DEPARTMENT OF THE INTERIOR

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Results of chemical analysis for sediments from Department of the Interior National Irrigation Water Quality Program studies, 1988-1990

By

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INTRODUCTION

In response to Congressional requests, the Department of the Interior (DOI) began a multi-agency program in 1985 to identify the nature and extent of potential water quality problems resulting from federally-funded irrigation projects in the western United States. Twenty areas were selected in 13 western states for reconnaissance level studies which started in 1986. The purposes of the reconnaissance studies were to identify problem elements in water, sediment and biota, and to determine which areas were appropriate for detailed studies. Analytical data for bottom sediments from 19 of those original areas have been published (Severson and others, 1987, Harms and others, 1990). Of these areas, seven were selected for detailed inves-tigations. This report presents bottom sediment analytical data for the twentieth original reconnaissance area, four additional reconnaissance areas, and partial data from three detailed study areas. The following descriptions briefly characterize each reconnaissance study area included in this report (figure 1):

<u>Pine River (Los Pinos) area, Colorado</u>: The Pine River project is located in southwestern Colorado. Water from Vallecito Reservoir irrigates approximately 200,000 acres located mostly on the Southern Ute Indian Reservation between Vallecito Reservoir in La Plata County and the Los Pinos River arm of Navajo Reservoir in northern New Mexico. The Colorado Division of Wildlife manages one wildlife area within project lands.

<u>Humboldt Wildlife Management Area, Nevada</u>: The Humbolt Wildlife Management Area (WMA) is located in a closed basin at the terminus of the Humbolt River in northwestern Nevada. The Nevada Department of Wildlife established the area of about 36,400 acres in 1954 as a migratory bird refuge along the Pacific Flyway to mitigate habitat loss due to irrigation. In addition to water from the Humbolt River, the area receives return flow from the Humbolt Irrigation Project which has irrigated 31,000 acres north and south of Lovelock. The Humbolt Mountains separate it from Stillwater Wildlife Management Area which was investigated during the initial reconnaissance studies in 1986-87 (Severson and others, 1987).

<u>Owyhee and Vale Projects, Oregon/Idaho</u>: The Owyhee Project irrigates about 118,000 acres along the Snake River in eastern Oregon and western Idaho. The Vale Project area is located just west of there along the Malheur River and supplies water to a smaller area of 35,000 acres. Return flow from both projects drains into the Snake River where it supports several wildlife management areas on the Oregon-Idaho border.

<u>Dolores River Project, Colorado</u>: After completion, the Dolores River Project will service three areas in southwestern Colorado totaling approximately 62,000 acres. Water will be diverted from the Dolores River basin to supply irrigation systems in the San Juan River basin. Drainage and return flow will therefore affect portions of Utah and New Mexico. Salts of sodium, sulfate and selenium are constituents of concern for this project because much of the area proposed for irrigation is underlain by the seleniferous Mancos Shale.

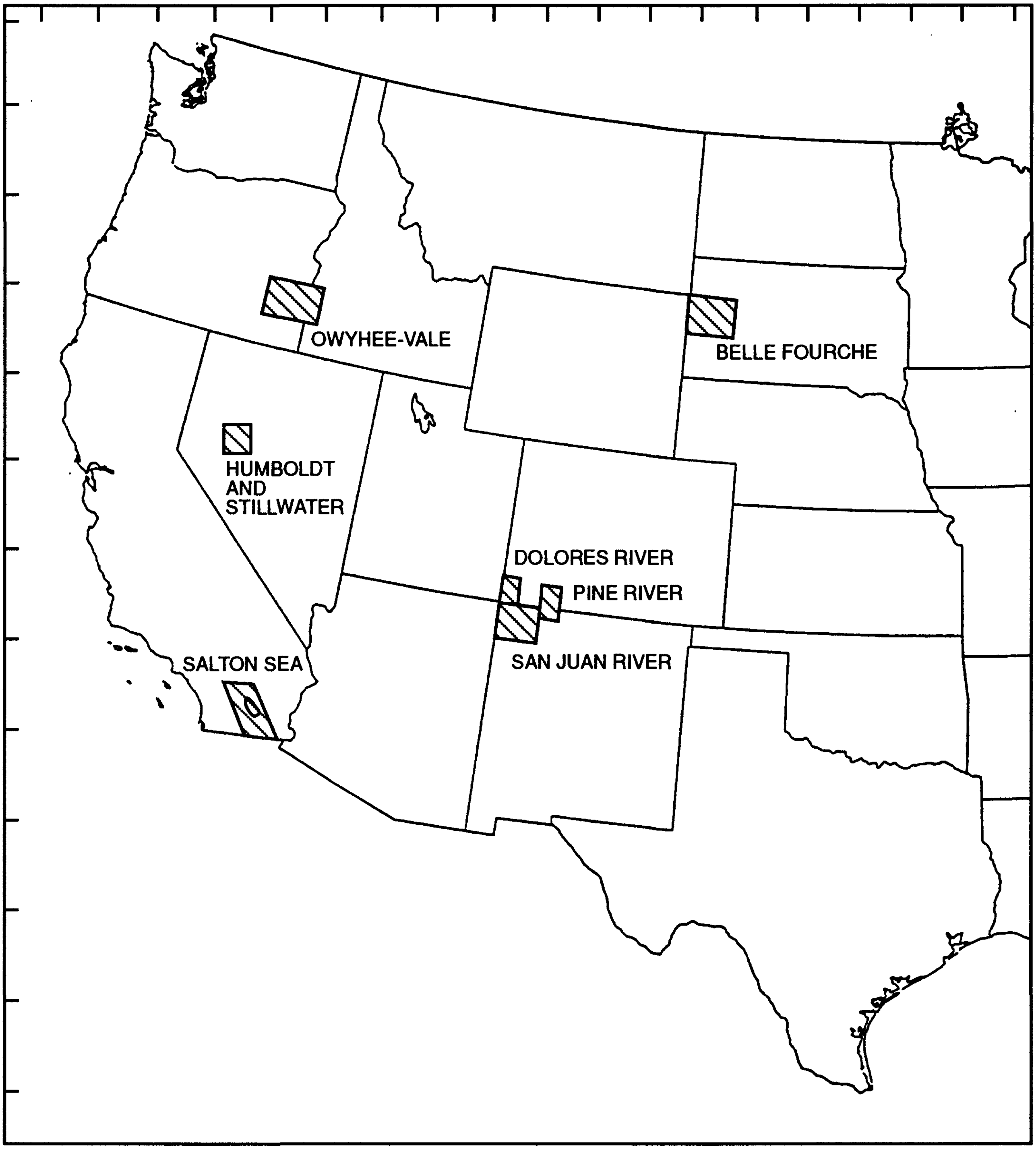

Figure 1. Map showing location of DOI sampling programs discussed in this report

San Juan River Area, New Mexico: Five irrigation projects in northwestern New Mexico contribute to the San Juan River reconnaissance study area. U.S. Bureau of Reclamation-constructed dams, canals and pumps currently irrigate about 67,000 acres mostly in a 90-mile strip along the river from Navajo Dam to the mouth of the Mancos River near the Colorado border. Roughly 60,000 acres will be added when the Navajo Indian Irrigation Project is complete. Ponds and wetlands interspersed among the project areas receive irrigation drainage and return flow and provide habitat for migratory birds and native fish. Selenium is the element of concern, since the Mancos Shale underlies a portion of the area.

Samples received from areas selected for additional sampling (Severson and others, 1987; Harms and others, 1990) include the following:

Belle Fourche Reclamation Project, South Dakota: The study area is located northeast of the Black Hills in western South Dakota. The project irrigates approximately 57,000 acres in the Belle Fourche River Basin from Belle Fourche Diversion Dam to Nine Mile Creek about 25 miles downstream. Two locations were resampled for the reconnaissance study due to improper processing of the original sediments (Roddy and others, 1991).

Stillwater Wildlife Management Area (WMA), Nevada: Federal and state agencies established the area (including the Stillwater Wildlife Refuge) of about 224,000 acres in the lower Carson River basin in 1948. It provides migratory bird habitat along the Pacific Flyway, similar to the Humbolt Wildlife Management area. In addition to its own water allocations, it receives drainage and return flow from approximately 66,000 acres of the Newlands (irrigation) Project. Reconnaissance studies showed mercury to be the primary element of concern (Severson and others, 1987, Hoffman and others, 1990). Data are presented here for samples taken to further characterize movement of mercury found in canals and drains.

Salton Sea Area, California: The original study area (Severson and others, 1987; Setmire and others, 1990) consisted of approximately 8300 square miles in the Imperial and Coachella Valleys in southeastern California and included the Salton Sea National Wildlife Refuge. Data are presented here for samples taken to determine selenium concentration changes in sediment cores from the Alamo River Delta at the southern end of the Salton Sea.

FIELD SAMPLING

Bottom sediments were collected by team members from Water Resources Division of the U.S. Geological Survey from late 1988 to 1990 after irrigation ceased. Samples were taken from the upper 5-10 cm of sediments deposited in streams, marshes, lakes and drainage ditches with a stainless steel coring device or wide-mouth glass jar. Several samples were collected at each site and mixed in a non-contaminating container to make a composite sample for each location.

SAMPLE PREPARATION

The wet samples were processed in the Branch of Geochemistry analytical laboratories of the U.S. Geological Survey in Denver, Colorado. All samples were air dried at ambient room temperature (about 20° C), disaggregated using a mechanical mortar and pestle, and sieved to pass a 2-mm (10-mesh) sieve. Material greater than 2 mm was discarded. Samples were then split into two portions: one portion was ground to pass a 100-mesh sieve (designated as the coarse fraction); the other portion was sieved to pass a 230-mesh sieve (.062 mm, designated as the fine fraction) and material not passing through the sieve was discarded. Two size fractions from each sample were therefore submitted for analysis—a coarse, ground fraction (<2 mm) which included any fine material present, and a fine fraction (<.063 mm).

ANALYTICAL TECHNIQUES

Several of the analytical techniques summarized below are discussed in detail in Baedecker (1987). Replicates, reagent blanks and reference materials were processed and analyzed simultaneously with samples.

Inductively coupled argon plasma-atomic emission spectroscopy (ICP-AES)

For a 40-element determination, samples were decomposed at low temperature (approximately 100° C) with a mixture of concentrated hydrochloric, nitric, perchloric and hydrofluoric acids. Samples were taken to dryness, redissolved in aqua regia (3 parts concentrated hydrochloric acid to 1 part concentrated nitric acid), and diluted with 1% nitric acid (v/v). Solutions were scanned simultaneously for 40 elements by ICP-AES (Crock and others, 1983). Lower limits of determination for elements reported are shown in table 1 for 29 elements which showed occurrences in the sediments. Determination limits for three elements by ICP-AES (As, Th, U) are not listed since results are reported by other methods.

Continuous-flow hydride generation atomic absorption spectroscopy

Arsenic and selenium were determined by hydride generation (Briggs and Crock, 1986, Crock and Lichte, 1982). Samples were decomposed by a mixture of concentrated nitric, perchloric, and hydrofluoric acids. Samples were taken to dryness, redissolved in concentrated hydrochloric acid and diluted with deionized water to a final concentration of 3 N. Samples then sat overnight to reduce selenium VI to selenium IV. Aliquots were reacted with sodium borohydride to generate the gaseous hydride in a continuous-flow system and selenium or arsenic hydride was quantitated in a heated quartz furnace by atomic absorption spectroscopy at the appropriate wavelength. Lower limits for determination are shown in table 1.

Cold vapor atomic absorption (AA) spectroscopy

Mercury was determined by cold vapor atomic absorption spectroscopy (Kennedy and Crock, 1987). Samples were digested with concentrated nitric acid and sodium dichromate in a glass test tube at 90° C for 3 hours and then diluted with deionized water. An aliquot was reacted with stannous chloride and hydroxlyamine hydrochloride in a continuous flow system to generate elemental mercury which was determined by a flameless atomic aborption spectrometer. The determination limit is shown in table 1.

Delayed neutron activation analysis

Uranium and thorium were determined by neutron activation analysis (McKown and Millard, 1987). Samples were irridiated and counted twice in the U.S.G.S. TRIGA reactor with BF_3 detectors. The first count quantitates delayed neutron emission primarily by uranium. For the second irradation, samples are placed in a cadmium-lined container which absorbs most neutrons in the thermal energy range and increases delayed neutron emission by thorium. Calculations were made based on instrument standardization by international reference standards and a series of equations whose re-iterative calculations converge on values for uranium and thorium. For geologic materials with a thorium/uranium ratio greater than 3, the co-efficient of variation for uranium is about 5 percent and for thorium about 10 percent. Determination limits are shown in table 1.

