Annex G

Drainage Structures Protection Plan

Annex G: Drainage Structures Protection Plan

G.1 General

Numerous drainage structures exist along the reservoirs of Ice Harbor, Lower Monumental, Little Goose, and Lower Granite dams. These structures were designed to allow passage of water from existing upslope drainages through highway and railroad embankments into the reservoirs created by the dams. They range in size from ranging in size from 200-millimeter (8-inch) diameter PVC pipes to 6.1- by 3.0-meter (20- by 10-foot) corrugated metal arch pipes.

A review of as-constructed contract drawings for various projects indicates additional culverts are present below current reservoir levels. These structures were installed for the original railroad construction as well as for temporary modification of the railroad alignment during dam construction. These culverts are typically 900 millimeters (36 inches) or larger in diameter. With reservoir impoundment and relocation of post-reservoir highway and railroad embankments, additional ponded areas were created on the landward side of relocated highway and railroad embankments, thus requiring additional post-reservoir drainage.

The existing drainage structures at or above the reservoir pools were identified, located, and cataloged in August of 1995 by visual reconnaissance from a boat along the shore of the four reservoirs. The locations of these drainage structures and the inventory survey data for each of the reservoirs is presented in Plates 6-1 through 6-8 of a separate report titled *Lower Snake River Reservoir Stabilization Plan* (Raytheon, 1997). The majority of the structures are 300- to 1500-millimeter (12- to 60-inch) diameter corrugated metal pipe (CMP) culverts with the remaining structures consisting of concrete or CMP arch culverts with cast-in-place headwalls and box culverts. At some locations, the culverts have a grouted rock apron at the outlet.

G.2 Standard Modifications

Seepage and surface runoff that flows down slope into natural depressions and impoundments created by man-made fills tends to locally saturate the soil and can cause instability. To control seepage from these depressions and fills, transverse interceptor drains or culverts were constructed in conjunction with the construction of highway and railroad embankments.

The drainage structures visible along the reservoir slopes encompass a range of elevations above the existing water surface depending on former and relocated alignments. Tables G1 through G4 summarize information on the physical characteristics of these drainage structures and the proposed modifications. This information, in conjunction with the review of the construction documents, was used to plan the drainage structure modifications for the proposed drawdown of the lower Snake River reservoirs.

Table G1. Lower Granite Drainage Structures Treatment

Feature No.	Dia	Unit Meas	Mat'l Type	Drop to Res (ft)	Treat-ment Code	River-mile	Bank (L /R)	Feature No.	Dia	Unit Meas	Mat'l Type	Drop to Res (ft)	Treat-ment Code	River-mile	Bank (L /R)	Feature No.	Dia	Unit Meas	Mat'l Type	Drop to Res (ft)	Treat-ment Code	River-mile	Bank (L /R)
D-1	36	Inch	CMP	3	ED	130.80	R	D-30	24	Inch	CMP	3	ED	120.80	R	D-59	36	Inch	CMP	4	ED	113.50	R
D-2	30	Inch	CMP	3	ED	130.55	R	D-31	2@48	Inch	CMP	3	ED	120.50	R	D-60	36	Inch	CMP	3	ED	113.20	R
D-3	36	Inch	CMP	3	SP	128.60	R	D-32	24	Inch	CMP	3	ED	120.20	R	D-61	24	Inch	CMP	4	ED	113.10	R
D-4	30	Inch	CMP	4	SP	128.45	R	D-33	36	Inch	CMP	3	ED	120.00	R	D-62	36	Inch	CMP	4	ED	112.90	R
D-5	24	Inch	CMP	2	SP	127.70	R	D-34	18	Inch	CMP	3	ED	119.80	R	D-63	30	Inch	CMP	5	ED	112.40	R
D-6	30	Inch	CMP	3	ED	127.45	R	D-35	10	Inch	CMP	6	ED	119.55	R	D-64	24	Inch	CMP	4	ED	112.00	R
D-7	2@36	Inch	CMP	3	ED	126.95	R	D-36	10	Inch	CMP	5	ED	119.40	R	D-65	24	Inch	CMP	3	ED	111.85	R
D-8	24	Inch	CMP	4	ED	126.70	R	D-37	30	Inch	CMP	2	ED	119.30	R	D-66	24	Inch	CMP	4	ED	111.80	R
D-9	36	Inch	CMP	3	ED	126.30	R	D-38	10	Inch	CMP	4	ED	119.05	R	D-67	30	Inch	CMP	4	ED	111.40	R
D-10	36	Inch	CMP	3	ED	126.00	R	D-39	24	Inch	CMP	3	ED	118.80	R	D-68	12	Inch	CMP	8	ED	110.90	R
D-11	30	Inch	CMP	2	ED	124.95	R	D-40	30	Inch	CMP	3	ED	118.45	R		18	Inch	CMP	0.5	ED	110.90	R
D-12	24	Inch	CMP	3	ED	124.50	R	D-41	24	Inch	CMP	2	ED	118.25	R		18	Inch	CMP	0.5	ED	110.90	R
D-13	2@48	Inch	CMP	4	ED	124.20	R	D-42	24	Inch	CMP	4	ED	117.95	R	D-69	48	Inch	CMP	4	ED	110.25	R
D-14	12	Inch	CMP	6	ED	123.85	R	D-43	30	Inch	CMP	4	ED	117.60	R	D-70	36	Inch	CMP	3	ED	110.00	R
D-15	24	Inch	CMP	3	ED	123.80	R	D-44	5	Feet	CMP	3	ED	117.30	R	D-71	3@30	Inch	CMP	3	SP	109.90	R
D-16	5	Feet	CMP	3	ED	123.80	R	D-45	24	Inch	CMP	3	ED	117.15	R	D-72	36	Inch	CMP	2	SP	109.80	R
D-17	2@48	Inch	CMP	3	ED	123.70	R	D-46	5	Feet	CMP	3	ED	117.00	R	D-73	48	Inch	CMP	2	SP	109.50	R
D-18	36	Inch	CMP	5	ED	123.60	R	D-47	36	Inch	CMP	3	ED	116.60	R	D-74	24	Inch	CMP	3	SP	108.95	R
D-19	18	Inch	CMP	4	ED	123.60	R	D-48	30	Inch	CMP	4	SP	116.40	R	D-75	30	Inch	CMP	3	SP	108.85	R
D-20	18	Inch	CMP	4	ED	123.45	R	D-49	12	Inch	CMP	8	SP	116.30	R	D-76	2@48	Inch	CMP	4	ED	108.70	R
D-21	10	Inch	CMP	8	SP	122.80	R	D-50	24	Inch	CMP	4	SP	116.10	R	D-77	36	Inch	CMP	3	ED	108.30	R
D-22	24	Inch	CMP	3	SP	122.75	R	D-51	30	Inch	CMP	4	SP	116.00	R	D-78	48	Inch	CMP	3	SP	108.00	R
D-23	24	Inch	CMP	3	SP	122.50	R	D-52	36	Inch	CMP	3	SP	115.65	R	D-79	18	Inch	CMP	4	SP	108.15	R
D-24	24	Inch	CMP	3	SP	122.20	R	D-53	36	Inch	CMP	3	ED	115.00	R	D-80	48	Inch	CMP	2	SP	108.20	L
D-25	30	Inch	CMP	3	SP	122.10	R	D-54	30	Inch	CMP	3	ED	114.55	R	D-81	18	Inch	CMP	3	ED	131.50	L
D-26	24	Inch	CMP	3	ED	121.80	R	D-55	48	Inch	CMP	4	ED	114.40	R	D-82	6	Feet	CMP	3	ED	137.30	R
D-27	24	Inch	CMP	3	ED	121.60	R	D-56	24	Inch	CMP	4	ED	114.25	R	D-83	6	Feet	CMP	4	ED	133.40	R
D-28	24	Inch	CMP	3	ED	121.30	R	D-57	36	Inch	CMP	3	ED	113.90	R	D-84	48	Inch	CMP	3	ED	132.90	R
D-29	36	Inch	CMP	3	ED	121.00	R	D-58	36	Inch	CMP	3	ED	113.80	R	D-85	2@24	Inch	CMP	4	ED	132.80	R

