 1859 and was connected to Sukkur barrage in 1932. Further south the alignment of the Fuleli canal runs on the ridge caused by the change of slope of the ground from south east to south.

2.7 Agro-climatic zones

On the basis of agro-ecology, Sindh province is divided into three main zones Figure-2.
Zone-A: The Right Bank of river Indus (upper Sindh).

a. Sub-Zone A1 Main area
b. Sub-Zone A2 Piedmont soil region

Zone-B: The left bank of river Indus.

a. Sub-Zone B1 Guddu Barrage command area
b. Sub-Zone B2 Sukkur Barrage command area

Zone-C: Lower Sindh.
In addition to the above three agricultural zones, there are two more zones in Sindh i.e., zone-D is a desert area in the east of Sindh, and
zone-E is the western hilly zone.

The fresh ground water is only available in zone- A and partly in zone-B; however, in zone- C, zone- D fresh ground water is very limited.

Figure-2 Agro-ecological Zones of Sindh (IIRE)

The left bank can be delineated into wheat-cotton-sugarcane zone that encompasses Guddu and Sukkur barrage commands, and mainly grows dry crops, wheat, cotton, sugarcane, oilseeds, millets, guar gum, etc. The main fruits grown in this zone include dates, mangoes, banana, guava, etc. The Kotri barrage command, mostly with non-perennial canal supplies, is marked out as wheat-paddy-sugarcane zone. This zone is best suited for sugarcane, paddy, oilseeds, and pulses. As the canal supplies are not available during winter (*Rabi*), wheat is grown with residual moisture. Banana is the main fruit grown in this zone. Towards the south, vegetables, coconut, guava, and oil palms are grown. The third zone is the non barrage areas,

mainly Nara and Thar deserts. This area grows rain-fed crops such as millets, pulses, cluster been, oilseeds, and some wheat.

2.8 Soils of Left Bank Area

The soils of the Left Bank area are mainly formed by alluvial sediments deposited by Indus River. Only the old dissected desert on eastern border of Left bank contains an admixture of aeolian sand transported from Rann of Kutch, later on dissected by river Indus. The extreme lower Southern part of Badin area is a mixture of river alluvial and sea deposits.

2.9 Soil Textural classification

The latest survey conducted by Soil and Reclamation Directorate SCARP Monitoring Organization WAPDA during 2005, following the criteria used in Soil Survey Manual Agriculture Hand Book 18. The Textural groups and their corresponding five soil series recognized and mapped by WAPDA are listed in Table-1.

Table- 1 Soil Textural Groups

S.No	Textural Group	Soil Series	Textural Classes	Characteristic
1.	Coarse	Jhang	Sand and Loamy sand	Soils are excessively drained and had very low nutrient and Water holding capacity.
2.	Moderately Coarse	Farida	Sandy loam and Fine sandy loam	Fairly retentive of moisture for plant nutrients. Potentially productive and capable of producing normal yields crops under good management. Not advised for raising high delta crops.
3.	Medium	Buchiana	Loam, Silt loam and Silt	Soils are moderately permeable and well retentive of moisture for plant nutrients, these have a high productivity potential and can grow wide variety of crops.
4.	Moderately Fine	Chuharkana	Sandy clayloam, Clay loam and Silty clay loam	Soils are moderately permeable and retain good quantity of moisture for plant nutrients. These are suited to grow high delta crops.
5.	Fine	Nokhar	Sandy clay, Silty clay and Clay	These soils have low permeability and develop cracks on alternative drying and wetting and pose difficulty in workability. These are mostly used for high delta crops.

The investigations carried out throughout the Left Bank of Indus used one to two sites per square mile. These locations were augured up to 180cm depth for textural classification. For mapping purpose, the data of previous survey by LIP & MP&RD WAPDA was used and maps prepared by using GIS technology. Overall and command wise acreage and their percentages of five (5) textural groups are given in Table-2

Table- 2 Command wise & Total area of Left Bank under different Textural Groups

S. No	Main Canal	Area in Acres	Percent of each Textural Group					Miscellaneous	Total	Remarks
			Coarse Texture	Moderately coarse texture	Medium Texture	Moderately Fine texture	Fine			
1.	Ghotki Feeder	304286	8.0	11.0	26.0	46.0	-	9.0	100	The miscellaneous Land type mostly covers the urban areas, grave yards, canal, drains and other Linear features.
2.	Nara Canal	1286746	3.0	20.0	43.0	29.0	-	5.0	100	
3.	Rohri Canal	998588	5	11.0	46.0	32.5	-	5.5	100	
4.	Khairpur Feeder East	506000	18	11.0	49.0	18.0	-	4.0	100	
5.	Khairpur Feeder West	300000	1.0	44.0	25.0	18.0	5.0	7.0	100	
6.	Pinyari	548672	3.0	23.0	31.0	29.0	-	14.0	100	
7.	Fuleli	74726	1.0	14.0	38.0	42.0	-	5	100	
8.	Lined (Akram Wah)	339108	0.5	11.5	36.0	39	-	13	100	
Total Left Bank Command area		9708725	5.0	18.0	37.0	32.0	-	8	100	

It is obvious from the table that as a whole, the dominant textures within the study area is medium Textured (37.0% Buchiana Series) and moderately fine textured (32.0% chuarkana), whereas minor part of area covered by moderately coarse textured (18% Farida) and coarse textured (5.0% Jhang) soils.

Soils Surface Salinity Status of Left Bank area

Command wise surface salinity status was observed during the S&R studies conducted by WAPDA Water Wing Scarp Monitoring Organization (SMO) South in 2005. These are the latest studies conducted by this organization; later on such type of studies has not been conducted by any organization. Hence on the basis of that data is collected, processed and presented for each canal command and on over all basis the whole of Left Bank area is shown in Table-3.

Total four categories namely Non-saline, slightly saline, moderately saline and strongly saline were recognized and mapped. The categories criteria for classification are according on soil survey manual Agricultural Hand Book 18. These classes are briefly described as under.

Table -3 Left Bank Command Wise Salinity Status of the Area

S. No	Main Canal	Area in Acres	Salinity Class- ECe dS/m at 25° C (% of area)				Miscellaneous area Total	Total
			Non-Saline 0-4	Slightly saline 4-8	Moderately saline 8-15	Strongly Saline > 15		
1.	Ghotki Feeder	984795	73	6.0	3.0	9.0	9.0	100
2.	Nara Canal	2431394	29	23	10	33	5.0	100
3.	Rohri Canal	998588	57	22	6.0	9.5	5.5	100
4.	Khairpur Feeder West	300000	72	13	4.0	4.0	7.0	100
5.	Khairpur Feeder East	506000	61	17	7.0	6.0	9.0	100
6.	Pinyari	981207	22	19	5.0	40	14	100
7.	Fuleli	1045651	44	21	10	20	5.0	100
8.	Lined Channel Akram Wah	531965	27	23	15	22	13	100
9.	Total area of Left Bank Command	9708725	48	18	7.5	18	8.5	100

1. Non Saline:

There are no visible salts on the soil surface and plant growth is not affected by salinity, this type of area covers about 48 percent of the total area in Left Bank.

2. Slightly Saline:

Plant growth is uneven patchy, salts are mostly present in patches and cover about 18 percent of the total area.

3. Moderately Saline:

Salts are fairly visible on the soil surface and growth of plants is affected and covers 7.5 percent of the total area.

4. Strongly Saline:

There is no cultivation except some salt loving natural vegetation. Mostly this area is lying abandoned and covers about 18 percent of the total area.

5. Miscellaneous Land type:

This is most important unit and includes built up area like cities, town, road, railway, canal drains and Industrial areas. It covers about 8.5 percent of the area.

2.9.1 Land use of the study area

Background:

Land use surveys have been carried out in the past by a number of Govt/ semi Govt agencies. These surveys have been conducted at different periods, using different methodologies and

classification criteria, depending upon the Land use situation of the area. The data produced is of high value and still serves as a base line for the forthcoming surveys, but it lacks both in uniformity and adequacy, hence in order to have a comprehensive soil survey of the Indus region a major program for fresh and updating the data was highlighted in Drainage Sector Environmental Assessment (DSEA) report for launching a National Drainage Program. In perspective of that a country wide survey was initiated for evaluating different aspects of Physical resources by using the latest technology, and Land use studies were one of them. These Studies were conducted by the Soils and Reclamation Directorate SMO under NDP program from 2000 and ended to 2005.

The above Studies were conducted on Canal command basis, and covered 14 canals of Right and Left bank of Guddu, Sukkur and Kotri barrages. For our Studies only the data of left bank command of eight (8) Canals offtaking from three (3) barrages have been collected, processed and documented.

2.9.2 Methodology used for Land use classification

The main objective of this survey was to map the different categories of Land use, mainly depending upon the availability of irrigation Water, nature of relief/ topography, types of soils, climate and management Table-4. Besides the socio-economic factors have also great influences on the Land use. For conducting Survey/ investigation SPOT images of 1:50,000 scale and Ground Topo sheets at the scale of 1:50,000 were used for appraisal and delineation of different categories and determination of over all status of the prevailing Land use. The main classes of Land use recognized and mapped in the eight Canal Command areas falling on the left bank of Indus for three barrages are presented in a tabular from (Table-4) individually described as under:

Cultivated Land

1. Perennially Canal Irrigated
2. (a) Non perennially Canal Irrigated

   (b) Canal Irrigated supplemented with Tubewells
3. Forest
4. Un productive Land
5. Miscellaneous Land type

Cultivated Land

This type of Land under each Canal Command has been found in normal conditions having no or a negeable hazard of salinity, high topography and shortage of irrigation water during low supplies from canal systems. Over all 6767289 acres (69.7%) of Canal commands of Indus Left bank study area are cultivated mostly by canal irrigation supplies, how ever within the fresh ground water zone are also being supplemented by Tube well irrigation system. This class is further bifurcated into three major categories as shown in Table-4 and mentioned as under.

3.1 Perennially Canal irrigated

3.2 Canal Irrigated supplemented by Tube wells.

3.3 Non perennially Canal Irrigated

Perennially Canal Irrigated

The major part of Land served by eight canal commands of three barrages of Indus left bank fall under this category covering an area of about 3299362 acres (34%). Mostly within this category all type of Kharif & Rabi crops are sown, however *major* cash crops are cotton, wheat, Rice and Sugar Cane. In some parts near the urban areas vegetables, fodder is sown for commercial purpose. The most of area is cultivated by mechanized farming

Non- Perennially canal Irrigated Lands

On Left bank area out of Eight Canals, the three major canals Ghotki feeder, Pinyari and Fuleli offtaking from Guddu and Kotri barrages respectively are non-perennial and are opened during the Kharif Supplies (summer season). However, the Ghotki feeder offtaking from Guddu Barrage is mostly supplying the irrigation water through out the year, even then this Canal is considered as non-perennial. Overall acreage under these Canal commands is almost 1593684 (16.4%) acres. In Kharif the Land is mostly under use of Rice, Sugarcane and Cotton crops, where as wheat and pulses are sown on moisture conserved by the soil after the rice harvesting and further supplemented by one or two irrigations during the required period by the crops. Most of the area is under mechanized farming.

Canal Irrigated supplemented with Tube Wells

The area under this system is benefited by two way irrigation system. Mostly these Lands lie in fresh ground water zone and are supplemented by tube well irrigation. The over all area under this category are served by this systems is about 1874243 acres (19.3%). As the area within this unit has no shortage of Irrigation water, therefore Lands are capable to grow all suitable crops including orchard, vegetables under the required climate conditions.

Forest

This category covers a very small area about 41531 acres (0.42%) of the study area this is because of the deforestation trend in the area & no further plantation up to the requirement is being planted either by public or private sector, only a little interest is taken by the forest department for the survival of remaining forest reserves in the area.

Presently unproductive Lands

This category is one of the most important, because most of the Lands due to some hazard are lying as such and are classified un-productive Lands. This category includes the sand dunes, highly saline Lands, waterlogged (under water) and high topographic soils which are not under the reach of irrigation system. These Lands over all occupies about 2210780 acres (22.88%) within the left bank command area. such type of Land only supported natural vegetation for grazing animals.

***Miscellaneous Land type*:** A mapable area is covered by this class which includes the villages, Towns, Cities, grave yards, industries and the linear features like road, railways, canal, drains etc. The total area under this category is about 689125 acres (7%) of the Indus left bank Study area.

Table-4 Land use Categories of Study area

S No	Name of Canal	Cultivated Canal Commanded Area					% of area	Forest	% of area	Un productive Land	% of area	Miscellaneous Land type	% of area	Total Area	% of area
		Perennially Canal Irrigated Land	% of area	Non Perennially Canal Irrigated Land	% of area	Canal irrigated+ Tubewell irrigation				Sand desert + under water + saline Land		Urban area + Grave yards+ Road+ Canal etc			
1	Ghotki Feeder	-	-	304286	31	392846	40	19666	2	177997	18	90000	9	984795	100
2	Khairpur feeder East	414920	82	-	-	15180	3	-	-	30360	6	45540	9	506000	100
3	Khairpur feeder West	260000	86.7	-	-	18000	6	-	-	1000	0.3	21000	7	300000	100
4	Nara	1286746	53	-	-	170000	7	18966	1	837682	32	118000	5	2431394	100
5	Rohri Canal	998588	34.3	-	-	1278217	44	1638	0.2	491180	16	158090	5.5	2927713	100
6	Lined channel (Akram Wah)	339108	64	-	-	-	-	-	-	120962	22.5	71895	13.5	531965	100
7	Pinyari	-	-	548672	56	-	-	1261	0.4	297674	30	133600	13.6	981207	100
8	Fuleli	-	-	740726	71	-	-	-	-	253925	24	51000	8.17	1045651	100
Total		**3299362**	**34.0**	**1593684**	**16.4**	**1874243**	**19.3**	**41531**	**0.42**	**2210780**	**22.88**	**689125**	**7.0**	**9708725**	100

3 Policies and Legal Framework

Pakistan's Environmental Policy is based on participatory approach to achieving objectives of sustainable development through legally, administratively and technically sound institutions. The Pakistan Environmental Protection Act was enacted on 6th December 1997 to provide for the protection, conservation, rehabilitation and improvement of environment, for the prevention and control of pollution, and promotion of sustainable development. The Act particularly focuses on implementation of Council's policies, delegation of powers to government agencies, enforcement of national Environmental Quality Standards, introduction of EIA/IEE review procedures/system, regulatory regime for hazardous substances/wastes, resource generation through establishment of Provincial Sustainable Development Fund and levy of Pollution Charge and providing appellant forum for environmental cases.

National Conservation Strategy

The Federal Cabinet's approval of National Conservation Strategy (NCS) on 1 March 1992 was a major milestone in Pakistan's environmental history. The NCS has three overriding objectives: conservation of natural resources, sustainable development, and improved efficiency in the use and management of resources. These, in turn, depend on three principles: achieving greater public partnership in development and environment management; merging environment and economics in decision-making; and focusing on durable improvements in the quality of life in Pakistan.

Besides the development of institutions such as the Environment Section in the Federal Planning and Development Division, and the Sustainable Development Policy Institute, there is substantive tangible evidence of the Strategy's implementation. This includes the formulation of provincial and district conservation strategies, the establishment of Environment Protection Agencies at the federal and provincial levels and the addition of a regular chapter on the environment in the national five-year plans.

Pakistan-National Conservation Goals

The National Conservation Strategy in itself is a "call for action" addressed to central and provincial governments, businesses, nongovernmental organizations (NGOs), local communities, and individuals. The sustainable development of Pakistan is viewed as a multigenerational enterprise. In seeking to transform attitudes and practices, the National Conservation Strategy recognizes that two key changes in values are needed: the restoration of the conservation ethic derived from Islamic moral values, called qanaat, and the revival of community spirit and responsibility, haquq-ul-abad.

The National Conservation Strategy Report recommends fourteen program areas for priority implementation: maintaining soils in croplands, increasing efficiency of irrigation, protecting watersheds, supporting forestry and plantations, restoring rangelands and improving livestock, protecting water bodies and sustaining fisheries, conserving biodiversity, increasing energy efficiency, developing and deploying renewable resources, preventing or decreasing pollution, managing urban wastes, supporting institutions to manage common resources, integrating population and environmental programs, and preserving the cultural heritage. It identifies sixty-eight specific programs in these areas, each with a long-term goal and expected outputs and physical investments required within ten years. Special attention has been paid to the potential roles of environmental NGOs, women's organizations, and international NGOs in working with the government in its conservation efforts. Recommendations from the National Conservation Strategy Report are incorporated in the Eighth Five-Year Plan (1993- 98).

Pakistan Environmental Protection Act, (PEPA) 1997

This Act stands at the apex of statutory law on environmental issues in Pakistan and takes precedence over all preceding federal and provincial legislations in setting nation–wide environmental standards and in laying down policies and procedures under the Pakistan National Conservation Strategy (PNCS). Pakistan Environmental Protection Council (PEPC), the apex body, established under this Act is responsible for comprehensive national environmental policy for mutation and legislation, and their implementation within the framework of the PNCS. Specifically, PEPC is empowered to approve National NEQS. Pak EPA is established to administer the PEPA, 1997. The Act is the guiding document in carrying out the environmental and social assessments.

National Environmental Quality Standards

Pak EPA with prior approval of the PEPC, established and issued NEQS vide Gazette of Pakistan Notification SRO 742 (1) 93 dated 24 August 1993. These NEQS were related to municipal and liquid industrial effluents, industrial gaseous emissions and motor vehicle exhaust and noise. These were revised and new standards were established in the Gazette of Pakistan as Notification SRO 549/ (1) /2000 of 8 August 2000. The NEQS specify the following standards:

Maximum allowable concentration of pollutants (32 parameters) in municipal and liquid industrial effluents discharged to inland waters, sewage treatment facilities, and the sea (three separate sets of numbers)

1. Maximum allowable concentration of pollutants (16 parameters) in gaseous emissions from industrial sources.
2. For power plant operating on oil or coal:
    a. Maximum allowable emission of sulfur dioxide from the power plant
    b. Maximum allowable increment in concentration of sulfur dioxide in ambient air due to operation of the plant
    c. Maximum allowable concentration of nitrogen oxides in ambient air when the plant is operating
    d. Maximum allowable emission of nitrogen oxide for steam generators as a function of heat input
    e. Maximum allowable concentration of pollutants (2 parameters) in gaseous emissions from vehicle exhaust and noise emission from vehicles.

Institutional Setup

Soon after the enactment of new law, Ministry of Environment, Local Government and Rural Development set its priorities to operationalize its provisions. The following series of actions were taken:

The following rules and regulations are in place:

i) National Environmental Quality Standards (Self-monitoring and Reporting by Industries) Rules, 2001.
ii) Environmental Samples Rules, 2001.
iii) Provincial Sustainable Development Fund Board (Procedure) Rules, 2001,
iv) Pollution Charge for Industry (Calculation and Collection) Rules, 2001.
v) National Environmental quality Standards (Environmental Laboratories Certification) Regulations, 2000.
vi) Pakistan Environmental Protection Agency (Review of IEE/EIA) Regulations, 2000.

vii) National Biosafety Rules, 2005
viii) Hospital Waste Management Rules, 2005

The following rules/regulations are notified:

1. Provincial Sustainable Development Fund (Utilization) Rules, 2002
2. Composition of Offences and Payment of Administrative Penalty Rules 2002
3. Hazardous Substances Rules, 2002

Delegation of Powers to Provincial Governments under section 26:

Ministry of Environment, Local Government and Rural Development had delegated functions and powers of it and the Federal Environmental Protection Agency under section 26 of the Act to the Provincial governments. The Provincial Governments have further delegated these powers and functions to Environmental Protection Agencies and also planning to sub-delegate selected powers to the local government.

Establishment of Environmental Tribunals under section 20:

The Federal Government has established two Environmental Tribunals one each in Karachi and Lahore. The Karachi Tribunal has jurisdiction over the Sindh and Balochistan provinces while Lahore Tribunal covers Punjab and new Provinces. It is intended to establish three more Tribunals so as to have independent Tribunal in each province and at the federal capital.

Designation of Environmental Magistrates under section 24:

The Federal and Provincial governments have designated senior civil judges as Environmental Magistrates to take all contraventions punishable in respect of handling of hazardous substances and pollution caused by motor vehicles.

Certification of Environmental Laboratory under section 6(l)(k):

An Environmental Laboratory Certification Regulation 2000 has been notified whereby a network of ethnically sound laboratories is being established through out the country. The certified laboratories will be authorized to test environmental samples and assist public and private sector to get their levels of emissions tested.

Establishment of Sustainable Development Board/Fund:

The Governments of Punjab, NWFP and Balochistan have reported establishment of Sustainable Development Board/Fund under section 9 and 10 of the Act. The Governors of NWFP and Balochistan have approved grant of Rs. 5.0 million for the Sustainable Development Fund in their respective province.

Pakistan Environmental Protection Council

The Pakistan Environmental Protection Council (PEPC) was first constituted in 1984 under section 3 of the Pakistan Environmental Protection Ordinance, 1983 with President of Pakistan as its Chairman. In 1994, an amendment was made in the Ordinance to provide for the Prime Minister or his nominee to be the head of the Council. The Council was reconstituted after enactment of the new law i.e. Pakistan Environmental Act 1997. Pakistan Environmental Protection Council is an apex statutory body. The Chief executive is the Chairperson of the Council and the Feral Minister for Environment, Local Government and Rural Development as its Vice Chairperson and Governors of all the provinces are its members besides others. The

council is represented by trade and industry, leading NGOs, educational intuitions, experts journalists and concerned ministries.

The Sindh Fisheries Ordinance, 1980

The Sindh Fisheries Ordinance, 1980 regulates fishing in the public waters, including the coastal areas, of Sindh. It empowers the government of Sindh to issue licenses for fishing in public waters, put restriction on the type of equipment that can be used for fishing, restrict fishing in certain areas or of certain species of fish, regulate the onshore trade of fish catch, and regulate the fish processing industry. Article 8 of the Ordinance prohibits the discharge of wastewater to public waters without the consent of the Director Fisheries. A copy of the EIA report will be sent to the Director Fisheries, Government of Sindh for his consent when the report is submitted to the SEPA for environmental approval.

Forest Act, 1927 and Later Amendments

This Act establishes the right of the Government to designate areas for reserved forest, village forest and protected forest and may acquire such areas for prohibiting or restricting the public use of the resources or other activities.

Protection of Trees and Brushwood Act, 1949

This Act prohibits cutting or lopping of trees and brushwood without permission of the Forest Department. In case of invoking of this Act, the Forest Department will be approached to seek its permission for cutting of trees.

The Antiquities Act, 1975 and the Sindh Cultural Heritage (Preservation) Act, 1994

The Antiquities Act of 1975 ensures the protection of Pakistan's cultural resources. The Act defines 'antiquities' as ancient products of human activity, historical sites, or sites of anthropological or cultural interest, national monuments, etc. The Act is designed to protect these antiquities from destruction, theft, negligence, unlawful excavation, trade, and export. The law prohibits new construction in the proximity of a protected antiquity and empowers the Government of Pakistan to prohibit excavation in any area that may contain articles of archaeological significance. Under the Act, the project proponents are obligated to ensure that no activity is undertaken within 61 m (200 ft) of a protected antiquity, and to report to the Department of Archaeology, Government of Pakistan any archaeological discovery made during the course of the project. The Sindh Cultural Heritage (Preservation) Act, 1994 is the provincial law for the protection of cultural heritage. Its objectives are similar to those of the Antiquity Act, 1975. No antiquity protected under these two laws was identified in the vicinity of the proposed project.

Sindh Local Government Ordinance

These ordinances were issued under the devolution process and define the roles of the district governments. Theses ordinances also address the land use, conservation of natural vegetation, air, water and land pollution, disposal of solid waste and wastewater effluents, as well as matters relating to public health. Under the new system of district governments, the Executive District Officer- Revenue (EDO-Revenue) is the Revenue Officer for the district.

Under Clause 48 of the 6th Schedule of this Ordinance, the local governments are empowered to restrict any project causing pollution to air, water or land. They may also initiate schemes for improving the environment vide this legislation. In case of this project, the local government

offices at union council level will be monitoring the project activities relating to environmental and social aspects.

Agreements, Protocols and Understandings at International Level

a) On international level, Pakistan is signatory to a number of agreements, protocols and understandings. Some of these are:
b) Framework Convention of climate change (New York, 1992).
c) Convention on Biological Diversity (Riode Janeiro, 1992).
d) Convention on Wetlands of international importance, especially as Waterfowl Habitat (RAMSAR, 1971)
e) Convention on Conservation of Migratory species of Wild Animals (Bonn, 1979) as a follow up to RAMSAR, 1971.
f) Protocol on substances that deplete the Ozone layer (Montreal, 1987)

3.1 *National Environmental Guidelines and Legislation - Pakistan Environmental Protection Act 1997*

The Pakistan Environmental Protection Act, 1997 (PEPA) is the basic legislative tool empowering the government to frame regulations for the protection of the environment. The PEPA is broadly applicable to air, water, soil, marine and noise pollution, as well as the handling of hazardous waste. Penalties have been prescribed for those contravening the provisions of the Act. The PEPA (as of August 2000) categorizes projects based on policy and guidelines required for filing, review and approval of environmental assessments as follows:

i. Environmental Impact Assessment (EIA) - Projects identified in Schedule A.
ii. Initial Environmental Examination (IEE) - Projects identified in Schedule B.
iii. Not requiring EIA or IEE - Projects identified in Schedule C.

The Physical works of the WSIP consist of rehabilitation and improvement of minors, distributaries and canals, which fall under Schedule "B" according to PEPA. Nonetheless, detailed environmental assessment of the WSIP-I sub-projects which consist of rehabilitation and improvement of minors, distributaries and canals, will be done at their detailed designing stage and EA reports will be submitted to Sindh EPA if required. On the other hand, package/contract would be submitted to Sindh EPA if the distributary/minor improvements are on channels located within or proximity to the protected area. In case of main/branch canals improvements consisting of large contract, each EA would be submitted to Sindh EPA.

Sindh Wildlife Protection Ordinance 1972 and Amendments of 2001

This ordinance provides for the preservation, protection, and conservation of wildlife by the formation and management of protected areas and prohibition of hunting of wildlife species declared protected under the ordinance. The ordinance also specifies three broad classifications of the protected areas:

National Parks - Hunting and breaking of land for mining are prohibited in national parks, as are removing vegetation or polluting water flowing through the park

Wildlife Sanctuaries - Wildlife Sanctuaries are areas that are left as undisturbed breeding grounds for wildlife. Cultivation, grazing and residing is prohibited in the demarcated areas. Special permission is required for entrance of general public. However, in exceptional circumstances, these restrictions are relaxable for scientific purpose or betterment of the respective area on the discretion of the authority.

Game Reserves - Game reserves are designated as areas where hunting or shooting is not allowed except under special permits.

3.2 *The Sindh Water Management Ordinance 2002*

The Government of Sindh has promulgated the Sindh Water Management Ordinance 2002 (SWMO 2002) on October 26, 2002. SWMO 2002 provided a framework for institutional reforms in water sector by decentralizing the water resources management and irrigation and drainage services. Under the SWMO 2002, SIDA has been established at the provincial level for overall water resources management with a board coming from stakeholders. Similarly, the AWBs are established at the canal command level, and FOs at the distributary/minor canal level consisting of water user's associations at the watercourse level. SIDA also has environmental and social unit that would be strengthened under WSIP to enhance SIDA's capacity in participatory planning and mainstreaming environmental issues in development and management of the water resources. SIDA would also be involved in addressing the social and environmental issues under the project and through monitoring arrangements ensuring that they are implemented properly.

a) The Convention on Wetlands of International Importance. Ramsar 1971
b) Pakistan is a signatory to the Ramasar Convention. The principal obligations of contracting parties to the Convention are:
c) To designate appropriate wetlands to the List of Wetlands of International Importance.
d) To formulate and implement planning so as to promote wise use of wetlands, to produce an EIA before transformations of wetlands, and to run national wetland inventories.
e) To establish nature reserves on wetlands and provide adequately for their wardening and through management to increase waterfowl populations on appropriate wetlands.
f) To train personnel competent in wetland research, management and wardening.
g) To promote conservation of wetlands by combining far-sighted national policies with coordinated international action, to consult with other contracting parties about implementing obligations arising from the Convention, especially about shared wetlands and water system.
h) To promote wetland conservation concerns with development aid agencies.
i) To encourage research and exchange of data on wetlands.
j) So far, 19 sites in Pakistan have been declared as wetlands of International Importance or Ramsar Sites. Since the specific locations of the project rehabilitation and improvement are not yet identified, it cannot be determined at this point whether or not any Ramsar site would be encountered during the execution of works. WSIP study however has analysed the impacts, if any, of distributary and canal lining on any nearby wetland in more generalized terms.

Offences and Penalties:

Whosoever:

a) Obstructs or willfully obstructs the flow of, diverts or takes water from any watercourse or any other source of water belonging to the SIDA, the AWBs or the FOs or their functionaries or unlawfully breaks or damages the watercourse or other equipments, machineries; or
b) Obstructs in the performance of official duties of any of the officer (s) or servant(s) of the SIDA, the AWBs or Fos or willfully neglects to allow him for making inspection, examination or enquiry in respect of any source of water;

c) Permits the watering of cattle or of animals or bathing or washing at or near the watercourse or other source of water belonging to SIDA, AWB and FO;
d) Permits steeping, hemp, jute, or any other dangerous material at, near or in any watercourse or other source of water;
e) Shall be punished with imprisonment of any description for a term not more than six months or with fine which may extend to a hundred thousand rupees or both per offence;
f) No offence punishable under this ordinance shall be bail able.

Control of Water Pollution

The following measures could be taken to control water pollution:

a) Legislation: For effective control of water pollution, legal provisions regarding water pollution should be enforced by the concerned offices.
b) Prohibition: Besides reserving separate water supplies for livestock, the following prohibition should be enforced to avoid contamination of the main sources of drinking water.
    i. Bathing and washing of clothes in canals
    ii. Discharging untreated or treated domestic, commercial and industrial sewerage in water bodies.
c) Judicious Use: Pesticide (Preferably less stable) and fertilizer should be very judiciously used to avoid chemical pollution of water through agriculture farm run-off.

National Resettlement Policy

To resettle and compensate people displaced by the development projects, the GOP has issued the Project Implementation and Resettlement of Affected Persons Ordinance, 2001. National Resettlement Policy was promulgated in March 2002. Pakistan Environmental Protection Agency has also issued the National Resettlement Policy Implementation Guidelines in October 2002.

Land Acquisition Act 1894

The present general law for acquisition of land for public purposes, the "Land Acquisition Act" was introduced in 1894. This Act is the principal statute laying down the framework for the exercise of the right of eminent domain of the State. The land acquired under the Act is vested in the Province and is only thereafter that the Province may transfer it to someone else.

In addition to the provisions of the Act, regulations setting out the procedure for land acquisition have been provided in the "Sindh Land Acquisitions Rules, 1983". These rules are applicable in the province of Sindh.

Review of the LA Act. A review of the key features of the 1894 Act are given below:

1. Under Section 4, it causes the publication of a preliminary notification notifying that the land is needed for a public purpose. This permits entry, survey and investigation of the land in question by an authorized Government servant. He shall pay compensation for any damage caused by such entry.
2. Under Section 5, a formal notification is issued that the particular land is needed for a public purpose. This notification is published in the official Gazette and the Collector is required to cause public notice to be given of the substance of the notification. Issuance of Section 5 has to take place not later than one year after notification of Section 4.
3. Any person interested in any land which has been notified under Section 5 may, within thirty days after the issue of the notification, object to the acquisition of the land under

Section 5-A. The Collector shall hear the objection, make necessary inquiries and submit a report within 90 days to the appropriate government authority. This authority must announce his decision which shall be final, within 90 days, otherwise the objection shall be deemed to have been admitted and the acquisition proceedings will come to an end.

