Bear River Black Canyon Substrate Survey

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by

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INTRODUCTION

The purpose of this study was to locate, characterize, and map potential salmonid spawning (and other) substrate of Bear River in the Black Canyon reach beginning at the Highway 34 crossing, downstream to the foot bridge upstream of Grace hydropower plant. Information collected during this survey contributes to baseline data regarding potential salmonid spawning and cold water aquatic life habitat available in Black Canyon. Also, it is anticipated this information will be useful in assessing effects of whitewater recreational boating flow releases on aquatic resources in the river through this reach.

METHODS

Study Area

The survey was conducted in Black Canyon, extending downstream from Grace Dam to the fishing access bridge near Grace Power Plant (Fig. 1). This approximately 6.5-mile reach encompasses the canyon portion of Bear River between Grace Dam and Grace Power Plant. Flows in this reach have historically (~ 80 years) been depleted due to water being diverted through the Grace flow-line to Grace Power Plant.

Survey

Idaho Department of Environmental Quality (DEQ) personnel conducted the survey of river substrates through the described reach 1-4 June 2004 prior to the 80 cubic feet per second (cfs) minimum flow being instituted later that month. Average flow through the upper river section (upstream of spring inflows in Black Canyon) during the survey ranged from approximately 8 to 13 cfs, as a result of irrigation water delivery requirements for a downstream diversion (Gentile Diversion). Deposits of potentially suitable salmonid spawning substrate in the study reach were located, described according to size class and thickness, and mapped. We defined potentially suitable spawning substrate as areas greater than or equal to 1 m^2, with substrate particles ranging between 1 mm and 128 mm. Smaller and larger substrate particles were recorded as sand and boulder, respectively. Water velocity at 5cm above substrates (Schmetterling 2000) was measured using a portable electromagnetic flow meter (Marsh-McBirney model 2000). Stream gradient was determined over a 100-meter reach encompassing each site. Specific locations were described in terms of distance from river left or right bank, percent wetted area, and representative water depth over the deposit. All sites were digitally photographed (Appendix A) and GPS information (latitude/longitude) was recorded for each site (Appendix B). Data was documented using standard DEQ Beneficial Use Reconnaissance Program (BURP) terminology.

Gravel substrate areas were characterized for median grain size and embeddedness using a Wolman (1954) or modified Wolman (BURP 2003) pebble count. A minimum of 10 substrate particles per substrate patch or 100 substrate particles along each survey transect were measured. Embeddedness (coverage of particles by fines $\leq$ 1 mm) of particles at each site was estimated as 0, 25, 50, 75, or 100%. Cross sectional elevation data was collected at 10 selected transects using a level, rod, and tape. These survey transects were permanently monumented with rebar and metal identification tags (Appendix C). Total substrate depth (to bedrock or refusal) was determined for each site and transect at selected locations using a graduated steel rod.

GIS Mapping
Locations of suitable substrate were determined using a Global Positioning Receiver (GPS) (Appendix B). Field-collected waypoints were corrected as necessary. Corrected information was exported from Pathfinder software as an ESRI shapefile point theme, imported into ArcGIS 8.3 ArcMap, and combined with other geospatial layers to display existing substrate locations.

RESULTS

Substrate
Thirty-four distinct substrate sites meeting the substrate size conditions and minimum patch size requirements were located (Fig. 1). Transects 1-5 were established and surveyed to characterize upper reach conditions within one mile of Grace Dam (transects incorporated 3349 linear feet; Fig. 2). Transects 6-10 were established and surveyed to characterize conditions at site 17 (transects incorporated 648 linear feet; Fig. 2). Total area of all sites excluding T1-T5 was 35,629 square feet. Sites 17 and 23a-23d encompassed 11,508 and 22,772 square feet, respectively, of this total area.

Two thousand twenty four (2,024) substrates were evaluated. Substrate size was measured along the medial axis of 1,327 samples (remaining particles < 1mm or > 512 mm were recorded as sand or boulder, respectively). Substrate varied from silt to boulders at most sites (Table 1). Median substrate size was 30 mm for all sites. Median substrate size decreased in a downstream direction (upper sites = 50 mm, middle sites = 35mm, lower sites = 15 mm).

