Prepared For:

WESTERN NUCLEAR, INC.
SPLIT ROCK MILL SITE
Jeffrey City, Wyoming

SITE GROUND WATER CHARACTERIZATION AND EVALUATION

APPENDIX I
BASELINE RISK ASSESSMENT
VOLUME 1 OF 1

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ATTACHMENTS

ACRONYMS AND ABBREVIATIONS

BRA	Baseline Risk Assessment
EA	Environmental Assessment
COC	constituent of concern
COPC	constituent of potential concern
EPA	U.S. Environmental Protection Agency
GWPP	Ground Water Protection Plan
HEL	health effect level
MCL	maximum contaminant level
mg/L	milligrams per liter
mrem/yr	millirem per year
NEPA	National Environmental Protection Act
NRC	U.S. Nuclear Regulatory Commission
pCi/L	picocuries per liter
QA/QC	Quality Assurance/Quality Control
RAGS	Risk Assessment Guidance for Superfund
RBC	risk based concentration
WNI	Western Nuclear, Inc.

CHEMICAL ABBREVIATIONS

Ag	Silver
Al	Aluminum
As	Arsenic
B	Boron
Ba	Barium
Be	Beryllium
Cd	Cadmium
Co	Cobalt
Cr(total)	Chromium
Cu	Copper
F	Fluoride
Hg	Mercury
Mn	Manganese
Mo	Molybdenum
Ni	Nickel
NH_3	Ammonia
NO_3	Nitrate
Pb	Lead
Ra-226+228	Combined Radium
Sb	Antimony
Se	Selenium
Th-230	Thorium-230
Tl	Thallium
U	Uranium
Zn	Zinc

I.1.0 INTRODUCTION

I.1.1 Purpose

This Baseline Risk Assessment (BRA) presents the baseline determination of potential risk to humans and environmental organisms associated with exposure to constituents of concern (COCs). As part of this determination, the BRA:

- Evaluates the current environmental risks
- Evaluates the current human health risks
- Evaluates the potential future environmental risks
- Evaluates the potential future human health risks
- Establishes the constituents of concern and of potential concern present at the site.

This assessment considers all relevant pathways and is based on data presented in the Western Nuclear, Inc. (WNI) Split Rock Site Ground Water Protection Plan (GWPP). The results of this assessment will serve as the primary means of documenting the current impacts at the Split Rock Site and will aid in the evaluation and selection of a preferred corrective action alternative.

I.1.2 Scope of the Evaluation

A BRA typically considers impacts that could occur if remedial action were not performed at a site. Under the National Environmental Protection Act (NEPA) process, the impacts are assessed for the baseline and projected future conditions at the site. This BRA evaluates if there are any unacceptable risks under present conditions and under appropriate future use scenarios. This assessment leads to the determination of whether corrective action would be required for the long-term protection of human health and the environment.

Five environmental media have been sampled at the Split Rock Site: (1) ground water, (2) soil, (3) vegetation, (4) sediment, and (5) surface water. Soils and vegetation were collected from the floodplain to the north of the site and from the Split Rock Formation area surrounding the site. Surface water and sediment were sampled in ephemeral ponds of the floodplain and the Sweetwater River.

The BRA examines both radionuclide and chemical impacts on or near the site that occurred as a result of ground water from the Split Rock Site. An evaluation of constituent concentrations presently beyond the edge of the tailing reclamation cover, considering existing pathways of exposure, are compared to protective environmental and human standards to determine if any risks exist under present conditions. In addition, anticipated future concentrations and exposure pathways are evaluated with respect to the protective standards to determine if potential future risks are acceptable. The risk evaluation considered the impacts of ground water, soil, vegetation, sediment and surface water on public health and safety and the environment.

I.1.3 Site Description

The site has been described in detail in the GWPP and its appendices. Generally, land near the site is used for seasonal grazing of livestock, and it is anticipated that land use will remain the same in the future under the Institutional Control Alternative. Jeffrey City, the nearest community, is hydrologically upgradient of the WNI site and, therefore, is not now, nor will it be in the future, impacted by site-derived constituents in ground water (see Appendix D).

I.2.0 EVALUATION OF CURRENT AND FUTURE POTENTIAL ENVIRONMENTAL RISKS

An Environmental Assessment (EA) was performed for the Split Rock Site in 1995 to evaluate the current potential influences of site operations and impacted ground water on the environment, including the Sweetwater River system. The EA, along with predicted future conditions, was used to determine future environmental risks.

I.2.1 Current Environmental Risks

Potential ecological exposures to current conditions (1995) at the site have been evaluated in the site EA, which is presented as an attachment to this BRA (Attachment I.b). A brief summary of the findings is presented here.

Physical, chemical, and biological characteristics of the Sweetwater River were measured and analyzed. The resulting data indicate that the portion of the river north of the site is of high quality and has not been negatively impacted by site activities. There are no impacts to aquatic organisms, including fish. Water quality in the Sweetwater River is good and there are no measurable changes to water quality attributable to the site, except under very low flow conditions. The small changes in water quality during low flow conditions will not have a negative impact.

Soil, vegetation, pond surface water, and sediment sample results from the area surrounding the site indicate that these environmental media may have elevated concentrations caused by site activities. A screening-level risk assessment was done as part of the EA to evaluate the potential for impacts to ecological receptors from exposure to the elevated constituent levels in these site media. Potential environmental receptors included mallard ducks, great blue herons, mule deer, and meadow voles.

This analysis indicated that there are no adverse effects on any receptors or to the Sweetwater River ecosystem.

I.2.2 Predicted Future Environmental Risks

Maximum loading of COCs to the river occurred concurrently with the EA performed in 1995. Loading to the river is predicted to rapidly decrease from this point in time. For example, the estimated maximum river concentration of uranium (which would occur at minimum low flow conditions) is approximately 0.4 milligrams per liter (mg/L) (see Appendix H, Attachment H.c), which is well below the value derived in the EA (Attachment I.b to this appendix) that is assumed to be protective of aquatic organisms (2.27 mg/L). Predicted concentrations of COCs are based on conservative low flow conditions, and actual annual flow conditions would result in much lower concentrations (see Appendix H, Attachment H.c). In general, the river flow is sufficient to maintain concentrations of COCs in the river at levels not measurably different than background. Constituents are all ready in a dissolved form by the time they reach the river and will not likely cause loading of the sediment; therefore, cumulative effects are not anticipated. A detailed description of the modeling effort to predict future loading to the river is provided in Appendix H.

Similarly, concentrations in soil, vegetation, pond surface water, and sediment will decrease over time. Current elevated concentrations of site-derived constituents will flush from soil sediment and surface water ponds as a result of spring flooding and crop irrigation. Future concentrations of constituents in ground water, which supply the site-derived constituents to these media, will decline significantly in the future. Therefore, the expected concentrations in vegetation, soil, sediment, and surface water ponds will be less than current conditions. Since the current conditions are not adversely impacting any potential environmental receptors, the lower future concentrations will not adversely impact any potential environmental receptor.

I.2.3 Summary of Potential Environmental Risk

Currently, there is no significant risk to any environmental receptor, including aquatic organisms in the Sweetwater River, that could be exposed to constituents derived from the site (Attachment I.b). Future concentrations are predicted to be less than current concentrations and will be at levels that will not impact any environmental receptor, including aquatic organisms or wildlife that may be exposed to constituents derived from the site.

I.3.0 EVALUATION OF THE HUMAN HEALTH RISKS ASSOCIATED WITH CURRENT AND POTENTIAL FUTURE EXPOSURE

I.3.1 Exposure Pathways

Assessment of both existing and future human exposure to site-derived constituents of potential concern (COPCs) was performed. The two media impacted by site-derived constituents to which humans may be reasonably exposed are ground water and floodplain soils (see Appendix F). Conservative exposure assumptions were utilized to assess risk from these media.

I.3.2 Human Risk Assessment

I.3.2.1 Current Human Risk - Ground Water

Assessment of the existing distribution of site-derived constituents indicates that there are no human receptors presently using the ground water within the maximum distribution of site-derived constituents. Therefore, there are no current risks to human health from ground water. Figure I-3-1 shows the current extent of the site-derived constituents and the location of existing domestic drinking water wells.

I.3.2.2 Current Human Risk Assessment - Floodplain Soils

While the EA (Attachment I.b) reached a conclusion of no risk to human health from floodplain soils, the radiological constituents (uranium, radium, and thorium) in the soils were further evaluated. The floodplain is used for agricultural purposes, floods seasonally, and could not reasonably support a residential use exposure scenario.

However, other uses of this area are possible. Therefore, an exposure scenario has been assumed that consists of a rancher that would spend up to 1 week per year on the floodplain. For the transient rancher, direct irradiation from the radionuclides in shallow floodplain soils, as well as ingestion and inhalation of the floodplain soil particulate material, are not likely to contribute significantly to the total risk, since the potential exposure is only 1 week each year. However, for completeness, all of these pathways were included in the evaluated scenario. The risks to human health from the shallow floodplain soils was calculated using the RESRAD computer code developed by the U.S. Nuclear Regulatory Commission (NRC) to evaluate residual radioactive contamination. Dose conversion factors assumed in the RESRAD modeling are adapted from the U.S. Environmental Protection Agency (EPA) Federal Guidance #11. Dose, as reported here, represents the committed effective dose equivalent from an annual exposure estimated for a receptor.

As discussed, the human exposure pathways quantitatively assessed for this scenario include:

- Direct irradiation from floodplain soils
- Ingestion of floodplain soils
- Inhalation of dust from floodplain soils

The maximum reported values for ^{234}U, ^{235}U, ^{238}U, ^{226}Ra, and ^{230}Th, were conservatively used to represent total exposure risk to the floodplain soils. Input soil data (depth = 30 inches) were obtained from the shallow floodplain soil sampling events of 1996 and 1997 (see Appendix F). The results of the RESRAD model are listed in Table I-3-1. In summary, the maximum dose is 0.5 millirem per year (mrem/yr) and occurs at time 0. Future doses would only decrease from this level. This dose is well below the NRC acceptable annual dose level for the general public from residual radioactivity at decommissioned sites of 25 mrem/yr (10 CFR Part 20.1402). No corrective actions are required for the floodplain soils.

I.3.2.3 Potential Future Human Risk

While there are no significant current risks to human health, a potential exists for future risks to human health if either new wells are installed or site-derived constituents continue to migrate. This section presents an evaluation to determine the site-derived constituents that could be in ground water at concentrations great enough to be a potential hazard to human health. It is assumed that access to ground water, for drinking water purposes, that has concentrations of site-derived constituents greater than health limits is unacceptable. Alternatives developed in Appendix H were developed to ensure that ground water with unacceptable concentrations could not be used for drinking water.

I.3.2.3.1 Identification of Constituents of Concern and Protective Standards

While no site-derived constituents are currently located near any domestic drinking water well, modeling indicates that constituents will continue to migrate. Therefore, constituents that could pose a risk to human health must be identified, and the concentrations at which those constituents pose significant potential risks must be determined. The identification of these constituents is a step-wise process that identifies the constituents that are potentially hazardous to human health related to former mill site activities that exist at concentrations above naturally existing concentrations.

I.3.2.3.1.1 Methods

The constituent screening process was applied to the tailing ground water grouping defined by the WNI ground water database as follows:

1. All constituents listed in 10 CFR Part 40, Appendix A and 40 CFR Part 192 were selected for consideration. It should be noted that none of the organic volatile or semi-volatile compounds listed in 10 CFR Part 40, Appendix A or 40 CFR Part 192 were identified in site tailing or ground water (see Appendix F). Therefore, the list of potential constituents included only metals and radionuclides.

2. Additional constituents reasonably assumed to be derived from byproduct material that could adversely impact human health and the environment were included in the list. Only those constituents for which the potential risks to human and ecological receptors could be reasonably estimated were included.

3. Maximum ground water concentrations from the tailing area for the period of January 1, 1996 through December 31, 1997 (see Table I-3-2), were compared to the lowest background concentration of the floodplain alluvium or Split Rock Formation aquifers. Those constituents that were not detected in concentrations greater than the lowest background concentration were discarded and are not considered potentially hazardous for this site.

4. The remaining constituents were further compared to maximum contaminant levels (MCLs) promulgated by the EPA. For those constituents that did not have promulgated MCLs, EPA Region 3 Risk-Based Concentrations (RBCs) were used as protective concentrations. The higher of background, MCL, and RBC values were considered to be the values protective of human health.

5. Any constituent for which the maximum measured concentration in the tailing area was greater than the larger of either: (a) the lowest ground water background value or (b) its respective MCL or RBC value, was considered a COPC.

6. Existing constituent concentrations beyond the edge of tailing reclamation were compared to the protective standards, considering existing human exposure pathways, to determine if there are any present risks to human health.

7. All COPC concentrations presently above the protective standards beyond the edge of the tailing reclamation cover are considered to be the only constituents with the potential to exceed protective standards in the future. Therefore, these constituents are considered to be COCs and would be the focus of corrective action alternative development and evaluation.

Risk based concentrations (RBCs), that are protective of human receptors, were identified for each constituent for which no MCL exists. It was assumed that RBCs are appropriate standards for the protection of human health. However, because some of the assumptions regarding the applicability of RBCs as protective standards may be questioned, health effect levels (HELs) were also calculated (see Attachment I.a) using standard risk assessment practices described in the EPA *Risk Assessment Guidance for Superfund (RAGS)* (EPA, 1989) and affiliated guidance. HELs are constituent concentrations that are determined to provide protection of human health at the potential points of exposure.

I.3.2.3.1.2 Site Constituent Data Set Development

A list of 25 constituents was originally identified for evaluation (Table I-3-2). The constituent list includes and exceeds those constituents listed in criterion 13 of 10 CFR Part 40, Appendix A and 40 CFR Part 192. The list of constituents was expanded to include constituents which may impact human health for which no regulatory requirements are presented in 10 CFR Part 40, Appendix A. It should be noted that, in addition to the NRC review of volatile and semi-volatile compounds performed in 1985, a review of organic compounds used in the mill processes was performed (Appendix F). A goechemical characterization of water quality conditions in the source area concluded that there are no listed organic compounds above levels of regulatory concern in the source area (see Appendix F). Therefore, this discussion focuses solely on inorganic and radionuclide constituents. The constituents considered include: Ag, Al, As, B, Ba, Be, Cd, Co, Cr(total), Cu, F, Hg, Mn, Mo, Ni, NH_3, NO_3, Pb, Ra-226+228, Sb, Se, Th-230, Tl, U, Zn.

Constituents were evaluated in three distinct areas :

1. The tailing impoundment and areas above the edge of tailing reclamation
2. The Split Rock Formation aquifer downgradient of the edge of tailing reclamation
3. The shallow floodplain alluvial aquifer.

The floodplain alluvial aquifer and the Split Rock Formation aquifer were considered separately due to the distinctly different baseline ground water qualities of these two aquifers (see Appendix F). The tailing and areas upgradient of the edge of the tailing reclamation cover were considered as the primary source term, which could potentially impact both aquifers and surface water bodies.

Water quality data for the period of January 1, 1996 through December 31, 1997, from the three areas described above were selected according to the following criteria:

- Only data from wells completed to monitoring well quality were included. Screening level data or data rejected for Quality Assurance/Quality Control (QA/QC) reasons were excluded. Exceptions to this condition are discussed below.
- The maximum value for each constituent at each monitoring location for the period of January 1, 1996 through December 31, 1997, was considered. These values are a conservative representation of present conditions. Pre-1996 data is considered to be non-representative of current conditions due to evolution of the ground water flow and geochemical conditions.
- All data qualified as U (non-detected, reported value is quantitation limit), J (estimated value), or UJ (non-detected, reported value is estimated) were retained for evaluation at their full reported value, while data qualified as R (rejected) were rejected from the data set. See Appendix F and Appendix K for detailed discussions of the database and data qualifiers. See Appendix J for a detailed discussion of QA/QC procedures for data quality review.

The wells evaluated for each area are summarized in Table I-3-3, and their locations are shown on Figure I-3-2.

I.3.2.3.1.3 Evaluation of Site Constituents

Maximum ground water concentrations from the tailing area for the period of January 1, 1996 through December 31, 1997 (see Table I-3-2), were compared to the lowest background concentration of the floodplain alluvium or Split Rock Formation aquifers. Table I-3-2 presents the maximum values of constituents from the tailing area, maximum concentrations from locations beyond the edge of tailing reclamation, background concentrations from each aquifer, and the protective standards for each of the 25 constituents initially considered.

The 8 constituents barium, boron, chromium, cobalt, copper, mercury, silver, and zinc were not identified anywhere in the site ground water (tailing area or beyond the edge of tailing reclamation) at levels above the larger of background, MCLs, or RBCs. Therefore, these constituents are not considered hazardous and are discarded from further discussion.

The remaining 17 COPCs are above the protective standards and, therefore, are retained for further evaluation. The final list of COPCs includes: Al, As, Be, Cd, F, Mn, Mo, Ni, NH_3, NO_3, Pb, Ra-226+228, Sb, Se, Th-230, Tl, and U. Several of the constituents are not explicitly referenced in 10 CFR Part 40, Appendix A, Criterion 13, imposed by 40 CFR Part 192. However, Criterion 13 indicates that the list of hazardous constituents is not exhaustive and additional constituents which may pose hazards to human health and the environment may be added to ensure comprehensive protection.

I.3.2.3.2 Constituents of Concern

Only those constituents that presently exceed protective standards beyond the edge of tailing reclamation have the potential to pose future hazards. The geochemical characterization presented in Appendix F demonstrates that future concentrations of all constituents from the source areas will not increase in the future and, therefore, no additional constituents should pose a potential future hazard to human health. It should be noted that none of the organic volatile or semi-volatile compounds listed in 10 CFR Part 40, Appendix A or 40 CFR Part 192 were identified in site tailing or ground water (see Appendix F).

Maximum concentrations for each of the 25 constituents considered for each well at or beyond the limits of the reclaimed tailing were determined for the period of January 1, 1996 through December 31, 1997 (see Table I-3-2). The maximum constituent concentration for all these wells were compared to the background concentrations of the Split Rock Formation and the alluvial floodplain aquifer and to the protective values (MCL or RBCs). If the maximum constituent concentrations for any well beyond the limits of the tailing reclamation cover exceeded the larger of background or protective standards, then the potential future hazards to human health and the environment would be unacceptable and additional protective measures would be necessary.

The maximum concentration of the constituents aluminum, antimony, arsenic, beryllium, cadmium, fluoride, lead, nickel, selenium, thallium and thorium-230 in ground water beyond the edge of the tailing reclamation cover do not exceed the larger of background or their protective standards. However, these constituents were detected in the tailing area above the protective standards but are not anticipated to ever exceed these standards beyond the edge of tailing reclamation in the future. Therefore, these constituents are considered only of potential concern, though they are not anticipated to pose a potential future hazard to human health and the environment.

The constituents of ammonia, manganese, molybdenum, nitrate, combined radium (Ra-226+228), and uranium were identified to be above the protective standards beyond the edge of the tailing reclamation cover and are therefore considered to be the COCs at the Split Rock Site. Although there are no existing receptors that are presently impacted by these constituents, the relative abundance and potential future transport of the constituents may pose a potential future hazard to human health and the environment. These are the COCs that will be addressed by the various corrective action alternatives. Specifically, uranium, which is the most abundant and most mobile constituent with the largest long-term source, will be the principal focus of the corrective action selection process. All alternatives that adequately address uranium will also adequately address all of the protection and corrective action concerns regarding all other COCs.

TABLES

Table I-3-1 Summary of Exposure Dose (mrem/yr) for Radionuclides by Pathway for the Floodplain Soils

Radionuclide	Direct Gamma	Ingestion of Soil	Inhalation of Soil	Total
Radium-226	3.63 E-1	1.08 E-2	4.21 E-5	
Thorium-230	3.08 E-5	5.31 E-4	1.23 E-3	
Uranium-234	9.56 E-5	2.53 E-3	4.61 E-3	
Uranium-235	2.62 E-2	8.76 E-3	1.08 E-2	
Uranium-238	2.43 E-2	1.85 E-3	3.16 E-3	
Total by Pathway	4.14 E-1	2.44 E-2	1.99 E-2	**4.59 E-1**

Table I-3-2 Exposure Point Concentrations Used in the Evaluation of Potential Risk

Constituents	Maximum Concentration From Tailing Area (mg/L)	Maximum Concentration Beyond Edge of Tailing Reclamation (mg/L)	Background Concentrations: Floodplain Alluvial Aquifer (mg/L)	Background Concentrations: Split Rock Formation Aquifer (mg/L)	Protective Human Standard (mg/L)
Aluminum	578	2.02	0.1	0.13	37 (RBC)[a]
Ammonia	0.16	2.35	0.011	0.015	0.5 (RBC)
Antimony	0.017	0.01	0.005	0.005	0.006 (MCL)[b]
Arsenic	2.64	0.058	0.024	0.1	0.05 (MCL)
Barium	0.1	0.21	0.346	0.14	2.0 (MCL)
Beryllium	0.084	<0.01[c]	0.004	0.01	0.004 (MCL)
Boron	1.36	0.98	0.093	0.182	3.3 (RBC)
Cadmium	0.188	0.014	0.008	0.014	0.005 (MCL)
Chromium	0.05	0.05	0.05	0.05	0.1 (MCL)
Cobalt	0.44	0.02	0.02	0.02	2.2 (RBC)
Copper	0.214	0.03	0.02	0.06	1.3 (MCL)
Fluoride	21.7	1.33	1.04	0.517	4 (MCL)
Lead	0.11	0.005	0.005	0.050	0.015 (MCL[d])
Manganese	126	49.1	2.39	0.53	0.73 (RBC)
Mercury	0.001	0.001	0.001	0.001	0.002 (MCL)
Molybdenum	0.55	0.22	0.1	0.1	0.18 (RBC)
Nickel	2.29	0.11	0.05	0.05	0.73 (RBC)
Nitrate	362	201	0.88	3.99	10 (MCL)
Radium 226 +228	2950 pCi/L	13.5	4.7	5.3	10 pCi/L (MCL)
Selenium	0.119	0.061	0.005	0.011	0.05 (MCL)
Silver	0.05	0.05	0.05	0.05	0.18 (RBC)
Thallium	0.075	0.013	0.013	0.003	0.002 (MCL)
Thorium 230	732 pCi/L	5.5	5.5	1.8	15 pCi/L (MCL[e])
Uranium (natural)	4.055	8.7	0.044	0.13	0.11 (RBC)
Zinc	3.99	6.07	6.07	0.075	11 (RBC)

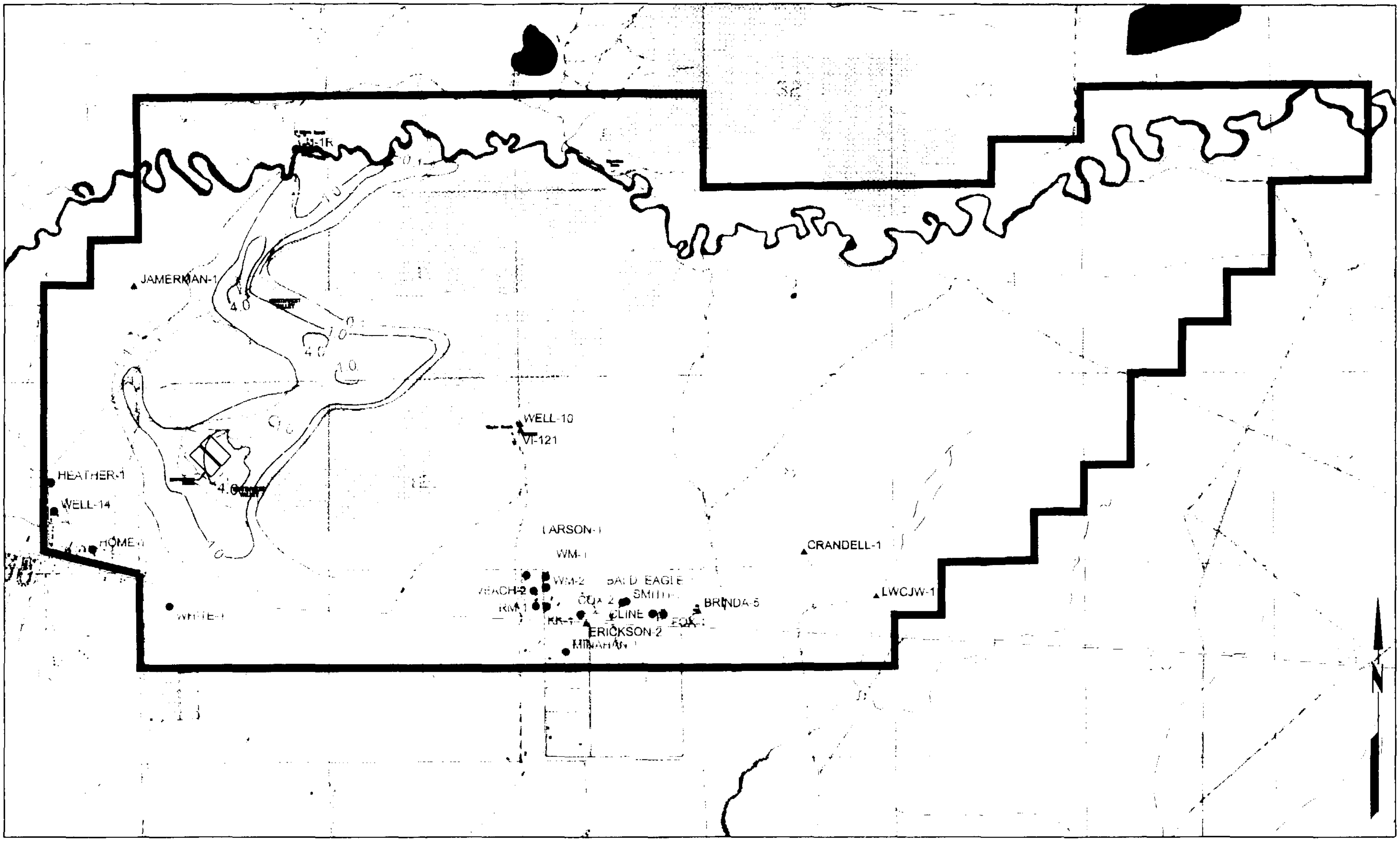
Notes: [a]RBC = risk-based concentration
[b]MCL = maximum concentration limit
[c]Number is highest detection limit (DL), all analyses <DL, all analyses are <DL with almost all DL ≤ protective standard
[d]0.015 mg/L level for lead is technically not an MCL but an EPA Action Level
[e]There is an EPA MCL value of 15 pCi/L for gross alpha; gross alpha would include both Th^{230} and $Ra^{226+228}$. Assuming the limit of 5 pCi for $Ra^{226+228}$ would allow for 10 pCi gross alpha from Th^{230}.