4. When the Provincial Government is satisfied, after considering the report, if any, made under Section 5-A, that any particular land is required for a public purpose, a declaration to that effect shall be made by an authorized officer of the Provincial government under Section 6. This should follow within six months of the publication of the Section 5 notification.
5. After the declaration under Section 6, the Commissioner shall "direct the Collector to take order for the acquisition of the land" under Section 7.
6. The Collector has then (Section 8) to cause the land to be marked out, measured and planned (if this was not done after Section 4).
7. Under Section 9, the Collector gives notice to all interested people that the Government intends to take possession of the land and if they have any claims for compensation that they be made to him at an appointed time.
8. Section 10 delegates power to the Collector to record statements of persons possessing any interest in the land or any part thereof as co-proprietor, sub-proprietor, mortgagee, tenant or otherwise.
9. Section 11 enables the Collector to make inquiry into "measurements, value and claim and issue the final award." Included in the award is the land's true area, his view of what compensation is warranted, and the appointment of that compensation to all interested people.
10. Though this section is the one that contains the final award, there are two other sections (Section 23 and Section 24) which appear as later sections in the Act but which chronologically actually take place prior to Section 11. This is because these two sections pertain to compensation and the criteria to be followed (Section 23) or not to be followed (Section 24) in arriving at appropriate compensation.
11. Section 23 includes such items as the market value of the land at the time of notification of Section 6, and various damages that may have been sustained at the time possession was taken.
12. Matters to be neglected in awarding compensation (Section 24) include such items as the degree of urgency which led to the acquisition, any disinclination of the person interested in the land to part with it, any expected increase in value of the land from its future use, etc.
13. When the collector has made an award under Section 11, he will then take possession under Section 16 and the land shall thereupon vest absolutely in the Government, free from all encumbrances.
14. Section 18 pertains to persons still dissatisfied with the award who may request the collector to refer the case to the Court for determination and decision. This does not affect the taking possession of the land.
15. In cases of emergency, where the Board of Revenue considers it expedient to take possession of any land at any time before an award under Section 11 has been made, it shall notify this fact in writing to the Collector intimating in addition the date by which the land is required by it.
16. Under Section 17, the Collector can, after causing a notice to this effect to be served on the person or persons interested in the land, take possession of the land subject to the liability of any amount which may be incurred on account of the acquisition.

Valuation of Land Compensation

Under Section 23, the matters to be considered in determining compensation are as follows:

Market value of the land

1. Damage sustained by the person interested by taking of any standing crops or trees.
2. Damage sustained by persons at the time of the Collector's taking possession of the land.
3. Damage sustained by the persons at the time of acquisition of land injuriously affecting his other property, movable or immovable, o If compelled to change his residence or place of business, the reasonable expenses incurred for such change, o Damage resulting from diminution of profits of land from declaration to actual taking possession by the Collector.
4. Furthermore, an additional sum of fifteen percent of the market value of the land is to be paid in consideration of the compulsory nature of the acquisition.
5. Paragraph 61 of the Standing Order 28 provides guidelines for determination of the market value, including consulting "respectable people who are disinterested."

Land for Land Compensation

Under the Act, the person whose land is being acquired cannot be compelled against his wishes to accept compensation in any form other than cash. However, Section 31 of the Act provides that the collector can, instead of awarding cash compensation in respect of any land, make any arrangement with a person having an interest in such land, including the grant of other lands in exchange. Where practically feasible, and if the PAP so desire, a formal consensus agreement will be entered into with those PAPs losing land opt to pay part of their cash compensation for land made available by the collector.

Time Frame for Payment of Compensation

1. The Land Acquisition Act provides that, when the Collector has made an award under Section 11, the Collector shall before taking possession of the land, tender payment of the full amount of compensation awarded by him to the persons entitled thereto under the award. Thus the compensation will be paid to the PAPs prior to possession of the land being taken by the implementing agency.
2. If the persons entitled to compensation under the award shall not consent to receive it, or if there be any dispute as to the title to receive the compensation or as to the appointment, the Collector shall deposit the amount of compensation in the Court to which a reference under Section 18 would be submitted.

3.3 The World Bank Policies and Directives - General Applicability

Environmental Assessment

The World Bank Operational Procedures (OP-4.01) as issued in January 1999 divides projects into 3 categories: Category A, B and C. The Environmental Assessment of the project is carried-out accordingly and an Environment Management Framework is prepared to address any potential impacts during implementation of the project.

Natural Habitat

So far, 54 wildlife sanctuaries and wetlands have been identified in Sindh. Out of this, 34 are in and around WSIP area and 5 have been declared as wetland of international importance (Ramsar Sites). The project works would be limited to rehabilitation and improvement of the existing systems only.

Nevertheless, an EMP would be required for each sub-project and impacts on any Natural Habitat, if any, would be identified along with the mitigation measures in accordance with Project EMF that outlines the broader principles to prepare the protected area management plan for the physical works within or in the close proximity of any of the protected areas.

3.4 Integrated Pest Management (IPM)

Improvement of watercourses would result in the availability of additional water leading to expansion in agricultural area and higher crop yields and corresponding higher use of pesticides. Inappropriate use of pesticides has been instrumental in the killing of non-targeted and friendly organisms, including birds, and has also included pest resurgences. The social costs of pesticide use have been high. These include: occupational poisoning, pesticide residues on food, drinking water contamination, pest resistance, loss of biodiversity, cost of prevention and abatement measures, and the cost of awareness campaigns. The main mitigating measure is the promotion of Integrated Pest Management (IPM) practices in the project area. Under this project, following supplementary IPM activities in the project area will be performed.

i. Launching awareness raising programs and dissemination of information on IPM;
ii. Training of farmers through Farmers Field School (FFS) and farmers training program in safe use of pesticides;
iii. Monitoring / testing of pesticide residue on agricultural crops.

Launching awareness programs

Under this, all modes of campaigning like as media would be used to disseminate awareness program by producing print material on IPM approach, holding seminars, workshops and field demonstration, etc. These activities will cover like pesticide handing usage, storage and disposal, type of pesticide application equipment, protective measures and ecologically friendly methods, promotion of bio-pesticide, training of Farmers by establishing Training of Facilitator (ToF) and Farmer Field School in the project under IPM approach.

Research and development on IPM approach has been initiated in our country since two to three decades ago. This has resulted to ask government and international agencies to allocate more funds for adopting IPM practices in agriculture and a study to test the suitability of Training of Trainers (ToT) / Farmer Field Schools (FFS) approach to IPM implementation on different crops.

Indigenously, biological control based IPM technologies for cotton, sugarcane, maize, fruit and vegetables has been developed but are not generally practiced. Different international organizations are applying IPM techniques on field crops through Training of Trainers (ToT) and Farm Field School (FFS).

The concept of dissemination of IPM knowledge stands since 1980 to address insecticide overuse, particularly the excessive use of broad – spectrum insecticides in irrigated field crops which were disrupting the ecosystem and hurting farmers' yields and profits. The international forums related to agriculture has promoted the concept through IPM programs for vegetables and field corps, and consider it as one of the most promising and successful approaches to promote participatory IPM. Normally, a ToF consists of participants (mostly agriculture officers, but also include representative from research, NGOs and other, including women) who are trained by experts of various disciplines over a cropping season.

ToF participants observe a selected field to carry out as agro-ecosystem analysis (AESA) and then discus what they had observed in the field: soils, Crop health, water requirements, insect pests and their natural economies etc.

On the basis of observations made, decisions are taken by consensus as to what is needed to be done next (including whether any spray of chemical pesticide is needed or not). As a next step, the participants are divided into groups and each group reproduces to a group of farmer, i.e called the FFS. This training continues throughout the crop season. The agriculture officers attend to their routine duties for remaining period.

Many of the facilitators become future resource persons and can establish ToFs with minimum expert support. Similarity many educated farmers develop into facilitators and can run FFSs themselves with little outside support. A chain reaction may start and over a short period of time a crop of well informed farmers comes into existence. The ToF/FFS concept essentially would lead to the development of a farmer-led participators approach.

Strategy

The main emphasis of this sub component is to promote IPM practices in the project area to integrate the all available technological options to control pest population to have sustainable production without affecting human beings, animals and environmental in general. Traditionally our agriculture extension and research system are not properly equipped to coup the increasingly complexity emerging in crop management. Therefore, there is earnest need to innovate integrated mechanism of crop management by involving farmers and officials to transfer them as facilitations. Under this ToF / FFs training system is designed to achieve the very objective of the sub components through establishment of farmer field school and training of facilitators as described in the relevant component.

Implementation Arrangements

Director General, Agriculture Extension (DGAE) will have the overall responsibility for the program and will be assisted by Director, Plant Protection (DPP) and Director, Agriculture Information. He will keep constant liaison with DG (AE&WM), Sindh Agriculture University, NRSP and / or any other NGO that would get associated with the program and convene coordination meetings with them on a quarterly basis.

Involuntary Resettlement

Improvement of irrigation and drainage system may cause some adverse impacts, temporary and/or permanent, on private assets requiring limited acquisition of land for civil works. Additionally, there may be a need for small-scale acquisition of land for rehabilitation and improvement of distributary/minor canals to be carried out by FOs. Precise impacts can only be determined after preparation of detailed designs.

4 Water Resources and Water Quality Assessment

4.1 Surface Water Resources

The main source of the surface water is River Indus. Irrigation water in the study area is diverted from Indus River through eight main canals. Ghotki Feeder Canal takes off from Guddu Barrage. Khairpur East Canal; Khairpur West Canal; Rohri Canal and; Nara Canal off take from Sukkur Barrage. Akram Wah; Fuleli Canal and; Pinyari Canal off take from Kotri Barrage. Salient features of the irrigation network which supply water in study area is presented in Table 4.2.2. (Phase-I Main Report) Annual entitlements and withdrawals of eight canals are presented in Table 4.2.3 (Phase-I Main Report).

Annual Water entitlement of Ghotki Feeder Canal is 3.484 MAF (Million acre feet) Khairpur West is 1.148 MAF, Khairpur East 1.319 MAF, Nara Canal 7.803 MAF, Rohri Canal 8.297MAF, Fuleli Canal 3.280 MAF, Pinyari Canal 2.593 MAF and Akram Wah 1.786 MAF with total annual entitlement of all 8 Canals is 29.562 MAF. Annual withdrawals of 8 Canals for years 2004-05, 2005-06, 2006-07, 2007-08, 2008-09 and 2009-10 were 26.7, 29.0, 24.8, 25.199, 22.02 and 23.696 MAF.

4.2 Groundwater Resources

Estimated ground water resources for the Sindh province varies between 13 to 16.2 MAF with an estimated safe yield between 4.4 to 8.1 MAF. More than 78% of the irrigated land in Sindh is underlain with saline or brackish water, which is unfit for agriculture. The shortage of irrigation water coupled with drought conditions in Sindh and the unreliability of canal water, have increased the importance of exploitation of groundwater wherever fresh water or even saline water of marginal quality is available. Fresh groundwater is found mostly in a strip parallel to the left bank of Indus River and some pockets in other areas. Reliable data on extent of groundwater use in the Province is not available. There are about 53,862 tubewells in Sindh. Of these 12,038 are public tubewells and 41,824 are in the private sector, though other unofficial estimates put the number of private tubewells much higher. The present number of tubewells is likely to be more than 70,000. Considering an operation factor of 8-10%, the groundwater pumping is estimated to be about 4.9 MAF on annual basis.

4.3 Rainwater Harvesting

Rainwater harvesting is process of accumulating and storing of rainwater for reuses before it reaches the aquifer. Water collected from the areas which are specially prepared for this purpose is called storm water harvesting.

The quantum of storm water in the study area generated from rainfall is 6.73 MAF as presented in Table 4.2.6. Out of which 5.46MA is generated in the eight canal command areas and 1.27 MAF in Thar area which is outside canal command area. Storm water is presently disposed of through drainage systems and accumulates in the depressions or create ponding situation in the fields.

4.4 Water Quality

Water pollution is detrimental to both the human health and biodiversity. Irrigation water is the main source of drinking water in many towns and villages, especially where the ground water is brackish. Thus, the downstream residents especially in southern Sindh are exposed to adverse health effects due to both biological and chemical contamination of water bodies. Of course, local practices such as washing clothes in irrigation channels and livestock wallowing add to the problem. Further, there is an increasing trend for municipal bodies to contract out municipal waste water to farmers for vegetables cultivation. While such recycling is income generating, adverse health effects occur both directly, through ingestion of the produce and bore worms and indirectly, via seepage of such water into the groundwater table and runoff into the irrigation

system. Water pollution also adversely affects biodiversity, particularly aquatic life of the wetlands and water bodies.

The use of chemical fertilizers, pesticides, insecticides, and fungicides has increased tremendously over the years. The run-off from irrigation feeds into surface water and also seeps into sub-soil water, as crops do not utilize all chemicals and or drains into water bodies resulting in water pollution. Deterioration of surface water quality also occurs when raw sewage and industrial toxic wastes and effluents are discharged into rivers, irrigation canals and drains. Untreated municipal sewage discharged into river Indus or canal systems of IBIS beyond the natural cleaning capacity of waters thereby affecting the fish and biotic life.

Ground water mining and lowering of water table are taking place in Irrigated areas of Indus Basin, Partially due to drought period, but largely due to development of private tube wells for irrigation purposes about 100,000 tube wells in Sindh (both public and private) have caused deterioration of ground water quality in sweet water areas by salt water intrusion as there exists a fringe of sweet water overlaying the saline water that comes up and mixes with sweet water due to up coning resulting in brackish water delivery in few days of the tube well installation.

None of the three major consuming sectors of water: agriculture, industry and household/ municipalities have proper wastewater disposal systems. As a result the effluent/ run off contaminate water bodies / reservoirs creating serious health and environmental problems. Not only are the poor, even more vulnerable to their impacts, they also contribute heavily to water pollution. This vicious circle originates in the deprivation of social and infrastructure services, being essentially rooted in a development process, which tends to bypass the poor.

In most of the cities, water is provided without any treatment or with inadequate treatment. Corrosion in pipes during conveyance adds to the contamination. The problem is further exacerbated by seepage from contiguously laid sewerage pipes as a result of pressure fluctuations. In slums, poor localities and villages the standard water supply sources are community stands posts. A recent World Bank report demonstrates that when a tap or a well is shared with neighbors, the likelihood of child or infant mortality is much higher compared to access from a residential piped water system.

In peri-urban areas, sewage water is used for irrigation. Adverse health impacts result when vegetables that are eaten raw, are watered with municipal discharges carrying toxic chemicals. The intrusion of urban waste water into the canal irrigation and river systems is a major problem that is likely to become more severe in future as residential and industrial expansion continues.

Generally the problems are inherently complex and require extensive monitoring and close inter-departmental and cross-provincial coordination.

Surface and Groundwater Quality…its impact on Ecosystem and Environment

The Pakistan Council of Research in Water Resources (PCRWR) launched "National Water Quality Monitoring Program" in 2002 through 2006 that aimed at undertaking water quality monitoring of major cities, rivers and storage reservoirs, canal, drains and natural lakes Figure-3. Different organizations including Pakistan Council of Research in Water Resources (PCRWR), Water and Power Development Authority (WAPDA), Environmental Protection Authority (EPA) and some individual consultants have conducted short-term studies on water quality. Results from various investigations and from the studies carried by various organizations such as PCRWR, WAPDA, and EPA indicate that water pollution has increased. The pollution levels are higher particularly in and around the big cities where industrial estates are present. The water quality deterioration problems are caused by the discharge of hazardous industrial wastes including persistent toxic synthetic organic chemicals, heavy metals, pesticide products, municipal wastes and untreated sewage water to natural water bodies. These substances mixed with water cause widespread water-borne and water related diseases.

The quality of water supplies in many cities is deteriorating at an alarming rate. The primary source of these supplies is canal water. As a result, diseases such as cholera, typhoid, dysentery, hepatitis, giardiasis, cryptosporidiosis and guinea worm infections are about 80% of all diseases, including diseases due to sanitation problem. All above mentioned diseases are responsible for 33% of deaths (UNICEF, 2009.).

Over pumping of groundwater due to extended drought has adversely affected the water quality. According to a recent study about 70% of the about 560 thousand tubewells in the Indus Basin are pumping sodic water (PCRWR Water Quality Monitoring Program). Such water is highly injurious to the soils resulting in reduced permeability and infiltration rates, particularly in the heavy textured soils. Surface-water from most of our rivers is also polluted due to dumping of solid wastes and industrial pollutants.

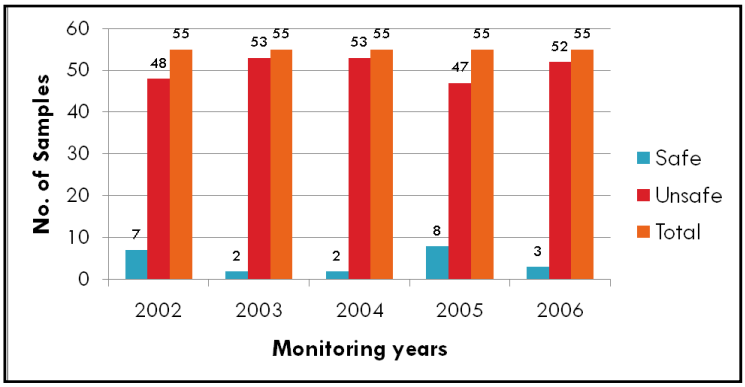


Figure-3 Water Quality of Sindh Province

(Source: PCRWR 2002-2006)

Due to industrial waste, heavy metals such as nickel, lead, zinc and cadmium have also been found in Indus water. Many water sources and watersheds are already of poor quality and require remediation and treatment. Both high-tech, energy-intensive technologies and low-tech, low-energy, ecologically focused approaches exist to treat contaminated water. Concerted efforts to widely adapt these technologies are needed; they need to be scaled up rapidly to deal with the tremendous amount of untreated wastes administered by city governments entering into waterways every day; and water and wastewater utilities need financial, administrative, and technical assistance to implement these approaches.

The Status of Drinking Water Sources

Pakistan Council of Research in Water Resources (PCRWR) generated the first detailed water quality profile of 23 major cities of the country. About 357 water samples from 364 selected water sources were collected adopting the uniform sampling criteria and analyzed for 79 physico-chemical parameters including, trace, ultra trace and bacterial indicators. The analytical findings were compared to the World Health Organization (WHO) guidelines and Pakistan Standards Quality Control Authority (PSQCA) standards for drinking water.

Analysis revealed the presence of three main water quality problems i.e. bacteriological (69%), arsenic (24%), nitrate (14%) and cities had a considerable percentage of bacteriological contamination (40-100%). A higher percentage of arsenic contamination was found in 9 cities, nitrate in 14 cities and fluoride in 4 cities. In Sindh province, all the 14 sources monitored in Hyderabad were found unfit mainly due to bacteriological contamination (93%), excessive levels of iron (47%), and turbidity (93%). Karachi the largest metropolitan city and capital of Sindh province revealed (93%) unsafe water sources due to bacteriological contamination, TDS and fluoride (4%), sodium, chlorides and sulphate (7%), nitrate (11%), and iron (18%); only 2 out of 28 samples were safe. In Sukkur, 11 out of 12 sources were unfit because of bacteriological contamination, turbidity (50%), hardness, sodium, chlorides, potassium, arsenic and fluoride (8%), nitrate (25%), sulphate and TDS (17%). Twenty two water samples including 6 dams, 9 rivers, 2 canals, 4 lakes and 1 drain, LBOD and RBOD; all were found microbiologically

contaminated. Main cause of microbiological contamination was due to the disposal of untreated sewage into water bodies.

4.5 Water Quality in Southern Sindh

About 300 water samples from water bodies of three southern districts Thatta, Badin and Tharparkar were tested measuring physical, chemical, and biological (total coliform) quality parameters. All four water bodies (dug wells, shallow pumps, canal water, and water supply schemes) exceeded World Health Organization (WHO) MPL for turbidity (24%, 28%, 96%, 69%), coliform (96%, 77%, 92%, 81%), and electrical conductivity (100%, 99%, 44%, 63%), respectively. Iron was major problem in all water bodies of district Badin ranging from 50% to 69%. Some common diseases found in the study area were gastroenteritis, diarrhea and vomiting, kidney, and skin problems (Memon and Soomro, 2010).

It is estimated that 20 million residents of Sindh depend on irrigation water for their domestic use, especially in areas where the groundwater is brackish. The contamination of irrigation water by coliform bacteria exceeds the limits set by WHO.

4.6 Groundwater Scenario of Left Bank area

A recent study conducted by the Indus Institute for Research and Education (IIRE) on groundwater quality in Sindh has portrayed the groundwater situation of Sindh at large. The scenario of the groundwater quality with respect to the left bank area Table-5

Table-5 Groundwater Quality of Water in the Left Bank Area

Sr.#	District	Samples Tested	Samples TDS mg/l <1000	Samples TDS mg/l >1000	% samples with High TDS
1	Ghotki	8	8	0	0
2	Sukkur	15	13	2	13
3	Khairpur	15	12	3	20
4	Nosharo Feroz	15	13	2	13
5	Hyderabad	20	17	3	15
6	Thatta	16	10	6	38
7	Badin	19	9	10	52
8	Tharparkar	18	3	15	83
9	Umerkot	10	6	4	40
10	Mirpurkhas	11	7	4	36
11	Sanghar	17	11	6	35
12	Nawabshah	14	11	3	21

Source: Shafique Ahmed Junejo (IIRE) Research Report. www.iire.org.pk/documents/groundwater_quality_insindh.pdf
Maximum Permissible Limits: TDS=<1000 mg/l, Arsenic=0.05 mg/l, Lead= 0.05 mg/l, Zinc=5.0 mg/l, Cadmium= 0.01 mg/l

Only Ghotki district had good quality water at all locations where the samples were taken. Whereas in other locations, the percentage of samples with higher TDS were 13% in Sukkur, 20% in Khairpur, 13% in Noshahro Feroz, 15% in Hyderabad, 38% in Thatta, 52% in Badin, 83% in Therparkar, 40% in Umerkot, 36% in Mirpurkhas, 35% in Sanghar and 21% samples in Nawabshah district. This had confirmed that lower Sindh districts have brackish underground water in most locations. Adjoining areas of river Indus have good quality water.

The heavy and trace elements (i.e., As, Cd) in the subsurface waters of Sindh area are generally above the permissible limits. The Arsenic contents are found higher at Maripur Mathelo, Rohri,

Sukkur VI, Tando Mohmmad Khan II, Mirpur Bathoro, Diplo, Nagarparkar, Bhalwa, Tandojam, Nawabshah I, Sanghar I.

The Lead concentration in groundwater is found high at Nousharo Feroz II 0.087 mg/l, Badin I 0.076 mg/l, Lakho pir 0.092 mg/l, Mithoro Chachar (Meghwar para) 0.068 mg/l, Mithoro Chachar (Bhel para) 0.078 mg/l, Nagarparkar 0.08 mg/l, Nagarparkar 0.062 mg/l, Bhalwa 0.071 mg/l, Mithi 0.065 mg/l, Tando Allahyar 0.074 mg/l, Umarkot, 0.084 mg/l, Sakarand 0.07 mg/l, Samaro 0.064 mg/l, Mirpur Khas North 0.069 mg/l. This may be due to Lithology, agricultural waste, municipal waste water percolation. The lack of proper outlet to rain water to its natural courses cannot be ignored, because due to this, water table rises which brings soluble minerals with it, which never go back after the water table fall down. Cadmium was also higher than permissible limits in groundwater.

The concentration of Zinc was found within the allowable limits of WHO (2004) except the sample collected from Sakrand which showed higher contents of Zn.

Salinity and Water logging

In 1975 the proportion of the IBIS area with groundwater less than 3 meters from the surface was 42% and the area with groundwater less than 2 meters from the surface was 22%. In Sindh the area with a depth less than 3 meters was 57%. Although groundwater use has increased significantly, about 22% of the command area of IBIS has a water table of less than 1.5m (Asianics, 2000). In Sindh Province presently, a small component of potential groundwater resources is being exploited by public and private tube wells. Total groundwater extraction is about 3.5 MAF, which includes pumping by 25,000 private tube wells and 4,100 SCARP tube wells.

Extent of Arsenic Contamination in groundwater

Preliminary analysis of the freshwater samples collected from nine districts of Sindh including Jamshoro, Qambar-Shahdadkot, Matiari, Shaheed Benazirabad Naushero Feroze, Khairpur, Ghotki, Sukkur and Dadu districts and analyzed for total dissolved solids (TDS) and arsenic contamination. The results indicated that 10% of the samples had arsenic contamination of 100ppb or above. Use of the arsenic polluted water may cause skin cancer if used continuously (Khuhawar 2006).

Women in Rural areas getting water from a watercourse for house hold use (Asian Water Development Outlook 2007)

Impact of water pollution The high pollution level of rivers and groundwater lead to different environmental consequences such as reduction of biodiversity, increase in water related diseases and decrease in agricultural productivity. The health of rivers, lakes, estuaries, coastal systems as well as marine resources is threatened by water pollution issues, such as eutrophication, toxics pesticides, heavy metals, acidification and siltation. Their main effects are ecosystem dysfunction, loss of biological diversity, alteration of aquatic habitats and contamination of downstream and marine ecosystems.

The cost of water pollution is higher than the cost of its prevention, and neglecting water pollution control entails high social and environmental costs. In rural areas of Sindh, due to consumption of polluted water for domestic use, 70% patients suffer from waterborne diseases. 3-4 million people die each year of waterborne diseases world-wide, including more than 2 million children who die from diarrhea (Bauder et al 2007). The degradation of water resources reduces social security. The impairment of water resources in regions where poverty already affects a great part of the population, can lead to greater social inequity and poverty intensification.

Sources of Water pollution in Sindh

The main sources of water pollution include: i) disposal of untreated sewage and city garbage into canals and river; ii) disposal of untreated industrial effluents into freshwater bodies; iii) seepage of fertilizers and pesticides from agriculture fields and soil; iv) disposal of highly toxic and high BOD laden sugar mill effluents into surface drains of the main drainage system; v) seawater intrusion from the river mouth towards the land (upto Thatta-Sujawal Bridge) carrying hyper saline water that percolates from river bed into the deep aquifers rendering the groundwater saline and unsuitable for domestic use; and vi) effluents of Kotri industrial area into river and canals.

Water Quality of Surface Drains Out Falling in LBOD System

The data of the drainage effluent of the surface drains of the LBOD system from 2005-06 to 2007-08 *(* Annexure-A Table-27) indicated that the Total Dissolved Solids (TDS) of the drains out falling in spinal drain from Shaheed Benazirabad onwards are in the range of 3,000 to 14,000 ppm. The SAR of the effluent ranges from 10 to 23. The allowable ranges for TDS are 2,000 ppm and SAR up to 18. The effluent shows higher values; therefore is not fit either for household use or for irrigation. However, if used in conjunction with canal water within permissible limits can be used if so desired. However, for bio-saline agriculture, the effluent can be used for growing salt tolerant grasses, trees and crops within acceptable ranges but there exist risk to the soil system. It is therefore proposed that the effluent of Kotri Barrage surface drains including Tando Bago Drain, Luwari Drain, Serani Drain, Fuleli Guni Drain, Karo Gungro and other surface drains which carry only the drainage water from adjacent fields and pancho water from rice fields including storm water of the monsoon rains is relatively better in terms of TDS and SAR within reasonable limits and therefore can be used for bio-saline agriculture or for irrigation of crops under severe water scarcity conditions.

4.7 Survey of the Project Area for Water Quality (2011-2012)

Water bodies of the project area were surveyed to evaluate the quality of water. These included the water of the drains carrying the drainage effluent of the LBOD drainage infrastructure and the water bodies used for human consumption. Drains discharging their effluent into the Spinal drain right from Nawabshah (Benazirabad) downwards mostly carry sugar mills effluent from distilleries not only during cane crushing season but almost round the year. Thus the drain water mostly remains polluted with sugar mill distillery effluent. Being organic in nature, it is oxygen consuming. This depletes the oxygen content of the drainage effluent thereby adversely affecting the biotic life of the drains specially the fish on which the communities living around the drains depend for their food needs. The data presented in Figure-4 and Table-28 is the detail of the samples collected from the drainage infrastructure and the analysis of certain important parameters to evaluate the quality of drain water flowing in our drains.

Adequate dissolved oxygen is the basic requirement for good quality water. Oxygen is a necessary element to all forms of life. Natural stream purification processes require adequate oxygen levels in order to provide for aerobic life forms. As dissolved oxygen levels in water drop below 5.0 mg/l, aquatic life is put under stress. Lower the concentration, the greater the stress. Oxygen levels that remain below 1-2 mg/l for a few hours can result in large fish kills.

Only two drain samples out of 35 samples tested were found having little more than 2 mg/l dissolved oxygen. The remaining 33 samples had DO below 2 mg/l and most of them possessed just 1mg/l. The dissolved oxygen level depicted that the entire drainage infrastructure is not favourable for the fish population in the drains. At many places, fish were found either dead or were dying of the short of DO.

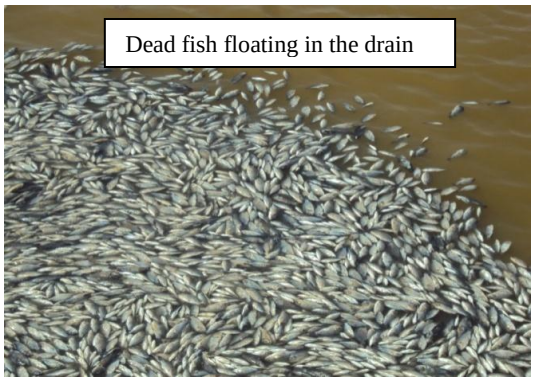
Farmers use drain water to save their crops under severe drought conditions when irrigation water is scarce. The analysis of the water samples collected from drains indicated that the TDS level of almost all samples was above 2000 ppm. Maximum allowable level of TDS for irrigation is 2000 ppm. Thus the water of the drains is not normally suitable for the crops. However, it could be used in conjunction with the canal water with suitable dilution. The samples ranged from 920 to 14630 ppm and averaged as 3919 ppm. Likewise the EC of the samples was in the range of 2.00 to 28.00 mS/cm. The maximum permissible level of EC for irrigation water is 3.00 mS/cm. Almost all samples were higher than the permissible limit. Therefore, the drain water is not suitable for irrigation. The TSS was however, within the acceptable range.

Water quality of Drinking Water Samples:

Seventy Eight (78) water samples from water bodies in domestic use of the communities living in the project area were collected for evaluating the water quality of the water bodies. The data presented in Table-30 and Figure-5 depicted that 48 (60%) water samples were within the maximum permissible range of 1000 ppm (TDS) for drinking water category. The remaining 40% samples had TDS above the maximum permissible range. All the samples had pH in the permissible range of 6-10. However, the EC values of the samples ranged between 0.3 to18. Similar to TDS, the EC values of 48 (60%) samples were equal to or below 2.0 mS/cm, while the rest had higher EC values ranging from 2.0 to 18 mS/cm. Thus the water bodies having TDS above 1000 ppm and EC above 2.0 ms/cm are not suitable for drinking as per the NEQs for drinking water in Pakistan.

Sugar Mill effluent pollution on water bodies

Environmental team of the LBG/Indus consultants visited ten sugar mills of district Badin and collected the data regarding the status of pollution of the sugar mill effluents discharged from the mills and most of these disposed off into the drainage infrastructure. The drains that receive the effluent of the various sugar mills are given in the following paragraphs.



Dead fish floating in the drain

Sugar Industry

Out of 33 sugar mills in Sindh, 30 are located on left bank of Indus. Three out of 33 sugar mills use the molasses to produce industrial alcohol (ethyl alcohol) a significant quantity of which is exported. Mills in Sindh have crushing capacity ranging from 4-9,000 metric tons per day. It is estimated that these mills discharge untreated effluents of about 25 million cubic meters per year in the irrigation and drainage systems (SDPI 2006). This untreated effluent have high BOD,

COD and TDS levels which pollute the water and are hazardous for humans and other biotic life. The sugar mills in Sindh mostly dispose off their effluents into the LBOD drainage system that kills the fish and induce toxic chemicals in the drainage system. Table-6 below gives the name of sugar mill, the source of water supply to the mill and the effluent disposal into the drain / water body.