Water Depth and Velocity
Maximum water depth at an individual site was 3.2 feet. Mean water depth at substrate sites ranged from 0 to 1.39 feet (all sites mean = 0.89 feet; Table 1), with greatest depth occurring at downstream sites (mean = 1.39 feet) and shallowest depth at T6-T10 (middle reach/site 17 transects, mean = 0.33 feet). Mean absolute (upstream/negative velocities were recorded as positive) water velocity ranged from 0.39 (T1-T5/upper sites) to 0.8 f/s (middle reach/site 17 transects). Paired velocity and depth measurements made at discrete substrate patches correlated negatively ($r^2 = 0.31$, $p<0.05$).

Cross Section Transects
Mean bankfull width of upper transects (T1-T5; mean = 212.04 feet) was significantly greater than site 17 transects (T6-T10; mean = 54.04 feet, $t = -6.4$, $p < 0.01$). Bankfull

width to mean bankfull depth ratio was significantly greater at upper (mean = 242.8) than lower transects (mean = 77.1, $t = 3.85$, $p < 0.02$).

DISCUSSION

We anticipate the increase in minimum flow (currently 80 cfs plus leakage with future proposed 65 cfs based on an Agreement in Principle with the Environmental Coordinating Committee to decommission the Cove facility), as measured at the gage downstream of Grace Dam will change conditions at most sites. Substrate was surveyed to estimated bankfull flow elevation, resulting in a number of sites (especially in conjunction with transects T1-T10) having shallow or no water coverage when initially surveyed; therefore number of sites reported in this survey will likely remain unchanged, but the number of sites inundated by water will increase. All sites will increase in water depth and likely increase in velocity under new minimum flow conditions. Water surface elevation at 93 cfs was measured at transects T1-T10 on 19 October 2004. Nearly all substrates surveyed in June were submerged at this flow.

Kershner, 1995, found high percentages of fine sediment present in Bonneville cutthroat trout (BCT) redds in St. Charles Creek, Idaho, and increased percent depth fines have been shown to reduce spawning success in trout (see Marcus et al. 1990 for review). In this study, eleven (11) sites exhibited 0% embeddedness. Although measures of embeddedness do not correlate directly with depth fines in gravels, we did not observe noticeable amounts of turbidity (i.e., fine sediment introduced into the water column) at numerous sites when measuring substrate depth (at a number of individual sites ≥ 0.2 feet) with a steel probe, likely indicating low amounts of depth fines. However, some sites that had suitable-sized substrate on the surface may not have sufficient depth (due to accretion at depth) to allow redd development. It is expected that embeddedness (possibly also depth-fines) will change, especially following future high flow releases. Further work could be done to measure depth fines at selected locations.

Because of the generalized distribution of potential spawning gravels in the reach near Grace Dam (discrete sites were not observable and could not be accurately defined in this reach), transects 1-5 were used to characterize the area. These sites were selected by transecting areas that displayed the most suitable-sized substrate in the reach. However, median substrate size determined at transects may not accurately indicate potential spawning habitat in these areas because of the (Wolman) method employed to obtain those data. Individual potential spawning sites (area $\geq 1\ m^2$) are not represented in this area as measurements were conducted randomly across transects. Additionally, characterization of substrates across transects was to obtain baseline data for monitoring potential changes resulting from future flow regime changes.

Suckers (*Catostomus sp*.) were observed in pre-spawning behavior at site 17 during the survey. Although no salmonids were observed exhibiting spawning behavior during the survey, our findings indicate significant potential spawning habitat (based on median substrate size) in this reach. Fluvial populations of closely-related Yellowstone cutthroat trout have been documented to spawn in mainstem rivers (Gresswell 1995). Given these conditions, future improvements to provide fish passage to this potentially viable spawning habitat may prove beneficial to mainstem Bear River fish.

Suitability for BCT Spawning

Observations of BCT spawning areas in Salt and Coal creeks, Wyoming indicated redd development in sand and small gravel ([1-16mm] Kershner 1995). Larger trout tend to use larger gravels than smaller trout for spawning (Bjornn and Reiser 1991). Large gravels (16-32mm) were the predominant substrate measured in redds investigated in Schmetterling's (2000) westslope cutthroat trout spawning study. Varley and Gresswell (1988) reported optimal Yellowstone cutthroat trout spawning gravel size was predominantly 12-85mm. Substrate size measured at all sites in this survey (median = 30) compares favorably with these numbers.