Hot-water extraction, ICP-AES

Samples for boron analysis were prepared by hot water extraction (Stewart and others, 1989). One part sample was added to 2 parts deionized water (1:2) and the mixture boiled in a hot-water bath for 1 hour. Solid-phase material was separated by centrifugation and an aliquot of supernatant taken for ICP-AES determination. Determination limits for this partial leach are shown in table 1.

Infrared spectroscopy

Total carbon was determined by combusting samples in an oxygen atmosphere at 1,370° C and measuring carbon dioxide generated by infrared analysis in a Leco* automated carbon analyzer (Jackson and others, 1987).

Coulometric titration

Carbon from carbonate was determined by coulometric titration of carbon dioxide. Samples were leached by 2 N perchloric acid and the carbon dioxide generated was converted to a strong acid by ethanolamine in a coulometric cell. The coulombs necessary to generate sufficient base for titration of the acid to an endpoint were measured and converted to percent carbon from a standard curve.

Organic carbon was calculated indirectly from the differences between total and carbonate carbon. Determination limits for all forms of carbon are shown in table 1.

QUALITY CONTROL

A reference sediment (KS-12E) from Kesterson Wildlife Refuge, California was included with samples to determine precision and accuracy of the analytical data. Geologic Division Personnel collected the sediment in bulk quantities in 1986. It was disaggregated, ground to <100 mesh, mixed, and analyzed for a 40-element suite by ICP-AES, arsenic and selenium by hydride generation, and mercury by cold vapor atomic absorption in 1988. Analytical replicates of this reference soil were analyzed simultaneously with sediments. Summary statistics for 13 replicates are shown in table 2 along with the mean from the previous set of reconnaissance studies. Values for water extractable boron are calculated from 11 replicates since two were improperly processed. Uranium statistics were calculated from 12 replicates since one value was an obvious outlier due to improper sample size. Ranges, standard deviations and percent relative standard deviations (%RSD's) for the earlier values can be found in Harms and others (1990).

DESCRIPTION OF RESULTS

Table 3 lists the lab identifiers, descriptions, and locations in degrees, minutes and seconds of latitude and longitude. The sample identifiers correspond to those in the data listings in table 5. Replicate samples taken in the field are identified in the sample description. In the data listing, the letter "C" or "F" has been added to the lab ID to represent the coarse fraction (<2 mm) or fine fraction (<.062 mm) respectively, except for Pine River where fine and coarse fractions were numbered consecutively. The year of collection is the last number for the sample. Table 4 lists lab ID's, sample descriptions, latitudes, longitudes and selenium data for the Salton Sea sediment cores.

The means and %RSD's of selected elements for 13 replicates of reference soil KS-12E are shown in table 2. Comparison of these means with those from previous studies (Harms and others, 1990) indicate comparability of data shown in table 5 with that from previous studies. The means for all elements from this report are within one standard deviation of means from Harms and others (1990) except for barium, strontium and uranium. Means for barium and strontium are within two standard deviations of the previous values, but the mean for uranium by delayed neutron activition is 34% higher than by ultra-violet fluorescence. The %RSD for uranium by the fluorescence method was 25% (data not shown) compared to 4% by neutron activation analysis and more reliance should therefore be placed on the neutron activation numbers. The lower values obtained by fluorescence should also be considered when comparing data from Harms and others (1990) to previous studies (Severson and others, 1987) where neutron activation analysis was used for uranium.

The %RSD for arsenic (31%) is high considering the fact that this constituent was present at 200 times its determination limit (table 1), but this value is comparable to that from Harms and others (1990) of 36%. The high %RSD may indicate that the reference material is inhomogeneous with respect to arsenic since 12 pairs of sediment analytical duplicates are all within 4% of each other (data not shown). The high %RSD's for beryllium (28%) and mercury (41%) reflect values which are close to the lower limits of determination for the techniques. The mean for selenium (2.9 ppm) is within one standard deviation of 2.4 ppm mean published by Harms and others (1990), but the %RSD (19%) is higher than for the previous set of analyses (3.6%).

Table 6 shows means and ranges from the western United States soils for constituents presented in this report, and ranges for all reconnaissance studies completed. All data are from the <2 mm or coarse size fraction. The maxima for chromium, copper and nickel in sediments are much lower than for the soils, whereas the maxima for selenium and molybdenum are an order of magnitude higher in sediments than in soils.

Table 7 compares geometric means for selected trace elements in the coarse fraction of sediments from each of the 24 studies completed by the DOI (Severson and others, 1987; Harms and others, 1990, this report). The grand mean bases on 334 samples from all areas is also shown. One sediment from Sweitzer Lake (GR12, 40 ppm selenium) was not included in the calculations since it was not part of the original study. Background sites taken outside of the irrigation-impacted areas were included in the calculations. The geometric mean for arsenic in sediments (5.3 ppm) is comparable to the mean for soils (5.5 ppm). The geometric mean for selenium in sediments (.47 ppm) is about twice that for the western soils (.23 ppm). Irrigation apparently has a large effect on the distribution of selenium in surficial materials. The geometric mean for mercury in sediments (.03 ppm) is lower than for soils (.046 ppm), but the difference is probably not significant. No direct comparison can be made between soil and sediment boron since the soil values are total boron and the sediment values are water extractable.

Comparing sediment data, two areas (Stillwater WMA and Belle Fourche) show much higher means for arsenic (12 and 15 ppm respectively) than for all sites (5.3 ppm). Three other areas (Kendrick, Middle Green River and Gunnison River/Sweitzer Lake) show much higher means for selenium (2.8, 3.9 and 4.0 ppm respectively) than for all sites (.47 ppm). Stillwater WMA also shows unusual concentrations of sediment mercury (.56 ppm compared to .03 ppm for all sites). Tulare Lake, Stillwater WMA and Malheur NWR all have water-extractable boron values an order of magnitude higher than the mean for all sites (1.8 ppm).

The DOI National Irrigation Water Quality Program has accumulated much valuable information since the original studies began in 1986. The studies have compiled chemical data from sediments impacted by federally-funded irrigation projects in the western United States which vary in age from more than eighty years old to less than two. Data generated from the reconnaissance sampling programs have assisted scientists in designing detailed studies to better define movement of elements by irrigation water. The data have also aided in the design of remediation programs for areas where wildlife has been impacted by drainage and have provided the basis for recommending acreage withdrawal from uncompleted projects to avoid problem geologic units and soil types. The data base, which now includes chemistry for sediments derived from soil types of widely-differing parent material, moisture regimens and ages, will provide valuable information for avoiding irrigation-related human and wildlife health problems in the future.

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Table 1. Techniques and lower limits of determination (LLD) for elements reported. Values in ppm dry weight unless otherwise noted

Method	LLD	Element
ICP-AES	2.0	La, Li, Mo, Ni, Sc, Sr, V, Y, Zn
	1.0	Ba, Be, Co, Cr, Cu, Yb
	4.0	Ce, Ga, Mn, Nb, Nd, Pb
	0.05%	Al, Ca, Fe, K
	0.005%	Mg, Na, P, Ti
Hydride Generation	0.1	As, Se
Cold Vapor AA	0.02	Hg
Delayed Neutron	1.0	Th
Activation	0.1	U
Hot-water Extraction		
ICP-AES	0.2	B
Infra-red Spectroscopy		
(Leco)	0.05%	Total C
Coulometric Titration	0.01%	Carbonate C
By Difference	0.05%	Organic C

Table 2. Summary statistics for selected elements in reference sample KS-12E. Values are in ppm unless noted, n=13

Element	Range	Mean (this report)	Standard Deviation	Relative Standard Deviation (%)	Mean 1988-89[1]
Al,%	7.2-7.8	7.5	.17	2.3	7.3
As	10-29	19	5.9	31	22
B	23-32	28[2]	3.2	11	25
Ba	720-800	760	23	3.0	730
Be	1-2	1.7	.48	28	2
Ca,%	2.9-3.2	2.9	.09	3.1	3
Ce	45-56	50	2.8	5.7	47
Co	12-14	13	.65	5.2	13
Cr	73-90	81	5.7	7.0	80
Cu	19-23	21	.95	4.5	21
Fe,%	3.0-3.2	3.1	.06	2.1	3
Ga	15-18	16	.95	5.8	16
Hg	.02-.08	.04	.02	41	.033
K,%	<.02-2.2	2.1	.06	2.9	2
La	26-33	29	1.7	6.0	28
Li	39-44	42	1.4	3.4	40
Mg,%	1.5-1.7	1.6	.04	2.7	1.6
Mn	410-460	430	17	4.1	420
Mo	all <2	--	—	—	<2
Na,%	2.2-2.4	2.3	.06	2.8	2.2
Nb	6-10	8.1	1.6	19.2	8.0
Nd	20-26	23	1.4	6.3	22
Ni	52-63	56	2.9	5.1	55
P,%	.06-.07	.06	.004	7.0	.06
Pb	15-21	18	2.3	13	17
Sc	10-11	10	.52	5.0	10
Se	1.7-4	2.9	.55	19	2.4
Sr	370-400	380	8.8	2.3	360
Th	10-14	11	1.3	10	11[3]
Ti,%	.29-.36	.33	.02	5.5	.33
U	3.2-3.7	3.5[4]	.15	4.3	2.2[5]
V	74-84	81	2.9	3.6	80
Y	15-18	16	.90	5.6	15
Yb	2-2	2.0	—	—	2
Zn	70-81	75	3.4	.5	73
Tot. C,%	1.1-1.3	1.2	.06	5.5	1.2
Org. C,%	.66-.88	.75	.07	.5	.82
Cbnt.C,%	.37-.42	.40	.02	3.9	.40

[1]Harms and others, 1990, [2]n=11, [3]by ICP-AES, [4]n=12, [5]by ultra-violet fluorescence

Table 3. Listing of sample identifiers, locations and descriptions

Lab ID	Field ID and sample description	Latitude	Longitude
	Pine River (Los Pinos), Colorado (Dave Butler)		
PR01,11	N1, Navajo Reservoir, Piedra arm	37-01-36	107-23-57
PR02,12	N2, Navajo Reservoir, Los Pinos arm	36-56-47	107-35-50
PR03,13	F, Florida River at Bondad	37-03-24	107-52-09
PR04,14	ST2, Salt Creek, .75 miles above mouth	37-07-54	107-46-20
PR05,15	B2, Beaver Creek at Highway 51	37-10-17	107-34-24
PR06,16	U2, Ute Creek near mouth	37-05-38	107-36-38
PR07,17	R2, Rock Creek at Highway 172	37-06-23	107-37-57
PR08,18	SP2, Spring Creek at La Boca	37-00-40	107-35-47
PR09,19	WSB2, West Sambrito Creek at mouth	37-00-14	107-28-35
PR10,20	SB2, Sambrito Creek at mouth	37-00-36	107-27-24
	Humboldt Wildlife Management Area, Nevada (Ralph Seiler)		
HR01	Toulon Drain at Derby Field Road	40-05-00	118-34-38
HR02	Toulon Lake	40-03-07	118-36-30
HR03	Army Drain 2	40-02-33	118-35-28
HR04	Humboldt River near Lovelock	40-03-03	118-28-05
HR05	Graveyard Drain	40-08-05	118-30-17
HR06	HRU, Humboldt River, upper valley road	40-18-41	118-22-15
HR07	UHL, Upper Humboldt Lake	40-00-09	118-37-20
HR08	RP, Ryepatch Reservoir	40-28-15	118-18-30
HR09	AFBMD, Humboldt River near Lovelock, field replicate	40-03-03	118-28-05
HR10	HRG, Humboldt River near Golconda	40-58-45	117-29-01
HR11	HRI, Humboldt River near Imlay	40-41-30	118-12-10
	Oyhee and Vale Rivers, Oregon/Idaho (Frank Rinella)		
OV01	Sand Hollow Creek drain	43-49-19	117-00-32
OV02	Sand Hollow Creek inflow	43-47-59	116-58-28
OV03	Succor Creek near Homedale, Idaho	43-37-05	116-57-14
OV04	Boise River near Parma, Idaho	43-46-54	116-58-17
OV05	Snake River at Marsing, Idaho	43-32-54	116-47-57
OV06	Owyhee River below Owyhee Reservoir	43-39-17	117-15-16
OV07	Owyhee River at Owyhee, Oregon	43-46-57	117-03-30
OV08	Overstreet Drain to Owyhee River	43-47-05	117-06-52
OV09	Malheur River near Ontario	44-03-12	116-58-51
OV10	Payette River near Payette, Idaho	44-02-33	116-55-27
OV11	Snake River at Weiser, Idaho	44-14-44	116-58-48

Table 3--cont.