Table-6 Water Supply Source & Disposal of Sugar Industry Effluent (Source: Ansari 2003)

S#	Name of Sugar Mills	Source of Water supply	Disposal in Water body
	Sugar Industry in NCAWB		
1	Sanghar Sugar Mill	Sub module No.3L Ex: Kanhar Feeder Ex. Mithrao Canal	Sanghar Main Drain at RD 43 + 645
2	Mirpur Khas Sugar Mill	Separate water course No.120/6 R Ex. Jamrao canal	M3R at RD 41+ 700
3	Tharparkar Sugar Mill	Separate pipe at RD 14.6 Ex: KGM Minor	SP2L at RD 04+900
4	Al-abbas Sugar Mill	RD 164.0 L/S Ex. West Branch	M1L at RD 04+200
5	Najima Sugar mill	Separate pipe from Silore feedrer at RD 13.250 Ex. Naukot Branch	Not identified/required yet
6	Digri Sugar Mill	Separate pipe from Murid Minor	
	Sugar industry in LBCAWB		
1.	Army Welfare Sugar Mill Badin	Akram Wah Division	RD-60 Sirani Branch Drain
2.	Mirza Sugar Mill, Badin	Akram Wah Division	3R Kadhan Pateji out fall Drain (KPOD) at RD-15 l
3.	Ansari Sugar Mill near Matli	Fulleli Division Akram Wah Division	Jagsi Sub Drain RD-16
4.	Khoski Sugar Mill	Akram Wah Division	RD-10 Khoski Link
5	Sindh Abadgar Sugar Mill	Akram Wah Division	Abad Sub Drain
6.	Pangrio Sugar Mill	Akram Wah Division	6R Tando Bago Sub-Drain
7	T. M. Khan Sugar Mills	Fulleli Division	5 R Tando M. Khan Branch drain at 58 RD
8	Seri Sugar Mills	Akram Wah Division	Not identified
9	Shah Murad Sugar Mills	Akram Wah Division	Not identified
10	Bhawany Sugar Mills	Akram Wah Division	Not identified

The Consultants have analyzed water samples from various sugar industries to estimate the physico-chemical parameters to assess the quality of the effluent Table-7 and Table-8. Research has indicated that the parameters such as pH, EC, TDS, DO, BOD, COD significantly exceeded the permissible limits, indicating the need of proper treatment of waste water before discharge into water bodies (Kumari *et al* 2006).

Table-7 Sugar Mill Effluent Analyses Results of Selected Sugar Mills

Parameter	Fauji	Matiari	Habib	NEQs
BOD5 mg/l	474	673	181	80
COD mg/l	2274	3673	634	150
TSS mg/l	396	272	653	150
pH	7.29	6.3	3.93	6-10
Oil & Grease	185	47	27	10

Source: Ansari 2003

Table-8 Results of Sugar Mill Effluent Analyses of Sugar Mills of Badin District during the year 2011

S. No.	Source/Sample ID	D.O mg/I	BOD mg/I	COD mg/I	TSS mg/I
1.	Lar Sugar Mills Sujawal	2.1	980	1740	1250
2.	Deewan Sugar Mills	1.8	840	1690	1080
3.	Army Welfare SM#01	2.4	390	780	800
4.	Shah Murad Sugar Mills	2.4	1100	1800	2600
5	Pangrio	2.2	740	1180	1800
6.	Bawani Talhar	2.7	180	260	340
7.	T.M.K Sugar Mills	2.6	210	300	450
8.	Sindh Aabadgar	2.5	800	1200	2400
9.	Seri Sugar Mills	1.9	920	1490	350
10.	Khoski Sugar Mills	-	330	500	300
Permissible Limits (WHO)		>4	80	150	150

Analyses were made at the Drainage Research Centre Tando jam WHO= World Health Organization.

Table-9 Water samples from Sugar Mill effluent laden Drain water collected in April 2012 from the various drains of LBOD and Kotri Surface Drainage System

S. No	Description of Site	GPS Reading	TDS (mg/l)	pH	EC mS/cm	TSS mg/l	DO mg/l	COD mg/l	BOD mg/l
1	M.M.D RD 152+040	25 12 18.0 N 69 10 12.2 E	4670	7.0	9.57	650	0.69	83	40
2	Karo Ghunghro main drain RD	24 38 16.6 N 68 23 6.6 E	13630	7.6	>range	5300	1.38	378	168
3	Guni Fuleli Main Drain RD 105	24 39 8.6 N 68 39 11.7 E	10730	7.6	>range	1950	0.79	728	340
4	IR sub drain of kapoor RD 29	4°40'4.11"N 68°11'50.20" E	13900	5.4	>range	8900	1.33	1685	>range
	WHO limits for waste water		**3500**	**6-10**	**7.0**	**150**	**>4**	**150**	**80**

The data presented in Table-7 and Table-8 indicated that the effluent discharging from the sugar mills is highly polluted. The Dissolved Oxygen level is far below the normal (above 5 mg/l) that depicts that it may cause the death of the biotic life in drains specially fish. Likewise, the BOD_5 and COD are also very higher than the WHO permissible limits. High BOD and COD have depleted the DO level in the effluent. This effluent when discharged in the drains provides food for the microbes thereby severely depleting the DO level in the drains. The Total Suspended Solids are also higher than the permissible limits that hinder the sun light to penetrate in water to help photosynthesis to increase the oxygen level of waters. The data presented in Table-9 is the analyses of the samples collected from the LBOD and Kotri surface drains in 2012. The results do match with the results of the previous analyses presented in Table-3 and 4. All the parameters are above the permissible limits except sample 1 whose BOD is within permissible range because of heavy dilution in MMD drain. Therefore, the results of the analyses of the samples collected from sugar mills or from the drains do suggest that the disposal of sugar mills effluent in drainage infrastructure is totally hazardous for the health of the humans, livestock and fish. It has therefore, been recommended that the EPA must enforce the EPA act 1997 and make it mandatory for the sugar mills to install in-house treatment plants to treat the out coming effluent before discharging into the water bodies. Limited effluent analysis of 10 sugarmills is given in Table-8.

Environmental Problems of Sugar Industry

There are various types of environmental impacts of sugar industry. The people living in the vicinity of sugar mills face various problems. They are summarized as under

Effluent from Rural Areas

Sugar processing is the main rural industry with liquid effluent. There are about 30 sugar mills in the Left Bank area. Most of the sugar mills are disposing their effluent into the drainage infrastructure of the LBOD. But whether disposal is direct or indirect, all effluent reaches the spinal drain through the main and branch drains, and thus action needs to be taken to assure that mill effluent is properly treated at source.

Effluent discharge from sugar mills is constituted of waste water from boiler and slush from the processing plant and is mainly organic, though small amounts of non-organic substances occur. Expected pollutants are: small amounts of lead acetate, sulphuric and hydrochloric acid, and caustic soda used in analysis and clarifying procedures; sulphur dioxide; fly-ash (soot from burners) and dust; plant and workforce sewage; process waste which includes bagasse, molasses and filter mud, and oils and grease from various sources in plant.

Of the process wastes, molasses spillage is perhaps the most difficult to deal with as it is solid and does not disperse easily. This and the chemicals can be detrimental to fish and other aquatic life. Fortunately these spillages are usually small and occasional, but nevertheless need to be treated seriously. Key monitoring criteria should include BOD_5, COD, TSS, DO and pH.

Major wastewater environmental parameters for the sugar industry (Chen 1985) are:

a) Biological oxygen demand, usually defined as BOD5 (5 day test), is the measure of the oxygen consuming capabilities of organic matter. The processes of decomposition of organic effluents exert a demand that can deplete the oxygen supply. The BOD_5 of effluents from a sugar factory can vary between a hundred to several thousand milligrams per litre (mg/1), but through proper treatment these values can be reduced to less than 25 mg/1.

b) Chemical oxygen demand (COD) is widely used to measure the total amount of oxygen required for oxidation of organics. Unlike the BOD_5, this test is relatively easy, but the disadvantage is that the COD test does not distinguish between biologically active and inert organic materials. Under different conditions, the COD can be about twice to several hundred times BOD_5.

c) Dissolved oxygen (DO) is also indicative of oxygen depletion, and indirectly an indicator as

to whether normal biological activity is inhibited or not.

d) Total suspended solids (TSS) are aesthetically displeasing, but where they settle to form sludge deposits in a drain, or other water body, they cover the bottom with a blanket of material that can destroy fish food fauna and flora. Deposits containing organic materials may deplete bottom oxygen supplies, and may produce noxious gases such as hydrogen sulphide, carbon dioxide and methane. In the sugar industry wastewater most suspended solids are inorganic and thus the potential impact is negligible. Ash and soot from the burners are the main solids of concern. While a significant portion can be earned a great distance down wind, the greater quantity settle near the factory and thus impacts on a limited area. Ash and soot mixed with liquid effluent can be carried for some distance in the drain.

e) Extreme changes in pH (acidity and alkalinity) can exert stress conditions or kill aquatic life outright. Wastes from sugar factories generally are fairly constant and in the neutral range so are not likely to cause concern.

4.8 Water Quality

The sugar industry effluent has high BOD, COD and Oil & Grease level, which pollute the receiving water body, making it, unfit for drinking, agriculture, fisheries & livestock use.

4.8.1 Air Pollution

Bagasse is used as fuel for boilers. The fly ash produced due to the combustion of baggase spreads all over the area surrounding the industry, causing air pollution. These problems are particularly high in boilers not equipped with scrubbing or cyclone system. The new sugar mills, having fly ash controlling device have, however, reduced this menace substantially.

4.8.2 Solid Waste

Two types of solid waste are produced during the manufacture of sugar. Bagasse is produced in a quantity of about 30% of the crushed cane. The bagasse contains 50% moisture. Press mud or filter cake is produced in vacuum filters and press filters. The mud is produced in a range of 3-8% of the crushed cane, depending on the nature of sugar manufacturing process. The mud contains nearly three quarters of moisture. On dry basis mud contains about 70% organic matter and about 29% minerals. Press mud is usually used by nearby farmers as manure, although in some cases its application as manure is preceded by biocomposting. Bagasse is also used for chip board and paper manufacture. Bagasse ash can be used as cement supplement.

4.8.3 Wastewater

The wastewater analysis suggested a very high pollution level as compared to the limits stipulated in the NEQS on all important parameters. They are particularly severe in the case of wastewater from distilleries. The BOD was in the range from 180 to 1100 mg/l as against the maximum allowable limit of 80 mg/l while the COD limit is 150 mg/l and the mills showed the COD from 260 to 1800 mg/l. The situation is equally drastic total suspended solids (TSS).

4.8.4 Fisheries

Since sugar mill effluents are highly organic in nature, their direct disposal to the ponds or lagoons give rise to noxious odours from the decomposition of organic matter. Their decomposition depletes the dissolved oxygen in the water that is vital for aquatic life, especially when the drain water flow is minimum.

4.8.5 Pungent Odor

People living around drains that receive the distillery effluent have complained that they are unable to sleep properly owing to the pungent odour of sugar mills effluents.

4.8.6 Ground water contamination

The sugar mills effluents seeping through the soil from unlined ponds, drains, lagoons or from dumps and spills contaminate the ground water. There were complaints by the people inhabiting

around sugar mills that their only source of water i.e. ground water was severely polluted so much so that they had to abandon its use.

4.8.7 Soil Pollution

Soils in the vicinity of sugar mills were found degraded due to the effects of sugar mills effluents and waste materials.

4.8.8 Livestock

People of villages complained that their livestock including buffalos and goats suffered diseases and some died due to the effect of the sugar mill effluents discharged into drains in the vicinity of their villages.

4.8.9 Wild life

The fish eating birds and other aquatic fauna are dependent on the drain system. All wetlands attract the local migratory wild life, particularly in winter. The contaminated water is always threat for wild life. The NCAWB drainage engineers witnessed the dead birds in the drains recently and attributed to the local sugar industry effluents.

4.9 Way forward

Disposal of sugar mill effluents into the drainage infrastructure have become a complex issue that has created multifarious problems for the community. The PEPA Act 1997 is the basic legislative tool empowering the government to frame regulations for the protection of the environment. The act is applicable to a broad range of issues and extends to air, water, soil, marine, and noise pollution, as well as to the handling of hazardous wastes. The relevant provisions of the act are that "Where the Federal Agency or a Provincial Agency is satisfied that the discharge or emission of any effluent, waste, air pollutant or noise, or the disposal of waste, or the handling of hazardous substances, or any other act or omission is likely to occur, or is occurring, or has occurred, in violation of the provisions of this Act, rules or regulations or of the conditions of a licence, and is likely to cause, or is causing or has caused an adverse environmental effect, the Federal Agency or, as the case may be, the Provincial Agency may, after giving the person responsible for such discharge, emission, disposal, handling, act or omission an opportunity of being heard, by order direct such person to take such measures that the Federal Agency or Provincial Agency may consider necessary within such period as may be specified in the order." It is very unfortunate that the EPA Act is implemented in letter and spirit.

4.10 Water Quality of the Province of Sindh with respect to Canal Command:

Water quality of the project area was monitored in 2010 and 2011 on the basis of the canal command area on the left bank canals of river Indus. The detailed data canal command wise of the left bank canals is given in Annexure-C (Table-31 & 32). The summary of the data is given in Table-10 Graph (Annexure E(1&2)

Table-10 Percentage of Canal Command Area with Useable, Marginal and Hazardous Water Quality in all Three Barrages.

Sr. No	Barrage	2010			2011		
		Usable	Marginal	Hazardous	Usable	Marginal	Hazardous
1	**Guddu**	48	45	06	78	20	02
2	**Sukkur**	40	53	08	54	34	12
3	**Kotri**	32	59	09	43	44	13
	Total	39	53	8	54	35	11

Useable=<1500 µS/cm, Marginal=1500-2700 µS/cm, Hazardous=>2700 µS/cm

The data in Table-10 gives the percentage of the area with useable marginal and hazardous water of each canal command. It shows that in all barrages the percentage of useable water has increased in 2011 as compared to 2010. Whereas, the area under marginal water was reduced in all barrage commands. The percentage of hazardous water was reduced in Guddu, but increased in Sukkur and Kotri barrages. The overall picture is satisfying due to a remarkable (15%)

increase in useable water percentage. This increase has resulted in lowering the marginal water percentage from 53% to 35%, a decrease of 18%. However, the hazardous water slightly increased from 8% to 11% just an increase of 3% on overall basis. Remarkable increase in useable water is a good sign for promotion of agriculture in all canal commands (Tables-31 and 32 and Annexure-E (1&2).

4.11 Conclusions on Water Quality

The groundwater in 78% area of Sindh is brackish while 22% area has fresh groundwater. Therefore majority of people use surface water of canal system for domestic use. Secondly entire southern Sindh comprising of districts Badin, Thatta, Tando Muhammad Khan and Tharparkar exclusively use canal water for domestic purpose. The water in canals is highly polluted due to the fact that all the municipal sewage and garbage is dumped into canals. The agro-chemicals spayed on crops also find their way into the canals and other depressions being used as drinking water bodies. Thus, a sizeable percentage of population is under direct threat of polluted water and their health is always on stack. Surprisingly the report of PCRWR on the water quality of cities of Sindh is not different from the position stated above. The report claims that over 90% samples tested were polluted and found unfit for human consumption.

The analysis of the samples collected from drains in three consecutive years 2005-07 were found having Total Dissolved Solids (TDS) of the drains outfalling in spinal drain from Nawabshah onwards are in the range of 3000 to 14000 ppm. The SAR of the effluent range from 10 to 23 (Figure-3). The allowable ranges for TDS are 2000ppm and SAR up to 18. The effluent shows higher values; therefore is not fit either for household use or for irrigation.

The water of drains was tested in 2012 again to determine the quality of the drainage effluent. It was observed that except one drain, the TDS was in the range of 2000 to 6000 ppm. This has confirmed the claim of the stakeholders that most of the drainage tube wells are non-functional therefore, the TDS dropped significantly as compared to 2006-07. Secondly most of the sugar mills dispose off their untreated effluent into the LBOD drainage infrastructure. This has created tremendous difficulties for the villagers, their livestock and the fish in the drains.

The report of the SMO WAPDA who monitors the water quality of canal commands have encouraging remarks that the quality of water in canal commands have improved and the quantum of useable water has increased from 39% to 54%, an increase of 15% in all canal commands.

About 80 samples from water bodies in project area were collected to ascertain the quality of drinking water in the area. The analysis indicated that 48 samples had TDS within the acceptable range of 1000 ppm where as 42 samples had TDS above the maximum allowable limit. This showed that almost half of the population using underground water use brackish water for domestic use.

In general the position of surface and groundwater is not satisfactory. Steps have been suggested to keep the water quality safe at least for human use. It is also proposed to avoid the disposal of sugar mill effluents directly into drains but in house treatment of the effluent must be carried out to utilize the sugar mill effluent for agriculture use under water scarcity conditions, simultaneously creating a favorable environment for fish, livestock, birds and other fauna dependent on these waters.

5 Impact Assessment on Flora and Fauna

5.1 Flora

Project / Study area

The study area covered under the regional plan is located in the left bank of Indus, delta and coastal zone stretching over 15 districts namely Ghotki, Sukkur, Khairpur, Naushahro Feroze, Nawabshah, Sanghar, Mirpur Khas, Umerkot, Badin, Thatta, Tharparkar, Tando Muhammad Khan, Tando Allahyar, Hyderabad and Matiari.

The study area covers the agricultural zone, coastal zone and arid zone of the above districts. The study covers the base line data of vegetation on different ecological zones, find out positive or negative environmental impacts on flora, one account of various structural and non structural interventions and prepare mitigation measures for addressing the adverse environmental effects. This study will be part of a regional management plan.

Pre-feasibilities/Feasibilities/Interventions

Pre feasibilities have been identified during phase II of the study and feasibilities are being prepared during phase III of the study. These have been grouped in three major categories as follows:

Drainage of waterlogged and saline soils

(a) Rehabilitation and improvement of LBOD drainage infrastructure

(b) Rehabilitation of LBOD and SCARP tube wells

(c) Privatization of fresh ground water SCARP tube wells.

Strom water disposal and drainage of left over areas

(a) Revival of natural water ways to drain out storm water.

(b) Second line of defense for left Bank of Indus down stream Kotri.

(c) Construction of elevated platforms for flood displaced persons.

Cross cutting areas

(a) Protective plantation of mangroves on coastal area of left bank

(b) Use of drainage water for forestation in LBOD and Kotri command areas.

(c) Bio saline agriculture in Badin and Thatha Districts.

(d) Rehabilitation of Deh AKRO II and Chotiari wetland complexes.

(e) Rehabilitation of coastal wet lands.

(f) Shrimp and mud crab farming coastal area of left bank.

(g) Introduction of brackish water for fish farming in LBOD command area.

The major feasibility studies requiring EIA include i) Rehabilitation of LBOD system ii) Revival of old water ways/Dhoras and their environmental impact.

5.2 Baseline Study of Flora/Vegetation in Designated Area

Irrigated Zone

The study area comprises of Ghotki, Sukkur, Khairpur, Naushahro Feroze, Nawabshah, Sanghar, Mirpur Khas, Umar Kot, Matiari, Tando Allahyar, Tando Muhammad Khan, Thatta and Badin district, the left Bank of Indus River. This is an irrigated zone commanded under Guddu Barrage,

Sukkur Barrage and Kotri Barrage with its network of canals distributaries and water courses. Where there is sweet water available in sub-soil, the agriculture is raised by installation of tubewells. The main crops raised in Kharif and Rabi season are Cotton, Wheat, Sugar cane, Rice. Besides various vegetables like Cabbage, Chilies, Radish, Tomato, Onion, Coriander, Brinjal, Citrus, Lady finger, Mint, Bitter gourd and fruits like Date palm, Papita, Grewia, Mango, Jaman, Guava, Banana, Mulberry, Nustberry, Sugar apple, Berry, Oil seeds of rape, and Sunflower is raised.

The agricultural zone is conspicuous of tree growth in various forms. Trees are grown not only with agricultural crop in the form of agroforestry but also as solitary or as in groves for shade, firewood and forage for cattle. The area is also marked with irrigated plantations raised by Sindh Forest Department to cater the needs of timber, fireweed and forage. In Ghotki, Sukkur and Khairpur the main species being the Talhee (*Dalbergia sissoo*) where as in rest of the irrigated plantation, Babul (*Acacia nilotica)* constitutes the predominant species. In addition to this various fast growing species like Mulberry, (*Morus alba*) Neem (*Melia azadirech*), Cono (*Conocarpus lanrceofolius*) are also raised for various economic and environmental returns.

In the agricultural fields, the trees are raised along field boundaries, water courses, in linear fashion as shelterbelts or wind breaks and individual scattered trees. The main species growing as shelterbelts or wind breaks are Eucalyptus, Conocarpus, Neem and *Agata grandiflora* (Manjadri).

The raising of *Acacia nilotica* (Babul) on close spacing in a block plantation for shorter rotation is a common practice of agro forestry in lower region, particularly in Sanghar, Matiari, Hyderabad and Mirpur Khas districts. The main objectives is to improve the fertility of soil on one hand and getting economic return in the form of small timber for mines. In addition to the hurries, area is utilized to get fodder for animals.

There are various trees growing along roads, opens spaces, otaques and open spaces for shade and aesthetic purpose Table-11. They include *Poinciana pulcherima* (Gold Mohar), *Albizzia procera* (Siris), *Melia azedarach* (Bakain), *Tamarindus Indica* (Tamarind) and *Pithecolobium dulce*, (Jungle Jalebee) and *Cassia fistula* (chimkani).

Table-11 Trees Growing in Irrigated Zone

Sr. No	Botanical Name	English Name	Local Name
1.	*Acacia nilotica*	Gum acacia	Baber
2.	*Albiaaiz procera*	Indian walnut	Achosirhan
3.	*Azadirachta indica*	Ash-leaved bead tree	Nim
4.	*Cassia fistula*	Pudding pipe tree	Amaltas
5.	*Conocarpus lancefoleus*	Ethiopian teak	Kono
6.	*Dalbergia sisso*	Shisham	Talee
7.	*Eucalyptus camaldulensis*	Red-gum	Sufado
8.	*Ficus bengalensis*	Ficus	Bur
9.	*Pithecellobium dulce*	Jangle pithecolobium	Jungle Jalebee
10.	*Salmalia malabarica*	Silk cotton tree	Simal

Sr. No	Botanical Name	English Name	Local Name
11.	*Sesbania aegyptica*	Egyptian sesbania	Manjathri
12.	*Terminalia arjuna*	Terminalia	Aarjan
13.	*Thespesia populnea*	Tulip tree	Pyrus peepal

Arid and Semiarid Zone

This is the area, where irrigation supplies, cannot command the area, or is insufficient to cater the needs of agriculture, or tree plantations. It falls in Umar Kot, Digri, Tando Bago and Badin districts. This area is conspicuous for various Xerophytes, Grasses, Creepers and Climbers. The species require irrigation to a minimal quantity and frequency. They sustain high temperature, Sodicity of soil and water logged conditions. The main species being *Prosopis spicegera,* (Kandi), *Prosopis glandulosa* (Devi), *Capparis aphylla* (Kirar), *Zizyphus mauritiana* (Ber), *Acacia jacquemontii* (Baveri), *Salvadora oleoides* (Khabar), *Tamarix aphylla, Tamarix dioeca (Lao), Tamarix articulate (Laee) and Acacia Senegal*. Various shrubs and herbs include, Calligonum palygonides, (Phog), *Aerva tomentosa* (Booh), *Sacchrum spontaneum* (Munj), *Solarium xanthocarpum* (Kanderi) and *Alhajee maurorum* (Kandero).

Various grasses also grow in this tract which depends upon rain water. They are *Panicum antidotale, (Gum), Chrysopogan jawarancusa (Kathari) and Desmostaechya bipinnata* (Dhub).

In Badin, the main arid species is Devi (*Prosopis julifloira*). The species is drought resistant species; require less quantity of water, growing on sites where sub-soil water level is below 80-100 feet. This species is a source of shade, forage, fire wood. Many people manufacture Coal in kilns and earn their lively hood. This Coal is used in manufacture of bricks. The species regenerates quickly through coppicing and propagate extensively through seed Table-12.

Table-12 Tree Growing in Arid and Semiarid Zone

Sr. No	Botanical Name	English Name	Local Name
1.	*Acacia jacquemontii*	Desert acacia	Baveri
2.	*Acacia Senegal*	Senegalian acacia	Khoomhhat
3.	*Aerva tomentosa*	Woolly Amaranthus	Boah
4.	*Alhajee maurorum*	Camel thom	Kandero
5.	*Amaranthus gracilis*	Amaranth strawberry blight	Mareero
6.	*Andropogon annulatus*	Sheda grass	
7.	*Argemone Mexicana*	Prickly poppy	Kanderi
8.	*Brachiaria ramose*	False creeping paspalum	Gandhaer
9.	*Calligonum polygonoides*	Calligonum	Phog
10.	*Calotropis procera*	Mudar/Rubber bush	Ak
11.	*Capparis spinosa*	Thorny caperbush	Kerar
12.	*Casuarina equisetifoia*	Indus pine	

Sr. No	Botanical Name	English Name	Local Name
13.	*Chenopodium album*	White goosefoot	Sag
14.	*Crotalaria burhia*	Rattle cord – hemp	Khup
15.	*Cucumis callosus*	Bitter cucumber	Chibhir
16.	*Datura alba*	Thorn apple	Dhotoro
17.	*Dodonaea viscose*	Dodonaea – Hob bush	Sanatho
18.	*Euphorbia royleana*	Milk Herb weed	Thoohar
19.	*Leptadenia pyrotechnica*	Leptadenia	Khip
20.	*Poa tenella*	Meadow grass	Drubh
21.	*Prosopis cineraria*	Prosopis	Kandi
22.	*Prosopis glandulosa*	Mesquite	Devi
23.	*Salvadora oleodes*	Salvadora	Khabar
24.	*Solanum xanthocarpum*	Thorn apple	Kandari
25.	*Suaeda fruticosa*	Goosefoot	Lani
26.	*Tamarix aphylla*	Tamarisk	Lawo
27.	*Tamaix dioica*	Tamarisk	Laee
28.	*Zizyhus mauritiana*	Berry	Ber

Wetland/Dhoras

There are many wetlands, locally called Dhoras which are inundated due to inadequate drainage system or excessive rain and storm water. The main Dhoras are, Rainee Dhoro, Husainabab – Mehrabpur Dhoro, Kandiaro - Moro Dhoro, Mehrab pur Bachal rahu Dhoro, Sohni Dhoro, Bhai khan Dhoro, Puran Dhoro, Digri – Sarfaraz Dhoro, Pangrio Dhoro, Hakro Dhoro, Naro Dhoro and Pithoro Dhoro. It was observed that storm water from catchment area ponds in these Dhoras, spill over and inundates the crops and settlements due to blockages. They are actually abandoned River courses on the sides of Indus. These Dhoras are obstructed by water courses, rail, roads and unauthorized settlements. They provide valuable feeding and resting grounds for many migrant birds, especially during seasonal migration. Collectively, these wet lands support large number of resident and migratory water birds. These wetlands are highly resilient. Major changes in water supplies from year to year cause only temporary changes in the cycle of flood and descication. But the species range remains almost unchanged Table-13. As salinities increase, plants may be replaced by blue-green algae *Cynobacteriaeaea* which, on decaying, on edge of Dhoras, provide food for swarms of flies, on which many birds feed.

The most widespread plants appeared *Typha angustata*, (Reed), which has an economic value as a source material for constructing temporary houses and shelters. Other hydrophytes like *Phragmites karka and Nymphaea lotus*, also occurs naturally. Aquatic vegetation, dominates the open water area, comprises of water lilies and *Potomogeton pectinatus*. Submerged aquatic vegetation dominates the open water area, filling the whole water profile from bottom to surface comprises of *Hydrilla verticellata*, (Panijo Booto) *Utricularia*, *Juncus maritimus* (Rush-kal),

Justica hetrocarpa (Water willow), *Azolla pinnata*. (Water velvet) *Eragrostis poaedes* (Makhnee gah), *Ipomea aquatica* (Naro), *Juncellus lavigatus* (Sedge) *Arundo donax* (Reed grass), *Bergia suffruticosa* (Panijo phog) and *Elusine aegyptica* (Gandher). This test of vegetation is clearly a critical aspect of the wetland ecosystem, the main food source for large and varied fish population in Dhoras.

Typha angustata (Reed) and juncus maritamus (rush) does not resists high level of salinity. They are fresh water plants thriving in water where electrical conductivity does not exceed about 3.5 m 5/cm. *Potomogeton pectinatus* can tolerate E.C upto 4.7m s/cm, where as other aquatic species can tolerate E.C more than 6.mS/Cm. The presence of substantial populations of submerged aquatics seems to be important flood source for both fish and water birds.

Table 13: Plants Growing in Ponds

Sr. No	Botanical Name	English Name	Local Name
1.	*Arundo donax*	Reed grass	Nar
2.	*Azolla pinnata*	Water velvet	Benafsho
3.	*Bergia suffruticosa*	-	Pani-jo-phog
4.	*Hydrilla verticillata*	Water thyme o oxygen weed	Pani-jo-booto
5.	*Juncus martimus*	Rush	Kal
6.	*Justica heterocarpa*	Water villow	Abi bed
7.	*Lotus garcinii*	Lotus	Paboro
8.	*Phragmites karka*	Water grass	Naro gah
9.	*Scirpus capitatus*	Sedge	Delo
10.	*Typha angustata*	Elephant grass	Pan
11.	*Typha elephantine*	Elephant grass	Pan

Mangroves/coastal areas

The Indus delta is built up by the discharge of large quantities of silt, washes down in Indus River from Kara Kuram and Himalayan Mountain ranges. The delta spread over in Kharochan Taluka over 108, 753 ha in study area. There are about 10 creeks and mud flats. Mangroves are dependent upon fresh water discharges from river Indus. The mangroves are dominant by a single species, *Avicennia marina*, which is over 95% of the trees, through a few stands of *Ceriops tagal, Brugiuirfera conjugate, Aegiceras carniculatum and Rhizophora mucronata* also occur. They are adapted to water logged and oxygen deficient tidal mud flats, where no other plant survive. These forests besides being environmental value, also protect the Karachi and Bin Qasim Ports from siltation and erosion. They act as breeding ground for shrimps, birds providing low grade timber in house construction, poles for boats, fuelwood for curing shrimps and fodder for live stock Table-14. It is a livelihood for animals. Local people use *Rhizaphora* poles is many house hold products. Mangroves protect the coast from wind and ocean currents.

Table 14: Trees Growing in Mangroves

Ser No	Botanical Name	English Name	Local Name
1.	*Avicennia marina*	Avicennia	Timar
2.	*Aegiceras carniculatum*	Black mangrove	Cheeanr
3.	*Bruguiera conjugate*		
4.	*Ceriops tagal*	Yellow mangrove	Kiriri
5.	*Rhizophora mucronata*	Coman mangrove	Kumeree

5.3 Fauna

Identification of Sources of Data

The sources of secondary and primary data were identified. These included published literature, technical articles through web watch and reviewed list of primary and secondary data. Regarding primary source and types of primary data procedure was adopted such as general survey, focused groups meetings, consultations with communities and specific surveys. Meetings were held with concerned stakeholders throughout the area under proposed interventions and necessary discussions were conducted and finally data was obtained.

Review of secondary information

Following published literature and policies/guidelines were studied and reviewed to assess the flora of the study area.

a) Pakistan Environmental Protection Act, 1997
b) Sindh Wildlife Protection Ordinance, 1972 and amendments 2001
c) The convention of wetlands of international importance Ramsar, 1976
d) Integrated social and environmental assessment for water sector improvement project
e) Phase I and II reports for Preparation of regional plan for left bank of Indus, delta and coastal zone
f) Base line study report for state of forestry resources (Thatta & Badin)
g) Wetland and Wildlife studies – supplements
h) Other relevant literature

Predominant endangered and extinct list of wildlife species, present in the study area

In order to collect the above information the process of consultants with local communities, professional judgments and secondary information has been used to prepare the list of above type of species.

Assessment of positive or negative impacts on fauna in study area

During field visits, this aspect was assessed on the basis of activities to be undertaken such as rehabilitation activates, use of machines, disposition of the earth, compaction, preparation of culvers, buildings, underpasses and by passes of the proposed projects.

Mitigation measures to address the adverse impacts have been undertaken in the report.

The primary and secondary data collected were organized, analyzed and incorporated in the report.

Baseline survey of Fauna in the study area

The study area comprising of 15 districts located on left bank of Indus is rich in natural resources, having diverse and productive habitats, ecosystems and faunal and floral resources. They protected areas, reserved and protected forests, wetlands, variety of fish both marine and inland, wildlife, agriculture and live stock and wetland resources. Some of wetlands of the study area are internationally recognized Ramsar sites. The wildlife in the study area consists of marine and terrestrial species and migratory birds visiting the area every year.