Schmetterling (2000) reported water depths of 0.15 – 0.75 feet as suitable for westslope cutthroat trout spawning beds in Blackfoot River, Montana. USACE (1991) recommends water depths of 0.5 – 2.5 feet as suitable for trout spawning in artificial channels. Two sites in this survey exceeded 2.5 feet depth, while 4 others will likely exceed this depth under the new minimum flow regime. Schmetterling (2000) reported suitable water velocities in spawning pits as 0.16 – 1.25 f/s. Four sites in this survey had mean water velocities < 0.16 f/s, while no sites had mean water velocities exceeding 1.25 f/s. Therefore, most sites surveyed were within the range reported for these spawning requirements. Based on our flow simulations using HEC-RAS (version 3.1.2; USACE 2004) we predict significant water velocity and shear stress increases as a result of the 65 cfs flow regime. This will result in increased velocity at most substrate sites that are not located in depressions.

Future Activities

Prior to whitewater boating flow releases, a minimum of 100 substrate of pebble and larger size classes will be marked with paint at each transect to assist in future monitoring of potential downstream transport during high flows. A distinct color will be applied at each transect. Within 1 week following several high flow events, adjacent downstream areas will be visually surveyed to determine percent and distance marked substrates have been transported. As part of the Black Canyon Monitoring Plan, transects 1-10 will be re-surveyed, and substrate size assessed annually to document substrate and channel conditions over time.

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Figure 1. Substrate survey site locations for Black Canyon substrate survey of 1-4 June 2004.

	Area (sq. feet)	Substrate Depth (feet)	embed-dedness (%)	substrate size (mm)	Substrates assessed	number of substrates < sand size	Sand (%)	number of substrates > boulder size	% boulder	Water Veloc. (f/s)]	Water Depth (feet) (<.05entered 0.01)	Mean Water Velocity (f/s)	Mean Water Depth (feet)	Gradient (%)
Sites 1-16														
total	669				191		0.00		0.00					
mean	22	0.23	4	16.95	12					0.56	1.39	0.58	1.43	0.02
median	8	0.15	0	15.00	11					0.42	1.30	0.45	1.29	0.02
mode	4	0.10	0	15.00	10					0.19	0.90	NA	NA	0.01
min	1	0.10	0	2.00	10					0.03	0.20	0.11	0.37	0.01
max	90	1.00	25	61.00	18					2.18	3.20	1.29	2.93	0.05
n	31	19	14	191	16	0	0	0	0	63	63	16	16	16
Sites 18-30														
total	31731				585		4		14					
mean	1670	0.23	38	46.41	37		7		16	0.46	1.33	0.41	1.50	0.01
median	12	0.20	38	35.00	16		7		13	0.30	1.40	0.33	1.62	0.01
mode	6	0.20	25	20.00	16		NA		NA	0.04	2.40	NA	NA	0.01
min	2	0.10	0	2.00	10		1		0	0.01	0.10	0.05	0.40	0.01
max	9000	0.55	75	415.00	110		11		39	1.59	2.80	1.19	2.43	0.03
n	19	12	14	473	16	26	5	84	5	52	52	14	14	15
T1-T5														
total					642		30		22					
mean		0.15		72.70			28		23	0.43	0.38		0.39	0.00
Median		0.15		50.00			20			0.24	0.35		0.37	0.00
Mode		NA		10.00			NA			0.01	0.20		NA	NA
min		0.10		3.00	106		16		3	0.01	0.10		0.31	0.00
max		0.20		350.00	164		53		42	2.56	0.90		0.50	0.01
n		2	0	309	5	190	5	143	5	49	49	5	5	4
T6-T10														
total	11508				606		34		8	41.93	16.69	4.12	1.64	0.01
mean		0.06	63	39.84	121		31		5	0.82	0.33	0.82	0.33	0.00
Median		0.10	63	35.00	116		35		4	0.68	0.30	0.85	0.34	0.00
Mode		0.10	NA	20.00	137		NA		NA	0.00	0.40	NA	NA	NA
min		0.00	63	3.00	105		0		0	0.00	0.00	0.70	0.28	0.00
max		0.70	63	150.00	137		64		16	2.57	0.80	0.91	0.39	0.01
n		68	1	354	5	203	5	49	5	51	51	5	5	5
All Sites														
total	35629				2024	419	0.21	276	14					
mean	482	0.27	23	46.54	48		22		15	0.57	0.89	0.54	1.19	0.01
median	11	0.20	25	30.00	15		16		10	0.38	0.70	0.44	1.01	0.01
mode	6	0.10	0	15.00	10		NA		0	0.24	0.20	NA	1.77	0.01
min	1	0.00	0	2.00	10		0		0	0.00	0.00	0.05	0.28	0.00
max	540	2.00	75	415.00	164		64		42	2.57	3.20	1.29	2.93	0.05
n	50	101	29	1327	42	419	15	276	15	215	215	40	40	40