OV12	Malheur River near Ontario, field rep.	44-03-12	116-58-51
OV13	Malheur River below Warm Springs	43-34-29	118-12-31
OV14	North Fork Malheur River at Beulah	43-54-28	118-09-08
OV15	Bully Creek near Vale	43-58-02	117-16-16
OV16	Malheur River on Lytle Bird	43-58-44	117-14-11
OV17	Willow Creek at railroad crossing	43-59-17	117-13-45
OV18	D drain to Malheur River	43-59-45	117-06-53
OV19	Bully Creek below Bully Creek Reservoir	44-01-04	117-23-04
OV20	Malheur Lake evaporite deposit	43-15-40	118-49-47
OV21	North Harney Lake evaporite deposit	43-16-50	119-17-30
OV21	Northe Malheur Lake evaporite deposit	43-20-53	118-58-46
	Dolores River, Colorado (Dave Butler)		
DUM01	CH1, Cahone Canyon	37-38-57	108-48-30
DUM02	CR1, Cross Canyon	37-40-36	108-52-44
DUM03	SJ3, San Juan River at Mexican Hat	37-08-49	109-51-51
DUM04	ME4, McElmo Creek below Yellow Jacket	37-19-33	109-02-57
DUM05	ME2, McElmo Creek near Cortez	37-19-23	108-40-22
DUM06	ME3, McElmo Creek near state line	39-19-27	109-00-54
DUM07	HD2, Hartman Draw near mouth	37-19-26	108-36-52
DUM08	YJ2, Yellow Jacket Canyon at mouth	37-19-46	109-02-31
DUM09	MN2, Mancos River near state line	37-00-12	108-56-25
DUM10	DD1, Dawson Draw	37-28-40	108-40-54
DUM11	AK1, Alkali Canyon	37-23-52	108-38-56
DUM12	SD1, Simon Draw below Cash Canyon	37-22-42	108-30-28
DUM13	TT1, Totten Reservoir	37-21-44	108-31-52
DUM14	PU1, Puett Reservoir	37-25-07	108-24-43
DUM15	SU1, Summit Reservoir	37-25-18	108-23-11
DUM16	WC1, Woods Canyon tributary	37-29-34	108-46-25
DUM17	SJ1, San Juan River-Four Corners	37-00-20	109-02-00
DUM18	NW1, Navajo Wash near Towoac	37-12-03	108-41-50
DUM19	QABM, McElmo Creek below Yellow Jacket, field replicate	37-19-33	109-02-57
	San Juan River, New Mexico (Paul Blanchard)		
NF01	South Pond, Gallegos Canyon	36-35-55	108-08-06
NF02	Middle Pond, Gallegos Canyon	36-38-41	108-07-02
NF03	North Pond, Gallegos Canyon	36-38-43	108-06-10
NF04	Ojo Amarillo Canyon, 1 mi below ponds	36-40-43	108-19-54
NF05	Southeast Pond, Ojo Amarillo Canyon	36-39-43	108-19-06
NF06	Gallegos Canyon	36-40-00	108-06-54
NF07	Hogback Project, east side	36-45-23	108-35-15
NF08	East Hammond site	36-42-07	107-55-20
NF09	San Juan River at Hammond Diversion	36-44-47	107-48-39
NF10	Hogback Project, west site	36-48-43	108-43-29

Table 3--cont.

NF11	Chaco River near mouth	36-46-14	108-38-38
NF12	San Juan River near Cudei	36-52-51	108-49-12
NF14	La Plata River at mouth	36-44-10	108-15-04
NF15	San Juan River near Fruitland	36-44-32	108-24-16
NF16	San Juan River near Gallegos Canyon	36-41-36	108-06-20
NF17	Fruitland Project site	36-43-33	108-22-34
NF18	West Hammond site	36-41-21	108-02-00
NF19	Hogback Marsh	36-46-28	109-39-35
	Belle Fourche, South Dakota (Bill Roddy)		
BF01	Horse Creek above Vale	44-39-08	103-21-59
BF02	Belle Fourche River	44-30-47	103-08-11
	Stillwater Wildlife Management Area, Nevada (Tim Rowe)		
SN01	D-line canal below East Lake	39-36-19	118-34-25
SN02	A-drain at powerline crossing	39-36-07	119-09-59
SN03	South Lead Lake at landing	39-36-43	118-31-05
SN04	Paiute drain at monitor	39-35-41	118-34-09
SN05	South Pond at outlet	39-37-08	119-07-35
SN06	TJ drain at wildlife entrance	39-36-32	118-33-14
SN07	De Braga Well 14-6 sediment	39-32-36	119-33-16
SN08	LLAH-1, core at 18′	39-36-51	118-32-57
SN09	LLAH-2, core at 17.5′	39-36-48	118-32-51
SN10	LLAH-3, core at 8′	39-36-45	118-32-42
SN11	LLAH-3, core at 13.5′	39-36-45	118-32-42
SN12	LLAH-4, core at 12.5"	39-36-41	118-32-34
SN13	LLAH-5, core at 13.5′	39-36-37	118-32-25
SN14	LLAH-6, core at 15′	39-37-05	118-29-24
SN15	LLAH-7, core at 8′	39-36-24	118-29-41
SN16	LLAH-8, core at 13′	39-37-19	118-30-33

Table 4. Selenium data for sediments from Salton Sea, California (Jim Setmire)

Lab ID	Sample description	Latitude	Longitude	ppm Se
SS01T	site 1	33-12-11	115-36-00	0.2
SS02T	site 2	33-12-26	115-36-43	0.5
SS05TT	site 5, top	33-13-12	115-37-55	0.2
SS05TB	site 5, bottom	33-13-12	115-37-55	0.5
SS16T	site 16	33-11-53	115-36-09	1.2
SS17T	site 17	33-11-55	115-36-09	1.5
SS19T	site 19	33-12-04	115-38-57	1.2
SS24T	site 24	33-07-27	115-41-50	0.5

TABLE 5. Analytical data for DOI studies 1988-1990

Sample	AL pct	AS ppm	XWB ppm	BA ppm	BE ppm	CA pct	CE ppm	CO ppm	CR ppm
				Pine River (Los Pinos), CO					
PR01F88	6.9	5.2	.5	620	2	2.3	61	13	38
PR02F88	5.6	5.6	<.4	640	2	.9	62	10	38
PR03F88	6.2	4.4	<.4	720	2	1.5	84	11	30
PR04F88	4.5	3.8	<.4	530	1	.6	63	8	25
PR05F88	5.4	4.8	<.4	730	1	.8	66	10	32
PR06F88	3.9	4.6	<.4	580	1	.7	55	8	29
PR07F88	4.5	5.4	<.4	540	1	.6	73	9	29
PR08F88	5.1	6.2	--	1,000	2	1.3	76	10	39
PR09F88	5.9	5.8	<.4	1,100	2	1.4	73	13	43
PR10F88	5.2	3.8	<.4	890	2	1.3	65	10	41
PR11C88	6.9	4.6	<.4	620	2	2.3	61	13	36
PR12C88	5.4	3.7	<.4	580	2	.8	56	10	35
PR13C88	5.9	4.8	<.4	810	2	1.1	67	10	22
PR14C88	4.5	2.9	.5	520	1	.6	56	10	21
PR15C88	5.6	12.0	<.4	880	1	1.0	61	11	19
PR16C88	3.7	6.5	<.4	550	1	.7	42	10	21
PR17C88	4.5	4.9	<.4	490	1	.6	58	14	21
PR18C88	3.9	6.4	<.4	760	1	1.0	47	10	25
PR19C88	5.8	8.5	<.4	1,000	2	.7	55	14	39
PR20C88	5.1	6.4	<.4	870	2	1.0	53	11	36
				Humboldt Wildlife Management Area, NV					
HR01F90	5.9	11.0	10.0	740	2	9.8	49	10	41
HR02F90	4.1	22.0	90.0	530	1	15.0	27	6	19
HR03F90	5.7	17.0	10.0	610	2	11.0	43	11	39
HR04F90	5.8	12.0	1.0	770	2	11.0	45	10	44
HR05F90	6.9	9.4	10.0	860	2	5.8	55	11	48
HR06F90	7.1	14.0	--	860	2	5.9	83	13	60
HR07F90	2.6	21.0	10.0	410	<1	25.0	18	6	19
HR08F90	7.7	13.0	2.0	760	2	5.1	64	14	55
HR09F90	5.8	13.0	9.0	760	2	11.0	42	11	43
HR10F90	5.7	11.0	--	1,000	2	10.0	72	11	43
HR11F90	6.3	5.4	--	950	2	8.0	60	9	48
HR01C90	6.0	8.6	8.0	950	2	6.1	45	7	26
HR02C90	3.8	18.0	99.0	600	1	15.0	25	6	16
HR03C90	5.2	15.0	10.0	580	1	14.0	38	10	32
HR04C90	6.2	6.4	4.0	990	2	3.7	46	6	26
HR05C90	6.5	8.4	20.0	910	2	5.8	51	9	36
HR06C90	7.2	5.8	1.0	900	2	2.8	53	6	24
HR07C90	2.5	20.0	21.0	400	<1	25.0	18	6	17
HR08C90	8.0	9.9	2.0	820	2	3.5	54	9	32
HR09C90	6.3	6.2	4.0	1,000	2	3.7	51	6	26
HR10C90	4.8	6.3	1.0	1,100	2	2.1	63	6	31
HR11C90	5.3	4.0	.7	1,100	2	1.6	47	4	24

TABLE 5. Analytical data for DOI studies 1988-1990

Sample	AL pct	AS ppm	XWB ppm	BA ppm	BE ppm	CA pct	CE ppm	CO ppm	CR ppm
Owyhee and Vale Rivers, OR/ID									
OV01F90	7.3	11.0	--	1,110	2	3.3	85	12	86
OV02F90	7.2	--	--	1,110	<3	2.6	150	15	84
OV03F90	6.4	7.4	.7	650	2	3.6	60	15	87
OV04F90	6.9	4.5	.7	924	2	2.2	64	10	60
OV05F90	4.6	2.6	1.0	606	1	9.9	52	8	61
OV06F90	7.1	4.2	2.0	749	2	3.0	51	19	114
OV07F90	6.8	8.6	2.0	673	2	3.5	56	13	65
OV08F90	6.1	4.3	.9	659	2	3.6	71	15	107
OV09F90	7.1	6.1	2.0	687	2	3.3	48	16	74
OV10F90	7.1	3.0	.5	811	2	2.3	70	12	62
OV11F90	5.5	2.9	.9	692	1	9.8	54	10	64
OV12F90	7.1	6.1	3.0	694	2	3.3	49	15	73
OV01C90	6.3	1.5	.2	1,240	2	1.1	58	5	23
OV02C90	5.7	1.2	<.2	1,570	1	.8	18	3	2
OV03C90	6.5	6.9	.5	958	2	3.2	55	14	63
OV04C90	6.4	1.0	.2	1,410	1	.9	36	3	8
OV05C90	4.8	2.9	.7	719	1	5.9	56	11	61
OV06C90	7.5	3.9	.8	999	2	3.5	48	19	99
OV07C90	7.2	7.5	1.0	856	2	3.5	58	15	70
OV08C90	6.4	5.9	.8	1,130	2	2.8	76	13	55
OV09C90	7.4	5.2	2.0	988	2	3.2	49	16	67
OV10C90	7.6	2.3	.5	1,000	2	2.3	67	11	37
OV11C90	6.4	2.6	.4	1,100	2	4.3	49	10	48
OV12C90	7.4	6.3	1.0	1,020	2	3.2	50	16	66
OV13F90	8.1	79.0	2.0	803	2	2.6	56	19	84
OV14F90	8.0	10.0	2.0	626	1	2.7	42	22	90
OV15F90	7.9	10.0	1.0	685	2	2.3	57	16	61
OV16F90	7.3	11.0	2.0	672	2	2.7	54	16	54
OV17F90	7.3	10.0	3.0	661	2	3.8	49	19	69
OV18F90	7.6	6.4	3.0	658	2	2.6	49	19	66
OV19F90	7.2	5.0	2.0	632	2	1.9	48	15	47
OV13C90	8.3	23.0	2.0	947	2	3.2	50	20	91
OV14C90	8.6	4.4	1.0	701	1	3.3	41	24	99
OV15C90	7.9	10.0	1.0	773	2	2.3	58	18	47
OV16C90	7.2	10.0	3.0	702	2	2.9	51	17	57
OV17C90	7.6	11.0	2.0	754	1	3.9	43	20	129
OV18C90	7.8	6.4	4.0	781	2	3.0	50	18	62
OV19C90	7.2	6.5	2.0	647	2	1.9	50	15	45
OV20C90	2.6	160.0	730.0	68	<1	3.3	12	7	22
OV21C90	2.6	45.0	910.0	181	<1	3.4	16	6	20
OV22C90	7.5	26.0	200.0	171	1	2.5	32	13	55

