UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

EFFECTS OF COAL STRIP MINING ON STREAM WATER QUALITY AND BIOLOGY, SOUTHWESTERN WASHINGTON

By L. A. Fuste' and D. F. Meyer

U.S. GEOLOGICAL SURVEY

WATER-RESOURCES INVESTIGATIONS REPORT 86-4056

Tacoma, Washington
1987

UNITED STATES DEPARTMENT OF THE INTERIOR

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CONVERSION FACTORS

For the convenience of readers who may prefer to use metric (International System) units rather than the inch-pound units used in this report, values may be converted by using the following factors:

Multiply inch-pound units	by	to obtain SI units
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
square mile (mi^2)	2.590	square kilometer (km^2)
cubic foot (ft^3)	0.02832	cubic meter (m^3)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
micromho per centimeter at 25° Celsius (umhos/cm at 25°C)	1.000	microsiemen per centimeter at 25° Celsium (uS/cm at 25°C)
degree Fahrenheit (°F)	°C = 5/9 (°F-32)	degree Celsius (°C)

National Geodetic Vertical Datum of 1929 (NGVD of 1929): A geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada formerly called mean sea level.

EFFECTS OF COAL STRIP MINING ON STREAM WATER QUALITY AND BIOLOGY, SOUTHWESTERN WASHINGTON

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ABSTRACT

Strip mining for coal in southwestern Washington may be affecting the water quality of streams. The possible effects of increased production or the opening of new mines is of concern to the Office of Surface Mining of the U.S. Department of the Interior. To investigate these possible effects, five streams were selected for study of water quality in each of the two coal-bearing areas--the Centralia-Chehalis coal district and Kelso-Castle Rock coal area. In the Centralia-Chehalis coal district, three of the streams have drainage basins in which mines are active.

Water in streams that drain unmined basins is typical of western Washington streams and is characterized as a mixed-water because calcium, magnesium, sodium, and bicarbonate ions predominate. A change in anionic composition from bicarbonate to sulfate in streams draining mined areas was not sufficient to change the general water composition and thus make the streams acidic. The largest downstream changes in water quality in both mined and unmined drainage basins were observed during summer low-flow conditions, when minimal dilution, increased water temperatures, and low dissolved-oxygen concentrations occurred. High dissolved solids were found in the mined drainage basins during this period. High concentrations of iron, manganese, and zinc were present in the bottom sediments of the mined basins. Moderate concentrations of chromium, cobalt, copper, and zinc were also found in the bottom sediments of a few unmined basins.

Streams with substrates of gravel-cobble or gravel-coarse sand had the most diverse benthic fauna and a higher number of ubiquitous taxa than streams with sand-silt substrates, which had the most dissimilar fauna. Mayflies, stoneflies, and caddisflies were rare at the site most affected by mining.

Streambed and bank materials were analyzed to assess stream erodibility; average basin slope and land use were determined to assess the potential for mass movement of unconsolidated material. The erosion potential of a basin appears to be related to the average basin slope and the amount of forested areas. Strip mining for coal in steep basins may lead to massive movements of unconsolidated spoils after vegetal cover is removed if the land disturbed is graded to pre-mining slopes.

A monitoring network of water quality and biological characteristics is proposed for selected drainage basins. The selection of sampling site was based on present mining activities, a general assessment of erosion potential, and the abundance of strippable coal deposits.

INTRODUCTION

Hydrologic information is needed to characterize conditions in mined and potential mining areas because, with the enactment of Surface Mining Control and Reclamation Act [1977 (PL 95-87)], mine-permit applications must, in part, assess hydrologic impacts of the proposed mining. This report presents hydrologic information for two coal-bearing areas of Washington with strippable coal reserves and will partly fulfill the needs of federal, state, and private agencies. These two areas, Centralia-Chehalis coal district and Kelso-Castle Rock coal area (fig. 1) contain higher strip-mining potential than any of the ten other coal-bearing areas in the State, and the high sulfur content of the coal indicates a potential for water quality degradation. In 1980, the U.S. Geological Survey began collecting water-quality and other hydrologic data in the two areas to assess the effects of future mining in unmined areas, and of increased production in mined areas.

Purpose and Scope

This report presents the results of a study conducted between 1980 and 1981 to (1) document baseline conditions of stream quality in unmined areas with strippable coal reserves in southwestern Washington; (2) determine the potential hydrologic effects that strip mining will have in these areas by comparing them with active areas mined; (3) evaluate the potential for erosion in unmined areas; and (4) propose a data-collection monitoring network that would provide baseline information in unmined areas for assessment of the effects of future coal strip-mining operations.

The scope of the work included selection of comparable sampling sites upstream and downstream of known strippable coal reserves; water sampling for selected physical and chemical analyses to describe the current water-quality conditions in mined and unmined areas; and biological (benthic invertebrate) sampling to assess the degree of benthic community similarity between sampling sites within and between streams in relation to mining efforts and types of habitat. Sediment samples collected from streambeds and banks, and field examination completed posterior to the period of water-quality and biological sampling were used to assess the erosion potential of streams in unmined areas.

Statistical analyses were utilized to help interpret the data collected. Water quality data were analyzed by factor analysis to select a set of physicochemical variables that would best characterize the water quality of the study areas. Biological data were analyzed by cluster analysis to assess the degree of similarity of benthic communities between sampling sites. Correlation analyses were used to determine which physiographic features in the basins studied were most closely associated with stream erodibility.

In this report, coal-bearing areas that are surrounded by older rocks and thus are clearly defined are called fields or districts, those covered by younger rocks and not clearly defined are called areas (after Beikman, Gower and Dana, 1961).

Acknowledgments

Mr. Ellis VonHeeder of the Washington State Department of Natural Resources provided maps of strippable coal reserves in Cowlitz, Lewis, and Thurston Counties. Wolfgang Dammers, Richard Brix, and Earl Finn of the Washington State Department of Fisheries (DOF) provided most of the information on the fishery conditions for several of the Cowlitz River and Chehalis River tributaries and for one tributary of the Columbia River.

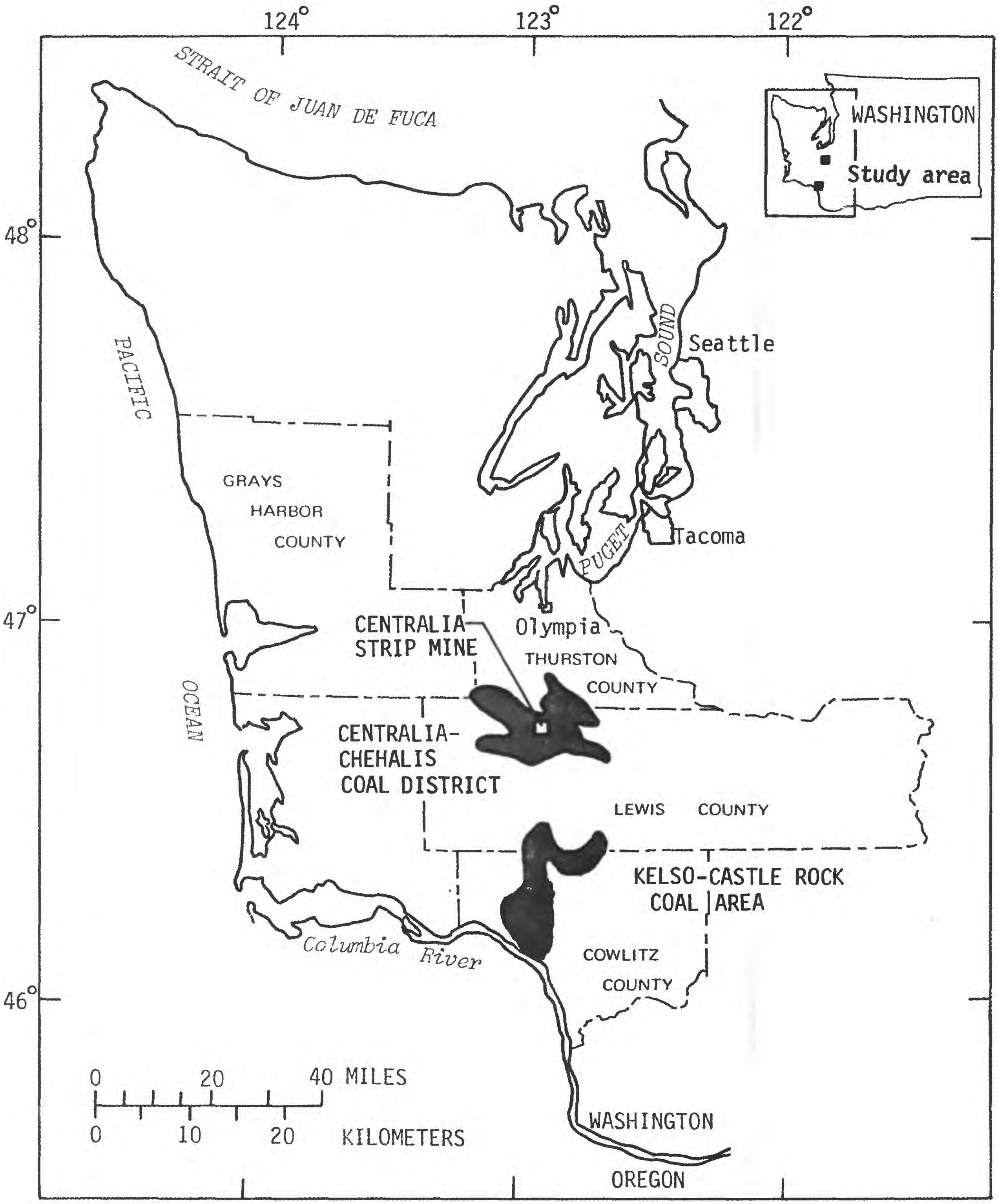


FIGURE 1.--Location of study areas in southwestern Washington.

SELECTION OF STUDY AREAS

During February 1980, eight streams were visited in the Centralia-Chehalis coal district and five streams in the Kelso-Castle Rock coal area, to select comparable sampling sites upstream and downstream of known strippable coal reserves. The site selections were based on minimal water quality effects from municipal and agricultural sources, presence of mining activities, sulfur content of coal, and areal distribution of local coal reserves. Water-quality and biological (benthic invertebrate) samples were collected at the time of the reconnaissance to aid in the selection of sampling sites.

With the exception of the Hanaford Valley, limited information is available regarding the location of strippable coal reserves in the Centralia-Chehalis district. Strippable coal reserves are defined as those with less than 200 feet of overburden. Recent economic considerations have made feasible stripping of coal reserves with thicker overburden. Accordingly, an estimate of the areal extent of coal reserves with overburden thickness of less than 500 feet was made (fig. 2) to select sampling sites on the western portion of this coal area.

Ten sampling sites were chosen on five creeks (Hanaford, Packwood, South Hanaford, Lincoln, and Deep) in the Centralia-Chehalis district (fig. 3), above and below potentially strippable coal reserves. Of the five, the Hanaford Creek basin contains the largest amount of strippable coal. The Packwood Creek basin, tributary to Hanaford Creek, contains an active mining site. South Hanaford Creek, another tributary of Hanaford Creek, receives drainage from an abandoned underground coal mine and a siltation pond located near the drainage divide with Packwood Creek. The Lincoln Creek basin appears to have extensive coal reserves along the alluvial valley floor. The Deep Creek basin has some coal but with minimal areal extent and was chosen to represent areas with small reserves.

Another 10 sampling sites were chosen on five creeks (Cedar, Salmon, Coal, Cline, and Foster) in the Kelso-Castle Rock area (fig. 4) above and below potentially strippable coal reserves (fig. 5). The Cedar and Salmon Creek basins contain the greatest amount of lignite in the region. The Coal Creek basin has the highest sulfur content (4.6 percent) of known coal reserves in Washington. The Cline and Foster Creek basins were chosen as representative of areas with small reserves.

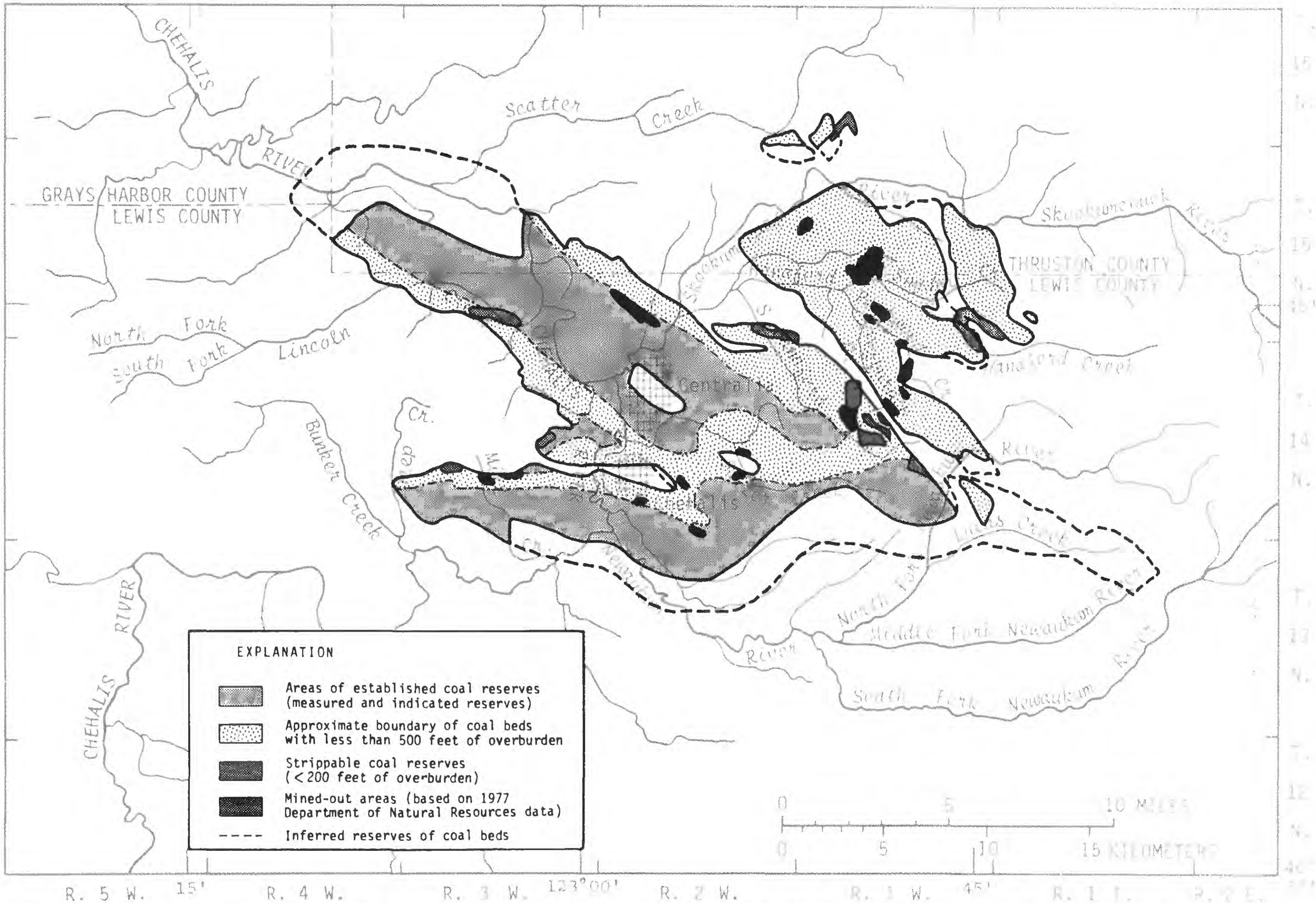


FIGURE 2.--Stripple coal reserves in the Centralia-Chehalis coal district (after Ellis VonHeeder, Washington State Department of Natural Resources, written communication, 1977). Areas of measured, indicated, and inferred reserves after Beikman, Gower, and Dana (1961).