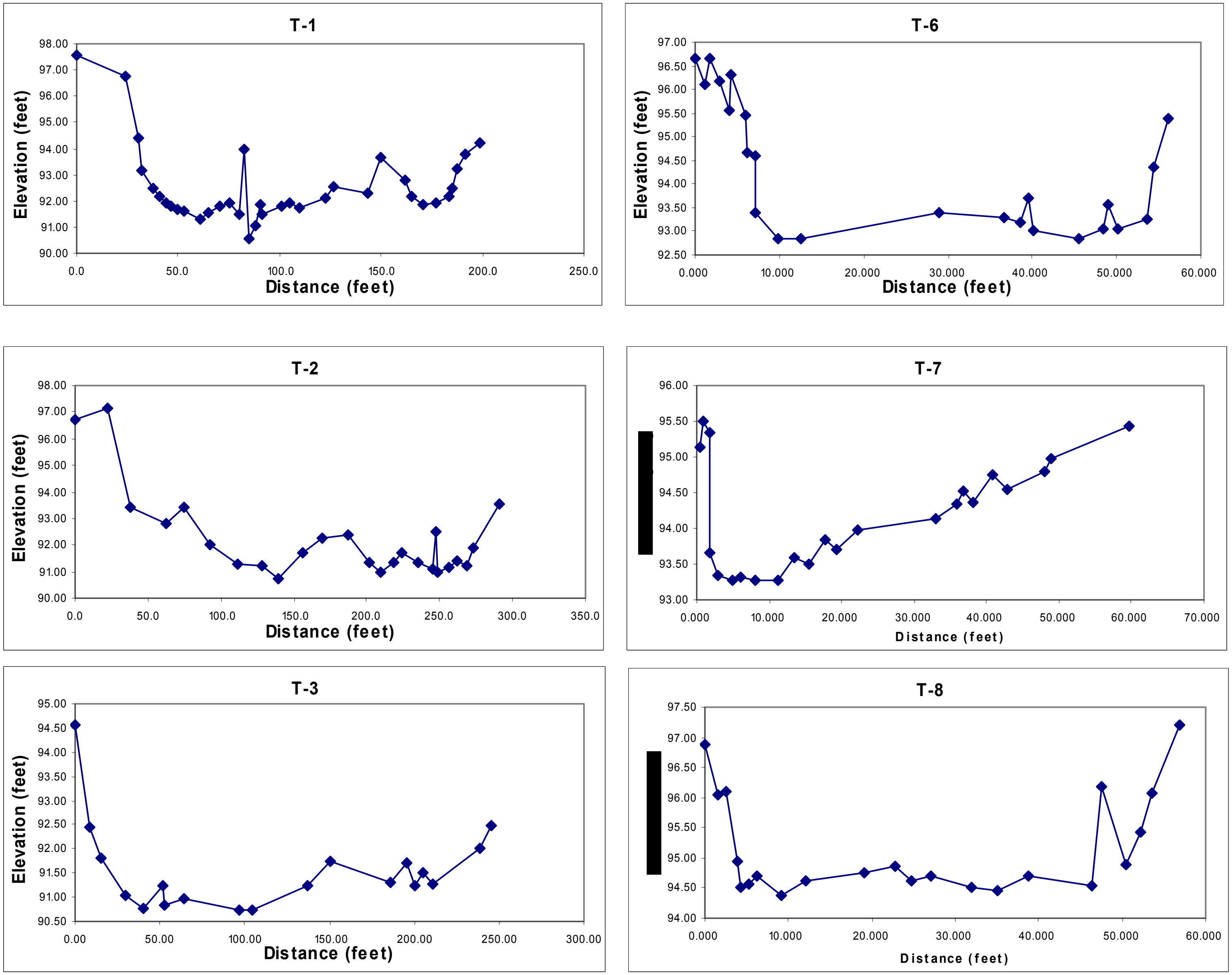
total non-sand/non-boulder substrates measured = 1327