Treatment Codes: ED =Energy Dissipater; SP = Slope Protection; CLC = Clean Lower Culvert

Material Types: PVC = Polyvinylchloride; CMP = Corrugated Metal Pipe; Steel = Steel Pipe; ABS = Black Plastic Pipe; WS = Welded Steel; CHA = Concrete Half Arch; CMPA = Corrugated Metal Pipe Arch

Table G1 continued. Lower Granite Drainage Structures Treatment

Feature No.	Dia	Unit Meas	Mat'l Type	Drop to Res (ft)	Treat-ment Code	River-mile	Bank (L /R)	Feature No.	Dia	Unit Meas	Mat'l Type	Drop to Res (ft)	Treat-ment Code	River-mile	Bank (L /R)	Feature No.	Dia	Unit Meas	Mat'l Type	Drop to Res (ft)	Treat-ment Code	River-mile	Bank (L /R)
D-86	2@36	Inch	CMP	3	ED	132.55	R	D-113	24	Inch	CMP	4	ED	142.80	L	D-137	24	Inch	CMP	3	SP	138.40	R
D-87	36	Inch	CMP	3	ED	132.30	R	D-114	24	Inch	CMP	10	ED,CLC	142.95	L	D-138	48	Inch	CMP	2	ED	137.95	R
D-88	24	Inch	CMP	3	ED	132.15	R	D-115	2@5	Feet	CMP/ G	8	EDC	143.60	L	D-139	18	Inch	CMP	2	SP	137.50	R
D-89	24	Inch	CMP	3	ED	132.10	R	D-116	36	Inch	CMP	0.5	ED	144.30	L								
D-90	24	Inch	CMP	3	ED	132.00	R	D-117	12	Inch	CMP	15	ED,CLC	144.80	L								
D-91	36	Inch	CMP	3	ED	131.80	R	D-118	24	Inch	CMP	20	ED,CLC	142.50	R								
D-92	24	Inch	CMP	4	ED	131.35	R	D-119	12	Inch	CMP	12	ED,CLC	142.40	R								
D-93	18	Inch	CMP	-1	ED	131.00	L	D-120	12	Inch	CMP	12	ED,CLC	142.30	R								
D-94	30	Inch	CMP	-1.5	ED	131.20	L	D-121	12	Inch	CMP	12	ED,CLC	142.10	R								
D-95	18	Inch	CMP	3	ED	131.30	L	D-122	12	Inch	CMP	10	ED,CLC	142.00	R								
D-96	24	Inch	CMP	4	ED	133.50	L	D-123	12	Inch	CMP	10	ED,CLC	141.85	R								
D-97	18	Inch	CMP	3	ED	133.85	L	D-124	12	Inch	CMP	12	ED,CLC	142.75	R								
D-98	18	Inch	CMP	3	ED	134.40	L		12	Inch	CMP	30	ED,CLC	142.8	R								
D-99	18	Inch	CMP	3	ED	134.60	L	D-125	12	Inch	CMP	8	ED	141.60	R								
D-100	18	Inch	CMP	4	ED	134.70	L	D-126	42	Inch	CMP	4	ED	141.45	R								
D-101	2@48	Inch	CMP	1	EDC	134.90	L	D-127	30	Inch	CMP	2	ED	141.30	R								
D-102	3@5	Feet	CMP	0	EDC	135.30	L	D-128	18	Inch	CMP	13	ED,CLC	141.10	R								
D-103	18	Inch	CMP	2	ED	135.50	L	D-129	36	Inch	CMP	4	ED	140.90	R								
D-104	18	Inch	CMP	3	ED	135.80	L		18	Inch	CMP	0	ED	140.90	R								
D-105	18	Inch	CMP	3	ED	136.10	L	D-130	24	Inch	CMP	5	ED	140.80	R								
D-106	18	Inch	CMP	3	ED	136.25	L	D-131*	24	Inch	Conc	3	ED	3.80	R								
D-107	24	Inch	CMP	3	ED	136.70	L	D-132*	24	Inch	CMP	15	ED,CLC	0.40	R								
D-108	18	Inch	CMP	3	ED	137.00	L		12	Inch	CMP	15	ED,CLC	0.40	R								
D-109	36	Inch	CMP	-1	EDC	138.10	L	D-133*	6	Feet	CMP	3	ED	0.20	R								
D-110	36	Inch	CMP	20	ED,CLC	138.20	L	D-134	4	Feet	CMP	2	ED	138.75	R								
D-111	24	Inch	CMP	10	ED,CLC	141.60	L	D-135	24	Inch	CMP	2	ED	138.60	R								
D-112	12	Inch	CMP	5	ED	141.55	L	D-136	4	Feet	CMP	2	ED	138.50	R								

Treatment Codes: ED =Energy Dissipater; SP = Slope Protection; CLC = Clean Lower Culvert

Material Types: PVC = Polyvinylchloride; CMP = Corrugated Metal Pipe; Steel = Steel Pipe; ABS = Black Plastic Pipe; WS = Welded Steel; CHA = Concrete Half Arch; CMPA = Corrugated Metal Pipe Arch