Table I-3-3 Areas and Well Locations for COPC[1] Identification

Tailing and Source Area Wells					
P-1	SP7-2	Well-4E	WN-32C	WN-33D	WN-37E
SP12-1	SP7-3	Well-4R	WN-33A	WN-34	WN-B
SP12-2	TEB-1	WN-32A	WN-33B	WN-35A	WELL-28
SP7-1	TEB-3	WN-32B	WN-33C	WN-35B	
Split Rock Formation Aquifer Wells (Below Edge of Tailing)					
MP-59	WN-21	SWEB-3	WN-40A	SWAB-18	SWAB-35
MP-60	WN-24	SWEB-4	WN-40B	SWAB-19	SWAB-36
MP-61	WN-25	SWEB-5	WN-41A	SWAB-20	SWEB-10
MP-62	WN-26	SWEB-6	WN-41B	SWAB-21	SWEB-11
GM-2	JC-HYD	SWEB-7	WN-42A	SWAB-22	SWEB-12
JC-1	KNIGHT	SWEB-8	WN-42B	SWAB-23	SWEB-13
KK-1	SWAB-1	SWEB-9	WN-43A	SWAB-24	SWEB-14
RM-1	SWAB-2	WELL-1	WN-43B	SWAB-25	SWEB-1P
WM-1	SWAB-3	WELL-2	JOHNSON	SWAB-26	SWEB-1R
WN-A	SWAB-4	WELL-3	SWAB-10	SWAB-27	WELL-27
WN-C	SWAB-5	WELL-5	SWAB-11	SWAB-28	WELL-30
COX-1	SWAB-6	WN-36A	SWAB-12	SWAB-29	WELL-31
COX-2	SWAB-7	WN-36B	SWAB-13	SWAB-30	WELL-5E
FOX-1	SWAB-8	WN-36C	SWAB-14	SWAB-31	DURBEN-1
SWICK	SWAB-9	WN-38B	SWAB-15	SWAB-32	ANDERSON-1
WN-15	SWEB-1	WN-39A	SWAB-16	SWAB-33	
WN-16	SWEB-2	WN-39B	SWAB-17	SWAB-34	
Floodplain Alluvial Aquifer Wells					
JAMERMAN-1	MP-26	MP-38W2	MP-42E1	MP-51	MP-69
JJ-1R	MP-26R	MP-39	MP-42E2	MP-52	MP-69X
MP-1	MP-27	MP-39E1	MP-42N1	MP-53	MP-7
MP-10	MP-28	MP-39E2	MP-42N2	MP-54	MP-70
MP-11	MP-29	MP-39S1	MP-43	MP-55	MP-8
MP-12	MP-3	MP-39S2	MP-43E1	MP-56	MP-9
MP-13	MP-30	MP-4	MP-43E2	MP-57	MP-99
MP-14	MP-31	MP-40	MP-43N1	MP-58	WN-17
MP-15	MP-32	MP-40N1	MP-43N2	MP-6	WN-18
MP-16	MP-33	MP-40N2	MP-44	MP-63	WN-19
MP-17	MP-34	MP-40W1	MP-45	MP-64	WN-23
MP-18	MP-35	MP-40W2	MP-46	MP-65	WN-38C
MP-2	MP-36	MP-41	MP-47	MP-65A	WN-39C
MP-22	MP-37	MP-41E1	MP-47R	MP-66	WN-40C
MP-23	MP-38	MP-41E2	MP-48	MP-67	WN-41C
MP-23R	MP-38S1	MP-41N1	MP-49	MP-66	WN-42C
MP-24	MP-38S2	MP-41N2	MP-5	MP-67	WN-43C
MP-25	MP-38W1	MP-42	MP-50	MP-68	

Notes: [1]COPC = Constituents of Potential Concern

FIGURES



• DOMESTIC WELLS
▲ STOCK WELLS
NRC LICENSE AND BOND AREA
EXISTING URANIUM CONCENTRATION (mg/L)

SHEPHERD MILLER INCORPORATED

FIGURE I-3-1
DOMESTIC AND STOCK WELLS

Project:	03-347\TASK3
File:	DOM-STCK-2.DWG

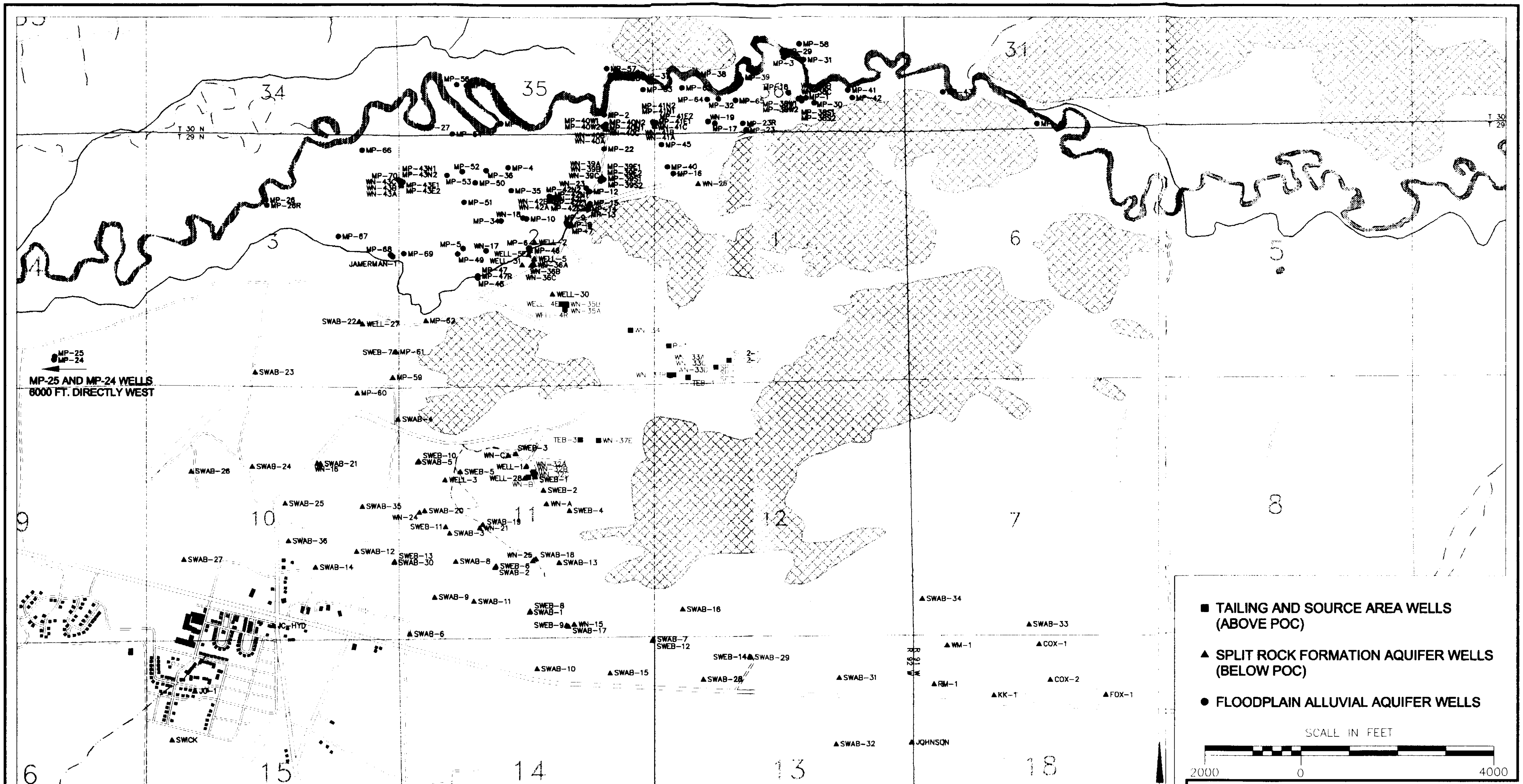


FIGURE I-3-2
WATER QUALITY SAMPLING LOCATIONS

SHEPHERD MILLER

Project:	03-347/TASK10
File:	FIG-I-A-1.DWG

Filename: E 347\TASK10\fig-i-a-1.dwg
Date: 06/04/1999
Time: 09:21:33.68

I.4.0 SUMMARY AND CONCLUSIONS

This BRA of the Split Rock Site was conducted to evaluate the presence of radiological and nonradiological hazards associated with the former uranium mill site. A detailed Environmental Assessment (EA) was conducted that evaluated soil, vegetation, sediment, and surface water, including the Sweetwater River. This assessment clearly shows that site-derived ground water does not currently adversely impact any ecological receptor. Additionally, modeling indicates that future ground water concentrations will continue to decline and, therefore, there will be no adverse future impacts to any ecological receptor.

Because impacted ground water is not currently used for drinking water by area residents, human health is currently not at risk. Future use of contaminated ground water as a drinking water source could, however, be associated with adverse health effects. A series of alternatives were developed (Appendix H) to address this potential future risk.

I.5.0 REFERENCES

U.S. Environmental Protection Agency (EPA). 1989. *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation (RAGS)*. EPA 400/89.

TABLE OF CONTENTS

LIST OF TABLES

ACRONYMS AND ABBREVIATIONS

EPA	U.S. Environmental Protection Agency
EPA-NCEA	EPA National Center for Environmental Assessment
HEL	health effect level
IRIS	Integrated Risk Information System
MCL	maximum contaminant level
RAGS	Risk Assessment Guidance for Superfund
RBC	risk based concentration
RfD	reference dose
TR	target risk

I.a.1.0 CALCULATION OF HEALTH EFFECT LEVEL

In order to evaluate the appropriateness of risk based concentrations (RBCs) for the Split Rock Site, site-specific health effects levels (HELs) were determined for the hazardous constituents that do not have promulgated maximum contaminant levels (MCLs). Of the 25 identified site constituents, 9 do not have MCL standards. Specifically, HELs were developed for aluminum, boron, cobalt, manganese, molybdenum, nickel, silver, uranium, and zinc. Only non-carcinogenic risk is considered since the U.S. Environmental Protection Agency (EPA) does not provide slope factors (for carcinogenic risk assessment) for any of these metals. HELs are constituent concentrations that are determined to provide protection of human health and the environment at the potential points of exposure.

Potential receptors considered at the site consist of offsite ranchers and their families residing near the potentially impacted area. Additional potential receptors could include fishermen and hunters, who occasionally visit the site, as well as site employees that maintain the Split Rock Site. Residents who use the local ground water downgradient from the site for domestic drinking water and other domestic uses represent the human receptor with the greatest potential risk. All other human receptors for ground water would be exposed infrequently and of short duration, resulting in much lower potential risk. Therefore, only the residential use scenario is evaluated for calculation of ground water HELs.

While human health is currently not at risk because area residents do not presently use contaminated ground water for drinking water, future migration of site-derived constituents could cause future exposure. For the calculation of HELs, a future resident is assumed to spend 2 weeks per year away from the residence, so that exposure frequency is 350 days per year for an exposure duration of 30 years. The resident is also assumed to drink 2 liters of water per day from an onsite well. These assumptions are in agreement with EPA guidance provided in *Risk Assessment Guidance for Superfund (RAGS)* (EPA, 1989). The equation used for calculating the HELs is:

$$HEL = \frac{TR \times BW \times AT \times RfD}{ED \times EF \times IR}$$

where:
- AT = Averaging time of 10,500 days (350 days/year x 30 years)
- BW = Body weight of 70 kilograms
- EF = Exposure frequency of 350 days per year
- ED = Exposure duration of 30 years, which is the upper range of time spent at a single residence
- IR = Ingestion rate of water (2 liters/day or 1.4 liters/day)
- TR = Target risk of 1.0
- RfD = Toxicity reference dose or the dose below which no adverse effect would be expected.

The target risk (TR) of 1.0 equals the minimum dose intake at which non-carcinogenic hazards might be manifested. Thus, the HEL calculated using this TR value is protective of human health at the points of exposure. The chemical specific reference dose (RfD) values are from the Integrated Risk Information System (IRIS) database (IRIS, 1999) or from the EPA National Center for Environmental Assessment (EPA-NCEA) (1999). Table I-a-1 lists the calculated HEL values and the corresponding RBC values issued by EPA Region 3 (EPA, 1999). The RBC values are essentially equal to the calculated HEL values and are thus appropriate protective standards.

I.a.2.0 REFERENCES

Integrated Risk Information System (IRIS). 1999. On-line service (www.epa.gov/iris/). U.S. Environmental Protection Agency, Washington, DC.

U.S. Environmental Protection Agency (EPA). 1989. *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation (RAGS)*. EPA 400/89.

U.S. Environmental Protection Agency (EPA). 1999. National Center for Environmental Assessment (NCEA) Superfund Technical Support Center.

TABLES

Table I-a-1 Calculated HEL Values with Corresponding RBC Values

Chemical	Oral RfD mg/kg/day	Source	HEL mg/L	RBC mg/L
Aluminum	1	EPA-NCEA	36.50	37
Boron	0.09	IRIS	3.29	3.3
Cobalt	0.06	EPA-NCEA	2.19	2.2
Manganese	0.14	IRIS	5.11	0.73*
Molybdenum	0.005	IRIS	0.18	0.18
Nickel	0.02	IRIS	0.73	0.73
Silver	0.005	IRIS	0.18	0.18
Uranium	0.003	IRIS	0.11	0.11
Zinc	0.3	IRIS	10.95	11

Note: *The RBC value reflects IRIS guidance for modifying the RfD value for non-food manganese sources. The HEL was calculated using the unmodified Rfd value.

APPENDIX I, ATTACHMENT b

ENVIRONMENTAL ASSESSMENT SPLIT ROCK MILL SITE, JEFFREY CITY, WYOMING

Shepherd Miller, Inc.

Fort Collins, Colorado

FINAL

Environmental Assessment Split Rock Mill Site, Jeffrey City, Wyoming

ENSR

March 1999

Document Number 5978-003-400

EXECUTIVE SUMMARY

The Split Rock Mill near Jeffrey City, Wyoming (the Site) was constructed in 1957 and operated until 1981. The mill and tailing disposal areas from Site operations encompass approximately 275 acres between two primary alluvial valleys, the Northwest and Southwest Valleys (NWV and SWV). Groundwater derived from the tailing drainage has migrated into the regional aquifer and out into the valleys. A Corrective Action Program for groundwater was initiated in 1990. The Split Rock Mill Site has undergone surface reclamation of the former tailing impoundment areas, and impacted areas in the vicinity of the Site have been remediated to federal guidelines for residual radioactivity.

An environmental assessment was conducted to establish whether the portion of the Sweetwater River north of the Site has been impacted by site-derived groundwater. Additional objectives included overall evaluation of the potential influences of former Site operations on the soil, vegetation, and ponds in the valleys surrounding the site and the potential for related human health or environmental impacts. To achieve these objectives, both systematic sampling of the Sweetwater River and opportunistic sampling of site media (soils, vegetation, pond sediment, and pond surface water) were conducted in October 1995. Samples were analyzed in the laboratory for metals and radionuclide constituents that may be associated with former Site operations. The laboratory data were analyzed and conservative evaluation procedures were used to assess the potential risks to human health and ecological receptors that may be exposed to these media.

Sweetwater River Analysis

For the Sweetwater River, physical, chemical, and biological (i.e., benthic abundance and diversity) characteristics were measured and analyzed. The resulting data indicate that the portion of the river north of the Site has a high quality ecosystem typical of cold water prairie streams. Although differences among specific ecological measurement endpoints were detected at some sampling locations, there is no apparent relationship with previous Site operations. Additionally, no chemical gradients were observed in the river water and sediment concentrations of constituents were consistently below applicable indices for potential ecological concern.

Opportunistic Sampling

Results of the opportunistic sampling of soil, vegetation, pond surface water, and sediment samples indicate that these environmental media may have been impacted. The potential for adverse impacts to human health and the environment, however, as a result of exposure to potentially impacted media is negligible. In general, surface soil concentrations were all well 8/27/98below both human health and environmental risk-based concentrations. Thorium-230 was detected (at 24 pCi/g) in a single soil sample collected from the NWV, at a location in direct proximity to the tailings reclamation cover area.

The area surrounding this sample location is known to have elevated uranium and/or thorium concentrations without elevated radium concentrations (i.e., it is a P2 area as defined by the Split Rock Radiological Verification Program). As such, soils in this area were either (1) included in the cleanup and verification program for radiological compliance with regulatory standards identified in the Radiological Verification Program (SMI 1995a) or (2) within the boundaries of the reclamation cover system.

Maximum vegetation concentrations of (1) the metals manganese, uranium, and zinc, and (2) the radionuclides radium and thorium exceeded the background vegetation concentration. The background vegetation concentrations were derived, however, from composite samples that may not contain vegetation types that are identical to the Site samples. Plant uptake of constituents can vary significantly among vegetation types. Further evaluation revealed that the measured maximum plant concentrations were below maximum tolerable levels (MTLs), which are defined as a dietary level for domestic animals that will not produce unsafe residues in food derived from the animal. Additionally, all plant concentrations were well below phytotoxic levels. Therefore, the constituent concentrations in vegetation at the Site will not adversely impact human health or the environment.

Metals concentrations in fish tissue from the Sweetwater River are not at levels that represent a potential for human health or ecological impacts from fish consumption.

Water and sediment concentrations in both Ponds 1 and 2 pose no unacceptable potential risk to aquatic organisms and livestock.

The uranium concentrations measured in samples collected in October 1995 from Pond 1 exceeded the Wyoming Department of Environmental Quality Livestock standard for groundwater; however, subsequent samples from Pond 1 collected in 1996 were all well below the uranium groundwater standard. Because uranium does not bioaccumulate in animal tissue, consuming beef would not likely pose a potential risk to humans.

Cross-Media Exposure Assessment

A screening ecological risk assessment was performed to evaluate the potential for impacts to ecological receptors from exposure to multiple Site media. Potential risks were evaluated using the hazard quotient (HQ) method. Receptors included mallard ducks, great blue herons, mule deer, and meadow voles. The potential for risks to migratory waterfowl, such as mallard ducks, due to exposure to multiple media (water, sediment, and vegetation) is negligible. Similarly, waterfowl such as great blue herons, may consume fish from the Sweetwater River and water from the ponds with negligible potential risks.

Meadow voles and mule deer were assumed to ingest vegetation from the Site and consume water from the ponds. No potential for unacceptable risk to terrestrial organisms was noted.

Summary and Conclusions

No adverse impacts to the Sweetwater River ecosystem were indicated from the systematic sampling of the river and subsequent data analysis. The concentrations measured in soil, vegetation, pond water, and pond sediment samples do not indicate any unacceptable potential risk from previous Site operations to human health or the environment.

CONTENTS

CONTENTS (Cont'd)

CONTENTS (Cont'd)

LIST OF TABLES

LIST OF FIGURES

GLOSSARY

This glossary is provided as a central location for definitions and acronyms pertaining to technical, or regulatory terminology.

Amphipod. A species of aquatic organisms often referred to as a "fresh-water shrimp".

Analyte. Any compound or chemical selected for analytical measurement in a collected water, soil, sediment, or tissue sample.

Benthic macroinvertebrates. Organisms that live either in or on the sediment of an aquatic system; includes organisms from several taxonomic groups such as insects, crustaceans (amphipods, isopods, decapods, benthic copepods), oligochaetes, and leeches.

Benthic community indices. Calculated terms used to define the organization, distribution, density, and species composition of benethic macroinvertebrates..

Benthos. "See benthic macroinvertebrates."

Bioaccumulation. General term describing a process by which chemicals are taken up by aquatic organisms or through consumption of food containing the chemicals.

Biota. All living organisms inhabiting an ecosystem.

Chronic. Involving a stimulus that continues for a long time; from weeks to years, depending on the reproductive life cycle of the aquatic species. Can be used to define either the exposure or the response to an exposure. The chronic toxicity test is used to study the effects of continuous, long-term exposure of a chemical or other potentially toxic material on aquatic or terrestrial organisms.

Community. An assemblage of multiple populations (a spatial grouping of organisms of one species) inhabiting a definable habitat or ecosystem.

Criterion (water quality, plural: criteria). An estimate of the concentration of a chemical in water which, if not exceeded, will protect an organism, community, or a prescribed water use or quality with an adequate degree of safety.

Deterministic assessment. A single-point estimate of potential risk.

GLOSSARY (Continued)

Endemic organism. Native organisms.

EPT Ratio. Ratio of the sum of *Ephemeroptera* (mayflies), *Plecoptera* (stoneflies), and *Trichoptera* (caddisflies) to chironomids.

Habitat. The living and non-living components of a community.

Hardness. The concentration of all metallic cations, except those of the alkali metals, present in water. Hardness is a measure of the concentration of calcium and magnesium ions in water and is frequently expressed as mg/L calcium carbonate equivalent.

LC_{50} - Median Lethal Concentration.

Matrix spike analyses. USEPA method to provide information about the effect of each sample matrix on the digestion and measurement methodology.

Probability Analysis. A simulation technique used to characterize the impact of uncertainty in risk estimates. Instead of single-point parameters for modeling, a probability density function describing the distribution of possible values is used.

Neonates. Term for offspring.

Pore water. Also called interstitial water; fills the spaces between sediment particles. Pore water accounts for over 50% by volume of surface sediment.

Primary consumers. Those organisms which feed only on plant matter and are in turn eaten by higher order consumers.

Risk. A statistical concept defined as the expected frequency or probability of undesirable effects resulting from exposure to known or potential environmental concentrations of a material.

Secondary consumer trophic level. Comprised of all animals in an ecosystem that feed on primary consumers.

Shannon Evenness. Ratio of the calculated Shannon-Wiener Diversity to maximum Shannon-Wiener Diversity, expressed as a valve between 0 and 1.

GLOSSARY (Continued)

Shannon-Wiener Diversity. Also called Shannon Diversity (or less properly, Shannon-Weaver Diversity); it is a measure of species diversity at a community level of biological organization.

Shannon Diversity takes into account the number of taxa and the number of individuals in each taxon. It is calculated with the following equation:

$$\text{Shannon Diversity } (H) = [N \log N - n_i \log n_i)/N$$

where: N = total number of organisms
n_i = number of organisms belonging to taxon $_i$

Sessile. Essentially stationary, often attached to the substrate.

Taxa, taxonomic. A classification of organisms based on a common set of evolutionary or physiological traits; grouping of a set of organisms into a taxon or taxonomic unit distinguishes them from other organisms, which tend to be more distantly related, evolutionarily. Taxa are defined at multiple levels of organism relatedness - organisms in the same species are very closely related, and relatedness decreases among genera, family, order, class, phylum, and kingdom.

Toxicity. The inherent potential or capacity of a material to cause adverse effects in a living organism.

Toxicity Tests. These tests are used to measure the degree of response produced in an organism by exposure to a specific concentration of chemical.

Transect. A linear sampling scheme that is extended across an area or between two points; equidistant points are designated along the transect at which samples are collected; the length of the transect and the distance between the sampling points is held constant between each location at which samples are to be collected.

Triad Analysis. Evaluation method incorporating three components: (1) chemical measurements in sediment, (2) toxicity testing, and (3) evaluation of biological community.

ACRONYMS

AVS	acid volatile surface
CAP	Corrective Action Program
CAS	Columbia Analytical Services
CCB	cross-contamination blank
COPC	contaminants of potential concern
EA	environmental assessment
ECB	external contamination blank
EPT	Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies)
FCETL	Fort Collins Environmental Toxicology Laboratory
GPS	Global Positioning System
ICP	inductively coupled plasma
LCS	laboratory control samples
MRL	maximum tolerable level
MTL	maximum tolerable level
NAS	National Academy of Science
NEV	Northeast Valley
NRC	Nuclear Regulatory Commission
NWV	Northwest Valley
PEL	probable effect level
QA/QC	quality assurance/quality control
QC	quality control
RPD	relative percent difference
SDG	sample delivery group
SEM	simultaneously extracted metals
SERA	screening ecological risk assessment
SMI	Shepherd Miller, Inc.
SOP	standard operating procedure
SWV	Southwest Valley
T&E	threatened and endangered [species]
TDS	total dissolved solids
the Site	Split Rock Mill site
TWP	Task Work Plan
m	micrometer
WDEQ	Wyoming Department of Environmental Quality
USEPA	United States Environmental Protection Agency

1.0 INTRODUCTION

Seepage from the tailing at the former Split Rock Mill site near Jeffrey City, Wyoming (the Site) to the underlying aquifer has impacted groundwater with metals and radionuclides, which have slowly migrated northwest and southwest of the Site. As a result, a groundwater Corrective Action Plan (CAP) has been implemented for the site. In keeping with the project mission to manage responsibly any potential environmental impacts at the Split Rock Site and to provide the required reasonable assurance of long-term protection of public health and the environment, an environmental assessment (EA) was designed to evaluate the current conditions at the Site with emphasis on the Sweetwater River ecosystem. This report presents the results of the EA.

1.1 Site Background

The Split Rock Mill and tailing disposal areas encompass approximately 275 acres in two alluvial valleys, the Northwest and Southwest Valleys (NWV and SWV), which are situated between surrounding granite outcrops. A third area, the Northeast Valley (NEV) was identified for purposes of the study. The Sweetwater River extends to the north of the site (Figure 2-1).

The mill was constructed in 1957 to process uranium ore and operated until 1981, processing a total of approximately 7.7 million tons of ore during the operational lifetime. During that period, process wastes in the form of mill tailing solids and acidic liquids were discharged to the tailing disposal area. Seepage from the tailing entered the groundwater and migrated down the NWV and SWV to the regional aquifer. In 1981 tailing disposal operations were terminated and steps were taken to contain and partially replace groundwater within the valleys by pumping wells.

In accordance with a federally-approved reclamation plan, the former mill was decommissioned, demolished, and buried on-site. A groundwater CAP was initiated at the Site in 1990. Surface reclamation of the former tailing disposal area was completed in 1998. Years of groundwater monitoring data (SMI 1996) indicate that elevated levels of several site-derived constituents in groundwater may have migrated outside of the boundaries of the original operating facility into the NWV and SWV.

1.2 Project Scope

The primary focus of the EA was the evaluation of potential environmental impacts to the section of the Sweetwater River adjacent to, and therefore potentially influenced by, the Site. In addition, surface soils, vegetation, and area ponds that may have been affected by site activities or by groundwater movement and surface expression of groundwater were evaluated to determine constituent concentrations and the potential for human health and/or environmental impacts due to exposure to these media. This report presents the results of a single sampling event in October 1995. The scope and methods used during the October sampling and the subsequent data analysis were based on the Risk Assessment Task Work Scope (SMI 1995b), and Task Work Plan (TWP) for the Split Rock Mill Site (ENSR 1995) (See Attachment 1). All work was performed in accordance with the Risk Assessment Component Quality Plan (ENSR 1996).

1.3 Objectives

The objective of the October 1995 sampling was to assess the overall environmental status of the Sweetwater River and to preliminarily evaluate any potential impact to the river from the influx of groundwater derived from the Site. Additional sampling of soils and vegetation from the valleys surrounding the site and of pond sediments and surface water in the floodplain between the site and the Sweetwater River was conducted to provide information regarding potential human health and environmental impacts and to help focus future sampling efforts at the site, if necessary. Finding of no potential for risk to humans and ecological receptors would eliminate the need for further study of these media.

Groundwater monitoring has been ongoing at the Site and results are presented elsewhere (WNI 1996). Potential risk associated with direct exposure to groundwater is not addressed in this document.

1.4 Report Organization

This report presents the results of the October 1995 sampling and analysis effort for the Split Rock Mill Site.

Section 2.0 describes the sampling locations, field and laboratory methods used, and any deviations from the Task Work Plan and Standard Operating Procedures (SOP).
Section 3.0 provides the analytical results, toxicity testing results, taxonomic identifications and diversity indices for the Sweetwater River.
Section 4.0 provides the results of the opportunistic soil, vegetation, surface water, and sediment sampling and evaluates the potential for human health and ecological impacts.
Section 5.0 presents the quality assurance/quality control (QA/QC) laboratory and field audit results.
Section 6.0 presents the conclusions of the October 1995 sampling effort.
Tables and figures are presented at the end of each section.
References are provided in Section 7.0.
Attachment 1 provides the Risk Assessment Task Work Plan.
Attachment 2 contains photographs of the sampling site locations.

Attachment 3 contains laboratory toxicity test reports.
Attachment 4 contains benthic macroinvertebrate data.
Attachment 5 presents the derivation of an aquatic benchmark for uranium.
Attachment 6 contains grain size data.
Attachment 7 contains figures showing results of regression analysis of toxicity endpoints versus sediment chemistry.
Attachment 8 presents a screening ecological risk assessment for the non-river areas.
Attachment 9 contains the data summary tables.

The sampling location names used in this report are, in some cases, different than the names for the same locations that are used in the Groundwater Protection Plan (GWPP) project database (Appendix K of GWPP). Table 1-1 shows the name of each sampling location discussed in this report, along with the corresponding name from the project database.