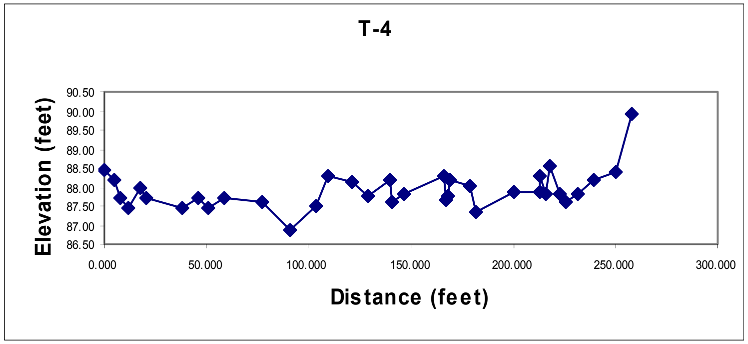
total substrates evaluated/measured including sand and boulders= 2024

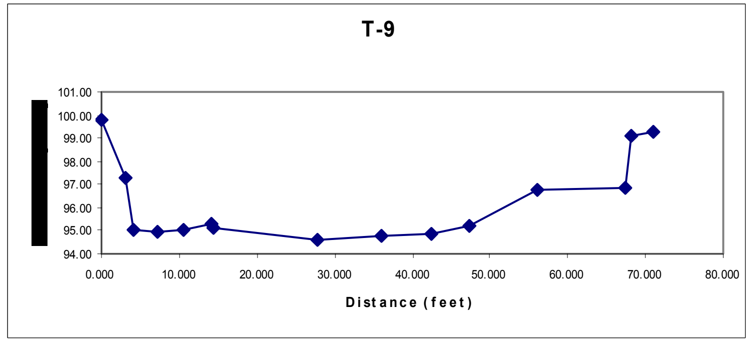
max. size excludes site 23

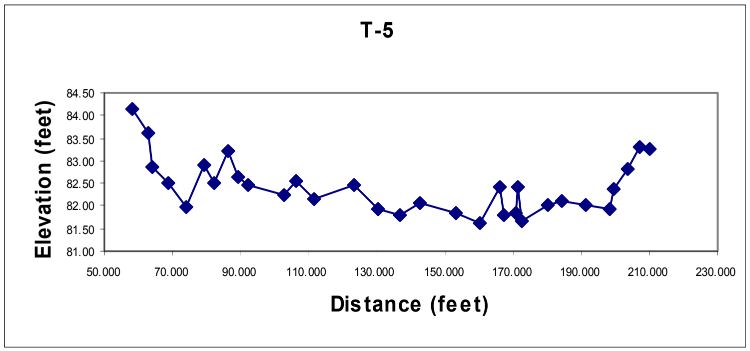
Table 1. Statistics for substrate site variables.

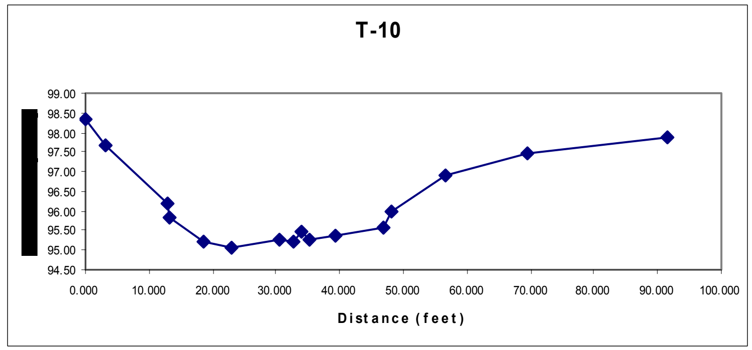
Figure 2. Transect cross sections T1-T10.