TABLE 5. Analytical data for DOI studies 1988-1990

Sample	AL pct	AS ppm	XWB ppm	BA ppm	BE ppm	CA pct	CE ppm	CO ppm	CR ppm
				Dolores River, CO					
DUM01F90	6.7	4.2	3.0	520	2	3.6	66	10	45
DUM02F90	5.8	3.4	2.0	510	2	1.9	57	8	38
DUM03F90	4.9	3.5	.3	880	1	2.7	82	8	29
DUM04F90	4.2	5.2	.6	990	1	4.3	63	8	32
DUM05F90	5.3	6.8	.9	540	1	5.9	60	9	46
DUM06F90	4.1	4.1	.6	910	1	4.2	61	7	34
DUM07F90	3.9	4.3	.7	430	1	2.7	90	6	37
DUM08F90	4.0	3.7	--	1,900	1	1.7	73	7	39
DUM09F90	6.4	7.8	1.0	450	2	6.6	64	11	64
DUM10F90	6.1	4.9	1.0	520	2	.9	68	10	47
DUM11F90	5.6	5.8	.7	480	1	4.1	64	12	43
DUM12F90	5.2	4.9	2.0	480	2	5.3	65	10	39
DUM13F90	5.5	6.1	1.0	510	1	11.0	53	9	40
DUM14F90	8.6	5.9	1.0	400	2	1.8	72	10	68
DUM15F90	9.1	4.8	1.0	500	2	.8	80	12	60
DUM16F90	5.5	3.9	2.0	550	1	2.3	62	9	41
DUM17F90	5.4	4.2	.5	820	1	2.8	86	8	37
DUM18F90	5.1	7.5	1.0	490	1	5.7	57	9	46
DUM19F90	4.1	5.4	.5	1,100	1	3.8	71	7	33
DUM01C90	5.8	4.1	2.0	470	1	2.8	58	9	36
DUM02C90	4.3	3.0	1.0	410	1	1.2	43	6	25
DUM03C90	3.3	1.9	.2	750	<1	1.3	33	3	11
DUM04C90	1.9	3.9	.4	770	<1	2.3	30	5	10
DUM05C90	2.9	5.5	.6	390	<1	5.1	38	8	18
DUM06C90	1.5	3.3	.4	470	<1	2.4	21	4	6
DUM07C90	1.1	2.5	.4	140	<1	1.4	23	4	7
DUM08C90	.9	2.0	.2	1,300	<1	.9	15	3	3
DUM09C90	6.4	8.3	1.0	500	1	7.1	65	11	62
DUM10C90	3.8	4.3	1.0	360	1	.7	42	6	24
DUM11C90	3.6	5.6	1.0	380	1	3.8	43	10	24
DUM12C90	3.0	4.0	1.0	330	<1	3.3	46	5	13
DUM13C90	5.7	7.6	1.0	520	1	11.0	57	9	40
DUM14C90	9.7	8.5	.8	450	2	1.8	88	11	70
DUM15C90	9.9	6.7	.9	540	2	.8	96	13	64
DUM16C90	4.1	3.3	1.0	450	1	1.8	44	6	23
DUM17C90	4.8	3.0	.6	910	1	1.8	69	6	22
DUM18C90	4.3	6.0	1.0	560	<1	4.8	43	8	27
DUM19C90	1.5	3.0	.3	800	<1	1.7	23	3	7

TABLE 5. Analytical data for DOI studies 1988-1990

Sample	AL pct	AS ppm	XWB ppm	BA ppm	BE ppm	CA pct	CE ppm	CO ppm	CR ppm
				San Juan River, NM					
NF01F90	5.1	3.6	1.0	700	1	3.9	76	8	30
NF02F90	4.3	2.1	2.0	490	1	14.0	54	8	24
NF03F90	7.1	5.1	1.0	690	2	8.9	78	12	33
NF04F90	7.4	2.5	1.0	980	2	4.5	86	12	24
NF05F90	7.8	4.9	1.0	900	2	5.9	91	12	33
NF06F90	4.9	4.9	--	1,800	1	1.3	220	10	51
NF07F90	6.7	3.5	1.0	520	2	5.3	72	11	53
NF01C90	4.1	2.6	.8	830	<1	1.1	39	4	9
NF02C90	4.3	2.4	2.0	600	1	9.6	45	7	18
NF03C90	6.4	4.1	1.0	740	2	5.8	66	10	31
NF04C90	6.4	2.9	9.0	1,100	1	2.6	63	9	15
NF05C90	8.1	4.7	1.0	890	2	5.4	93	12	33
NF06C90	3.6	2.9	<.2	1,000	<1	.4	40	3	3
NF07C90	6.3	4.4	1.0	610	1	3.9	64	10	43
NF08F90	6.2	2.6	2.0	790	2	1.7	96	10	29
NF09F90	5.9	3.0	.4	830	2	.8	76	9	28
NF10F90	6.2	3.8	2.0	500	1	6.3	72	10	37
NF11F90	5.7	4.6	--	1,600	1	3.0	96	10	31
NF12F90	5.4	3.0	.3	940	1	1.7	98	8	30
NF14F90	7.4	4.6	.5	810	2	1.4	88	11	31
NF15F90	6.2	3.3	.6	970	2	1.2	93	9	29
NF16F90	5.0	2.9	--	1,500	1	.8	200	9	43
NF17F90	7.2	3.6	2.0	550	2	5.1	78	12	34
NF18F90	5.9	2.6	3.0	650	1	7.1	84	9	28
NF19F90	7.1	4.5	2.0	430	2	7.3	77	11	45
NF08C90	4.7	1.5	1.0	850	1	.7	45	5	11
NF09C90	3.9	2.6	.2	880	<1	.2	28	3	3
NF10C90	5.3	3.2	2.0	590	1	3.8	55	8	25
NF11C90	4.2	4.1	.2	1,100	<1	1.2	36	4	6
NF12C90	4.3	3.0	.2	990	<1	.8	44	5	8
NF14C90	5.9	3.4	.4	1,000	1	1.0	56	7	14
NF15C90	4.1	2.4	.2	890	<1	.4	41	4	6
NF16C90	3.8	5.9	<.2	900	<1	.4	36	3	5
NF17C90	6.7	3.4	1.0	610	2	3.7	71	11	29
NF18C90	5.1	2.2	2.0	760	1	3.3	55	7	16
NF19C90	7.0	2.6	2.0	430	2	6.5	75	12	43
				BElle Fourche River, SD					
BF01F88	5.2	12.0	2.9	1,140	2	4.2	47	14	62
BF02F88	5.7	370.0	2.9	927	2	3.2	48	19	61
BF01C88	4.1	39.0	3.1	1,670	2	6.4	48	20	46
BF02C88	4.3	180.0	2.4	800	1	2.4	39	15	40

TABLE 5. Analytical data for DOI studies 1988-1990

Sample	AL pct	AS ppm	XWB ppm	BA ppm	BE ppm	CA pct	CE ppm	CO ppm	CR ppm
				Stillwater Wildlife Management Area, NV					
SN01C89	7.8	10.0	15.0	887	2	5.0	42	10	25
SN02C89	7.9	42.0	16.0	726	1	3.1	34	15	35
SN03C89	7.1	33.0	43.0	662	2	4.1	43	13	29
SN04C89	7.8	23.0	12.0	765	2	2.7	51	16	37
SN05C89	8.2	33.0	40.0	717	1	4.2	39	16	33
SN06C89	7.3	35.0	50.0	747	2	4.4	36	10	22
SN07C89	7.4	15.0	--	775	2	3.0	47	15	35
SN08C89	7.9	25.0	49.0	847	2	3.7	55	17	32
SN09C89	7.3	17.0	45.0	779	2	3.5	48	15	33
SN10C89	7.1	4.8	15.0	796	2	2.1	41	6	13
SN11C89	7.8	16.0	16.0	803	2	4.4	54	15	30
SN12C89	7.6	28.0	40.0	745	2	2.7	49	16	32
SN13C89	6.9	6.6	31.0	767	2	1.7	42	6	8
SN14C89	7.6	43.0	76.0	624	2	3.5	48	17	35
SN15C89	7.8	17.0	39.0	1,010	2	5.9	53	16	30
SN16C89	8.2	140.0	48.0	735	2	4.1	42	22	132
SN01F89	7.8	11.0	--	852	2	5.7	49	11	31
SN02F89	--	56.0	--	--	--	--	--	--	--
SN03F89	6.9	35.0	67.0	641	2	4.3	45	13	32
SN04F89	8.0	22.0	19.0	795	2	2.9	52	15	37
SN05F89	8.1	40.0	43.0	682	1	4.4	39	16	34
SN06F89	6.8	43.0	--	639	1	7.2	48	13	32
SN07F89	--	--	--	--	--	--	--	--	--
SN08F89	7.8	24.0	--	833	2	3.7	55	16	31
SN09F89	7.5	16.0	66.0	799	2	3.3	51	15	34
SN10F89	6.8	1.8	8.0	779	2	1.2	40	3	2
SN11F89	7.8	16.0	--	789	2	4.0	55	15	27
SN12F89	7.8	24.0	--	786	2	3.2	50	14	30
SN13F89	6.8	4.7	--	767	2	1.2	39	4	4
SN14F89	7.8	47.0	99.0	951	2	4.1	55	18	44
SN15F89	7.7	16.0	46.0	1,100	2	6.4	56	15	29
SN16F89	8.3	240.0	77.0	729	2	3.8	45	23	129

TABLE 5. Analytical data for DOI studies 1988-1990

Sample	CU ppm	FE pct	GA ppm	HG ppm	K pct	LA ppm	LI ppm	MG pct	MN ppm	MO ppm
				Pine River (Los Pinos), CO						
PR01F88	27	3.5	16	.06	1.8	34	31	.93	520	<2
PR02F88	24	2.6	14	.06	1.5	32	23	.46	550	<2
PR03F88	25	2.9	15	.06	1.7	44	18	.50	570	<2
PR04F88	20	2.3	11	.02	1.2	32	16	.32	450	<2
PR05F88	22	2.5	13	.04	1.6	35	21	.38	1,000	<2
PR06F88	19	1.9	10	.04	1.4	29	18	.29	610	<2
PR07F88	20	2.6	11	.04	1.3	37	17	.32	630	<2
PR08F88	24	2.9	13	.04	1.4	40	22	.42	540	<2
PR09F88	27	3.4	15	.04	1.5	39	25	.48	790	<2
PR10F88	27	2.7	13	.10	1.3	35	24	.44	610	<2
PR11C88	28	3.4	16	.08	1.8	35	31	.93	550	<2
PR12C88	22	2.5	13	.04	1.5	29	22	.43	530	<2
PR13C88	19	2.6	15	.02	1.8	35	15	.41	540	<2
PR14C88	16	2.3	11	<.02	1.0	29	15	.31	550	<2
PR15C88	12	2.9	13	<.02	1.5	34	17	.30	820	<2
PR16C88	14	2.1	9	<.02	1.1	22	18	.27	620	<2
PR17C88	12	2.5	10	<.02	.9	28	16	.29	940	<2
PR18C88	14	2.5	11	.02	1.0	24	18	.31	640	<2
PR19C88	21	4.1	15	.04	1.4	28	25	.47	640	<2
PR20C88	19	3.2	13	.02	1.2	27	24	.41	630	<2
				Humboldt Wildlife Management Area, NV						
HR01F90	21	2.4	14	.08	1.8	29	59	1.40	840	2
HR02F90	15	1.5	10	.02	1.6	15	95	2.10	550	10
HR03F90	29	2.5	16	.04	1.7	24	62	1.30	1,800	<2
HR04F90	21	2.5	14	.04	1.9	26	70	1.50	810	<2
HR05F90	39	2.8	17	.04	2.2	33	62	1.40	890	3
HR06F90	18	3.6	16	.12	2.1	48	43	1.10	860	3
HR07F90	17	1.3	8	.08	.8	11	46	1.30	1,100	5
HR08F90	29	3.7	18	.08	1.9	36	54	1.40	600	<2
HR09F90	24	2.5	14	.10	1.9	26	70	1.50	800	<2
HR10F90	19	2.4	15	.08	1.8	41	43	1.10	3,000	2
HR11F90	16	2.1	16	.10	2.0	35	40	1.10	730	<2
HR01C90	13	1.5	14	.04	2.3	27	35	.74	550	<2
HR02C90	13	1.3	9	.02	1.6	15	89	1.90	510	9
HR03C90	30	2.1	14	.04	1.6	21	55	1.10	1,600	<2
HR04C90	8	1.5	13	.02	2.4	30	29	.60	320	<2
HR05C90	35	2.2	16	<.02	2.2	30	51	1.20	750	<2
HR06C90	6	1.8	16	.06	2.4	31	21	.49	340	<2
HR07C90	16	1.2	8	.02	.8	11	45	1.30	1,100	4
HR08C90	18	2.7	18	.02	2.2	30	34	.91	420	<2
HR09C90	10	1.5	14	.02	2.5	31	30	.60	310	<2
HR10C90	10	1.4	12	.02	2.3	39	23	.43	680	<2
HR11C90	6	1.1	12	<.02	2.6	32	20	.35	210	<2