Table 1-1
Comparison of ENSR and Project Database Sample Location Names

	ENSR Location Name	GWPP Project Database Location Name
Sweetwater River Sampling Locations		
	SR-R1	ENSR-R-1
	SR-R2	ENSR-R-2
	SR-S1	ENSR-S-1
	SR-S2	ENSR-S-2
	SR-S3	ENSR-S-3
	SR-S4	ENSR-S-4
	SR-S5	ENSR-S-5
	SR-S6	ENSR-S-6
	SR-S7	ENSR-S-7
Surface Water (Pond) Locations		
	Pond 1	WET-01
	Pond 2	WET-02
Opportunistic Soil Sampling Locations		
Northeast Valley		
	NEV-1	NEV-1
Northwest Valley		
	NWV-1	NWV-1
	NWV-2	NWV-2
	NWV-3	NWV-3
	NWV-4	NWV-4
	NWV-5	NWV-5
	NWV-6	NWV-6
	NWV-7	NWV-7
	NWV-10	NWV-10
	NWV-13	NWV-13
Southwest Valley		
	SWV-1	SWV-1
	SWV-2	SWV-2
	SWV-3	SWV-3
	SWV-4	SWV-4
	SWV-5	SWV-5
	SWV-6	SWV-6
	SWV-7	SWV-7
	SWV-8	SWV-8
	SWV-9	SWV-9
	SWV-10	SWV-10
Reference Area		
	REF-1	REF-1
	REF-2	REF-2
	REF-3	REF-3

2.0 METHODOLOGY

All sampling and analysis methods used in this effort were consistent with guidelines set forth in the Risk Assessment Task Work Plan (TWP) for the Split Rock Mill Site (ENSR 1995). Field sampling was overseen by ENSR and Shepherd Miller, Inc (SMI). Laboratory toxicity testing and taxonomic identification of collected invertebrates was conducted by ENSR at its Fort Collins (Colorado) Environmental Toxicology Laboratory (FCETL). Chemical analysis of water, sediment, soil, vegetation, and fish tissue was conducted by Columbia Analytical Services (CAS), Kelso, Washington. Radiological analysis of all samples was provided by Energy Laboratories, Casper, Wyoming. In addition, metals analysis of vegetation, fish tissue, and sediment was conducted by Energy Laboratories.

2.1 Constituents of Potential Concern

Constituents of potential concern (COPC) were selected based on previous site investigations and knowledge of Site activities. The chemicals included in the analysis are:

arsenic	selenium
cadmium	silver
copper	uranium (natural)
iron	zinc
lead	radium (-226 and -228)
manganese	thorium -230
molybdenum	uranium (-234,-235, and -238)
nickel	

Additional analysis for (1) major ions, including calcium, magnesium, sodium, potassium, sulfate, chloride, ammonium, nitrate, and fluoride, and (2) other parameters, such as pH total dissolved solids (TDS), were also performed on selected samples.

2.2 Sweetwater River

The assessment consisted of three principle components:

- chemical analysis of surface water and sediment
- laboratory toxicity testing of sediment
- in-situ benthic macroinvertibrate community investigations.

These components constitute the three legs of a sediment quality triad analysis (Chapman 1986), intended to discern whether links exist between chemical measurements and biological (laboratory and in-situ effects). Data are considered together to provide a more complete picture of potential chemical impacts than could any individual component. Data of one type (e.g., chemical measurements) are interpreted in the context of data of the other types (e.g., toxicity) in an attempt to form plausible cause-and-effect relationships.

Statistical methods are used to discern patterns among field observations and evaluate the existence of cause-and-effect relationships. If statistical procedures show that no relationship currently exists between contaminant concentrations and observed biological effect it would suggest that contaminants deriving from Split Rock milling operations do not currently adversely impact the Sweetwater River ecosystem. This assessment was designed to definitively identify the presence or absence of potential risk and was not intended to fully characterize the risks.

Six experimental sampling locations on the Sweetwater River were tentatively identified in the TWP, along with two reference locations. Once in the field, six exact sampling locations were selected based on preliminary identification in the TWP, accessibility, and site conditions. Sample locations were marked with a flagged stake, and Global Positioning System (GPS) readings were taken at each sampling flag. Sampling locations are shown on Figure 2-1.

A transect was established perpendicular to the river at each sampling locations. Three sampling locations were equally spaced across each transect. The initial sampling location on the transect was located just within the river channel, and the remaining river width was subdivided into thirds for placement of the subsequent stations.

Each river sampling site was characterized according to *Wyoming Department of Environmental Quality (WDEQ) Bioassessment Field Data Sheets.* Field observations included relative abundance of aquatic biota (filamentous algae, macrophytes, periphyton, slimes, and fish), stream order, channelization, sheen, color, odor, flow conditions, substrate surface type and general observations. Specific parameters measured in the field included stream depth, stream width, pH, dissolved oxygen, temperature, and conductivity (Table 2-1). Each site was photographed from the position of the sampling transect; photographs are provided as Attachment 2.

2.2.1 Water Chemistry

Water samples were collected by SMI personnel as surface grabs in pre-labeled, certified clean plastic containers. Care was taken not to disturb the river bottom. General sampling guidelines (e.g., required sample volumes, preservation, shipping) as defined in the TWP were followed. Samples for total recoverable metals analysis were placed on ice and delivered to CAS and Energy

Laboratories; filtered samples (0.45 μm) for dissolved metals were not analyzed but were preserved and retained for potential submittal should the total recoverable samples indicated the presence of elevated concentrations of material. Dissolved metals concentrations are assumed to be less than total concentrations; given the generally low values reported for total recoverable metals in the water samples collected (see Section 3.0), dissolved metals concentrations were assumed to be below levels of potential concern and thus were not determined. Analytical parameters and methodologies were consistent with those specified in the TWP.

2.2.2 Sediment Chemistry

River sediment samples were collected as surface grabs concurrently with the sediment toxicity sampling efforts to provide sediment quality (chemistry and grain size) data useful in interpreting the results of biological sampling and sediment toxicity tests. Samples were analyzed for total recoverable metals (following extraction by EPA method 3050), and splits of the samples were preserved and held in the event it was determined that analysis for simultaneously extracted metals (SEM) was necessary to establish the bioavailability to benthic receptors. In general, because the total concentrations were not significantly different from reference location concentrations (see Section 3), analysis for SEM was not performed. Sediment grain size was also determined.

Sediment samples were collected at each of the three stations along the transect to a penetration depth of <10 cm (providing three replicate samples per site) using either a hand-held Ekman dredge (for water depths 2-4 ft and muddy sediments), a ponar dredge (for water depths 2-4 ft and sandy or rocky sediments), or a stainless steel spoon (for water depths <2 ft and cobble bottom). Sediments were transferred directly into pre-labeled, certified clean 1 gallon Nalgene® containers. Each container was filled completely to eliminate headspace. All dredges and other equipment were decontaminated between sampling sites in accordance with Standard Operating procedure (SOP) No. 3003 (see Appendix A of the TWP).

Overlying water samples for laboratory determination of hardness and alkalinity (measured in association with sediment toxicity testing) were collected prior to the initiation of dredging at each site. Samples were obtained as surface grabs in 500 ml plastic containers.

All sediment and overlying water samples were stored at 4°C upon collection and returned to ENSR's FCETL facility. Upon arrival, samples were inspected, logged into the laboratory tracking system, and placed under refrigeration in the dark. Samples were left unopened until the day that they were scheduled for toxicity testing. At that time, the entire contents of the sediment sample was transferred to a decontaminated plastic basin and thoroughly homogenized (using a mechanized stainless steel auger) in accordance with SOP No. 5208. All tests were preformed out prior to exceedence of the sample holding times.

Once each sample was homogenized, two 250-ml sediment aliquots were transferred to pre-labeled, certified clean, glass jars and capped tightly. These samples were shipped on ice via overnight carrier to CAS and Energy Labs for analysis of parameters listed in the TWP.

2.2.3 Sediment Toxicity

Hyalella azteca (freshwater amphipod) and *Ceriodaphnia dubia* (water flea) toxicity tests were initiated simultaneously with the collection of sediment aliquots for chemical analysis (i.e., toxicity tests were conducted using the same post-homogenized sediment sample as that submitted for chemical analysis). Static-renewal toxicity tests were conducted by exposing laboratory-reared organisms to Sweetwater River sediment samples overlain with laboratory reconstituted water. The test water was reconstituted from ASTM Grade I Laboratory Water (Milli-Q) (ASTM 1991) and had hardness and alkalinity values equivalent to those determined for the overlying water samples from the Sweetwater River. Toxicity testing procedures were consistent with those described in the TWP. These procedures and associated testing protocol are included as Attachment 3.

Sweetwater River sediment toxicity tests were initiated over the course of three weeks (between October 27 and November 10, 1995). Three sites were randomly designated each week for testing until all sites had been tested. A laboratory control sediment (Florissant Sediment provided by the U.S. Biological Survey, Midwest Science Center) was tested simultaneously each week.

Overlying water was renewed daily and sediments were left undisturbed throughout the course of testing. *Hyalella azteca* were monitored at test termination for rates of growth and mortality. *Ceriodaphnia dubia* were monitored daily for rates of reproduction and mortality. Tests were considered valid as long as control organism survival percentage was at least 80%.

Porewater sampling devices (or peepers), containing ASTM Grade I laboratory water and fitted with semi-porous (1 micron) polycarbonate membranes, were inserted into the sediment test samples at test initiation and left undisturbed for the first seven days of testing. At that time, peepers were removed from each of the five replicate site sediment test containers and the internal water was composited from all vials placed into a common sediment porewater sample. As a result of passive diffusion, the peepers were assumed to have sampled the free metal (ionic) fraction of the sediment interstitial waters into which the devices were placed. Seven-day filtrate (0.45 micron) samples were acidified in the FCETL and were refrigerated for potential analysis of dissolved metals concentrations. Because of the low sediment concentrations (i.e., nondetect), pore water analysis was not performed.

2.2.4 Fish Tissue

Fish were collected for tissue metals and radionuclide analysis to determine if detectable residues exist in fish tissues. Because fish feed on macrobenthos that may contain concentrations of metals and radionuclides, fish tissue residues are excellent indicators of bioaccumulative potential.

Rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), and cutthroat trout (*Salmo clarkii*) were collected from the Sweetwater River using electrofishing equipment in general accordance with procedures described in the TWP. Fish were collected in association with sampling at locations SR-S2, SR-S4, SR-S7, and SR-R1 (Figure 2-1).

Fish were placed on ice following collection and then frozen at the end of the day. Upon completion of sampling, all frozen fish were returned to the FCETL for homogenization. Fish were kept frozen until they were homogenized. The homogenization process followed SOP No. 3352 (see TWP), which consisted of chopping the fish (if they were >50mm) and then blending the coarse-chopped tissue in a pre-cleaned kitchen blender. All fish collected from a single sampling site were composited for homogenization. The homogenized tissue was then transferred to a pre-labeled, certified-clean glass vial and refrozen. Samples were then shipped on ice via overnight carrier to Energy Laboratories for total metals analysis. All scale samples (for aging) were archived at the FCETL.

2.2.5 Benthic Invertebrate Abundance

Benthic macroinvertebrates are organisms that live either in or on the sediment of an aquatic system. They may include organisms from several taxonomic groups such as insects, crustaceans amphipods, isopods, decapods, benthic copepods, mollusks, oligochaetes, and leeches. Because benthic macroinvertebrates are generally sessile or attached to substrate and have limited home ranges, their occurrence and condition can be compared to water quality and sediment characteristics at a particular location. The abundance and diversity of specific kinds of benthic macroinvertebrates can be an indicator of the general health of an aquatic system and, when compared against suitable reference locations, may also be a measure of physical or chemical impacts.

Individual quantitative benthic macroinvertebrate samples were collected using a 600 μm Hess sampler at the three sampling locations along the transect at each sampling site. Invertebrates were collected from an undisturbed area of the river bottom prior to sediment sampling. The Hess sampler was placed over the sediments just upstream of each transect point, and the rock and surface material located within the sampler walls was agitated using a level of effort consistent across all locations. All organisms and debris collected within the Hess sampler were transferred to pre-labeled, wide-mouth plastic container containing 10% buffered formalin.

One qualitative macroinvertebrate sample was also collected at each location. Dip nets were passed across all surfaces (i.e., bottom sediment, submerged vegetation, banks) within and adjacent to the sampling area. Collected organisms were transferred from the net into pre-labeled plastic containers and preserved with 10% buffered formalin.

All preserved samples were returned to FCETL, where they were recorded in a biological sample receipt log and assigned a laboratory sample number. Organisms were picked from each sample according to SOP No. 3340. Analysis generally included washing the sample through a stack of sieves ranging from 2 mm to 0.15 mm. Each fraction was then hand picked on a light table using a magnifying viewer. All organisms were transferred to and preserved in glass vials with 70% isopropanol. At a minimum, all vials were labeled with the following information: number, replicate identification number, date collected, project number, project name, ENSR laboratory number, preservative, and general taxonomic group. All organisms contained in the post-sorted samples were then identified to lowest practical taxon and enumerated by FCETL personnel using methods described in Pennak (1978) and Merritt and Cummins (1978). The mean organism density and total number of taxa per sample replicate were determined. The Shannon-Wiener (Weaver) Diversity index was calculated for each replicate and for the mean density per location using the following equation:

$$H' = (N \log N - n_i \log n_i)/N$$

Where: H' = Shannon-Wiener Diversity Index
N = Total abundance
n_i = Abundance of each taxon

Taxonomy data sheets are included in Attachment 4 to this report. A reference collection containing representative organisms from each taxon identified was prepared from the samples and archived at the FCETL.

2.3 Opportunistic Sampling

Opportunistic sampling of soil, vegetation, sediment, and surface water was performed at areas away from the river to provide preliminary information about the extent and magnitude of potential impacts elsewhere within the study area. Sampling locations were selected based on site features and biased in an attempt to sample locations with the greatest potential for impact. Samples of surface soil, vegetation, sediment and surface water were collected from the NWV, SWV, and the NEV.

2.3.1 Soil and Vegetation

Sample locations selected within each area are shown on Figure 2-1. Vegetation and corresponding soil samples were collected from 13 NWV locations, 11 SWV locations and 2 NEV locations. Soil samples were collected from a depth of 0 to 8 inches after the removal of loose organic matter from the surface, if present. Additional vegetation samples were collected from two ponds in the NWV. Procedures used to collect soil and vegetation samples are described in the TWP Attachment 1.

2.3.2 Sediment and Surface Water

Two sediment and one overlying water samples were collected from each of two ponds in the NWV (Pond 1 and Pond 2 on Figure 2-1).

2.3.3 Reference Samples

Soil and vegetation samples were collected from three locations in the Sweetwater River flood plain approximately 3 miles west of the site. These locations are assumed to be outside the potentially impacted area (REF1, REF2 and REF3 on Figure 2-1).

2.3.4 Sample Analysis

Some samples collected from each of the three areas were submitted to Energy Laboratories for radionuclide analysis and to CAS for analysis of metals. Samples that were not submitted for analysis were held pending the results of the initial round of analysis. Samples were selected based on their potential for impact due to site features and their proximity to the source. The location of the samples collected and those submitted for analysis are shown on Figure 2-2 and 2-3. The samples submitted for analysis are also identified in Table 2-2.

2.4 Deviations from the Task Work Plan

Surface soil samples were generally collected according to the SOPs presented in Appendix A to the TWP. The following exceptions were documented during the field effort.

SOP 3170 indicated that surface soil samples would be collected by digging three 12-inch square pits. Instead, a single round pit approximately 8 inches deep and 10 inches in diameter was dug and a single bowl was placed in the pit. Samples were collected by scraping soil from around the entire pit. The original SOP was designed for collection at CERCLA sites and was excessively cautious for the needs of this EA.

The soil scraped into the bowl was mixed; however, coarse fragments were not removed as stated in SOP 3170 because the sample analysis to be used included entrainable metals and leachable metals.

Soil pH was measured following the procedures stipulated in SOP No. 3204, however, rather than measure soil pH in the field, the samples were stored at $4^{0}C$ until all samples could be measured at one time.

Vegetation samples were collected for analysis of radionuclides and metals. The vegetation samples included a variety of sagebrush, shrubs, and grasses, as well as, vegetation from ponds located in the vicinity of the Split Rock Site. Sampling procedures for metals followed SOP No. 3160.

Energy Laboratories indicated that they needed a much higher volume of material for radionuclide analysis than the amount stipulated in the SOP. The laboratory-required target volume for vegetation samples for radionuclide analysis was approximately 17 pounds wet weight. Each sample container was filled with the same variety of vegetation as that collected for the metals analysis.

Sediments from ponds were collected by compositing three samples in each location. Each composite consisted of approximately a 10 cm depth cross-section of the sediment and was collected using a stainless steel spoon rather than a dredge, as the pond was relatively shallow.

Decontamination of the Ekman dredge followed the SOP with the exception of the acid rinse. The acid would have corroded the surface of the dredge; therefore, this step was eliminated.

Table 2-1
Field Measurements – Sweetwater River

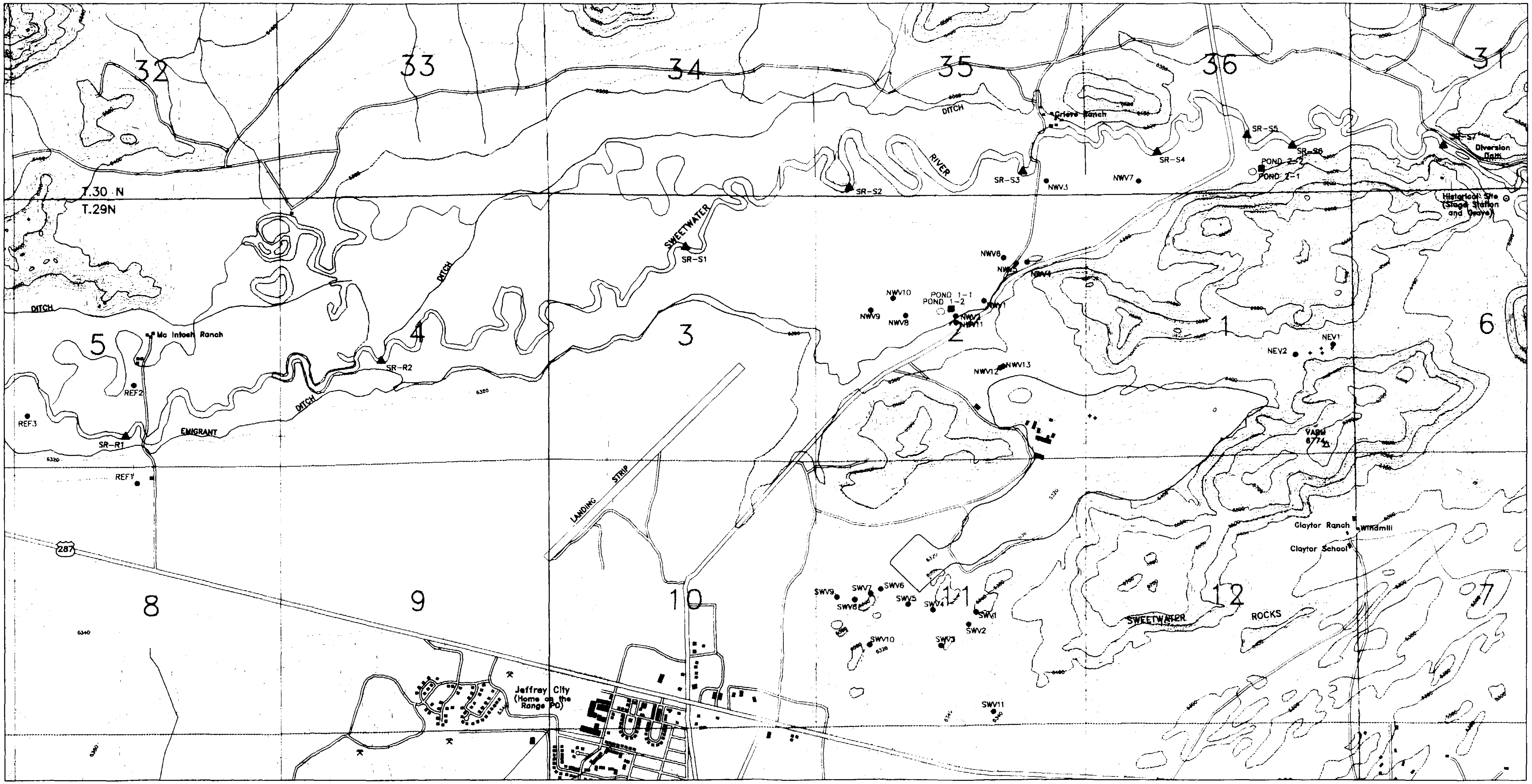
Parameter	LOCATION								
	SR-R1	SR-R2	SR-S1	SR-S2	SR-S3	SR-S4	SR-S5	SR-S6	SR-S7
Stream Width (ft)	41	51	59	52	42	44	40.5	35	77
Stream Depth (in)	6	8	8	7	8	12	6	12	18
Stream Flow (cfs)	50.52	34.02	41.52	64.82	58.62	35.80	53.50	41.02	43.72
pH	8.4	8.8	8.7	8.5	7.7	8.1	8.6	8.6	8.2
Temperature (°C)	10	9	8	10	7	10	10	11	7
Dissolved Oxygen (mg/L)	8.9	8.9	9.4	10.0	8.3	8.5	9.5	9.0	8.8
Conductivity (µS/cm)	285	287	298	350	303	302	320	330	306

Notes:
Cfs = cubic feet per second
µS/cm = Microsiemens per centimeter

Table 2-2
Summary of Opportunistic Samples Submitted for Laboratory Analysis

Location	Soil Samples	Vegetation Samples	Sediment Samples	Surface Water
Southwest Valley	SWV1, SWV3, SWV5, SWV7, SWV10	SWV1-SWV9 (metals analysis) SWV1-SWV7 (radionuclide analysis)	None Collected	None Collected
Northwest Valley	NWV1, NWV2, NWV4, NWV5, NWV6, (+ replicate), NWV10, NWV13	NWV1, NWV3	None Collected	None Collected
Northeast Valley	NEV1	NEV1	None Collected	None Collected
Reference	REF1	REF1, REF2, REF3	None Collected	None Collected
Ponds	NA	Pond 1-1 Pond 2-2	Pond 1-1, 2 Pond 2-1, 2	Pond 1-1 Pond 2-1

NA = Not applicable



LEGEND

- • SAMPLING LOCATIONS (SOIL, VEGETATION)
- ■ SAMPLING LOCATIONS (SEDIMENT, SURFACE WATER, VEGETATION)
- ▲ RIVER SAMPLING LOCATIONS

SCALE IN FEET

2000 0 4000

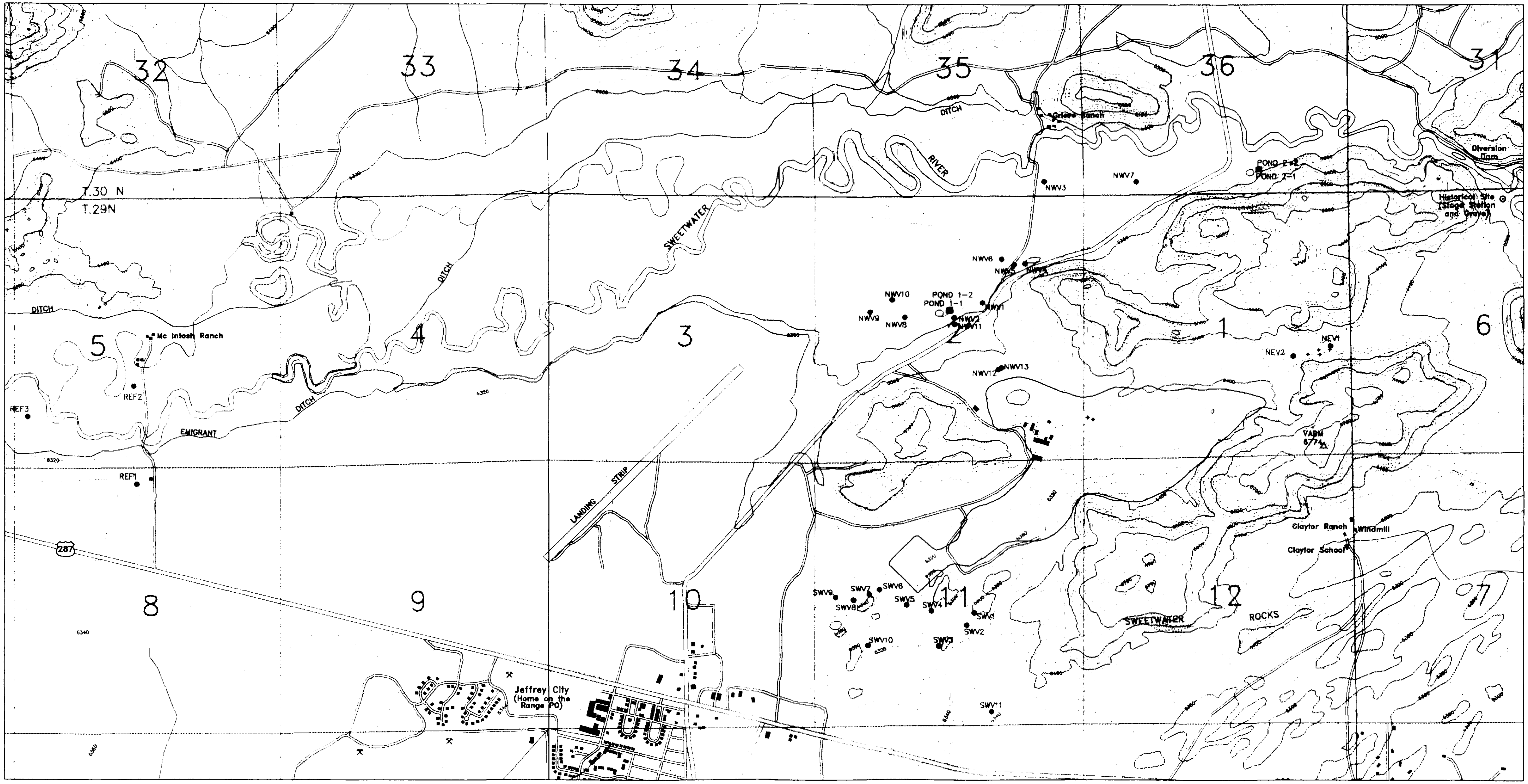
N

FIGURE 2-1
SPLIT ROCK SITE
SAMPLE LOCATIONS

SHEPHERD MILLER INCORPORATED

Project:	03-347/T13
File:	SAMPLE-1.DWG

Date: 06/L
Time: 08:25:40.18



LEGEND

- • SURFACE SOIL SAMPLING LOCATIONS
- ▪ POND SEDIMENT SAMPLING LOCATIONS
- • ▪ SAMPLES ANALYZED

SCALE IN FEET

2000 0 4000

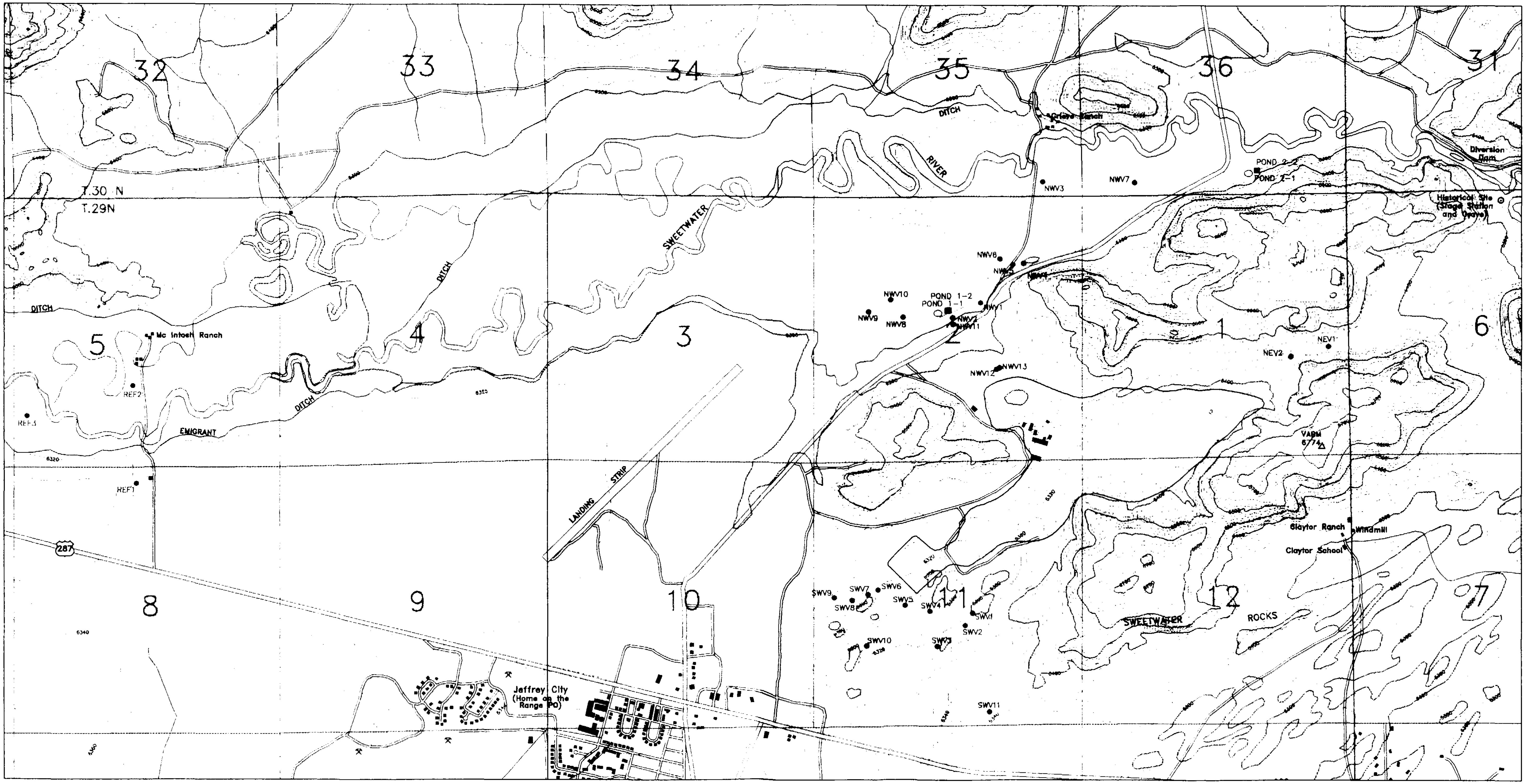
N

FIGURE 2-2
SPLIT ROCK SITE
SOIL/SEDIMENT SAMPLES ANALYZED

SHEPHERD MILLER
INCORPORATED

Project:	03-347/T13
File:	SAMPLE-2.DWG

Filename: 347\TASK13\SAMPLE-2.dwg
Date: 1999
Time: 14:12



LEGEND

- • VEGETATION SAMPLING LOCATIONS
- ■ POND SAMPLING LOCATIONS
- •■ SAMPLES ANALYZED (NOTE: SWV8 & SWV9 ONLY SUBMITTED FOR METAL ANALYSIS)

SCALE IN FEET

2000 0 4000

N

FIGURE 2-3
SPLIT ROCK SITE
VEGETATION SAMPLES ANALYZED

SHEPHERD MILLER INCORPORATED

Project: 03-347/T13

File: SAMPLE-3.DWG

Filename: E:\ 7\TASK13\SAMPLE-3.dwg
Date: 06 99
Time: 08:41:26.69

3.0 SWEETWATER RIVER SAMPLING RESULTS

3.1 Introduction

Various analyses were conducted on the samples that were collected from the Sweetwater River. These analyses included:

- Measurement of the physical and chemical characteristics of the surface water and sediment
- Toxicity testing and statistical analyses of various endpoints pertaining to aquatic species
- Fish population distribution patterns
- Quantitative and qualitative analyses of benthic macroinvertebrates including total density, mayfly density, taxa, Ephemeroptera, Plecoptera, and Trichopetera (EPT), mayfly taxa, EPT ratio, Shannon-Wiener diversity, and Shannon evenness
- Characterization of benthic communities.