* Indicates drainage structure on Clearwater River

Table G2. Ice Harbor Drainage Structures Treatment

Feature No.	Dia	Unit Meas	Mat'l Type	Drop to Res (ft)	Treat-ment Code	River-mile	Bank (L /R)	Feature No.	Dia	Unit Meas	Mat'l Type	Drop to Res (ft)	Treat-ment Code	River-mile	Bank (L /R)	Feature No.	Dia	Unit Meas	Mat'l Type	Drop to Res (ft)	Treat-ment Code	River-mile	Bank (L /R)
D-1	8	Inch	PVC	4	ED	11.90	R	D-30	8	Feet	CHA	15	EDC,CLC	31.20	R	D-55	12	Inch	CMP	10	ED,CLC	40.20	R
D-2	36	Inch	CMP	5	SP	13.61	R	D-31	24	Inch	CMP	40	SP	32.20	R	D-56	18	Inch	CMP	15	ED,CLC	41.50	R
D-3	36	Inch	CMP	5	SP	14.00	R	D-31	18	Inch	Steel	15	ED	32.20	R	D-57	5	Feet	CHA	25	ED,CLC	40.50	L
D-4	5	Feet	CMP	3	ED	14.80	R	D-32	24	Inch	CMP	40	SP	32.30	R	D-58	24	Inch	CMP	10	ED,CLC	38.25	L
D-5	36	Inch	CMP	6	SP	18.00	R	D-32	24	Inch	Steel	15	ED	32.30	R	D-59	24	Inch	CMP	10	ED,CLC	37.50	L
D-6	8x8	Feet	CBC	5	EDC	18.20	R	D-33	2	Feet	CMP	2	ED	32.60	R	D-60	24	Inch	CMP	3	ED	37.40	L
D-7	36	Inch	CMP	2	ED	18.40	R	D-33	3	Feet	CMP	3	ED	32.60	R	D-61	24	Inch	CMP	3	ED	37.30	L
D-8	36	Inch	CMP	0	ED	18.60	R	D-34	24	Inch	CMP	50	SP,CLC	32.70	R	D-62	5	Feet	CMPA	5	ED	37.40	L
D-9	36	Inch	CMP	0	ED	19.10	R	D-35	30	Inch	WS	30	SP,CLC	34.65	R	D-63	30	Inch	CMP	10	ED,CLC	37.20	L
D-10	4.5	Feet	CMP	10	SP,CLC	21.20	R	D-36	8	Feet	CHA	30	SPC,CLC	35.15	R	D-64	12	Inch	CMP	3	ED	37.10	L
D-11	3	Feet	CMP	?	SP	21.60	R	D-37	5	Feet	CMP	6	ED	35.94	R	D-65	18	Inch	CMP	6	ED	37.05	L
D-12	18	Inch	CMP	2	SP	21.57	R	D-38	18	Inch	CMP	2	ED	36.10	L	D-66	4	Feet	CMP	10	ED,CLC	28.70	L
D-13	36	Inch	CMP	15	SP,CLC	21.60	R	D-39	12	Inch	CMP?	3	ED	36.00	L	D-67	24	Inch	CMP	25	ED,CLC	28.00	L
D-14	36	Inch	CMP	20	SP,CLC	21.70	R	D-40	12	Inch	CMP	15	ED,CLC	35.73	L	D-68	24	Inch	CMP	20	SP,CLC	26.40	L
D-15	36	Inch	CMP	?	SP	21.75	R	D-41	24	Inch	CMP	6	ED	35.40	L	D-69	3	Feet	CMP	30	SP,CLC	26.35	L
D-16	Unk		CMP	<5	SP	21.85	R	D-42	24	Inch	CMP	1	ED	35.05	L	D-70	6	Feet	CMP	30	ED,CLC	24.40	L
D-17	4.5	Feet	CMP	25	SP,CLC	22.00	R	D-43	36	Inch	CMP	3	ED	34.15	L	D-71	3	Feet	CMP	30	SP,CLC	23.90	L
D-18	4	Feet	CMP ?	-1.5	ED	22.15	R	D-44	Unk	Inch	Unk	Unk	ED	33.65	L	D-72	3	Feet	CMP	30	SP,CLC	23.85	L
D-19	4	Feet	CMP	0	ED	22.70	R	D-45	18	Inch	CMP	5	ED	31.30	L	D-73	24	Inch	CMP	40	SP,CLC,	23.00	L
D-20	18	Inch	Metal	10	ED,CLC	25.45	R	D-46	15	Feet	CMPA	-3	ED	30.40	L	D-74	3	Feet	CMP	40	SP,CLC	22.60	L
D-21	2@ 6	Feet	CMP	-3/-1.5	EDC	26.20	R	D-47	24	Inch	CMP	4	ED	30.17	L	D-75	24	Inch	CMP	30	SP,CLC	17.40	L
D-22	18	Inch	ABS	25	ED,CLC	26.50	R	D-48	15	Feet	CMPA	-3	EDC	29.80	L	D-76	30	Inch	CMP	5	ED	17.10	L
D-23	24	Inch	CMP	5	ED	26.83	R	D-49	8	Feet	CHA	12	EDC	37.70	R	D-77	20x10	Feet	CMPA	-1	ED	17.00	L
D-24	4	Feet	CMP	35	ED,CLC	27.60	R	D-50	24	Inch	CMP	-0.5	ED	38.40	R	D-78	4	Feet	CMP	10	SP,CLC	16.80	L
D-25	4	Feet	CMP	6	ED	28.00	R	D-51	12	Inch	CMP	10	ED,CLC	39.15	R	D-79	<12	Inch	CMP	6	SP	15.90	L
D-26	3	Feet	CMP	35	ED,CLC	29.40	R	D-51	12	Inch	CMP	3	ED	39.15	R	D-80	24	Inch	CMP	15	SP,CLC	14.10	L
D-27	18	Inch	CMP	20	SP,CLC	30.50	R	D-52	12	Inch	CMP	7	ED	39.30	R	D-81	4	Feet	CMP	30	SP,CLC	13.00	L
D-28	18	Inch	ABS	30	ED,CLC	30.80	R	D-53	12	Inch	CMP	6	ED	39.50	R	D-82	24	Inch	CMP	40	SP,CLC	10.50	L
D-29	18	Inch	ABS	30	ED,CLC	31.00	R	D-54	12	Inch	CMP	8	ED	39.80	R	D-82	24	Inch	CMP	25	SP,CLC	10.50	L

Treatment Codes: SP = Slope Protection; ED =Energy Dissipater; SPC = Slope Protection with concrete treatment; EDC = Energy Dissipater with concrete treatment; CLC = Clean Lower Culvert

Material Types: PVC = Polyvinylchloride; CMP = Corrugated Metal Pipe; Steel = Steel Pipe; ABS = Black Plastic Pipe; WS = Welded Steel; CHA = Concrete Half Arch; CBC = Concrete Box Culvert; CMPA = Corrugated Metal Pipe Arch

Table G3. Lower Monumental Drainage Structures Treatment

Feature No.	Dia	Unit Meas	Mat'l Type	Drop to Res (ft)	Treat-ment Code	River - mile	Bank (L /R)	Feature No.	Dia	Unit Meas	Mat'l Type	Drop to Res (ft)	Treat-ment Code	River-mile	Bank (L /R)	Feature No.	Dia	Unit Meas	Mat'l Type	Drop to Res (ft)	Treat-ment Code	River-mile	Bank (L /R)
D-1	30	Inch	CMP	5	ED	61.15	R	D-23	30	Inch	CMP	30	ED,CLC	66.50	R		Includes Concrete Headwall						
D-2	42	Inch	CMP/G	40	EDC, CLC	62.80	R	D-24	30	Inch	CMP	45	ED,CLC	66.60	R	D-44	3	Feet	CMP	30	SP,CLC	58.70	L
D-3	36	Inch	CMP	40	ED,CLC	63.00	R	D-25	30	Inch	CMP	50	ED,CLC	66.70	R	D-45	12'x 10'	Arch	Conc	3	EDC	56.05	L
D-4	36	Inch	CMP	30	ED,CLC	63.10	R	D-26	30	Inch	CMP	50	ED,CLC	66.80	R		Includes large Concrete Headwall						
D-5	30	Inch	CMP	35	SP,CLC	63.20	R	D-27	30	Inch	CMP	50	ED,CLC	66.90	R	D-46	3	Feet	CMP/G	5	ED	54.80	L
D-6	30	Inch	CMP	10	SP,CLC	63.30	R	D-28	8	Feet	CMP	70	SPC	69.90	R	D-47	30	Inch	CMP	10	ED,CLC	53.10	L
D-7	30	Inch	CMP/G	30	SPC, CLC	63.40	R	D-29	48	Inch	CMP	120	SPC	70.20	R	D-48	8	Feet	CMP/G	1	EDC	51.90	L
D-8	30	Inch	CMP	40	SP,CLC	63.50	R	D-30	36	Inch	CMP	12	ED	69.10	L		Conc Grouted Riprap around Culvert						
D-9	24	Inch	CMP	40	SP,CLC	63.60	R	D-31	5	Feet	CMP	1	ED	68.50	L	D-49	30	Inch	CMP	15	ED,CLC	51.60	L
D-10	30?	Inch	CMP	40	SP,CLC	63.80	R	D-32	48	Inch	CMP	0	ED	68.30	L	D-50	24	Inch	CMP	4	ED	51.20	L
D-11	30	Inch	CMP	35	SP,CLC	63.90	R	D-33	24	Inch	CMP	8	ED	67.10	L	D-51	12'x 6'	Conc Box Culvert		Below	EDC	50.90	L
D-12	30?	Inch	CMP	35	SP,CLC	64.00	R	D-34	5	Feet	CMP	50	SP,CLC	67.10	L		Includes large Concrete Headwall						
D-13	30	Inch	CMP	40	SP,CLC	64.20	R	D-35	4	Feet	CMP	15	ED	66.00	L	D-52	4	Feet	CMP/G	1	EDC	50.30	L
D-14	8	Feet	CMP/G	4	EDC	64.50	R	D-36	36	Inch	CMP	3	ED	65.70	L	D-53	18	Inch	CMP	15	SP,CLC	50.20	L
D-15	30	Inch	CMP	40	ED	64.73	R	D-37	12	Inch	CMP	2	ED	65.55	L	D-54	18	Inch	CMP	15	SP,CLC	50.15	L
D-16	30	Inch	CMP	50	ED,CLC	64.80	R	D-38	36	Inch	CMP	4	ED	65.30	L	D-55	3	Feet	CMP	1	SPC	50.00	L
D-17	Unknown			Below	ED	65.10	R	D-39	24	Inch	CMP	3	ED	65.10	L								
D-18	30	Inch	CMP	40	ED,CLC	65.40	R	D-40	36	Inch	CMP	3	ED	64.05	L								
D-19	54	Inch	CMP/G	50	EDC, CLC	65.45	R	D-41	8	Feet	CMP	4	EDC	59.25	L								
D-20	30	Inch	CMP/G	40	EDC,CLC	65.80	R	D-42	24	Inch	CMP	50	SP,CLC	59.25	L								
D-21	30	Inch	CMP	60	ED,CLC	65.90	R	D-43	36	Inch	CMP	60	SPC,CLC	59.00	L								
D-22	36	Inch	CMP	50	ED, CLC	66.30	R																