TABLE 5. Analytical data for DOI studies 1988-1990

Sample	CU ppm	FE pct	GA ppm	HG ppm	K pct	LA ppm	LI ppm	MG pct	MN ppm	MO ppm
				Owyhee and Vale Rivers, OR/ID						
OV01F90	16	3.0	20	.08	2.1	48	36	.95	3,280	<2
OV02F90	24	2.5	20	.76	2.1	88	20	.79	3,080	<5
OV03F90	25	3.5	15	.02	1.7	36	28	1.47	577	<2
OV04F90	16	2.4	16	.04	2.0	39	26	.81	1,150	<2
OV05F90	16	2.0	10	.02	1.4	32	22	1.31	378	<2
OV06F90	34	4.4	17	.12	1.4	32	28	1.60	655	<2
OV07F90	25	3.4	15	.04	1.7	34	35	1.26	608	<2
OV08F90	18	3.4	14	.02	1.7	41	26	1.47	690	<2
OV09F90	28	3.5	16	.04	1.6	30	29	1.15	641	<2
OV10F90	20	3.0	16	.02	1.8	43	25	.89	480	<2
OV11F90	16	2.4	12	.02	1.4	33	24	1.14	441	<2
OV12F90	27	3.5	16	.02	1.6	31	30	1.15	632	<2
OV01C90	3	1.1	13	<.02	2.5	36	12	.36	412	<2
OV02C90	2	.2	10	<.02	2.6	12	8	.05	420	<2
OV03C90	16	3.0	15	.02	2.0	34	23	1.14	532	<2
OV04C90	3	.5	12	<.02	2.6	22	11	.13	257	<2
OV05C90	11	1.9	11	.02	1.6	34	18	1.01	376	<2
OV06C90	26	4.2	16	.02	1.9	32	22	1.56	653	<2
OV07C90	21	3.3	16	.02	2.0	36	32	1.19	597	<2
OV08C90	13	2.3	15	<.02	2.3	45	23	.88	645	<2
OV09C90	22	3.6	18	.04	1.9	33	21	1.04	594	<2
OV10C90	15	2.5	17	<.02	2.0	40	21	.63	480	<2
OV11C90	11	2.0	14	<.02	2.1	31	17	.73	411	<2
OV12C90	21	3.7	17	.02	1.9	32	20	1.03	585	<2
OV13F90	36	4.1	18	.06	1.1	29	23	1.09	958	<2
OV14F90	39	4.3	17	.02	1.0	23	20	1.01	857	<2
OV15F90	29	4.2	19	<.02	1.5	32	31	.91	1,630	<2
OV16F90	32	4.0	17	.02	1.6	29	32	1.09	748	<2
OV17F90	32	3.9	17	.02	1.5	28	32	1.18	898	<2
OV18F90	36	4.0	17	<.02	1.6	27	27	1.08	640	<2
OV19F90	33	3.7	16	.02	1.6	27	26	.85	677	<2
OV13C90	26	3.9	17	.02	1.2	29	21	1.16	928	<2
OV14C90	34	4.4	18	.02	1.1	23	20	1.15	955	<2
OV15C90	23	3.8	19	<.02	1.7	33	26	.81	1,840	<2
OV16C90	29	4.0	16	.04	1.6	29	28	1.09	727	<2
OV17C90	26	3.8	17	.04	1.5	24	23	1.50	879	<2
OV18C90	32	3.8	17	.02	1.8	28	24	1.08	626	<2
OV19C90	33	3.7	16	.04	1.6	28	26	.84	700	<2
OV20C90	21	1.3	6	<.02	.9	8	13	1.47	259	119
OV21C90	16	1.1	6	<.02	1.2	10	38	1.25	277	6
OV22C90	28	3.1	15	.02	1.4	19	21	1.31	502	21

TABLE 5. Analytical data for DOI studies 1988-1990

Sample	CU ppm	FE pct	GA ppm	HG ppm	K pct	LA ppm	LI ppm	MG pct	MN ppm	MO ppm
					Dolores River, CO					
DUM01F90	20	2.3	16	<.02	1.8	35	48	.99	510	<2
DUM02F90	18	2.1	13	<.02	2.0	30	36	.74	420	<2
DUM03F90	15	1.9	11	<.02	2.0	43	21	.74	430	<2
DUM04F90	16	2.0	9	.02	1.7	34	27	1.10	480	<2
DUM05F90	18	2.3	12	.04	1.7	32	33	1.50	490	3
DUM06F90	13	1.9	9	.02	1.8	33	26	1.10	490	2
DUM07F90	11	2.1	8	.04	1.5	46	22	.87	630	<2
DUM08F90	12	2.5	10	<.02	1.9	37	24	.49	640	<2
DUM09F90	25	2.6	17	.04	1.9	35	40	1.60	310	6
DUM10F90	19	2.5	14	.02	2.0	34	37	.74	430	<2
DUM11F90	16	2.2	12	<.02	1.8	33	34	.89	560	2
DUM12F90	17	2.2	12	.04	1.6	35	31	.87	570	<2
DUM13F90	21	2.4	14	.04	1.6	29	34	.99	450	<2
DUM14F90	21	3.2	20	.08	2.0	38	51	1.10	400	<2
DUM15F90	22	3.6	22	.10	2.0	44	54	.94	500	<2
DUM16F90	19	2.2	14	.04	2.0	31	31	.79	670	<2
DUM17F90	19	2.1	12	.04	2.0	45	23	.90	410	<2
DUM18F90	19	2.3	11	.04	1.7	31	34	1.70	290	5
DUM19F90	12	2.0	10	<.02	1.7	37	26	1.00	500	2
DUM01C90	17	2.0	13	.04	1.7	32	42	.83	420	<2
DUM02C90	10	1.5	9	.02	1.5	23	27	.49	270	<2
DUM03C90	5	.8	6	<.02	1.9	18	11	.29	220	<2
DUM04C90	5	1.1	4	.02	.8	18	18	.34	370	<2
DUM05C90	7	1.6	6	.02	.9	21	23	.70	540	<2
DUM06C90	5	.9	<4	<.02	.6	13	15	.30	410	<2
DUM07C90	3	.6	<4	<.02	.3	12	11	.21	460	<2
DUM08C90	3	.6	<4	<.02	.4	10	11	.11	230	<2
DUM09C90	28	2.7	14	.04	1.9	37	41	1.50	320	3
DUM10C90	12	1.6	8	<.02	1.2	23	25	.42	280	<2
DUM11C90	11	1.8	8	.02	1.1	23	25	.60	500	<2
DUM12C90	6	1.1	8	<.02	.6	26	20	.42	270	<2
DUM13C90	24	2.4	13	.04	1.6	31	35	1.00	420	<2
DUM14C90	23	3.5	22	.04	<0	48	59	1.30	410	<2
DUM15C90	24	3.9	22	.08	2.0	53	61	1.00	540	<2
DUM16C90	13	1.4	8	<.02	1.6	24	24	.54	470	<2
DUM17C90	12	1.5	10	<.02	2.1	38	17	.56	340	<2
DUM18C90	11	1.9	8	.02	1.6	25	26	1.00	270	<2
DUM19C90	4	.9	<4	<.02	.7	14	15	.25	290	<2

TABLE 5. Analytical data for DOI studies 1988-1990

Sample	CU ppm	FE pct	GA ppm	HG ppm	K pct	LA ppm	LI ppm	MG pct	MN ppm	MO ppm
					San Juan River, NM					
NF01F90	17	1.9	11	.02	1.7	40	21	.59	790	<2
NF02F90	13	1.9	12	.02	1.2	29	21	.62	1,300	3
NF03F90	20	2.7	17	.04	1.5	42	28	1.10	830	2
NF04F90	27	2.9	18	.02	1.7	45	22	.90	500	<2
NF05F90	22	2.9	19	.04	1.6	50	26	1.00	580	<2
NF06F90	18	2.7	11	.02	2.0	110	16	.32	740	<2
NF07F90	29	2.8	17	.04	1.7	40	36	1.40	830	<2
NF01C90	5	.7	7	.04	2.3	24	11	.19	220	<2
NF02C90	11	1.5	11	.04	1.5	26	17	.48	910	3
NF03C90	16	2.3	15	.04	1.8	36	23	.87	620	<2
NF04C90	16	2.0	14	<.02	2.0	34	15	.54	370	<2
NF05C90	23	2.9	20	.04	1.8	52	27	1.00	550	<2
NF06C90	2	.5	7	<.02	2.5	23	6	.06	200	<2
NF07C90	23	2.4	14	.04	1.9	35	30	1.00	650	3
NF08F90	20	2.4	16	.02	2.2	52	21	.66	1,200	<2
NF09F90	27	2.1	14	<.02	2.2	40	20	.47	660	<2
NF10F90	27	2.9	15	.02	1.7	40	27	.93	480	<2
NF11F90	18	2.3	14	.02	1.8	52	19	.75	630	<2
NF12F90	19	2.0	11	.02	2.1	52	19	.59	460	<2
NF14F90	28	2.8	18	.02	2.1	49	21	.65	390	<2
NF15F90	21	2.3	14	<.02	2.3	50	20	.51	580	<2
NF16F90	15	2.8	12	<.02	2.1	110	17	.36	580	<2
NF17F90	36	3.3	19	.04	1.7	43	26	.94	930	<2
NF18F90	31	2.3	15	<.02	1.9	46	21	.75	450	<2
NF19F90	34	3.0	18	.04	1.7	43	35	1.10	890	<2
NF08C90	9	1.0	10	.04	2.5	25	11	.28	450	<2
NF09C90	3	.4	6	.04	2.8	17	6	.07	220	<2
NF10C90	18	2.1	13	.04	2.0	30	19	.62	360	<2
NF11C90	5	1.1	9	.06	2.0	21	8	.15	340	<2
NF12C90	6	.9	10	.04	2.5	24	10	.18	300	<2
NF14C90	16	1.7	13	.02	2.5	33	12	.32	280	<2
NF15C90	5	.6	8	.02	2.7	24	8	.12	250	<2
NF16C90	3	.5	7	.02	2.4	21	8	.09	200	<2
NF17C90	29	2.8	17	.04	1.9	40	23	.79	690	<2
NF18C90	17	1.5	12	.04	2.4	32	14	.44	280	<2
NF19C90	33	2.8	18	.10	1.8	42	33	1.00	810	<2
					Belle Fourche River, SD					
BF01F88	19	3.9	13	.12	1.8	27	41	1.45	686	<2
BF02F88	31	6.8	16	.20	1.7	29	34	1.25	1,770	<2
BF01C88	21	8.7	12	.06	1.5	31	31	1.10	1,490	5
BF02C88	19	5.8	11	.10	1.7	24	23	.76	1,310	3

TABLE 5. Analytical data for DOI studies 1988-1990

Sample	CU ppm	FE pct	GA ppm	HG ppm	K pct	LA ppm	LI ppm	MG pct	MN ppm	MO ppm
				Stillwater Wildlife Management Area, NV						
SN01C89	20	2.3	17	.16	2.0	25	39	1.04	443	<2
SN02C89	34	3.4	18	.06	1.5	20	26	1.27	689	5
SN03C89	43	3.3	17	3.60	1.9	26	62	1.49	560	8
SN04C89	45	4.4	20	.76	1.9	30	61	1.51	945	3
SN05C89	40	3.9	19	.06	1.7	23	47	1.89	931	5
SN06C89	24	2.5	17	.16	2.0	22	39	1.06	560	34
SN07C89	44	3.6	19	.28	2.2	28	110	1.35	628	<2
SN08C89	41	4.0	20	.04	2.3	33	129	1.80	765	3
SN09C89	64	3.8	18	.06	1.8	28	116	1.68	618	4
SN10C89	20	2.1	16	<.02	2.5	24	49	.58	469	<2
SN11C89	39	3.8	22	.08	2.2	33	111	1.63	911	<2
SN12C89	42	4.0	20	.02	2.0	29	149	1.83	669	<2
SN13C89	16	2.0	16	<.02	2.6	23	46	.56	474	<2
SN14C89	41	3.6	20	.02	2.4	29	111	1.84	1,310	33
SN15C89	48	3.5	20	.04	2.3	32	114	2.05	860	5
SN16C89	52	4.8	19	<.02	1.9	24	61	1.96	715	13
SN01F89	21	2.7	18	.18	1.9	29	43	1.23	531	2
SN02F89	--	--	--	--	--	--	--	--	--	--
SN03F89	44	3.4	17	3.90	1.9	28	65	1.58	593	8
SN04F89	41	4.3	21	.72	1.9	30	58	1.45	895	3
SN05F89	42	4.1	20	.04	1.6	23	49	1.96	1,010	6
SN06F89	33	3.3	17	.26	1.7	28	50	1.45	927	42
SN07F89	--	--	--	--	--	--	--	--	--	--
SN08F89	42	3.9	20	.02	2.3	33	125	1.75	790	4
SN09F89	57	3.5	19	.04	2.0	29	108	1.60	633	4
SN10F89	11	1.6	16	<.02	2.7	22	32	.26	395	<2
SN11F89	38	3.7	21	.10	2.2	32	108	1.57	907	<2
SN12F89	37	3.4	18	.04	2.1	30	122	1.61	714	<2
SN13F89	12	1.7	16	<.02	2.7	22	36	.37	431	<2
SN14F89	42	3.7	21	.06	2.5	32	111	1.81	1,460	33
SN15F89	48	3.3	21	.04	2.2	33	106	1.98	890	5
SN16F89	62	5.5	20	<.02	1.9	26	71	1.77	752	18