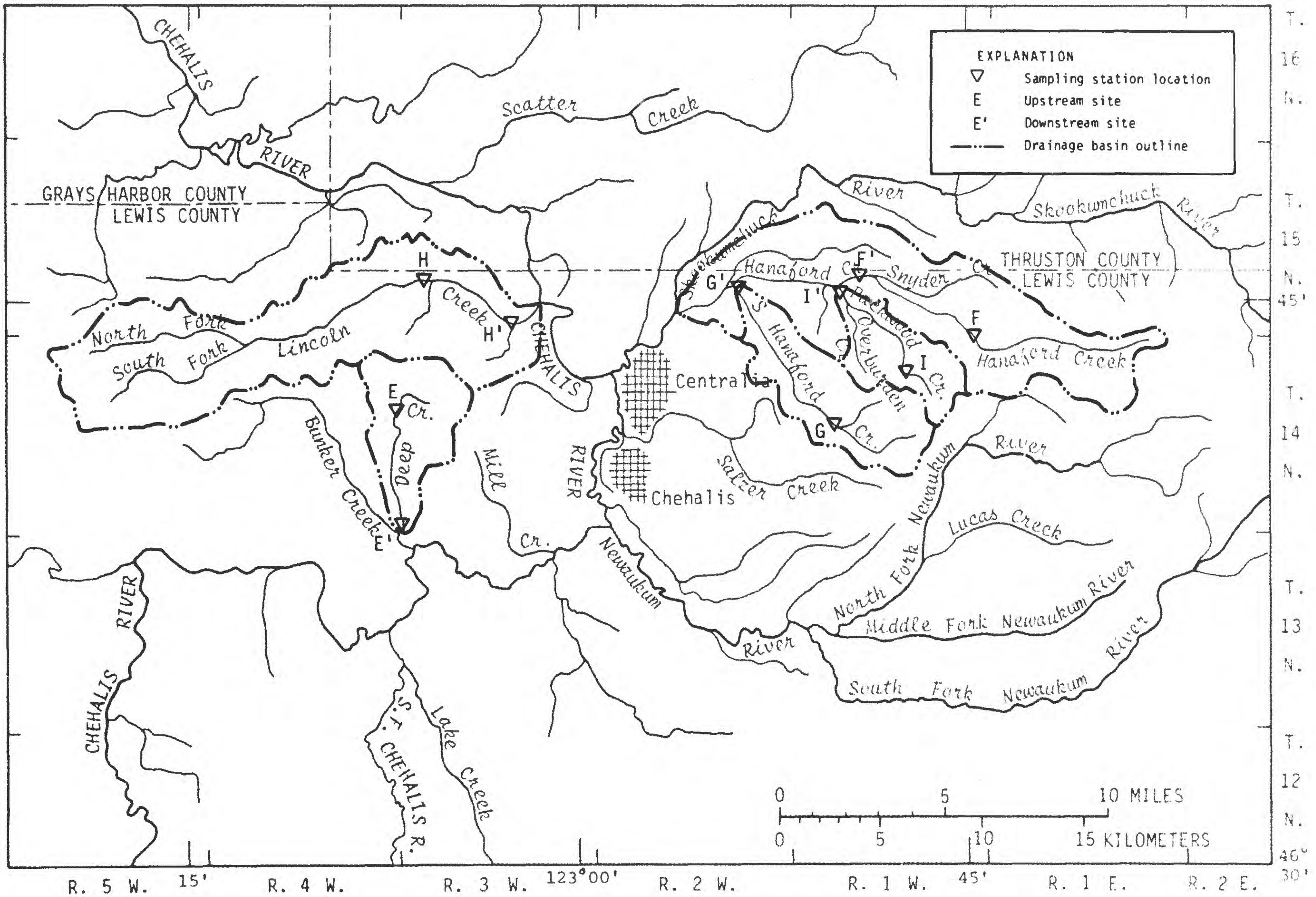


FIGURE 3.--Location of streams and sampling sites in the Centralia-Chehalis coal district.

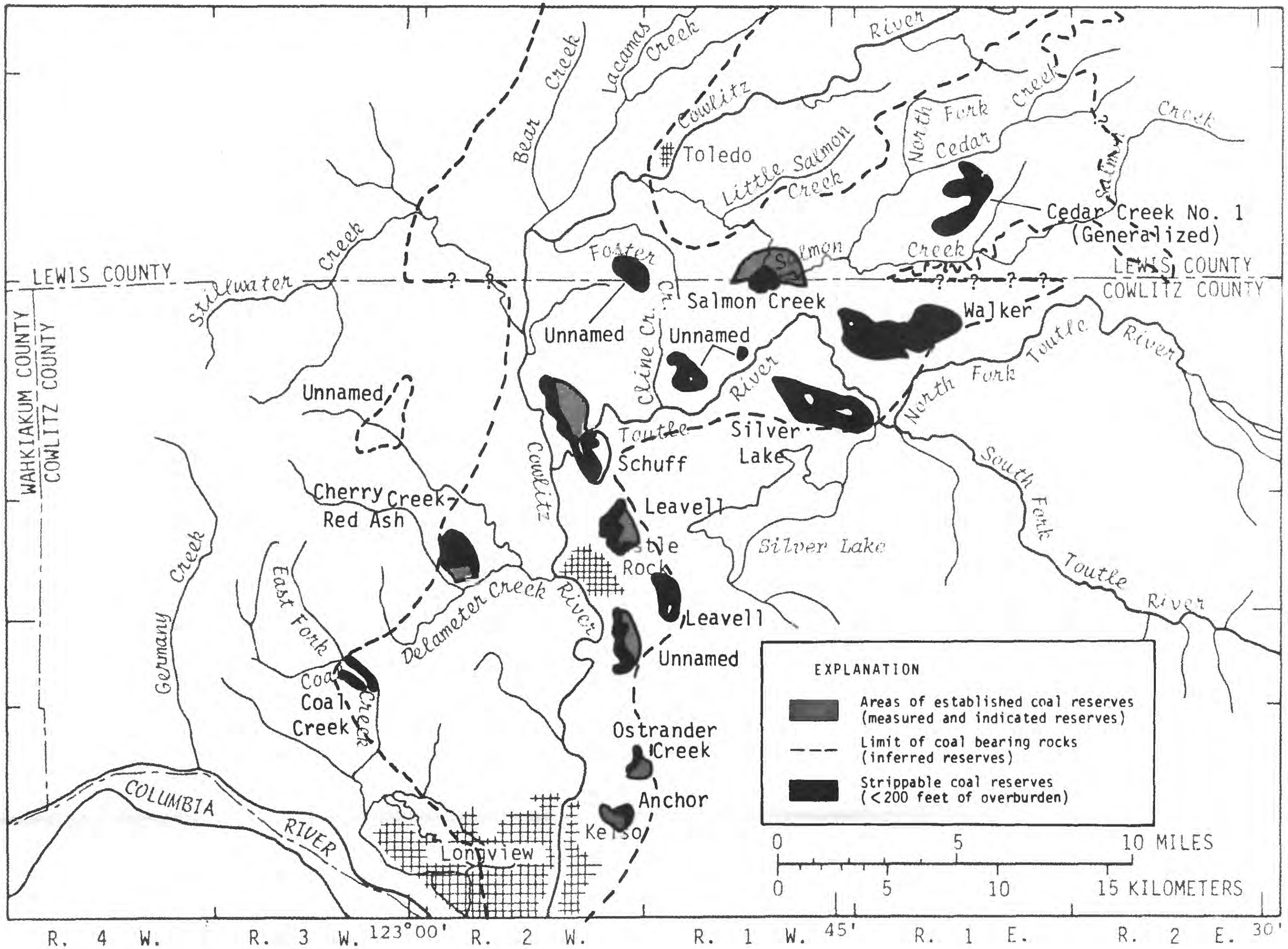


FIGURE 4.--Strippable coal reserves in the Kelso-Castle Rock coal area (modified after Beikman, Gower, and Dana, 1961, and Ellis VonHeeder, Washington State Department of Natural Resources, written communication, 1977).

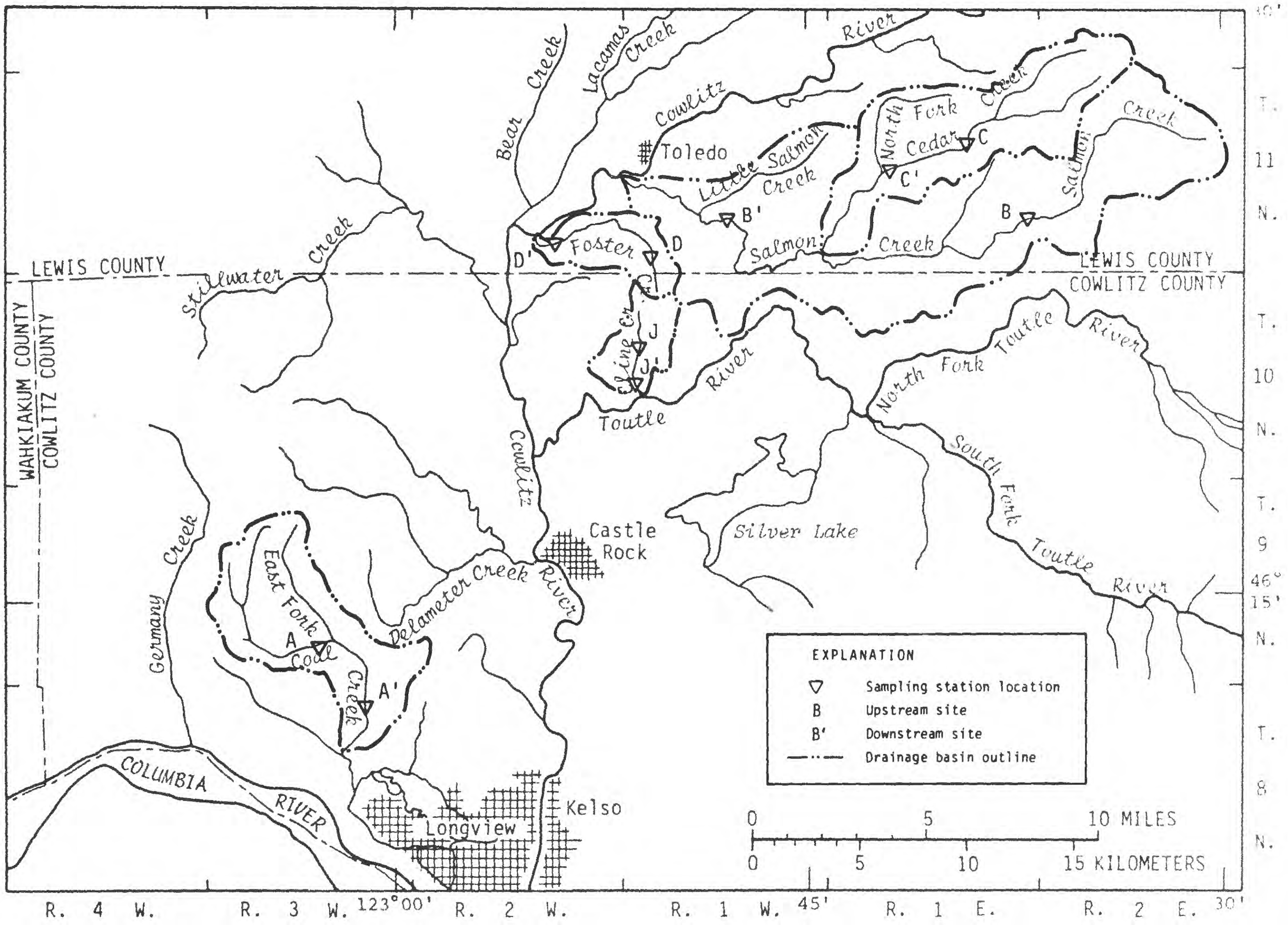


FIGURE 5.--Location of streams and sampling sites in the Kelso-Castle Rock coal area.

DESCRIPTION OF STUDY AREAS

The Centralia-Chehalis and Kelso-Castle Rock coal reserves are within the Pacific Coast Coal Province, which consists of widely scattered small coal deposits in Washington, Oregon, and California. The coal deposits in Washington, in the foothills of the Cascade Range, are mostly of subbituminous grade but include some lignite and anthracite (U.S. Environmental Protection Agency, 1975a). The thermal efficiency of coal in Washington is relatively low, the ash and sulfur content is also low. The coal beds have undergone considerable deformation, as indicated by folds, faults, and vertical or steeply dipping seams. Because of this deformation underground mining is generally not feasible and the active mining operations tend to be small. The coal reserves were largely unmined before 1975.

The Centralia-Chehalis and Kelso-Castle Rock coal-bearing areas have the largest known strippable coal reserves in Washington (E. R. VonHeeder, oral commun., 1980). The total reserves in each of Whatcom, Skagit, King, and Pierce Counties are larger (table 1) than those in the Kelso-Castle Rock coal area, but conventional strip mining is impractical because most of the deposits have overburden thicknesses of more than 500 feet and the coal-bearing rocks are faulted.

More detailed descriptive information on mine prospects, coal beds, geology, topography, and vegetation is presented by Snavely and others (1958) for the Centralia-Chehalis coal district, and by Roberts (1958) for the Kelso-Castle Rock coal area.

Centralia-Chehalis Coal District

The Centralia-Chehalis coal district in southwestern Thurston and northwestern Lewis Counties, is 570 square miles in size, the largest of the subbituminous coal fields in Washington. The coal beds are in the upper and lower parts of the Skookumchuck Formation of late Eocene age. In 1977, the Washington State Department of Natural Resources (DNR) estimated the total reserves of subbituminous coal in this area to be near 3.7 billion tons (E.R. VonHeeder, written commun., 1980). Of these, 13 million tons in state-administered lands are strippable by conventional mining methods. Besides the coal, there are prospects for production of oil and gas from favorable structures in marine sedimentary rocks (Snavely and others, 1958).

In 1980, the only active strip mine in Washington was in the Centralia-Chehalis coal district at a site about 7 miles northeast of Centralia (fig. 6). The coal was mined by Washington Irrigation and Development Company (WIDCO) and was used in the nearby Centralia powerplant operated by the Pacific Power and Light Company. In 1980, active mining was confined to the Packwood Creek drainage basin and to an area north-northwest of the powerplant between North Hanaford Creek and the Skookumchuck River. The operation provides 5 million tons of subbituminous coal per year to the generating plant

TABLE 1.--Location, sulfur content, and total coal reserves of coal-bearing areas in Washington

[Sulfur content is listed as minimum/weighted average/maximum]

Coal deposits	Coal-bearing areas	Sulfur content[a] in percent	Total reserves[b] in millions of tons
Whatcom County	Chuckanut formation	0.3/0.8/1.9	[c]333.90
Skagit County	Cokedale and Hamilton area	.2/ .4/1.0	506.96
Kittitas County[d]	Roslyn field	.3/ .4/0.5	[e]272.40
	Taneum and Manastash area	---	40.47
King County	Newcastle-Grand Ridge area	.5/ .6/ .8	309.60
	Renton, Cedar Mountain, Tiger Mountain, Niblock, and Taylor areas	.4/ .7/1.9	144.91
	Green River district	.3/ .6/1.6	[f]536.51
Pierce County	Wilkeson-Carbonado coal field	.6/ .7/1.1	[g]244.00
	Spiketon area	.4/ .5/ .8	88.84
	Fairfax-Montezuma and Ashford areas	.4/ .5/1.1	34.55
	Melmont area	.4/ .5/ .7	16.49
Lewis and Thurston Counties	Centralia-Chehalis district	.6/1.1/4.4	[h]3,673.96
Eastern Lewis County	Cinebar, Morton, and Summit Creek areas	.3/ .6/1.2	47.32
Cowlitz and Lewis Counties	Kelso-Castle Rock area	.2/ .6/4.6	[h]149.19

[a]Sulfur content is based on weighted average for several different seams with different percents of sulfur, considering total tonnage for each coal seam for which a sulfur analysis was available.