Treatment Codes: SP = Slope Protection; ED =Energy Dissipater; SPC = Slope Protection with concrete treatment; EDC = Energy Dissipater with concrete treatment; CLC = Clean Lower Culvert

Material Types: PVC = Polyvinylchloride; CMP = Corrugated Metal Pipe; Steel = Steel Pipe; ABS = Black Plastic Pipe; WS = Welded Steel; CHA = Concrete Half Arch; CMPA = Corrugated Metal Pipe Arch; CMP/G = Corrugated Metal Pipe with grouted rock apron

Table G3 continued. Lower Monumental Drainage Structures Treatment

Feature No.	Dia	Unit Meas	Mat'l Type	Drop to Res (ft)	Treat-ment Code	River mile	Bank (L /R)	Feature No.	Dia	Unit Meas	Mat'l Type	Drop to Res (ft)	Treat-ment Code	River-mile	Bank (L /R)	Feature No.	Dia	Unit Meas	Mat'l Type	Drop to Res (ft)	Treat-ment Code	River-mile	Bank (L /R)
	Conc Grouted Riprap around Culvert								Conc Grouted Riprap around Culvert														
D-56	18	Inch	CMP	15	SP,CLC	49.90	L	D-76	4	Feet	CMP/G	5	EDC	44.60	L								
D-57	18	Inch	CMP	15	SP,CLC	49.80	L	D-77	2	Feet	CMP/G	6	EDC	44.50	L								
D-58	24	Inch	CMP	15	SP,CLC	49.70	L		Conc Grouted Riprap around Culvert														
D-59	24	Inch	CMP	15	SP,CLC	49.60	L	D-78	Unknown (Submerged ?)				EDC	44.15	L								
D-60	3	Feet	CMP/G	3	EDC	49.40	L	D-79	4	Feet	CMP/G	3	EDC	43.60	L								
D-61	18	Inch	CMP	8	ED	49.20	L	D-80	18	Inch	CMP	10	SPC	43.40	L								
D-62	18	Inch	CMP	8	ED	49.10	L	D-81	18	Inch	CMP	12	ED,CLC	43.00	L								
D-63	24	Inch	CMP	8	ED	49.00	L	D-82	18	Inch	CMP	12	ED,CLC	42.60	L								
D-64	2@4	Feet	CMPs	1	ED	48.80	L	D-83	24	Inch	CMP	12	ED,CLC	42.50	L								
	Conc Grouted Riprap around Culvert							D-84	8	Feet	CMP/G	4	EDC	41.80	L								
D-65	2	Feet	CMP/G	2	SPC	48.65	L																
D-66	18	Inch	CMP	8	SP	48.45	L																
D-67	2	Feet	CMP	8	ED	47.80	L																
D-68	2	Feet	CMP	8	ED	47.60	L																
D-69	3	Feet	CMP/G	3	EDC	47.50	L																
D-70	24	Inch	CMP	10	ED	47.30	L																
D-71	24	Inch	CMP	1	ED	47.20	L																
D-72	24	Inch	CMP/G	1	EDC	47.10	L																
D-73	30	Inch	CMP	2	ED	47.05	L																
D-74	18	Inch	CMP	2	ED	46.80	L																
D-75	2@5	Feet	CMPs	3	EDC	45.20	L																

Treatment Codes: SP = Slope Protection; ED =Energy Dissipater; SPC = Slope Protection with concrete treatment; EDC = Energy Dissipater with concrete treatment; CLC = Clean Lower Culvert
Material Types: PVC = Polyvinylchloride; CMP = Corrugated Metal Pipe; Steel = Steel Pipe; ABS = Black Plastic Pipe; WS = Welded Steel; CHA = Concrete Half Arch; CMPA = Corrugated Metal Pipe Arch; CMP/G = Corrugated Metal Pipe with grouted rock apron