3.2 Surface Water and Sediment Physical and Chemical Characteristics

3.2.1 Surface Water Chemistry

Analytical results demonstrated consistency between constituent concentrations measured at the two surface water sample locations (SR-S3 and SR-S7) and the upstream reference location (SR-R1)(Table 3-1). Laboratory water quality measurements (hardness, alkalinity, conductivity, pH) also remained nearly constant across all sites evaluated (Table 3-2). Detection limits are shown in Table 3-1 next to each chemical constituent associated with a non-detect value.

In terms of absolute measurements, most surface water constituent concentrations were well below applicable freshwater chronic criteria (Table 3-1). Copper, cadmium, lead, molybdenum, nickel, selenium, and silver were not detected. Measured detected concentrations of arsenic, iron, manganese, uranium, and zinc did not vary significantly from reference locations. The concentrations ranged from as low as 1.5% to as high as 50% of the respective freshwater chronic criteria for aquatic life. No WDEQ criterion exists for uranium; however, Parkhurst et al. (1984) reported a median lethal concentration (LC_{50}) for brook trout of between 5.5 to 23 mg/L, which is three orders of magnitude greater than the concentrations measured in the Sweetwater River. Using methodology suggested by USEPA Region 8 an aquatic benchmark was derived for uranium, based on the Parkhurst et al. (1984) data. The derived benchmark for chronic exposure is 2.27 mg/L at a hardness of 100 ppm, similar to the Sweetwater River. All measured uranium concentrations were well below this benchmark. The methodology is provided in Attachment 5.

Radium-228 was measured at location SR-S3 at a concentration twice the reference site concentration; however, all radionuclide concentrations are less than or equal to 1% of the radiological benchmark value.

Based on the data presented in Tables 3-1 and 3-2, surface water within the portion of the Sweetwater River directly north of the Site may be characterized as being of high quality-that is, this surface water will not likely adversely impact the aquatic system.

3.2.2 Sediment Grain Size

A split of the sediment samples used to conduct toxicity tests were submitted for determination of weight fraction grain size. Knowledge of grain size may assist in the characterization of the contaminant distribution. Generally, contaminants tend to bind to fine silty sediments and not to coarse materials. Data reports for these analyses are included in Attachment 6. A summary of the average sediment grain size (average obtained for the three replicates) for each transect location is provided in Table 3-3. To compare grain size statistically, grain size for each replicate was divided into three groups: (1) >850 μm, (2) 212 to 849 μm, and (3) <212 μm. The means for each site were then statistically analyzed using Tukey's multiple comparison test ($p = 0.05$) (West and Gulley 1994). The results of these analyses indicated that grain size was not significantly different at any of the sampling locations.

3.2.3 Sediment Chemistry

Average sediment concentrations obtained for each sampling location are provided in Table 3-4. Chemical data were statistically analyzed using Toxstat 3.4 (West and Gulley 1994). If data met parametric assumptions then parametric analysis of variance (ANOVA) and Tukey's multiple range test were used. If data did not meet parametric assumptions then Kruskal-Wallis and Dunn's test were used. Of the chemicals analyzed, statistically significant differences were only observed for total iron, total manganese, and thorium-230. The statistical results for these three chemicals are summarized in Table 3-5 and in Figures 3-1, 3-2, and 3-3.

The iron concentration measured at SR-S2 was statistically different (greater) than that at reference location SR-R2, being 1.5 times greater than the SR-R2 concentration; however, the SR-R1 and SR-S2 iron concentrations were not statistically different. Manganese concentrations from location SR-S2 were statistically different from concentrations at the reference locations.

The manganese concentration at SR-S2 was 5 times greater than the manganese concentrations at both the reference locations. The thorium-230 concentration in sediment at SR-R1 was statistically higher than at the two locations furthest downstream (SR-S6 and SR-S7).

Environmentally acceptable freshwater sediment criteria/guidance values from Ingersoll et al. (1996) that represent probably effects levels (PELs) are compared with sediment concentrations from the Sweetwater River in Table 3-4. Sediment metal concentrations measured in the Sweetwater River were well below the PELs, indicating that impacts to the aquatic environment have not likely occurred. Based on the sediment chemistry results, the operation of the Split Rock Mill has not adversely impacted the Sweetwater River.

3.3 Toxicity Testing

Whole sediment toxicity tests were conducted on samples collected from transect locations along the Sweetwater River. Data reports, including copies of the laboratory benchsheets, are included in Attachment 3. For reference, the results of the toxicity tests, averaged across the three replicate sampling locations collected at each sampling site, are summarized in Tables 3-6 (*Ceriodaphnia dubia*) and 3-7 (*Hyalella azteca*). These same data are presented graphically in Figures 3-4 and 3-5.

Toxicity test data were statistically analyzed using parametric or non-parametric tests, depending on the homogeneity and variance of the data. If the data were homogeneous and had equal variance, Tukey's test (parametric) for multiple comparisons was used. Conversely, if the data were not homogeneous or had unequal variance, the Kruskal-Wallis test (non-parametric) for multiple comparisons was used. These methods were used to identify significant differences in organism performance among transect locations; i.e., these analyses were conducted on mean values for the three replicate sediment samples collected at each transect. Statistical differences are summarized in Tables 3-6 and 3-7 and in Figures 3-4 and 3-5, and the results are discussed below.

3.3.1 Ceriodaphnia dubia

3.3.1.1 Survival Percentages

Survival percentages for the reference and downstream locations ranged from 90% to 100%, with the single exception of SR-S6 (77% survival). Although the survival percentage at SR-S6 appears to be lower, no statistically significant differences were detected among survival rates for any of the sampling locations, giving no indication of adverse impacts to the Sweetwater River attributable to Split Rock Mill operations.

3.3.1.2 Reproduction

With the exception of samples collected from SR-S6 (minimum) and SR-S5 (maximum), *Ceriodaphnia dubia* reproduction was generally consistent among the nine sites tested. Mean reproduction at SR-S6 was significantly less than that observed at SR-R2 and in SR-S1 through SR-S5, but not significantly less than that observed at SR-S7 (see Figure 3-4). Reproduction at SR-S5 was significantly greater than that at SR-R1, SR-S6, and SR-S7.

No trends corresponding to proximity to the Site were evident in these data. These results, thought less conclusive than the *Ceriodaphnia dubia* survival data, do not necessarily indicate that adverse impacts to the Sweetwater River have occurred that are attributable to previous Split Rock mill Site operations. Regression analyses between *Ceriodaphnia dubia* endpoints and sediment chemical data showed no strong correlations (Attachment 7).

3.3.2 Hyalella azteca

3.3.2.1 Survival Percentages

Survival percentages in Sweetwater River sediment samples (reference and downstream) were low (27% to 69%; see Figure 3-5) in comparison to concurrent tests conducted with laboratory control sediment (81% to 95%; see Attachment 3). Although survival percentages in the Sweetwater River samples were reduced relative to that observed in the laboratory controls, no statistically significant reduction in *Hyalella azteca* survival percentages were detected for any of the downstream locations, when compared with the reference locations jointly (Figure 3-5). Among all the tests conducted, the minimum survival percentage was observed in SR-R2 samples. The survival percentage in SR-R2 was significantly reduced compared to that observed in SR-R1, SR-S2, and SR-S3 sediment samples. Again, no trends corresponding to proximity to the Site were evident in the data; these results by themselves do not indicate that adverse impacts attributable to the Site have occurred.

3.3.2.2 Growth

Hyalella azteca growth is a relatively insensitive endpoint due to the poor precision when measuring weights less than 0.001 mg. After evaluating these data, no statistically significant differences were detected among pooled organism weights for any of the sampling locations tested (Table 3-7, Figure 3-5). Regression analyses between *Hyalella azteca* endpoints and sediment chemical data show no strong correlations (Attachment 7). Therefore, this endpoint did not provide any indication of adverse impacts to the Sweetwater River attributable to Split Rock Mill Site operations.

3.4 Fish Population Distribution Patterns

The extent of effort required to collect the number and biomass of fish necessary for tissue residue analyses provides a qualitative measure of fish distribution patterns within the portion of the river that was sampled. The collection time and travel distance required to collect three to four suitably sized (20 to 40 cm) trout were recorded at each location, as follows:

Location	Time Required (hours)	Distance Traveled (miles)
SR-R1	0.75	0.5
SR-S2	0.75	0.25
SR-S4	0.50	0.17
SR-S7	0.58	0.28

Time and distance parameters were essentially consistent across the four locations, indicating no apparent avoidance by fish of stream habitat potentially influenced by Site operations. Any slight differences between locations are likely a function of habitat or other physical constraints within the river. The number, species, and physical characteristics of the fish collected from the Sweetwater River are shown in Table 3-8.

The results of laboratory analysis of fish tissue are discussed in Section 4.4.

3.5 Benthic Macroinvertebrate Analysis

Benthic macroinvertebrate samples were collected at each of the sampling locations. Three quantitative and one qualitative sample were evaluated for the number of organisms present in each taxon. Summary tables of all the benthic data are presented in Attachment 4. For each quantitative sample, the density of organisms was calculated (number/m^2) along with the number of taxa. Several other indices, or metrics, are important in the evaluation of benthic macroinvertebrate data. These indices are listed on the tables in Attachment 4, include mayfly, stonefly, and caddisfly density and taxa, EPT (the sum of these three insect orders) density and taxa, EPT: Chironomid ratio (EPT: C ratio), Shannon diversity, and Shannon evenness. The qualitative sample was evaluated only for the taxa in each sample. These parameters are summarized in Table 3-9.

The quantitative samples were statistically compared among all locations to determine if significant (α=0.05) differences occurred. If the data were homogenous and had equal variance, parametric analysis of variance accompanied by Tukey's multiple range test was used. Some of the data sets were transformed to meet the requirements of parametric analysis; transformations consisted of log, natural log, or square root transformations. If the data did not meet the assumptions for parametric analysis, even after transformation, nonparametric analyses were conducted using the Kruskal-Wallis test with Dunn's multiple range test.

Although there was significant variation in the number of taxa present at the different sites, some taxa tended to occur at all or most locations. *Dubiraphia*, a riffle beetle commonly found in fast-flowing lotic systems, was present at all sites (although not always in the quantitative samples). Common mayflies include *Baetis*, *Stenonema*, *Leptophlebia*, and *Tricorythodes*. Hydropsychidae, the family of net-spinning caddisflies, was well-represented at most sites by *Hydropsyche*.

Density varied considerably among locations (Figure 3-6). Mean density (or abundance) ranged from over 5,000/m^2 at SR-S7 (Table 3-9). Density generally declined going from the upstream to the downstream locations, although density at SR-S2 and SR-S3 was higher than at SR-S1 or SR-R2. EPT and mayfly density patterns were generally similar to the total density pattern. The presence of these three orders are generally considered to be indicative of good water quality conditions (United States Environmental Protection Agency [USEPA] 1989). Mayflies, in particular, have been shown to be sensitive to pollutants, especially metals (Kiffney and Clements 1994).

Like density, the number of benthic macroinvertebrate taxa identified was greater at the upstream locations (Figure 3-7). SR-S2 had the greatest number of taxa, with 27, while only half that number were identified at SR-S5. At SR-S1 through SR-S3 and SR-S1 and SR-R1 and SR-R3, most of all of the taxa identified at the site were included in the quantitative sample, indicating that distribution of benthos was relatively uniform and the stream, at that location, was fairly homogenous. At the downstream sites, however, not only did the number of taxa decrease, but a larger proportion was collected in the qualitative sample. The proportion of EPT taxa also decreased in the downstream sites (SR-S4 through SR-S7).

A comparison of the density of EPT to chironomids, (EPT:C ratio) is often a useful indicator of stream condition. The EPT:C ratios were very high at SR-R1 and SR-R2 and SR-S2 (Figure 3-8). EPT:C ratios were less than 5 for all other sites. The lower ratios suggest that, because hironomid abundance is increasing relative to EPT, stream quality is decreasing. This does not, however, necessarily indicate decreasing water quality of the presence of toxicants, since other factors can affect organism abundance, as described in Section 3.6.

Shannon (or Shannon-Wiener) diversity and evenness indices were also calculated (using the natural log) using the quantitative benthic macroinvertebrate data (Figures 3-9 and 3-10). The Shannon diversity index increased from 1.57 at SR-R1 to a maximum of 2.15 at SR-S3. The index then decreased again to a minimum of 1.52 at SR-S7. Evenness, which compares the Shannon diversity index to a theoretical maximum, increased going downstream. The closer the evenness index is to 1, the more evenly distributed the benthic organisms are among the taxa present. The minimum evenness was at SR-R1 (0.52); the maximum evenness was at SR-S7 (0.78).

In conclusion, statistically significant (α=0.05) differences were found among locations for total, EPT, and mayfly density and total, EPT, and mayfly taxa (Table 3-10). No significant differences were found for the EPT:C ratio, Shannon diversity, or Shannon evenness. For both density and taxa, there were generally differences among the farthest upstream and the farthest downstream locations. For total density, for example, SR-R1 was significantly different from SR-S4 through SR-S7; SR-R2 and SR-S1 through SR-S3 were significantly different from SR-S7 only. The greatest dichotomy occurred with EPT taxa, where SR-R1 and SR-S2 and SR-S3 values were significantly different from SR-S4 through SR-S7 values, and only two locations, SR-R2 and SR-S1, were not significantly different from any other location.

3.6 Characterization of Benthic Communities

The results of the benthic macroinvertebrate data analysis demonstrate that there are significant and substantial differences in benthic community structure between the upstream reference locations and the two farthest downstream locations (SR-S6 and SR-S7). While changes in biotic communities can sometimes be correlated with toxicants, physical habitat characteristics are often more important in determining benthic population structure. Benthic community parameters were compared against sediment chemistry, grain size analysis, substrate type, and water velocity data using simple and stepwise multiple regression modeling. When benthic taxa data were regressed against sediment chemical data, iron, and to a lesser extent uranium, were identified as being significant predictors of the number of taxa. The correlation with iron was positive (i.e., taxa increased with increasing iron concentrations) while the correlation with uranium was negative (i.e., taxa decreased with increasing uranium concentrations). The r^2 value with iron alone was 0.66; it increased to 0.85 with uranium. The number of EPT taxa was also correlated with iron (r^2=0.60), 850-μm sediment (r^2=0.78), and 212-μm sediment (final r^2=0.90). Other benthic parameters were positively correlated with sediment thorium-230 concentrations.

Despite the apparent correlation of some benthic parameters with some sediment chemical data, the relationships are likely indirect at best and do not represent an actual cause-and-effect relationship. The results of laboratory toxicity test using know sensitive invertebrates showed no relationship to sediment chemical data, and, in the cases of thorium-230 and iron, increasing concentrations seemed to be related to a healthier benthic community. Previous experience on similar projects has shown that it is often habitat factors that control benthic macroinvertebrate abundance, particularly the availability of desirable substrate and food.

Field measurements included stream discharge, cross-sectional area, and substrate condition (e.g., percent cobble, coarse sand, and fine sand). Substrate measurements were made at each site where a replicate benthic sample was collected (Table 3-11). Water velocity was calculated from stream discharge and cross-sectional area. Using substrate condition measurements as independent variables in stepwise regression modeling, the percentage of sand or coarse gravel was selected as the variable that best explained the variation in several parameters, including EPT taxa, and density and total taxa. The resulting regression coefficients explained substantially less than 50% of the observed variability in the benthic data (Table 3-12).

When mean benthic density and taxa measurements were correlated with water velocity, the resulting r^2 values were not particularly high (Table 3-12). However, a plot of flow versus density and number of taxa clearly show that, with the exception of SR-S5, a strong correlation exists (Figures 3-11 and 3-12). SR-S5, which is directly below a road, has low benthic density and number of taxa, but also has high water velocity. When SR-S5 data are excluded from the dataset, the amount of benthic data variance explained by water velocity improves substantially (Table 3-12). Including water velocity in the replicate dataset (assuming equal water velocity across the river) and conducting additional stepwise regression analysis (without SR-S5 data) substantially improves the regression coefficient further (Table 3-12). In all cases, water velocity was the only variable that provides a significant improvement in the regression model.

There was a substantial change in the physical habitat in the downstream sample locations. Water velocity generally decreases, the percentage of cobble and gravels decreases, and the percentage of sand and silt increases. Many of the organisms found at the upstream locations are typical of clear-running lotic systems with relatively high water velocity. Net-spinning caddisflies (*Hydropsychidae*) are one group that are especially dependent upon water velocity to keep organic particles suspended so they may be eaten. In addition, these and other invertebrates require hard, consolidated substrates for net and case construction and, for scrapers, formation of aufwuch (attached flora and fauna).

Water velocity accounts for a substantial portion of the variation in the benthic data. Because only a single water velocity value was calculated for a single location, across-stream differences in velocity were not taken into consideration. It was apparent during field collection that conditions were not consistent across a single location. There were variations in water velocity and, subsequently substrate type. For example, at SR-S6 there was an estimated 35% coarse gravel at the location where the first replicate was collected but only 5% coarse gravel at the locations where replicates 2 and 3 were collected. Benthic macroinvertebrate densities in the three replicates were 500, 174, and 58 organisms/m^2, respectively.

SR-S5 did not follow the pattern of benthic density and diversity apparent at the other sites, although the low density of benthos in Replicate 3 is probably directly associated with the presence of 100% sand at that replicate location. It is possible that the water discharge, and therefore the velocity, measured at that site may have been overestimated. The location had recently been disturbed by wildlife or livestock that may have destroyed some invertebrates and caused others to drift. Downstream drift of upstream benthos may not have yet reestablished the benthic populations. Since the other sites, both upstream and downstream, clearly adhere to the water velocity model, there is no reason to believe that SR-S5 benthic populations have been impacted by chemical factors.

In conclusion, benthic macroinvertebrate populations were significantly different between the upstream and downstream locations. There were substantial differences both in the diversity of organisms and in their densities. These differences can be closely linked to habitat, predominantly the percentages of substrate types and water velocity. No evidence of chemical impacts could be identified.

3.7 Summary of Results for the Sweetwater River

This section summarizes the results of Sweetwater River sample analysis. The results are summarized by sampling locations.

SR-S1 and SR-S3. No statistically significant differences, relative to reference locations, were detected among the three types of assessment endpoints. No potential for ecological risk was indicated.

SR-S2. Concentrations of iron and manganese in sediment samples were statistically higher than those measured in reference samples. These concentrations, however, were far below published PELs and would therefore not cause adverse toxicological effects. Statistical differences were not detected for toxicity data or benthic community indices. Therefore, the Site operations have not adversely affected the Sweetwater River ecosystem.

SR-S4, SR-S5, and SR-S7. Statistically significant decreases in benthic community indices, relative to upstream reference sites, were detected. However, differences between upstream and downstream locations appear to be a function of changing physical conditions in the stream. No relationship between community measurements and chemical or toxicological impacts was suggested; thus, the Site operations have not adversely affected the Sweetwater River ecosystem.

SR-S6. Sediment toxicity and impacts to benthic communities were observed. However, no relationship to sediment chemistry was detected. Single linear regression analyses between toxicity and each chemical/physical endpoint analyzed (e.g., sediment metals concentrations, sediment radionuclide concentrations, and grain size) revealed no significant correlations.

Stepwise regression analyses confirmed this result. Also, no statistically significant differences between reference location and SR-S6 sediment chemical parameters were detected. Based on these combined results, the Site operations have not adversely affected the Sweetwater River ecosystem.

Table 3-1
Summary of Sweetwater River Surface Water Data

Chemical/Parameter	LOCATION				
ENSR location name	SR-R1	SR-S3	SR-S3 (dup)	SR-S7	
Database location name	R-1	ENSR-S-3	ENSR-S-3 (dup)	ENSR-S-7	
Sample Date	10/19/95	10/18/95	10/18/95	10/17/95	Freshwater
Sample ID	R-1-SW-01-951019	S-3-SW-01-951018	S-8-SW-01-951018	S-7-SW-01-951017	Chronic
Lab ID	95-59287	95-59285	95-59283	95-59282	Criteria[a]
Calcium (mg/L)	34.3	36.2	36.3	36.3	NA
Chloride (mg/L)	6.5	7.7	8.6	8.6	230
Dissolved Organic Carbon (mg/L)	3	<2	3	3	NA
Fluoride (mg/L)	0.19	0.21	0.2	0.21	NA
Nitrate + Nitrite (mg/L)	<0.1	<0.1	<0.1	<0.1	NA
Ammonium (mg/L)	<0.1	<0.1	<0.1	<0.1	NA
Phosphorus (mg/L)	<0.1	<0.1	<0.1	<0.1	NA
Potassium (mg/L)	4.2	4.4	4.4	4.4	NA
Magnesium (mg/L)	6.7	7	7	7	NA
Silica (mg/L)	14.8	15.5	15.7	15.8	NA
Sodium (mg/L)	14.8	17.2	17.4	17.7	NA
Sulfate (mg/L)	37.4	39.6	40.5	40.4	NA
Total Dissolved Solids (mg/L)	174	188	195	197 JE	2000[f]
Arsenic (mg/L)	0.003	0.002	0.003	0.003	0.19
Cadmium (mg/L)	<0.007	<0.007	<0.007	<0.007	0.0011[b]
Copper (mg/L)	<0.003	<0.003	<0.003	<0.003	0.012[b]
Iron (mg/L)	0.24	0.22	0.21	0.2	.1
Lead (mg/L)	<0.002	<0.002	<0.002	<0.002	0.0032[b]
Manganese (mg/L)	<0.01	<0.01	<0.01	0.03	0.0120[e]
Molybdenum (mg//L)	<0.05	<0.05	<0.05	<0.05	0.88[e]
Nickel (mg/L)	<0.008	<0.008	<0.008	<0.008	0.160[b]
Selenium (mg/L)	<0.003	<0.003	<0.003	<0.003	0.005
Silver (mg/L)	<0.003	<0.003	<0.003	<0.003	0.004[c]
Uranium, Natural (mg/L)	0.003	0.003	0.003	0.004	2.27[e]
Zinc (mg/L)	0.02	0.02	0.02	0.03	0.11
Radium-226 (pCi/L)	<0.2	0.4	0.4	<0.2	400[d]
Radium-228 (pCi/L)	1.2	3	2.8	1.4	300[d]
Thorium-230 (pCi/L)	<0.4	<0.4	<0.4	<0.4	400[d]
Uranium-234 (pCi/L)	NC	NC	NC	2.4	4000[d]
Uranium-235 (DL = 0.2 pCi/L)	NC	NC	NC	<0.2 JL	4000[d]
Uranium-238 (pCi/L)	NC	NC	NC	1.8	4000[d]

DL = Detection Limit, NC = Not conducted, NA = Not Available

JE = reported value is estimated due to exceedance of holding time limit; JL = reporting limit is estimated due to laboratory blank cont

[a]Wyoming Department of Environmental Quality (WDEQ) criteria unless otherwise noted

[b]Assumes hardness = 100 mg/l as $CaCO_3$

[c]Aquatic Life Acute Value using 100 mg/L hardness

[d]Radiological Benchmarks from Rocky Flats (DOE 1996)

[e]Value is derived from Parkhurst et al 1994 (see Attachment 1)

[f]WDEQ Special Fish and Aquatic Life Concentration

Table 3-2
Laboratory Water Quality Measurements – Sweetwater River

SITE	Hardness (mg/L as $CaCO_2$)	Alkalinity (mg/L as $CaCO_3$)	Conducitivity (µS/cm)	pH (standard units)
SR-R1	100	90	278	8.2
SR-R2	100	92	285	8.4
SR-S1	100	94	287	8.4
SR-S2	106	97	288	8.4
SR-S3	106	98	295	8.1
SR-S4	106	97	299	8.4
SR-S5	108	95	301	8.3
SR-S6	104	98	302	8.3
SR-S7	104	98	300	8.2

Note: Measurements conducted at the Fort Collins Environmental Toxicology Laboratory.