T-4
Elevation (feet)
90.50
90.00
89.50
89.00
88.50
88.00
87.50
87.00
86.50
0.000
50.000
100.000
150.000
200.000
250.000
300.000
Distance (feet)


T-9
[redacted]
101.00
100.00
99.00
98.00
97.00
96.00
95.00
94.00
0.000
10.000
20.000
30.000
40.000
50.000
60.000
70.000
80.000
Distance (feet)


T-5
Elevation (feet)
84.50
84.00
83.50
83.00
82.50
82.00
81.50
81.00
50.000
70.000
90.000
110.000
130.000
150.000
170.000
190.000
210.000
230.000
Distance (feet)


T-10
[redacted]
99.00
98.50
98.00
97.50
97.00
96.50
96.00
95.50
95.00
94.50
0.000
10.000
20.000
30.000
40.000
50.000
60.000
70.000
80.000
90.000
100.000
Distance (feet)

Appendix B. GPS substrate site location information

ID	Longitude	Latitude	Comment (site)	Max_PDOP	GPS_Date	GPS_Time	Unfilt_Pos	Filt_Pos	Std_Dev	GPS_Height (m)	Horz_Prec	Vert_Prec	Point_ID
1	-111.777274307	42.567863040	*17 T10	5.3	6/4/2004	01:12:05pm	23	23	0.424995	1610.457	1.312	1.649	1
2	-111.799661722	42.543582470	FOOT BRIDGE	2.8	6/1/2004	10:26:44am	24	24	0.323207	1539.424	0.890	1.676	2
3	-111.798657216	42.550690861	*1 TRAVERTINE CLIFF	3.1	6/1/2004	11:29:54am	42	42	1.036769	1552.755	1.195	1.935	3
4	-111.798167499	42.553571573	*2	3.7	6/1/2004	12:08:26pm	29	29	2.407279	1556.608	0.745	1.115	4
5	-111.797757373	42.554083803	*3	3.8	6/1/2004	12:45:42pm	20	20	0.800382	1560.586	1.025	1.289	5
6	-111.797423008	42.554267276	*4	5.4	6/1/2004	12:55:45pm	34	34	2.242718	1558.510	1.062	1.187	6
7	-111.796134994	42.556036751	*5	2.1	6/1/2004	01:21:55pm	20	20	0.851964	1563.028	0.832	1.251	7
8	-111.796043628	42.556116514	*6	2.5	6/1/2004	01:32:39pm	21	21	1.136687	1561.287	0.815	1.301	8
9	-111.798522259	42.561543874	*7	3.0	6/1/2004	02:25:04pm	21	21	1.422448	1576.604	0.829	1.094	9
10	-111.798814881	42.561725775	*8	2.6	6/1/2004	02:39:42pm	20	20	1.811467	1573.963	1.065	1.299	10
11	-111.793585148	42.563244618	*9	4.3	6/1/2004	03:34:44pm	21	21	1.799676	1587.534	1.414	2.691	11
12	-111.792725271	42.563232847	*10	4.4	6/1/2004	03:54:13pm	21	21	0.509660	1594.836	1.096	2.322	12
13	-111.790099818	42.564747942	*11	4.2	6/1/2004	04:18:53pm	16	16	0.479896	1598.986	1.177	2.742	13
14	-111.790266607	42.565041412	*12	3.0	6/1/2004	04:36:45pm	20	20	0.506525	1598.670	1.190	1.779	14
15	-111.790256148	42.564819851	*13	4.1	6/1/2004	04:47:49pm	21	21	3.279271	1592.952	1.149	1.552	15
16	-111.785460342	42.565605530	*14	3.5	6/2/2004	10:20:55am	30	30	0.980073	1601.010	0.956	1.817	16
17	-111.785139514	42.565556768	*15	3.7	6/2/2004	10:36:41am	20	20	0.823746	1607.320	1.058	1.669	17
18	-111.782731336	42.565541654	*16	3.5	6/2/2004	11:02:35am	35	35	1.010661	1609.359	0.873	1.502	18
19	-111.779331539	42.567588613	*17 TAIL END	2.4	6/2/2004	11:36:59am	20	20	0.394800	1612.798	0.845	1.564	19
20	-111.777200895	42.567672895	*17 HEAD OF SITE	3.7	6/2/2004	11:47:15am	20	20	1.719629	1612.999	0.812	1.273	20
21	-111.773950931	42.566131844	*18	6.0	6/2/2004	12:50:53pm	32	32	2.215726	1614.777	1.781	1.479	21
22	-111.773069906	42.566041892	*19	5.4	6/2/2004	01:04:39pm	28	28	3.200191	1612.376	1.319	1.658	22
23	-111.771386359	42.566219197	*20	4.9	6/2/2004	01:21:33pm	30	30	4.936222	1614.065	0.923	1.367	23
24	-111.768720835	42.566729213	*21	2.6	6/2/2004	01:42:24pm	20	20	1.136586	1612.715	0.813	1.328	24
25	-111.767828444	42.566849158	*22	4.1	6/2/2004	01:55:11pm	40	40	1.714427	1618.757	0.985	1.377	25
26	-111.767937678	42.566731271	*23LOWER	2.7	6/2/2004	02:16:08pm	8	8	0.487828	1618.048	1.177	1.388	26
27	-	42.567368853	*23UPPER	3.7	6/2/2004	02:50:03pm	26	26	2.988203	1616.127	1.097	1.208	27