Table G4. Little Goose Drainage Structures Treatment

Feature No.	Dia	Unit Meas	Mat'l Type	Drop to Res (ft)	Treat-ment Code	River-mile	Bank (L /R)	Feature No.	Dia	Unit Meas	Mat'l Type	Drop to Res (ft)	Treat-ment Code	River-mile	Bank (L /R)	Feature No.	Dia	Unit Meas	Mat'l Type	Drop to Res (ft)	Treat-ment Code	River-mile	Bank (L /R)
D-1	24	Inch	CMP	3	ED	81.70	R	D-30	3	Feet	CMP	3	ED	71.60	R	D-59	24	Inch	CMP	20	ED,CLC	98.80	R
D-2	24	Inch	CMP	12	ED,CLC	81.50	R	D-31	24	Inch	CMP	5	SP	71.50	R	D-60	4	Feet	CMP	5	ED	98.50	R
D-3	30	Inch	CMP	5	ED	81.00	R	D-32	2@36	Inch	CMP	2	SP	71.20	R	D-61	24	Inch	CMP	4	ED	98.20	R
D-4	30	Inch	CMP	4	ED	80.95	R	D-33	36	Inch	CMP	3	SP	71.00	R	D-62	18	Inch	CMP	10	ED	97.90	R
D-5	2@4	Feet	CMP	4	ED	80.90	R	D-34	24	Inch	CMP	3	SP	70.90	R	D-63	4	Feet	CMP	5	ED	97.55	R
D-6	30	Inch	CMP	4	ED	80.50	R	D-35	36	Inch	CMP	3	SP	70.80	R	D-64	24	Inch	CMP	3	ED	97.50	R
D-7	3@30	Inch	CMP	2	ED	80.40	R	D-36	24	Inch	CMP	3	SP	83.10	L	D-65	24	Inch	CMP	4	ED	94.10	R
D-8	30	Inch	CMP	5	ED	79.90	R	D-37	18	Inch	CMP	6	SP	83.10	L	D-66	24	Inch	CMP	4	ED	93.50	R
D-9	4	Feet	CMP	0.5	ED	79.85	R	D-38	24	Inch	CMP	6	SP	83.10	L	D-67	24	Inch	CMP	6	ED	93.30	R
D-10	4	Feet	CMP	0.5	ED	79.80	R	D-39	24	Inch	CMP	15	ED,CLC	105.30	L	D-68	18	Inch	CMP	12	ED,CLC	92.80	R
D-11	18	Inch	CMP	2	ED	79.70	R	D-40	24	Inch	CMP	4	ED	105.40	L	D-69	24	Inch	CMP	8	ED	92.20	R
D-12	18	Inch	CMP	2	ED	79.40	R	D-41	18	Inch	CMP	4	ED	106.40	L	D-70	30	Inch	CMP	15	ED,CLC	91.40	R
D-13	18	Inch	CMP	2	ED	79.30	R	D-42	24	Inch	CMP	8	ED	107.10	L	D-71	24	Inch	CMP	4	ED	91.10	R
D-14	18	Inch	CMP	2.5	ED	79.00	R	D-43	18	Inch	CMP	8	ED	107.20	L	D-72	36	Inch	CMP	4	ED	90.05	R
D-15	18	Inch	CMP	3	ED	78.80	R	D-44	24	Inch	CMP	5	ED	107.10	R	D-73	24	Inch	CMP	5	ED	89.90	R
D-16	18	Inch	CMP	3	ED	78.50	R	D-45	24	Inch	CMP	5	ED	107.00	R	D-74	4	Feet	CMP	3	ED	89.75	R
D-17	24	Inch	CMP	3	ED	78.20	R	D-46	30	Inch	CMP	8	ED	105.10	R	D-75	18	Inch	CMP	3	ED	89.30	R
D-18	36	Inch	CMP	5	ED	75.50	R	D-47	30	Inch	CMP	8	ED	105.00	R	D-76	18	Inch	CMP	4	ED	88.90	R
D-19	3	Feet	CMP	3	ED	74.90	R	D-48	30	Inch	CMP	8	ED	104.80	R	D-77	4	Feet	CMP	4	ED	88.80	R
D-20	24	Inch	CMP	5	ED	74.70	R	D-49	30	Inch	CMP	6	ED	104.40	R	D-78	24	Inch	CMP	10	ED	88.45	R
D-21	18	Inch	CMP	2	ED	74.60	R	D-50	6	Feet	CMP	5	ED	103.50	R	D-79	4	Feet	CMP	5	ED	88.40	R
D-22	24	Inch	CMP	2.5	ED	74.50	R	D-51	36	Inch	CMP	6	ED	102.90	R	D-80	24	Inch	CMP	6	ED	88.00	R
D-23	36	Inch	CMP	3	ED	74.10	R	D-52	18	Inch	CMP	30	ED,CLC	102.80	R	D-81	30	Inch	CMP	4	ED	87.80	R
D-24	24	Inch	CMP	2	ED	73.95	R	D-53	24	Inch	CMP	25	SP,CLC	102.50	R	D-82	30	Inch	CMP	6	ED	87.65	R
D-25	24	Inch	CMP	2	ED	73.30	R	D-54	24	Inch	CMP	15	SP,CLC	102.40	R	D-83	2@3	Feet	CMP	4	ED	87.05	R
D-26	24	Inch	CMP	3	ED	72.90	R	D-55	3	Feet	CMP	25	ED,CLC	101.60	R	D-84	36	Inch	CMP	3	ED	86.90	R
D-27	3@3	Feet	CMP	3	ED	72.65	R	D-56	24	Inch	CMP	8	ED	99.90	R	D-85	18	Inch	CMP	2	ED	86.50	R
D-28	30	Inch	CMP	5	ED	71.80	R	D-57	24	Inch	CMP	2	ED	99.40	R	D-86	4	Feet	CMP	6	ED	84.20	R
D-29	3	Feet	CMP	3	ED	71.70	R	D-58	3	Inch	CMP	6	ED	99.00	R								

Treatment Codes: ED =Energy Dissipater; SP = Slope Protection; CLC = Clean Lower Culvert

Material Types: PVC = Polyvinylchloride; CMP = Corrugated Metal Pipe; Steel = Steel Pipe; ABS = Black Plastic Pipe; WS = Welded Steel; CHA = Concrete Half Arch; CMPA = Corrugated Metal Pipe Arch

G.3 Methodology for Drainage Structure Modifications

The study team evaluated existing culverts with respect to three conditions: 1) their position relative to the existing full reservoir water surface, 2) natural soil and rock slopes between drainage structure inverts and natural channel (full drawdown) elevations as taken from the U.S. Geological Survey quadrangle maps (scale 1:24,000), and 3) position of the culverts with respect to existing and potential drainage areas. Based on these evaluations, the team determined that four types of modification would be required to allow culverts and other drainage structures to continue to function after the reservoirs are drawn down.

Drain modifications consist primarily of extending a narrow riprap blanket along the drainage path below the outlet of the drainage structure to provide erosion protection of the underlying material. Additional actions that may be required for individual culverts include cleaning currently visible culverts and culverts submerged below normal reservoir level; diverting and combining drainage flows from two or more areas into a single culvert; or installing additional culverts. These modifications to the drainage structures are discussed in more detail below.

G.3.1 Extending a Riprap Blanket Below the Outlet of the Drainage Structure

The simplest and most common alternative for modifying the drainage structure is to extend a riprap blanket from the existing outlet of the drainage structure down to the restored natural river elevation. Two alternatives were selected for accomplishing this protection option. The primary difference in the two approaches is the steepness of slope from the drain discharge down to the restored natural river elevation. For both alternatives, the study team assumed that many of the areas of slope protection were accessible by existing roads or access roads developed for placement of riprap for railroad and highway embankments.

The first alternative (see Figure G1) would be used in areas where the natural slope abutting the embankment fill was steep and had a continuous elevation drop to the natural riverbed. These categories of drainage structures are given the treatment code SP (for “slope protection”) in Tables G-1 through G-5. This approach applies a riprap blanket for slope protection for drainage structures extending from the outlet of the drainage structure to the natural river level. The width of the riprap blanket would vary depending on the diameter of the existing culvert, as follows: 1) culverts less than or equal to 900 millimeters (3 feet) would have a riprap blanket 3.0 meters (10 feet) wide; 2) culverts sized from 900 millimeters to 1,500 millimeters (3 feet to 5 feet) would have a riprap blanket 4.6 meters (15 feet) wide; and 3) culverts greater than 1,500 millimeters (5 feet) would have a riprap blanket 6.1 meters (20 feet) wide.

The thickness of the riprap blanket and outlet pad would be 0.6 meter (2 feet) for riprap placed by conventional placement methods. Riprap would be well graded from a maximum size of 1.5 times the average rock size, or 0.3 meter (1 feet), to 25.4-millimeter (1-inch) spalls suitable to fill the voids between the rocks.

In developing this modification plan, the study team assumed the maximum vertical drawdown for the four projects would be 27 meters (90 feet) near the dams. Areas that would require longer lengths of slope protection are typically located either nearer the dams where the greatest reservoir drawdown would occur, or high up on the slope. Most of the rock in this slope protection category would be larger than the material of the natural or embankment slope on which it would be placed.