This chapter of report provides the baseline of Fauna in various types of ecosystems in the study area. The data/information has been collected from primary and secondary data sources and surveys in the study area conducted prior to preparation of this report. List of protected areas in study area is given in Table-15

Table-15 Protected Areas in Sindh and Study Area

S. No	Name of Protected Area	Area (ha)	District	Habitat
1.	Kirthar National Park	308733	Dadu/Karachi	Arid/Semi Arid
	Wildlife Sanctuaries			
2.	Bijoro Chabh	121	Thatta	Wetland
3.	Cut Munarkt Chach	405	Thatta	Wetland
4.	Deh Akro-II	20243	Nawabshah	Wetland complex
5.	Dhoung Block	2098	Shikarpur	Riverine Forest
6.	Drigh Lake	164	Larkana	Wetland
7.	Ghandak Dhoro	31	Jacobabad	Wetland
8.	GulIel Kohri	40	Thatta	Wetland
9.	Gulsher Dhund	24	Hyderabad	Wetland
10.	Hub Dam	27219	Karachi	Wetland
11.	Hudero Lake	1321	Thatta	Wetland
12.	Hudero Lake	1321	Thatta	Wetland
13.	Haleji Lake	1704	Thatta	Wetland
14.	Hilaya	324	Thatta	Wetland
15.	Keti Bunder North	8948	Thatta	Wetland
16.	Keti Bunder South	23046	Thatta	Wetland
17.	Khadi	81	Thatta	Wetland
18.	Khat Dhoro	11	Larkana	Wetland
19.	Kinjher Lake	130468	Thatta	Wetland
20.	Kot Dinghano	30	Nawabshah	Wetland
21.	Lakhat	101	Nawabshah	Wetland
22.	Lung Lake	19	Larkana	Wetland

S. No	Name of Protected Area	Area (ha)	District	Habitat
23.	Mahal Kohistan	70577	Dadu	Arid/Semi Arid
24.	Majiran	24	Thatta	Wetland
25.	Marho Kotri	162	Thatta	Wetland
26.	Miani Dhand	57	Hyderabad	Wetland
27.	Mohabat Dero	16	Nawabshah	Wetland
28.	Munarki	12	Thatta	Wetland
29.	Nara Desert	223590	Sukkur/Khairpur	Desert
30.	Norang	243	Thatta	Wetland
31.	Rann of Kutch	320463	Badin/Tharparkar	Desert& Marshy
32.	Samno Dhund	23	Hyderabad	Wetland
33.	Sadnai	84	Thatta	Wetland
34.	ShahLanko	61	Thatta	Wetland
35.	Takkar	43513	Khairpur	Desert/Semi Desert

Reserved Forests in the study Area

Of the total area of 82,000 ha under irrigated plantations in Sindh, an area of 65,175 ha is located on left bank of Indus in various districts where as the rest 16,825 ha is located on right bank of Indus. These irrigated plantations are legally declared as reserved forests and are also game reserves and game sanctuaries for wildlife. The names of forests located on left bank of Indus and their area are listed in Tabel 16:

Table -16 District-wise Area of Irrigated Plantations on Left Bank of Indus in Sindh

District	Area (Ha)
Ghotki	11,431
Khairpur	5,013
Naushahro Feroze	634
Nawabshah	1,933
Sanghar	9,121
Umerkot	500
Hyderabad	3,282
Tando Muhammad Khan	7,918
Thatta	15,833

Badin	9,510
Total	65,175

Game Reserves in the Study Area

Under Wildlife Protection Act, 1972 Game Reserves has been declared. List of Game Reserves is shown in Table 17:

Table- 17 List of Game Reserves in Sindh and Study Area

S. No	Game Reserves	Area (ha)	District	Eco-zone
1.	Deh Jangisar	314	Thatta	Arid/Semi Arid
2.	Deh Khalifa	429	Thatta	Arid/Semi Arid
3.	Dosu Forest	2312	Larkana	Riverine Forest
4.	Hala	954	Hyderabad	Riverine Forest
5.	Indus river Dolphin Game Reserve (From Sukkur to Guddu Barrage)	44200	Jacobabad/Ghotki/Shikarpur & Sukkur	River Indus
6.	Khipro Forest	3885	Sanghar	Irrigated Forest
7.	Mando Dero	1234	Sukkur	Semi Arid & Cultivated
8.	Mirpur Sakro	777	Thatta	Semi Arid
9.	Nara	109966	Khairpur	Desert & Wetland
10.	Pai Forest	1969	Nawabshah	Riverine Forest
11.	Sahib Samo	349	Hyderabad	Riverine Forest
12.	Surjan, Sumbak, Eri & Hothiano	406302	Dadu	Arid/Semi Arid
13.	Tando Mitho Khan	5343	Sanghar	Desert & Semi Arid

Wetlands in Sindh and study area

Table-18: List of Wetlands of International Importance in Sindh

Name of Site	Location	District	Surface Area (hectares)	Wetland Type	Recognition RAMSAR Site No, (RS#)
Indus Dolphin Reserve	28° 01 N 69° 15 E	Between Guddu and Sukkur Barrages	125,000 44200	River	2001 RS#1065
Jubho Lagoon	24° 20 N 68° 40 E	Thatta	706	Brackish lagoon, mudflats, marshes	2001 RS#1067

Nurri Lagoon	24° 30 N 68° 47 E	Badin	2540	Brackish lagoon, mudflats	2001 RS#1069

Table- 19: List of Wetlands in Sindh and Study Area

Name of Site	**Location**	**District**	**Surface area (hectares)**	**Wetland type**
Nara Canal area	26°00-27°15N 68°47-69°18E	Khairpur and Sanghar	300000	200 small, freshwater, brackish and saline lakes and marshes
Soonhari lake	26° 10N 69° 04E	Sanghar	245	Small saline lake and brackish marshes
Sadhori lake	26° 12N 69°07E	Sanghar	Unknown	Shallow freshwater lake
Sanghriaro lake	26° 07 N 69° 12 E	Sanghar	380	Shallow brackish lake
Khipro lakes	25°32-25°49N 69°29-69°38 E	Sanghar	30000	30 small brackish and saline lakes
The Tando Bago lakes	24°45-24°50 N 68°50-69°05 E	Badin	unknown	11 shallow fresh and slight brackish lakes and marshes
Phoosna lakes	24° 48 N 68° 54 E	Badin	160	2 shallow slightly brackish lakes
Charwo Lake	24°50N 69° 00 E	Badin	100	Shallow freshwater lake and marshes
Khanjo (Khowaja lake)	24°47N 69° 05 E	Badin	500	Freshwater lake and associated marshes
The Badin and Kadhan lagoons	24°15-24° 30 N 68°35-69°05 E	Badin	unknown	Very shallow brackish lagoons and wet mudflats
Shahbundar Salt Waste and Jafri lakes	24°06-24°12 N 67°54-68°15 E	Thatta	20000	Salt waste and large brackish to saline lake
Mahboob Shah Lake	24° 30 N 68° 03 E	Sujawal	100	Small fresh to brackish lake and marshes(small lakes in the region: Karo, Karajo, Chatch and Ghungri)
Hadero Lake	24° 49 N 67° 52 E	Thatta	1321	Brackish lake
Outer Indus Delta	23° 45-24° 45N 67° 10-68° 15E	Karachi to Indian border	300000 200000 mangroves	Tidal river channels, creeks, sandy islands, mangrove swamps, inter tidal flats

5.4 Ramsar Recognized sites in Sindh and study area

The study area has three wetland complexes viz Deh Akro II wetland complex, Chotiari wetland complex and Coastal wetland Complex. They are considered as biodiversity hotspots due to the availability of diverse habitats and relatively low anthropological disturbance Table-19.

The Indus Dolphin Reserve is spread over 135 km from the Sukkur upstream to the Guddu Barrage. In 1974, the entire area was declared the home of the endangered Blind Dolphin (IUCN Red Data Book). The major threats it faces include split populations of the dolphins due to dams and barrages on the River Indus, reduction in habitat size during dry season, high turbidity, pollution, and hunting. The number of dolphins at the site has increased from 150 in 1974 to 620 in 2001.

Jubho Lagoon is a shallow, small brackish water lagoon with mudflats and marshes that support a large concentration of migratory birds including flamingos and endangered Dalmation pelicans, a rare species in the world. This was declared a Ramsar site in 2001 because of the efforts made by IUCN Pakistan.

Nurruri Lagoon is also a brackish, privately owned lagoon with barren mudflats that is visited by large concentrations of migratory water birds. It was also declared a Ramsar site in 2001. Increased salinity, sea intrusion, population pressures, agricultural and industrial pollution are major threats to this site.

Deh Akro is a wildlife sanctuary consisting of four major habitats; desert, wetland, marsh, and agricultural. Located 330km northeast of Karachi, it is a natural inland wetland ecosystem, which supports a variety of rare and endangered wildlife species. This area hosts a considerable number of rare fauna. Many indigenous fish species are also found here. Water scarcity during a persistent dry spell is adversely affecting this area.

Runn of Kutch is part of the great Thar desert and comprises of stablized sand dunes, with broad inter-dunal valleys of alluvial soil, connected across the frontier with India, which includes permanent saline marshes, coastal brackish lagoons, tidal mudflats, and estuarine habitats. The site supports many locally and globally threatened species, including the Great Indian bustard (Choriotis nigficeps), Houbara bustard (Chlamydotisundulata), Sarus crane (Grus antigone), and hyena (Hyeana hyaena) and supports more than 1% of the biogeographical population of flamingos.

Indus Delta is the fifth largest delta in the world. The fan-shaped delta consists of creeks, estuaries, mud flats, sand dunes, mangrove habitat, marshes and sea bays. It shelters 82,669 mangroves, mostly Avicenna marina which comprises 97% of the total mangrove area in the country and is said to be the largest coastal mangrove forest in the world. A large number of species of birds (including the threatened Dalmatian pelican) of fish and shrimps, and of dolphins (Plumbeous dolphin, Finless porpoise, and Bottlenose dolphin), humpback whale and reptiles are found here. The area is rich in archaeological and religious heritage.

5.5 Common birds in the study area

The area is very important of resident and migratory bird species. More than 100 species of have been recorded from the area. Table 20 lists the important birds of the study area:

Table-20 Important Birds of Sindh and study area

S. No	English Name	Scientific Name	Local Name
1.	Great Bustard	*Ardeotis nigricps*	Barri Tiloor, Hukria
2.	Houbara/Macqueen's Bustard	*Chlamydotis macqueeni*	Tiloor, Houbaia
3.	Common/ Blue Peafowl	*Paro cristatus*	Neela More, *Mor*
4.	Black Francolin/ Partridge	*Francolinus francolinus*	Kala Titer, Karo Titar
5.	Grey Francolin/ Partridge	*Francolinus pondicerianus*	Bhura Titer, Achho Tittar
6.	Yellow Legged Green Pigeon	*Treron phocnicoptera*	Harrial Kabutar
7.	Red Turtle Dove	*Streptopclia tranquebarica*	Surkh Fakhta
8.	Dalmatian Pelican	*Pelecanus crispus*	Hawasal, pain Pakhhi
9.	Lesser Flamingo	*Phoenicopterus minor*	Lum Dheeng/Laakho Jani
10	Oriental Darter/Anhinga/Snake bird	*Anhinga melanogaster*	Jall Kawwa
11.	WhiteStork	*Ciconia ciconia*	Safaid Laqlaq/Achhhi Toor
12.	Painted Stork	*Mycteria leucocephala*	Rangeen Laqlaq, Chit rod toor
13.	Greater Painted Snipe	*Rostratula benghalensis*	Rangeen Isnif
14.	Sociable Lapwing	*Vanellus gregarius*	Tattihri, Sehkari teeto
15.	Pheasant tailed Jacana	*Hydrophasianus*	Peehoo, Peehoorri
16.	Spot Billed Duck	*Anas poecilorhyncha*	Hanjar Batakh, Khanjar
17.	Marbled Teal	*Marmaronetta ahgustirostris*	Mar Marin Batakh
18.	Mallard	*Anas platyrhynchos*	Neel Sar, Neergi
19.	Brahminy/ Ruddy Shefduck	*Tadorna ferruginea*	Surkhab, Lallo Hanj
20.	Brown Headed Gull	*Larus brunaicephalus*	Bhori Sar Kina
21.	Caspian Tern	*Sterna caspia*	Caspian Dhumarah, Kekrah
22.	Indian Skimmer/ Scissors-Bill	*Rynchops albilcullis*	Qainchi Chounch/Pann Cheer
23.	Sarus Crane	*Grus antigone*	Sarus Koonj
24.	Imperial Eagle	*Aquila heliacal*	Shahi Oqab
25.	Pallas's Fish Eagle	*Haliacctus leucorhyplus*	Palasi Oqab, Machh manga
26.	Peregrine Falcon	*Falco peregrines*	Behri/Kala Shaheen
27.	Saker Falcon	*Falco cherrug*	Charagh/Saker Baaz
28.	Eurasian Eagle Owt/Great-HornedOwl	*Babo bubo*	Oqabi Ullu
29.	Lesser Golden-backed Woodpecker	*Dinopium benghalense*	Sunheri Khatkhat
30.	Sindh Pied Woodpecker	*Picoides assimilis*	Sindhi Khatkhat
31.	Blue Cheeked Bee Eater	*Merops persicus*	Barra Mugs Khot/Traklo

S. No	English Name	Scientific Name	Local Name
32.	Golden Oriole	*Oriolus oriolus*	Sunheri Peelak, Peelkio
33.	Indian Treepie/ Rufous Treepie	*Devdrocitta vagabunda*	Nabatati Zagh/Katar Khaan
34.	Common/ Punjab Raven/ Desert Raven	*Corvus corax subcorax*	Doodh kaag/Paharri Kawwa
35.	Pied Crested/Jacobin Cuckoo	*Clamator jacobinus*	Choti Dar Koel/Tarro
36.	Rosy Starling/Rosy Pastor	*Sturnus roseus*	Tillear, gulabi Myna
37.	Jordan's Babbler	*Chrysomma altirostre*	Jorden Ki Ghoghai, Doomni, Pinjhrro
38.	Sindh Jungle Sparrow	*Passer pyrrhonotus*	Sindhi Gorria, Jungli Chirria
39.	Red Avadavat/redMunia	*Amandara formosa*	Surkh Piddi, Garrho Cheeho
40.	Baya Weaver	*Ploceus philippinus*	Baya, Borrhi

5.6 Mammals in the study area

A variety of mammals are found in the study area that include Hog deer, Chinkara, Desert Cat, Fishing Cat, Caracal, Smooth coated Ottor, Wild boar, Desert hare, Foxes, Jackal and Feral wild ass. Table-21 and Table-22 lists the important mammals in Sindh and the study area:

Table-21 Important Mammals of Sindh and study area

S. No	English Name	Scientific Name	Local Name
1.	Sindh Ibex / Persian Wild Goat	*Capra aegagrus blythi*	Sarah, Pahari Bakra
2.	Afghan Urial / Asian Wild Sheep	*Ovis vignei blanfordi*	Gad, Pahari Dumba
3.	Indian Desert Gazelle / Chinkara	*Gazella bennettii*	Chinkara, Hiran
4.	Black Buck / Indian Savana Antilope	*Antilope cerricapra*	Kala Hiran
5.	Hog Deer / Parah Deer	*Axis porcinus*	Phara, Barasingha
6.	Blue Bull / Nilgai	*Boselaplus tragocamelus*	Neel Gai, Rojh
7.	Indian Wild Ass / Gorkhar / Onagar	*Equus hemionus*	Khur Jungli Gadha, GorkharKhuchhar
8.	Striped Hyaena		Hyaena hyaena
9.	Indian Desert Wolf	*Cains lupus pallipus*	Bherria, Bagharr
10.	Indian Desert Fox	*Vulpes vulpes pusillus*	Lomrri, Lomarr
11.	Caracal / Red Lynx	*Felis caracal*	Siah Gosh, Harola
12.	Jungle Cat / Swamp Cat	*Felis chaus*	Jungli Billi
13.	Fishing Cat	*Prionailurus viverrinus*	Machhi khor billi
14.	Small Indian Civet	*Viverricula indica*	Mushk Billi, Rasse
15.	Honey Badger / Ratel	*Mellivora capensis*	Bijju, Gor Pat
16.	Scaly Anteater / Pangolin	*Manis crassicandata*	Chiunti Khor, Chhalerano
17.	Indus Blind Dolphin	*Platanista minor*	Bulhann, Susu Dolphin, Andhy Dolphin
18.	Smooth Coated Otter	*Lutrogale perspicillata*	Udh Bilao, Luddharr
19.	Flying Fox / Fulvous Fruit Bat	*Rousettus leschenaultii*	Urra Lomrri, Meva Khore Chimgadar
20.	Blue Whale / Sulphur Bottom Whale	*Balaenoptera musculus*	Neeli Whale, Mangrail
21.	Mouse-like Hamster	*Calomyscus hotsoni Hamster*	Chooha

Table- 22 Important Mammal Species of Wild Animals of the Arid Zones of Sindh

Sr. No.	Common Name	Zoological Name	Habitat	Status
1.	Indian Gazelle (Chinkara)	*Gazella gazelle*	Thar, Nara bordering area and Kirthar National Park	Original population of Thar and Nara seems to

Sr. No.	Common Name	Zoological Name	Habitat	Status
				be exterminated
2.	Sindh Ibex (Sarain)	*Capra agagrus*	Arid hills and rocks of Kirthar range and Kirthar National Park (K. N.Park)	Protected in Kirthar National Park and areas of local sardars
3.	Urial	*Ovis orientalis*	Kirthar range and K.N. Park.	Protected in K. N. Park and Daryaro mountains of Larkana
4.	Nilgiri	*Boselaphus tregocamelus*	South of Nagarparkar migrant from India	Rarely found
5.	Asiatic wild ass	*Equis hemionus*	Ran of Kutch and Thar	Endangered
6.	Indian crested porcupine	*Hystrix mica*	Thar, Nara and Kohistan	Common
7.	Indian Hare	*Lopus migrcollis davanus*	Thar and Kohistan	Common in Mithi and Diplo
8.	Indian Pangolin	*Manis crassicaudata*	Kohistan	Rare
9.	Panther or Leopard	*Panthera pardus*	Kohistan	Rare
10.	Indian Wolf	*Canis lupus pallipea*	Kirthar range and Thar	Rare
11.	Jackal	*Canis aurius*	Thar, Nara and Kohistan	Common
12.	Desert Fox	*Vopus vulpus pusilla*	Tharparkar and Kohistan	Rare
13.	Wild cat	*Verricula indica*	Thar	Rare
14.	Common mangoose	*Herpestes edwardsi*	Tharparkar	Rare
15.	Striped Hyena	*Hyena hyena*	Thar and Kohfstan	Rare
16.	Desert cat	*Fells libyca*	Tharparkar	Rare
17.	Honey Badger	*Mellivora capensia*	K.N Park	Rare
18.	Wild boar	*Sus scrota*	Nara	Common

5.7 Reptiles and Amphibians in the study area

A considerable population of marsh crocodiles is recorded in chotiari and Deh Akro II complexes. A variety of snakes and monitor lizards and geckos are also found in the area. Table 9 lists the important Repties in Sindh and the study area Table-23.

Table- 23: Important Reptiles and Amphibians of Sindh

S. No	English Name	Scientific Name	Local Name
1.	Indian Ocean Green Turtle	*Chelonia mydas*	Samundri Subz Katchhwa
2.	Pacific Olive Ridley Turtle	*Lepidochelys olivacea*	Sumundri Zaituni Katchhwa
3.	Spotted Pond Turtle	*Geoclemys hamiltoni*	Talabi Katchhwa
4.	Indian Sawback River Turtle	*Kachuga tecta*	Daryai Katchhwa
5.	Starred Tortoise	*Geochelone elegans*	Sitara Katchhwa
6.	Marsh/Snub-Nosed Crocodile	*Crocodylus palustris*	Magar Much, Mugger, Wagu
7.	Yellow/Striped Monitor – Lizard	*Varanus flavescens*	Goh, Dhari Dar Goh
8.	Fat-Tailed/Leopard Gecko	*Eubleparis macularius*	Hann Khann, Cheetah Chhupkali
9.	Banded Dwarf Gecko	*Tropiocolotes helenac*	Dhari Dar Chhoti Chhupkali
10.	Sindh Broad Tailed	*Gecko teratolepis fasciata*	Sindh Moti Dum Chhupkali
11.	Orange Tailed Sand Skink	*Eumeces schncideri*	Narangi Dum Regmahi, Makh Chatti
12.	Indian Sand Swimmer	*Ophiomorus tridactgylus*	Regmahi, Makh Chatti
13.	Indian Spiny Tailed Lizard	*Uromastix hardwicki*	Sandha, Sandho
14.	Indian Chameleon	*Chamaeleo zeylanicus*	Rung Badal Girgit
15.	Indian Rock Python	*Molurus*	Azdaha, Arrarh Blah
16.	Russelle Sand Boa	*Eryx conicus*	Russelle Ki Do Muhi
17.	Oxus/Black Cobra	*Naja oxiana*	Kala Naag, Cobra
18.	Indian Common Krait	*Bungarus caeruleus*	Sang Choor, Peeun Blah
19.	Russelle's Viper	*Vipera russelii*	Ghorriala, Dumbhar Blah
20.	Red Spotted Diadem Snake	*Sphalcrosoplis arenarius*	Shahi Naag, Korarr
21.	Pakistan Ribbon/Sand Snake	*Psammophis leithi*	Regis Amp, Shehgi
22.	Glossy Bellied Racer	*Coluber ventromaculatus*	Paharri Samp, Par Blah
23.	Common Rat Snake/Dhaman	*Ptyas mucosus*	Dhamman, Kua Mar
24.	Sindh River Snake	*Enhydris pakistanicus*	Daryai Samp
25.	Beaked Sea Snake	*Enhydrina schistosus*	Chonch Dar Samundari Samp
26.	Annulated Sea Snake	*Hydrophis cyanocinctus*	Dhari Dar, Samundari Samp

S. No	English Name	Scientific Name	Local Name
27.	Slender Blind Snake	*Typhlops porrects*	Andha Samp, Sampolia
28.	Tiger Bull Frog	*Rana tigerina*	Maindak Dedhar
29.	Indus Toad	*Bafo andersori*	Khushki Ka Maindak

5.8 Common fish types in study area

About 60 species of fish have been recorded in the study area. Common fish species are listed in Table 24 as under: In coastal area various fish, shrimp, and mud crab species are available.

Table-24 List of common fish types in study area

Scientific name	Common name
Catla catla	*Thailhi*
Labeo rahita	*Rohu*
Labeo calbasu	*Dahi*
Labeo gonius	*Seriah*
Osteobrma catio	*Makhni*
Puntius sophore	*Chidu*
Puntius ticto	*Popri*
Puntius sarana	*Khirni*
Chela lebuca	*Dannbhra*
Cirrhinus reba	*Suni*
Cirrhinus mrigala	*Morakhi*

6 Archeological and Heritage Sites

Baseline survey of Archeological and Heritage Sites in the study area

This chapter of report provides the baseline of important archeological and heritage sites. The data/information has been collected from primary and secondary data sources and surveys in the study area conducted prior to preparation of this report.

6.1 The stakeholders

The stakeholders governing the the Cultural and archeological heritage include: the Government of Pakistan, the provincial government of Sindh, its Local Body system, the national and provincial institutions dealing with history, archaeology and culture such as the Ministry of Culture and Tourism, Government of Pakistan, the Pakistan Tourism Development Corporation (PTDC), the Department of Culture and Tourism, Government of Sindh, the Sindh Tourism Development Corporation (STDC), Directorate of Archaeology, Government of Sindh, the government-run Sindhi Adabi Board, Sindh Text Board, Sindhology and NGOs representing civil society besides knowledgeable persons can deliver a lot through individual as well as collective effort.

There is lot of local knowledge and awareness with the individuals located in the small villages and towns in the study area. Also a number of NGOs have emerged in Sindh with great cultural awareness. During the process of meetings with stakeholders the information on this aspect of EIA was collected. The combined approach of all stakeholders have contributed in the study area's cultural heritage in a befitting manner.

6.2 List of project area's heritage sites

Following list provides the names of heritage sites in the study area, their location in the district and its status of protection.

1. KOTDIJI - a pre-Indus site in Khairpur district. (Protected).
2. KAHOO JO DARO - a major Buddhist site at Mirpurkhas. (Protected).
3. LAKHYAN JO DARO - a mature Indus site in Sukkur city area. (Protected).
4. VINJNOTH - a mature Indus site near Sukkur. (Protected).
5. AROR DARO is a mound having characteristics of a Buddhist site. (Unprotected).
6. ARORE is a stone-age site near Rohri in Sukkur district. It contains a Hindu temple of Kalkan Devi, an ancient mosque attributed to Arab general Mohammed Bin Qasim and a stone-age factory of flint and other tools. (Protected)
7. AGHAN KOT is a fort near Badin. (Unprotected)
8. ASOORAN JO DARO is located near Badin. (Unprotected)
9. DARO Tando Jam: It is a mound having archaeological significance located near Tando Jam in Hyderabad district. (Unprotected)
10. BRAHMAN ABAD: It is also called Mansoorah. Basically a site of Rai dynasty turned capital of Sindh by Muslims after conquest of Sindh by Arab General Mohammed Bin Qasim. (Protected)
11. BUDDHA JO TAKAR: It is a Buddhist Stupa in ruins near Tando Mohammed Khan. (Unprotected)
12. RUINS of Badin - It is probably a Buddhist site near Badin. (Protected).
13. THUL MIR RUKUN: It is the only Buddhist Stupa of Sindh in good shape. It is located at Daulatpur Safan near Moro in Naushehro Feroz district. (Protected)
14. BAKHAR FORT: Both ruins and a fort of Bakhar were the capital of Sindh in Raja Dahar's reign. (Protected)

15. DAHLEEL KOT: It is a fort made from baked bricks near Sakrand. (Unprotected)
16. KALHORA TOMB – Tomb of Ghulam Shah Kalhoro, a ruler of Kalhoro dynasty of Sindh at Hyderabad. (Protected)
17. TOMB of Ghulam Nabi Kalhoro is also at Hyderabad. (Protected)
18. GANJO TAKAR CAVES-: It is a stone-age site near Hyderabad. (Unprotected)
19. HYDERABAD FORT: Also known as Neron Kot, this magnificent fort is made of fine baked clay bricks used by Kalhora rulers of Sindh. (Protected)
20. KACHO QILO, Hyderabad: It is a fort made of clay bricks at Hyderabad used by Kalhora rulers of Sindh. (Protected)
21. KOTDIJI FORT: It is the most beautiful and well maintained fort of Talpurs made of red baked bricks by the side of National Highway near Khairpur (Mirs'). (Protected)
22. KOT LALOO in Nawabshah district is a shambles these days. (Unprotected)
23. MASOOM SHAH MINARET: Hovering over city of Sukkur, the Masoom Shah's minaret is a monument of Kalhora dynasty. (Protected)
24. MOOMAL JI MA'ARI: Located at Mirpur Mathelo about 10 kilometers in east of Ghotki, there are ruins of a palace attributed to Moomal, the heroine of Sindh's famous folklore of Moomal-Rano. The site is about 40 feet above ground level. (Protected)
25. WATAYO'S GRAVE: Last resting place of Watayo Faqir, a legend of Sindh's folk wisdom. It is located at Nasarpur town of Hyderabad district. (Unprotected)
26. TOMB of Mian Noor Mohammad Kalhoro, ruler of Sindh, located at Daulatpur in Naoshehro district. (Protected).
27. RAKAS JO ROONO: It is a cave near Kotdiji. (Unprotected)
28. ROOPA MA'ARI: The ruins of Sindh's ruler Dodo Soomro's palace near Badin. (Unprotected)
29. MIR SHAHDAD JO QUBO The tomb of Talpur ruler Mir Shahdad at Shahpur Chakar in Sanghar district. (Protected)
30. SATIYUN JO ASTHAN: Site of chaste women at Sukkur. (Protected)
31. ARORE: At Arore, there are two tombs of 'Sohagin' (woman her husband alive or in company) and, 'Dohagin' (woman with her husband dead or separated). They are constructed in Exposed Brick style of architecture. (Unprotected)
32. CHITTORI: The group of Talpur tombs at Chittori in district Mirpur Khas. (Protected)
33. HYDERABAD: A group of Talpur tombs at Hyderabad besides those of the rulers of Sindh. (Protected)
34. TOMB OF SOHNI: Shrine of Sonhi, heroine of Sindh's folklore of Sohni-Mehar at Shahdadpur (Sanghar district). (Unprotected)
35. TOMB OF SASSUI: At Sanghar Patyoon in Lasbelo district of Balochistan. (Unprotected)
36. SHADI SHAHEED: The stone-age factory of flint in Khairpur district. (Unprotected)
37. NEENH TAKAR: A hill with unique formation located at Arore near Rohri. (Unprotected)
38. KARAR LAKE: A small sweet water lake located at Bhit Shah attributed to the memory of Sindh's greatest poet Shah Abdul Latif Bhitai. (Protected)
39. TOMBS OF MIRS: Located at Hyderabad, the tombs of Sindh's Talpur rulers are unique in architecture. (Unprotected)

6.3 Sites in Thar Desert

1. UMARKOT: Locally known as Amarkot, the fort is famous for the birth of Moghul emperor Akbar the great and imprisonment of Marui by Sindh's ruler Umar Soomro. (Protected)
2. THAHARIYO HALEPOTO: The coalfield of Thar where ruins of Buddhist period exist near Slamkot of Thar district. (Unprotected)
3. RUINS OF PA'ARI NAGAR: The ruins of Jain temples and settlements near Nagar Parkar town of Thar district. (Unprotected)
4. NAO KOT: Built by Talpur rulers of Sindh on the first sand dune of Thar near Mirpurkhas. (Protected)
5. TALPUR TOMBS: Ruins of four tombs of Talpur rulers are scattered in Tharparkar district. (Unprotected)
6. MARUVI'S WELL: A monument attributed to Marui, the heroine of Sindh's folklore of Umar-Marui located at Bhalwa village in Nagar Parkar taluka of Thar district. According to the legend, Maruvi was abducted by King Umar from this well and captivated in Umarkot. (Protected)
7. GORI TEMPLE: A magnificent Jain temple in Nagar Parkar taluka of Thar desert. (Protected)
8. ROOPLO KOLHI'S MONUMENT: The site where Rooplo Kolhi was executed by British troops while in pursuit of conquering Sindh in 1843 AD. (Unprotected)
9. MIRGHI KUNN: A Hindu tirath in Gordharo River of Karoonjhar Mountain where people drop ashes of the dead in the water of a natural spring. (Unprotected)
10. JAIN TEMPLES: Located at Nagar Parkar town of Thar, the ruins of Jain temples are magnificent in architecture. (Unprotected)
11. ANCHALYA SAR: A Shiva temple and natural spring about 200 feet above ground level in Karoonjhar mountain of Thar. (Unprotected)
12. KAJLA SAR: A legendary pond of water near Pa'ari Nagar in Thar. (Unprotected)
13. KAROONJHAR TIRATHS: A number of Hindu tiraths located in Karoonjhar with pre-Camberian stone formation at Nagar Parkar town of Thar. (Unprotected)
14. BHODESAR MOSQUE: Built by Mohmmed Shah Begro in mid eighties near Bhodesar waterpond near Nagar Parkar town of Thar. (Protected)

7 Impacts of the Interventions on Flora and Fauna

7.1 Environmental Impacts on Flora

Rehabilitation of LBOD

In order to check the rising water table and to dispose off storm water, through surface runoff, in Nawabshah, Sanghar and Mirpur Khas area, a system of drainage was laid out. The main objective was to enhance the agriculture output by reducing water logging, salinity and reclamation of saline lands.

A system of surface drains discharging in the sea via spinal drains, tidal links and deep tubewells to intercept seepage of water and control the ground water table into surface drains is the main component of project. There are several drainage systems in Badin and Kotri area, which comprises of spinal drains, Dhoro Puran link drains, Dhoro Puran outfall drain (DPOD), Kudhan Patajee outfall drain (KPOD), Fuleli Guni outfall drain, Karo Ghungro outfall drain and Tidal Link.

There will be little environmental effect on the ecosystem due to the proposed interventions. The positive effect is substantial. The rehabilitation of LBOD system and revival of Dhoras and water ways may cause some problems temporarily during construction phase as some of the ground vegetation will be removed due to mechanical/machinery use activities but will improve the area after the interventions are completed and in operation especially the vegetation in particular and overall environment in general.

Disposal of Excavated Earth: The rehabilitation of LBOD and its distributions and Dhoras may cause lot of earth work as such it should be disposed of properly. The excavated earth can be used in spoil banks proper cuts and fill methodology tag can be employed.

Dust Pollution: Dust pollution will cause negative impact on respiration. The mitigation measures are to sprinkle the roads with water.