TABLE 5. Analytical data for DOI studies 1988-1990

Sample	NA pct	NB ppm	ND ppm	NI ppm	P pct	PB ppm	SC ppm	SE ppm	SR ppm	TH ppm
					Pine River (Los Pinos), CO					
PR01F88	1.00	7	31	17	.11	14	10	.7	270	12
PR02F88	.65	6	30	15	.06	15	8	.6	130	12
PR03F88	.94	7	38	11	.05	16	8	.4	160	19
PR04F88	.96	6	29	9	.05	13	5	.2	120	13
PR05F88	.84	7	32	12	.06	14	6	.3	210	16
PR06F88	.72	4	28	10	.05	12	5	.4	120	12
PR07F88	.97	7	35	9	.05	12	5	.5	120	18
PR08F88	.57	8	36	14	.06	15	7	.5	160	23
PR09F88	.54	8	37	17	.07	17	8	.7	160	21
PR10F88	.52	6	32	15	.06	16	7	.8	170	17
PR11C88	1.00	8	31	17	.10	14	11	.8	280	10
PR12C88	.68	6	28	14	.06	13	7	.7	130	11
PR13C88	1.10	4	31	9	.05	15	6	.3	150	12
PR14C88	1.00	5	27	9	.05	12	5	.2	120	9
PR15C88	1.70	6	29	10	.08	12	5	.4	360	9
PR16C88	.63	4	22	12	.06	13	4	.3	110	9
PR17C88	1.10	4	29	10	.09	13	5	.4	130	6
PR18C88	.58	<4	25	13	.07	13	5	.3	110	8
PR19C88	.62	6	31	18	.10	16	8	.8	120	13
PR20C88	.54	5	30	16	.09	15	7	.6	130	10
					Humboldt Wildlife Management Area, NV					
HR01F90	1.60	7	27	17	.14	15	9	.9	620	11
HR02F90	4.50	<4	17	11	.10	9	5	1.2	1,100	3
HR03F90	1.30	6	22	19	.11	20	9	.6	620	8
HR04F90	1.30	<4	25	21	.10	20	9	.5	720	9
HR05F90	1.60	10	28	19	.11	17	10	.7	480	12
HR06F90	1.80	5	39	20	.11	46	10	.2	450	--
HR07F90	.68	<4	17	12	.06	6	4	1.4	1,200	4
HR08F90	1.50	11	35	22	.11	15	13	.4	420	13
HR09F90	1.20	<4	23	21	.09	23	9	.5	720	6
HR10F90	1.10	<4	36	27	.11	440	8	.4	470	15
HR11F90	1.50	<4	30	21	.08	17	8	.3	470	9
HR01C90	1.80	5	22	10	.10	14	5	.4	500	7
HR02C90	5.50	<4	16	10	.09	8	5	1.0	1,100	7
HR03C90	1.30	4	23	18	.09	25	7	.6	670	6
HR04C90	1.80	<4	22	10	.07	14	5	.1	410	7
HR05C90	1.70	7	26	15	.10	12	8	.6	490	9
HR06C90	2.20	5	26	8	.06	16	6	<.1	430	9
HR07C90	.75	<4	18	11	.06	7	4	1.1	1,200	<5
HR08C90	2.10	7	27	13	.06	26	9	.3	450	11
HR09C90	1.90	4	23	10	.07	16	5	<.1	420	7
HR10C90	1.20	<4	30	12	.09	140	4	<.1	240	10
HR11C90	1.50	<4	23	8	.06	16	4	.2	260	8

TABLE 5. Analytical data for DOI studies 1988-1990

Sample	NA pct	NB ppm	ND ppm	NI ppm	P pct	PB ppm	SC ppm	SE ppm	SR ppm	TH ppm
				Owyhee and Vale Rivers, OR/ID						
OV01F90	1.96	24	36	25	.12	27	8	.5	402	--
OV02F90	2.33	30	60	26	.09	470	7	--	398	--
OV03F90	1.29	6	31	29	.10	11	11	.4	262	7
OV04F90	1.82	11	29	16	.09	19	7	.4	330	13
OV05F90	.94	<4	26	14	.11	10	6	.6	334	10
OV06F90	1.47	8	28	38	.14	16	15	.4	319	9
OV07F90	1.12	8	30	27	.10	12	11	.5	238	10
OV08F90	1.29	<4	35	26	.06	12	10	.2	250	11
OV09F90	1.44	9	29	30	.10	12	12	.4	287	8
OV10F90	1.76	13	33	19	.10	16	9	.2	327	13
OV11F90	1.16	5	28	18	.09	13	8	.5	377	9
OV12F90	1.46	7	28	28	.10	14	12	.4	291	8
OV01C90	2.38	16	22	9	.03	13	3	<.1	363	7
OV02C90	2.02	4	8	5	.01	13	<2	<.1	394	4
OV03C90	1.54	5	29	23	.08	12	9	.2	297	7
OV04C90	2.37	5	14	2	.02	14	<2	<.1	391	6
OV05C90	1.21	6	27	13	.10	11	6	.4	286	7
OV06C90	1.98	11	29	38	.15	12	17	.2	354	5
OV07C90	1.45	9	32	29	.10	14	11	.4	286	9
OV08C90	1.57	<4	36	17	.07	14	7	.1	274	12
OV09C90	1.93	8	31	23	.10	12	14	.2	319	6
OV10C90	2.24	16	31	14	.08	17	8	.1	428	11
OV11C90	1.92	8	23	14	.07	12	7	.2	384	7
OV12C90	1.98	7	31	23	.09	11	13	.2	322	7
OV13F90	1.48	14	28	32	.08	59	15	.2	338	5
OV14F90	1.60	9	24	41	.10	15	16	.5	320	5
OV15F90	1.50	13	30	22	.08	16	14	.2	304	5
OV16F90	1.20	12	28	27	.10	14	14	.4	266	7
OV17F90	1.57	10	26	32	.10	14	14	.6	364	6
OV18F90	1.75	9	27	29	.09	12	14	.4	314	7
OV19F90	1.48	10	26	22	.08	13	13	.2	256	6
OV13C90	1.70	12	28	29	.08	21	16	.5	364	3
OV14C90	1.90	7	24	36	.10	22	17	.4	359	4
OV15C90	1.83	12	32	19	.08	16	13	.2	310	7
OV16C90	1.31	11	28	22	.10	14	15	.3	273	5
OV17C90	1.96	6	24	54	.09	10	14	.5	407	6
OV18C90	1.95	11	28	25	.09	13	14	.3	344	7
OV19C90	1.47	9	27	20	.08	11	13	.2	252	6
OV20C90	13.20	<4	7	14	.20	<4	5	.7	231	<5
OV21C90	10.60	<4	9	9	.11	5	4	.2	234	<3
OV22C90	5.99	6	20	27	.07	8	12	.2	366	2

TABLE 5. Analytical data for DOI studies 1988-1990

Sample	NA pct	NB ppm	ND ppm	NI ppm	P pct	PB ppm	SC ppm	SE ppm	SR ppm	TH ppm
					Dolores River, CO					
DUM01F90	.62	7	30	19	.06	16	9	4.3	410	13
DUM02F90	.75	6	27	15	.06	13	7	.5	200	12
DUM03F90	1.20	<4	37	13	.04	15	5	.2	240	14
DUM04F90	.79	<4	32	14	.06	17	6	.5	240	12
DUM05F90	.75	<4	28	20	.08	16	7	1.1	330	15
DUM06F90	.82	<4	28	13	.06	15	5	.4	230	11
DUM07F90	.73	<4	39	10	.05	16	5	.2	140	21
DUM08F90	.75	<4	30	12	.03	19	5	.1	240	--
DUM09F90	.60	7	32	30	.10	17	9	2.8	280	12
DUM10F90	.67	6	30	18	.06	13	8	.7	150	17
DUM11F90	.73	<4	28	23	.06	16	7	.2	720	12
DUM12F90	.68	6	30	19	.06	16	6	.5	270	15
DUM13F90	.49	5	27	18	.07	19	7	1.1	450	9
DUM14F90	.24	9	31	25	.08	18	12	.5	150	18
DUM15F90	.31	10	39	22	.09	20	12	.5	130	21
DUM16F90	.82	5	27	16	.07	16	7	1.5	190	12
DUM17F90	1.10	<4	37	12	.05	18	6	.3	230	15
DUM18F90	.72	<4	28	24	.09	17	7	1.6	240	9
DUM19F90	.77	<4	34	12	.06	16	5	.4	240	15
DUM01C90	.53	<4	27	16	.05	18	7	3.6	330	8
DUM02C90	.50	<4	20	11	.04	15	5	.4	130	6
DUM03C90	.86	<4	14	5	.02	11	2	<.1	150	4
DUM04C90	.30	<4	15	4	.03	8	2	.1	170	3
DUM05C90	.39	<4	20	11	.05	15	4	.5	230	5
DUM06C90	.24	<4	11	3	.02	9	2	.1	140	2
DUM07C90	.11	<4	10	4	.02	9	<2	<.1	64	4
DUM08C90	.10	<4	8	<2	.01	7	<2	<.1	110	1
DUM09C90	.55	5	34	31	.09	26	9	2.5	310	10
DUM10C90	.35	<4	21	11	.04	14	4	.4	98	7
DUM11C90	.42	<4	22	13	.04	14	4	.2	400	6
DUM12C90	.51	<4	21	7	.05	10	3	.2	200	5
DUM13C90	.46	4	30	18	.07	21	7	1.1	440	8
DUM14C90	.23	9	39	26	.09	25	13	.5	170	15
DUM15C90	.28	10	44	25	.09	28	14	.5	140	15
DUM16C90	.57	<4	22	10	.04	12	5	1.0	160	5
DUM17C90	1.20	<4	30	8	.04	15	4	.1	210	8
DUM18C90	.81	<4	24	15	.06	12	5	1.1	240	7
DUM19C90	.24	<4	12	4	.02	8	<2	.1	130	2

TABLE 5. Analytical data for DOI studies 1988-1990

Sample	NA pct	NB ppm	ND ppm	NI ppm	P pct	PB ppm	SC ppm	SE ppm	SR ppm	TH ppm
San Juan River, NM										
NF01F90	.87	5	31	12	.07	15	6	.8	530	12
NF02F90	.67	4	25	10	.08	15	6	37.0	1,500	10
NF03F90	.47	7	34	16	.07	18	9	1.9	1,000	12
NF04F90	1.60	7	37	12	.06	19	9	5.3	590	12
NF05F90	.68	6	40	14	.06	20	10	1.5	350	14
NF06F90	1.20	<4	91	12	.06	18	7	.3	230	45
NF07F90	.58	6	34	20	.08	24	10	6.8	340	11
NF01C90	1.00	<4	16	5	.03	11	2	.3	240	3
NF02C90	.80	<4	21	8	.06	12	5	29.0	1,000	6
NF03C90	.57	<4	29	14	.06	17	8	1.5	660	8
NF04C90	1.70	<4	28	8	.05	13	5	2.9	500	8
NF05C90	.76	8	41	14	.06	19	11	1.4	340	13
NF06C90	.95	<4	17	2	.01	12	<2	.1	140	6
NF07C90	.77	6	27	17	.06	25	8	5.7	300	9
NF08F90	1.10	9	41	12	.07	18	7	.5	300	17
NF09F90	1.40	<4	34	12	.04	15	6	.1	160	10
NF10F90	.74	8	33	16	.06	32	8	5.5	420	11
NF11F90	1.50	<4	44	10	.06	16	6	.4	380	15
NF12F90	1.30	<4	44	10	.06	20	6	.3	230	18
NF14F90	1.30	9	40	13	.07	19	8	.3	290	13
NF15F90	1.30	<4	42	11	.05	25	7	.2	220	18
NF16F90	1.20	<4	88	10	.04	20	7	.1	170	53
NF17F90	1.00	9	36	14	.06	25	10	.5	500	13
NF18F90	.78	<4	36	11	.07	17	7	1.6	900	9
NF19F90	.58	11	34	16	.06	44	10	4.5	440	9
NF08C90	1.10	<4	19	6	.03	13	3	.2	180	6
NF09C90	1.10	<4	9	3	.01	15	<2	.1	130	4
NF10C90	.94	5	23	10	.04	25	6	4.4	300	8
NF11C90	1.30	<4	16	4	.02	11	<2	.1	270	3
NF12C90	1.20	<4	19	4	.03	15	2	.1	180	6
NF14C90	1.40	5	28	7	.03	12	4	.2	290	9
NF15C90	1.10	<4	18	3	.02	19	<2	.1	150	4
NF16C90	1.20	<4	12	3	.02	13	<2	<.1	130	5
NF17C90	1.10	8	31	13	.05	22	9	.4	400	10
NF18C90	.97	5	24	7	.04	14	4	.8	480	5
NF19C90	.59	9	36	16	.06	39	10	3.3	400	13
Belle Fourche River, SD										
BF01F88	.51	6	23	37	.16	18	9	2.8	222	10
BF02F88	.55	8	24	41	.15	19	11	2.2	242	11
BF01C88	.46	5	26	48	.47	18	8	3.5	319	8
BF02C88	.50	6	20	33	.16	15	7	1.7	206	7