Some areas requiring slope protection, specifically those next to concrete headwalls and other large diameter drainage structures, have a matrix of cement grout or gunite binding the rock together, thus creating a more erosion-resistant surface. The energy dissipative effects of the ungrouted rocks may not be sufficient to protect the slope downstream of the culvert exits on these structures. Consequently, grouting of the riprap slope protection would be required in these locations. These drainage structures are given the treatment code SPC (for "slope protection with concrete treatment") in Tables G-1 through G-5.

The second treatment alternative (see Figure G2) is used in areas where the natural elevation contours from the culvert to the original riverbed are fairly flat, having either minimal elevation loss or elevation loss spread over a long distance. In this situation, a riprap blanket with the same rock gradation as in the first treatment alternative would be placed for a distance of 6.1 meters (20 feet) along the drainage path, beginning at the outlet of the culvert, to dissipate energy. The thickness of the energy dissipater would be 0.6 meter (2 feet). The width of the riprap blanket would vary from 3 meters (10 feet) for drains with a maximum diameter of 0.9 meter (3 feet), up to a maximum of 6.1 meters (20 feet) for the larger diameter structures. These structures are assigned the treatment code ED (for "energy dissipater") in Tables G-1 through G-5. If concrete treatment is required, the designated treatment code assigned is EDC (for "energy dissipater with concrete treatment").

In the tables, the treatment code NT (for "no treatment") has been used for some of the culverts. At some locations, a lower culvert is positioned at the same location or within 0.16 kilometers (0.1 mile) of a higher culvert (greater than 3.0 meters [10 feet] above reservoir level). To minimize slope protection, the study team assumed that, in these situations, the lower culvert would pass flows and the upper culvert would probably remain "high and dry." Therefore, no treatment was planned for the higher culverts. Existing documents indicate that some of the lower culverts were sized for temporary construction and, therefore, might not have adequate size and flow capacity. However, additional lower culverts were noted on the as-constructed drawings. Consequently, the study team determined that the number of upper culverts requiring slope protection is likely to be conservative.

G.3.2 Cleaning Culverts

Existing culverts that are visible above the present normal reservoir water surface might be plugged. Cleaning would be needed to allow these culverts to properly function. Based on its field observations, the study team estimated 25 percent of existing culverts for all the reservoirs would require cleaning.

The team's review of as-constructed contract documents for railroad and highway relocations at both the Little Goose and Ice Harbor Dams identified currently submerged culverts that also would require cleaning. At Little Goose Dam, the number of submerged culverts was found to total 40 percent of the number of culverts visible above the reservoir water surface. Because of the similarity in railroad relocations and construction at both Little Goose and Lower Granite reservoirs, the team also assumed that the number of submerged culverts at Lower Granite would be 40 percent of the visible culverts. At Ice Harbor Reservoir, the number of submerged culverts was found to be 7 percent of the total number of visible culverts. This assumption was also used at Lower Monumental Reservoir because of the similarity of Lower Monumental railroad relocation and construction with that at Ice Harbor. Review of design memoranda for Ice Harbor Dam indicates that some of the lower culverts were intentionally plugged after construction. The study team conservatively assumed all of these lower elevation culverts would require cleaning (see Figure G3).

Based on these assumptions, 28 culverts would require cleaning at Ice Harbor Reservoir, 28 culverts at Lower Monumental Reservoir, 60 culverts at Little Goose Reservoir, and 102 culverts at Lower Granite

Reservoir, resulting in a total of 218 culverts needing to be cleaned. The estimated average length of culvert to be cleaned is 30.5 meters (100 feet).

G.3.3 Adding Culverts

Drawdown conditions may create new or re-established drainage paths that require new culverts to be installed at lower elevations to allow for proper drainage. The study team estimated that a quantity of new culverts equal to 10 percent of the existing culverts would need to be installed at each of the reservoir sites. These additional culverts would be constructed by the cut and cover method.

G.3.4 Diverting and Combining Drainage Flows

In some of the locations that require installation of a new drain, it may be more cost-effective to collect water flows from adjacent run-off areas and route the discharge to the Snake River via one new outfall (Figure G4). The receiving discharge structure might need to be enlarged to accommodate combined flows. Pipe jacking or horizontal boring through the existing embankments would install these new enlarged drains, assuming that an open cut in the existing embankment is not practical. The casing of the horizontal boring would be used as the drain conduit. No additional pipe would be needed inside the casing.

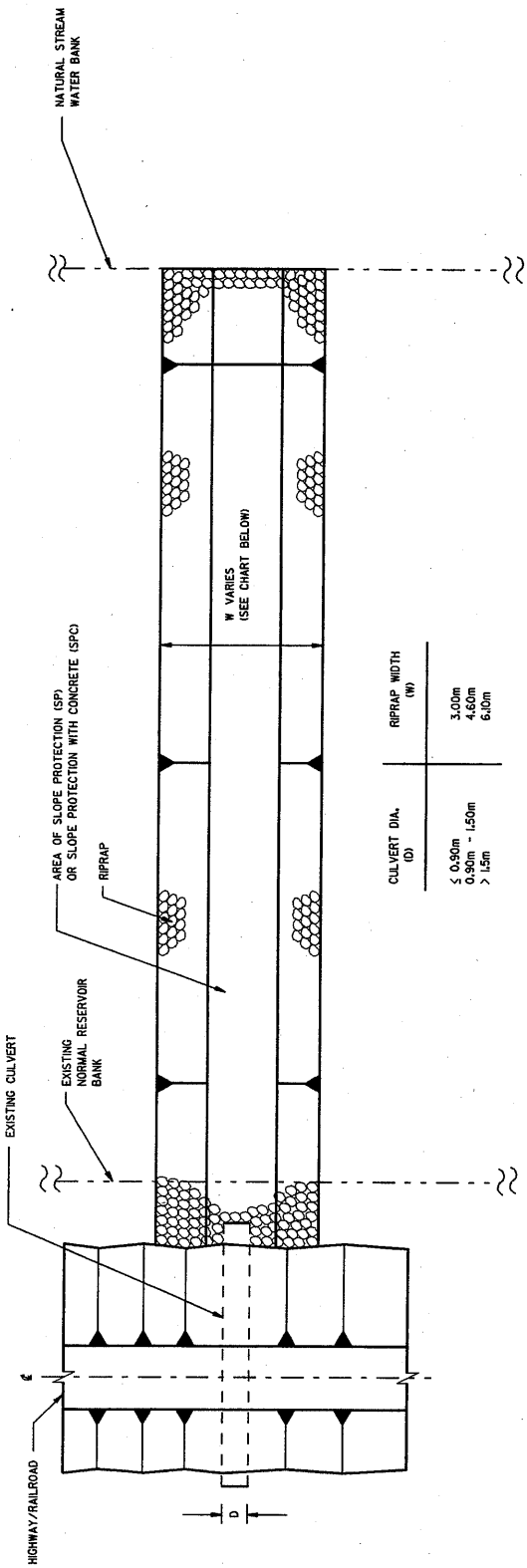
The study team could not determine the number of sites where this alternative would be more cost effective than cleaning or replacement of individual culverts, but estimated a quantity of 3 percent of the total number of culverts identified for cost estimating purposes.