Table 3-3
Results of Sediment Grain Size Analyses – Sweetwater River

Site	Mean Grain Size (% mass removed by the sieve size listed) ± Standard Deviation							
	2000 µm	850 µm	600 µm	425 µm	212 µm	106 µm	45 µm	<45 µm
SR-R1	78.35 ± 5.12	11.33 ± 3.11	3.7 ± 0.55	2.45 ± 0.62	2.75 ± 1.74	0.89 ± 0.49	0.39 ± 0.13	0.15 ± 0.03
SR-R2	76.27 ± 9.86	14.06 ± 6.02	3.89 ± 2.07	2.39 ± 1.32	2.50 ± 0.54	0.65 ± 0.09	0.16 ± 0.12	0.08 ± 0.04
SR-S1	76.33 ± 7.21	10.36 ± 0.49	3.62 ± 1.11	2.67 ± 1.02	4.00 ± 2.38	1.74 ± 2.22	1.02 ± 1.46	0.25 ± 0.35
SR-S2	75.52 ± 6.36	12.25 ± 2.14	3.81 ± 1.52	2.25 ± 1.12	3.34 ± 1.53	1.65 ± 1.11	0.91 ± 0.82	0.26 ± 0.20
SR-S3	48.88 ± 42.31	21.49 ± 12.61	10.73 ± 14.27	8.25 ± 12.06	7.19 ± 6.14	2.10 ± 0.14	1.13 ± 0.69	0.24 ± 0.14
SR-S4	68.13 ± 20.60	17.26 ± 13.76	4.46 ± 3.92	2.95 ± 2.41	3.98 ± 3.20	2.09 ± 0.99	0.91 ± 0.47	0.22 ± 0.12
SR-S5	50.75 ± 30.56	25.32 ± 23.02	9.07 ± 7.46	6.03 ± 3.07	6.67 ± 2.15	1.69 ± 1.97	0.31 ± 0.48	0.09 ± 0.06
SR-S6	46.63 ± 31.09	29.42 ± 15.54	8.9 ± 7.93	6.30 ± 5.93	6.68 ± 5.16	1.34 ± 0.26	0.57 ± 0.18	0.15 ± 0.02
SR-S7	21.13 ± 20.00	34.42 ± 16.28	18.61 ± 14.70	11.66 ± 10.34	8.15 ± 6.74	3.26 ± 2.52	2.37 ± 1.77	0.39 ± 0.26

Note: Mean and standard deviation based on three replicates for each sample location.

Table 3-4
Summary of Sediment Chemical Analyses – Sweetwater River
(Mean ± Standard Deviation)

Chemical	DL	PEL	Location								
			SR-R1	SR-R2	SR-S1	SR-S2	SR-S3	SR-S4	SR-S5	SR-S6	SR-S7
Arsenic (mg/kg)	0.5	48	1.8 ± 0.6	2.1 ± 0.8	2.7 ± 0.7	3.6 ± 3.0	1.9 ± 0.4	1.2 ± 0.2	2.9 ± 1.1	2.0 ± 0.8	1.7 ± 0.3
Cadmium (mg/kg)	0.02	32	0.02 ± 0.01	0.02 ± 0.00	0.02 ± 0.01	0.06 ± 0.03	0.1 ± 0.06	0.09 ± 0.10	0.03 ± 0.01	0.05 ± 0.03	0.02 ± 0.00
Copper (mg/kg)	0.05	100	2.23 ± 0.45	1.90 ± 0.63	2.75 ± 0.84	3.36 ± 1.68	1.64 ± 0.49	1.71 ± 0.55	2.02 ± 1.00	1.33 ± 0.17	1.44 ± 0.49
Iron (mg/kg)	4	250,000	4630 ± 2487	3143 ± 876	2863 ± 915	7087 ± 1120	3577± 988	4603 ± 1485	2893 ± 1142	3140 ± 924	3140 ± 370
Lead (mg/kg)	0.02	55	3.49 ± 1.14	3.12 ± 1.48	2.98 ± 0.62	2.48 ± 0.45	2.00 ± 0.77	1.82 ± 0.21	3.08 ± 1.64	1.87 ± 0.61	1.52 ± 0.28
Manganese (mg/kg)	0.5/1.0	1,200	68 ± 9.30	78 ± 11	132 ± 36	405 ± 297	117 ± 32.90	76 ± 8.70	186 ± 58.80	72 ± 18	131 ± 125
Molybdenum (mg/kg)	1.0	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nickel (mg/kg)	0.2	24	2.5 ± 0.4	2.8 ± 1.1	3.0 ± 0.9	3.1 ± 1.8	1.9 ± 0.4	2.0 ± 0.8	2.2 ± 0.06	1.6 ± 0.05	1.8 ± 0.3
Selenium (mg/kg)	0.5	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
Silver (mg/kg)	0.02	3.7	ND	ND	ND	ND	ND	ND	ND	ND	ND
Uranium (mg/kg)	0.03	1,200[a]	0.73 ± 0.03	1.16 ± 0.11	0.64 ± 0.01	1.01 ± 0.04	1.04 ± 0.07	1.19 ± 0.10	1.18 ± 0.01	1.36 ± 0.10	1.22 ± 0.13
Zinc (mg/kg)	0.5	110	5.3 ± 1.6	5.7 ± 1.7	6.7 ± 2.0	5.2 ± 1.2	4.6 ± 0.3	4.7 ± 0.7	5.7 ± 1.3	4.2 ± 0.2	5.5 ± 1.6
Radium-226 (pCi/g)	0.02	4E+05[a]	1.00 ± 0.01	0.63 ± 0.03	0.60 ± 0.01	0.83 ± 0.01	0.63 ± 0.03	0.63 ± 0.01	0.80 ± 0.04	0.83 ± 0.30	0.53 ± 0.02
Radium-228 (pCi/g)	0.1	3E+05[a]	0.80 ± 0.04	0.33 ± 0.02	0.23 ± 0.02	.083 ± 0.03	0.80 ± 0.06	0.50 ± 0.03	0.60 ± 0.06	0.80 ± 0.03	0.47 ± 0.02
Thorium-230 (pCi/g)	0.02-0.05	NA[a]	0.33 ± 0.06	0.21 ± 0.06	0.17 ± 0.09	0.28 ± 0.04	0.23 ± 0.06	0.15 ± 0.09	0.20 ± 0.11	0.12 ± 0.08	0.12 ± 0.08

DL = Detection limit; NA = Not available; ND = Not detected

PEL = Probable effect levels (Ingersoll et al. 1996)

[a]Radiological Benchmarks from Rocky Flats (DOE 1996)

Note: For replicates within a site in which a chemical was not detected, the detection limit was used to calculate the mean for that site.

Table 3-5
Summary of Statistical Differences Among Sediment Chemistry Measurements – Sweetwater River
(Mean ± Standard Deviation)

Location	Iron (mg/kg)	Manganese (mg/kg)	Th-230 (pCi/g)
SR-R1	4630 ± 2487 (AB)	68 ± 9 (A)	0.33 ± 0.06 (B)
SR-R2	3143 ± 506 (A)	78 ± 11 (A)	0.21 ± 0.06 (AB)
SR-S1	2863 ± 915 (A)	132 ± 36 (AB)	0.17 ± 0.09 (AB)
SR-S2	7087 ± 1120 (B)	405 ± 297 (B)	0.28 ± 0.04 (AB)
SR-S3	3577 ± 988 (AB)	117 ± 33 (AB)	0.23 ± 0.06 (AB)
SR-S4	4603 ± 1485 (AB)	76 ± 9 (A)	0.15 ± 0.09 (AB)
SR-S5	2893 ± 1142 (A)	186 ± 59 (AB)	0.20 ± 0.11 (AB)
SR-S6	3140 ± 924 (A)	72 ± 18 (A)	0.12 ± 0.08 (A)
SR-S7	3140 ± 876 (A)	131 ± 125 (AB)	0.12 ± 0.08 (A)

Notes: Statistical comparisons were made using Tukey's multiple comparisons test ($p = 0.05$). Means sharing a common letter within a column are not significantly different ($n = 3$).

Table 3-6
Results of Whole Sediment Toxicity Tests Conducted with *Ceriodaphinia dubia*

Location	Mean Survival (%) ± St. Dev.	Statistical Comparisons[1]	Mean Young Produced ± St. Dev.	Statistical Comparisons[2]
SR-R1	93 ± 12	A	21.9 ± 2.2	AC
SR-R2	93 ± 6	A	26.7 ± 1.8	AB
SR-S1	100 ± 0	A	27.3 ± 1.7	AB
SR-S2	100 ± 0	A	27.9 ± 3.6	AB
SR-S3	93 ± 12	A	25.7 ± 5.9	AB
SR-S4	93 ± 12	A	25.9 ± 4.3	AB
SR-S5	100 ± 0	A	32.9 ± 0.7	B
SR-S6	77 ± 15	A	15.9 ± 4.3	C
SR-S7	90 ± 10	A	21.7 ± 2.7	AC

Note: Means sharing a common letter within a column are not significantly different (n = 3) (e.g., SR-S6 is significantly different from SR-S4 because, for the mean young produced, C is not common to both, but SR-S6 is not significantly different from SR-S7 because C is common to both).

[1]Statistical comparisons made using Kruskal-Wallis' multiple comparisons test (p = 0.05).
[2] Statistical comparisons made using Tukey's multiple comparisons test (p = 0.05).

Table 3-7
Results of Whole Sediment Toxicity Tests Conducted with *Hyalella azteca*

Location	Mean Survival (%) ± St. Dev.	Statistical Comparisons[1]	Mean Weight (f) ± St. Dev.	Statistical Comparisons[1]
SR-R1	68 ± 5	A	0.063 ± 0.006	A
SR-R2	27 ± 11	BC	0.063 ± 0.015	A
SR-S1	55 ± 8	AB	0.040 ± 0.010	A
SR-S2	69 ± 8	A	0.057 ± 0.006	A
SR-S3	62 ± 22	A	0.067 ± 0.006	A
SR-S4	46 ± 9	AB	0.043 ± 0.006	A
SR-S5	47 ± 13	AB	0.043 ± 0.006	A
SR-S6	40 ± 14	AB	0.060 ± 0.020	A
SR-S7	56 ± 7	AB	0.067 ± 0.015	A

Note: Means (n = 3) sharing a common letter within a column are not significantly different.

[1]Statistical comparisons made using Tukey's multiple comparisons test (p = 0.05).

Table 3-8
Fish Tissue Collection Data

Location	Number of Fish Collected	Species Identified	Weight (g)	Length (cm)	Age (years)[1]
SR-S2	4	***Salmo trutta***	625	39.5	4
		Salmo trutta	250	29.6	2
		Salmo clarki	380	39.3	3
		Oncorhynchus mykiss	655	41.8	4+
SR-S4	4	***Oncorhynchus mykiss***	350	32.9	3
		Oncorhynchus mykiss	295	32.5	2
		Salmo trutta	170	25.7	1+
		Salmo trutta	45	16.5	0
SR-S7	3	***Salmo clarki***	290	33.6	2
		Salmo clarki	56	19.0	1
		Salmo clarki	62	20.5	1
SR-R1	3	***Salmo trutta***	615	41.5	4+
		Salmo trutta	385	34.2	2+
		Oncorhynchus mykiss	575	39.0	4

[1]Age determined by annuli on scales.

Table 3-9
Summary Statistics for the Benthic Macroinvertebrate Data

Parameter	Location								
	SR-R1	SR-R2	SR-S1	SR-S2	SR-S3	SR-S4	SR-S5	SR-S6	SR-S1
Total Density[1]	5155.0	2271.3	2100.8	3825.5	2829.4	220.95	290.71	244.21	100.79
Taxa (Quantitative)	21	16	19	27	21	11	11	9	7
Taxa (Qualitative)	14	13	7	10	16	12	10	13	11
Total Taxa	22	18	20	28	21	17	14	15	15
Mayfly Density[1]	1104.6	1817.8	228.69	379.85	662.79	93.02	23.26	131.78	3.88
EPT Density[1]	4771.3	2077.5	565.91	2961.2	1713.1	120.16	85.28	143.42	27.14
EPT Taxa (Quant.)	15	11	13	21	16	7	6	6	4
EPT Taxa (All)	15	12	13	21	16	11	9	8	7
EPT/Chiro. Ratio	33.27	23.3	0.53	31.83	2.57	1.72	0.81	4.11	0.88
Shannon Div.	1.57	1.72	1.7	1.92	2.15	1.88	1.86	1.63	1.52
Shannon Even.	0.52	0.62	0.58	0.58	0.71	0.76	0.77	0.74	0.78
Discharge (cfs)	50.52	34.02	41.52	64.82	58.62	35.8	53.5	41.02	43.72
Depth (ft)	0.5	0.67	0.67	0.58	0.67	1	0.5	1	1.5
Width (ft)	41	51	59	52	42	44	40.5	35	77
Area (sq ft)	20.5	34	39.33	30.33	28	44	20.25	35	115.5
Flow (ft/s)	2.46	1	1.06	2.14	2.09	0.81	2.64	1.17	0.38

[1]Number/m^2

Table 3-10
Results of Statistical Comparison of Benthic Macroinvertebrate Parameters Among Sampling Sites

	PARAMETER															
Location	**Total Density**		**EPT Density**		**Mayfly Density**		**Total Taxa**			**EPT Taxa**		**Mayfly Taxa**				
SR-R1	A		A		A		A			A		S3	A			
SR-R2	A	B	A	B	A	B	A	B	C	A	B	S1	A	B	C	
SR-S1	A	B	A	B	A	B	A	B	C	A	B	R2	A	B	C	
SR-S2	A		A		A	B	A			A		R1	A	B		
SR-S3	A	B	A	B	A	B	A	B		A		S2	A	B		
SR-S4	C	B	C	B	A	B			C		B	S6	A	B	C	
SR-S5	C	B	C	B	A	B		B	C		B	S4	A	B	C	
SR-S6	C	B	C	B	A	B			C		B	S5		B	C	
SR-S7	C		C			B			C		B	S7			C	

Note: Sites with the same letter were not significantly different (α = 0.05).

Table 3-11
Substrate Types Observed at Each Replicate Station at Each Sampling Site

Location	Replicate (Station)	Percent Cobble	Percent Coarse Gravel	Percent Fine Gravel	Percent Sand	Percent Silt
SR-R1	1	0	60	30	5	5
SR-R1	2	10	50	30	5	5
SR-R1	3	20	40	30	5	5
SR-R2	1	40	40	10	0	10
SR-R2	2	0	10	10	40	40
SR-R2	3	0	5	80	10	5
SR-S1	1	20	10	10	20	40
SR-S1	2	30	30	20	5	15
SR-S1	3	30	30	20	5	15
SR-S2	1	60	20	5	10	5
SR-S2	2	60	20	5	10	5
SR-S2	3	10	30	15	40	5
SR-S3	1	20	25	25	15	15
SR-S3	2	5	5	65	10	15
SR-S3	3	0	0	0	0	30
SR-S4	1	10	40	20	20	10
SR-S4	2	0	10	40	50	0
SR-S4	3	0	5	20	70	5
SR-S5	1	10	10	45	20	15
SR-S5	2	20	40	20	20	0
SR-S5	3	0	0	0	100	0
SR-S6	1	5	35	30	15	15
SR-S6	2	0	5	10	65	20
SR-S6	3	0	5	10	65	20
SR-S7	1	0	0	2	94	4
SR-S7	2	0	0	2	94	4
SR-S7	3	0	0	0	94	4

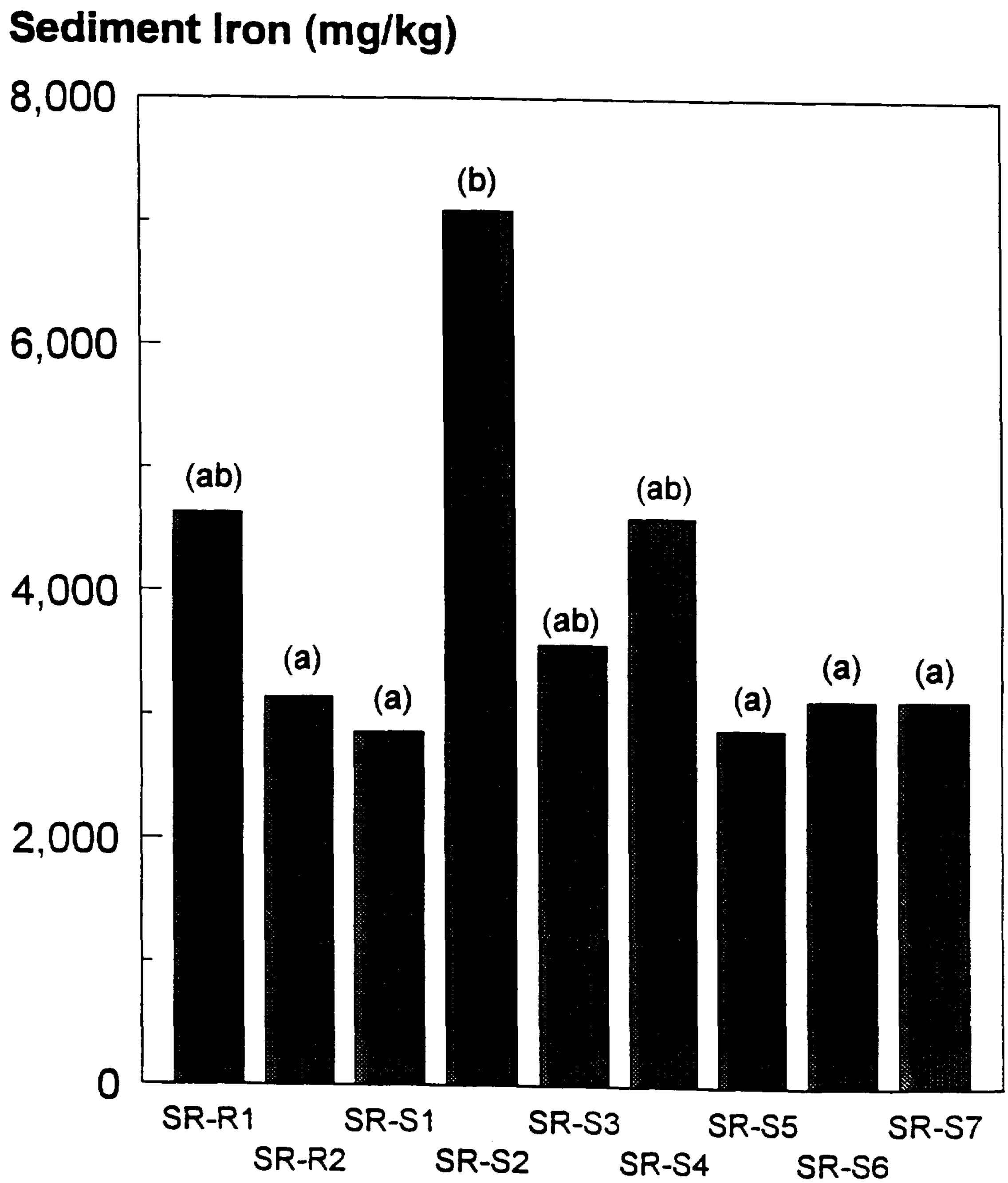
Note: Substrate type and proportions are visual estimations only.

Table 3-12
Results of Stepwise and Simple Linear Regression Analyses of Benthic Parameters

Dependent Variable	Stepwise Regression using Replicate Data (all Sampling Sites) and Including Substrate Type Only		Stepwise Regression using Replicate Data and Including Substrate Type and Water Velocity				Simple Regression using Average Site Data using Water Velocity only as the Independent Variable	
			Including SR-S5		Excluding SR-S5		Including SR-S5	Excluding SR-S5
	Independent Variable(s)	r^2	Independent Variable(s)	r^2	Independent Variable(s)	r^2	r^2	r^2
Density[a]	Sand	0.20	Sand	0.17	Water Velocity	0.37	0.30	0.79
Taxa[b]	Sand	0.38	Sand, Water Velocity	0.43	Water Velocity	0.64	0.29	0.68
EPT Density[a]	Coarse Gravel	0.18	Water Velocity	0.15	Water Velocity	0.40	0.29	0.71
EPT Taxa[b]	Sand	0.30	Sand, Water Velocity	0.37	Water Velocity	0.65	0.26	0.70
EPT Chiron Ratio	None	0	None	0	Water Velocity	0.18	0.16	0.42

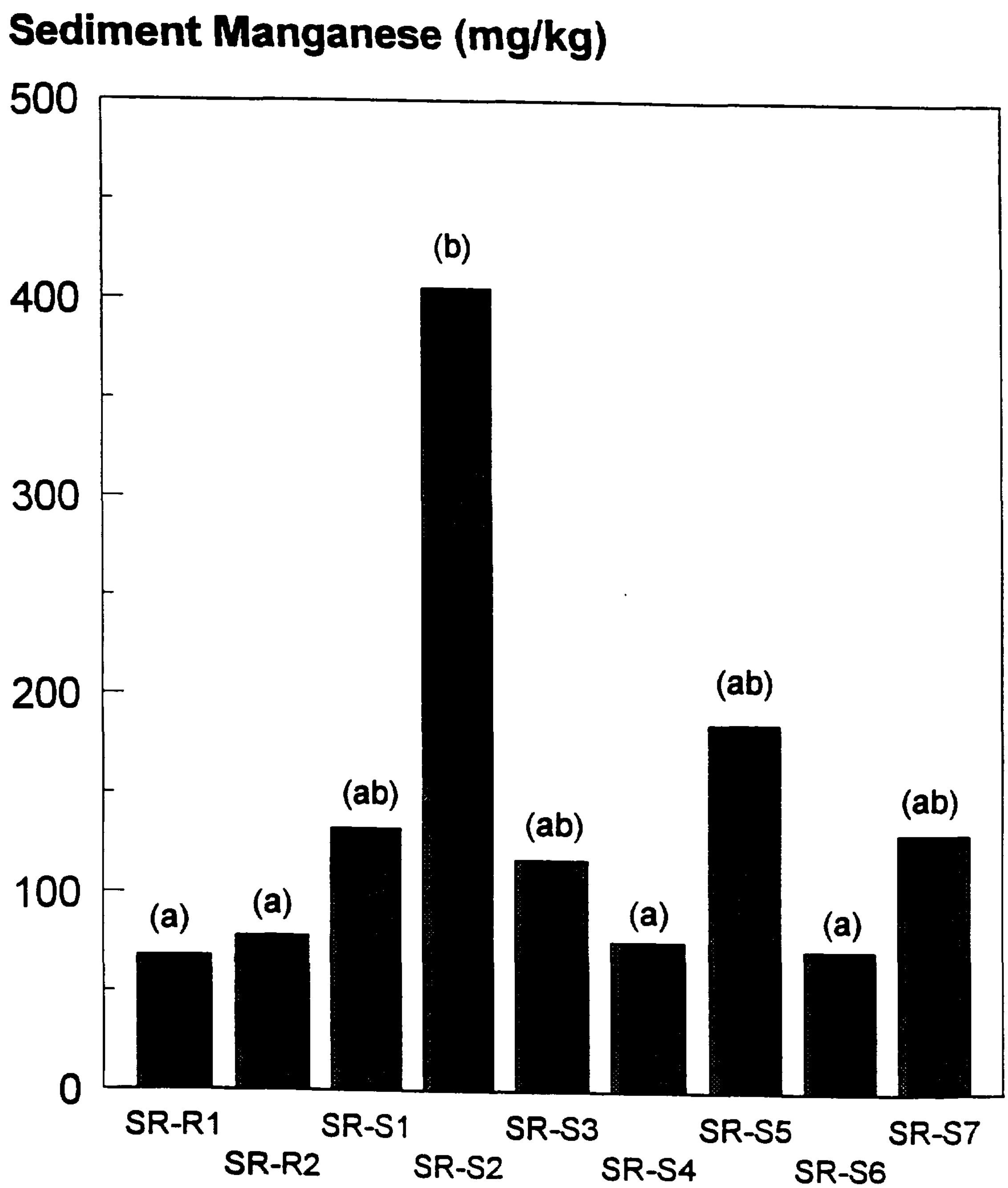
[a]Organisms/m^2

[b]Taxa in quantitative sample only



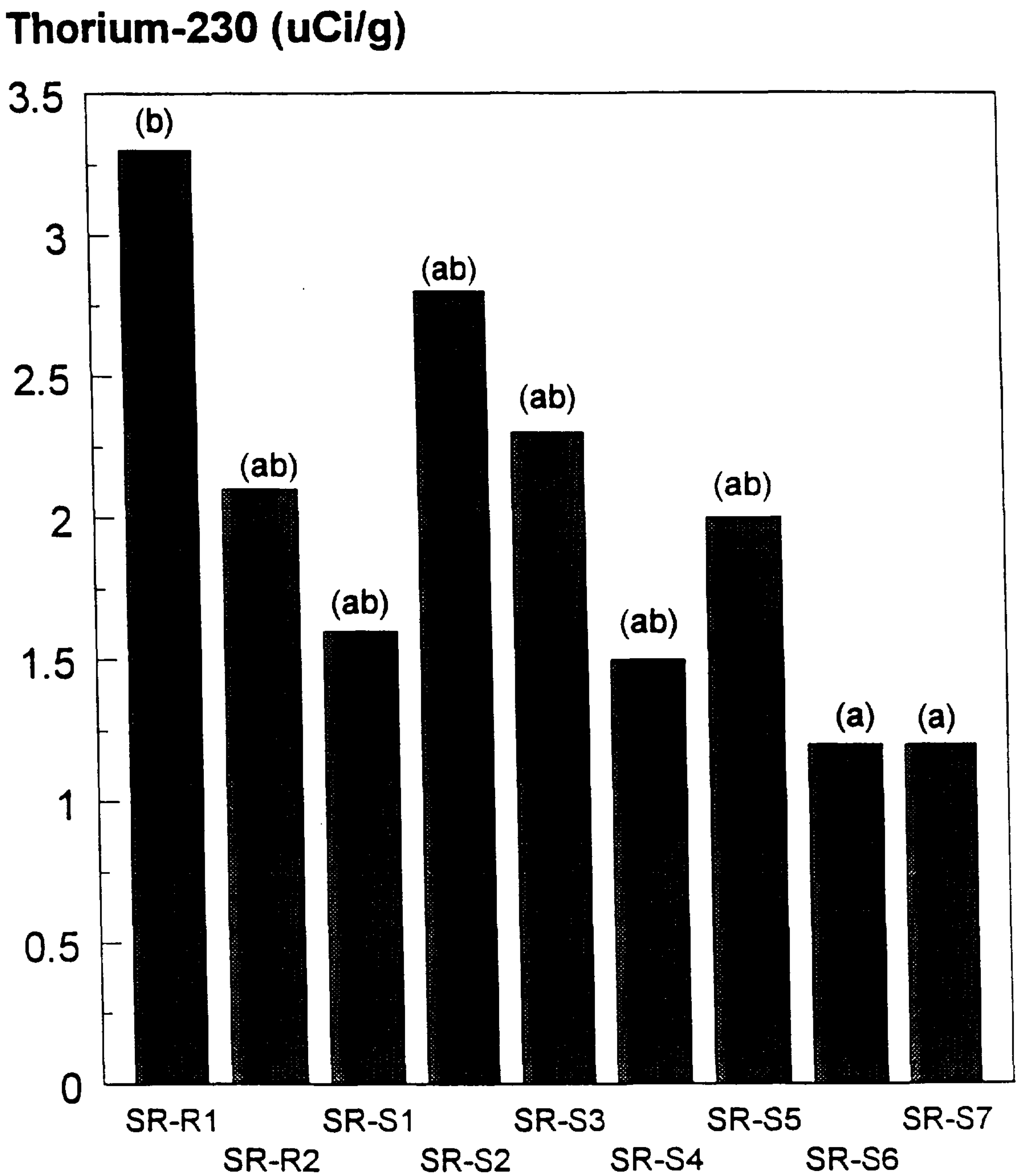
Means sharing a common letter within a column are not significantly different.

Figure 3-1. Sweetwater River Ecological Assessment, Sediment Chemistry Results - Total Iron



Means sharing a common letter within a column are not significantly different.