[b]Total reserves - measured, indicated, and inferred (Beikman, Gower, and Dana, 1961).

[c]Moen, 1969.

[d]Sulfur content information available for the Roslyn coal field only.

[e]Walker, 1980.

[f]New resource of 179.2 million tons of bituminous coal, (Morris and Ames, 1980).

[g]Estimate overlaps a small portion of reserves estimated by Beikman, Gower, and Dana, 1961 (Cooley and others, 1983).

[h]Reserves for Centralia-Chehalis coal district and Kelso-Castle Rock coal areas based on coal-reserve data from Washington Department of Natural Resources (E. VonHeeder, written commun., 1977). All other calculations are based on data from Beikman, Gower, and Dana, 1961).

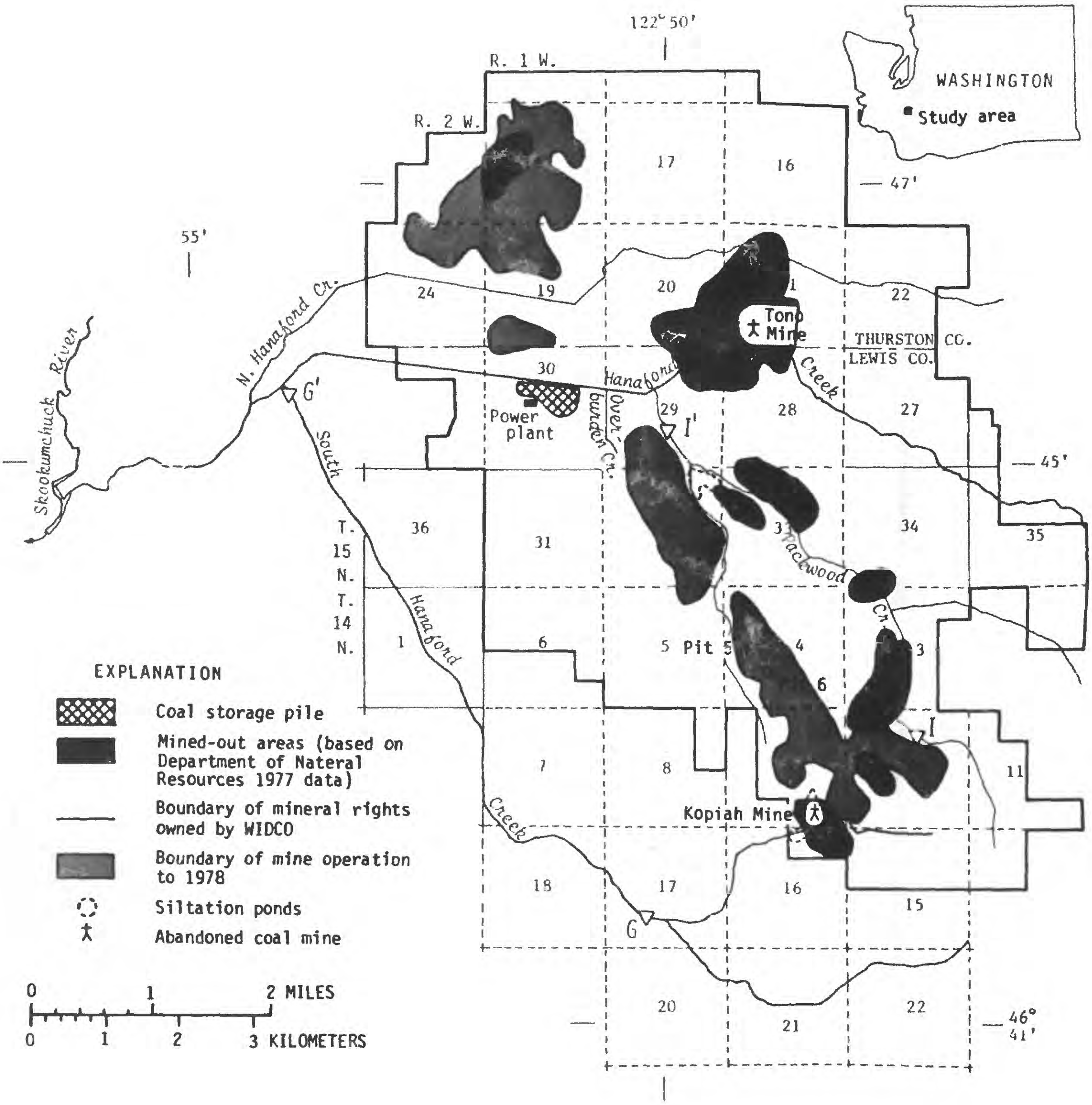


FIGURE 6.--Location of Centralia strip-mining area (modified after F.A. Packard, U.S. Geological Survey, written communication, 1976).

(Lowinger, 1978). Before mining began, the terrain was characterized by poorly drained valleys and ridges that have locally steep slopes. Along the ridges grew Douglas fir, big-leaf maple, alder, and vine maple.

The sulfur content of coal in the Centralia-Chehalis coal district is, on the average, the highest in the State (1.12 percent, table 1). This average is a weighted average calculated by using only those coal reserves for which analyses of coal sulfur-content were available. The ash content of the coal is relatively high, ranging between 4.6 and 25 percent, and averaging about 12 percent.

In 1981, the maximum depth to which WIDCO was strip mining coal was 325 to 350 feet below land surface (John Wisch, WIDCO, oral commun., 1981). Settling ponds were used to contain silt-laden runoff from the drainage basins of Overburden, Packwood, and South Hanaford Creeks, and from the coal pile at the generating plant. To increase settling efficiency, flocculants were added to the settling pond in Overburden Creek and to the pond receiving effluent from the coal pile. Prospect investigations in 1982 by several mining companies revealed new potentially strippable coal areas in and around the Lake Creek basin, a tributary of the South Fork Chehalis River. This discovery will probably result in a combination of the Centralia-Chehalis, Kelso-Castle Rock, and intervening areas as a newly defined coal-bearing area (T. Walsh, Washington Department of Natural Resources, oral commun., 1986).

Kelso-Castle Rock Coal Area

The 300-square-mile Kelso-Castle Rock coal area is in southwestern Lewis County and in north-central and western Cowlitz County. It is in and adjacent to, the lower valley of the Cowlitz and Toutle Rivers (Roberts, 1958). The coal beds of the area occur in the Cowlitz Formation of late Eocene age and the Toutle Formation of late Eocene and early Oligocene age (Beikman, Gower, and Dana, 1961).

The total reserves (table 1) in the Kelso-Castle Rock coal area are approximately 149 million tons (E. R. VonHeeder, Department of Natural Resources, written commun., 1980). Of these, 59 million tons in state-administered lands are strippable by conventional mining methods. The thinnest coal beds are subbituminous and range in thicknesses from 2.5 to 10 feet. The thickness of lignite ranges from 5 feet for the Silver Lake and Walker beds along the Toutle River, to more than 20 feet for beds between Salmon and Cedar Creeks (see fig. 4). The overburden thickness tends to be less than 60 feet. Some coal beds are exposed along the banks of Salmon and Cedar Creeks and the banks of Cowlitz and Toutle Rivers and their tributaries (Roberts, 1958).

The ash content of coal in the Kelso-Castle Rock area ranges from 5.9 to 34 percent and averages about 16 percent, slightly higher than values for the Centralia-Chehalis area. The average sulfur content of coal is 0.63 percent (weighted average), similar to values for other coal-bearing areas of the State.

Climate and Land Use

The Centralia-Chehalis coal district and Kelso-Castle Rock coal area have a moist, temperate climate generally characterized by mild temperature and moderate amounts of rainfall. For 1970 to 1979, the mean annual temperature was 51.6°F at the Centralia weather stations and 51.3°F at Longview; mean annual precipitation was 46.3 inches at Centralia and 46.7 inches at Longview.

In the Centralia-Chehalis coal district, more than 80 percent of the land is undeveloped (table 2) and much is forested and harvested for lumber. A small percentage of the land in three of the basins (Lincoln, Hanaford, and South Hanaford) is urban. The Packwood Creek basin is the only basin where mining constitutes a significant land use (16 percent). However, some land (0.3 percent) in the South Hanaford Creek basin is used for mining-related activities, such as siltation reservoirs.

In the Kelso-Castle Rock coal area, most of the land is forested (table 2) and logging is done in most of the drainage basins. In the lower Foster Creek valley, large areas of land (37 percent) are used for crops (peas and alfalfa) and pasture. Small portions (1 to 2 percent) of land within the Salmon and Coal Creek basins are also used for agriculture. The only urban areas are in the Foster and Coal Creeks drainage basins, where they represent 2 to 3 percent of land use.

Stream Channel Characteristics

Sampling sites for the collection of chemical, biological, and sediment samples were chosen to be representative of the stream within the portion of the basin being considered. A summary of the stream channel characteristics of each site is shown in table 3. Most of the smaller streams and a few of the moderately-sized ones have channels with relatively small (less than 10) width-to-depth ratios and low water velocities. The streambanks are composed of clay, probably of paludal or lacustrine origin (Snavely and others, 1958) and pool-and-riffle sections are rare. Some reaches of upper Foster, South Hanaford, and Packwood Creeks have been channelized to promote better drainage. A notable exception is Coal Creek with a natural sequence of pool and riffles.

The larger streams typically have width-to-depth ratios ranging from 20 to 50. The banks are composed of alluvium and are covered by recent flood deposits. Alternate bars, pools, and riffles are common in these streams, except where bedrock has been exposed. The pools generally contain finer material than the riffles, which commonly are composed of gravel.

Most of the channels at the sampling sites are in relatively broad valleys, unconstrained by valley walls or bedrock, and about half are armored. In this report, an armored reach is defined as one in which the bed is protected from erosion by low magnitude floods by a covering of coarse particles. Channels at both upstream and downstream sites on Coal and Cedar Creeks, and on the downstream site of Cline Creek, show no evidence of lateral migration or incision because they are restricted by bedrock. At Salmon Creek, only migration is restricted by bedrock.

The upstream site (I) on Packwood Creek is located below an impoundment created on the original stream channel by a mudslide in August 1979. The streambed at the site is atypical, in that it consists of riprap embedded in clay and silt and underlain by concrete. Riprap has been placed on the streambed and along the banks to reduce erosion. Most of the basin has been denuded by coal-stripping operations and presently is being reclaimed by replacing the overburden, grading to the approximate original contour, planting grass, and fertilizing.

TABLE 2.--Physiographic and land-use data for each of the basins studied in southwestern Washington

[Site: E = upstream, E' = downstream; average stream slope: (elevation 85 - elevation 10) / (0.75 x stream length), where elevation 85 and elevation 10 are the elevations at 85 percent and 10 percent, respectively, from the mouth to the divide; average basin slope: (contour length x contour interval) / (basin area) x 100; average slope in area of coal reserves: equation for average basin slope is used but considering only areas where estimated reserves with less than 500 feet of overburden are found; drainage density: total channel length/basin area (Horton, 1932); land use: (U.S. Department of the Interior, 1979); water: reservoir, siltation ponds; barren land: quarries, strip-mined areas.]

Basin	Designation	Drainage area, in square miles	Average stream slope in feet per feet	Average basin slope in percent	Average slope in area of coal reserves in percent	Drainage density in feet per feet x 10	Estimated area of coal occurrence (500 feet overburden), square miles	Land use, in percent				
								Urban and Industrial	Agricultural	Forest	Water	Barren land
Centralia-Chehalis Coal District												
Deep	above site E	5.20	0.038	19.4	---	7.6	----	0	0	100.0	0	0
Creek	between sites E and E'	6.02	.006	20.9	1.9	7.5	0.18	0	2.0	98.0	0	0
	above site E'	11.02	.018	20.2		7.5	----		1.9	98.0	0	0
Lincoln	above site H	28.94	.028	25.2	24.1	8.5	.49	0	0	100.0	0	0
Creek	between sites H and H'	9.30	.002	17.1	14.1	8.9	6.60	5.7	0	94.3	0	0
	above site H'	38.24	.022	21.3	14.8	8.7	----	3.8	0	96.2	0	0
Hanaford	above site F	10.22	.065	22.6	21.1	9.8	3.37	0	4.0	94.5	.8	.3
Creek	between sites F and F'	9.50	.004	15.1	17.5	6.1	5.49	.6	12.1	86.7	.3	.3
	above site F'	19.72	.040	18.2	18.9	7.7		.4	9.7	89.5	.5	.2
South	above site G	5.94	.035	19.0	1.4	6.4	.95	.1	13.8	86.1	0	0
Hanaford	between sites G and G'	8.39	.001	16.9	1.6	7.6	1.31	.1	14.9	85.0	0	0
Creek	above site G'	14.33	.014	18.5	1.5	6.6		.1	14.5	85.4	0	0
Packwood	above site I	1.47	.047	28.4	25.3	8.0	.80	0	0	100.0	0	0
Creek	between sites I and I'	6.54	.004	19.3	17.2	7.6	3.66	0	.3	83.6	0	16.1
	above site I'	8.01	.020	21.0	18.7	7.7		0	.2	70.3	0	13.6

TABLE 2.--Physiographic and land-use data for each of the basins studied in southwestern Washington--continued

[Site: E = upstream, E' = downstream; average stream slope: (elevation 85 - elevation 10) / (0.75 x stream length), where elevation 85 and elevation 10 are the elevations at 85 percent and 10 percent, respectively, from the mouth to the divide; average basin slope: (contour length x contour interval) / (basin area) x 100; average slope in area of coal reserves: equation for average basin slope is used but considering only areas where estimated reserves with less than 500 feet of overburden are found; drainage density: total channel length/basin area (Horton, 1932); land use: (U.S. Department of the Interior, 1979); water: reservoir, siltation ponds; barren land: quarries, strip-mined areas.]