TABLE 5. Analytical data for DOI studies 1988-1990

Sample	NA pct	NB ppm	ND ppm	NI ppm	P pct	PB ppm	SC ppm	SE ppm	SR ppm	TH ppm
Stillwater Wildlife Management Area, NV										
SN01C89	2.62	9	21	13	.09	19	8	.1	667	9
SN02C89	2.11	7	18	16	.10	16	12	5.0	525	9
SN03C89	2.27	8	23	19	.11	22	10	.8	608	16
SN04C89	1.63	10	27	22	.12	22	13	.6	481	16
SN05C89	2.78	7	21	19	.11	16	13	5.0	589	8
SN06C89	3.33	8	17	12	.08	18	8	.8	712	<9
SN07C89	3.16	9	23	25	.08	18	11	.2	540	--
SN08C89	2.54	8	27	22	.09	22	12	.2	566	16
SN09C89	2.31	8	25	24	.10	19	11	.7	598	11
SN10C89	2.96	8	20	8	.05	16	6	<.1	274	10
SN11C89	2.00	10	27	20	.10	22	12	.1	683	16
SN12C89	2.60	8	24	20	.09	20	12	.6	548	15
SN13C89	3.43	9	19	7	.05	13	6	<.1	245	8
SN14C89	4.67	8	24	28	.09	19	11	.6	574	11
SN15C89	2.79	8	27	28	.10	19	12	<.1	751	13
SN16C89	4.01	11	24	59	.12	15	17	.4	518	9
SN01F89	2.57	11	24	16	.12	20	10	.1	696	10
SN02F89	--	--	--	--	--	--	--	5.9	--	8
SN03F89	2.16	7	23	18	.12	20	11	.9	620	15
SN04F89	1.79	9	27	21	.12	22	12	.6	520	15
SN05F89	2.93	7	23	19	.12	17	13	4.9	603	9
SN06F89	2.80	8	25	17	.11	17	10	1.1	898	<13
SN07F89	--	--	--	--	--	--	--	--	--	--
SN08F89	2.42	9	29	20	.09	22	12	.2	556	12
SN09F89	2.38	8	25	23	.09	19	11	.6	586	12
SN10F89	3.12	10	18	3	.04	13	5	<.1	172	7
SN11F89	2.08	10	24	20	.09	20	12	.1	625	14
SN12F89	2.67	8	26	19	.09	19	11	.4	652	12
SN13F89	3.33	11	19	4	.04	13	5	<.1	190	6
SN14F89	3.96	9	25	27	.10	20	12	.3	663	14
SN15F89	2.70	8	29	23	.11	23	11	.1	900	15
SN16F89	3.44	14	26	47	.13	14	19	.5	511	9

TABLE 5. Analytical data for DOI studies 1988-1990

Sample	TI pct	U ppm	V ppm	Y ppm	YB ppm	ZN ppm	C %TOT	C %ORG	C %CBNT
				Pine River (Los Pinos), CO					
PR01F88	.36	3.6	100	21	2	86	1.65	1.33	.32
PR02F88	.34	4.1	81	18	2	67	.84	.76	.08
PR03F88	.38	5.1	71	20	2	61	.61	.38	.23
PR04F88	.38	4.4	66	15	2	48	.27	.25	.02
PR05F88	.36	5.3	78	18	2	66	.59	.55	.04
PR06F88	.31	5.1	58	16	2	45	.43	.35	.08
PR07F88	.44	5.6	74	17	2	50	.33	.31	.02
PR08F88	.41	8.2	90	21	3	66	.48	.24	.24
PR09F88	.41	6.4	100	22	2	85	.58	.31	.27
PR10F88	.35	5.4	90	19	2	74	.57	.32	.25
PR11C88	.36	3.8	99	21	2	84	2.05	1.74	.31
PR12C88	.30	3.3	76	17	2	70	.75	.67	.08
PR13C88	.27	3.2	58	16	2	55	.38	.25	.13
PR14C88	.28	2.6	63	14	2	49	.19	.17	.02
PR15C88	.27	3.3	72	17	2	59	.40	.33	.07
PR16C88	.19	2.5	58	14	1	51	.40	.28	.12
PR17C88	.24	2.7	65	17	2	50	.16	.14	.02
PR18C88	.18	2.9	73	17	1	57	.27	.08	.19
PR19C88	.30	3.6	110	21	2	93	.15	.08	.07
PR20C88	.24	3.4	100	21	2	77	.29	.12	.17
				Humboldt Wildlife Management Area, NV					
HR01F90	.30	6.2	82	16	1	80	3.80	1.36	2.44
HR02F90	.17	7.9	49	9	1	50	5.92	1.67	4.25
HR03F90	.26	4.9	86	15	2	88	4.58	1.58	3.00
HR04F90	.26	3.7	84	15	2	94	4.47	1.58	2.89
HR05F90	.35	5.0	89	19	2	99	2.32	1.10	1.22
HR06F90	.45	--	120	24	3	82	1.50	.38	1.12
HR07F90	.12	9.2	55	6	<1	46	9.21	1.71	7.50
HR08F90	.47	4.9	110	23	2	90	1.08	.21	.87
HR09F90	.26	3.6	84	16	2	94	4.52	1.59	2.93
HR10F90	.30	5.1	75	21	2	84	4.12	1.54	2.58
HR11F90	.30	5.0	68	18	2	73	2.54	.70	1.84
HR01C90	.20	3.8	56	15	1	48	1.92	.58	1.34
HR02C90	.15	6.0	44	9	<1	45	5.48	1.36	4.12
HR03C90	.21	3.9	76	14	2	77	5.09	1.35	3.74
HR04C90	.19	2.9	55	16	2	44	1.05	.40	.65
HR05C90	.26	4.1	73	18	2	80	2.49	1.19	1.30
HR06C90	.23	3.2	61	17	2	37	.36	.08	.28
HR07C90	.11	8.1	52	6	1	43	8.46	1.11	7.35
HR08C90	.32	3.5	77	20	2	60	.47	.12	.35
HR09C90	.20	2.7	56	15	1	44	.97	.33	.64
HR10C90	.21	3.0	63	18	2	39	.57	.26	.31
HR11C90	.14	2.4	50	14	1	31	.26	.10	.16

TABLE 5. Analytical data for DOI studies 1988-1990

Sample	TI pct	U ppm	V ppm	Y ppm	YB ppm	ZN ppm	C %TOT	C %ORG	C %CBNT
			Owyhee and Vale Rivers, OR/ID						
OV01F90	.36	--	54	23	2	112	2.26	1.75	.51
OV02F90	.38	--	61	22	<3	65	.79	.57	.22
OV03F90	.45	2.9	88	23	3	73	1.03	.49	.54
OV04F90	.32	4.8	56	18	2	80	1.20	1.02	.18
OV05F90	.28	2.8	52	16	2	53	4.33	1.71	2.62
OV06F90	.64	3.3	131	24	3	82	1.72	1.70	.02
OV07F90	.40	2.8	75	25	3	82	1.69	1.10	.59
OV08F90	.44	3.5	97	23	3	68	.83	.25	.58
OV09F90	.48	2.3	93	25	3	84	1.20	.78	.42
OV10F90	.48	3.9	79	20	2	74	1.11	1.00	.11
OV11F90	.34	3.0	63	18	2	60	3.86	1.32	2.54
OV12F90	.47	2.1	92	24	3	85	1.24	.82	.42
OV01C90	.17	2.0	23	11	1	24	.06	<.05	.03
OV02C90	.03	.7	5	4	<1	8	<.05	<.05	.01
OV03C90	.35	2.2	76	24	3	61	.89	.53	.36
OV04C90	.06	1.4	9	6	<1	19	.08	.07	.01
OV05C90	.26	2.4	50	17	2	47	2.57	1.20	1.37
OV06C90	.59	2.3	129	25	3	68	.70	.69	.01
OV07C90	.43	2.6	81	27	3	77	1.47	1.02	.45
OV08C90	.29	2.6	64	28	3	53	.49	.14	.35
OV09C90	.47	2.0	102	33	4	82	.62	.44	.18
OV10C90	.41	3.1	66	17	2	63	.95	.90	.05
OV11C90	.30	2.2	55	17	2	47	1.38	.59	.79
OV12C90	.46	2.1	102	33	4	82	.57	.41	.16
OV13F90	.57	1.8	113	29	3	79	.28	.24	.04
OV14F90	.55	1.7	123	28	3	110	2.01	2.01	<.01
OV15F90	.59	2.3	111	29	3	88	.76	.71	.05
OV16F90	.45	2.0	98	30	3	90	1.36	1.11	.25
OV17F90	.53	2.1	115	26	3	96	1.46	.92	.54
OV18F90	.52	2.0	109	28	3	87	.84	.73	.11
OV19F90	.44	2.2	89	28	3	88	1.07	1.05	.02
OV13C90	.58	1.7	116	29	3	72	.75	.74	.01
OV14C90	.55	1.7	133	27	3	110	1.76	1.74	.02
OV15C90	.50	2.2	99	37	4	86	.48	.44	.04
OV16C90	.46	2.2	105	31	4	86	1.56	1.34	.22
OV17C90	.48	1.8	132	26	3	92	.96	.53	.43
OV18C90	.49	1.9	109	33	4	83	.80	.68	.12
OV19C90	.43	2.3	86	30	3	88	1.30	1.28	.02
OV20C90	.15	7.6	191	8	<1	23	4.81	1.70	3.11
OV21C90	.12	1.5	113	9	1	24	5.74	1.79	3.95
OV22C90	.38	3.7	112	22	2	97	.55	.13	.42

TABLE 5. Analytical data for DOI studies 1988-1990

Sample	TI pct	U ppm	V ppm	Y ppm	YB ppm	ZN ppm	C %TOT	C %ORG	C %CBNT
				Dolores River, CO					
DUM01F90	.31	5.1	60	22	2	65	2.06	1.10	.96
DUM02F90	.31	4.1	54	19	2	53	1.40	1.18	.22
DUM03F90	.31	6.2	49	21	2	52	.83	.17	.66
DUM04F90	.27	5.4	55	19	2	50	1.57	.15	1.42
DUM05F90	.25	4.3	81	18	2	75	2.23	.35	1.88
DUM06F90	.25	4.9	50	18	2	46	1.50	.26	1.24
DUM07F90	.34	10.3	50	24	3	40	1.13	.33	.80
DUM08F90	.44	--	60	24	3	36	.43	.01	.42
DUM09F90	.28	5.2	140	19	2	100	2.95	.84	2.11
DUM10F90	.32	4.9	66	19	2	61	.86	.72	.14
DUM11F90	.28	4.4	60	18	2	58	1.55	.42	1.13
DUM12F90	.27	4.7	53	18	2	70	2.79	1.36	1.43
DUM13F90	.21	3.7	62	15	1	100	4.85	1.68	3.17
DUM14F90	.29	5.5	94	20	2	93	2.75	2.44	.31
DUM15F90	.34	5.3	92	24	2	93	2.19	2.19	<.01
DUM16F90	.30	4.1	53	19	2	55	1.66	1.13	.53
DUM17F90	.31	6.4	58	22	2	54	1.11	.39	.72
DUM18F90	.24	4.9	83	18	2	77	2.39	.65	1.74
DUM19F90	.29	6.6	53	21	2	45	1.42	.23	1.19
DUM01C90	.25	3.6	51	19	2	56	1.71	1.00	.71
DUM02C90	.19	2.4	37	13	1	37	1.27	1.12	.15
DUM03C90	.13	1.4	20	8	<1	21	.32	<.01	.33
DUM04C90	.08	1.2	21	8	<1	26	.70	.05	.65
DUM05C90	.10	1.8	37	12	1	42	1.60	.12	1.48
DUM06C90	.06	.8	18	6	<1	20	.52	<.01	.62
DUM07C90	.05	.8	10	5	<1	15	.43	.03	.40
DUM08C90	.04	.7	10	4	<1	12	.25	<.01	.25
DUM09C90	.26	4.6	150	21	2	100	3.09	.90	2.19
DUM10C90	.17	2.0	39	12	1	39	.56	.42	.14
DUM11C90	.15	2.3	39	12	1	41	1.27	.24	1.03
DUM12C90	.11	1.7	25	9	<1	37	1.43	.60	.83
DUM13C90	.21	3.1	66	16	2	100	4.90	1.86	3.04
DUM14C90	.33	4.8	110	24	2	110	2.59	2.30	.29
DUM15C90	.38	5.0	100	28	2	100	2.23	2.23	<.01
DUM16C90	.18	2.2	35	13	1	38	1.38	.96	.42
DUM17C90	.24	3.6	40	17	2	41	.79	.32	.47
DUM18C90	.15	2.2	57	14	1	58	1.84	.35	1.49
DUM19C90	.07	1.0	17	7	<1	19	.49	<.01	.49