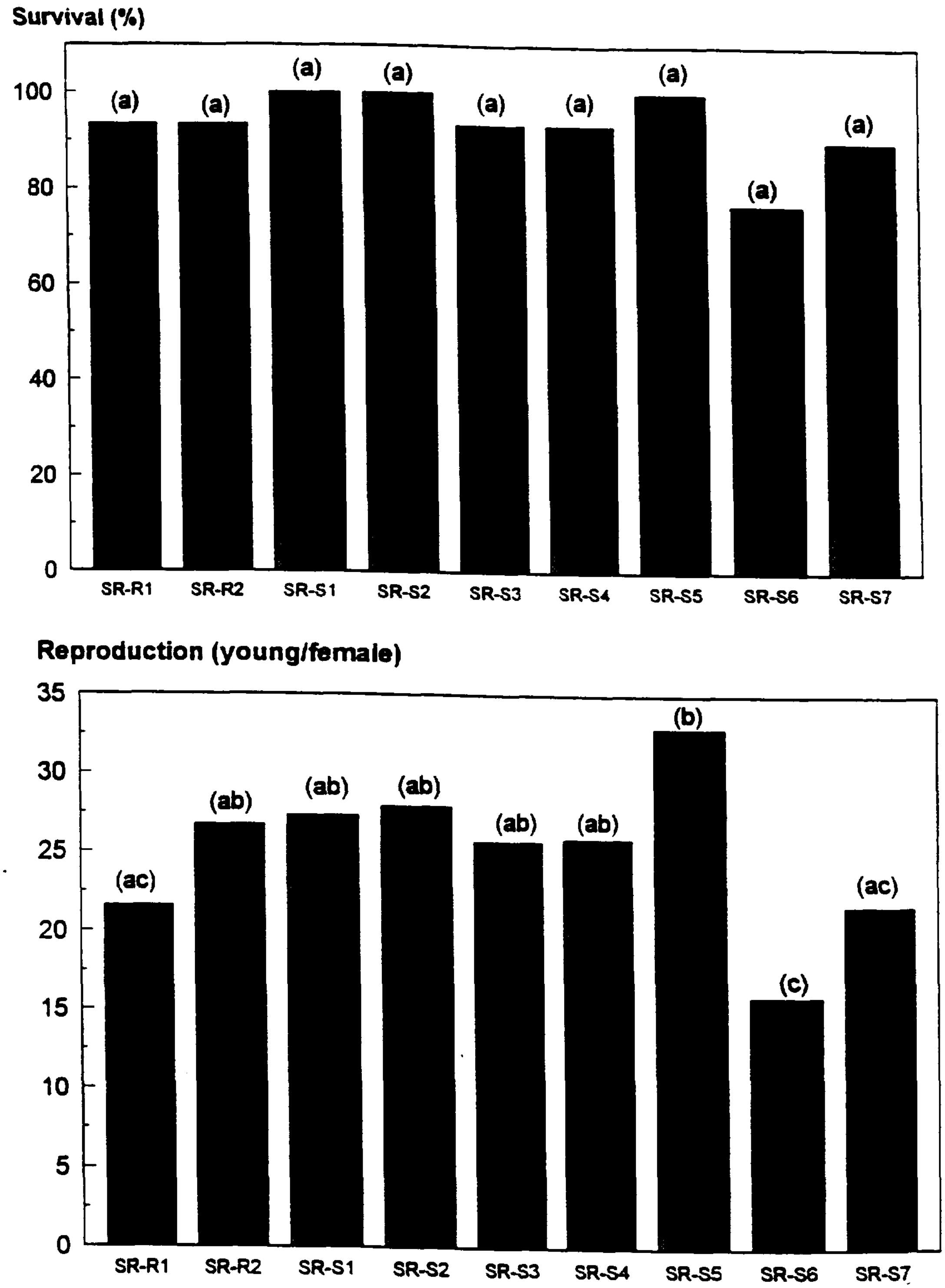
Figure 3-2. Sweetwater River Ecological Assessment, Sediment Chemistry Results - Total Manganese



Note: All values are multiplied by 0.0000001.

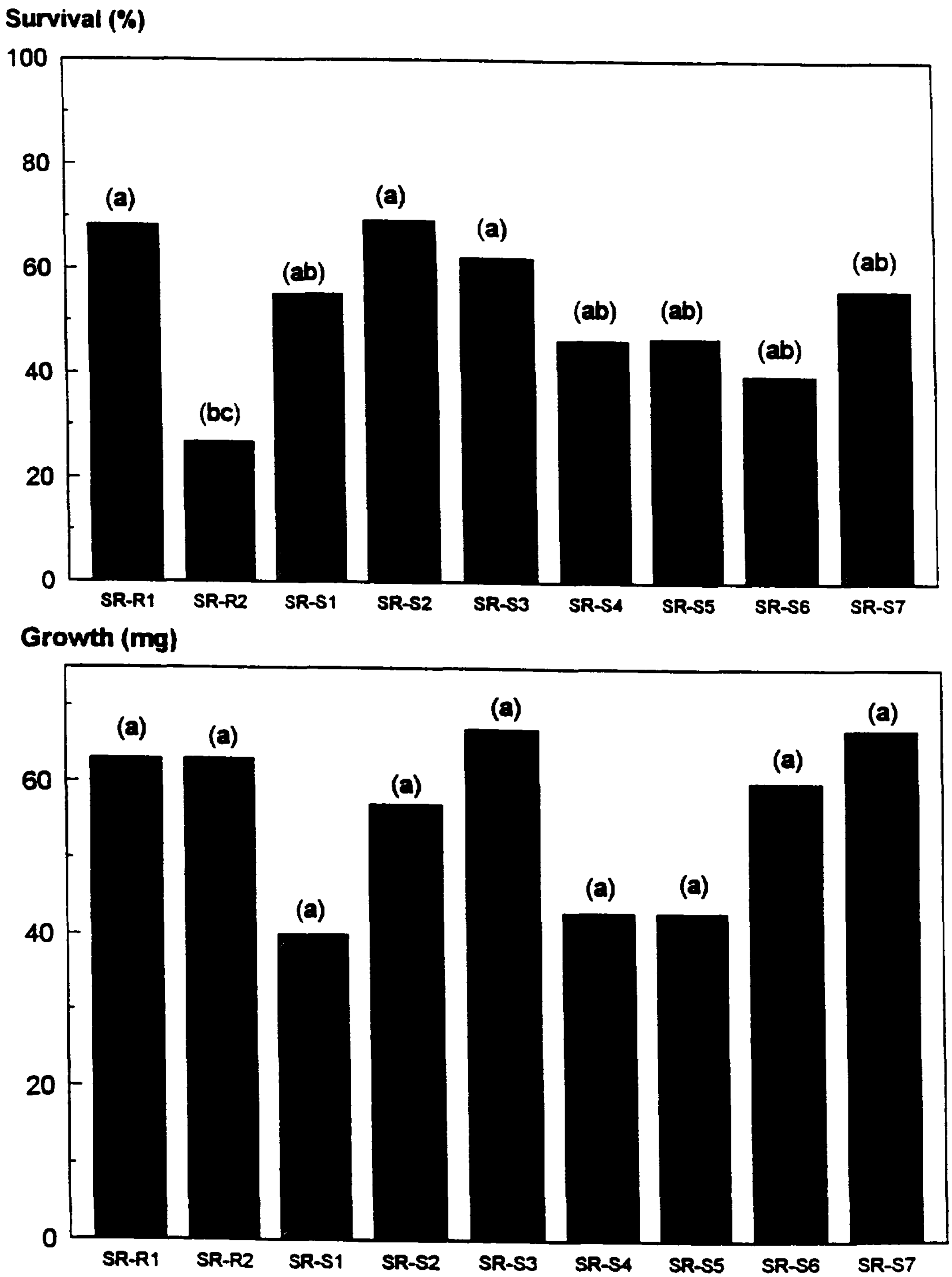
Means sharing a common letter within a column are not significantly different.

Figure 3-3. Sweetwater River Ecological Assessment, Sediment Chemistry Results - Total Thorium-230



Means sharing a common letter within a column are not significantly different.

Figure 3-4. Sweetwater River Ecological Assessment, Sediment Toxicity Testing Results - *Ceriodaphnia dubia*



Means sharing a common letter within a column are not significantly different.

Figure 3-5. Sweetwater River Ecological Assessment, Sediment Toxicity Testing Results - *Hyalella azteca*

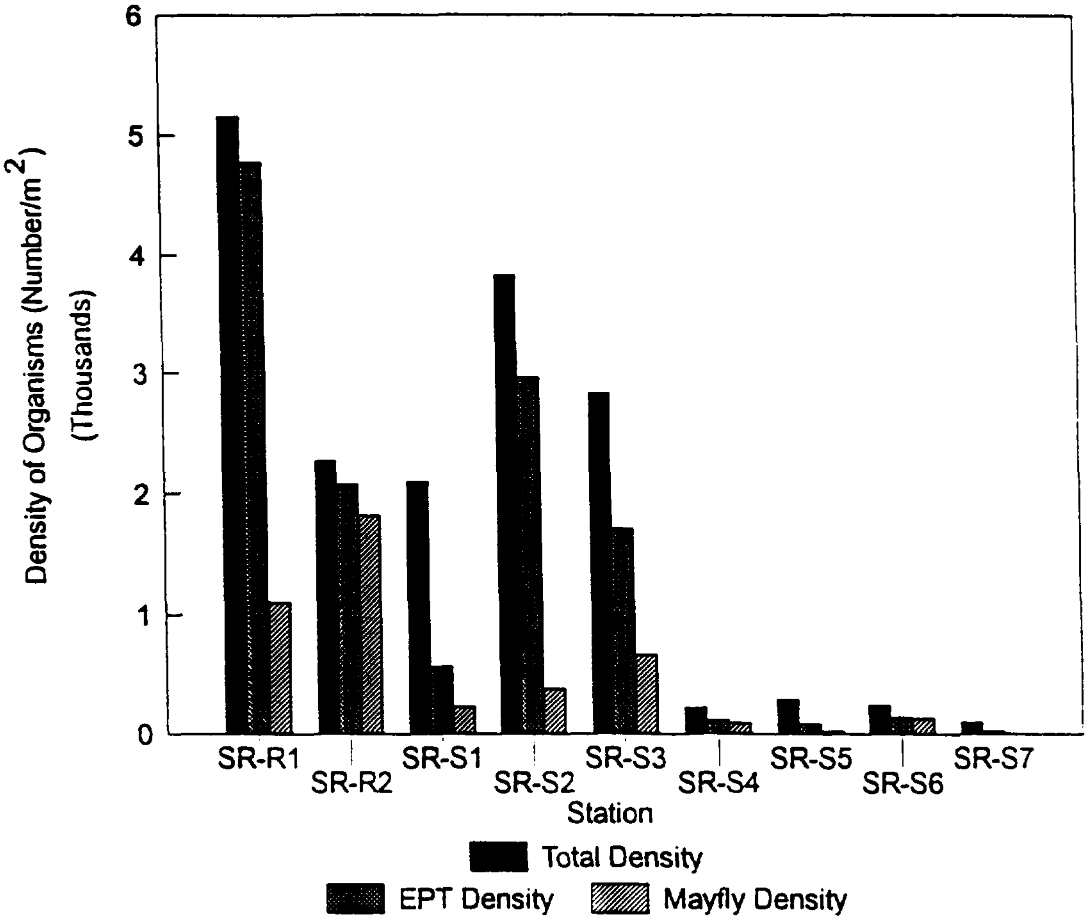


Figure 3-6. Mean Density of Benthic Macroinvertebrates at Each Sampling Site

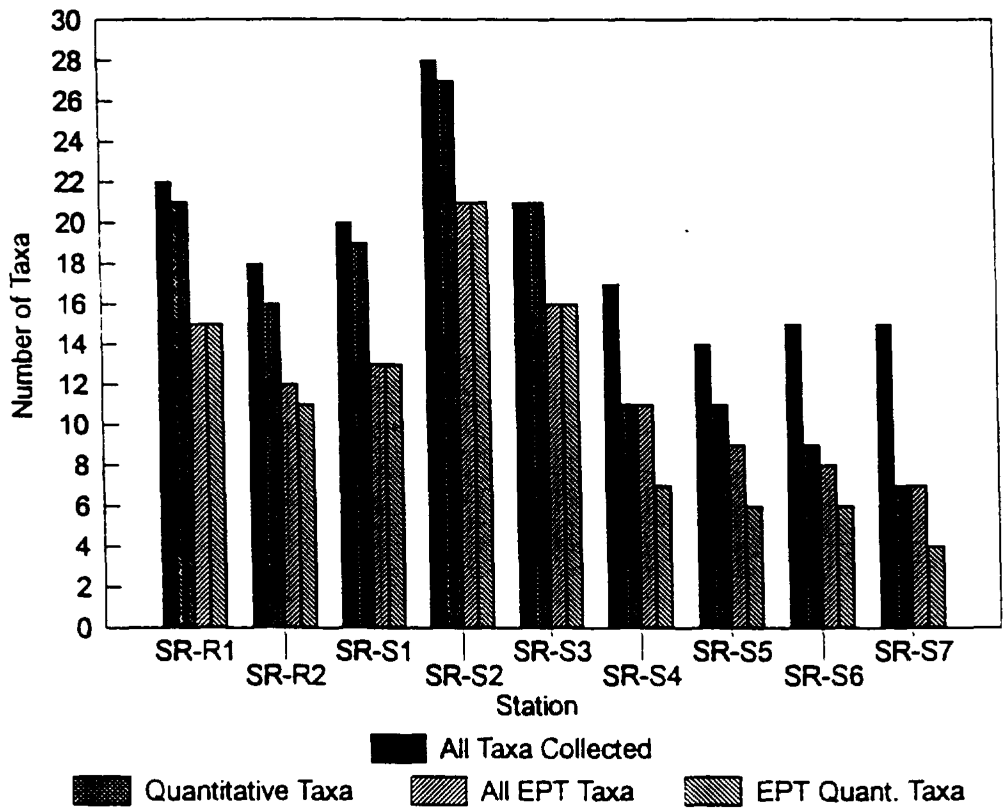


Figure 3-7. Number of Benthic Macroinvertebrate Taxa at Each Sampling Site

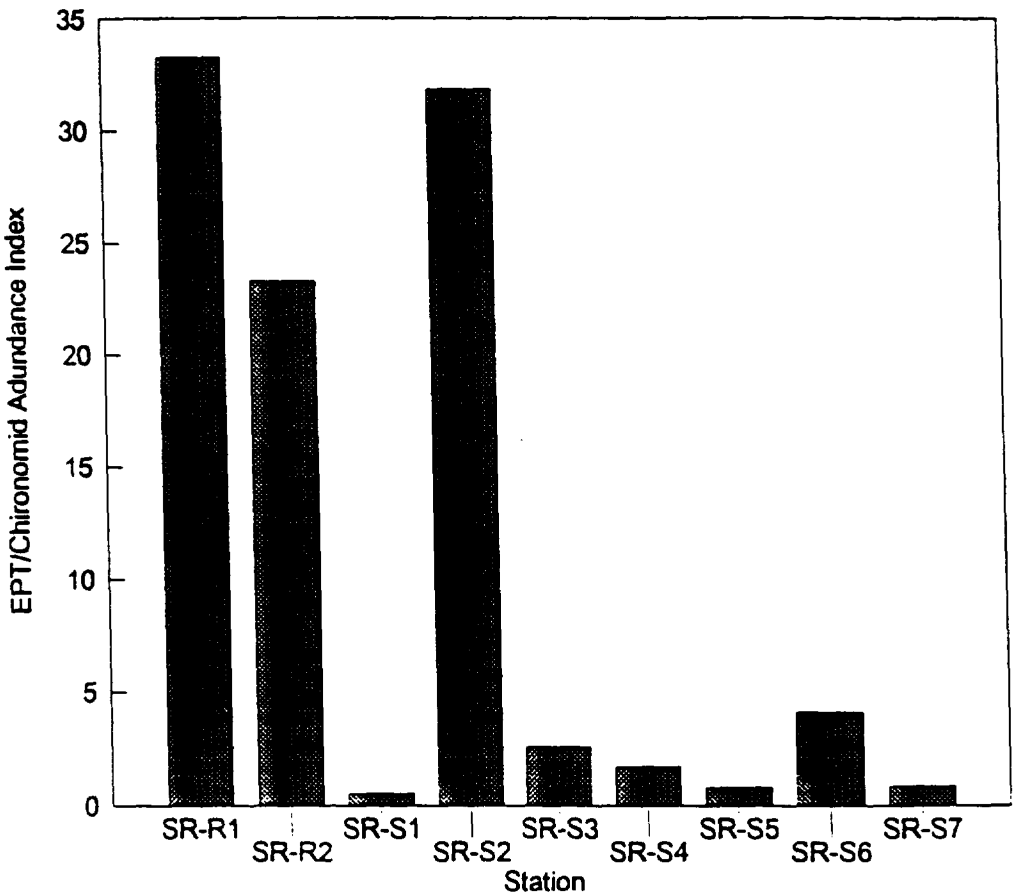


Figure 3-8. Ratio of Ephemeroptera, Plecoptera, and Trichoptera (EPT) Density to Chironomidae Density at Each Sampling Site

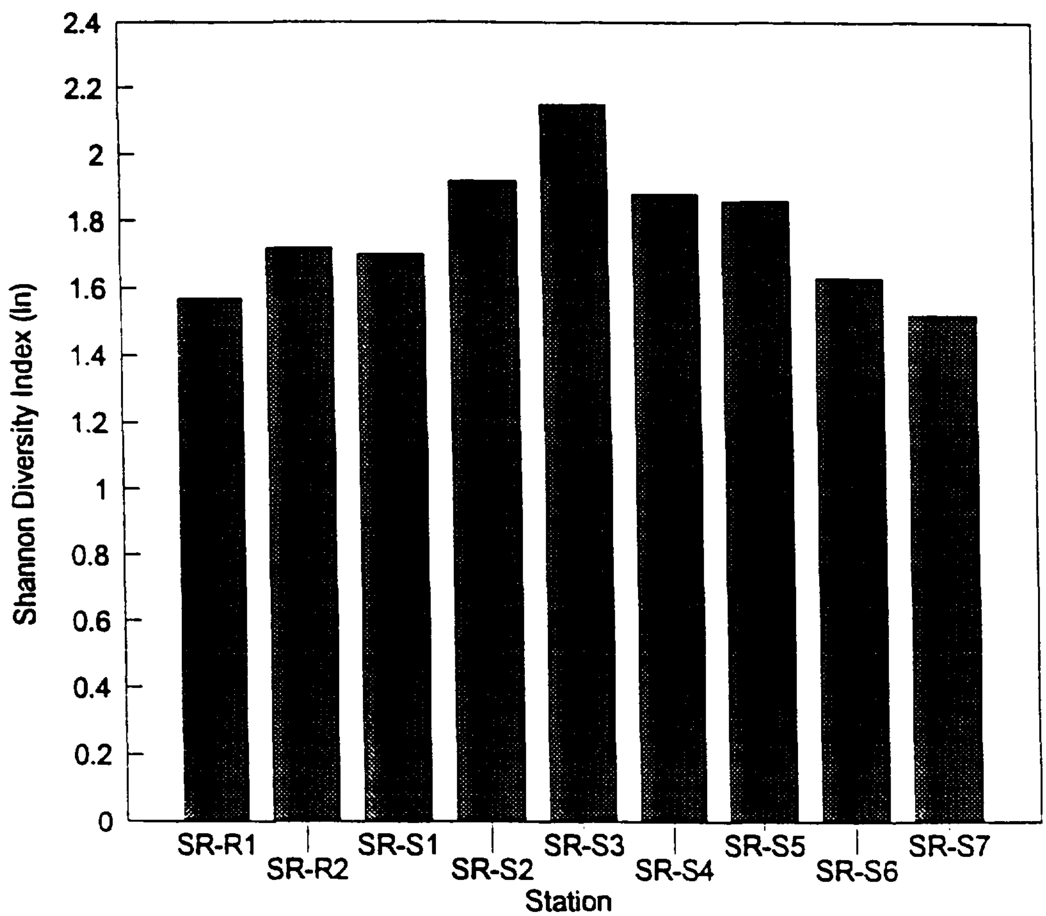


Figure 3-9. Shannon Diversity Index at Each Sampling Site

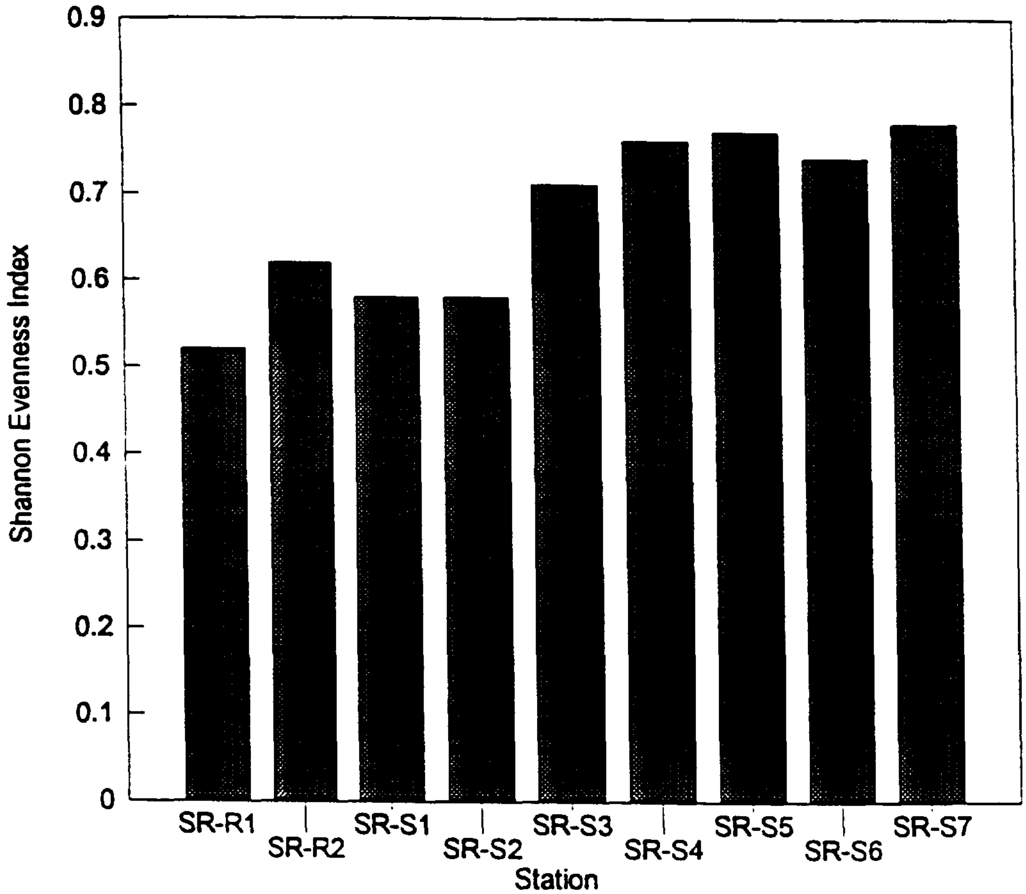


Figure 3-10. Shannon Evenness Index at Each Sampling Site

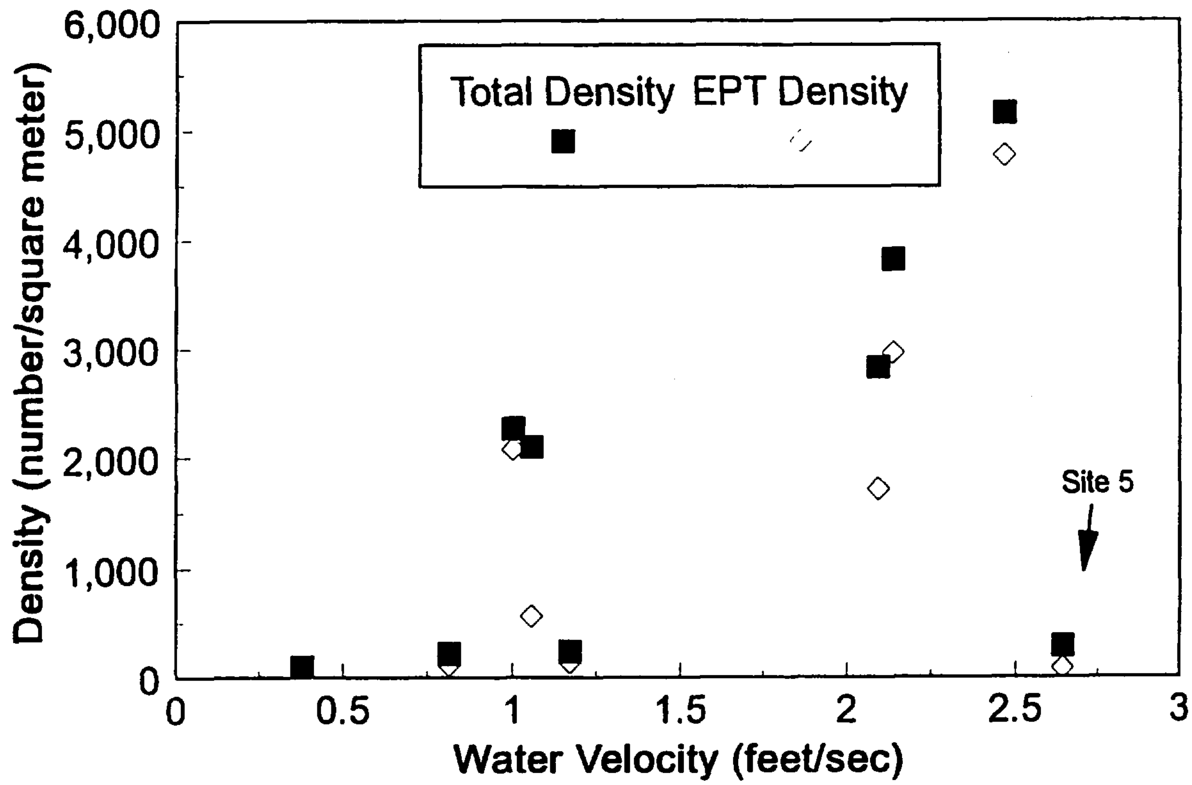


Figure 3-11. BenthicMmacroinvertebrate Density Plotted Against Water Velocity at the Sample Site

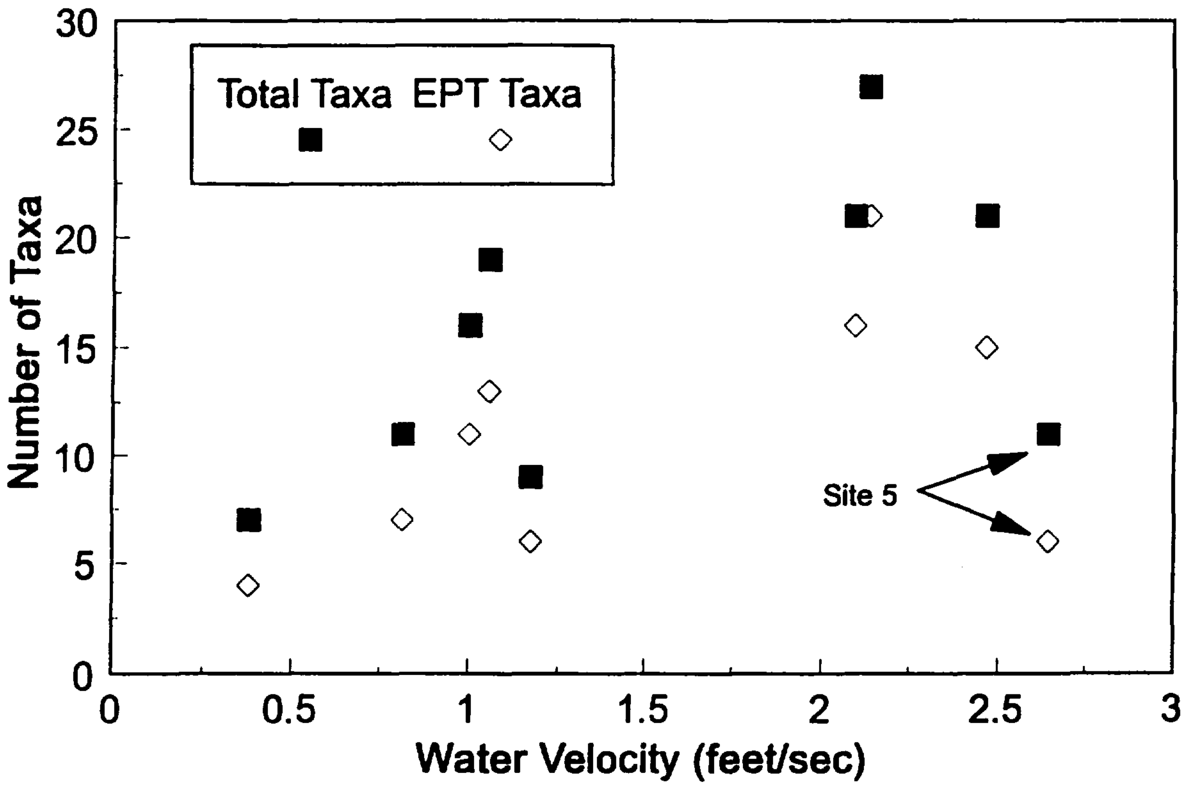


Figure 3-12. Number of Benthic Macroinvertebrate Taxa Plotted Against Water Velocity at the Sample Site

4.0 OPPORTUNISTIC SAMPLING RESULTS

Opportunistic or biased sampling of soil, vegetation, pond sediment, and pond surface water was conducted in three areas (the NWV, NEV, and SWV) to ascertain whether the potential exists for human health or environmental impacts from exposure to media potentially affected by historical milling operations. To determine the potential for risk, Site media were compared with risk-based media benchmarks for human health and ecological receptors.