Basin	Designation	Drainage area, in square miles	Average stream slope in feet per feet	Average basin slope in percent	Average slope in area of coal reserves in percent	Drainage density in feet per feet x 10	Estimated area of coal occurrence (500 feet overburden), square miles	Land use, in percent: Urban and Industrial	Agricultural	Forest	Water	Barren land
Kelso-Castle Rock Coal Area												
Coal	above site A	8.35	.037	17.9	10.7	10.2	.02	0	0	100.0	0	0
Creek	between sites A and A'	9.07	.020	19.5	18.8	6.8	.40	2.5	1.9	95.6	0	0
	above site A'	17.42	.034	18.7	18.3	8.4		1.6	1.2	91.4	0	0
Salmon	above site B	17.48	.042	18.9	....	5.5	....	0	0	100.00	0	0
Creek	between sites B and B' excluding Cedar Creek basin	30.14	.005	15.0	17.9	6.5	2.35	0	.7	99.3	0	0
	above site B' excluding Cedar Creek basin	47.62	.017	16.4		6.0		0	.6	99.4	0	0
	above site B'	70.43		16.1		5.5						
Cedar	above site C	10.67	.015	14.7	....	5.8	....	0	0	100.0	0	0
Creek	between sites C and C'	5.20	.025	16.1	9.5	6.4	.87	0	0	100.0	0	0
	above site C'	15.87	.025	15.1		6.0		0	0	100.0	0	0
Foster	above site D	0.61	.070	20.2	....	12.1	....	0	0	100.0	0	0
Creek	between sites D and D'	4.51	.008	7.8	12.9	6.6	.48	3.5	37.0	59.5	0	0
	above site D'	5.12	.019	9.3		7.4		3.3	34.5	55.5	0	0
Cline	above site J	1.34	.034	17.6	....	13.1	....	0	0	100.0	0	0
Creek	between sites J and J'	3.02	.012	16.4	14.4	11.6	.35	0	0	100.0	0	0
	above site J'	4.36	.026	16.8		12.1		0	0	100.0	0	0

TABLE 3.--Stream-channel characteristics of the sampling sites

Stream	Site[1] (see fig. 3)	Local valley fill	Predominant stream channel substrate	Armoring	Width-depth ratios
		Centralia-Chehalis Coal District			
Deep Creek	E	Clay	Sand and gravel	No	11.17
	E'	Clay	Silt and clay	No	15.31
Lincoln Creek	H	Clay	Sand and Silt	No	11.16
	H'	Clay	Sand and silt	No	15.03
Hanaford Creek	F	Alluvium	Gravel and cobbles	Yes	51.35
	F'	Clay	Sand and clay	No	10.69
South Hanaford Creek	G	Clay	Silt and clay	No	8.52
	G'	Clay	Silt and clay	No	6.98
Packwood Creek	I[2]	--	---	--	--
	I'	Clay	Silt and clay	No	5.04
		Kelso-Castle Rock Coal Area			
Coal Creek	A	Bedrock	Gravel and cobbles	Yes	29.37
	A'	Bedrock	Gravel and cobbles	Yes	9.03
Salmon Creek	B	Alluvium	Boulder and cobbles	Yes	21.87
	B'	Alluvium	Gravel and cobbles	Yes	30.88
Cedar Creek	C	Bedrock	Sand and gravel	Yes	21.66
	C'	Bedrock	Sand and gravel	Yes	7.68
Foster Creek	D	Clay	Silt and clay	No	9.00
	D'	Clay	Silt and clay	No	5.60
Cline Creek	J	Alluvium	Silt and clay	Yes	10.00
	J'	Bedrock	Sand	Yes	10.45

[1] E = upstream site, E' = downstream site.
[2] Upper Packwood Creek is not a representative reach; no data were collected.

DATA-COLLECTION METHODS

Temporal variations of selected water-quality characteristics were examined to document baseline conditions in unmined basins and to describe the water quality of streams receiving drainage from mined areas. Water quality characteristics that were analyzed include pH, concentrations of total and dissolved iron, total and dissolved manganese, dissolved solids, trace metals, common ions and nutrients. Additional data collected include streamflow measurements, inventory of benthic invertebrates, sampling of bottom materials for trace metal analysis, suspended sediments and particle size analysis of streambed and bank sediments. A summary of the data collected and their sampling frequency is shown in table 4. The streamflow measurements were made using vertical axis current meters (Buchanan and Somers, 1976) except at the upstream site of Foster Creek, where volumetric techniques were used. Water-quality data were obtained according to the methods described by Brown, Skougstad, and Fishman (1974).

Instantaneous discharge measurements made during the study period were correlated with discharge from continuously gaged sites located in basins with similar topography and basin area. Results suggest that the instantaneous discharge measurements were more representative of average streamflow conditions during July to October than during March to May. Instantaneous discharges per unit area were also plotted for those times when streams were measured in order to compare upstream and downstream sites. It was postulated that drainage basins denuded of vegetation by strip mining or agriculture would have a greater water yield per unit area than undisturbed basins. Based on available data, no discernible pattern was observed in surface-water yield between upstream and downstream sites in all basins except for Hanaford Creek.

Each of the six discharge measurements made at Hanaford Creek revealed that the discharge per square mile was about 50 percent less at the downstream site than at the upstream site indicating that ground-water contribution to the stream as it flows through the drainage area of the lower site is probably small. A t-test for paired comparisons showed no significant differences ($P<0.05$) in surface-water yield between sampling sites at each stream except for Hanaford Creek where a significant difference may exist ($P<0.10$).

Benthic invertebrates were sampled at each site, but collection techniques were not uniform because of the wide spectrum of habitats encountered. Stream depths ranged from 2 inches in Cline Creek to 4 feet in Lincoln Creek; bottom materials ranged from boulder and cobbles to sand and clay. At sites with cobble-boulder, cobble-gravel, or gravel-sand substrates, replicate samples of benthic invertebrates were collected using a Surber sampler and composited at the site. In those streams where the streambed substrate was predominantly silt-clay or sand-clay, or where stream depth precluded the use of the Surber sampler, benthic invertebrates were collected synoptically with a dip net. Attempts were made to sample all possible habitats. The mesh size of the dip net was larger (1000 micrometers) than that of the Surber sampler (210 micrometers). Synoptic samples of benthic organisms were collected from Lincoln, South Hanaford, Cline and Packwood Creeks, and the upstream site of Foster Creek. All samples were preserved in 70-percent ethanol and taxonomically identified in the laboratory.

TABLE 4.--Sampling frequency for physicochemical and biological constituents at study sites

Sampling frequency	Sampling period	Physicochemical and biological constituents	Analysis Location	Remarks
Monthly	March to May and July to October, 1980	Instantaneous discharge Specific conductance Dissolved oxygen Water temperature Alkalinity and acidity (hot) pH	Field	
		Turbidity Suspended sediments Benthic Invertebrates	Laboratory	U.S. Geological Survey, District Laboratory, Tacoma, WA
Seasonal	April to October 1980	Dissolved and total recoverable Fe and Mn Total $NO_2 + NO_3$ as N Total P as P Dissolved common ions: Ca, Mg, Na, K, Cl, F, Silica, and SO_4	Laboratory	U.S. Geological Survey, Central Laboratory, Arvada, Co.
	April, August to October 1980	Dissolved trace metals: Al, As, Cd, Cr, Cu, Pb, Se, Hg, Zn, and Co		
	April, September 1980	Total recoverable trace metals: (same as dissolved)		
	August 1981	Grain size analysis: bed and bank sediments		U.S. Geological Survey, Sediment Laboratory, Sacramento, CA
		Pebble counts	Field	Sacramento, CA

Bottom sediments were sampled once, in September 1980, at each of the 20 sampling sites and analyzed for trace metals usually associated with mining activities. Bottom sediments can serve as a sink for trace metals transported downstream, both dissolved in water and adsorbed on suspended sediments. Trace metals adsorbed on sediments deposited over a long period of time can reflect not only present but also past conditions. Sampling was restricted to a thin layer (1 inch) of the streambed surface (R.F. Middleburg, U.S. Geological Survey, written commu., 1977, 1979).

Water samples for suspended-sediment analysis were collected by depth integration at most sites using equal-width increments. However, because of low water velocities (less than 1.5 feet per second) at the upstream site of Lincoln and Cline Creeks, samples were collected at the surface over the width of the stream by hand-dipping.

Streambed and bank sediment samples were also collected, in August 1981, and analyzed for grain-size distribution. Local valley fill was characterized as either clay, alluvium, or none (bedrock), but was not sampled (see table 3). Some streams were incised into the valley fill, but streambank deposits were generally present at the base of the erosional banks. Each bed sample consisted of either composited grab samples taken at equal intervals across the bed, or by a modified Wolman Count (Wolman, 1954), using grab samples to measure particles smaller than 16 millimeters. Bank material samples were composited from equally spaced grab samples taken from recently deposited bank sediments.

The composite grab samples of the bed and bank materials were sieved by either standard dry- or wet-sieve techniques. The volumetric data of pebble counts were converted to mass assuming a specific weight of 2.7 grams per cubic centimeter and an ellipsoidal grain shape; then, each gram was placed into size classes by length of the intermediate axis. The particle-size distribution of the bed material was determined by combining the pebble count data with the composite sample of the matrix, weighted by the percentage of matrix points in the pebble count.

The median, graphic mean, and graphic standard deviation (σ_G) of the grain sizes of the bed and bank material samples were calculated using techniques outlined by Folk (1974), and are presented and analyzed in phi units (Krambein and Graybill, 1965). The median grain size is defined as the grain size of the 50th percentile. The graphic mean is defined as the average of the 16th, 50th, and 84th percentiles. The graphic standard deviation (σ_G) is defined as half the difference between the 16th and 84th percentiles. Phi units are defined as the negative logarithm (to the base 2) of the grain diameter in millimeters. Phi units are negative for grains coarser than 1 millimeter and positive for finer grains. Sediments deposited by a single event have, in theory, grain sizes which exhibit log-normal distribution.

Effects of the 1980 eruption of Mount St. Helens on the study area were not assessed. The eruption occurred during the study but, except for Cline Creek it was assumed that all the drainage basins being compared were equally affected. Data from the downstream side in Cline Creek during August to October were collected 500 feet further upstream from the original sampling location due to the complete destruction of this site resulting from a mud flow in the Toutle River.

WATER QUALITY OF THE CENTRALIA-CHEHALIS COAL DISTRICT

Chemical and Physical Characteristics

At both upstream and downstream sites on all study streams the pH values of water (fig. 7) were typical of western Washington streams. Slight variations between the upper and lower reaches of South Hanaford and Packwood Creeks may be due to current (1980) land-use practices such as strip-mining activity or agriculture.

Dissolved-solids concentrations (fig. 7) ranged from 43 to 117 mg/L (milligrams per liter) in Deep, Lincoln, and Hanaford Creeks. Packwood and South Hanaford Creeks had higher concentrations of dissolved solids than other streams during both high and low flows (90 to 1,350 mg/L). Calcium, magnesium, sodium and sulfate were the major ions contributing to the increase in dissolved solids. The increases in these minerals were consistently higher at the downstream site on Packwood Creek than at its upstream site but higher at the upstream site on South Hanaford Creek than at the lower site. Both upper South Hanaford Creek and lower Packwood Creek receive drainage from nearby siltation ponds, and upper Packwood Creek is impounded by a mudslide from spoil piles of overburden.

Concentrations of dissolved iron were generally less than 500 ug/L (micrograms per liter) in all streams except during low flows. Concentrations were as high as 2,500 ug/L during low flow in the upper reaches of Packwood Creek where the stream is impounded (fig. 8). Most of the iron concentrations at both sites in South Hanaford were in suspended phase throughout the study. The concentrations of iron associated with the suspended sediments are significantly greater at the downstream sites of Packwood and South Hanaford Creeks than at the upper sites (table 5). The other streams studied show much less of an increase from upstream to downstream sites.

Dissolved manganese ranged from near zero to more than 5,000 ug/L (South Hanaford Creek, fig. 8). Concentrations as high as 2,000 ug/L were measured at Packwood Creek, but concentrations were low (5 to 340 ug/L) for Deep and Lincoln Creeks. Although Hanaford Creek drains a mined area, it had consistently low concentrations (less than 50 ug/L) because samples were collected upstream from the influence of the mine. A sharp increase in concentration of dissolved manganese in Deep and Lincoln Creeks occurred during August; this is attributed to low streamflow, consequent ground-water inflow and poorly oxygenated waters.

Comparisons of the concentration of manganese associated with suspended sediment reveal that the mined streams have the largest increase in manganese downstream. The increased concentrations of iron and manganese in the lower reaches of South Hanaford Creek may be attributed to channelization work done during the course of the study.

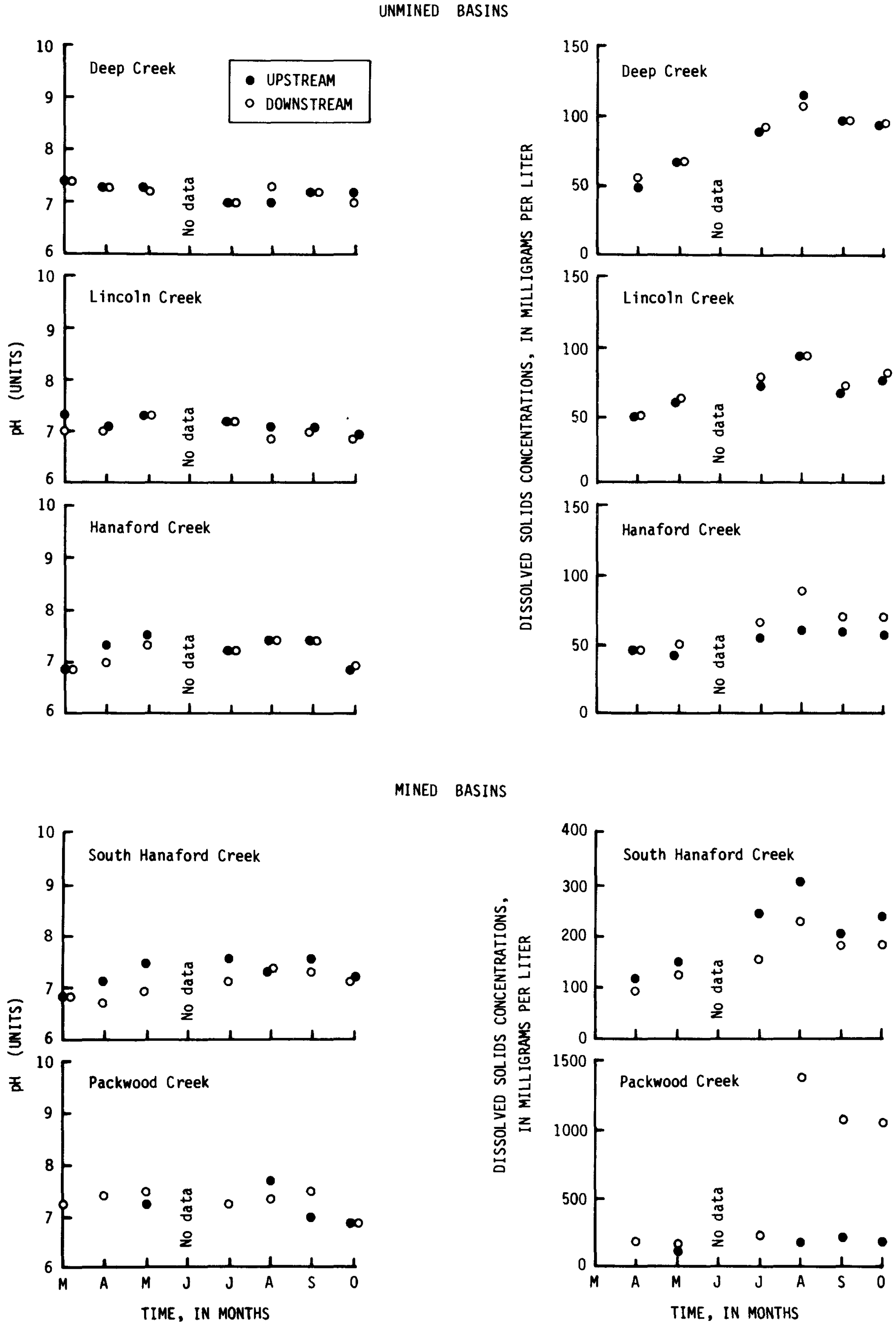


FIGURE 7.--pH and dissolved-solids concentrations (residue at 180 °C) in streams of the Centralia-Chehalis coal district during March-May and July-October 1980.