TABLE 5. Analytical data for DOI studies 1988-1990

Sample	TI pct	U ppm	V ppm	Y ppm	YB ppm	ZN ppm	C %TOT	C %ORG	C %CBNT
				San Juan River, NM					
NF01F90	.31	4.7	47	19	2	61	2.80	1.77	1.03
NF02F90	.20	7.5	42	14	2	57	7.39	3.57	3.82
NF03F90	.26	4.8	66	19	2	76	4.45	1.96	2.49
NF04F90	.37	7.4	75	19	2	68	1.73	.79	.94
NF05F90	.32	4.1	76	22	2	66	3.19	1.72	1.47
NF06F90	.71	--	66	35	4	42	.40	.21	.19
NF07F90	.30	5.4	110	21	2	100	2.82	1.16	1.66
NF01C90	.11	8.3	18	9	1	23	.72	.53	.19
NF02C90	.16	8.6	34	11	1	43	5.87	3.31	2.56
NF03C90	.22	6.6	54	16	2	64	3.06	1.55	1.51
NF04C90	.24	6.3	48	13	1	45	.81	.40	.41
NF05C90	.32	5.1	77	22	2	69	2.90	1.62	1.28
NF06C90	.07	4.0	8	6	<1	9	<.05	<.05	.05
NF07C90	.26	5.2	88	17	2	87	2.20	1.04	1.16
NF08F90	.40	5.8	53	21	2	59	2.53	2.23	.30
NF09F90	.32	3.6	49	16	2	48	.38	.30	.08
NF10F90	.31	6.7	72	20	2	150	3.07	1.43	1.64
NF11F90	.42	7.2	58	24	3	49	.91	.20	.71
NF12F90	.39	6.8	54	24	3	65	.45	.02	.43
NF14F90	.36	4.0	73	21	2	69	.58	.37	.21
NF15F90	.39	5.4	56	22	2	86	.37	.22	.15
NF16F90	.68	16.7	72	38	4	41	.14	.06	.08
NF17F90	.35	6.2	79	21	2	96	2.48	1.11	1.37
NF18F90	.31	6.1	54	18	2	54	3.11	1.24	1.87
NF19F90	.33	5.3	83	21	2	150	3.43	1.09	2.34
NF08C90	.16	2.4	22	9	<1	26	.94	.85	.09
NF09C90	.05	.9	7	4	<1	10	<.05	<.05	.02
NF10C90	.23	4.8	54	14	1	100	2.28	1.36	.92
NF11C90	.11	1.5	18	9	<1	20	.19	<.05	.16
NF12C90	.12	1.9	20	9	<1	35	.18	.06	.12
NF14C90	.19	2.2	39	12	1	38	.38	.27	.11
NF15C90	.07	1.3	13	7	<1	35	.05	<.01	.05
NF16C90	.11	1.6	12	7	<1	11	<.05	<.05	.04
NF17C90	.32	5.5	69	18	2	82	1.99	.91	1.08
NF18C90	.20	3.5	32	12	1	35	1.52	.72	.80
NF19C90	.32	4.7	79	20	2	140	3.15	1.24	1.91
				Belle Fourche River, SD					
BF01F88	.20	4.1	140	19	2	104	2.43	.97	1.46
BF02F88	.25	3.5	126	19	2	112	1.73	.76	.97
BF01C88	.17	5.6	133	26	2	124	2.65	.82	1.83
BF02C88	.16	3.1	93	16	2	89	1.14	.48	.66

TABLE 5. Analytical data for DOI studies 1988-1990

Sample	TI pct	U ppm	V ppm	Y ppm	YB ppm	ZN ppm	C %TOT	C %ORG	C %CBNT
				Stillwater Wildlife Management Area, NV					
SN01C89	.28	5.2	67	12	1	54	1.49	.69	.80
SN02C89	.34	3.4	113	13	2	75	4.83	4.83	<.01
SN03C89	.30	9.6	103	12	2	73	4.25	3.48	.77
SN04C89	.41	6.6	116	15	2	104	2.08	1.78	.30
SN05C89	.38	5.5	125	14	1	77	1.57	1.07	.50
SN06C89	.26	34.4	77	10	1	55	2.01	1.13	.88
SN07C89	.34	--	105	14	2	85	.92	.46	.46
SN08C89	.38	4.3	115	15	2	103	1.20	.47	.73
SN09C89	.37	5.7	132	14	2	89	3.78	3.20	.58
SN10C89	.24	3.2	43	18	2	54	.37	.12	.25
SN11C89	.37	5.0	115	15	2	100	1.39	.39	1.00
SN12C89	.37	3.7	118	14	2	87	.96	.59	.37
SN13C89	.22	2.7	30	18	2	50	.20	.04	.16
SN14C89	.36	6.1	115	14	2	86	.79	.17	.62
SN15C89	.37	7.3	127	14	2	98	1.57	.19	1.38
SN16C89	.59	3.7	161	15	2	69	.33	.07	.26
SN01F89	.35	6.6	82	15	2	61	1.52	.57	.95
SN02F89	--	4.6	--	--	--	--	4.31	4.29	.02
SN03F89	.32	10.6	107	14	2	75	4.43	3.55	.88
SN04F89	.41	6.4	112	15	2	99	1.89	1.60	.29
SN05F89	.40	5.9	131	14	2	78	1.70	1.13	.57
SN06F89	.35	56.6	107	14	1	73	3.33	1.55	1.78
SN07F89	--	--	--	--	--	--	--	--	.67
SN08F89	.37	4.8	113	15	2	101	1.18	.44	.74
SN09F89	.38	5.6	135	14	2	89	2.62	2.14	.48
SN10F89	.20	2.8	17	20	3	42	.05	<.01	.05
SN11F89	.37	5.3	112	15	2	99	1.17	.39	.78
SN12F89	.37	4.1	106	15	2	78	.89	.42	.47
SN13F89	.21	2.8	19	19	2	45	.10	.03	.07
SN14F89	.38	6.5	118	16	2	88	.94	.15	.79
SN15F89	.36	6.9	122	15	2	93	1.70	.09	1.61
SN16F89	.67	5.1	190	16	2	80	.21	.02	.19

Table 6. Element concentrations from selected soil and sediment studies. Values in ppm unless noted, all values are from coarse fraction

	soil		sediment		
	Western United States[1]		1986-87 DOI Studies[2]	1988-89 DOI Studies[3]	Present Studies
Element	geometric mean	observed range	observed range	observed range	observed range
Al, %	5.8	.5->10	1.0-9.5	1.8-9.7	.87-9.9
As	5.5	<.1-97	10-30	.6-120	1-37
B	23[4]	<20-300	<.4-130[5]	<.4-390[5]	<.4-91[5]
Ba	580	70-5000	56-1100	67-2200	68-1900
Be	.68	<1-15	<1-2	<1-3	<1-2
Ca, %	1.8	.06-32	.6-20	.23-20	.23-25
Ce	65	<15-300	14-130	6-290	12-220
Co	7.1	<3-50	2-21	2-40	3-24
Cr	41	3-2000	1-120	3-330	2-130
Cu	21	2-300	3-85	3-520	2-64
Fe, %	2.2	.1->10	.42-4.6	.36-6.3	.24-8.7
Ga	16	<5-70	4-22	4-23	<4-22
Hg	.046	<.01-4.6	<.02-20	<.02-1.0	<.02-3.9
K, %	1.8	.19-6.3	.62-2.9	.12-4.2	.28-2.8
La	30	<30-200	8-69	3-190	8-110
Li	22	5-130	7-110	4-220	6-150
Mg, %	.74	>03->10	.26-2.5	.04-4.8	.05-2.1
Mn	380	30-5000	80-1400	66-4500	200-3300
Mo	.85	<3-7	<2-54	<2-73	<2-120
Na, %	.97	.05-10	.1-4.1	.16-8.5	.1-13
Nd	36	<70-300	6-58	<4-100	7-91
Ni	15	<5-700	3-71	<2-160	2-59
P, %	.032	.004-.45	.01-.18	.01-.41	.009-.47
Pb	17	<10-700	6-190	<4-500	<4-470
Sc	8.2	<5-50	2-16	<2-30	<2-19
Se	.23	<.1-4.3	<.1-120	<.1-43	<.1-37

Table 6.--continued

	soil		sediment		
	Western United States[1]		1986-87 DOI Studies[2]	1988-89 DOI Studies[3]	Present Studies
Element	geometric mean	observed range	observed range	observed range	observed range
Sr	200	10-3000	72-1200	59-1600	64-1500
Th	9.1	2.4-31	<2.6-40	<4-45	1.3-53
Ti, %	.22	.05-2	.05-.44	.02-1.1	.03-.71
U	2.5	.68-7.9	<.14-23	.15-21[6]	.67-57
V	70	70-500	16-220	5-310	5-190
Y	22	<10-150	5-83	4-34	4-38
Yb	2.6	<1-20	<1-3	<1-4	1-4
Zn	55	10-2000	15-150	10-1600	8-150
Tot.C, %	1.7	.16-10	--	<.05-13	<.05-9.2

[1]Shacklette and Boerngen, 1984; [2]unpublished data, coarse fraction of samples from Severson and others, 1987; [3]Harms and others, 1990; [4]total; [5]hot water soluble; [6]ultra-violet fluorescence

Table 7. Geometric means for selected trace elements in sediments from 24 areas of DOI irrigation reconnaissance studies, 1986-1990. Values in ppm dry weight of coarse fraction

Location	Arsenic	Selenium	Mercury	Water extractable boron
All sites (334)	5.3	0.47	0.03	1.8
Tulare Lake, CA[1]	5.6	.44	.02	12
Salton Sea, CA[1]	3.0	.26	.02	1.6
Sun River, MT[1]	8.3	.92	.03	3.7
Milk River, MT[1]	5.4	.25	<.02	5.6
Laguna Atascosa NWR, TX[1]	6.9	.36	.03	4.0
Kendrick, WY[1]	5.2	2.8	.02	1.7
Stillwater Wildlife Management Area, NV[1]	12	.26	.56	11
Middle Green River, UT[1]	3.7	3.9	.02	3.1
Lower Colorado, AZ[1]	6.3	.89	.03	.96
Belle Fourche, SD[2]	15	.88	.02	1.6
Angostura, SD[2]	9.0	.74	.02	.94
American Falls, ID[2]	2.4	.26	.02	.97
Riverton, WY[2]	2.1	.23	<.02	.44
Middle Arkansas River, CO[2]	2.5	.54	.02	.80
Gunnison River and Sweitzer Lake, CO[2]	8.4	4.0	<.02	.97
Middle Rio Grande River, NM[2]	4.2	.17	.02	.88

Table 7--cont.

Location	arsenic	selenium	mercury	water-extractable boron
Malheur National Wildlife Refuge, OR[2]	4.8	.27	.02	13
Klamath Basin Refuge Complex, CA[2]	5.2	.36	.04	1.1
Sacramento Refuge Complex, CA[2]	7.5	.19	.03	.66
Pine River, CO[3]	5.6	.43	.02	<.4
Humboldt Wildlife Management Area, NV[3]	8.7	.26	.02	5.2
Owyhee/Vale Rivers, OR/ID[3]	6.6	.21	.02	2.0
Dolores River, CO[3]	4.1	.32	.02	.66
San Juan, NM[3]	3.1	.57	.03	.70

[1]unpublished data, coarse fraction of samples from Severson and others, 1987; [2]Harms and others, 1990; [3]this report