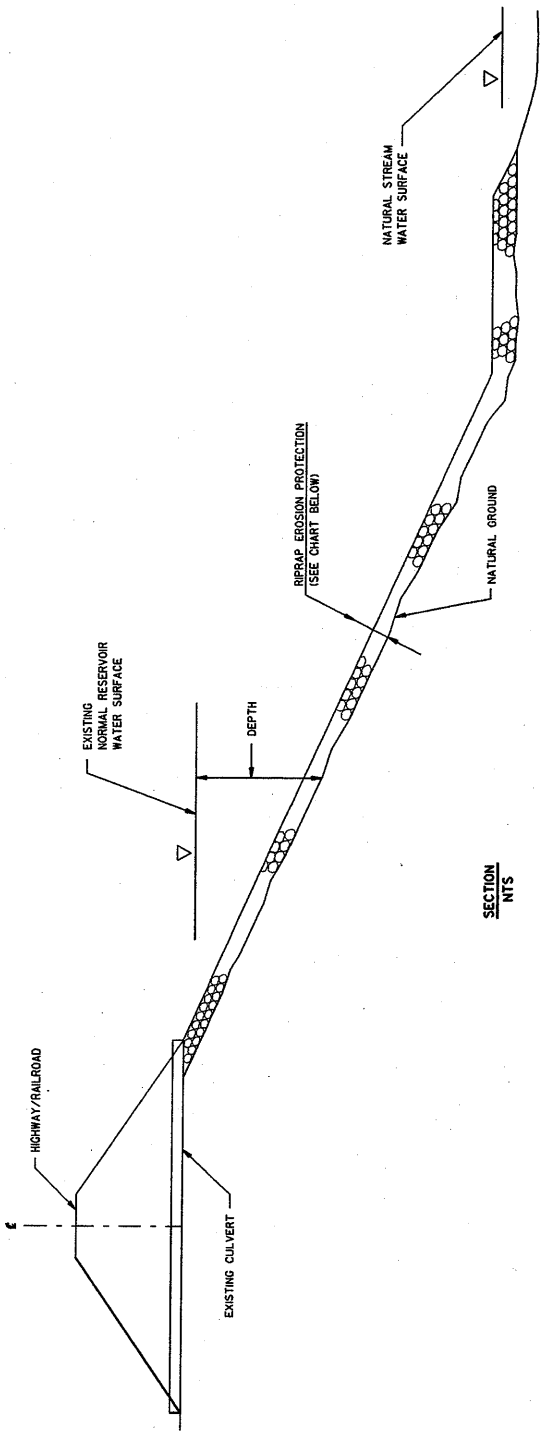
G.4 Construction Scenario

Modifications to the existing drainage structures would provide some logistical challenges. Because the drains are spaced far apart, have difficult land access, and require placement of narrow strips of riprap extending down steep slopes. Overland access is possible to all drainage structures via haul roads developed for transportation and placement of riprap. Additional rock would be hauled for drainage structure modifications and placement done concurrently or immediately following riprap placement in a specific reach.

Placement would be by conventional methods. An excavator would prepare the slope, if necessary, for riprap placement. Some excavation may be necessary to form a channel to limit the dispersion of drainage flows and thereby minimize damage to the embankment slope. Subsequent placement of concrete to stabilize riprap would be done with a concrete pump and appropriate nozzle if pneumatic application is necessary.

The source of acceptable riprap materials is discussed in Annex F of this report and applies to any material placed for drainage protection.





US Army Corps of Engineers
Walla Walla District

LOWER SNAKE RIVER JUVENILE SALMON MIGRATION FEASIBILITY STUDY

DRAINAGE STRUCTURE SLOPE PROTECTION
PLAN AND SECTION

Figure:
G1

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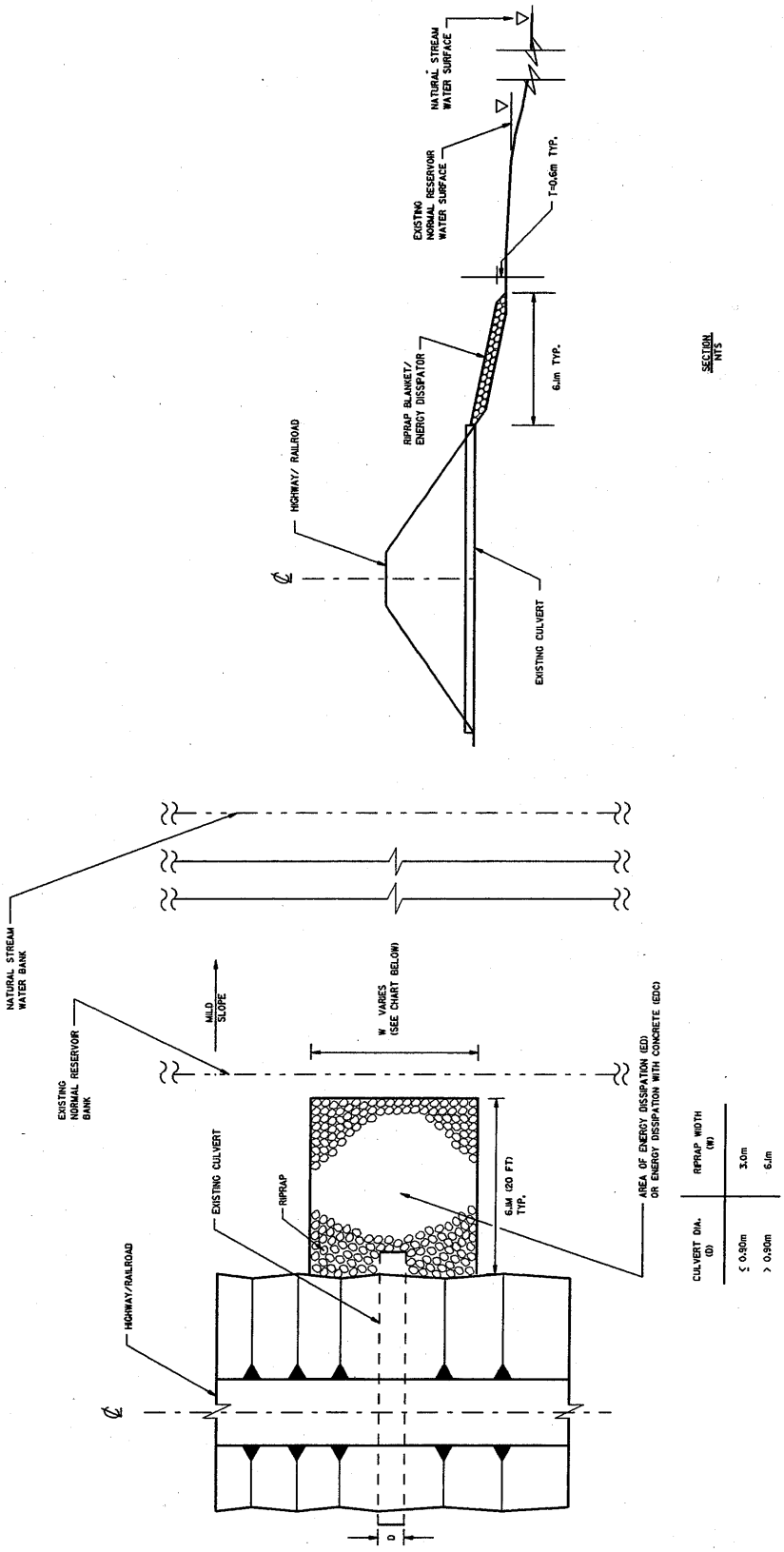
SHEET WAN SCALES



US Army Corps of Engineers
Walla Walla District

LOWER SNAKE RIVER JUVENILE SALMON MIGRATION FEASIBILITY STUDY

DRAINAGE STRUCTURE ENERGY DISSIPATOR
PLAN AND SECTION

Figure:
G2

SHEET MAIN SCALE:

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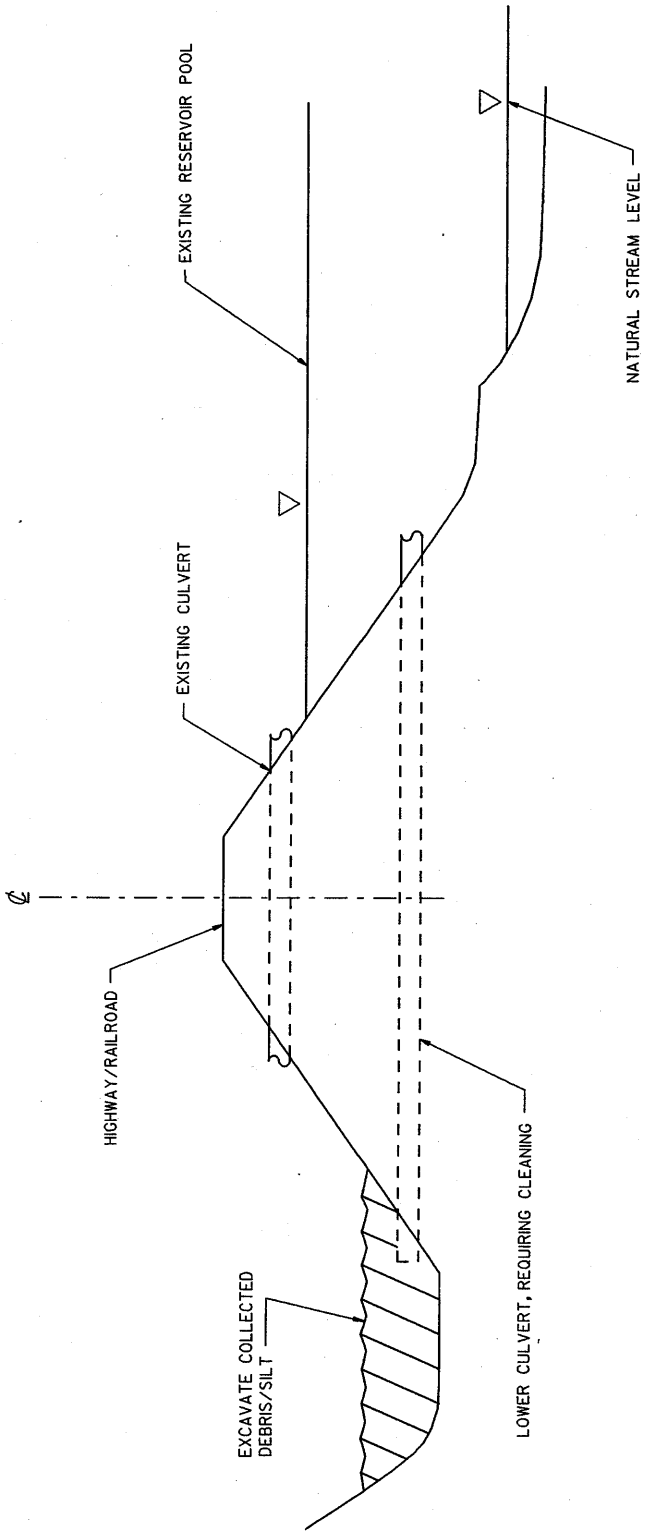

CLEAN LOWER CULVERT - CROSS SECTION

NOT TO SCALE

US Army Corps of Engineers
Walla Walla District

LOWER SNAKE RIVER JUVENILE SALMON MIGRATION FEASIBILITY STUDY

LOWER CULVERT CLEANING
CROSS SECTION

Figure:
G3

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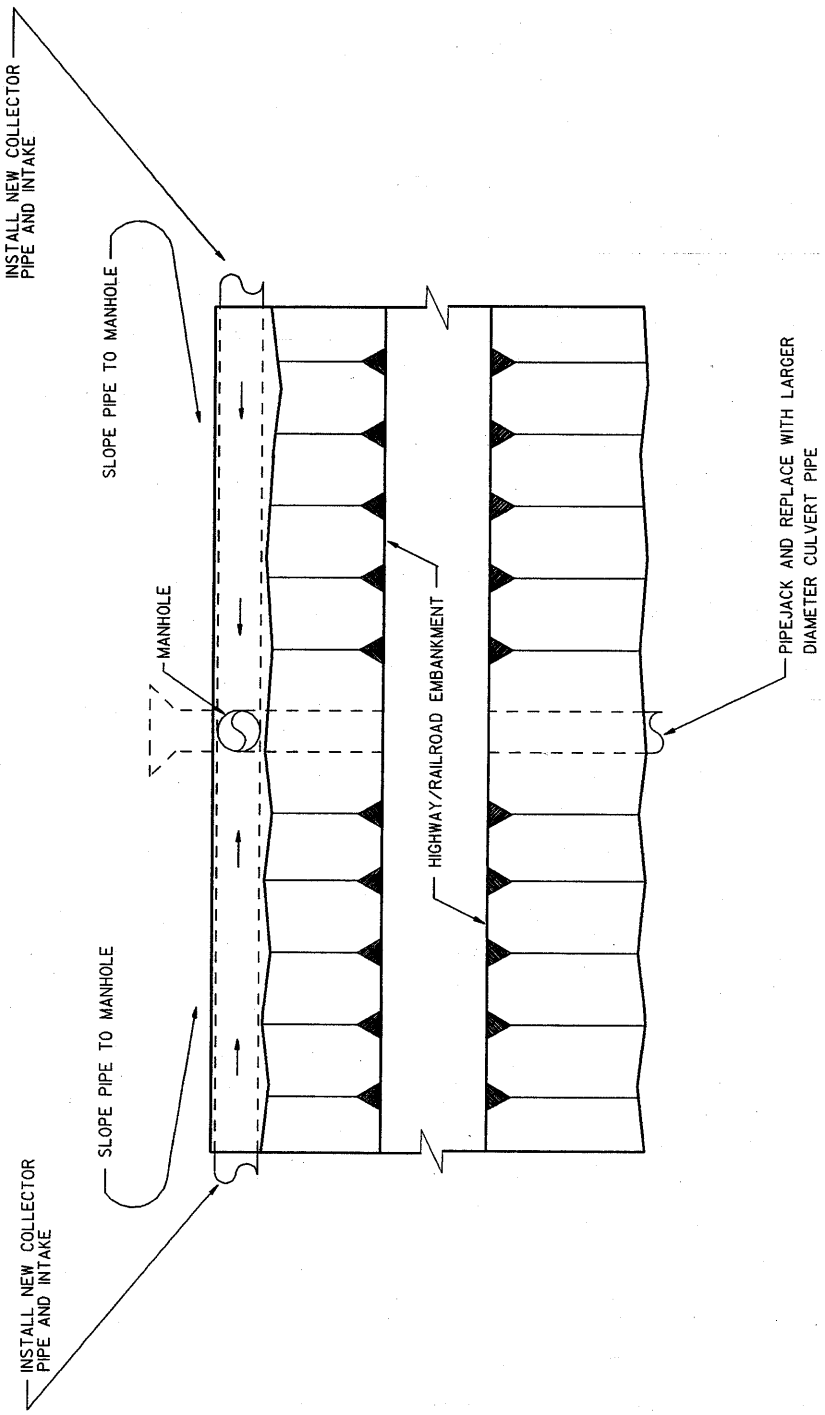
SHEET MAIN SCALE



DIVERT/COMBINE DRAINAGES - PLAN VIEW

NOT TO SCALE

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LOWER SNAKE RIVER JUVENILE SALMON MIGRATION FEASIBILITY STUDY

DIVERT/COMBINE DRAINAGES
PLAN VIEW

Figure:
G4

SHEET MAIN SCALE:

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