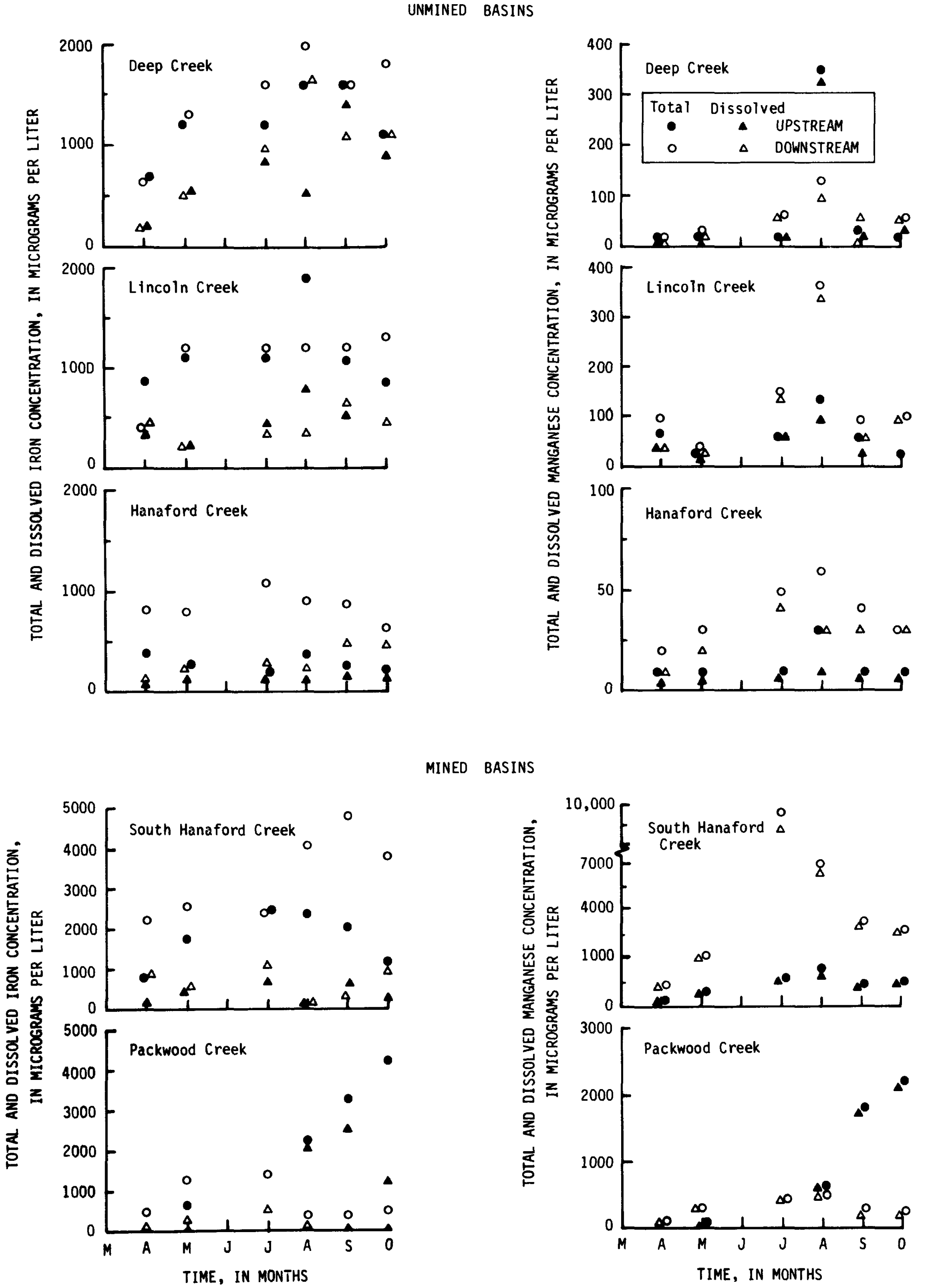


FIGURE 8.--Total- and dissolved-iron and manganese concentrations in the Centralia-Chehalis coal district during April-May and July-October 1980.

TABLE 5.--Concentrations of suspended iron and manganese per gram of suspended sediments for sampling sites in the Centralia-Chehalis coal district.

Stream and site location on figure 3		Concentrations, in micrograms per gram of suspended sediment	
		Iron	Manganese
South Hanaford Creek	G	109,000	1,500
	G'	163,000	14,300
Packwood Creek	I	61,000	5,200
	I'	140,000	9.000
Deep Creek	E	91,000	3,600
	E'	112,000	1,400
Lincoln Creek	H	55,000	2,000
	H'	67,000	2,600
Hanaford Creek	F	46,000	1,500
	F'	47,000	900

Suspended sediment concentrations at the time of sampling were very low and comparable between streams. The siltation ponds in Packwood and South Hanaford Creeks appeared to be very efficient in retaining sediments derived from the strip-mining operation, even during periods of moderate flow. Their efficiency during peak flows was not determined.

Trace Metals in Water and Bottom Sediments

Concentrations of dissolved trace metals (table 6) were generally below concentrations stipulated in the Primary Drinking Water Regulations (U.S. Environmental Protection Agency, 1975b) and in reported toxicity threshold levels (U.S. Environmental Protection Agency, 1976). During low flow, higher concentrations of aluminum (1,200 ug/L) were found in Hanaford Creek and of zinc (120 mg/L) in Deep Creek, and both elements were mostly in suspended phase. Samples taken during higher flows in April did not differ significantly from low flow samples in concentrations of dissolved trace metals.

Concentrations of total-recoverable trace metals in the bottom sediments were, with some exceptions, similar in all streams. The concentrations of iron and manganese in the bottom sediments of Packwood and South Hanaford Creeks were higher at the lower sites but for probably different reasons. If the siltation ponds on both streams are trapping the coarse materials, then the sampling sites below siltation ponds should have a higher percentage of fines in the bottom material. This was confirmed by grain size analysis and examined later in the report when the erosion potential of the study streams is discussed. Greater concentration of iron, manganese and other trace elements would be expected with the lines than with the coarse sediments. This was observed in Packwood Creek only where concentrations of copper, zinc, iron, and manganese were higher below the siltation ponds. Although not investigated in this study it is probable that greater temporal exposure of weathered material to air and water in the Packwood basin may contribute to higher concentrations of iron, manganese, and other trace elements in bottom sediments than the upstream site of South Hanaford Creek, which is also under the influence of mine drainage but has much less overburden exposed. Higher concentrations of iron and manganese at the lower reaches in South Hanaford Creek probably originated from channelization activities. Chromium, cobalt, copper, and zinc concentrations appear to be higher in both reaches of Lincoln Creek. These concentrations may not be representative of what is present in the bed sediments because of the wide differences among streams in particle size of bed sediment. Explanation of the anomalously high concentrations may require further investigation.

TABLE 6.--Concentrations of dissolved and total-recoverable metals in water and recoverable trace metals in bottom sediments in the Centralia-Chehalis coal district during September 1980 [Trace metals analyses of bottom sediments were made on particle sizes less than 2 millimeters.]

Stream	Site[1]	Aluminum (Al) Dis-solved	Aluminum (Al) Total	Arsenic (As) Dis-solved	Arsenic (As) Total	Cadmium (Cd) Dis-solved	Cadmium (Cd) Total	Chromium (Cr) Dis-solved	Chromium (Cr) Total	Cobalt (Co) Dis-solved	Cobalt (Co) Total	Copper (Cu) Dis-solved	Copper (Cu) Total	Lead (Pb) Dis-solved	Lead (Pb) Total	Mercury (Hg) Dis-solved	Mercury (Hg) Total	Selenium (Se) Dis-solved	Selenium (Se) Total	Zinc (Zn) Dis-solved	Zinc (Zn) Total
		Concentrations in water, in micrograms per liter																			
Deep	E	100	100	2	2	<1	<1	<10	<1	<3	<50	2	5	2	2	<0.1	<0.5	<1	<1	<4	10
Creek	E'	300	500	2	2	<1	<1	<10	5	<3	<50	2	6	2	2	< .1	< .5	<1	<1	<4	120
Lincoln	H	100	200	2	3	<1	<1	<10	5	3	50	2	5	3	3	< .1	< .5	<1	<1	<4	10
Creek	H'	100	200	1	2	<1	<1	<10	6	3	<50	2	5	2	3	< .1	< .5	<1	<1	<4	10
Hanaford	F	100	200	1	1	<1	<1	<10	<1	<3	<50	2	4	<1	1	< .1	< .5	<1	<1	<4	10
Creek	F'	100	1,200	1	1	<1	<1	<10	<1	<3	<50	2	8	3	3	< .1	< .5	<1	<1	<4	10
S. Hanaford	G	<100	500	1	1	<1	<1	<10	5	3	<50	2	5	2	2	< .1	< .5	<1	<1	<4	10
Creek	G'	<100	500	1	2	<1	<1	<10	3	4	<50	2	5	2	2	< .1	< .5	<1	<1	<4	10
Packwood	I	<100	200	1	2	<1	<1	<10	5	<3	50	<1	3	2	2	< .1	< .5	<1	<1	<4	20
Creek	I'	<100	200	1	1	<1	<1	<10	5	<3	<50	1	3	3	3	< .1	< .5	<1	<1	<4	10

Stream	Site[1]	Arsenic (As)	Cadmium (Cd)	Chromium (Cr)	Cobalt (Co)	Copper (Cu)	Iron (Fe)	Lead (Pb)	Manganese (Mn)	Mercury (Hg)	Selenium (Se)	Zinc (Zn)
		Concentrations in bottom sediments, in micrograms per gram of dry weight										
Deep	E	6	<1	8	20	23	19,000	10	800	<0.01	<1	48
Creek	E'	3	<1	6	10	14	7,800	10	440	< .01	<1	23
Lincoln	H	4	<1	25	30	40	24,000	10	770	< .01	<1	51
Creek	H'	9	<1	20	40	29	3,200	10	560	< .01	<1	62
Hanaford	F	2	<1	6	20	31	15,000	<1	600	< .01	<1	32
Creek	F'	2	<1	4	10	19	10,000	10	470	< .01	<1	27
S. Hanaford	G	5	<1	7	10	16	13,000	10	350	< .01	<1	39
Creek	G'	5	<1	9	20	14	18,000	10	920	< .01	<1	46
Packwood	I	3	<1	4	10	5	4,600	10	290	< .01	<1	12
Creek	I'	4	<1	8	30	23	17,000	10	2,400	< .01	<1	110

[1] E = upstream site, E' = downstream site; see figure 3 for site locations.

WATER QUALITY OF THE KELSO-CASTLE ROCK COAL AREA

Chemical and Physical Characteristics

None of the streams in the Kelso-Castle Rock area receives drainage from mining activities. The pH of water at both upstream and downstream sites for all streams was within the range expected for western Washington streams (fig. 9). Differences in pH between sites in Foster Creek are greater than differences between sites on other streams. This may be related to intensive agricultural activity in the downstream reaches of Foster Creek.

Except for Cline Creek, the dissolved-solids concentrations in the Kelso-Castle Rock area ranged from 24 to 111 mg/L (fig. 9). Larger concentrations (174 mg/L) of dissolved solids measured for Cline Creek in August may have been caused by road construction in its lower reaches.

Dissolved iron ranged in concentration from near zero to 2,100 ug/L and dissolved manganese, from near zero to 390 ug/L (fig. 10). Dissolved-manganese concentrations were more variable between sampling sites on Cedar, Foster, and Cline Creeks than on Coal and Salmon Creeks. Increases in manganese tend to be correlated with decreases in dissolved oxygen. Although a similar correlation would be expected for iron, a decrease in iron was observed for Cline Creek in August when dissolved-oxygen concentrations were smallest. This is attributed to the influence of pH on iron concentrations and to road construction near the downstream site, which may have influenced the availability of iron. Dissolved-iron concentrations were similar for most sites throughout the sampling period. The only exception was in the upper reaches of Foster Creek where iron was predominantly in suspended phase.

A comparison of the concentrations of iron and manganese associated with suspended sediments between sampling sites shows that downstream differences are negligible for both trace elements (table 7). All of the concentrations of suspended iron are larger at all upstream sites than at the downstream sites. Similar observations were made with manganese except for Foster and Cline Creeks where concentrations at the downstream site were about twice the concentrations at the upstream sites. The cause of this anomaly was not determined for Foster Creek but it was noted that the lower reaches are among the most heavily cultivated. Cline Creek may have been influenced by road construction in the area.

Suspended sediment concentrations at the time of sampling were very small and similar from one stream to the next (see table 14, end of report). These measurements are only indicative of average flow conditions and do not represent peak flow events.

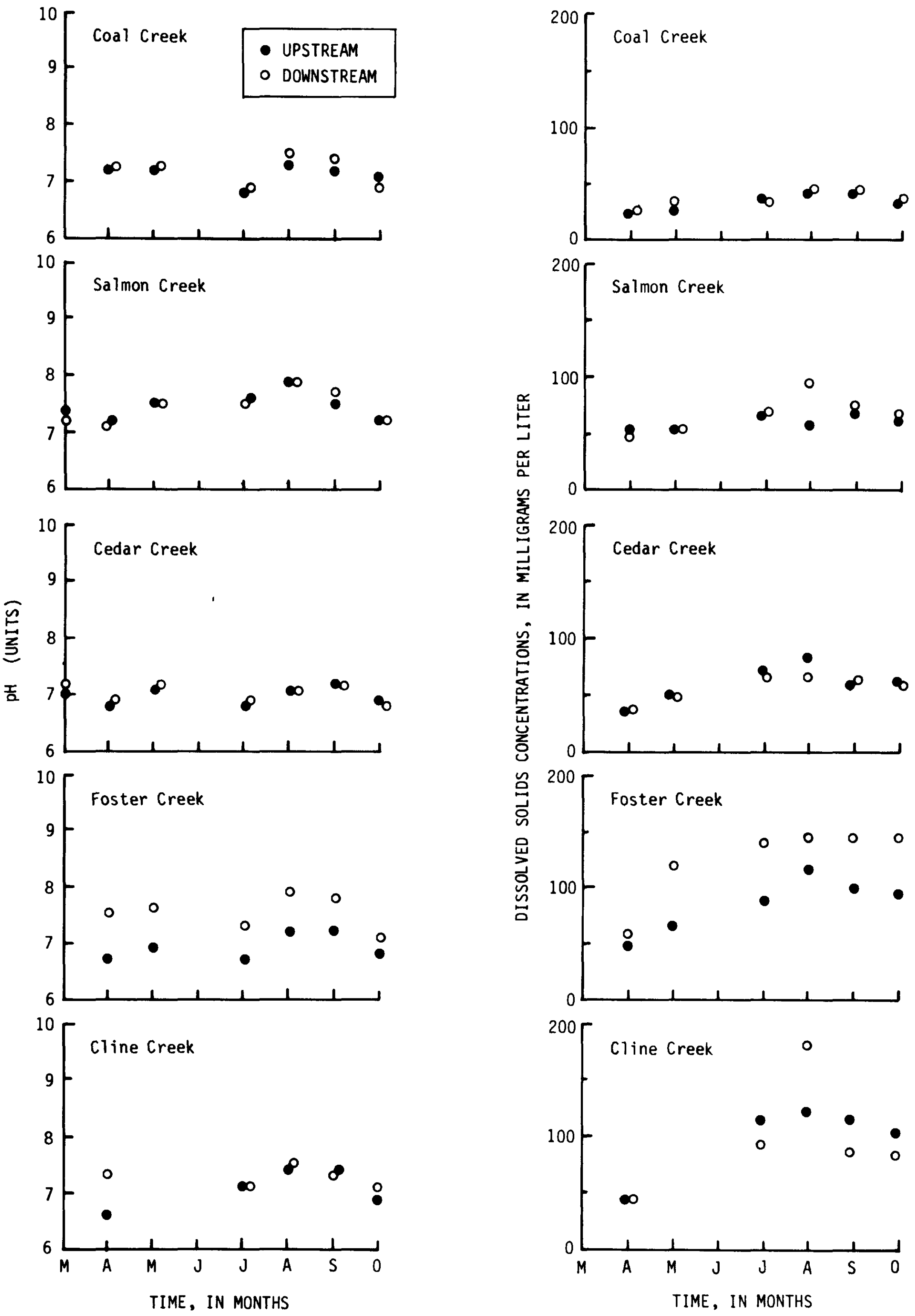


FIGURE 9.--pH and dissolved-solids concentrations (residue at 180 °C) in streams of the Kelso-Castle Rock coal area during March-May and July-October 1980. (For August the calculated value of dissolved solids in Foster and Cline Creeks was used instead of the residue at 180 °C because of analytical error.)