Noise Pollution: Operation of a large number of earth moving machineries would cause noise level exceeding allowable limit of 80 to 90 dB. The Canadian labour code regulation Jan 1973 states that no employee can work in a place where noise reaches to 90 dB. The employees should wear ear protection gears.

Excavation of Borrow Pits: Excavation of material from borrow pits may damage ecosystem and upset the aquifer. The impact is small. The site should be restored after compaction of work.

Destruction of Flora and Fauna: In the construction period, the flora may be affected. There is possibility of tree removal during project activity. It was observed that there is no any tree or vegetation along LBOD. Mitigation measures need avoidance of access roads through vegetation and compensating damage by planting at last 5 trees for every tree cut.

Raising of Bunds: Raising of bunds in LBOD system will reduce the over flow of drainage water in adjoining area. This will save the agriculture field to be effected by saline effluent.

The overall system has a positive effect on flora of the tract, as the soil will be reclaimed by lowering the water table to a considerable depth. As such in those areas, where the tree growth has been effected due to salinity and water logging can be planted with trees, shrubs and herbs. The existing floras will get and impetus of growth.

Revival of natural waterways/Dhoras

After the revival of Dhoras, aquatic species will reappear, which were disappeared due to accumulation of saline effluent collected from adjoining lands. The main species to be rehabilitated are *Hydrilla vertecellata, (Pani-jo-Booto), Juncus mritimus, (Rush-kal), Arundo donax, (Reed-nargah), Elusine aegyptica, (ground grass - gandher gah), Ipomea aquatica (Naro) and Typha angustata, (Reed)*. These species serve as food for fishes and various indigenous migratory birds.

The intervention in revival of Dhoras, will enhance the green vegetative cover in and around Dhoras. The appearance of blue- green algae, cynobacteriaecea will be replaced by the above mentioned aquatic species.

It is expected that revival of Dhoras and providing safe passage to storm water, will evacuate water with minimal destruction to human lives, damage to standing crops and loss of livestock. During construction phase the ground vegetation may be removed temporarily due to use of heavy machinery, cut and fill of earth and at places construction of borrow pits. The area under agricultural crops will be affected as the crops will be cut / destroyed during the construction work and excavation. But after completion there are ample positive impacts on the vegetation as lot of vegetation will grow/regrow along the banks of dhoras and crops are grown in the catchment area. The major positive impact will be in the catchment areas from where the storm water will be disposed of in a shorter period of time saving the lives of people, livestock, habitations, crops and other vegetative cover. Hence, the positive impacts after completion will surpass the negative impacts during construction. Thus, the intervention is environment friendly and beneficial. It is suggested that after completion of revival of dhoras the banks may be planted with trees in linear fashion.

Rehabilitation of Tubewells

It will increase the farm productivity and farm income. The waterlogging will be reduced by this intervention which will improve the environment and the floral wealth will increase. Hence, there is a positive impact of this intervention.

Ghotki SCARP Saline Zone

This intervention will comprise of the following activities:

(a) A grid of drains serving the 25 thousand ha.

(b) 900 Km of surface drainage system.

(c) Water course improvement covering 3000 ha.

The main objective of this intervention is to improve the degraded lands of Ghotki area which at present have been badly affected by the waterlogging and salinity. Due tho these problems the productivity of the area has been significantly declined. Hence, the impacts of this intervention will be positive on the vegetation.

Privatization of Tubewells

The main objective of this intervention is to change the management of fresh water tubewells from the government to the private sector. The efficiency of the tubewells will increase which will ultimately be beneficial for the flora/vegetation wealth of the area. There is no any negative impact of this intervention but the positive impact is substantial. In addition, it will relieve the

Government of expenses, supplement the irrigation system and will enhance the productivity of crops.

Plantation of mangroves in coastal area

This intervention will increase tree cover in the coastal belt of study area over an area of more than 25,000 ha. There is no any negative impact of this intervention on vegetation during execution because no any machinery will be used and also no any manual activity will take place during land preparation and planting activities. After execution there will be enormous positive impacts due this intervention as mangroves have lot of protective and productive functions. Hence, this intervention is environment friendly.

The plantation of mangroves will revitalize the mangrove plantations along the coastal belt. The mangroves are hard hit due to negligible fresh water flows from River Indus, flow of pollutants and drainage of effluents. Sea water intrusion will be arrested resulting in increase in fish and shrimp population and firewood and small timber for local population. The establishment of mangrove plantations will serve as carbon sink. The main species *Rhizophora mucronata* which is at the brink of extinction will be revived.

Forestation through cyclic/conjunctive use of drainage water and Bio-saline Agriculture

The main objective of both the interventions is to use saline water for forestation and agriculture purposes. Halophytes (Trees and crops) will be grown through above interventions which will ultimately improve tree/vegetative cover in the degraded areas and ultimately make them productive. Hence, there is no any negative impact of both the interventions but immense positive impacts on vegetation and overall environment. Thus these are environment friendly options/solutions.

It is estimated that salt tolerant crops, grasses and trees will be grown on about 1.25000 acres by introducing bio Saline agriculture in Badin and Thatta districts. This will have positive impact on the environment and will bring more area under vegetative cover and enhance productivity.

Table- 25 List of salt-tolerant trees, grasses and crops

Ser No	Type	Name of species
1.	Trees	*Eucalyptus camaldulensis, Prosopis spicegera, julifloira, Causurina equisetifolia, Parkensonia aculeate, Conocarpus lanrceofolius, Tamarix articulate, Agati grandiflora, Cordea myxa, Cordea rothii, Hardwickia binata (Arjan), Jatropha curcas (Diesal plant), Leucaena lencocephala (Ipil ipil), Prosopis cineraria, Helianthus annus (sunflower).*
3.	Grasses/Herbs/Vegetables	*Aelopus logopoides (saline soil plant-Kalar gah), Andropogon annulatus (Sheda grass-deno), Brassica juncae (Rape-toorio). Chloris barbata (Rhodes grass-jaroon gah), Coyza canadensis (Flax leaf fleabane-Gidar waro gah), Eclipta alba (Eclipta-Bhangro gah), Elusine aegyptica (Goose-grass – Gandher gah), Frankenia pulverentula (powdery sea heath-khario), Heloxylon recurvum (Heloxylon-Khar), Pennesetum typhoides (Millet - Bajra), Portulaca oleracea (Small purelance -*

		loonak), Rumex dentatus (Toothed dock - choko), Sisymbrium irio (wild mustard - Irio), Spinaceae oleraceae (Spinach - Palak)
4.	Crops	Barley, Rice, Cotton, Tomatoes, Onion, Melon

Rehabilitation of Deh Akro II and Chotiari wetland complex

Rehabilitation of Deh Akro II and Chotiari wetland complex will arrest the seepage to the lands along Chotiari Lake and improve the habitat of wetlands of wildlife and migratory birds. The activity in Deh Akro II are i) provision of fresh water from Nara canal to dhandhs through construction of underground pipeline for improving the water regime and for the benefit of wildlife in the complex which is a Ramsar site.

Interventions for Fisheries development

There are two interventions proposed in the regional plan as under:

1. Introduction of brackish water fish in LBOD command area and
2. Shrimp and Mud crab farming in the coastal area

The objective of both the interventions is to improve the fisheries resource in the regional plan area for improving the livelihood of the communities living in the LBOD command area and the coastal belt. Both the interventions will involve construction of fish ponds and fish hatcheries which will not involve any activity detrimental to the flora/vegetation of the area. Both the interventions are environment friendly.

7.2 Impact of the Interventions on Fauna

Rehabilitation of LBOD system

A system of surface drains discharging in the sea via spinal drain and tidal link a network of main drains and sub-drains was established under LBOD Project. For containing the rising water table and to dispose off storm water, through surface runoff, in Nawabshah, Sanghar and Mirpur Khas area, a system of drainage was laid out. The main objective was to enhance the agriculture output by reducing water logging, salinity and reclamation of saline lands. This system due to inadequate maintenance has not achieved its objectives during the 2011 rain storm. Rehabilitation of this system has been taken up in the regional master plan as a priority intervention. The main activities involved include removal of rubbish vegetative growth from bed, de-silting, putting of silt on banks, plugging of breaches, repair of inlets and other structures etc. Most of above operations will be undertaken through use of machinery.

This activity will not have adverse impact on the big wildlife i.e mammals but during construction due to use of machinery brown aspect of environment i.e noise and dust pollution will have temporary adverse impact on the reptiles living in the soil or birds taking refuge in the ground vegetation and the people working on the work. The positive impact on fauna and flora will be substantial after completion of the work not only within the limits of drainage system but also in its catchment area as the fauna and flora will be provided with rich habitat and will flourish. Thus overall environment of the area will improve significantly.

Revival of natural waterways/Dhoras

It is intended to revive the old natural waterways for the quick disposal of storm water so as to reduce the adverse impacts of storm water on populations, villages, crops, livestock etc. Under this scheme the major water ways identified are Dhoro puran, Dhoro Naro, Hakro dhoro, Sarfaraz dhoro, Sohni dhoro and other minor Dhoras. During the process of detailed survey it revealed that at some places the dhoras are still available but at many places these have either illegally encroached or permanently allotted to people for agriculture purposes. At Mirpurkhas, Jhudo, Naokot, Digri and other towns there are permanent constructions. During construction/revival of these dhoras the activities involved include excavation of earth, construction of embankments, disposal of excavated earth, excavation of borrow pits, dragging of earth from adjoining fields, construction of bridges, culverts, bypasses, underpasses and other structures. Most of the above operations will be undertaken by using heavy machinery, thus will create noise pollution and air pollution detrimental to the people working on site and adjoining village habitations.

Impact on Fauna

The operations described above during the construction will not have adverse impact on the big wildlife i.e mammals but during construction due to use of machinery will have temporary adverse impact on the reptiles living in the soil or birds taking refuge in the ground vegetation. The brown aspects of environment i.e noise and dust pollution will have some negative impacts on the health of the people working on the work and adjoining habitations.

The major positive impact will be in the catchment areas from where the storm water will be disposed of in a shorter period of time saving the lives of people, livestock, habitations, crops and other vegetative cover. In addition, the fish and migratory and domestic bird species will be provided with a fertile habitat and ample green infrastructure for their reproduction, growth and productivity. Hence, the positive impacts after completion will surpass the negative impacts during construction. Thus, the intervention is environment friendly and beneficial.

It is proposed that after completion of revival of dhoras the banks may be planted with trees in linear fashion so as to mitigate the negative impacts due to temporary operations during construction and also the land use for tree planting will have positive environmental, social and economical impacts.

7.3 Impact of other Interventions of Regional Master Plan on Fauna

Following other feasibility projects are proposed in the master plan.

1. Rehabilitation of LBOD and SCARP Tubewells
2. Privatization of FGW SCARP Tubewells
3. Rehabilitation of coastal wet lands
4. Rehabilitation of Deh Akro II and Chotiari wetland complexes
5. Protective plantations of mangroves in coastal area of left Bank
6. Use of drainage water for forestation in the LBOD and Kotri area
7. Bio saline agriculture in Badin and Thatta district
8. Shrimp and Mud crab farming in coastal areas of left Bank
9. Brackish water fish farming in LBOD area
10. Ghotki SCARP (saline zone)
11. Elevated platforms for flood displaced persons

Projects 1 and 2 pertain to the vertical drainage i.e SCARP and Fresh Ground Water tubewells.

In project 1 the objective is to rehabilitate the tubewells installed/constructed during SCARP and LBOD periods and make them functional.

The main objective of privatization of fresh ground water intervention is to change the management of fresh water tubewells from the government to the private sector. The efficiency of the tubewells will increase which will ultimately be beneficial for the flora/vegetation wealth of the area. There is no any negative impact of this intervention but the positive impact is substantial. In addition, it will relieve the Government of expenses, supplement the irrigation system and will enhance the productivity of crops.

The activities involved in both are manageral only thus will not have any negative impact on the environment but will reduce the water logging and salinity from the agricultural lands and ultimately increase the farm productivity and farm income. Thus, the proposed projects will improve the overall environment and the floral and faunal wealth will flourish/increase in the area. Hence, there is positive impact of this intervention.

Projects 3 and 4 pertain to rehabilitation of important wetlands in the study area. All the wetlands are declared as protected area as they used to be rich in biological diversity. Due to some adverse environmental and social factors these complexes have been degraded and it is essential to rehabilitate them so that the biological diversity (flora and fauna) be restored.

The objective of coastal wetlands is to revive their productivity especially fisheries which is the main source of livelihood of coastal fishermen communities. The activities involve check entry of tidal water into dhandhs, supply freshwater to dhandhs and promote fisheries. The ultimate objective is to improve the ecosystem to improve the productivity of wetlands. Addressing above problems and achievement of desired objectives is environment friendly especially with respect fauna and flora.

Rehabilitation of Deh Akro II and Chotiari wetland complex will arrest the seepage to the lands along Chotiari Lake and improve the habitat of wetlands of wildlife and migratory birds. The activity in Deh Akro II is provision of fresh water from Nara canal to dhandhs through construction of underground pipeline for improving the water regime and for the benefit of wildlife in the complex which is a Ramsar site.

Intervention 5 pertains to Plantation of mangroves in coastal area. The main objective of this intervention is to plant mangroves in the coastal area and will increase tree cover in the coastal belt of study area. The main wildlife in this area is fisheries of various kinds which reproduce, grow and thrive in the mangrove area. There is no any negative impact of this intervention on the wildlife during execution because no any machinery will be used and also no any manual activity will take place during land preparation and planting activities. After execution there will be enormous positive impacts due this intervention as mangroves have lot of protective and productive functions. Hence, this intervention is environment friendly.

In addition, the mangroves will also improve the overall environment of the coastal belt by arresting sea intrusion, coastal erosion, mitigation of adverse impacts of polluted water effluents, in increase in fish and shrimp population and will serve as carbon sink.

The interventions **6 and 7 on Forestation through cyclic/conjunctive use of drainage water and Bio-saline Agriculture** are proposed with an objective of using saline water for forestation and agriculture purposes. Halophytes (Trees and crops) will be grown through above interventions which will ultimately improve tree/vegetative cover in the degraded areas and

ultimately make them productive. These interventions will not have any negative impact on the fauna but will have immense positive impacts on vegetation and overall environment. Thus these are environment friendly options/solutions.

Interventions 8 and 9 pertain to Fisheries development. There are two interventions proposed in the regional plan such as i) Introduction of brackish water fish in LBOD command area and ii) Shrimp and Mud crab farming in the coastal area. The objective of both the interventions is to improve the fisheries resource in the regional plan area for improving the livelihood of the communities living in the LBOD command area and the coastal belt. Both the interventions will involve construction of fish ponds and fish hatcheries which will not involve any activity detrimental to any faunal species of the area. Both the interventions are environment friendly.

Intervention 10 namely Ghotki SCARP Saline Zone comprises of the activities such as (a) grid of drains serving the 25 thousand ha (b) 900 Km long surface drainage system and (c) water course improvement covering 3,000 ha. The main objective of this intervention is to improve the degraded lands of Ghotki area which at present have been badly affected by the waterlogging and salinity. Due to these problems the productivity of the area has been significantly declined. During construction phase of this project some vegetation will be cut either by machinery or manually thereby the habitat for wild animals and birds population may be disturbed. The impacts of this intervention in the catchment area are expected to be positive on the flora and fauna as due to implementation of this project the waterlogging and salinity will be reduced and the area will be productive.

For the trees of economic importance when cut especially along water courses it is proposed mitigate the adverse impact by planting trees along the watercourses and potential drains.

Intervention on Construction of elevated platforms in the study area has been proposed to save the displaced people and their belongings and livestock etc. form abrupt floods due to breaches of river bunds, irrigation networks and drainage networks and also storm floods. There are no any significant negative impacts on the wildlife of any kind due to this intervention. The positive environmental impacts are substantial, hence environment friendly intervention.

Execution of Regional Plan Initiatives

The plan has identified the problem of waterlogging and salinity as key problem adversely affecting the project area's archeological and heritage sites. In order control this problem following interventions has been proposed in the regional plan through surface drainage disposal and vertical drainage options.

Drainage of waterlogged and saline soils

(a) Rehabilitation and improvement of LBOD drainage infrastructure

(b) Rehabilitation of LBOD and SCARP tube wells

(c) Privatization of fresh ground water SCARP tube wells.

Strom water disposal and drainage of left over areas

(a) Revival of natural water ways to drain out storm water.

The ultimate objectives of above interventions are to control waterlogging and salinity and explore measures to dispose off the storm water in shortest possible time so that no ponding is created around the sites of archeological sites, around villages, agricultural lands and wastelands. Execution of above projects may be prioritized and funding provided expeditiously.

Options for mitigation and future actions on Archeological Sites

Execution of Regional Plan Initiatives

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7.4 Heritage Management Plan

To save the cultural heritage sites from being crumbled to dust under adverse environmental conditions and neglect, all stakeholders including the Government, must evolve a strategy containing short and long-term plans for the study and preservation of the Cultural Heritage sites of Sindh.

The future demands some serious and persistent effort to explore the cultural heritage of Sindh in totality and preserve it for the posterity. The best possible option to that end could be to mobilize stakeholders for generating funds to preserve the heritage sites and other places of great cultural value with utmost honesty and dedication.

The Government may earmark a handsome budget from the national resources to keep the national heritage of Sindh intact. The Government of Sindh may also contribute optimally towards such a national effort from its provincial budget besides strictly implementing the Antiquity Act within its jurisdiction to safeguard the heritage.

The best possible measure would be to diagnose the ailment eating up the archaeological ruins in Sindh and suggest remedy to that chronic malaise. The expertise of local experts must also be explored and pooled up for this great task. The preservation plan, thus evolved, must be implemented in a foolproof manner.

Secondly, the site museums may be set up at all important excavated archaeological sites. The museums serve both as centers of visual education and dissemination of knowledge. So far, the object-finds unearthed through excavations have mostly been kept in Karachi while some selected pieces have been displayed in the National Museum. The establishment of site museums would provide an opportunity to the research scholars to study the antiquities right at the excavated sites in their true perspective.

Strengthening of provincial department of archaeology:

The cultural wealth of Sindh is so vast and varied in nature that it is not possible for the existing Department of Archaeology to handle it single-handedly. Thus, the province of Sindh may strengthen the department of Archaeology for taking comprehensive measures to preserve its cultural heritage for posterity.

7.5 EIA plan based on ICID Checklist for I & D and Flood Control Development Projects

The major use of matrices is to indicate cause and effect by listing activities along the horizontal axis and environmental parameters along the vertical axis. In this way the impacts of both individual components of projects as well as major alternatives can be compared. The simplest matrices use a single mark to show whether an impact is predicted or not.

The ICID checklist is presented in Table-26 to present the anticipated impact of the project interventions on overall environment of the area. The ranking indicate the consultant's opinion that 36% of the indicators show that the project will have very likely positive impact; whereas 49% indicators show that the project interventions shall have possibly positive impact. Only 15% environmental parameters indicate that there is no likely impact or the impact cannot be judged at this stage. The overall picture is very encouraging indicating very positive impacts of the project interventions on completion of the project components.

Table-26 Identification of Environmental & Social Effects of Regional Plan Project Interventions

Project name/location: Regional Plan Preparation Date: November 2012

For each environmental effect place a cross (X) in one of the columns		Positive or very likely	Positive impact possible	No impact likely	Negative impact possible	Negative impact very likely	No judgment possible at present	Comments
Hydrology	1.1 Low flow regime	-	-	-	-	-	X	-
	1.2 Flood regime		X					
	1.3 Operation of dams	-	-	-	-	-	X	-
	1.4 Fall of water table	X	-	-	-	-	-	-
	1.5 Rise of water table	-	-	X	-	-	-	-
Pollution	2.1 Solute dispersion	-	X	-	-	-	-	-
	2.2 Toxic substances	X	-	-	-	-	-	-
	2.3 Organic pollution	-	X	-	-	-	-	-
	2.4 Anaerobic effects	-	X	-	-	-	-	-
	2.5 Gas emissions	-	X	-	-	-	-	-
Soils	3.1 Soil salinity	-	X	-	-	-	-	-
	3.2 Soil properties	X	-	-	-	-	-	-
	3.3 Saline groundwater	X	-	-	-	-	-	-

For each environmental effect place a cross (X) in one of the columns		Positive or very likely	Positive impact possible	No impact likely	Negative impact possible	Negative impact very likely	No judgment possible at present	Comments
	3.4 Saline drainage	-	X	-	-	-	-	-
	3.5 Saline intrusion	-	X	-	-	-	-	-
Sediments	4.1 Local erosion	-	X	-	-	-	-	-
	4.2 Hinterland effects	-	X	-	-	-	-	-
	4.3 River morphology	-	X	-	-	-	-	-
	4.4 Channel regime	-	-	X	-	-	-	-
	4.5 Sedimentation	-	-	X	-	-	-	
	4.6 Estuary erosion	-	-	X	-	-	-	-
Ecology	5.1 Project lands	-	X	-	-	-	-	-
	5.2 Water bodies	X	-	-	-	-	-	-
	5.3 Surrounding area	-	X	-	-	-	-	-
	5.4 Valleys and shores	-	-	X	-	-	-	-
	5.5 Wetlands and plains	-	X	-	-	-	-	-
	5.6 Rare species	-	X	-	-	-	-	-
	5.7 Animal migration	--	X	-	-	-	-	-
	5.8 Natural Industry	-	-	X	-	-	-	-
Socio-economic	6.1 Population change	X	-	-	-	-	-	-
	6.2 Income and amenity	X	-	-	-	-	-	-
	6.3 Human migration	X	-	-	-	-	-	-
	6.4 Resettlement	X	-	-	-	-	-	-
	6.5 Women's role	X	-	-	-	-	-	-
	6.6 Minority groups	-	X	-	-	-	-	-
	6.7 Sites of value	-	X	-	-	-	-	-

For each environmental effect place a cross (X) in one of the columns		Positive or very likely	Positive impact possible	No impact likely	Negative impact possible	Negative impact very likely	No judgment possible at present	Comments
	6.8 Regional effects	-	X	-	-	-	-	-
	6.9 User involvement	X	-	-	-	-	-	-
	6.10 Recreation	X	-	-	-	-	-	-
Health	7.1 Water and sanitation	X	-	-	-	-	-	-
	7.2 Habitation	X	-	-	-	-	-	-
	7.3 Health services	-	X	-	-	-	-	-
	7.4 Nutrition	X	-	-	-	-	-	-
	7.5 Relocation effect	X	-	-	-	-	-	-
	7.6 Disease ecology	X	-	-	-	-	-	-
	7.7 Disease hosts	X	-	-	-	-	-	-
	7.8 Disease control	X	-	-	-	-	-	-
	7.9 Other hazards	-	X	-	-	-	-	-
Imbalances	8.1 Pests and weeds	-	X	-	-	-	-	-
	8.2 Animal diseases	-	X	-	-	-	-	-
	8.3 Aquatic weeds	-	X	-	-	-	-	-
	8.4 Structural damage	-	X	-	-	-	-	-
	8.5 Animal imbalances	-	X	-	-	-	-	-
Number of crosses		19	26	6	0	0	2	Total=51

[1] Adapted from International Commission on Irrigation and Drainage (ICID) website

Positive or Very likely impact = 36%

Positive impact possible = 49%

No impact likely = 11

No judgment possible = 4

Total = 100%

8 Social Impact Assessment

8.1 Rationale

The purpose of this report is to present the findings of the household surveys and consultations with stakeholders and village communities the Consultant conducted in communities residing along dhoras suggested for revival. The consultations were conducted according to the requirements set out in the Terms of Reference:

1. Carry out environmental and social assessments in each sub area, and propose clustering of sub-s where these assessments are not cost effective to carry out separately. Undertaking environmental and social assessment in batches of sub-s may also form the basis for broader assessments for the whole study/ area;
2. Review the social conditions in the subs, and undertake social assessment of the Project;
3. Have consultations with the beneficiaries to develop appropriate methodology and levels of cost sharing/recovery for the Project works;

8.2 Community consultations - approach and methodology

The social impact study is related to the area that is traversed by the major dhoras on the Left Bank of Indus. The study includes the following dhoras and drains: Dhoro Puran, Sonhi Dhoro, Dhoro Naro, Hakro Dhoro, Dhoro Pithoro, Bhaikhan Dhoro and D4 Drain. The total length of dhora and the proposed D4 drain is more than 700 km.

The main objective of this phase of community consultations was to discuss with communities proposed revival of dhoras and possible constructions of drains in the leftover areas. The major outcome expected was communities' views and opinions, their perceptions of possible impact of the proposed interventions as well as the mitigation measures as perceived by the communities.

In accordance with the main objective of the study, the following sample selection criteria were determined:

i. Major dhoras which have inactive parts considered for revival
ii. Dhoras which are running but are partially encroached or blocked
iii. Drains proposed for constructions
iv. Districts which are traversed by the sampled dhoras/proposed drains
v. Talukas in each district traversed by dhoras/proposed drains
vi. Villages situated within 200m from the dhora/proposed drain

Following the sample selection criteria, a multilevel sampling method has been adopted. The sample included six major dhoras and the longest proposed drain in the area. These dhoras traverse seven districts and 33 talukas. Two to three villages from each taluka (in total 91 villages) were randomly chosen for community consultations and data collections on village profile and household surveys. In each sampled village, the team conducted:

- Open community consultations (separate for men and women)
- Household survey with six respondents (3 men and 3 women) randomly chosen and
- One Key Informant interview on village profile

Overall, open community consultations were conducted in **91 sample villages in seven districts**. In total, **2,815 persons** (**1,333 men and 1,482 women)** participated in the community consultations. In addition, data on the socioeconomic profile of local population were collected

by semi-structured household questionnaires. In each village, six household questionnaires were completed. Overall, **543 persons (271 women and 272 men)** were interviewed.

8.3 Main Findings

The following is the summary of views and opinions brought up at the community consultations:

8.3.1 Perceived positive impact

Surveyed communities reported 9,573flood affected households, which makes 91% of all surveyed households. There are 9,373 households with some structures affected by the 2011 flood and 1,306 with the agriculture land affected. The most stated positive impacts which revival of dhoras would bring were as follows:

- Water will drain out fast
- Water logging and salinity will decrease
- Agriculture production will increase
- Houses and land will be safe
- Livestock will get sufficient drinking water
- Diseases will decrease
- Necessary drainage system will be developed
- Paid local labour will rise

Generally, local communities were satisfied with the proposal. They expect to be saved from flooding, damages and constant relocation during rainy seasons. People expect only rain water to flow in dhoras as they would use it for livestock and domestic purposes. The most cited benefits were that dhoro will enable fast draining of water and that land, houses and livestock will be saved from floods. The most of people's concerns were related to bunds which should be elevated and additionally straightened. In addition, people want to see dhoras revived along the entire length. Communities expect Government's seriousness and honesty throughout the planning, implementation and the monitoring of the Project and post-Project operation and maintenance.

'Puran is our mother; our descendants were always looking at Puran as mother; they saw it running. And that was the time when nearby lands were all green. Now, since many years we see it as our mother has passed away because all nearby lands are facing drought condition day by day.' Ghulam Mohammad Khoso village, Dhoro Puran, Tharparkar

8.3.2 Perceived negative impact

A great majority of consulted population (78.1%) think that revival of dhoras will not have any negative impacts at all. The rest of the respondents think that the Project would be successful if it is done honestly and timely. In addition, consulted communities think that, once work is completed, operation and maintenance will be of utmost importance for the project.

Some of the agriculture communities in Mirpurkhas area were reluctant to discuss the revival of dhoro as their villages are almost entirely built in the dhoro and the proposed interventions would affect their structures and crops planted inside the dhoro. People think that it would be a very challenging task but with Government seriousness and dedication, the Project could be accomplished successfully.

Some of the perceived negative impacts of the proposed interventions are summarized below:

- Crops and structures inside the dhoro will be affected

- Access to other sides will be hard if bridges are not constructed
- Possible damage or cut of bunds would harm local communities
- Improper monitoring, maintenance and management will damage the whole area
- Potential overflowing will damage houses and livestock
- Any backflow will affect the area
- It may involve relocation of people

8.4 Perceived mitigation measures

More than 85% of consulted persons gave their vision of the mitigation measures which should minimize potential negative impact of the Project. The most common suggestions were:

- Ensure proper deep de-silting of dhoras by advanced machinery
- Make bunds stronger and ensure that villages are not easily flooded
- Build safety bunds around villages
- Have safe place for people if they have to move during the flood
- Ensure proper access from one to the other bank of a dhoro
- Prevent backflow by installation of gates
- Ensure timely and proper compensation for lost crops, structures and other affected assets
- Implement the Project and establish operation and maintenance of dhoras with honesty, sincerity and without corruption
- Involve local communities in every stage of the Project

Communities' readiness to participate in the project implementation

Almost without exception, respondents expressed their support for the proposed dhoras revival as well as the readiness to participate. **95.6%** stated that they are ready to cooperate with Government in every way they could. Most of ordinary people are poor and cannot contribute money, but they suggested paid daily labour, collecting donations, giving information to the working team, looking after construction material etc. Also, if local labour hired on daily wages, villagers would be able to contribute a day or two of work on a voluntary basis. Consulted communities expect the Government to involve them in operation and maintenance activities. *'Each time we have been ignored in development schemes; it is our basic right to get work in all schemes because our youngsters are jobless and they need work.'* Village Dhano Kolhi, Bhai khan Dhoro, Badin. People insist that, before any work, the Government should present them the work plan, consult with affected communities again and fully compensate those who would lose crops and structures due to dhoras revival.

8.5 Recommendations

The following is the summary of the key recommendations the Consultant has formulated on the basis of the data analysis and suggestions expressed at consultations with potentially affected communities living along major dhoras proposed for revival. In the opinion of the Consultant, these recommendations must be considered at all stages (planning, construction and operation and maintenance phases) of the interventions.

1 Review and consider people's suggestions in the course of planning dhoras revival or new drains construction.

2 Ensure transparency at all stages of the proposed interventions. Share the detailed project plan with communities by conducting another wave of consultations with potentially affected villagers.
3 Ensure consistent and meaningful inclusion of local communities and other stakeholders at all stages of the project through continuous consultations and by providing proper feedback about any action taken.
4 Compensate fully all affected persons before any works.
5 As per people's suggestions, establish people's committees at a village level and ensure local labor on daily wages whenever practicable.
6 Involve local communities in the dhoras maintenance on paid basis whenever practicable.

9 Overall Environmental Impact Assessment of Project Interventions

An **environmental impact assessment** (EIA) is an assessment of the possible positive or negative impacts that a proposed project may have on the environment. The purpose of the assessment is to ensure that decision makers consider the ensuing environmental impacts when deciding whether to proceed with a project. It is the process of identifying, predicting, evaluating and mitigating the biophysical, social, and other relevant effects of development proposals prior to major decisions taken and commitments made.

The Regional Plan for the Left Bank of Indus, Delta and Coastal zone is being preparaed by the LBG / Indus Associated Consultants under a study by SIDA. A number of interventions are proposed after detailed consultation and agreement by the stakeholders of the area through field visits, group discussions, seminars, workshops at village, district, AWBs, regional and national level. In first phase, issues and problems of the area were identified through rigorous consultative process. In second phase, solutions of the major issues were sorted out after detailed interaction with stakeholders, personnel of government line departments, NGOs, technocrats, AWBs and SIDA authorities selecting most appropriate options, initially for preparing pre-feasibilities and later feasibility studies under third phase of the project. The environmental impacts were assessed for the interventions selected for the feasibility studies are as under:

No major negative impacts are expected from the selected projects. However, the anticipated impacts are minor and temporary while the benefits are long lasting and permanent in nature. Following is the summary of the impacts of the individual interventions:

1. Rehabilitation and Improvement of LBOD Outfall System KPOD, DPOD, Tidal Link

The proposed intervention will address the issue of drainage in the project area by disposing flood/drainage water into sea. It is environment friendly and supportive in reducing water accumulation thereby helping to address the water logging issue. It has positive effect on environment of the area.

The proposed intervention will also address the issue of overloading of the drainage infrastructure and will divert appreciable quantity of the drainage effluent (mostly storm water) to the thirsty Thar area where it will be utilized for recharging the underground aquifers and also for growing agriculture. Efforts will be made to give passage to water flow through natural water ways under gravity. If unavoidable, the displaced persons of the locality will be compensated by providing alternate livelihood and space provisions by appropriate re-settlement procedures. However, the overall impact of the intervention will be environment friendly

Positive impacts

a. Drainage effluent from the project area will find its way to the sea through enhanced drainage system

b. The storm water will be evacuated within a time frame of 3-7 days in most places This will save the crops from inundation and failure as experienced in the previous design.

c. Agriculture production will increase due to control of water logging and salinity on one hand and threat to the crop damage due to ponding of storm water.

d. Overall environment of the area will improve

e. Tidal control structure will minimize sea intrusion to cropped areas as well as stop backflow of sub-drains outfalling in KPOD.

f. The salinity of the dhands that have tremendously increased due to tidal interference and seawater intrusion will be minimized and dhand ecosystem will be revived by the ecosystem approach.