In addition, a SERA was conducted for multiple-media or cross-media exposure, using the opportunistic sample results for site-specific ecological receptors (Attachment 8). Results are presented below.

4.1 Soil

A comparison of the maximum soil concentration from each of the three valleys with the concentration from a single reference location (REF 1) is shown in Table 4-1. The complete summary of all soil concentrations is provided in Attachment 3. Risk-based concentrations (RBCs) for soil were conservatively derived by the USEPA Region 9 for protection of human health and are shown on Table 40-1, along with ecological RBCs for soil protective of terrestrial animals. The human health RBCs for arsenic, uranium, and zinc were derived by combining the most current USEPA toxicity values with standard exposure factors for residential exposure in order to estimate concentrations in environmental media that are protective of humans (including sensitive groups), over a lifetime.

Human health soil RBCs for radionuclides are either regulatory guidelines or were derived by combining USEPA toxicity values with standard residential exposure factors for ingestion of soil and external irradiation. The ecological RBCs for metals ar published ecotoxicity values for protection of plants, soil fauna and microorganisms (van den Berg et al. 1993). RBCs for radionuclides are benchmark concentrations derived for protection of wildlife at the Rocky Flats site (DOE 1996).

None of the soil concentrations from the three valleys exceed the human or ecological risk-based concentrations, with the exception of radum-226 and thorium-230. The maximum soil concentration of thorium-230 was from the sample location NWV-13, which is within an area known to have elevated uranium and/or thorium concentrations without elevated radium concentrations. As a result, soils in this area have been cleaned up and verified of radiological compliance with regulatory standards identified in the Split Rock Radiological Verification Program (SMI 1995) or were contained within the boundaries of the reclamation cover system. The radium-226 soil sample from the NEV was collected from a location that has been cleaned up and verified for compliance with regulatory guidelines as defined in the Verification Program. Following final cleanup and verification, soil concentrations in areas around the Split Rock Mill Site will not pose an unacceptable potential human health or ecological risk. In general, all soil concentrations were substantially less than protective RBCs.

4.2 Vegetation

A total of 15 different species of vegetation were identified from the samples collected during the October 1995 sampling effort (Table 4-2). A summary of the maximum site vegetation concentrations from the three areas and the site reference vegetation concentrations is shown on Table 4-2. Maximum site vegetation concentrations were compared with the background mean plus 2 times the standard deviation vegetation concentration to determine whether site concentrations are elevated above the reference vegetation concentrations for the area.

Manganese concentrations in both vegetation samples from the NWV and from the single sample from the NEV were nearly twice the reference mean concentration. The maximum zinc concentration from NWV-01 barely exceeded the reference mean zinc concentration. Maximum uranium concentrations in vegetation from all three valleys exceeded the mean reference concentration of 0.07 mg/kg. The maximum uranium concentration in vegetation was 4.6 mg/kg, from location NVW-01. The radium-226 soil sample from the NEV was collected from a location that has been cleaned and verified for compliance with regulatory guidelines as defined in the Radiological Verification Program (SMI 1995). The complete summary of results is shown in Attachment 3.

In order to determine whether impacted vegetation poses a potential risk, the maximum vegetation concentrations from each valley were compared with maximum tolerable levels (MTLs), which represent the dietary levels established by the National Academy of Science (NAS) (1992) that will not impair animal performance or result in unsafe residues in food products consumed by humans. All maximum concentrations detected in the valleys surrounding the site were well below the applicable MTLs.

MTLs for the specific radionuclides do not exist; however, radium and thorium concentrations in vegetation from the NWV did not exceed their reference concentrations. The maximum radium and thorium concentrations in the SWV were less than reference concentrations by more than 2.5 times. The single vegetation sample analyzed from the NEV had maximum radionuclide concentrations up to 14 times higher than the reference vegetation samples. The sample location area has been impacted by wind-blown tailing material. The NEV has been remediated since the October 1995 sampling event. Because the metals concentrations are all much lower than the MTLs for safe residue levels in meat and because the radionuclides do not bioaccumulate in meat, adverse impacts to wildlife and to humans consuming wildlife have not likely occurred.

4.3 Pond Sediment and Surface Water

Two ponds in the NWV floodplain were sampled (Figure 2-1). Both ponds exhibit periodic drying; however, because of the unusually wet spring of 1995 both ponds still contained water in October 1995. Surface water samples collected from the two ponds were evaluated for potential impacts by comparison with WDEQ standards for the protection of livestock and aquatic organisms or USEPA values for protection of aquatic organisms (Tables 4-4 and 4-5). Because the WDEQ does not provide radiological standards, benchmarks derived at Rocky Flats (DOE 1996) for the protection of aquatic species were used.

The concentration of selenium in the pond water was approximately 80% of the WDEQ aquatic standard, and the uranium concentration in Pond 1 exceeded the derived chronic value of 2.27 mg/L. Subsequent sampling of surface water by SMI from Pond 1 in May, June, and August 1996 provided uranium concentrations in Pond 1 water ranging from 0.4 to 2.2 mg/L, indicating that the average concentration is much lower than the October 1995 value of 6.8 mg/L. (The unusually heavy precipitation in the spring of 1995 likely caused unusually elevated uranium concentrations in Pond 1 for the October 1995 sampling event). All other pond water constituents were well below their aquatic standards or appropriate benchmark values, indicating that adverse impacts to aquatic communities are not likely to occur.

Table 4-5 compares pond water with WDEQ groundwater standards for the protection of livestock and radiological benchmark values. With the single exception of uranium in surface water from Pond 1, all constituent concentrations were well below levels of regulatory concern. As noted previously, subsequent sampling of surface water from Pond 1 in 1996 indicates that the concentrations are typically well below the WDEQ value of 5 mg/L.

Sediment concentrations from Pond 1 and Pond 2 were compared with PELs for freshwater sediment from Ingersoll et al. (1996) for metals and radiological benchmark values derived for the Rocky Flats site (DOE 1996). All sediment constituent concentrations were well below their sediment benchmark values for protection of the aquatic environment (Table 4-6).

4.4 Fish Tissue

Fish tissue analysis results from three locations on the Sweetwater River (SR-S2, SR-S4, and SR-S7) and reference fish tissue concentrations from fish collected at each of the river reference sites (SR-R1) are shown on Table 4-7. Risk-based fish tissue benchmarks are shown on the table for comparison.

All of the fish tissue concentrations were well below risk-based levels for human consumption. The tissue concentration of arsenic in the combined fish sample from location SR-S4 on the Sweetwater River is approximately 61% of the RBC. However, the arsenic tissue concentration from this location does not differ from the arsenic concentration in fish collected upstream at the reference location. Manganese and nickel concentrations in fish collected at SR-S4 are approximately 3 times higher than the upstream reference location; however, both manganese and nickel represent only a small fraction of the RBC; therefore, it is not likely that ingestion of fish from the Sweetwater River adjacent to the Site would pose a risk to human health.

4.5 Cross-Media Exposure

Because ecological receptors would likely be exposed to multiple Site media, a screening-level assessment of site-specific receptors potentially exposed to soil, water, vegetation, and fish was performed and documented in the SERA, which is presented in Attachment 8 and summarized below.

Site specific receptors include mallard ducks, great blue herons, mule deer, and species similar to the meadow vole that have been observed at or are likely to inhabit the site. Herons could be exposed by potential ingestion of water from the surface water ponds and ingestion of fish from the Sweetwater River. Mallard ducks could be exposed by ingestion of pond vegetation, incidental pond sediment ingestion, and ingestion of pond water. Mule deer and meadow voles could be exposed by ingestion of vegetation and surface water from the ponds. Because terrestrial animals ingest only small amounts of soil usually less than 2 to 3 percent of the total dietary intake), soil ingestion was not included in the cross-media evaluation.

No threatened and endangered species have been noted at the Site; however, animals of these species, such as the black-footed ferret, could conceivably inhabit the Site in the future if conditions change to encourage habitation. A receptor with a small home range (i.e., the meadow vole) was included in the SERA to assure that potential impacts to T&E species were not overlooked.

The results indicate that birds, such as great blue herons, are not likely to be impacted by ingesting surface water from the ponds and fish from the sampled locations along the Sweetwater River. Migratory waterfowl, such as mallard ducks, are also not likely to be adversely impacted by ingesting pond water, sediment, and pond vegetation. Terrestrial animals, including any T&E

species that might inhabit the Site in the future and potentially ingest pond water and vegetation, are also not likely to be adversely impacted.

Table 4-1
Comparison of Background and Risk-Based Soil Concentrations With Soil Concentrations from the NWV, SWV, and NEV

Chemical	Risk-Based Concentration (RBC)		Reference (n=1)	NWV (n=11)		SWV (n=5)		NEV (n=1)	
	Human[a]	Ecological[b]		Maximum	% of lowest RBC	Maximum	% of lowest RBC	Maximum	% of lowest RBC
Calcium (mg/L)	1,000,000[c]	NA	1170	81,300	2%	1,250	<1%	316	<1%
Chloride (mg/L)	NA	NA	8.00	14,100	NA	8.0	NA	6.0	NA
Magnesium (mg/kg)	1,000,000[c]	NA	909	13,200	<1%	557	<1%	249	<1%
Potassium (mg/L)	1,000,000[c]	NA	874	9,091	<1%	603	<1%	239	<1%
pH (standard units)	NA	NA	6.09	9.97	NA	5.53-7.07	NA	5.50	NA
Sodium (mg/kg)	1,000,000[c]	NA	81	37,700	<1%	50.0	<1%	40.0	<1%
Sulfate,Soluble (mg/kg)	NA	NA	12.2	44,000	NA	39.0	NA	15.0	NS
Arsenic (mg/kg)	38	40	0.76	13.9	36.5%	1.43	3.4%	1.14	7%
Cadmium (mg/kg)	38	12	<1.00	1.0	24%	<1.0	<8.3%	<1.0	<2.9%
Copper (mg/kg)	2,800	190	2.90	13.3	7%	2.9	1.5%	1.0	<1%
Iron (mg/kg)	23,000[d]	NA	2330	12,635	55%	1,660	7.2%	992	<4%
Lead (mg/kg)	400[e]	290	<5.00	9.5	3.2%	<5.0	1.7%	<5.0	<1%
Molybdenum (mg/kg)	380	480	<10	<10	<2.6%	<10	2.6%	<10	<5%
Nickel (mg/kg)	1,500	210	<5.00	14.3	6.8%	<5.0	2.3%	<5.0	<1%
Selenium (mg/kg)	380	100	<0.10	10.3	10.3%	<0.1	<1%	0.57	<5%
Silver (mg/kg)	380	50	<5.00	<5.00[g]	<10%	<5.0	<10%	<5.0	<10%
Uranium (mg/kg)	230	3030[J]	0.45	88.7	38.6%	2.7	1.2%	16.7	7.3%

Table 4-1 Cont.
Comparison of Background and Risk-Based Soil Concentrations With Soil Concentrations from the NWV, SWV, and NEV

Chemical	Risk-Based Concentration (RBC) Human[a]	Risk-Based Concentration (RBC) Ecological[b]	Reference (n=1)	NWV (n=11) Maximum	NWV (n=11) % of lowest RBC	SWV (n=5) Maximum	SWV (n=5) % of lowest RBC	NEV (n=1) Maximum	NEV (n=1) % of lowest RBC
Zinc (mg/kg)	23,000	720	12.4	44.7	6.2%	11.4	<1.5%	3.8	<1%
Radium-226 (pCi/g)	5[f]	5[i]	0.5	3.7	74%	1.7	34%	6.7	134%
Radium-228 (pCi/g)	5[f]	3[i]	0.3	1.1	36.7%	1.0	33%	0.6	20%
Thorium-230 (pCi/g)	5[f]	NA	0.3	24	480%	0.9	18%	2.1	42%

[a]Risk-based concentrations are USEPA Region 9 residential benchmark values for a target risk level of 10^{-4} and a Hazard Quotient of 1.0, unless otherwise specified.
[b]Dutch National Institute of Public Health and Environment Protection Ecotoxicological Intervention values for soil (Van den Berg et al. 1993).
[c]Essential nutrient benchmark values in soil, derived from the National Research Council's Recommended Daily Allowance, Adequate and Safe Intake Level, or report on Observed Average Daily Intake Levels. Where values greater than unity were derived, the value was reset to 1,000,000.
[d]USEPA Region 3 risk-based concentration for a 1.0 target hazard quotient.
[e]Lead concentration is based on the USEPA uptake biokinetic model and represents the USEPA screening level for residential soil (ref).
[f]Values for Radium, and Thorium, are regulatory soil guideline values, as defined in SMI 1995a.
[g]Ag values were all less than the detection limit of 5.0 ppm with the single exception of the duplicate sample for NWV-7 (25 ppm). This values is probably in error and was disregarded.
[h]Value derived assuming external irradiation and soil ingestion for protection at 15 mrem/year.
[i]Soil Benchmarks for protection of wildlife at Rocky Flats, Colorado (DOE 1996).
NA = Not available
NWV = Northwest Valley
SWV = Southwest Valley
NEV = Northeast Valley

Table 4-2
Plant Species List for Split Rock Mill Site

Scientific Name	Common Name
Salsola iberica	Russian thistle
Typha latifolia	Wildleaf cattail
Chrysothamnus nauseosus	Rubber rabbitbrush
Artemisia cana	Silver sagebrush
Ceratoides lanata	Winterfat
Vulpia octoflora	Sixweekgrass
Lepidium virginicum	Peppergrass
Chrysothamnus vicidiflorus	Douglas rabbitbrush
Agropyron intermedium	Intermediate wheatgrass
Oryzopsis hymenoides	Indian ricegrass
Bromus tectorum	Cheatgrass
Descurainia sophia	Flixweed
Artemisia tridentata ssp. wyomingensis	Wyoming big sagebrush
Agropyron smithii	Western wheatgrass
Calamovilfa longifolia	Prairie sandreed

Table 4-3
Comparison of Reference Vegetation Concentrations with Vegetation Collected from the NWV, SWV, and NEV

Chemical	Reference (n=3) Mean + S.D.	Maximum Tolerance Level (MTL) (NAS 1992)	NWV (n=2)		SWV (n=9 for metals; n=7 for RADs)		NEV (n=1)	
			Maximum	% of MTL	Maximum	% of MTL	Maximum[a]	% of MTL
Arsenic (mg/kg)	(<1.2)	50	(<1.5)	---	(<1.5)	---	(<1.5)	---
Cadmium (mg/kg)	(<0.5)	0.5	(<0.5)	--	(<0.5)	--	(<0.5)	---
Copper (mg/kg)	2.9	100	1.4	1.4%	3.0	3%	2.1	2.1%
Lead (mg/kg)	(<2.0)	30	(<2.0)	---	(<2.0)	---	(<2.0)	---
Manganese (mg/kg)	37.6	1,000	70.4	7%	28.5	2.9%	71.8	7.2%
Molybdenum (mg/kg)	(<4.0)	5	(<4.0)	---	(<4.0)	---	(<4.0)	---
Nickel (mg/kg)	(<2.0)	50	(<2.0)	---	(<2.0)	---	(<2.0)	---
Selenium (mg/kg)	(<1.5)	2	(<1.5)	---	(<1.5)	---	(<1.5)	---
Silver (mg/kg)	(<2.0)	100	(<2.0)	---	(<2.0)	---	(<2.0)	---
Uranium (mg/kg)	0.07	40	4.6	12%	0.18	1%	0.36	<1%
Zinc (mg/kg)	9.1	500	9.5	1.9%	6.5	1.3%	8.6	1.7%
Radium-226 (pCi/g)	0.071	NA	0.051	NA	0.14	NA	1.0	NA
Radium-228 (pCi/g)	0.065	NA	0.027	NA	0.14	NA	0.08	NA
Thorium-230 (pCi/g)	0.024	NA	0.006	NA	0.03	NA	0.31	NA
Uranium-234 (pCi/g)	NA	NA	0.34	NA	0.023	NA	NA	NA
Uranium-235 (pCi/g)	NA	NA	0.03	NA	0.002	NA	NA	NA
Uranium-238 (pCi/g)	NA	NA	0.47	NA	0.024	NA	NA	NA

Values in ( ) = detection limit; NA = not available
NWV = Northwest Valley
SWV = Southwest Valley
NEW = Northeast Valley

Table 4-4
Comparison of Measured Water Concentrations for Ponds 1 and 2 with Applicable Water Quality Standards[a]

Chemical	CONCENTRATION		Wyoming Chronic Aquatic Standard	Percent of Standard	
	Pond 1	Pond 2		Pond 1	Pond 2
Arsenic (mg/L)	0.004	0.004	0.19	2%	2%
Cadmium (mg/L)	<0.007	<0.007	0.015[b]	<47%	<47%
Copper (mg/L)	<0.003	0.004	0.197[b]	<2%	<2%
Lead (mg/L)	<0.002	0.004	0.211[b]	<1%	<1%
Manganese (mg/L)	0.09	0.35	1.1[c]	8%	32%
Molybdenum (mg/L)	<0.05	<0.05	0.88[c]	<6%	<39%
Nickel (mg/L)	<0.008	<0.008	2.563[b]	<1%	<2%
Selenium (mg/L)	0.004	<0.003	0.005	80%	<60%
Silver (mg/L)	<0.003	<0.003	1.177[b]	<1%	1%
Uranium (mg/L)	6.79	0.15	2.27	>100%	<6%
Zinc (mg/L)	0.02	0.01	1.731[b]	1%	<1%
Radium-226 (pCi/L)	0.7	1.1	400[e]	<1%	<1%
Radium-228 (pCi/L)	2.6	1.8	300[e]	<1%	<1%
Thorium-230 (pCi/L)	<0.4	<0.4	400[e]	<1%	<1%
Uranium-234 (pCi/L)	2,780	NC	4,000[e]	70%	NC
Uranium-235 (pCi/L)	137	NC	4,000[e]	3%	NC
Uranium-238 (pCi/L)	2,200	NC	4,000[e]	55%	NC
Hardness (as $CaCO_3$)[f](mg/L)	2,701	506	NA	NA	NA

[a]For the protection of aquatic life.
[b]These metals are hardness-dependent; standard is calculated from an equation based on hardness of the pond water.
[c]Value is the lowest chronic value based on daphnids.
[d]Value is derived according to USEPA Region 8 protocol (Attachment 5).
[e]Radiological Benchmarks are from Rocky Flats (DOE 1996).
[f]Hardness is calculated from calcium and magnesium concentrations.
NC = analysis not conducted
NA = not available

Table 4-5
Comparison of Pond Water Concentrations with WDEQ Livestock Protection Values

Chemical	CONCENTRATION		WDEQ Livestock Standard	Percent of Standard	
	Pond 1	Pond 2		Pond 1	Pond 2
Arsenic (mg/L)	0.004	0.004	0.2	2%	2%
Cadmium (mg/L)	<0.007	<0.007	0.05	<14%	<14%
Copper (mg/L)	<0.003	0.004	0.5	<1%	<1%
Lead (mg/L)	<0.002	0.004	0.1	<2%	<2%
Manganese (mg/L)	0.09	0.35	NA	NA	NA
Molybdenum (mg/L)	<0.05	<0.05	NA	NA	NA
Nickel (mg/L)	<0.008	<0.008	NA	NA	NA
Selenium (mg/L)	0.004	<0.003	0.05	8%	6%
Silver (mg/L)	<0.003	<0.003	NA	NA	NA
Uranium (mg/L)	6.79	0.15	5.0	135%	<3%
Zinc (mg/L)	0.02	0.01	25.0	<1%	<1%
Radium-226 (pCi/L)	0.7	1.1	5	14%	22%
Radium-228 (pCi/L)	2.6	1.8	5	52%	36%
Thorium-230 (pCi/L)	<0.4	<0.4	15	<2.7%	<2.7%
Uranium-234 (pCi/L)	2,780	NC	4,000[a]	70%	NA
Uranium-235 (pCi/L)	137	NC	4,000[a]	3%	NA
Uranium-238 (pCi/L)	2,200	NC	4,000[a]	55%	NA

[a]Radiological Benchmarks are from Rocky Flats (DOE 1996).

NC = analysis not conducted
NA = not available

Table 4-6
Comparison of Maximum Sediment Concentrations in Ponds 1 and 2 with Sediment Benchmark Values for the Protection of Aquatic Organisms[a]

Chemical	MAXIMUM CONCENTRATION (MG/KG)		PEL (Ingersoll et al. 1996)	Percent of PEL	
	Pond 1	Pond 2		Pond 1	Pond 2
Arsenic (mg/kg)	7.98	12.9	48	17%	26%
Cadmium (mg/kg)	<1.0	1.9	3.2	<31%	59%
Copper (mg/kg)	10.5	15.2	100	10%	15%
Iron (mg/kg)	7,890	16,600	250,000	3%	6%
Lead (mg/kg)	<5.0	<5.0	55	9%	<9%
Manganese (mg/kg)	370	496	1,200	30%	41%
Molybdenum (mg/kg)	<10.0	<10.0	33	23%	51%
Nickel (mg/kg)	7.6	17.1	24	32%	71%
Selenium (mg/kg)	1.33	1.52	NA	NA	NA
Silver (mg/kg)	<5.0	<5.0	3.7[d]	<135%	<135%
Uranium (mg/kg)	105.37	17.76	12,000[b]	<1%	1%
Zinc (mg/kg)	38.0	51.3	540	7%	9%
Radium-226 (pCi/L)	1.9	6.1	400,000[c]	<1%	<1%
Radium-228 (pCi/g)	1.8	2.3	300,000[c]	<1%	<1%
Thorium-230 (pCi/g)	1.2	2.2	NA	NA	NA
Uranium-234 (pCi/g)	39.	NA	10,000[c]	<1%	NA
Uranium-235 (pCi/g)	1.7	NA	10,000[c]	<1%	NA
Uranium-238 (pCi/g)	30	NA	4,000[c]	<1%	NA

[a]The benchmarks in this table represent the probable sediment effects level (PEL) from Ingersoll et al. (1996) unless otherwise stated.
[b]Calculated from Uranium-238 radiological benchmark and specific activity of Uranium-238 of 0.33 pCi/μg uranium.
[c]Radiological Benchmarks are from Rocky Flats (DOE 1996).
[d]Effects Range Medium (ERM) value, from Long et al. (1995).
NA = not available

Table 4-7
Comparison of Risk-Based Fish Tissue Concentrations and Reference Location Concentrations with Maximum Fish Tissue Results

Chemical	Risk-based Concentration (rbc)[a]	Reference (n=1)	Maximum Fish Tissue Concentration	Percent of RBC
Arsenic (mg/kg)	1.8	1.2	1.1	61%
Cadmium (mg/kg)	5.9	0.12	0.06	1%
Copper (mg/kg)	470	6	9	2%
Iron (mg/kg)	3,000	225	269	9%
Lead (mg/kg)	NA	0.11	0.3	NA
Manganese (mg/kg)	270	14.5	47.8	18%
Molybdenum (mg/kg)	60	0.06	0.1	<1%
Nickel (mg/kg)	230	1.12	3.0	1%
Selenium (mg/kg)	58	3	3	5%
Silver (mg/kg)	58	0.07	0.14	<1%
Uranium (mg/kg)	35	<2.99E-08	<2.99E-08	<1%
Zinc (mg/kg)	3,000	96	99.6	3%
Radium-226 (pCi/g)	5.1	<1.49E-09	1.94E-08	<1%
Radium-228 (pCi/g)	6.2	<7.46E-09	7.46E-09	<1%
Thorium-230 (pCi/g)	41	<1.49E-09	7.16E-09	<1%

[a]RBC estimated assuming the following:
Ingestion rate of fish = 12.4 gram per day (recreational anglers; Finley et al. 1994)
Fraction of fish from potentially impacted area = 0.50
Exposure frequency = 350 day per year (default EPA residential value; USEPA 1989)
Exposure duration = 30 year (default EPA residential value; USEPA 1989)
Body Weight = 70 kg (default EPA residential value; USEPA 1989)

5.0 QUALITY ASSURANCE/QUALITY CONTROL RESULTS

5.1 Laboratory Audit

On October 31, 1995, a phase audit of the FCETL was conducted by ENSR. A phase audit evaluates whether applicable quality assurance/quality control (QA/QC) procedures and protocols have been implemented. Phases examined included the receipt, storage, and disposal of test articles; the culture of organisms; test initiation; and test termination. Associated logbooks were intensively reviewed and technicians were observed during various testing procedures. In addition, a data audit was performed for the *Hyalella azteca* and *Ceriodaphnia dubia* studies conducted for the Site. During the data audit, raw data forms and logbooks were examined for transcription and calculation errors and for completeness and legibility of entered data. A few minor errors were discovered and were corrected immediately. Only minor deficiencies were discovered during the phase audit and data audit, and none affected the outcome of the *Hyalella* and *Ceriodaphnia* studies. The study reports were reviewed to ensure that the reports accurately represented the raw data.

5.2 Field Audit

A field audit was carried out by ENSR during the on-site sampling. All procedures were performed in accordance with applicable SOPs or were appropriately documented in field notebooks and on field sampling forms.

5.3 Cross-Contamination and External Contamination Blanks

Cross-contamination blanks (CCBs) and external contamination blanks (ECBs) were collected three times during the course of sediment sample collection. Each CCB consisted of a filter paper wipe that was wiped across the inside of the collection dredge (or across the surface of the stainless steel spoon, when used) following decontamination of the dredge (or spoon) between sample locations. This CCB was collected, fully digested, and analyzed for the metals of interest to provide information about the effectiveness of the decontamination process and the degree to which metals may have been transferred via a contaminated dredge or spoon from one sample to the next. The ECB consisted of an unused wipe that was digested and analyzed for the metals of interest in order to estimate what portion of the metals present in the CCB may be attributable to the wipe or the sampling process itself.

Section 5.4.3 presents the results of the CCB and ECB analysis.

5.4 Quality Control Review of Laboratory Data

A quality control (QC) review was conducted for three sample delivery groups (SDGs) of sediment, fish tissue, and associated QA/QC samples analyzed by Columbia Analytical Services (CAS Project #5978-003), as follows:

Service Request K9506961, Samples K-9506961-001 to –018, samples collected from 10/26/95 to 11/2/95

Service Request K9507245, Samples K-9507245-001 to –015, samples collected from 11/25/95 to 1/19/95

Service Request K9600093, Samples K960092-001 to –006, QA/QC field blanks for bulk sediment samples collected from 10/17/95 to 10/19/95.

Sediment samples analyzed in the first two SDGs were actually subsets of bulk samples collected from 10/17/95 to 10/19/95. The bulk samples were then used to set up laboratory studies of potential sediment toxicity, from which the sediment subsamples were collected.

CCBs were identified by a sample ID of "CC", and ECBs were identified by a sample ID of "EC".

Sediment samples were analyzed for total metals and for acid volatile sulfide (AVS), while the fish tissue samples and sediment QA/QC samples were analyzed only for total metals. The total metals (11 in all) included arsenic, cadmium, copper, iron, lead, manganese, molybdenum, nickel, selenium, silver, and zinc. CAS reported metals results on a dry weight basis and AVS results on an "as received" (wet) basis.