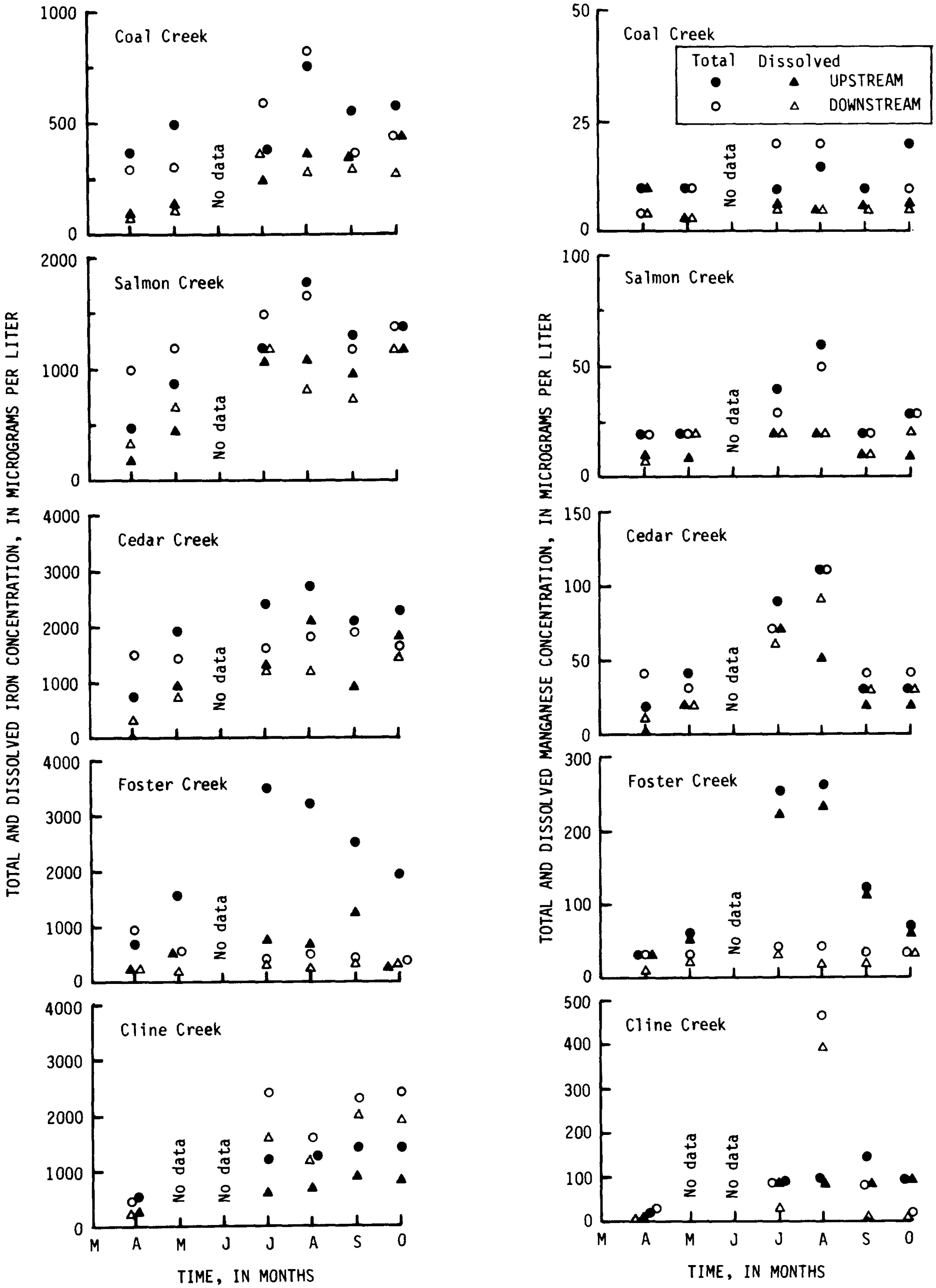


FIGURE 10.--Total- and dissolved-iron and manganese concentrations in Kelso-Castle Rock coal area during April-May and July-October 1980.

TABLE 7.--Concentrations of suspended iron and manganese in suspended sediments for sampling sites in the Kelso-Castle Rock coal area

Stream	Site (see fig. 3)	Concentration, in micrograms per gram of suspended sediment	
		Iron	Manganese
Coal Creek	A	76,000	3,000
	A'	53,000	2,600
Salmon Creek	B	83,000	3,600
	B'	78,000	2,400
Cedar Creek	C	115,000	2,800
	C'	83,000	2,000
Foster Creek	D	139,000	1,100
	D'	50,000	2,300
Cline Creek	J	113,000	7,000
	J'	111,000	11,275

Trace Metals in Water and Bottom Sediments

Concentration of dissolved trace metals (table 8) were generally below concentrations stipulated in the Primary Drinking Water Regulations (U.S. Environmental Protection Agency, 1975b) and in the reported toxicity threshold levels (U.S. Environmental Protection Agency, 1976). During low flows, larger concentrations of chromium (11 ug/L) were found in Foster Creek and of copper (13 mg/L) in Cline Creek, and both elements were mostly in suspended phase. Samples taken during higher flows in April did not differ significantly from low-flow samples in concentrations of dissolved trace metals.

Concentrations of total-recoverable trace metals in the bottom sediments were, with some exceptions, similar in all streams. Larger levels of arsenic and chromium were found in Coal Creek than in the other streams. As in the Centralia-Chehalis coal district, further sampling of bottom sediments and analysis of metals in sediment samples fractionated according to particle size would be needed to better understand the distribution of trace metals.

TABLE 8.--Concentrations of dissolved and total-recoverable metals in water and recoverable trace metals in bottom sediments in the Kelso-Castle Rock coal area during September 1980 [Trace metal analyses of bottom sediments were made on particle sizes less than 2 millimeters.]

Stream	Site[1]	Concentrations in water, in micrograms per liter																			
		Aluminum (Al)		Arsenic (As)		Cadmium (Cd)		Chromium (Cr)		Cobalt (Co)		Copper (Cu)		Lead (Pb)		Mercury (Hg)		Selenium (Se)		Zinc (Zn)	
		Dis-solved	Total	Dis-solved	Total	Dis-solved	Total	Dis-solved	Total	Dis-solved	Total	Dis-solved	Total	Dis-solved	Total	Dis-solved	Total	Dis-solved	Total	Dis-solved	Total
Coal	A	<100	200	1	2	<1	<1	<10	7	<3	<50	2	4	2	2	<0.1	<0.5	<1	<1	<4	10
Creek	A'	100	200	1	1	<1	<1	<10	5	<3	<50	2	7	2	2	< .1	< .5	<1	<1	<4	20
Salmon	B	100	500	1	1	<1	<1	<10	5	3	<50	2	9	<1	2	< .1	< .5	<1	<1	<4	20
Creek	B'	100	200	1	2	<1	<1	<10	5	<3	<50	2	5	2	2	< .1	< .5	<1	<1	<4	20
Cedar	C	100	200	1	1	<1	<1	<10	5	<3	<50	2	4	2	2	< .1	< .5	<1	<1	<4	10
Creek	C'	100	200	1	1	<1	<1	<10	<1	<3	<50	2	5	<1	1	< .1	< .5	<1	<1	<4	20
Foster	D	100	200	<1	2	<1	<1	<10	11	<3	<50	2	6	<1	4	< .1	< .5	<1	<1	<4	10
Creek	D'	100	200	1	1	<1	<1	<10	11	<3	<50	1	3	<1	1	< .1	< .5	<1	<1	<4	10
Cline	J	<100	200	2	3	<1	<1	<10	5	<3	<50	1	13	2	2	< .1	< .5	<1	<1	<4	30
Creek	J'	<100	100	1	2	<1	<1	<10	6	<3	<50	<1	5	3	3	< .1	< .5	<1	<1	<4	20

Stream	Site[1]	Concentrations in bottom sediments, in micrograms per gram of dry weight										
		Arsenic (As)	Cadmium (Cd)	Chromium (Cr)	Cobalt (Co)	Copper (Cu)	Iron (Fe)	Lead (Pb)	Manganese (Mn)	Mercury (Hg)	Selenium (Se)	Zinc (Zn)
Coal	A	5	2	15	30	19	25,000	10	890	<.01	<1	47
Creek	A'	23	2	10	20	19	16,000	10	450	<.01	<1	49
Salmon	B	4	1	5	20	15	17,000	10	490	<.01	<1	25
Creek	B'	1	1	7	10	17	5,900	<1	290	<.01	<1	21
Cedar	C	1	1	5	10	3	5,700	<1	270	<.01	<1	14
Creek	C'	2	1	5	10	5	7,600	10	300	<.01	<1	19
Foster	D	4	<1	4	10	14	9,400	10	310	<.01	<1	25
Creek	D'	2	1	5	20	11	9,700	10	250	<.01	<1	57
Cline	J	2	<1	5	10	7	6,000	10	270	<.01	<1	19
Creek	J	3	<1	4	20	14	9,200	10	720	<.01	<1	21

[1] E = upstream site, E' = downstream site' see figure 3 for site locations.

COMPARISON OF WATER QUALITY AND BIOLOGICAL CHARACTERISTICS BETWEEN MINED AND UNMINED BASINS

Water Quality

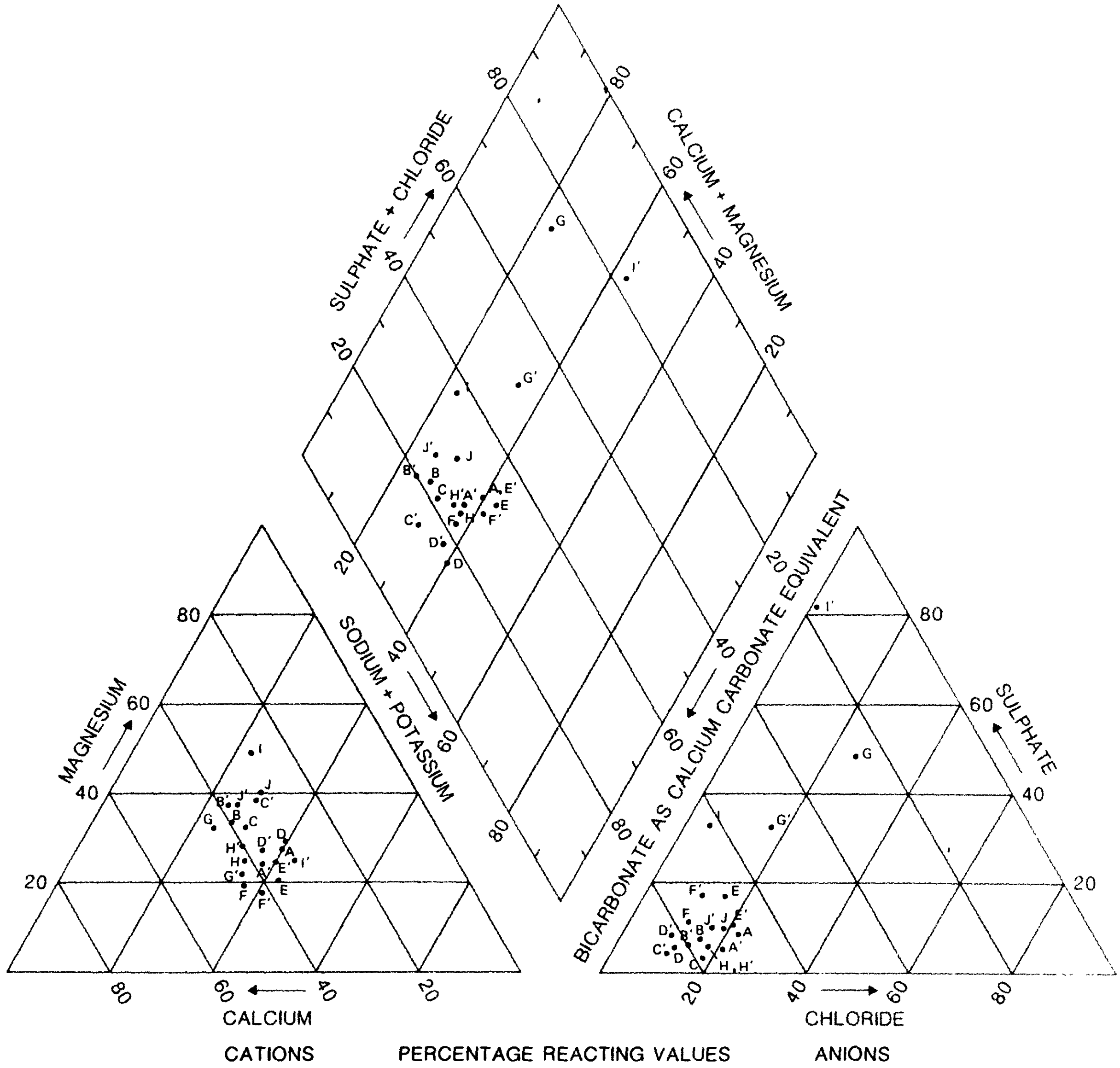
Streams in the study basins are typical of southwestern Washington streams in water chemistry except for Packwood and South Hanaford Creeks, which are affected by coal-strip mining. The water in the unmined basins is characterized as a mixed-water type (fig. 11) in which calcium, magnesium, sodium, and bicarbonate are the major ions. Differences between upstream and downstream sites were minimal, which indicates little human influence on water chemistry. Sulfate is the dominant anion of the downstream site in Packwood Creek and at the upstream site in South Hanaford Creek. Siltation ponds used in the stripping operation are upstream from both these sampling sites. Some of the increase in sulfate at the upstream site on Packwood Creek over the downstream site and at the downstream site on South Hanaford Creek over the upstream site is attributed to grading and channelization operations as well as to the effects of the siltation ponds. The largest variations in specific conductance were found in the two mined basins; values ranged from 185 to 1,570 uS/cm (microsiemens per centimeter at 25° Celsius) for Packwood and from 129 to 419 uS/cm for South Hanaford Creek.

Turbidity values of less than 10 Nephlometric Turbidity Units (NTU) generally apply to streams in both coal areas and values of 1 or 2 NTU were common. The largest value, 25 NTU, was found at the lower South Hanaford Creek site during late summer when some channelization of the lower reaches was being done.