Negative impacts

a. More water from the project area will enter the LBOD system. The O&M activities are not taken on regular basis with the result the erosion of the banks of the drains will make the system vulnerable and unstable.

b. The process of erosion of tidal link banks and bed yet continues and may extend with the passage of time. Until the system becomes stable, there is always risk of extended flooding in the inland areas.

c. Under heavy rains as of the intensity of 2011 rains the system may not handle the storm water resulting in damage to crops, people and the property

d. Many isolated pockets exist in various areas of the left bank as pointed out in 5 core engineering report. Such pockets need to be connected to the drainage infrastructure for drainage disposal otherwise; depressions may hold storm water months as observed in 2011 rains.

e. Irrigation system in the event of heavy rains if not closed at least one week before rains, may add to the grievances of the people as in 2011 rains.

f. Culverts of suitable cross section if not provided at places of inadequate discharge may create ponding of water in isolated pockets / depressions.

2. Activation of Natural Waterways (Dhoras)

In pre-LBOD period, mainly the natural waterways were open and used to convey storm water to the sea or depressions evacuating the cropped areas in a couple of days. The LBOD caused dhora blockages at most places that caused ponding of water in isolated pockets resulting in inundation of vast cropped areas and settlements. Activation of the blocked water ways is of paramount value to vacate the storm water from these areas. Suitable siphons are proposed wherever the drainage system blocks these water ways. Moreover, the left over areas are also connected with dhora system so most of the inundated areas are now part of the drainage system.

Positive impacts

a. Natural waterways (dhoras) are the streams that used to flow under gravity carrying the river water during floods. These dhoras were blocked by the large banks of the spinal drain and other branch drains, roads, and irrigation infrastructure. These waterways will be revived, so all storm water will find its way to sea under gravity.

b. All leftover areas are proposed to be connected with dhoras. Therefore, no storm water will stay in cropped areas but will find its way through dhoras to the sea. Thus the cropped areas and settlements will be saved.

c. Grievances of the storm water flood affecties will be addressed and huge losses to the tune of billions of rupees will be minimized.

d. Communication system will not be affected by the locals who give deliberate cuts in metalled roads and canals to evacuate their lands, villages and towns.

e. The outbreak of contagious diseases could be checked that occurred due to ponding of water in depressions for months that provided breeding places for the mosquitoes and other disease causing organisms.

f. Marketing of agricultural produce will continue thus the chances of failure of the perishable goods due to non-availability of road infrastructure will be avoided.

g. Losses to the common man with regard to the failure of crop, death of animals and loss of housing and property would be minimized.

h. Bypasses to the cities and towns that are located in the way of dhoras are provided to avoid loss of their valued buildings and inundation of the areas of these towns. eg. Naukot, Jhudo, Digri, and Mirpurkhas

Negative impacts

Following negative impacts are of marginal nature and most of these are manageable with proper management during the execution of the project.

a. Under heavy monsoons, the storm water flow in dhoras may overtop and flood nearby fields and settlements
b. Locals have blocked dhoras and made path ways across dhoras for their personal works. Now the foot bridges across dhoras will be at distant places therefore, inconvenience will be created to the locals
c. At a number of places, the dhoras have been filled by the zamidars and are being cultivated. Such cultivated areas will be abandoned.
d. Some places in dhoras are occupied as settlements. These will be vacated, though compensation will be paid to the affectees.
e. At present the natural waterways (dhoras) are full of natural vegetation. Variety of fauna lives and thrives in these natural hideouts. Therefore, the wild life in such places will be affected.
f. Storm water in dhoras was being used for crops under water scarcity conditions, but now after revival of dhoras, the water will flow to its destination thus cannot be used for crops in case gates are not provided to stop the flow of storm water.
g. At some places, the stagnant water in dhoras is used as fish ponds for the local population, but after revival of dhoras, these fish ponds will not work instead, fish nets will be used fishing in dhoras

3. Rehabilitation of SCARP Drainage Tubewells of LBOD System

The tubewells were installed to lower down the water table but it reported that about half of the tubewells are non-functional. Rehabilitating the tubewells will lower down the water table and will help increasing the agricultural production. The intervention is environment friendly and beneficial for the community as a whole.

4. Privatization of FGW SCARP Tubewells

This intervention will privatize the public fresh groundwater tubewells. This intervention will increase the water availability for agriculture thereby increasing agricultural production with increase in cropping intensity and yields. This option is environment friendly and will help minimizing water logging and salinity.

5. Rehabilitation of Coastal Wetlands

This intervention shall help to revive the degraded ecosystem of the coastal dhands using internationally accepted “ecosystem approach”. The fish, reed grasses wild life and the migratory birds will occupy the dhands and improve the overall ecology of the area. The salinity of dhands will improve and the storm water will be stored that would supplement the irrigation supplies. This will certainly reduce the seawater intrusion and increase the livelihood opportunities for the communities. The intervention would prove environment friendly and supportive for communities.

6. **Protective Plantation of Mangroves**

The protective plantation of mangroves will help reduce the thrust of the cyclones and storms and will save the coast from degradation providing an effective biological wall against the strong winds and sea tides. Further, the intervention will address the problem of sea intrusion as the mangroves have the capacity to stop the movement of the sea water in the inland areas. The mangroves are also the store houses of biodiversity, breeding grounds for fish breeding and water fowl nesting and staging and, the saviors of coastline. Mangroves also provide livelihood and employment opportunities for the poor coastal communities. Thus the proposed project is environment friendly and socially acceptable.

7. Use of Drainage Water for Forestation in the LBOD Area

The proposed intervention will help utilize the drainage effluent together with irrigation water for growing forests in conjunctive or cyclic forms. A number of tree species utilize saline water for their growth and development and also take up salinity of the water or soil thus reducing the overall salinity of the area. The water of the surface drains is moderately saline and is not hazardous to growing trees. This intervention will add to the income of the people possessing marginal unproductive land.

8. Bio-saline Agriculture for marginal lands of Badin and Thatta Districts

This is an environment friendly intervention and will uplift the socio-economic conditions of the people holding marginal lands. Although the use of brackish water will alter the salinity conditions of the lands but the effect will be minimal because, the lands are already marginal while the drain water will have salinity between 1000-1500 ppm reasonably well suited for growing salt tolerant agricultural crops, grasses, oil seed crops, trees and bushes as well as grasses as fodder for the livestock without increasing the land salinity.

9. Rehabilitation of Dek Akro II and Chotiari Wetland Complex

The proposed intervention is environment friendly and supportive for wildlife conservation and development of fisheries and other wild animals in both Deh Akro-II and Chotiari wetland complexes. The activities proposed in Deh Akro II are intended to improve the shortage of freshwater for wetland ecosystem and in Chotiari wetland complex due to construction of Moat and Interceptor drains will reduce the water logging in the areas adjoining the Chotiari reservoir wetlands. The proposed intervention is thus environment friendly.

10. Shrimp & Mud Crab Farming in Coastal Areas of Left Bank

The proposed intervention is environment friendly with no apparent negative environmental impact. The intervention shall also add to the livelihood of the people and create employment opportunities for the coastal communities. The socio-economic conditions of the people of the area shall improve. The shrimp and mud crab species are the export commodities and will earn foreign exchange for the country.

11. Brackish Water Fish Farming in LBOD Drainage System

The proposed intervention does not pose any significant threat to the environment and ecology of the project area. The main aim of the intervention is to utilize the drainage effluent for the development of saline fish farms in the vicinity of the LBOD branch drains. This intervention will not have any significant effect on the surrounding soils. The intervention shall create livelihood opportunities for the people of the area.

9.1 Environmental Monitoring and Management Plan

Monitoring and supervision are basic requirements to the success of a project implementation. It is very fundamental requirement to monitor the project activities so tha all the proposed mitigation measures are strictly adhered to. Mitigation measuresto reduce the environmental degradation and social impacts relating to air quality, soil degradation, and water quality deterioration, loss of habitat and disruption of wild life will need to be addressed. The details are given in Table-33 and Enoronmental Codes and Procedures in Annexure-H Table-34.

9.2 General Conclusions

1. Water resource management issues in the Sindh province are complex and multi-dimensional and require a comprehensive analysis and consideration of various factors to identify the existing issues and develop feasible and publically accepted solutions which will improve water management and increase agricultural productivity.
2. Regional Plan for the Left Bank of Indus, Delta and Coastal Zone has the following key objective: "*to prepare a regional master plan for addressing the flooding issues and providing proper drainage to the area on the left bank of the Indus River through appropriate structural and non-structural measures, including remedial measures for*

any outstanding deficiencies in the Left Bank Outfall Drainage system, measures for retention and/or safe disposal of drainage, storm and flood water, improvement of wetlands in the delta area and in the coastal zone".

3. Almost half of the soils of the province are non-saline while the remaining half possess salinity from slight to severe and thus require management alternatives to reclaim and develop it for crop production
4. Perennially canal command area comprises of 34% land, non-perennial 16%, canal irrigated supplemented with tube wells is 19%, forest lands 0.42%, unproductive lands 23% and miscellaneous including urban, graveyards, roads, canals and settlements account for about 7%.
5. Almost 92% of urban water supplies do not meet international drinking water quality standards. Water resources of Pakistan are facing the four major water quality tribulations such as bacteriological contamination (28-100%), arsenic (0-100%), nitrate (0-50%) and fluoride (0-55%) in all the four completed phases (2001-2005) by the PCRWR.
6. Drains water was saline with TDS in the range of 3,000 to 14,000 ppm and SAR in the rage of 10-23 in 2005-07. At present the samples show TDS in the range of 920 to 14630 ppm and averaged as 3919 ppm with EC in the range of 2.00 to 28.00 mS/cm in 2012. Underground drinking water samples collected from rural areas showed that 60% were within permissible range of 1000 ppm while 40% above range.
7. Sugar mill effluent discharged from our sugar mills had DO below 3 mg/l, BOD in the range from 210 to 1100 mg/l, COD in the range from 260 to 1800 mg/l and TSS in the range from 340 to 1800 mg/l. All these parameters were very high compared to WHO deadline. This showed that all the effluent was highly polluted.
8. Sugar mill laden drain waters were tested and it was noted that TDS was in the range from 4670 to 13900 mg/l, TSS in the range from 650 to 8900 mg/l, BOD in the range from 40 to 340 mg/l and COD in the range from 83 to 1685 mg/l and DO <1.5 mg/l. This indicated that fish cannot survive in this sugar mill effluent laden drainage water in drains
9. Recommendations from the Social Impact Assessment are:
    a. Review and consider people's suggestions in the course of planning dhoras revival or new drains construction.
    b. Ensure transparency at all stages of the proposed interventions. Share the detailed project plan with communities by conducting another wave of consultations with potentially affected villagers.
    c. Ensure consistent and meaningful inclusion of local communities and other stakeholders at all stages of the project through continuous consultations and by providing proper feedback about any action taken.
    d. Compensate fully all affected persons before any works.
    e. As per people's suggestions, establish people's committees at a village level and ensure local labor on daily wages whenever practicable.
    f. Involve local communities in the dhoras maintenance on paid basis whenever practicable.
10. There are remarkable impacts of the project interventions on the fauna, flora, archeological and heritage sites and if there are any, these will be mitigated with managerial inputs.

Annexure-A

Table-27 Water Quality of Surface Drains Out Falling in LBOD System

(TDS=Total Dissolved Solids in '000' and SAR =Sodium Absorption Ratio)

2005 2007	1		2		3		4		5		6		7		8		9		10	
Parameter	TDS	SAR	TDS	SAR	TDS	SAR	TDS	SAR	TDS	SAR	TDS	SAR	TDS	SAR	TDS	SAR	TDS	SAR	TDS	SAR
Mar,05	2.1	9.9	2.1	10.1	2.5	10.9	3.8	14.5	13.0	21.6	12.5	23.0	10.4	31.5	6.3	17.8	6.9	19.4	2.5	18.5
Apr,05	3.2	13.9	4.1	10.5	5.6	17.0	6.1	18.0	10.0	20.3	7.0	16.0	31.6	27.2	18.5	25.9	9.8	19.8	8.7	19.3
May,05	0.0	0.0	0.0	0.0	7.0	17.4	6.8	18.3	10.0	20.3	7.0	16.0	31.6	27.2	31.8	25.9	13.2	19.8	11.6	19.3
Jun,05	0.0	0.0	0.0	0.0	10.3	20.0	10.2	14.0	8.2	20.0	5.7	14.0	33.4	34.6	30.6	25.3	10.6	21.3	9.4	18.2
Jul,05	0.0	0.0	0.0	0.0	5.9	11.9	7.3	9.5	6.8	12.2	5.0	7.1	9.6	15.7	15.8	21.8	9.7	16.2	7.8	14.9
Aug,05	0.0	0.0	0.0	0.0	4.4	9.4	4.6	11.6	3.7	17.2	3.4	18.3	2.7	11.3	2.5	6.9	3.3	8.3	2.7	7.5
Sep,05	3.7	17.4	3.7	18.8	4.9	13.7	7.7	11.8	6.0	14.2	6.1	14.8	4.0	6.4	4.1	4.6	4.2	11.4	5.2	11.5
Oct,05	2.7	10.5	4.1	11.9	5.2	14.9	5.8	13.6	6.1	11.9	10.0	21.6	4.1	9.7	3.7	12.1	4.4	9.0	5.9	15.8
Nov,05	2.0	7.9	3.4	11.0	4.6	7.3	4.7	8.9	5.2	12.2	8.9	15.3	2.9	8.8	4.8	8.3	3.8	11.1	4.8	8.2
Dec,05	3.0	10.0	4.1	11.0	4.6	9.6	5.6	18.5	6.9	15.8	5.5	12.4	4.3	9.5	5.9	9.6	5.8	11.0	5.5	9.4
Jan,06	5.4	9.9	12.3	19.2	7.4	13.2	7.3	13.3	14.2	25.0	11.0	17.4	14.8	20.4	19.6	29.1	11.9	20.0	13.0	25.0
Feb,06	5.0	6.9	3.8	12.5	4.8	6.5	7.9	13.7	6.9	12.3	5.8	8.7	2.8	10.6	4.9	10.9	4.8	10.2	4.6	5.7
Mar,06	2.9	7.8	3.8	10.6	3.9	5.9	5.2	6.6	7.7	15.8	12.7	22.4	5.2	9.8	6.0	10.8	4.2	6.3	5.9	6.0
Apr,06	5.2	11.9	5.4	17.8	3.3	14.3	6.0	11.5	9.9	21.9	16.2	29.7	8.5	22.2	14.8	40.4	5.6	10.7	6.4	11.4
May,06	3.2	6.9	3.5	7.5	6.2	16.7	5.6	14.2	7.3	16.8	10.7	23.6	19.0	34.1	16.4	31.8	8.6	17.2	9.1	17.6
Jun,06	4.3	11.3	4.8	14.4	6.9	19.3	7.1	21.9	5.2	10.5	6.0	12.3	12.0	25.7	7.5	18.0	5.9	17.0	5.1	14.5
Jul,06	2.8	11.7	3.9	8.1	4.8	11.1	6.4	15.4	3.7	14.8	2.9	12.6	6.2	11.0	6.2	9.9	3.2	14.1	3.8	13.7
Aug,06	3.1	13.6	5.4	11.9	6.2	13.2	7.6	17.9	5.1	10.2	4.8	10.0	19.7	31.5	19.5	27.8	6.2	9.6	7.0	22.0
Sep,06	3.1	13.9	4.6	11.3	7.0	13.2	7.5	21.1	11.0	14.3	12.0	24.9	4.7	7.8	8.8	17.1	5.6	19.0	7.0	15.0
Oct,06	3.6	13.9	6.6	15.3	7.6	16.9	8.0	19.8	6.1	18.0	4.8	12.6	12.3	23.5	14.5	32.6	6.5	15.6	6.8	19.1
Nov,06	3.3	14.6	3.2	14.0	5.8	19.0	6.4	18.4	8.0	17.6	6.2	14.5	14.9	30.8	19.7	37.0	7.2	21.0	8.1	22.6
Dec,06	3.3	13.8	3.0	11.5	4.9	9.6	6.2	17.2	7.2	8.9	10.2	20.9	13.9	29.7	12.4	22.5	8.1	14.8	6.5	12.1
Jan,07	6.1	11.6	11.0	20.2	8.4	11.1	7.8	13.5	9.0	13.6	12.6	17.8	13.3	23.1	9.9	17.5	10.1	16.7	9.4	19.8
Feb,07	6.5	15.2	7.7	19.9	5.7	9.3	6.9	20.7	8.9	18.0	10.0	17.2	8.9	16.5	11.4	25.9	8.2	18.0	7.4	15.9
Mar,07	4.7	10.2	4.8	7.6	8.0	15.0	7.8	22.5	11.0	28.5	22.3	38.9	15.7	28.1	19.7	36.3	12.0	29.6	11.2	23.9
Apr,07	3.3	14.6	3.8	14.9	5.5	14.5	6.0	19.2	8.8	19.6	14.9	31.7	19.3	34.9	23.6	39.3	10.4	29.8	9.4	27.3
May,07	3.7	14.4	6.9	9.8	7.9	17.8	7.1	14.9	6.1	12.4	22.2	39.5	22.7	38.5	25.5	37.4	11.7	19.9	10.6	21.0
Jun,07	3.2	12.2	5.7	7.8	7.3	13.7	7.0	16.4	2.9	12.4	6.4	11.1	17.5	35.0	18.0	36.7	8.6	20.9	5.9	10.3

1. East Nawabshah Main Drain (Zero Point)
2. East Nawabshah Main Drain (RD-70)
3. West Nawabshah Main Drain (Zero Point)
4. West Nawabshah Main Drain (RD-95)
5. Sanghar Main Drain (Zero Point)
6. Sanghar Main Drain (RD-94)
7. Mirpurkhas Main Drain (RD-44)
8. Mirpurkhas Main Drain (RD-184)
9. Spinal Main Drain (RD-159)
10. Spinal Main Drain (RD-456)

Annexure-B(1)

Table-28 Water Quality of Drains of LBOD System (Year 2012)

S. No	Description of Site	GPS Coordinates		TDS mg/l	pH	EC mS/cm	TSS mg/l	DO mg/l
1	Sub Drain East Near Jam saib	26°16'14.70"N	68°32'1.74"E	390	8	0.77	N.A	N.A
2	Drain Bakar shah	25°53'43.44"N	68°48'35.71"E	1760	8.1	3.57	N.A	N.A
3	Singhoro Branch drain 59+734 RD	25°57' 46.3"N	68°53'36.99"E	1840	8	3.78	1.45	1.27
4	M3R Drain RD 47 Sub-drain	25 30 49 N	69 05 07 E	1900	7.4	3.87	0.1	1.24
5	SMS Drain (Main) N.Shah East Nawabshah Jam Datar Rd	26°15'51.97"N	68°30'10.28"E	2930	7.5	5.9	1.35	1
6	SMS Drain Nawab shah East	26°15'51.97"N	68°30'10.28"E	2930	7.5	5.9	N.A	N.A
7	Sanghar Main drain RD 28+500 Near Sanghar City	26° 03 26.9 N	68 57 29.9 E	2980	7.6	6.12	1.05	1.15
8	Spinal Drain RD 815	25°56'21.00"N	68°42'24.65"E	3230	7.5	6.57	1.55	1.01
9	Spinal Drain RD 815	25°56'18.68"N	68°42'26.48"E	3230	7.5	6.57	N.A	N.A
10	Singhoro Branch drain RD 00	25 49 33 N	68 58 33 E	3500	7.9	7.19	1.45	1.27
11	MMD RD 52+835	24° 59 56.8" N	69 17" 16.2 E	3540	7.4	7.27	0.4	1.12
12	LBOD Spinal Under pass RD 790	25°54'21.33"N	68°45'0.08"E	3570	7.4	7.26	1.5	0.73
13	Gjra Drain	26°12'12.08"N	68°33'33.81"E	3640	7.6	7.42		
14	Sanghar Main drain RD 00 At entry point of Spinal drain	25 49 07 N	68 58 51.7 E	3650	8.2	7.49	1.6	1.36
15	LBOD Spinal at R.D 711	25 48 59 N	68 58 54.3 E	3680	7.6	7.53	0.45	1.27
16	LBOD Spinal RD 775 Jhole-T.Adam Road	25 53 29 N	68 48 41.1 E	3690	7.3	7.53	1.5	0.73
17	LBOD Spinal RD 295	24 52 13.4 N	69 19 35.2 E	3790	7.4	7.74	0.85	1.04
18	DPOD at weir RD 159	24 33 19.1 N	69 09 54.1 E	4000	7.2	8.17	0.5	2.77
19	West drain near RD 816 spinal	25°56'27.26"N	68°42'23.54"E	4050	7.5	8.27	N.A	N.A

S. No	Description of Site	GPS Coordinates		TDS mg/l	pH	EC mS/cm	TSS mg/l	DO mg/l
20	LBOD Spinal near Sindhri Chowk	25 41 49 N	69 07 14. E	4170	7.4	8.55	0.45	1.23
21	LBOD Spinal drain RD. 305	24° 53' 21.8" N	69° 20' 16.2" E	4250	7.6	8.69	0.85	1.09
22	LBOD Spinal drain RD 548	25 29 33.3 N	69 10 51.1 E	4320	7.4	8.91	0.4	1.13
23	Mir western Drain	24 38 56.8 N	68 47 22.2 E	4440	7.6	9.11	0.35	1.79
24	LBOD Spinal RD 212	24 37 41.2 N	69 13 37.8 E	4470	7.4	9.19	0.7	1.35
25	LBOD Spinal drain after junction of LBOD Branch Drain	24 40 33.2 N	69 11 31.3 E	4610	7.4	9.49	0.9	1.74
26	Downstream Weir RD-159	24 33 19.1 N	69 09 54.1 E	4770	7.6	9.81	0.5	2.77
27	LBOD Spinal near Jammabad-Samaro R.D	25 16 42.7 N	69 20 32.5 E	4770	7.4	9.84	0.61	0.4
28	LBOD Branch Drain Rd 204	24 40 48.5 N	69 13 5.4 E	5350	7.4	11.06	0.7	1.25
29	M.M.D Mirpur Khas RD 29 On Mirpur-T.A.Yar Road	25 30 50.2 N	68 56 53 .8 E	5530	7.8	11.4	0.85	1.36
30	Nawab shah west drain Rd 114	26°12'6.18"N	68°33'31.77"E	5630	7.8	11.56	N.A	N.A
31	Nawab Shah West Drain (NW.D) N.W.D 203	26°12'6.18"N	68°33'31.77"E	6190	7.7	12.77	1.4	0.93
32	M.M. R.D 206+320	25 18 07 N	69 05 6.8 E	6350	6.7	12.85	0.7	1.02
33	Guni Fuleli out fall drain RD 26	24 39 22.3 N	68 41 29.9 E	6350	7.2	13.18	0.55	0.64
34	Drain Nawab shah-Dour road	26°10'4.54"N	68°19'3.18"E	14630	7.6	>range	N.A	N.A
35	Singhoro Branch Drain RD 13+832	25°51' 44.27" N	68°58' 15.40" E	2100	8.3	4.15		
36	Singhoro Branch Drain RD 91+242	26° 1' 48.70" N	68°50' 54.40" E	2060	8.3	4.12		
37	3 R Sub Drain RD 0+00	25° 46' 36.96"N	69° 2'4.03"E	2030	8.3	4.09		
38	Patoyun Branch Drain RD 64+602	25°41'6.21"N	68°58'28.96"E	1410	8.1	2.83		
39	Sanghar Main Drain RD 12+400	25°50'52.94"N	69° 0'27.04"E	920	8.3	1.82		
40	Shadi Bahadur Branch Drain RD 42+00	24°42'54.21"N	69° 8'14.93"E	1500	8.1	3.01		
41	Mirpurkhas Main Drain RD 0+00	24°56'37.77"N	69°18'17.75"E	5560	8.1	11.22		
42	Mirpurkhas Main Drain RD 197+995	25°16'57.12"N	69° 4'52.62"E	4890	8.0	9.85		

Table-29 Sugar Mill effluent ladden Drain water (Year 2012)

S. No	Description of Site	GPS Reading		TDS (mg/l)	pH	EC mS/cm	TSS mg/l	DO mg/l	COD mg/l	BOD mg/l
1	M.M.D RD 152+040	25 12 18.0 N	69 10 12.2 E	4670	7	9.57	0.65	0.69	83	40
2	Karo Ghinghro main drain RD	24 38 16.6 N	68 23 6.6 E	13630	7.6	>range	5.3	1.38	378	168
3	Guni Fuleli Main Drain RD 105	24 39 8.6 N	68 39 11.7 E	10730	7.6	>range	1.95	0.79	728	340
4	IR sub drain of kapoor RD 29 BR drain	24 396 54.4 E	68 11 50.2 E	13900	5.4	>range	8.9	1.33	1685	>range

Table-30 Drinking water samples collected from the Project Area (Year 2012) **Annexure- B(2)**

Date	S. No	Description of Site	GPS Coordinates		TDS (ppm)	pH	EC mS/cm
5.4.2012	1	Rohri Canal N. Shah/Sakrand Road	26° 8'49.47"N	68°19'27.70"E	150	8.5	0.3
5.4.2012	2	Jamrao West-C LBOD under pass	25°54'22.41"N	68°45'5.21"E	190	8.4	0.37
6.4.2012	3	Mithrao Canal near Sindhri R.D	25 42 50.4 N	69 08 10.3 E	190	8.1	0.38
5.5.2012	4	Water Coarse at Jamesabad-Digri Road	25 05 5.96 N	69 11 70.22 E	190	7.7	0.38
7.5.2012	5	HandPump at Village Wango Patan	24 37 08 N	69 14 46.22 E	190	7.7	0.38
5.4.2012	6	T.Well Nawabshah/Dour Road TW	26°24'4.35"N	68°18'51.14"E	200	8.7	0.31
5.4.2012	7	Jamrao East-LBOD under pass	25°54'21.33"N	68°45'0.08"E	200	8.3	0.37
6.6.2012	8	Village H. Muhammad Qasim Thebo	25 14.5296 N	69 07.4931 E	200	8	0.41
21.6.2012	9	Village Haji Badal Nohri	25 32.6128 N	69 21.5192 E	200	7.2	0.39
6.6.2012	10	Village Bhitaro Sharif	25 31.4168 N	68 56.5257 E	210	7.4	0.43
6.4.2012	11	Nara Canal Bakhoro Mori	26 04 3.4 N	69 01 3.9 E	210	8.4	0.39
6.4.2012	12	Chotiari Dam	26 05 47 N	69 09 22.9 E	260	8.2	0.52
20.6.2012	13	Girhor Sharif	25 17.8129 N	69 33.4652 E	270	7.9	0.52
20.6.2012	14	Village Haji mahmood	25 16.4953 N	69 19.8606 E	300	7.8	0.6
8.6.2012	15	Village Saindad Aaliani	24 53.6153 N	69 20.4639 E	310	7.7	0.62
20.6.2012	16	Village Talho junejo	25 23.5289 N	69 39.5731 E	350	7.8	0.71
10.4.2012	17	Guni phulleli Irri canal	25 13 08 N	68 28 11.2 E	370	7.9	0.74
6.4.2012	18	T.W near Tando Adam	25 44 45 N	68 40 3.8 E	380	7.6	0.75
28.6.2012	19	Village Ghulam Hyder Bagrai	25 53.8249 N	68 35.1545 E	410	7.6	0.83
7.5.2012	20	Ali Wah (Shadilarg-Badin Road)	24 39 27.7 N	68 58 44.30 E	440	7.3	0.88
7.5.2012	21	Bahadur Wah (Shadilarg-Badin Road)	24 39 27.61 N	69 58 43.96 E	440	7.6	0.88
5.4.2012	22	T.W Pai Forest	26° 7'11.17"N	68°16'21.94"E	540	7.5	1.06
6.6.2012	23	Village Imam Khan	25 18.1680 N	69 05.8484 E	540	7.8	1.06
15.6.2012	24	Qabaili Chack	24 32.9626 N	69 12.4625 E	560	7.8	1.15
28.6.2012	25	Village Syed Jhandlo	25 53.2868 N	68 34.3300 E	570	8	1.15
15.6.2012	26	Single Chack-10	24 35.5156 N	69 12.5744 E	580	7.5	1.15
28.6.2012	27	Village Haji Gulab Rahoo	26 00.7417 N	68 27.3673 E	580	7.6	1.13
15.5.2012	28	Hand Pump Nauabad city	25 48 43.95 N	68 57 00.80 E	590	8.7	1.18

Date	S. No	Description of Site	GPS Coordinates		TDS (ppm)	pH	EC mS/cm
7.6.2012	29	Village Ramo Rawdan	25 09.8228 N	69 11.6634 E	640	7.8	1.36
15.6.2012	30	Single Chack-10	24 35.5156 N	69 12.5744 E	640	7.6	1.29
30.5.2012	31	Hand Pump Nauabad city	25 48 43.95 N	68 57 00.80 E	650	7.5	1.3
11.5.2012	32	HandPump at RD 84+100 of LBOD Br.	24 57.28 08 N	69 07 51.27 E	660	7.6	1.31
10.4.2012	33	Pinyari Canal Irrigation	25 13 08 N	68 28 11.2 E	680	7.3	1.36
8.6.2012	34	Kot Mir Jan Muhammad	24 52.1281 N	69 20.0839 E	680	7.4	1.36
26.6.2012	35	Village Muhammad Hashim	25 15.4916 N	68 53.8319 E	680	7.5	1.36
8.6.2012	36	Village Haji Faqir Leghari	25 00.2317 N	69 17.3110 E	690	7.9	1.39
26.6.2012	37	Village Haji Abdul Rehman	25 25.1450 N	68 47.0198 E	690	7.5	1.38
26.6.2012	38	Village Sono Bhagat	25 08.6617 N	68 53.7264 E	700	7.4	1.43
5.4.2012	39	bet: Hala, Saeedabad	25°52'47.52"N	68°24'17.45"E	700	7.4	1.4
12.4.2012	40	Daro Branch near Sujawal Town	24 36 57.9 N	68 03 5.8 E	780	7.9	1.57
5.5.2012	41	Hand Pump (Drinking water for Khan	25 37 17.9 N	68 57 39.53 E	780	7.1	1.59
14.6.2012	42	Village Muhammad Juman Malah	24 23.7309 N	68 49.7760 E	820	7.9	1.63
20.6.2012	43	Khansahib Atta Muhammad	25 22.2624 N	69 35.4009 E	820	7.5	1.64
5.4.2012	44	Tube well near NWW bet: Hala, Bhitshah	25°48'31.10"N	68°26'25.98"E	870	7.7	1.75
6.6.2012	45	Village Bhitaro Sharif	25 31.4168 N	68 56.5257 E	880	7.2	1.76
30.5.2012	46	Hand Pump near Shahpur chakar	26 09 25.70 N	68 37 57.9 E	900	7.5	1.8
14.6.2012	47	Village Khalifo Qasim	24 44.9996 N	69 06.5302 E	910	7.5	1.81
5.5.2012	48	Hand Pump at village Thari Nizamani	25 03 22.12 N	68 49 49.50 E	950	7.2	1.9
6.6.2012	49	Village Jan Muhammad Dal	25 37.7052 N	68 57.9251 E	1030	7.8	2.09
14.6.2012	50	Village Gul Muhammad Kapri	24 38.5636 N	69 13.7133 E	1080	7.5	2.14
6.6.2012	51	Village Bhitaro Sharif	25 31.4168 N	68 56.5257 E	1140	7.2	2.27
7.4.2012	52	Tando Ghulam Ali Tube well/ Lift Pump	25 08 39.4 N	68 52 48.8 E	1170	7.1	2.39
6.6.2012	53	Village Bhitaro Sharif	25 31.4168 N	68 56.5257 E	1210	7.1	2.43
14.6.2012	54	Village Yar Muhammad Bhurgari	24 39.3691 N	69 01.7209 E	1220	7.6	2.41
28.6.2012	55	Village Pahar Khan Jamali	26 03.2865 N	68 25.0606 E	1230	7.7	2.45
28.6.2012	56	Village Khabar Gaho	25 53.3767 N	68 33.8601 E	1230	7.6	2.45
5.5.2012	57	Hand Pump village Abdullah Banjeer	24 02 11.63 N	69 41 09.8 E	1360	7.2	2.73