CAS provided laboratory results, a summary QA/QC report, and a complete raw data package for the analyses. A QC review was conducted by SMI as described in SMIU Standard Operating Procedure No. 6, "Data Validation and Quality Control Review of Analytical Laboratory Data Packages." The QC review included checking for analysis of samples within holding times, by requested methods, and using requested detection limits. Field and laboratory results were checked for potential blank contamination, for percent recovery of analytes from spiked samples and reference samples, and for precision of laboratory and field duplicate analyses.

The results of the QC review are summarized in the following sections.

5.4.1 Holding Times

Metals samples were analyzed within the 6-month holding time suggested by SW-846, "Test Methods for Evaluating Solid Waste" USEPA, 1986, and Revision 1, July 1992.

AVS samples were analyzed on 11/14/95 and 11/22/95, or at 18, 12, 11 and 7 days following collection. The draft method for AVS analysis states that "Holding time for samples should not exceed 14 days" (USEPA 1991). AVS results for the nine samples collected on 10/26/95 exceeded the recommended holding time and were thus qualified as estimated (J) or nondetected, estimated (UJ).

5.4.2 Analytical Methods and Detection Limits

Analyses were conducted using either Inductively Coupled Plasma (ICP) by USEPA Method 6010 (iron, manganese, molybdenum, nickel, and zinc) or ICP Mass Sectroscopy (MS) by USEPA Method 200.8 (arsenic, cadmium, copper, lead, selenium, and silver), providing method reporting limits (MRLs) as low or lower than those requested for risk assessment purposes. The only exception was iron, for which the laboratory reported a higher MRL than requested; this is not expected to affect data quality.

5.4.3 Blank Contamination

Small amounts of copper and lead were reported in laboratory method blanks accompanying the sediment and fish tissue samples. However, since these samples were reported to contain more than 5 times the amounts detected in the method blanks, no sample results were qualified on the basis of blank contamination.

Two of the field CCBs were reported to contain anonymously high concentrations of metals. Wipe sample SR-S7-BQ-CC-01 contained a copper concentration of 0.334 mg, while wipe sample SR-S3-SE-CC-01 contained a copper concentration of 0.146 mg. The metals in the CCB in the SR-S7 set may have been leached from the surface of the sediment sampling dredge by an initial acid rinse. After the first several samples collected in the SR-S7 set, the acid rise step was discontinued and a stainless steel spoon was used instead. The source of the high cadmium concentration in the CCB in the SR-S3 set (samples collected using a stainless steel spoon) is not known.

Comparison of results from CCBs with their corresponding ECBs indicates that the metals content of the ECBs varied. For the SR-S7 and S1-R1 sets of blanks, the metals content of the ECB was lower than that of the CCB for all metals analyzed (as would be expected). For the SR-S3 set of blanks, the metal content of the ECB exceeded that of the CCB for arsenic, lead, manganese, nickel, silver, and zinc. The reason for the difference is unknown.

It is unlikely that metals associated with the dredge surface would result in contamination of a sediment sample because of the large volume of sediment collected in the dredge and the fact that samples were taken from the sediment in the center of the dredge. ENSR personnel also noted that the cadmium concentration in the CCB blank in the SR-S3 was small in comparison with the concentration of the sediment sample collected immediately after this CCB. This further suggests that actual cross-contamination was unlikely to have occurred. Based on this analysis, the QC reviewer elected not to qualify sediment sample data on the basis of the cross-contamination blanks.

The laboratory method blank run with the QC/QC field blank samples contained small amounts of copper and lead. Lead concentrations in the field QA/QC blanks were grater than 5 times the amount reported in the method blank and therefore are not considered to have been affected by the laboratory blank contamination, based on EPA guidance. However, low-concentration QA/QC field blank sample results for copper were less than 5 times the amount of copper in the laboratory blank and were therefore changed in nondetects at the reported values, following USEPA guidance (1994).

5.4.4 Spiked Samples and Reference Samples

Recoveries of spiked analytes in laboratory control samples (LCSs) and matrix spike samples were acceptable. Percent recoveries of metals were within the supplier's control limits for the metals LCS and within the control limits of 50-150 percent recovery for solid samples. For the AVS LCS, recoveries ranged from 66 to 96 percent and were judged acceptable. Recoveries from matrix spike samples of sediment ranged from 82 to 130 percent for metals samples. Recoveries from AVS matrix spike samples of sediment ranged from 85 to 110 percent for SDG K95006961 but were not calculated for SDG K9507245 because the concentration of AVS in the sample was more than 4 times the amount spiked. Matrix spike samples were not prepared for the cross-contamination wipe blank samples because of the small sample size (each sample was a sheet of filter paper). No solid reference samples were submitted to CAS.

5.4.5 Duplicate Precision

For laboratory duplicate samples, precision measured by relative percent difference (RPD) between the sample and duplicate was acceptable (within $\pm$ 35 percent) for all analytes except nickel in SDG K9506961. Nickel results for SDG 9506961 were qualified as estimated (J) due to poor duplicate precision. Duplicates were not prepared for the CCBs, due to the limited amount of sample material available.

RPD for field duplicate sample/duplicate pairs were acceptable. The field sample, duplicate pairs included in the following samples analyzed for metals in SDG K9507245 were:

SR-S1-SE-EX-01/SR-S1-SE-FR-01 (K95-07425-001 and –002)
SR-R2-SE-EX-03/SR-R2-SE-FR-03 (K95-07425-010 and –011)

Initial and continuing calibration results wee also summarized by CAS and were acceptable, ranging from 97-109 percent recovery.

5.5 Summary

Based on the QC review, laboratory data from CAS appear to be of acceptable overall quality and suitable for their intended use. Low copper concentrations in the CCBs were changed to nondetects at the reported values, due to copper concentrations measured in the accompanying laboratory method blank. No data were rejected in the QC review. Data qualified as estimated included (1) nine AVS concentrations because the sample analysis was performed after the 14-day holding time and (2) nickel concentrations in SDG K9506961 due to poor precision of nickel concentrations in the duplicate analysis.

The accuracy and precision of laboratory analyses were acceptable based on the recoveries of analytes from spiked samples and comparison of the results of duplicate analyses. The laboratory provided QC summaries for results of spiked and duplicate samples, calibration results, and a raw data package. Frequencies of field duplicate samples (1 per 20 field samples) for metals were as described in the TWP (ENSR 1995).

6.0 CONCULSIONS

6.1 Sweetwater River Sampling

Based on the analysis of laboratory data, the portion of the Sweetwater River north of the Site, has a high quality ecosystem typical of third order, cold water prairie streams. Physical land use patterns within the vicinity of the river (e.g., cattle grazing, bridge crossings, and agricultural activities) have likely affected the river to a greater extent than have any potential chemical influences derived from previous operations at the Split Rock Mill Site.

Chemical gradients were not observed in river water or sediment analytical data, indicating that groundwater influences are not significant. Chemical constituents in surface waters and sediments, where detected, were low and were homogeneous across sampling locations. Concentrations were consistently below applicable indices of potential ecological concern.

Table 6-1 displays a matrix summarizing statistical differences in assessment endpoints between upstream reference and downstream experimental sampling locations. For each location monitored, plus signs (+) signify differences from reference sites (i.e., potential adverse effects), and minus signs (-) signify that differences were not detected. Although differences among specific ecological endpoints were detected at selected sampling locations no single location was characterized as being simultaneously: a) chemically impacted, as evidenced by sediment chemical analyses; b) ecologically impacted, as evidenced by benthic invertebrate analyses; and c) toxicologically impacted, as evidenced by laboratory bioassay analyses. Based on the evaluations conducted, groundwater intrusion and/or sediment constituents are currently not adversely affecting ecological receptors within the Sweetwater River.

In summary, the accumulated chemical, toxicological, and ecological data collected at each of the Sweetwater River sampling locations do not suggest that any adverse environmental impacts have occurred that can be attributed to Split Rock Mill operations. Additional ecological assessment within the river channel, therefore, does not appear to be warranted.

6.2 Opportunistic Sampling of Soil, Vegetation, Sediment, Surface Water, and Fish Tissue

Soil concentrations exceeded the reference concentrations at some locations; however, surface soil does not contain concentrations of Site metals that would pose a risk to humans or ecological receptors in the area. Measured radium concentrations in soil in the NEV valley exceeded reference levels and Nuclear Regulatory Commission (NRC) soil guidelines. The NEV has undergone remediation during 1996 to meet radiological guidelines determined to be protective of human health and the environment. Thorium-230 was elevated at a single location within the NWV, near the Site. This location was within the area where cleanup and radiological verification was concluded or will be within the boundary of the reclamation cover system.

Concentrations of manganese in vegetation from the NWV and NEV exceeded reference location vegetation concentrations. Zinc concentrations in vegetation in the NEV also exceeded the reference location concentration.

Some differences between Site samples and reference samples could be attributable to the variance among vegetation type, since each sample was a composite of the available vegetation. Comparison of all vegetation sample results to MTLs indicates that actual constituent concentrations in vegetation would not pose an unacceptable potential risk to wildlife, livestock, or to humans potentially ingesting animal products.

The uranium concentration measured in Pond 1 during October 1995 exceeded the Wyoming Livestock standard by 1.3 times. Subsequent sampling by SMI during 1996 indicates that the uranium concentration in pond surface water is typically much lower than the Wyoming standard. No adverse health impacts would be expected to occur if the maximum concentration in these waters was ingested by wildlife or livestock, and there would be no impact to humans that might consume meat from these livestock

Metals concentrations in fish tissue from the Sweetwater River are not present at levels that represent a potential for human health impacts from fish consumption. Wildlife potentially exposed to several Site media will not be adversely impacted.

In summary, although some media near the Site may have been impacted by previous Site operations (e.g., vegetation, surface soils, and pond sediment), as shown by comparison with samples from unaffected reference locations, the concentrations in those media are too low to adversely impact humans or animals. Therefore, based on these results/data, no additional study of the site media is warranted.

Table 6-1
Summary of Sediment Quality Triad Results

Transect Location	Potential For:		
	Toxicity Impacts	Benthos Impacts	Chemistry Impacts
SR-S1	-	-	-
SR-S2	-	-	+
SR-S3	-	-	-
SR-S4	-	+	-
SR-S5	-	+	-
SR-S6	+	+	-
SR-S7	-	+	-
SR-R1	-	-	-
SR-R2	+	-	-

Notes: A plus sign for toxicity indicates organism performance significantly less (p = 0.05) than at one or both of the reference locations. A plus sign for benthos indicates a significantly different (p = 0.05) benthic invertebrate endpoint from that observed in one or both of the reference locations. A plus sign for chemistry indicates an average chemical measurement significantly higher (p = 0.05) than that measured in one or both of the reference locations.

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ATTACHMENT 1

SPLIT ROCK MILL RISK ASSESSMENT TASK WORK PLAN

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

LIST OF TABLES

LIST OF FIGURES

GLOSSARY

This glossary is provided as a central location for definitions and acronyms pertaining to technical, or regulatory terminology.

Amphipod. A species of aquatic organisms often referred to as "fresh-water shrimp".

Analyte. Any compound or chemical selected for analytical measurement in a collected water, soil, sediment, or tissue sample.

Benthic macroinvertebrates. Organisms that live either in or on the sediment of an aquatic system; includes organisms from several taxonomic groups such as insects, crustaceans (amphidpids, isopods, decapods, benthic copepods), oligochaetes, and leaches.

Benthic community indices. Calculated terms used to define the organization, distribution, density, and species composition of organism groups inhabiting the sediment of aquatic systems.

Bioaccumulation. General term describing a process by which chemicals are taken up by aquatic organisms from water directly or through consumption of food containing the chemicals.

Biota. All living organisms inhabiting an ecosystem.

Chronic. Involving a stimulus that continues for a long time; from weeks to years, depending on the reproductive life cycle of the aquatic species. Can be used to define either the exposure or the response to an exposure. The chronic toxicity test is used to study the effects of continuous, long-term exposure of a chemical or other potentially toxic material on aquatic or terrestrial organisms.

Community. An assemblage of multiple populations (a spatial grouping of organisms of one species) inhabiting a definable habitat or ecosystem.

Criteria (water quality). An estimate of the concentration of a chemical in water which, if not exceeded, will protect an organism, community, or a prescribed water use or quality with an adequate degree of safety.

Endemic organism. Native organisms.

Habitat. The living and non-living components of a community.

GLOSSARY (Continued)

Hardness. The concentration of all metallic cations, except those of the alkali metals, present in water. Hardness is a measure of the concentration of calcium and magnesium ions in water and is frequently expressed as mg/L calcium carbonate equivalent.

Matrix spike analyses. USEPA method to provide information about the effect of each sample matrix on the digestion and measurement methodology.

Neonates. Term for offspring.

Pore Water. Also called interstitial water; fills the spaces between sediment particles. Pore water accounts for over 50% by volume of surface sediment.

Primary consumers. Those organisms which feed only on plant matter and are in turn eaten by higher order consumers.

Risk. A statistical concept defined as the expected frequency or probability of undesirable effects resulting from exposure to known or potential environmental concentrations of a material.

Secondary consumer trophic level. Comprised of all animals in an ecosystem that feed on primary consumers.

Sessile. Essentially stationary, often attached to the substrate.

Stessors. Site-specific contaminants of potential concern that may pose adverse effects to human health or the environment.

Taxa, taxonomic. A classification of organisms based ona common set of evolutionary or physiological traits; grouping of a set of organisms into a taxon or taxonomic unit distinguishes them from other organisms, which tend to be more distantly related, evolutionarily. Taxa are defined at multiple levels of organism relatedness-organisms in the same species are very closely related, and relatedness decreases among genera, family, order, class, phylum, and kingdom.

Toxicity. The inherent potential or capacity of a material that may cause adverse effects in a living organism.

Toxicity Tests. The means by which the toxicity of a chemical is determined. The test is used to measure the degree of response produced by exposure to a specific concentration of chemical.

GLOSSARY (Continued)

Transect. A linear sampling scheme that is extended across an area or between two points; equidistant points are designated along the transect at which samples are collected; the length of the transect and the distance between the sampling points is held constant between each location at which samples are to be collected.

Triad Analysis. Evaluation method incorporating three components: (1) chemical measurements in sediment, (2) toxicity testing, and (3) evaluation of biological community.

1.0 INTRODUCTION

This Task Work Plan (TWP) describes the approach for the evaluation of potential environmental impacts associated with current conditions at the former Split Rock Mill (the Site) at Jeffrey City, Wyoming. This evaluation will be performed in preparation for a groundwater Alternate Concentration Limit (ACL) application to the U.S. Nuclear Regulatory Commission (NRC). ACL guidance (NRC 1994) requires that potential current and future risks to human health and the environment be evaluated at the most likely points of exposure (POE). Site-affected groundwater could potentially impact the Sweetwater River; therefore, it is likely that the section of the river north of the Site is a potential POE for environmental receptors. The emphasis of the evaluation, therefore, is on the Sweetwater River ecosystem.

All tasks described in this TWP are consistent with:

- the overall objectives of the Split Rock Risk Assessment effort (as described in the Risk Assessment Task Work Scope); and
- the overall Mission of the Groundwater Protection Program (GWPP).

The tasks described in this TWP must be performed for potential ecological and human health risks to be understood. Regardless of the direction taken during subsequent phases of evaluation at the Site, the tasks presented in this work plan have been determined to be required for defining the initial scope of environmental impacts (if they have occurred) and for designating, with certainty, those areas that have not been affected by Split Rock Mill operations. Once identified, these unaffected areas can be exempted from future investigations, and thus costs can be saved without jeopardizing the integrity of the results.

This TWP presents a systematic approach for assessing the overall environmental status of the Sweetwater River. Opportunistic sampling of soils, vegetation, irrigation/drainage ditch sediments, and water and sediments from ponds will also be conducted to: (1) provide information regarding potential human health and environmental impacts from exposure to media from the area surrounding the Site and (2) to focus future sampling efforts at the Site.

The approach for sampling the river and for collecting the opportunistic samples is described in the following sections.

1.1 Sweetwater River

Sampling of the Sweetwater River itself will be conducted systematically, so that definitive conclusions regarding the presence or absence of impacts within the river system may be reached.

The ecological assessment of the Sweetwater River will concentrate on river sediments and will have three principle components, involving:

- chemical analysis;
- laboratory toxicity testing; and
- in-situ benthic macroinvertebrate community investigations.

These components constitute the three legs of a sediment quality triad analysis (Chapman 1986), intended to discern whether links exist between chemical measurements and biological (laboratory and in-situ) effects. Data from these three components will be considered together to provide a complete picture of potential chemical impacts. Data of one type (e.g., chemical measurements) will be interpreted in the context of data of the other types (e.g., toxicity) to form plausible cause-and-effect relationships and to gauge the extent to which measured constituents are biologically available and/or toxicologically effective under laboratory and field conditions. Surface water samples will also be collected for analysis and fish samples will be collected and analyzed for distribution and tissue concentrations.

Laboratory and field procedures will quantify the nature, spatial extent, and magnitude of any contamination and coincident sediment toxicity or community impacts in the Sweetwater River in the vicinity of the Split Rock Site. A determination will then be made as to whether any potentially elevated chemical concentrations in river sediments are necessarily associated with toxicity and/or adverse impacts on resident biota.

1.2 Opportunistic Sampling

Opportunistic sampling of vegetation, soil, and pond surface water and sediment will provide preliminary information about the extent and magnitude of potential impacts elsewhere within the Site boundaries (i.e., as conveyed through pathways that may not be related to the river). For opportunistic sampling, sampling locations will be designated based on Site features and their potential for providing the maximum amount of information useful in defining subsequent phases of the Site investigation.

2.0 TASK OBJECTIVES

2.1 Sweetwater River

The proposed approach for evaluating potential impacts to the Sweetwater River will characterize what, if any, relationships exist between contaminants derived from the former Split Rock Mill operations and the Sweetwater River sediment chemistry, toxicity, and benthic community structure. The scope of this initial investigation effort is sufficient only to definitively demonstrate the presense or absence of impacts within the Sweetwater River ecosystem. It is not intended to fully characterize/quantify impacts, should there be any, or to direct remedial decisions. If it is determined that this is necessary, more comprehensive evaluation of impacts within the river and within adjacent habitats would be required.

Specific questions that will be addressed by the proposed river sampling include:

- Can sediment contaminant concentrations, if they exist, be correlated with toxicity in laboratory exposures with benthic organisms?
- Can sediment contaminant concentrations, if they exist, be correlated with altered benthic community structure?
- Can laboratory toxicity and in-stream effects, if they exist, be related in terms of sediment chemistry and spatial distribution?
- If contaminant-induced effects are observed, what proportion of habitat in the Sweetwater River appears to be impacted, and to what extent can those impacts be attributed to Split Rock Mill operations?

The proposed studies are intended to provide a complete picture of potential contaminant impacts within the portion of the Sweetwater River being sampled. All studies have been designed to complement those proposed by other disciplines (e.g., hydrology), resulting in maximal overall project efficiency and minimal project costs.

Based on the study results either:

- A decision will be made with certainty that negligible ecological impact is currently associated with sediments in the Sweetwater River, as they are influenced by former Split Rock Mill operations; or

- A decision will be made that additional investigation is warranted to quantify the extent of impact present within the river system as a whole.

The proposed sediment toxicity testing program has been designed to allow inferences to be made relating observed effects, if any, with physical and chemical parameters measured in the Sweetwater River. Although cause-and-effect relationships can be defined only under controlled experimental conditions, the results of regression/correlation analyses and multivariate analysis of variance (MANOVA) can be used to discern patterns among field observations and to suggest probable causes for any impacts that may be observed. If relationships can be clearly established, the results from a limited number of sampling/testing sites may be applied to other locations, thereby providing a cost-effective basis from which to further assess possible impacts throughout the river system. Alternatively, if statistical procedures show that no relationship currently exists between contaminant concentrations and observed biological effects, it would suggest that negligible risk can be attributed to contaminants derived from Split Rock Mill operations.

For the assessment of the Sweetwater River sampling/testing sites will correspond to points adjacent to the predicted groundwater flow from the Split Rock Mill Site into the Sweetwater River. Each site will be characterized from field and laboratory data to provide a comprehensive picture of potential impacts. Samples will be collected and split for laboratory toxicity testing and chemical analysis. Appropriate techniques will also be applied to evaluate benthic community structure, organism density, and diversity. Results from test sites will be statistically compared with those from reference sites (likely two comparable upstream sites on the Sweetwater River) to determine the relative magnitude of observed effects and to clarify the relationship between contaminant concentrations and impacts to Sweetwater River biota.

The results of the testing program will be used to evaluate both depositional zones in the river, where potentially contaminated fine particulates predominate, and other areas containing coarse sediments that may be more typical of the Sweetwater River system. Sample results and site characteristics derived from hydrological, geological, and previous chemical investigations at the Site will be analyzed jointly in order to more readily interpret the assembled results.

2.2 Opportunistic Sampling

Limited investigations will be conducted to evaluate the potential extent of operations-derived contamination in areas not directly associated with the Sweetwater River that could impact ecological receptors. Opportunistic sampling of pond sediments, soils, pond surface water, and pond and area vegetation will be conducted. Areas most likely to be affected by and/or most vulnerable to impacts will be identified, based on site reconnaissance. These include hydrologically downgradient portions of the site, irrigated fields, ponds, and ditches that are located in the valleys to the southwest (SWV), northwest (NWV), and northeast (NEV), as shown in Figure 2-1. Opportunistic sampling in these areas will not be systematic but rather will provide a snap-shot picture of prevailing conditions. These will form the basis for ensuing site investigations, if necessary, aimed at characterizing ecological risks across the Site in general.

Potential human health risks due to Site-derived contaminants will also be evaluated using the results of the opportunistic sampling. The objective of the evaluation will be to focus subsequent human health risk investigations at the Site, should they be necessary. The results will be used to designate potential chemicals of concern (COCs) for human receptors and to estimate the extent of variance expected to be found in subsequent, more comprehensive chemical data sets. Opportunistic sampling results will be useful for:

- designing an appropriate sampling strategy that may allow for quantitative evaluation of potential human health impacts, if necessary; and
- developing a conceptual site model that identifies pathways to be included in subsequent risk evaluations, should they be necessary.

Brown and rainbow trout specimens collected from the Sweetwater River will be analyzed to provide an indication of the potential for transfer of contaminants from the river ecosystem to human receptors. Measured fish tissue contaminant concentrations will be compared with benchmarks derived by the U.S. Environmental Protection Agency (USEPA) corresponding to both a human health cancer risk of 10^{-4} and a non-cancer hazard quotient of 1 (USEPA 1995). Although such benchmarks are derived based on a conservative 10^{-6} risk level, the NRC generally utilizes a 10^{-4} risk level; therefore, the benchmark concentrations will be modified to reflect a 10^{-4} risk level.

If measured fish tissue values do not exceed the benchmark values, it will be assumed that negligible, if any, potential exists for human health impacts due to fish consumption. If benchmarks are exceeded, further evaluation of tissue concentration variances and fishing activity/tissue consumption patterns may be warranted.

3.0 EXISTING DOCUMENTS AND DATA

Limited data regarding potential environmental contaminants are available for the Split Rock Mill Site and the surrounding area. The majority of the available data are from surface water from the period from 1977 to1995. The following briefly describes the type and source for all available data.

Surface Water

Limited sampling of upland surface waters (i.e., ponds) adjacent to the mill site was conducted in 1977 (D'Appolonia 1977). Samples were obtained at five locations adjacent to the mill and tailings pile. Samples were collected from the tailings pond (S-1), impoundment water adjacent to the acid-plant (S-2), and three seepage ponds located southwest of the facility tailings pile (S-3, S-4, S-5). Results of these analyses are presented in Table 4.5 of D'Appolonia (1977). Measured concentrations varied considerably depending on sampling location.

Table 4.6 of D'Appolonia (1977) presents surface water data for the Sweetwater River for the fourth quarter of 1976. Results of this monitoring effort appear similar to the results reported in Canonie (1989). The D'Appolonia report suggests that additional monitoring data exist; however, the extent of the additional monitoring effort could not be identified.

Surface water samples have been collected from the Sweetwater River during the period from 1981 to the present (Canonie 1989, Western Nuclear, Inc. [WNI] 1995). Three sample locations have been monitored as part of this effort and they are located:

- west of the Mill site, upstream of any potential influence from Jeffrey City and Mill site operations (S-7);
- adjacent to the Mill site in the vicinity of a bridge crossing the river at the Grieve Ranch (S-6); and
- northeast and downstream of the Mill site near the Split Rock historical site.

Water samples were analyzed for a variety of analytes including, but not limited to, beryllium, cadmium, molybdenum, nickel, selenium, radium, thorium, and uranium. Monitoring results for the period from 1981 to 1987 are presented in Appendix H of Canonie (1989) and in semi-annual reports prepared by WNI. Results of these analyses showed no significant differences between upstream and downstream locations, and the concentrations of measured analytes were below ambient water quality concentrations . Monitoring results from 1987 to the present are presented in WNI (1995). No statistical evaluation has been conducted on data collected since 1987; however, review of the available data does not suggest a substantial shift in the measured concentrations of analytes.

Aquatic Sediments

No contaminant data are available for sediments obtained from either the Sweetwater River or from surface waters located adjacent to the Mill site.

Terrestrial Soils

As part of the sampling efforts conducted in 1977 (D'Appolonia 1977), surface soil samples were collected from nine locations adjacent to the mill operational area (three each to the southwest, northeast, and northwest of the mill site) and one "control" location located approximately due north of the site. Soil samples were obtained from three separate depths: less than 18 cm, 25 to 46 cm, or 91 to 107 cm. Concentrations of a number of different materials were determined as part of this effort, including several metals and metalloids, as well as several nutrients (e.g., nitrate and phosphorous). Results of soil characteristics and elemental concentrations are contained in Appendix H and Table 5.1, respectively, of the D'Appolonia report.

Animal Tissue Residues

No fish, avian, or terrestrial mammal tissues have been sampled at the mill site or surrounding areas. Therefore, no direct empirical information is available regarding the bioaccumulative potential of any of the Site contaminants.

Plant Tissue Residues

A variety of plant tissues (i.e., upper stalk, lower stalk, and root) obtained from mill site resident plants were sampled and analyzed for 15 different nutrients and potential site contaminants in 1977 (D'Appolonia 1977). This information was again summarized in the Final Environmental Impact Statement (FEIS) (WNI 1980). Approximately seven different species of plants were sampled. Study results are contained in Table 5.5 of the D'Appolonia report. Briefly, the authors concluded that concentrations of lead, arsenic, selenium, fluoride, vanadium, boron, free cyanide, molybdenum, and magnesium were present at concentrations higher than typically expected in vegetation. No explanation was given.

Summary

Limited environmental fate and effects data are available for the area of interest. The available data include chemical analyses of Sweetwater River water samples and plant tissue concentrations collected in upland areas adjacent to the mill site. No information, however, is available regarding the type or extent of sediment contamination that may exist. No quality assurance/quality control (QA/QC) evaluation of the data was conducted as part of the data review effort; the data was assumed to be of acceptable quality. Detection limits cited in historical data summaries appear to be acceptable for risk assessment purposes.

Based on comparison with federal Ambient Water Quality Criteria, extant water sampling data from the Sweetwater River do not suggest an immediate concern to water-column-dwelling aquatic organisms. With the large amount of historical surface water data available, it is not necessary to collect additional surface water for analysis of potential impacts. Since any contaminants in the river are anticipated to have entered via either surface water runoff or groundwater intrusion, it is likely that they would be present to a higher degree in river sediments than in river water. To address this, efforts during the fall 1995 sampling period will focus on the evaluation of sediment concentrations and potential impacts to sediment-dwelling organisms.

As previously described, plant tissue analyte concentrations, collected in 1977 and in additional ongoing vegetation sampling, were stated to be higher than expected in vegetation. This, however, does not necessarily indicate adverse effects to either the plants surveyed or to the consumers of these plants. The fall 1995 sampling effort will involve limited opportunistic sampling of plant tissues for selected analytes. This information will be used to supplement the 1977 data and to assess what changes, if any, have occurred over the 18 years since the last sampling. In addition, samples of species that are more important from a food chain perspective (e.g., alfalfa, *Typha*) will be taken, in order to assess the potential impacts to humans and wildlife.