In Packwood Creek, dissolved iron and manganese concentrations were also larger at the upper reaches than the lower reaches. In the impoundment above the upstream site the water was stagnant, the conditions where reducing because of organic matter, the temperature was high, and the oxygen concentration was low, all of which may have contributed to the increase in iron and manganese. The siltation ponds just above the downstream site appear to be providing an ideal quiescent, well-aerated environment that causes most iron and manganese to precipitate or to adsorb to small particulate matter.

Factor analysis was used to select a set of water-quality variables that could be used to best explain the water-quality characteristics of the study basins. The 15 variables chosen (table 9) are most commonly used to describe water-quality conditions in streams receiving coal-mine drainage. Details of the factor analysis technique are described by Cooley and Lohney (1962), Morrison (1967), and Helwig and Council (1979). Each variable was discharge weighted and averaged for the four low-flow months from July to October. It was assumed that the maximum effects of coal-mine drainage would be evident during this period of low flow and minimal dilution.

Separate factor matrices were generated for the unmined basins (Lincoln, Cline, Foster, Deep, Salmon, Cedar, Coal, and Hanaford Creeks) and the mined basins (Packwood and South Hanaford Creeks) to determine whether or not a



EXPLANATION

Basin	Upstream site	N	Downstream site	N
Centralia-Chehalis coal district:				
Deep Creek	E	6	E'	6
Lincoln Creek	H	6	H'	6
Hanaford Creek	F	6	F'	6
South Hanaford Creek	G	6	G'	6
Packwood Creek	I	4	I'	6
Kelso-Castle Rock coal area:				
Coal Creek	A	6	A'	6
Salmon Creek	B	6	B'	6
Cedar Creek	C	6	C'	6
Foster Creek	D	6	D'	6
Cline Creek	J	5	J'	5

N = number of observations

FIGURE 11.--Piper diagram of major cations and anions in stream samples collected during April-October 1980. (Each point represents a discharge-weighted mean value.)

TABLE 9.--Factor loadings of water-quality variables for the unmined and mined basins during July to October 1980

Variables	Unmined basins Factors[a]			Mined basins Factors		
	1	2	3	1	2	3
Discharge	-0.592	-0.449	0.117	0.764	0.422	0.488
pH	.288	- .752	- .116	- .114	.005	- .993
Dissolved oxygen	- .136	- .681	.594	.090	- .957	.274
Alkalinity (as $CaCO_3$)	[b].984	.081	.059	- .162	- .980	- .118
Acidity (as $CaCO_3$)	.201	.870	.049	- .019	.985	.171
Dissolved calcium	.949	.064	- .144	.984	.177	.026
Dissolved magnesium	.959	.154	- .084	.993	.083	.080
Dissolved sodium	.939	.105	- .114	.998	.020	.051
Dissolved chloride	.648	.142	- .209	- .531	.757	- .380
Dissolved sulfate	.420	.039	- .574	.995	.033	.089
Dissolved solids	.985	.023	.068	.996	.063	.057
Dissolved aluminum	.126	.045	.917	- .184	.891	- .413
Dissolved iron	.100	.051	.140	- .505	- .861	- .064
Dissolved manganese	.353	.862	- .023	- .575	- .500	.647
Suspended sediment	.138	.739	- .169	- .925	.270	.268
Percent variance	46.6	26.4	13.3	48.8	36.7	14.5
Cumulative percent variance	46.6	73.0	86.3	48.8	85.5	100

[a]Varimax rotation of factors using the software program Factor Procedure (Hellwig and Council, 1979).
[b]Loadings of 0.800 or greater are underscored.

different set of variables would explain the differences observed in each factor. Only the first three factors (shown in table 9 as columns 1, 2, and 3 for both mined and unmined basins) were considered for interpretation since they explain more than 85 percent of the total variation in the system.

In order to eliminate medium-range factor loadings (correlations between the factors and the original variables), "vari-max rotation" (Wallis, 1965; Mahloch, 1974) was used. This type of rotation facilitates ascribing each of the factors to specific entities of chemical or physical significance, and thus permits a better explanation of the observed co-variation of the variables used (Cattell, 1965).

There are no absolute limits in determining which variables were the most important. The magnitudes of the factor loadings are considered to be a function of the number of variables used and the percent variance explained by the factors. The criterion for variable selection was subjective and conservative, and based on a selected range of factor loading values. For purposes of this discussion, those variables whose factor loadings having values equal or greater than 0.8 are underscored and shown in table 9 to represent those variables that have significant correlation. Care must be taken in extrapolating the interpretations made in this factor analysis as being applicable to areas other than the two coal areas discussed in this report.

The factor-analysis matrix for the unmined basins shows calcium, magnesium, sodium, alkalinity, and dissolved solids to have the highest loadings and thus the greatest potential for describing water type. Similar loadings were found in the mined basins, except that sulfate replaced alkalinity as the major anionic contribution. Acidity and dissolved manganese also appear to be important variables. The source of the manganese is uncertain but it may be released because of heavy vegetation and decomposing organic debris in the alluvium at many sites.

Variables with high factor loadings (such as acidity, alkalinity, dissolved oxygen, aluminum, and iron) that are influenced by oxidation-reduction reactions were found in the factor-analysis matrix for the mined basins. Acidity in the mined basins appears to be less related to the hydronium ion and more related to other species such as iron and aluminum compounds that combine with hydroxide ions. Low levels of dissolved oxygen may also lead to the release of iron compounds. The abundance of carbonate minerals exposed to weathering during the stripping operation may have contributed to the high net alkalinities (alkalinity as $CaCO_3$ milligrams per liter) - acidity as $CaCO_3$ milligrams per liter) found in stream water at the mined basins. Values of pH poorly characterize the water of streams that receive mine drainage; high loading of pH appears only on the third factor, which explains only 14.5 percent of the total variation.

Water-quality differences between the mined and unmined basins appear to be slight. Sulfate becomes more abundant in the mined basins, but is insufficient to significantly alter the pH of the water nor to make the streams more acidic.

Biological Characteristics

The areal distribution and abundance of macroinvertebrates in each stream were used to describe the benthic communities. The general stream habitats are described by means of presence or absence data for benthic invertebrates collected at each site. Each sampling site was also characterized biologically by its substrate composition and the structure of its associated benthic community.

The presence or absence data for benthic invertebrates are summarized in table 10. The summary is based on the percentage composition of invertebrate fauna at each sampling site. A total of 223 macroinvertebrate taxa were identified from the 20 sampling sites (see table 15, end of report). Five orders of aquatic insects (Ephemenoptera, Plecoptera, Trichoptera, Diptera, and Coleoptera) composed over 64 percent of the taxa found at most of the sites.

Most of the study streams have lotic environments that are populated predominantly by insect fauna. Lincoln and South Hanaford Creeks, on the other hand, had lentic habitats in which the non-insect fauna was more abundant but less diverse than the insect fauna. A significant amount of coarser sediment (gravel, cobbles) on a streambed was associated with a more diverse fauna than was bed material dominated by sand, silt, or clay. Of all the sites sampled, the upstream site of Packwood Creek had the most impoverished of fauna. Mayflies, stoneflies, and caddisflies were virtually absent. The impoverishment is attributed to location of the site downstream from an impoundment and to the substrate, which consists of clay and riprap underlain by concrete; also, the stream has long periods of low streamflow, high water temperatures and low dissolved-oxygen concentration.

The presence or absence data were analyzed using "normal" classification (Clifford and Stephenson, 1975), which compares entities with the corresponding attributes. In this study, the sampling sites were considered the entities, and the taxa the attributes. Jaccard's index of similarity was used in the analysis to create a matrix of resemblances between all sites (Boesch, 1977). Index values range from completely dissimilar sites ($S_j = 0$) to completely similar sites ($S_j = 1$). Jaccard's index is expressed as follows:

$$S_j = \frac{a}{a+b+c}$$

where

S_j = Jaccard's Similarity Index,
a = number of times a species occurs at both sites,
b = number of times a species occurs at one site but not the other, and
c = number of times a species occurs at the other sites but not the one.

The resemblance matrix was examined using cluster analysis (unweighted pair group method) in order to group the sampling sites based on their degree of similarity. This classification method of grouping is explained by Sneath and Sokal (1963). Distortion of the relationship originally expressed in the resemblance matrix, as introduced by this method of classification, was found to be insignificant.

TABLE 10.--Percentage composition of benthic invertebrates and numbers of taxa collected during March to October 1980 at upstream and downstream (indicated by "'") sites on study streams.

	Centralia - Chehalis coal district									
	Deep Creek		Hanaford Cr.		South Hanaford Cr.		Lincoln Cr.		Packwood Cr.	
Order	E	E'	F	F'	G	G'	H	H'	I	I'
Ephemenoptera	8.5	11.0	14.1	9.9	9.3	8.5	10.6	8.2	3.7	8.0
Plecoptera	18.3	17.8	18.0	14.1	7.4	4.3	6.4	6.1	3.7	12.0
Trichoptera	14.1	17.8	16.7	14.1	3.7	10.6	2.1	6.1	3.7	10.0
Diptera	25.4	24.7	21.8	29.6	27.8	21.3	27.7	20.4	48.1	22.0
Coleoptera	7.0	2.7	5.1	7.0	11.1	8.5	2.1	8.2	11.1	12.0
Odonata	0	0	2.6	1.4	1.9	4.3	2.1	2.0	0	0
Hemiptera	2.8	0	0	0	3.7	6.4	6.4	6.1	0	4.0
Collembola	2.8	2.7	0	2.8	3.7	2.1	2.1	0	3.7	2.0
Neuroptera	0	0	0	0	1.8	0	2.1	2.0	0	0
Others	21.1	23.2	21.8	21.1	29.6	34.0	38.3	41.0	25.9	30.0
Insecta	56	56	61	56	38	31	29	29	20	35
Non-insecta	15	17	17	15	16	16	18	20	7	15
Total number of taxa	71	73	78	71	54	47	47	49	27	50

	Kelso - Castle Rock coal area									
	Coal Creek		Salmon Creek		Cedar Creek		Foster Creek		Cline Creek	
Order	A	A'	B	B'	C	C'	D	D'	J	J'
Ephemenoptera	13.9	11.8	15.5	11.7	11.7	13.5	9.1	10.6	10.0	16.7
Plecoptera	10.1	11.8	16.5	15.6	15.6	13.5	6.8	10.6	12.0	16.7
Trichoptera	19.0	16.1	16.5	18.2	11.7	10.8	9.1	12.9	16.0	20.0
Diptera	29.1	26.9	21.7	22.1	26.0	27.0	50.0	28.2	32.0	20.4
Coleoptera	5.1	5.4	6.2	5.2	10.4	8.1	4.5	4.7	0	11.1
Odonata	0	0	0	1.3	0	1.4	2.3	2.4	0	0
Hemiptera	0	2.2	2.1	0	0	0	0	5.9	4.0	1.9
Collembola	1.3	1.1	1.0	1.3	2.6	0	2.3	1.2	2.0	1.9
Neuroptera	0	0	0	0	0	1.4	2.3	1.2	2.0	0
Others	21.5	24.7	20.6	24.7	22.1	24.3	13.6	22.4	22.0	11.1
Insecta	62	70	77	58	60	56	38	66	39	48
Non-insecta	17	23	20	19	17	18	6	19	11	6
Total number of taxa	79	93	97	77	77	74	44	85	50	54

Some allowance was given to weakly clustering strategies (Williams, 1971) with a minimal amount of chaining to obtain the highest clusters because the type of configuration the data would have was unknown. In view of the similarities in water chemistry, climate, and to some degree, the topography of the basins studied, most of the benthic community differences between sampling sites are probably more related to differences in bottom substrate than to water quality.

Both lotic and lentic type habitats were found at sampling sites in the study area (fig. 12). The sites with lotic type habitats grouped together well with respect to internal resemblance but the sites with lentic-type habitats were divided into two groups (lentic 1 and lentic 2). Sampling sites with predominantly sand-silt substrates and low water velocity typical of lentic habitats (lentic group 2), had similarity coefficients that ranged from 0.28 to 0.43 percent. Sites with predominantly cobble-gravel or gravel-coarse sand substrates and relatively high water velocity, characteristic of lotic habitats, had higher levels of internal resemblance (0.47 to 0.66 similarity coefficients) and much more clearly defined clusters.

Three sampling sites with similarity coefficients ranging from 0.28 to 0.37 (lentic group 2, fig. 12) clustered poorly with the rest of the sites. The upstream site in Packwood Creek (1) is not representative of the original channel conditions because an impoundment has been created by unstable spoils. The upstream sampling site of Lincoln Creek (H) is deeper, more sluggish, and turbid than the downstream site. Water movement was almost negligible when samples were collected. Another site not representative of the original stream habitat was the downstream site of Cline Creek (J'). A logjam upstream of that site traps most of the sand and silt being carried by the stream, resulting in exposed bedrock substrate downstream of the logjam.

The presence or absence data of table 13 include ubiquitous as well as rare taxa of macroinvertebrates; thus, it seemed reasonable to expect a higher intra-group resemblance in lotic stream environments with ubiquitous taxa than in lentic stream environments with rare taxa in which the probability of co-occurrence is low (Boesch, 1977). This was shown to be the case when the data were analyzed by the clustering method.

The degree of similarity between benthic communities may be used to establish reference sampling sites which could enable an assessment of the biological effects of mining on streams. The biological characteristics of a reference sampling site may be used to monitor trends at downstream sites below a mining operation. In order to do this, the organisms present downstream should be characteristic of a similar reference habitat and pre-mining conditions should be known. If mining occurs, biological sampling methods will have to be adapted to lotic or lentic habitats. Additional biological sampling is necessary to refine both the level of similarity observed between sites and the level of taxonomic identifications, particularly in lentic habitats, where benthic communities were most dissimilar.

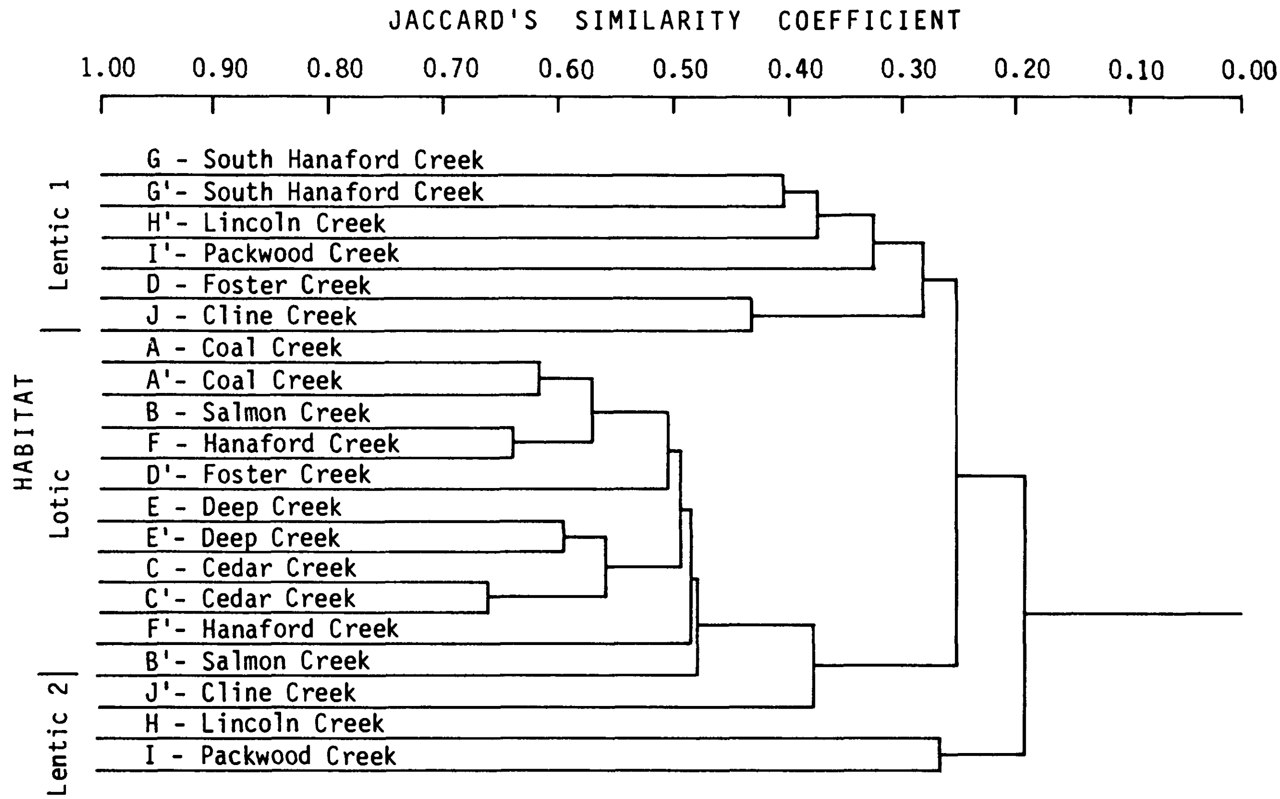


FIGURE 12.--Dendrogram showing clustering of sampling sites based on presence-absence data of benthic organisms found during May and July through October 1980. Average linkage and unweighted pair group method was used in the clustering process (Clifford and Stephenson, 1975). A = upstream, A' = downstream.