Date	S. No	Description of Site	GPS Coordinates		TDS (ppm)	pH	EC mS/cm
30.5.2012	58	Hand Pump (Nawabshsh Sanghar Road)	26 08 28.04 N	68 44 09.7 E	1360	7.5	2.73
7.4.2012	59	T.W Shaikh Bhirkio	25 16 34 N	68 37 13.3 E	1370	7.5	2.76
7.6.2012	60	Village Bachal Chang	25 02.3410 N	69 16.0554 E	1390	7.4	2.76
21.6.2012	61	Village Haji razi Wijlo	25 30.5852 N	69 12.8051 E	1420	7.5	2.87
6.6.2012	62	Village Muhammad Ishaq	25 15.0725 N	69 06.7351 E	1480	8	2.95
14.6.2012	63	Village Gul Muhammad Kapri	24 38.5637 N	69 13.7135 E	1540	7.7	3.08
10.4.2012	64	Hand Pump Nory Channel	24 37 17.9 N	69 14 37.3 E	1650	7.1	3.32
6.6.2012	65	Village Bhitaro Sharif	25 31.4168 N	68 56.5257 E	1790	6.9	3.71
26.6.2012	66	Village Agha Muzamil	25 06.8965 N	68 53.3139 E	1900	7.4	3.081
15.5.2012	67	Hand Pump (birani village)	25 47 19.03 N	69 48 57.27 E	2080	8.6	4.23
20.6.2012	68	Mitho Khaskheli	25 16.4953 N	69 19.8606 E	2130	7.1	4.24
11.5.2012	69	HandPump at RD 17+600 of LBOD Br.	24 43 13.14 N	69 10 16.58 E	2210	7.5	4.42
7.5.2012	70	Escape Channel (shadi larg-Badin Rd)	24 39 9.9 N	68 58 23.53 E	2380	6.9	4.79
20.6.2012	71	Bodar Farm	25 17.8129 N	69 33.4652 E	2860	7.1	5.73
20.6.2012	72	Girhor Sharif	25 17.8129 N	69 33.4652 E	2880	7.1	5.74
7.6.2012	73	Village Bachal Chang	25 02.3410 N	69 16.0554 E	3030	7.3	6.09
15.6.2012	74	Mitho Khaskheli	25 16.4941 N	69 19.8623 E	3050	7.1	6.09
11.5.2012	75	Hand Pump (Tando Bago City)	24 47 98 N	68 57 35.08 E	3640	6.8	7.30
4.4.2012	76	Pinyari Canal (Near Talhar City)	24 53 13.12 N	68 4810.86 E	3880	7.7	7.99
7.6.2012	**77**	Village Faqir Ghulam Ali Leghari	25 09.9103 N	69 09.9835 E	6970	6.9	14.07
7.6.2012	78	Village 264 Jhudo	25 02.3410 N	69 16.0554 E	9390	6.8	18.98

Annexure-C

Table -31 Canal command wise water quality of sindh as of post monsoon 2010

(000) ha

Description	U	M	H	Total
GUDDU BARRAGE				
Ghotki Feeder	186.83	177.67	24.50	389.00
Total	**186.83**	**177.67**	**24.50**	**389.00**
SUKKUR BARRAGE				
Nara Canal	200.73	778.00	38.27	1017.00
Rohri Canal	611.26	459.49	124.25	1195.00
Khairpur Feeder East	101.03	101.83	28.14	231.00
Khairpur Feeder West	105.27	13.01	2.72	121.00
Total	**1018.29**	**1352.33**	**193.38**	**2564**
KOTRI BARRAGE				
Lined Channel	92.25	136.36	7.39	236.00
Fuleli Canal	98.85	306.91	3.24	409.00
Pinyari Feeder	141.72	158.90	84.38	385.00
Total	**332.82**	**602.17**	**95.01**	**1030**
Total Sindh	**1537.94**	**2132.17**	**312.89**	**3983**

Useable=<1500 µS/cm, Marginal=1500-2700 µS/cm, Hazardous=>2700 µS/cm

Table-32 Canal command wise water quality of sindh as of post monsoon 2011

(000) ha

Description	U	M	H	Total
GUDDU BARRAGE				
Ghotki Feeder	304.63	76.39	7.98	389.00
Total	**304.63**	**76.39**	**7.98**	**389.00**
SUKKUR BARRAGE				
Nara Canal	432.76	393.05	191.19	1017.00
Rohri Canal	771.01	333.68	90.31	1195.00
Khairpur Feeder East	79.59	123.33	28.08	231.00
Khairpur Feeder West	106.79	10.77	3.44	121.00
Total	**1390.15**	**860.83**	**313.02**	**2564**
KOTRI BARRAGE				
Lined Channel	64.69	165.12	6.19	236.00
Fuleli Canal	151.00	196.02	61.98	409.00
Pinyari Feeder	227.94	96.39	60.67	385.00
Total	**443.63**	**457.53**	**128.84**	**1030**
Total Sindh	**2138.41**	**1394.75**	**449.84**	**3983**

Useable=<1500 µS/cm, Marginal=1500-2700 µS/cm, Hazardous=>2700 µS/cm

Annexure-D (1)

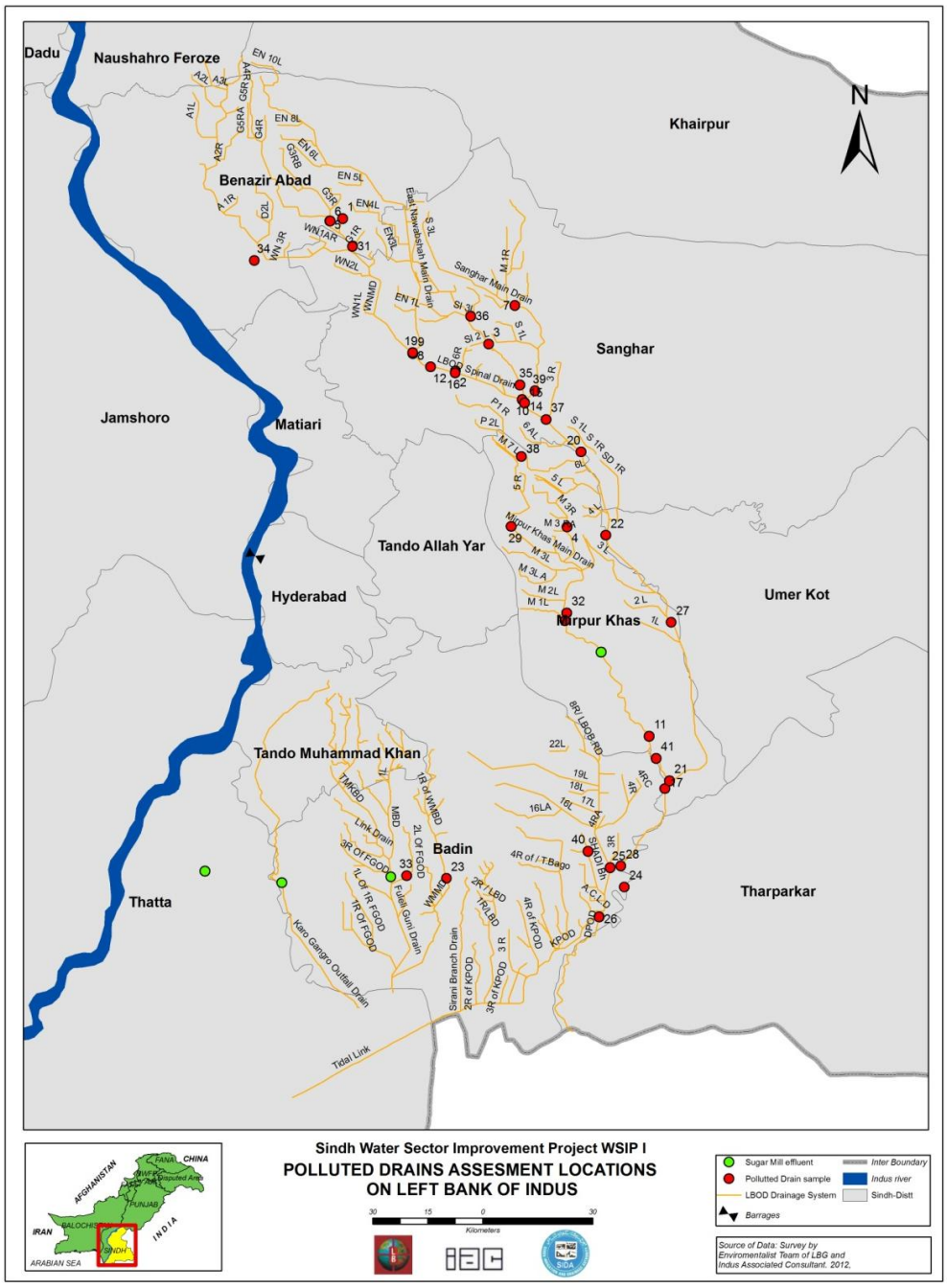

Figure-4 Graph showing the locations of the drains where the samples for water quality were collected

Annexure-D (2)

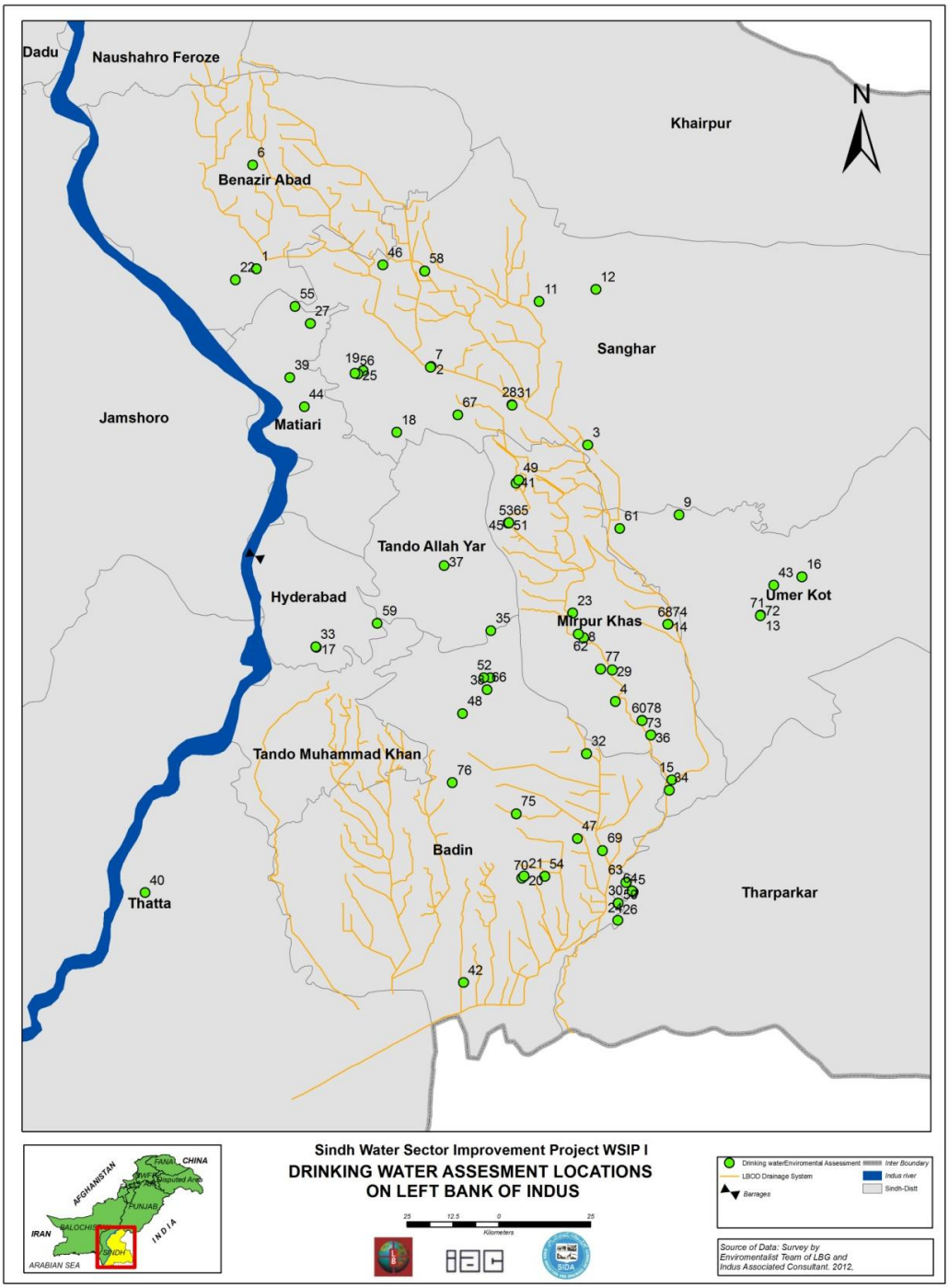

Figure-5Locations of the Drinking water bodies where the samples for water quality were collected

Annexure-E (1)

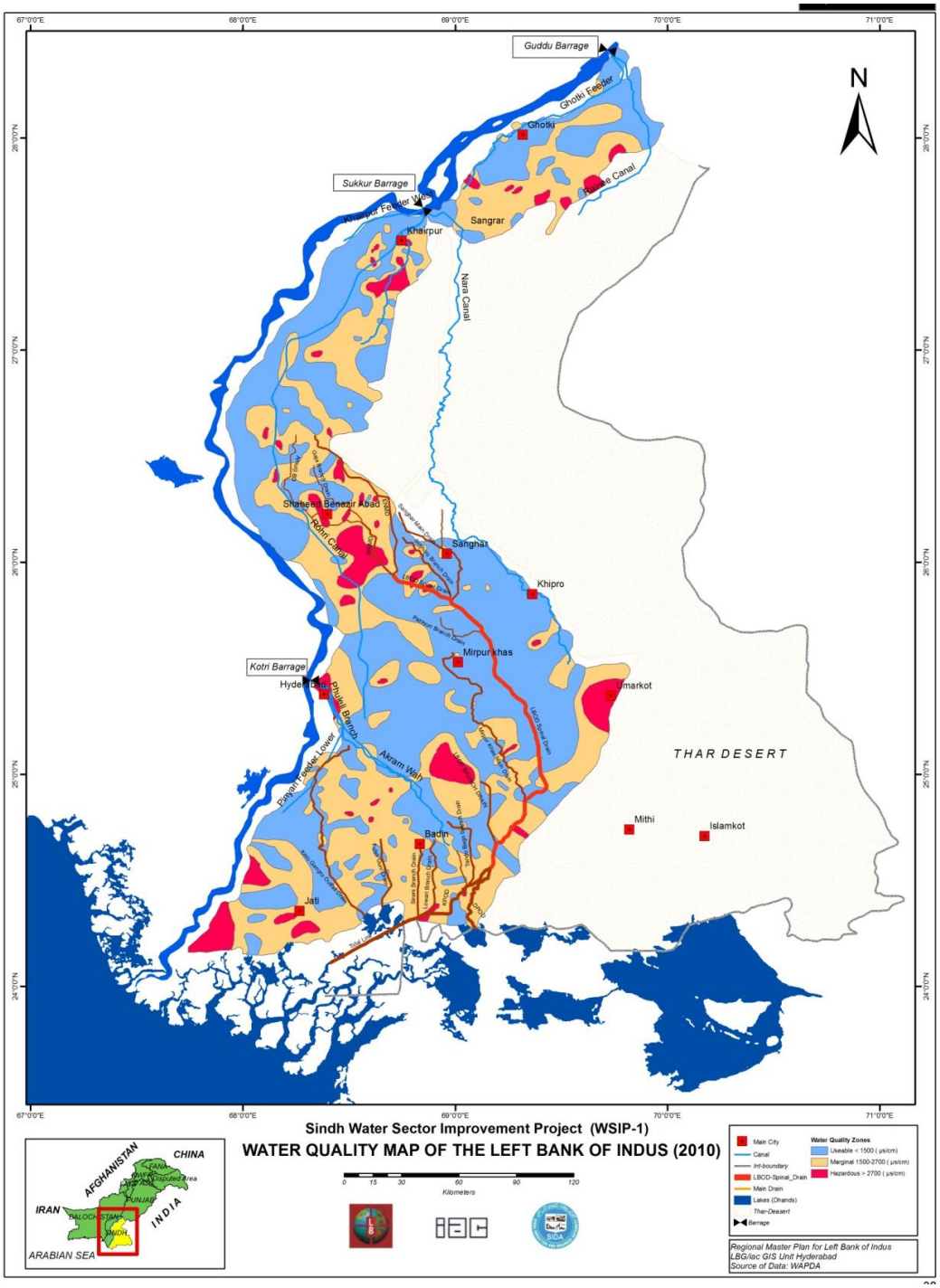

Figure-6 Water quality status of the Left Bank of Indus command Area during the Year 2010

Annexure-E (2)

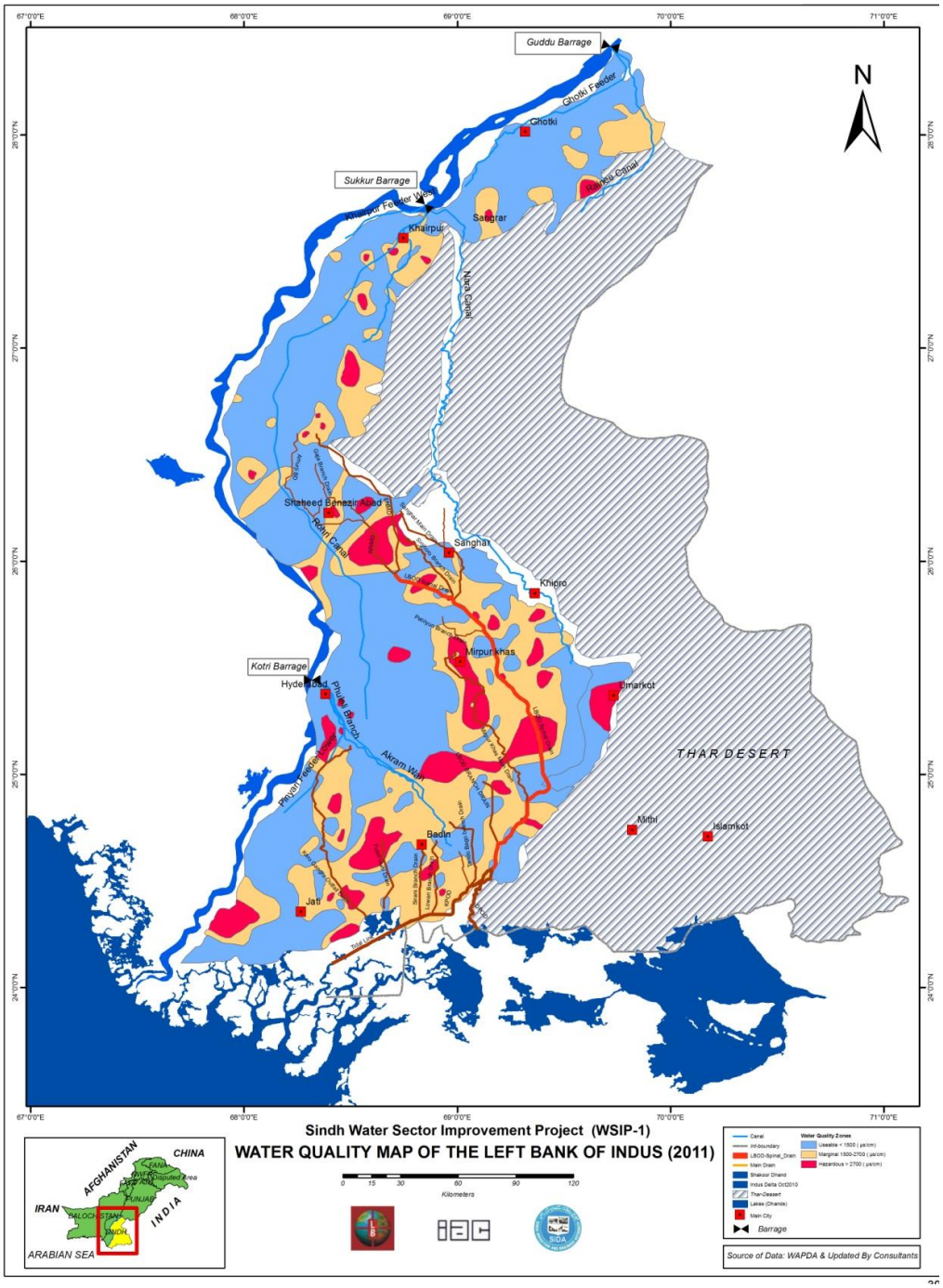

Figure-7 Water quality status of the Left Bank of Indus command Area during the Year 2011

Annexure-G

Table-33 Environmental Management Plan (EMP)

S/N	Source of Impact	Potential Impact	Mitigation Measures	Responsibility		
				Implementation	**Supervision**	**Monitoring**
1	Rehabilitation and Improvement of LBOD main, branch and sub-drains	a) Scattered excavated earth b) Unattended borrow pits causing water ponding and mosquito breeding grounds, safety hazards and unpleasant esthetic look of the area c) Tree cutting in expanded reaches d) Dust, construction waste, noise, and other pollution due to traffic, oil spills, etc e) Changes in surface /groundwater quantity & quality	a) Bidding documents would include proper disposal of excavated earth as integral part of the rehabilitation works b) Restoration and leveling of borrow pits will be mandatory in the bidding documents c) Mandatory plantation of at least three trees in place of cutting one grown up tree d) The bidding documents would include removal of waste, standards for control of dust, noise, oil spills, management of the construction traffic etc. e) Ensuring proper disposal of added effluent and	GoS/SIDA would Implement the projects incorporating the detailed EMP in the bidding documents SIDA EMU would work with project implementing agency incorporating and ensuring Environment works in accordance with agreed national and international standards	GoS /SIDA and Donors supervision missions, with involvement of environmental specialists as and when required	GoS / SIDA and Donors supervision missions, with involvement of environmental specialists as and when required

S/ N	Source of Impact	Potential Impact	Mitigation Measures	Responsibility		
				Implementation	**Supervision**	**Monitoring**
		f) Change in land productivity g) Impact on wetlands, protected areas and livelihood h) Impact on aquatic and terrestrial life i) Impact on communication	steps to minimize the water quality deterioration f) Impact on land productivity, wet lands, protected areas, aquatic life, flora and fauna would be assessed in detail and included in the construction and implementation plans			
2	Clearing of area for construction camps	Disturbance to Flora and fauna	The Contractor shall take full care to preserve and protect from damage trees, native shrubbery & vegetation. Minimal unnecessary damage to vegetation	Contractor During camp establishment	GoS /SIDA and Donors supervision missions.	GoS / SIDA and Donors supervision missions.
3	Inhabitation of construction camp by workforce	Safety of workforce	Provide necessary services for drainage, lighting, roads and paths, parking places, fencing, sanitation, cook houses, fire prevention and fire fighting equipment.	Contractor. All camp sites	GoS /SIDA and Donors supervision missions.	GoS / SIDA and Donors supervision missions.
4	Disturbance to local population	The Contractor shall nominate a full time, qualified Community Liaison Officer among his senior staff to address	All camp sites	Contractor	GoS /SIDA and Donors supervision missions.	GoS / SIDA and Donors supervision missions.

S/ N	Source of Impact	Potential Impact	Mitigation Measures	Responsibility		
				Implementation	**Supervision**	**Monitoring**
		grievances and other community related issues				
5	Health of workforce	Quality of water to the approved by the Engineer	All camp sites	Contractor	GoS /SIDA and Donors supervision missions.	GoS / SIDA and Donors supervision missions.
	Workforce activities	Disturbance to wildlife	Hunting, poaching or trapping of wildlife/game reserves is strictly prohibited and shall be included in a Code of Conduct to be signed by all Contractors Staff	Contractor	GoS /SIDA and Donors supervision missions.	GoS / SIDA and Donors supervision missions.
	Movement of vehicles within the camp	Traffic accidents	The Contractor shall include measures to prevent traffic accidents in the Traffic Management Plan	Contractor	GoS /SIDA and Donors supervision missions.	GoS / SIDA and Donors supervision missions.
	Increase in dust generation due to excavation and movements of hauling trucks along rough access road	Regular watering of unpaved alleys / pathways or exposed soils / ground. Hauling trucks should be covered with canvass or any equivalent materials	The Contractor shall include measures to prevent dust generation in the Traffic Management Plan	Contractor	GoS /SIDA and Donors supervision missions.	GoS / SIDA and Donors supervision missions.
	Operation of plant, General equipment and construction	Hauling trucks should be covered with canvass or any equivalent materials.	Movement shall be performed in a manner to minimize damage to grazing land, crops and properties.	Contractor	GoS /SIDA and Donors supervision	GoS / SIDA and Donors supervision

S/N	Source of Impact	Potential Impact	Mitigation Measures	Responsibility		
				Implementation	**Supervision**	**Monitoring**
	machinery				missions.	missions.
		Damage to crops and flora and fauna	The contractor shall ensure a high level of maintenance of plant in order to reduce fuel and oil leakage that may cause damage to flora and fauna	Contractor	GoS /SIDA and Donors supervision missions.	GoS / SIDA and Donors supervision missions.
		Ground, ground water & water course pollution	The Contractor shall keep flexible booms and surface skimmers on site in good condition and ready for speedy deployment	Contractor	GoS /SIDA and Donors supervision missions.	GoS / SIDA and Donors supervision missions.
			The Contractor shall prepare a pollution control plan to cover ground, ground water and water course pollution prevention and control measures	Contractor	GoS /SIDA and Donors supervision missions.	GoS / SIDA and Donors supervision missions.
			Contractor's activities shall be performed by methods that will prevent entrance or accidental spillage of contaminants into flowing streams, flowing or dry watercourses, lakes and underground water sources.	Contractor	GoS /SIDA and Donors supervision missions.	GoS / SIDA and Donors supervision missions.
			The contractor shall ensure a high level of maintenance of	Contractor	GoS /SIDA and Donors	GoS / SIDA and Donors

S/ N	Source of Impact	Potential Impact	Mitigation Measures	Responsibility		
				Implementation	**Supervision**	**Monitoring**
			plant in order to reduce polluting emissions		supervision missions.	supervision missions.
		Air Pollution	The Contractor shall prepare a pollution control plan to cover air pollution prevention measures	Contractor	GoS /SIDA and Donors supervision missions.	GoS / SIDA and Donors supervision missions.
			Low emission batching plants shall be installed no closer than 500 m (1,600 ft) from any Contractor settlement	Contractor	GoS /SIDA and Donors supervision missions.	GoS / SIDA and Donors supervision missions.
			The Contractor shall plan his work on the basis of a six-day working week from 6am to 6pm	Contractor	GoS /SIDA and Donors supervision missions.	GoS / SIDA and Donors supervision missions.
		Noise	The contractor shall ensure a high level of maintenance of plant in order to reduce noise	Contractor	GoS /SIDA and Donors supervision missions.	GoS / SIDA and Donors supervision missions.
		Noise generation that can affect the residents (beneficiaries and nearby residents)	Schedule noisy construction activities during daytime.	Contractor	GoS /SIDA and Donors supervision missions.	GoS / SIDA and Donors supervision missions.
		Health and safety of workforce and public	Contractor to prepare and implement the Health and Safety Plan to be approved	Contractor	GoS /SIDA and Donors	GoS / SIDA and Donors

S/N	Source of Impact	Potential Impact	Mitigation Measures	Responsibility		
				Implementation	**Supervision**	**Monitoring**
			by the Engineer		supervision missions.	supervision missions.
6	Revival of natural water ways (dhoras) for safe evacuation of the storm water from the project area	a) Scattered excavated earth b) Unattended borrow pits causing water ponding and mosquito breeding grounds, safety hazards and unpleasant esthetic look of the area c) Tree cutting in expanded reaches d) Dust, construction waste, noise, and other pollution due to traffic, oil spills, etc e) Changes in surface /groundwater quantity & quality f) Change in land productivity	a) Bidding documents would include proper disposal of excavated earth will be carried out as integral part of the rehabilitation works b) Mandatory restoration and leveling of borrow pits will be mandatory in the bidding documents c) Mandatory plantation of at least three trees in place of cutting one grown up tree d) The bidding documents would include removal of waste, standards for control of dust, noise, oil spills, management of the construction traffic etc. e) Ensuring proper disposal of added effluent and steps to minimize the water quality	GoS/SIDA would Implement the projects incorporating the detailed EMP in the bidding documents SIDA EMU would work with project implementing agency incorporating and ensuring Environment works in accordance with agreed national and international standards	GoS and SIDA and Donors supervision missions, with involvement of environmental specialists as and when required	GoS and SIDA and Donors supervision missions, with involvement of environmental specialists as and when required

S/N	Source of Impact	Potential Impact	Mitigation Measures	Responsibility		
				Implementation	**Supervision**	**Monitoring**
		g) Impact on wetlands, protected areas and livelihood h) Impact on aquatic and terrestrial life i) Impact on communication	deterioration f) Impact on land productivity, wet lands, protected areas, aquatic life, flora and fauna would be assessed in detail and included in the construction and implementation plans			
7	Washing of clothes in the dhoras and other water bodies in close vicinity of Dhoras and Buffalo crossings etc.	Contamination of water and deterioration of water quality by detergents, soaps and animals.	Washing bays be located and designed in consultation with the FOs and local community, particularly for dhoras carrying rain water to minimize water contamination. Proper buffalo wallows and crossings to be identified jointly with the FOs and AWBs	FOs, AWB	FOs assisted by their Assistant Engineer, AWB	SIDA Environmental Unit
8	Supply of appropriate O&M equipment to FOs	No impact	Not required	FO/AWB	FOs assisted by their Assistant Engineer	SIDA Environmental Unit
9	Increased agricultural activity	Possible increase in use of chemicals and pesticides.	A Pest Management Plan (PMP) is under implementation under the Sindh OFWM Project and national Integrated Pest	SIDA/AWB/FOs	GoS and SIDA and Donors supervision missions.	SIDA Environmental Unit

S/ N	Source of Impact	Potential Impact	Mitigation Measures	Responsibility		
				Implementation	**Supervision**	**Monitoring**
			Management (IPM) project covering whole Sindh.			
10	Employment to Locals	Generation of employment	Hiring priority shall be given to qualified local residents.	Contractor	GoS /SIDA and Donors supervision missions.	GoS / SIDA and Donors supervision missions.
11	Criminal activities	Increase in the incidence of crime and accidents	Strictly require contractor to enforce (crime & accident) safety rules & regulations in coordination with Local Police Officials	Contractor	GoS /SIDA and Donors supervision missions.	GoS / SIDA and Donors supervision missions.
12	Solid Waste	Generation of solid waste, particularly rehabilitation debris	Set-up temporary disposal mechanism in site without obstructing vehicular and pedestrian traffic flow. Dispose of the generated waste properly and daily.	Contractor	GoS /SIDA and Donors supervision missions.	GoS / SIDA and Donors supervision missions.
13	Traffic congestion	Increased traffic, possible congestion, including risk of vehicular and related accidents	Strict enforcement of traffic rules and regulations.	Contractor	GoS /SIDA and Donors supervision missions.	GoS / SIDA and Donors supervision missions.

Annexure-H

Table-34 Environmental Codes of Practice (ECoP)

1. Waste Management

Activity	Environmental Impact	Environmental Management Guidelines
Generation of general waste	Soil, surface water & ground water pollution from the improper management of wastes and excess materials from the construction site.	a. Develop waste management plan for various specific waste streams (e.g., reusable waste, flammable waste, construction debris, food waste etc.) prior to commencing of construction and submit to PIC for approval. b. Organize disposal of all wastes generated during construction in an environmentally acceptable manner. This will include consideration of the nature and location of disposal site, so as to cause less environmental impact. c. Minimize the production of waste materials through the '3 Rs' (Reduce, Recycle and Reuse) approach. d. Segregate and reuse or recycle all the wastes, wherever practical. e. Collect and transport non-hazardous wastes to all the approved disposal sites. f. Train and instruct all personnel in waste management practices and procedures as a component of the environmental induction process. Provide refuse containers at each worksite. g. Request suppliers to minimize packaging where practicable. Place a high emphasis on good housekeeping practices. h. Maintain all construction sites in a clean, tidy and safe condition and provide and maintain appropriate facilities for temporary storage of all wastes before transportation and final disposal.