	111.766674304													
28	-111.766107679	42.567488357	*23UPPER UP	4.3	6/2/2004	03:00:49pm	51	51	2.714363	1616.826	1.211	1.513	28
29	-111.765786198	42.567806000	*24	4.4	6/2/2004	03:26:17pm	11	11	1.633530	1618.726	1.385	2.605	29
30	-111.764464341	42.570001666	*25	4.4	6/2/2004	03:51:17pm	4	4	1.116456	1626.744	1.136	2.727	30
31	-111.755203887	42.574370954	*26	5.9	6/2/2004	05:06:31pm	4	4	2.583103	1631.866	3.436	2.083	31
32	-111.751715072	42.575716131	*27	3.1	6/2/2004	05:34:14pm	21	21	0.917610	1643.259	1.271	1.473	32
33	-111.732688606	42.585592756	*T1	4.1	6/3/2004	09:19:41am	36	36	2.364453	1669.844	1.125	2.085	33
34	-111.734281479	42.584917704	*T2	3.3	6/3/2004	10:44:15am	26	26	5.666021	1670.006	0.992	1.616	34
35	-111.737767434	42.585073841	*T3	3.6	6/3/2004	12:00:59pm	21	21	3.629534	1668.930	0.817	1.204	35
36	-111.742223829	42.584909888	*T4	5.4	6/3/2004	12:57:26pm	22	22	0.950994	1670.925	1.091	1.639	36
37	-111.744567764	42.585189849	*T5	5.2	6/3/2004	01:49:58pm	21	21	0.461379	1666.936	1.088	1.644	37
38	-111.747764642	42.581803965	*28 TRAVEL DWN RIVER	2.1	6/3/2004	02:46:54pm	18	18	0.410748	1660.736	0.970	1.123	38
39	-111.748282460	42.581026640	*29	5.0	6/3/2004	03:03:17pm	27	27	3.369983	1659.000	2.222	2.536	39
40	-111.748368415	42.580696452	*30	4.2	6/3/2004	03:13:15pm	15	15	1.083796	1656.253	0.772	1.250	40
41	-111.779173470	42.567776178	*17 T6	4.5	6/4/2004	10:13:47am	45	45	2.403506	1611.583	1.091	2.138	41
42	-111.778692620	42.568007187	*17 T7	3.1	6/4/2004	11:02:36am	21	21	1.855055	1613.318	0.893	1.598	42
43	-111.778281310	42.567959356	*17 T8	3.2	6/4/2004	11:33:10am	22	22	2.129555	1612.655	0.963	1.504	43
44	-111.777883366	42.567970553	*17 T9	6.0	6/4/2004	12:44:18pm	21	21	3.616416	1609.152	2.183	1.617	44

All measurements taken with GeoExplorer 3, differentially corrected

Appendix C. Survey transect location and identification information.

Site	Latitude	Longitude	Azimuth from RP to LP	Tag Location	Tag I.D. #
T-1	42 35' 08.091" N	111 43' 57.521" W	127 ESE	LP	135
T-2	42 35' 05.489" N	111 44' 03.291" W	148 SSE	LP	216
T-3	42 35' 06.235" N	111 44' 55.982" W	139 SSE	LP	252
T-4	42 35' 05.729" N	111 44' 31.985" W	186 S	LP	43
T-5	42 35' 06.775" N	111 44' 40.521" W	144 SSE	LP	196
T-6	42 34' 04.238" N	111 46' 45.176" W	120 ESE	LP	83
T-7	42 34' 04.962" N	111 46' 43.461" W	178 S	LP	101
T-8	42 34' 04.754" N	111 46' 41.808" W	158 SSE	LP	132
T-9	42 34' 04.730" N	111 46' 40.480" W	174 S	LP	193
T-10	42 34' 04.400" N	111 46' 38.221" W	212 SSW	LP	116