Generation of hazardous wastes	Health hazards and environmental impacts due to improper waste management practices	a. Collect chemical wastes in 200 litre drums (or similar sealed container), appropriately labelled for safe transport to an approved chemical waste depot. b. Store, transport and handle all chemicals avoiding potential environmental pollution. c. Store all hazardous wastes appropriately in bunded areas away from water courses. d. Make available Material Safety Data Sheets (MSDS) for hazardous materials on-site during construction. e. Collect hydrocarbon wastes, including lubricating oils, for safe transport off-site for reuse, recycling, treatment or disposal at approved locations. f. Construct concrete or other impermeable flooring to prevent seepage in case of spills

2. Management of Fuels and Hazardous Substances

Activity	Environmental Impact	Environmental Management Guidelines
Fuels and hazardous goods.	▪ Materials used in construction have a potential to be a source of contamination. ▪ Improper storage and handling of fuels, lubricants, chemicals and hazardous goods/materials on-site, and potential spills from these goods may harm the environment or health of construction workers.	a. Prepare pollution control procedures and submit the plan to the Engineer. b. Train the relevant construction personnel in handling of fuels and spill/pollution control procedures. c. Store dangerous goods in bunded areas on a top of a sealed plastic sheet or other impervious material away from watercourses. d. Refuelling should occur only within bunded areas. e. Make available MSDS for chemicals and dangerous goods on-site. Transport waste of dangerous goods, which cannot be recycled, to a designated & approved disposal site. f. Provide absorbent and containment material (e.g. absorbent matting) where hazardous material are used and stored and train personnel in their correct use. g. Provide protective clothing, safety boots, helmets, masks, gloves, goggles, to the construction personnel, appropriate to materials in use. h. Make sure all containers, drums, and tanks that are used for storage are in good condition and are labelled with expiry date. Any container, drum, or tank that is dented, cracked, or rusted might eventually leak. Check for leakage regularly to identify potential problems before they occur. i. Store hazardous materials above flood plain

		level. j. Put containers and drums in temporary storages in clearly marked areas, where they will not be run over by vehicles or heavy machinery. The area should preferably slope or drain to a safe collection area in the event of a spill. k. Put containers and drums in permanent storage areas on an impermeable floor that slopes to a safe collection area in the event of a spill or leak. l. Take all precautionary measures when handling and storing fuels and lubricants, avoiding environmental pollution m. Avoid the use of material with greater potential for contamination by substituting them with more environmentally friendly materials.

3. Water Resources Management

Activity	Environmental Impact	Environmental Management Guidelines
Handling use storage & disposal of hazardous material and waste	Water pollution from the storage, handling and disposal of hazardous materials and general construction waste, and accidental spillage	a. Follow the management guidelines proposed in ECoPs for Waste Management and Management of Fuels & Hazardous Substances. b. Minimize the generation of sediment, oil and grease, excess nutrients, organic matter, litter, debris and any form of waste (particularly petroleum and chemical wastes). These substances must not enter watercourse or underground water tables
Discharge from construction sites	During construction both surface and groundwater quality may be deteriorated due to construction activities in the river, sewerages from construction sites and work camps. The construction works will modify groundcover and topography changing the surface water drainage patterns, including infiltration and storage of storm water. The change in hydrological regime leads to increased rate of runoff and in sediment and contaminant loading, increased flooding, groundwater contamination, and affect habitat of fish and other aquatic biology	a. Install temporary sediment basins, where appropriate, to capture sediment-laden run-off from site b. Divert runoff from undisturbed areas around the construction site Stockpile materials away from drainage lines Prevent all solid and liquid wastes entering waterways by collecting solid waste, oils, chemicals, bitumen spray waste and wastewaters from brick, concrete and asphalt cutting where possible and transport to a approved waste disposal site or recycling depot. c. Wash out ready-mix concrete agitators and concrete handling equipment at washing facilities off site or into approved bunded areas on site. Ensure that tires of construction vehicles are cleaned in the washing bay (constructed at the entrance of the construction site) to remove the mud from the wheels. This should be done in every exit of each construction vehicle to ensure the locai roads are kept clean.
Soil erosion and siltation	Soil erosion and dust from the material stockpiles will increase the sediment and contaminant loading of surface water bodies.	a. Stabilize the cleared areas not used for construction activities with vegetation or appropriate surface water treatments as soon as practicable following earthwork to minimize erosion b. Ensure that roads used by construction vehicles are swept regularly to remove sediment. c. Water the material stockpiles (where appropriate), access roads and bare soils on an as required basis to minimise dust. Increase the watering frequency during the periods of high risk (eg. High winds)

Construction activities in water bodies	Construction works in the water bodies will increase sediment and contaminant loading, and effect habitat of fish and other aquatic biology.	a. Monitor the water quality in the runoff from the site, and improve work practices as necessary b. Minimize the generation of sediment, oil and grease, excess nutrients, organic matter, litter, debris and any form of waste (particularly petroleum and chemical wastes). These substances must not enter waterways, storm water systems or underground water tables. c. Use environment friendly and non toxic slurry during construction of piles to discharge into the river. d. Reduce infiltration of contaminated drainage through storm water management design e. Do not discharge cement and water curing used for cement concrete directly into water courses and drainage inlets
Drinking water	Groundwater at shallow depths might be contaminated and hence not suitable for drinking purposes.	a. Control the quality of groundwater to be used for drinking water on the basis of NEQS standards for drinking water. Safe and sustainable discharges are to be ascertained prior to selection of pumps. b. Tube wells will be installed with due regard for the surface environment, protection of groundwater from surface contaminants, and protection of aquifer cross contamination c. All tube wells, test holes, monitoring wells that are no longer in use or needed shall be properly decommissioned

4. Drainage

Activity	Environmental Impact	Environmental Management Guidelines
Excavation and earthworks, and construction yards	Lack of proper drainage for rainwater, surface water, liquid waste or wastewater owing to the construction activities harms environment in terms of water and soil contamination, and mosquito growth.	a. Provide alternative drainage for rainwater if the construction works/earth-fillings cut the established drainage line b. Rehabilitate road drainage structures immediately if damaged by contractors' road transports. c. Build new drainage lines as appropriate and required for wastewater from construction yards connecting to the available nearby recipient water bodies. Ensure wastewater quality conforms to the relevant standards before being discharged into recipient water bodies. d. Ensure the internal roads/hard surfaces in the construction yards/construction camps have adequate storm water drainage to accommodate high runoff during downpour and that there will be no stagnant water remaining in the area at the end of the downpour. Construct wide drains instead of deep drains to avoid sand deposition in the drains that will require frequent cleaning. Protect natural slopes of drainage channels to ensure adequate storm water drains. Regularly inspect and maintain all drainage channels to assess and alleviate any drainage congestion problem. Reduce infiltration of contaminated drainage through storm water management design
Ponding of water	Health hazards due to mosquito breeding	a. Do not allow ponding of water especially near the waste storage areas and construction camps. b. Discard all the storage containers that are capable of storing of water, after use or store them in inverted position

5. Management of Soil Quality

Activity	Environmental Impact	Environmental Management Guidelines
Storage of hazardous and toxic chemicals	Spillage of hazardous and toxic chemicals will contaminate the soils	a. Strictly manage the waste management plans proposed in Table H.1 and storage of materials in Table H.2 b. Construct appropriate spill contaminant facilities for all fuel storage areas. c. Establish and maintain a hazardous materials register detailing the location and quantities of hazardous substances including storage, use and disposal d. Train personnel and implement safe work practices for minimizing the risk of spillage e. Identify the cause of contamination, if it is reported,

		and contain the area of contamination. The impact may be contained by isolating the source or implementing controls around the affected site Remediate the contaminated land using the most appropriate available method
Construction material stock piles	Erosion from construction material stockpiles may contaminate the soils	Protect the toe of all stockpiles, where erosion is likely to occur, protect with silt fences, straw bales or bunds

6. Control of Sediment & Erosion

Activity	Environmental Impact	Environmental Management Guidelines
Clearing of construction sites	Cleared areas and slopes are susceptible to erosion of top soils that will affect the growth of vegetation causing ecological imbalance.	a. Reinstate and protect cleared areas as soon as possible. b. Cover unused area of disturbed or exposed surfaces immediately with mulch/grass turfings/tree plantations
Construction activities and material stockpiles	The impacts of soil erosion are Increased run off and sedimentation causing a greater flood hazard downstream destruction of aquatic environment in nearby lakes, streams, and reservoirs caused by erosion and/or deposition of sediment damaging the spawning grounds of fish, and destruction of vegetation by burying or gullying	a. Locate stockpiles away from drainage lines b. Protect the toe of all stockpiles, where erosion is likely to occur, with silt fences, straw bales or bunds c. Remove debris from drainage paths and sediment control structures d. Cover loose materials and water them if required e. Divert natural runoff around construction areas prior to any site disturbance f. Control drainage through a site in protected channels or slope drains Install ‘cut off drains' on large cut/fill batter slopes to control water runoff speed and hence erosion g. Observe the performance of drainage structures and erosion controls during rain and modify as required.

7. Management of Borrow Pits

Activity	Environmental Impact	Environmental Management Guidelines
Development and operation of borrow areas	Where borrow pits are developed there shall be impacts on local topography, landscape and natural drainage	a. Reuse excavated or disposed material available in the project area to the maximum extent possible b. Identify borrow pits in consultation with SIDA & PIC. c. Obtain the borrow material from barren land or land without tree cover. d. Borrow pits should be located no closer than 5m of the toe of an embankment. e. Where borrow pits are to be continuous strip pits,

		ridges of not less than 8 m widths shall be left at intervals not exceeding 300 m and small drains should be cut through the ridges to facilitate drainage Slope the bed level of the borrow pits, where possible, towards the nearest cross drain, if any, and do not lower the bed of a borrow pit below the level of the cross-drain, to ensure efficient drainage. f. Follow the below for restoration of borrow areas: g. Return stockpiled topsoil to the borrow pit if is used for agriculture h. Return stockpiled topsoil to the borrow pit and all worked areas to be stabilized with vegetation (using local plants)

8. Management of Air Quality

Activity	Environmental Impact	Environmental Management Guidelines
Construction vehicular traffic	Air quality can be adversely affected by vehicle exhaust emissions and combustion of fuels.	a. Fit vehicles with appropriate exhaust systems and emission control devices, in compliance with the NEQS. Maintain these devices in good working condition. b. Operate the vehicles in a fuel efficient manner c. Cover haul vehicles carrying loose & dusty materials when moving d. outside the construction site e. Impose speed limits on all vehicle movement at the worksite to reduce dust emissions f. Control the movement of construction traffic as per the traffic management plan g. Water construction materials (where appropriate) prior to loading and transport h. Service all vehicles regularly to minimise emissions Limit the idling time of vehicles to not more than 2 minutes
Construction machinery	Air quality can be adversely affected by emissions from machinery and combustion of fuels.	a. Fit machinery with appropriate exhaust systems and emission control devices. Maintain these devices in good working condition. b. Focus special attention on containing the emissions from generators Machinery causing excess pollution (e.g. visible smoke) will be banned from construction sites c. Service all equipment regularly to minimise emissions
Construction activities	Dust generation from construction sites, material stockpiles and access roads is a nuisance in the environment and can be a health hazard.	a. Water the material stockpiles & access roads on an as required basis to minimise the production of dust. Increase the watering frequency during periods of high risk (e.g. high winds) b. Minimise the extent and period of exposure of the bare surfaces Reschedule earthwork activities or

		vegetation clearing activities, where practical, if necessary to avoid periods of high wind and if visible dust is blowing off-site

9. Management of Noise & Vibration

Activity	Environmental Impact	Environmental Management Guidelines
Construction vehicular traffic	Increased noise levels in the project area	a. Maintain all vehicles in accordance with manufactures maintenance procedures to ensure good working order b. Make sure all drivers will comply with the traffic codes concerning maximum speed limit, driving hours, etc.
Construction machinery	Noise and vibration may have an impact on people, property, fauna, livestock and the natural environment	a. Appropriately site all noise generating activities to avoid noise pollution to local residents b. Use the quietest available plant and equipment c. Modify equipment to reduce noise (for example, noise control kits, lining of truck trays) d. Maintain all vehicles in accordance with manufactures maintenance procedures to ensure good working order e. Install acoustic enclosures around generators to reduce noise levels. Fit high efficiency mufflers to appropriate construction equipment
Construction activity	Noise and vibration may have an impact on people, property, fauna, livestock and the natural environment	a. Notify adjacent residents prior to any typical noise event outside of daylight hours b. Educate the operators of construction equipment on potential noise problems and the techniques to minimize noise emissions c. Employ best available work practices on-site to minimize occupational noise levels d. Notify affected people if/when noisy activities will be undertaken Plan activities on site and deliveries to and from site to minimise impact e. Monitor and analyse noise and vibration results and adjust construction practices as required. f. Avoid undertaking the noisiest activities at night near the residential areas

10 Protection of Flora

Activity	Environmental Impact	Environmental Management Guidelines
a. Vegetation clearance	b. Local flora are important to provide shelters for the fauna, offer fruits and/or timber/fire wood and protect soil erosion. As such damage to flora has wide range of adverse environmental impacts.	c. Reduce disturbance to surrounding vegetation. Use appropriate type and minimum size of machine to avoid disturbance to adjacent vegetations. d. Get approval from supervision consultant for clearance of vegetation. e. Make selective and careful pruning of trees where possible to reduce need of tree removal. f. Control noxious weeds by disposing of at designated dump site or burn on site. g. Clear only the vegetation that needs to be cleared in accordance with the designs. These measures are applicable to both the construction areas as well as to any associated activities such as sites for stockpiles, disposal of fill and construction of diversion roads, etc. h. Do not burn cleared vegetation - where feasible, chip or mulch and reuse it for the rehabilitation of affected areas, temporary access tracks or landscaping. Mulch provides a seed source, can limit embankment erosion, retains soil moisture and nutrients, and encourages re-growth and protection from weeds. i. Return topsoil and mulched vegetation (in areas of native vegetation) to approximately the same area of the roadside it came from. j. Avoid work within the drip-line of trees to prevent damage to the tree roots and compacting the soil. Minimize the length of time the round is exposed or excavation left open by clearing and re-vegetating the area at the earliest practically possible. k. Ensure excavation works occur progressively and re-vegetation is implemented at the earliest practicable stage l. Provide adequate knowledge to the workers regarding nature protection and the need to avoid felling trees during construction m. Supply appropriate fuel in the work caps to prevent fuel wood collection

10. Protection of Fauna

Activity	Environmental Impact	Environmental Management Guidelines
Construction activities	The location of construction activities can result in the loss of wild life habitat and habitat quality	Limit the construction works to within the CoI (as per Table H.10)
	Impact on migratory birds, habitat and active nests	a. The Contractor is not be permitted to destruct active nests or eggs of migratory birds b. Minimize tree removal during the bird breeding season. c. Minimize the release of oil, oil wastes or any other substances harmful to migratory birds to any waters or areas frequented by migratory birds.
Vegetation clearance	Clearance of vegetation may impact shelter, feeding and/or breeding and/or physical destruction and severing of habitat areas	a. Restrict the tree removal to the minimum required. b. Retain tree hollows on site, where appropriate c. Leave dead trees where possible as habitat for fauna d. Fell the hollow bearing trees in a manner which reduces the potential e. for fauna mortality. After felling, hollow trees will remain unmoved f. overnight to allow animals to move of their own accord.
Construction camps	Illegal poaching	Provide adequate knowledge to the workers regarding protection of flora and fauna, and relevant government regulations and punishments for illegal poaching.

11. Protection of Fisheries

Activity	Environmental Impact	Environmental Management Guidelines
Construction activities in the canal	The main potential impacts to fisheries are hydrocarbon spills and leaks from boats and disposal of wastes into the canal	a. Ensure that boats used in the project are well maintained and do not ailow leakage of oil to contaminate river water. b. Contain accidental spillage and make an emergency oil spill containment plan to be supported with adequate equipments materials and human resources c. Do not dump wastes, be it hazardous or non-hazardous into the nearby water bodies or in the canals.
Construction activities on the land	The main potential impacts to aquatic flora and fauna are increased suspended solids from earthworks erosion, sanitary discharge from work camps, and hydrocarbon spills	Adopt mitigation measures proposed in Table H.3: Water Resources Management and Table H.4:Drainage Management

12. Traffic Management

Activity	Environmental Impact	Environmental Management Guidelines
Construction vehicular traffic	Increased traffic use of roads by construction vehicles will affect the movement of normal road traffics and the safety of the road- users.	a. Prepare and submit a traffic management plan to PIC for their approval. b. Include measures in the traffic management plan to ensure uninterrupted traffic movement during construction: detailed drawings of traffic arrangements showing all detours, temporary road, temporary diversions, necessary barricades, warning signs/lights, road signs, etc. Provide signs at strategic locations of the roads complying with the schedules of signs contained in the Pakistani Traffic Regulations. c. Install and maintain a display board at each important road intersection on the roads to be used during construction, which shall clearly show the following information in Urdu: d. Location: chainage and village name e. Duration of construction period f. Period of proposed detour/alternative route g. Suggested detour route map h. Name and contact address/telephone number of the concerned personnel i. Name and contact address/telephone number of the Contractor j. Inconvenience is sincerely regretted
	Accidents and spoilage of fuels and chemicals	a. Restrict truck deliveries, where practicable, to day time working hours. b. Restrict the transport of oversize loads. c. Operate road traffics/transport vehicles, if possible, at non-peak periods to minimise traffic disruptions. d. Enforce on-site speed limit

13. Management of Contractors Camp

Activity	Environmental Impact	Environmental Management Guidelines
Siting and Location of construction camps	Campsites for construction workers are important locations that have significant impacts such as health and safety hazards on local resources and infrastructure of nearby communities	a. Locate the construction camps at areas which are acceptable considering a balance of environmental, cultural and social aspects. b. Consider the location of construction camps away from communities in order to avoid social conflict in using the natural resources such as water or to avoid the possible adverse impacts of the construction camps on the surrounding communities. **c.** Submit to PIC for approval a detailed layout plan for the development of construction camps showing the relative locations of all temporary buildings and facilities that are to be constructed together with the location of site roads, fuel storage areas (for use in power supply generators), solid waste management and dumping locations, and drainage facilities, prior to the development of the construction camps. Local authorities responsible for health, religious and security matters shall be duly informed on the set up of camp facilities so as to maintain effective surveillance of public health, social impacts and security
Construction Camp Facilities	Lack of proper infrastructure facilities, such as housing, water supply and sanitation facilities will increase pressure on the local services and generate substandard living standards and health hazards	a. Adequate housing for all workers b. Safe and reliable water supply. Water supply from tube wells that meets the national standards c. Hygienic sanitary facilities and sewerage system. Provide separate latrines and bathing places for males and females with total isolation by wall or by location. Female toilets should be clearly marked in language understood by the persons using them to avoid miscommunication. d. Treatment facilities for sewerage of toilet and domestic wastes Storm water drainage facilities - shallow v drains should be provided on both sides of any camps roads to drain off storm water. e. Pave the internal roads of at least haring-bond bricks to suppress dusts and to work against possible muddy surface during monsoon. **f.** Provide in-house community/common entertainment facilities. Dependence of local entertainment outlets by construction staff is to be discouraged/prohibited to the extent possible.
Disposal of waste	Management of wastes is crucial to minimise impacts on the environment, such as soil or water pollution.	a. Ensure proper collection and disposal of solid wastes within the construction camps b. Encourage waste separation by source; organic wastes in one container and inorganic wastes in another container at household level. c. Store inorganic wastes in a safe place within the household and clear organic wastes on daily basis

		to waste collector. Establish waste collection, transportation and disposal systems supported by adequate manpower and equipments/vehicles. d. Dispose organic wastes in a designated safe place on daily basis. At the end of the day cover the organic wastes with a thin layer of sand so that flies, mosquitoes, dogs, cats, rats etc are not attracted. Where waste is disposed of in a pit take care to protect groundwater from contamination by leachate formed due to decomposition. Cover the bed of the pit with impervious layer of materials (clay, thin concrete) to protect groundwater from contamination. e. Locate the garbage pit/waste disposal site min 500 m away from the residence so that peoples are not disturbed with the odour likely to be produced from anaerobic decomposition of wastes at the waste dumping places. Encompass the waste dumping place with fencing to prevent access to children **f.** Do not establish site specific landfill sites. All solid waste will be collected and removed from the work camps and disposed in approval waste disposal sites.
Fuel supplies for cooking purposes	Illegal sourcing of fuel wood by construction workers will impact the natural flora and fauna	a. Provide fuel to the construction camps for their domestic purpose, in order to discourage them to use fuel wood or other biomass. b. Make available alternative fuels like natural gas or kerosene to the workforce to prevent them using biomass for cooking. **c.** Conduct awareness campaigns to educate workers on preserving the biodiversity of the project area, and relevant government regulations and punishments associated with improper wildlife protection
Health and Hygiene	There will be a potential for diseases to be transmitted including malaria, exacerbated by inadequate health and safety practices. There will be an increased risk of work crews spreading sexually transmitted infections and HIV/AIDS	a. Provide adequate health care facilities within construction sites. Provide first aid facility round the clock. Maintain stock of medicines in the facility and appoint a doctor on site. b. Provide transport facility for the labourers during emergency to be transported to nearest hospitals. c. Provide initial health screening of the labourers coming from outside areas d. Train all construction workers in basic sanitation and health care issues and safety matters, and on the specific hazards of their work e. Provide HIV awareness programming, including STI (sexually transmitted infections) and HIV information, education and communication for all workers on regular basis f. Complement educational interventions with easy

		access to condoms at campsites g. Provide adequate drainage facilities throughout camps to ensure that disease vectors habitats (stagnant water bodies, puddles) do not form. Place display boards at strategic locations within the camps containing messages on best hygienic practices
Safety	Inadequate safety facilities at the construction camps may create security problems and fire hazards	a. Provide appropriate security personnel (police /home guard or private security guards) and enclosures to prevent unauthorized entry in to the camp area. b. Maintain register to keep track of personnel present in the camp at any given time. c. Encourage use of flameproof material for the construction of labour housing/site office. Ensure that these houses/rooms are of sound construction and capable of withstanding storms/cyclones. d. Provide appropriate type of fire fighting equipments suitable for the construction camps e. Display emergency contact numbers clearly and prominently at strategic places in camps. f. Communicate the roles and responsibilities of labourers in case of emergency in the monthly meetings with contractors
Site Restoration	Restoration of the construction camps to original condition requiring demolition of construction camps and disposal of material	a. Dismantle and remove from the site all facilities established within the construction camp including the perimeter fence and lockable gates at the completion of the construction work. b. If possible, dismantle camps in phases as the work decreases (do not wait for completion of the entire work) c. Give prior notice to the labourers before demolishing their camps/units d. Maintain the noise levels within the national standards during demolition activities e. Reuse the camp material to the maximum extent. Dispose remaining debris at the designated waste disposal site. f. Restore the site to its original condition or to an agreed condition with the landowner defined prior to the commencement of the works (in writing)

14. Cultural Heritage

Activity	Environmental Impact	Environmental Management Guidelines
Construction activities near religious and cultural sites	Disturbance from construction works to cultural and religious sites, and contractors lack of knowledge on cultural issues causing social disturbances	a. Do not block access to cultural and religious sites, wherever possible b. Restrict all construction activities within the foot prints of the construction sites. c. Stop construction works that produce noise (particularly during prayer time) should there be any mosque/religious/educational institutions close to the construction sites and the users make any objections. d. Take special care and use appropriate equipment when working next to a cultural/religious institution. Stop work immediately and notify the site manager if, during construction, an archaeological or burial site is discovered. It is prohibited to recommence work in the vicinity of the site until approval to continue is given by the Engineer. Show appropriate behaviour with all construction workers especially women and elderly people Allow the workers to participate in prayers during construction time. Resolve cultural issues in consultation with local leaders and the Engineer.Establish a mechanism that allows local people to raise grievances arising from the construction process. Inform the local authorities responsible for health, religion and security before commencement of civil works so as to maintain effective surveillance over public health, social and security matters.

15. Health & Safety

Activity	Environmental Impact	Environmental Management Guidelines
General construction works	Construction works may pose health and safety risks to the construction workers and site visitors leading to severe injuries and deaths. The population in the proximity of the construction site and the construction workers will be exposed to a number of biophysical health risk factors, (e.g. noise, dust, chemicals, construction material, solid waste, waste water, vector transmitted diseases etc), risk factors resulting from human behaviour (e.g. STD, HIV etc) and road accidents from construction traffic.	a. Implement suitable safety standards for all workers and site visitors which should not be less than those laid down on the international standards (e.g. International Labour Office guideline on 'Safety and Health in Construction; World Bank Group's 'Environmental Health and Safety Guidelines') and contractor's own national standards or statutory regulations, in addition to complying with the national acts and rules of the Government of Pakistan b. Provide the workers with a safe and healthy work environment, taking into account inherent risks in its particular construction activity and specific classes of hazards in the work areas, c. Provide personal protection equipment (PPE) for workers, such as safety boots, helmets, masks, gloves, protective clothing, goggles, full- face eye shields, and ear protection. Maintain the PPE properly by cleaning dirty, and replacing damaged, PPE. d. Safety procedures include provision of information, training and protective clothing to workers involved in hazardous operations and proper performance of their job e. Appoint an environment, health and safety manager to look after the health and safety of the workers f. Inform the local authorities responsible for health, religious and security before commencement of civil works and establishment of construction camps so as to maintain effective surveillance over public health, social and security matters g. The Contractor shall follow the ECoPs presented in the following tables to reduce health risks to the construction workers and nearby community: Table H.4: Drainage Management Table H.2: Fuels and Hazardous Goods Management Table H. 8: Air Quality Management Table H.9: Noise and Vibration Management Table H.13: Road Transport and Road Traffic Management
	Child and pregnant labour	Do not hire children of less than 14 years of age and pregnant women or women who delivered a child within 8 preceding weeks, in accordance with

		the Pakistani Labour Laws and Employment of Child Act (1977).
Accidents	Health and safety of workforce, exasperated if adequate health care is not available	a. Ensure health care facilities and first aid facilities are readily available. Appropriately equipped first-aid stations should be easily accessible throughout the project area b. Document and report occupational accidents, diseases, and incidents. Prevent accidents, injury, and disease arising from, associated with, or occurring in the course of work by minimising, so far as reasonably practicable, the causes of hazards. In a manner consistent with good international industry practice. c. Identify potential hazards to workers, particularly those that may be life-threatening and provide necessary preventive and protective measures. d. Provide awareness to the construction drivers to strictly follow the driving rules e. Provide adequate lighting in the construction area
Construction Camps	Lack of proper infrastructure facilities, such as housing, water supply and sanitation faciiities will increase pressure on the local services and generate substandard living standards and health hazards	a. (Construction Camp Management): b. Adequate ventilation facilities c. Safe and reliable water supply. Water supply from deep tube wells that meets the national standards d. Hygienic sanitary facilities and sewerage system e. Treatment facilities for sewerage of toilet and domestic wastes f. Storm water drainage facilities. g. Recreational and social facilities h. Safe storage facilities for petroleum and other chemicals in accordance with Table H.2 i. Solid waste collection and disposal system in accordance with Table H.1. j. Arrangement for trainings k. Security fence at least two metres in height. l. Sick bay and first aid facilities
Water and sanitation facilities at the construction sites	Lack of water sanitation facilities at construction sites cause inconvenience to the construction workers and affect their personal hygiene.	a. The contractor shall provide latrines at the construction sites. Location of facilities should be at least six metres away from any storm drain system and surface waters. These latrines should be cleaned once a day. b. Contractor should provide drinking water facilities to the construction workers at all the construction sites

Source MMP (2012)

Annexure-I(1)

Field Response of the Communities on the Environmental and Social Impacts on the Proposed Regional Plan Interventions

Q. No	Village	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	N
1	Concealed pockets and non existence of drainage outlets inundated crops and villages	x	x	x	x			x	x		x	x					x		x	x		11
2	Vegetation, trees bushes were destroyed due to stagnant water				x				x	x			x	x				x	x		x	8
3	Deforestation due to human interference has reduced the fauna of the area				x		x		x		x	x		x			x		x			8
4	Fish cannot survive in drains due to pollution by sugar mill effluents disposed in drains	x	x	x	x	x	x	x		x				x				x			x	11
5	Most of the tube wells are non-functional thus the water logging and salinity still prevails		x			x		x			x	x		x								6
6	Revival of dhoras / natural water ways would evacuate the rain water from fields and settlements		x	x		x	x	x		x			x	x		x		x	x		x	12
7	Underground water quality poor and not useable for drinking except near canals/watercourses	x	x			x	x	x				x	x			x			x			9
8	To use storm water for irrigation, dhoras may be provided with gated structures			x		x		x		x			x						x		x	7
9	There is severe water scarcity for irrigation and domestic use	x			x				x	x						x		x	x			7
10	Unprecedented rains caused overtopping of drains, dhoras and some where irrigation canals		x					x			x	x		x								5
11	Health, school, road facility non-existent	x	x			x			x							x		x	x	x	x	9
12	Drainage and flooding caused partial migration of people				x				x													2

	for search of livelihood																				
13	Diseases erupted due to rain water ponding for months in residential areas and crop lands		x				x		x		x		x	x					x			7
14	Acute shortage of fodder for animals caused mortality in livestock	x			x			x		x		x		x					x	x		x	9
15	Unprecedented rains destroyed most crops and caused damage to houses and property	x	x		x		x		x	x		x	x	x		x	x						11
16	In pre-LBOD time all rain water used to evacuate in 3 days but now it is stagnant since 4 months	x		x				x					x	x		x							6
17	Coastal wetland ecosystem may be revived to attract migratory birds, local fish and create livelihood														x	x							2
18	Mangrove forests may be grown in coastal areas														x	x							2
19	Fertile soils have been degraded due to stagnant water for long time	x		x			x				x			x							x	x	7
20	The seasons have changed due to climate change								x					x					x				3
21	Overall impact of the proposed interventions on environment of the area would be positive	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	20

Table-35 (a) Field Response of the Communities on the Environmental and Social Impacts as a result of the Proposed Regional Plan Interventions

Annexure-I(2)

Field Response of the Communities on the Environmental and Social Impacts on the Proposed Regional Plan Interventions

	Village	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	N
1	Concealed pockets and non existence of drainage outlets inundated crops and villages	x	x			x	x	x			x		x	x	x	x	x		x	x		13
2	Vegetation, trees bushes were destroyed due to stagnant water									x	x	x		x			x		x	x	x	8
3	Deforestation due to human interference has reduced the fauna of the area		x		x			x		x				x		x	x		x	x	x	10
4	Fish cannot survive in drains due to pollution by sugar mill effluents disposed in drains					x							x					x				3
5	Most of the tubewells are non-functional thus the water logging and salinity still prevails												x		x							2
6	Revival of dhoras / natural water ways would evacuate the rain water from fields and settlements			x	x		x			x	x			x		x	x	x			x	10
7	Underground water quality poor and not useable for drinking except near canals/watercourses	x	x			x	x	x		x		x						x				8
8	To use storm water for irrigation, dhoras may be provided with gated structures		x						x						x							3
9	There is severe water scarcity for irrigation and domestic use			x	x	x	x					x				x						6
10	Unprecedented rains caused overtopping of drains, dhoras and some where irrigation canals			x				x			x			x	x		x	x	x	x		9
11	Health, school, road facility non-existent	x				x	x															3
12	Drainage and flooding caused partial migration			x																	x	2

	of people for search of livelihood																					
13	Diseases erupted due to rain water ponding for months in residential areas and crop lands	x		x			x				x	x					x					6
14	Acute shortage of fodder for animals caused mortality in livestock		x	x		x											x	x	x		x	7
15	Unprecedented rains destroyed most crops and caused damage to houses and property	x	x		x		x	x	x		x	x	x	x	x	x				x	x	14
16	In pre-LBOD time all rain water used to evacuate in 3 days but now it is stagnant since 4 months		x							x									x		x	4
17	Coastal wetland ecosystem may be revived to attract migratory birds, local fish and create livelihood																					0
18	Mangrove forests may be grown in coastal areas																					0
19	Fertile soils have been degraded due to stagnant water for long time	x			x	x		x			x				x		x	x		x	x	10
20	The seasons have changed due to climate change				x					x					x	x		x	x			6
21	Overall impact of the proposed interventions on environment of the area would be positive	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	20

Table-35 (b) Field Response of the Communities on the Environmental and Social Impacts as a result of the Proposed Regional Plan Interventions