Fisheries

The effects of coal-mining activities on resident fisheries are well documented. Increases in siltation and suspended solids commonly reduce available spawning and rearing areas on streams affected by strip mining. Most of the information on salmon and trout fisheries in both coal areas was obtained from Finn (1973), Washington Department of Fisheries (1973), and Phinney and Bucknell (1975).

Coal mining operations in the lower Hanaford Creek valley have resulted in the loss of spawning and rearing areas of coho salmon. The lower 9 miles upstream from the mouth of Hanaford Creek have been channelized; the reach near the Centralia powerplant includes no spawning areas but is used by coho salmon for access to the spawning grounds upstream. In 1973, the upper 8 miles of Hanaford Creek was considered to have the best spawning and rearing habitats in the entire Chehalis basin. Recent logging in the upper watershed has contributed to siltation of the spawning beds; however, some resident trout populations have been observed in these reaches of the stream. The Washington Department of Fishing (DOF) has periodically surveyed Hanaford Creek since mining began in 1970 and has found no change in spawning that can be related directly to effluent from mining operations.

Because most of the surface-water drainage flows in Packwood Creek through coal-mine siltation ponds, the upstream reaches are inaccessible to salmonids; however, salmon yearlings have been found near the mouth. The upstream reaches of South Hanaford Creek are inaccessible and unsuitable for salmon use, and are very prone to flooding during periods of heavy rainfall.

Coho yearlings are planted each year in the main stem of Lincoln Creek by the DOF, but there has been a relatively small rate of return migration. This stream is known to have very good resident trout fisheries. The limiting factors for coho and chum populations in Lincoln Creek are unstable streamflows, limited spawning areas, and high water temperatures during the summer. Although little information is available for fisheries in Deep Creek, the limiting factors are generally similar to those described for Lincoln Creek; however, native trout populations have been reported in the downstream reaches.

Salmon Creek has an excellent run of coho salmon, but most spawn within a 6-mile reach, between 14 and 20 miles upstream from the mouth. Only the lower 0.6 mile of Cedar Creek, one of the major tributaries to Salmon Creek, is used by coho for spawning because the Cedar Creek Falls hamper their upstream passage. Resident trout and minnows also have been observed in this reach of Cedar Creek downstream from the falls.

Cline Creek, a tributary of the Toutle River had coho habitation in 1973 in the vicinity of the mouth. A waterfall about 0.3 mile upstream from the mouth prevents further upstream migration. Mudflows from the May 18, 1980, eruption of Mount St. Helens obliterated a large part of the lower Cline Creek and prevented access of salmon to the stream.

Small to moderate coho runs occur in Coal Creek and coho fry are released periodically into the creek. There are good spawning and rearing conditions in both upstream and downstream reaches; however, because of several barriers upstream, such as cascades and waterfalls which serve to limit migration, coho are found only in the lower 2 miles from the mouth of the creek. Most of Coal Creek is inhabited also by migrating steelhead and native trout.

Foster Creek, a tributary of the Cowlitz River, is used by coho salmon for spawning in the lower 0.5 mile from the mouth of the creek; a steep gradient further upstream impedes upstream migration.

Erosion Potential

Factors affecting erosion potential relate to the erodibility of the streambed and banks, and the stability of the basins with regards to mass movement of unconsolidated material. Changes in flow characteristics and sediment load are a probable consequence of strip mining in the areas now unmined. Streambed and bank materials were analyzed to assess stream erodibility, and average basin slope and land use were determined to assess the potential for mass movement of unconsolidated materials in the mined and unmined study basins. Results of grain-size analyses of streambed and bank sediments at each of the sampling sites are shown in table 11.

The erodibility of sediment is a complex problem, but it is related to particle size. Fine sand is the particle size most easily eroded; resistance to erosion increases with a decrease in sediment particle size (particularly with an increase in clay content) and with an increase in particle size toward the gravel and cobble range (Vanoni, 1975).

The local valley fill at the sampling sites was characterized on the basis of visual observation during field visits, but was not sampled. Valley fill was classified either clay, alluvium, or absent (bedrock). Streambed and bank materials recently deposited by the streams varied with valley fill. The bottom sediments of the streambed incised in clay valley fill (see table 3, page 18) were fine grained and had mean grain sizes smaller than 1 millimeter (0 phi); however, they commonly contained large quantities of sand-size material. Recent streambank deposits composed of clay are coarser than the original clay valley fill into which the stream channels are incised. Bottom sediments in stream channels not incised in clay valley fill, except the upstream site on Lincoln Creek, had mean grain sizes larger than 1 millimeter. At the upstream site of Lincoln Creek, the local valley fill is composed of clay, similar to the valley fill into which other channels were incised; however, the channel was not incised into these deposits.

Most of the sediment from stream channels incised in clay valley fill exhibited log-normal particle-size distribution, although most of the distributions were skewed. Most of the sediment in the stream channels not incised in clay valley fill showed bimodal, or trimodal size distributions,

TABLE 11.--Statistical summary of particle-size analyses for streambed and bank sediments at each of the sampling sites

Stream	Site (see figure 3)	Bed					Bank				
		Median		Graphic mean		σ_G	Median		Graphic mean		σ_G
		phi	mm	phi	mm		phi	mm	phi	mm	
Deep	E	[a]-1.6	3.0	-1.3	2.5	2.2	2.7	0.15	2.7	0.15	1.5
Creek	E'	1.5	0.35	1.4	0.38	1.4	3.2	0.11	3.2	0.11	1.0
Lincoln	H	1.6	0.33	1.8	0.29	2.2	1.5	0.35	1.9	0.27	1.7
Creek	H'	1.0	0.50	1.1	0.47	1.0	3.4	0.095	3.3	0.10	1.1
Hanaford	F	-4.1	17.	-3.4	11.	4.0	2.3	0.20	2.3	0.20	1.6
Creek	F'	1.1	0.47	0.8	0.57	1.5	2.6	0.16	2.9	0.13	1.1
South											
Hanaford	G	1.5	0.35	1.3	0.41	1.9	No bank deposits				
Creek	G'	[b]Greater than 5.0 phi (<0.06 mm)					Greater than 5.0 phi (<0.06 mm)				
Packwood	I	No data available					No data available				
Creek	I'	2.0	0.25	0.9	0.54	2.6	No bank deposits				
Coal	A	-7.6	194.	-6.5	91.	2.2	0.0	1.0	0.3	0.81	3.7
Creek	A'	-6.3	79.	-5.0	32.	4.1	1.9	0.27	1.2	0.44	2.2
Salmon	B	-8.9	478.	-7.2	147.	3.3	2.7	0.15	2.9	0.13	1.2
Creek	B'	-6.2	74.	-4.9	30.	3.4	2.4	0.19	2.7	0.15	1.3
Cedar	C	-3.0	8.0	-2.4	5.3	3.1	2.3	0.20	2.7	0.15	1.0
Creek	C'	-3.0	8.0	-2.5	5.7	3.2	2.3	0.20	2.5	0.18	1.5
Foster	D	6.3	0.01	5.8	0.018	2.7	No bank deposits				
Creek	D'	1.4	0.38	1.4	0.38	1.1	No bank deposits				
	D'	[c]-4.2	18.	-3.2	9.2	3.3	3.6	0.082	3.3	0.10	1.2
Cline	J	0.7	0.62	0.0	1.0	2.5	1.8	0.29	1.9	0.20	1.4
Creek	J'	-2.4	5.3	-3.2	9.2	5.0	1.9	0.27	2.1	0.23	0.8

[a] phi units = $-\log_2$ diameter (mm).
[b] Pipet analysis, required to define sediment finer than 5 phi, was not done.
[c] Streambed and bank samples were collected slightly upstream of the downstream sampling site at Foster Creek as well as at the sampling site.

(for example, Coal Creek, fig. 13) with modes as large as 512 millimeters (9 phi). These large grain-size sediments represent channel armor that commonly is moved only by rare catastrophic floods. The finer grain-size sediments in the streams not incised in clay valley fill represent the more recent sediments that are transported by more frequent flows of lesser magnitude; therefore, these samples represent sediments transported during more than one depositional event.

The erosion potential of a basin appears also to be related to the average basin slope. Basin slope in the study areas correlated directly with the percent of the basin in forest and correlated inversely with the percent of the basin in agriculture (see table 2, page 16). In addition to potential changes in rainfall-runoff relations resulting from the removal of forests, the loss of the binding mechanism of tree roots in coal mine areas can result in mass movements of the unconsolidated mining spoils if these spoils were returned to near high relief pre-mining slopes. This phenomenon was observed in upper Packwood Creek, where basin slope is steepest. The upper channel has become dammed by mass movement of recent coal mine spoils.

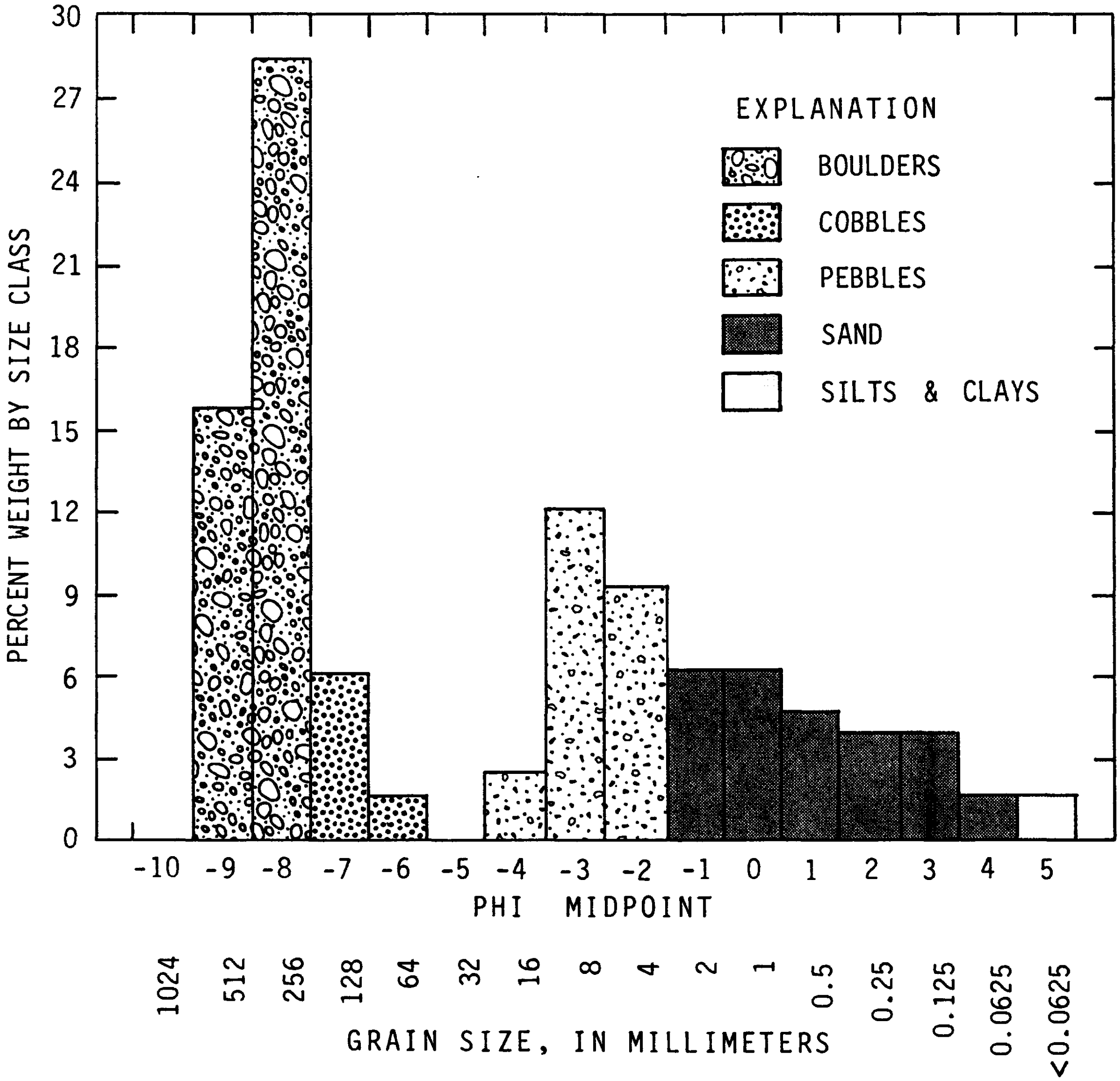


FIGURE 13.--Frequency histogram of percent weight by size class for each grain size (or phi-size class) at the downstream site of Coal Creek (channel sample).

PROPOSED MONITORING NETWORK

The fourth purpose of this report is to propose a data-collection monitoring network that would provide baseline information in unmined areas for assessment of the effects of future coal-strip mining operations.

Site Selection

Three types of data-collection stations will be needed to adequately evaluate the effects of strip-mining operations: (1) reference, (2) trend, and (3) synoptic. Reference stations could be located upstream from any existing or potential coal mining, to provide baseline information for the assessment of future downstream effects. Trend stations could be located downstream from major mining activity so that trends in water-quality changes due to mining could be detected. Synoptic sampling stations could be located in nearby unmined basins to provide general hydrologic information of unmined areas with strippable coal reserves. Data collected at synoptic sites would be used to select future reference and trend-monitoring sites in the event stripping operations begin in a new area. The main criterion for selecting synoptic data-sites would be the mining priority assigned to a particular coal reserve. The selection of reference, trend, and synoptic sampling sites, listed in table 12, are based on current mining activities, abundance of strippable coal reserves, and average basin slope.

Hanaford Creek below North Hanaford Creek and North Hanaford Creek above its mouth are proposed as trend sites. Although these sites were not used in this study, data available from a previous study by Packard (U.S. Geological Survey, written commun. 1976), suggests that these sites could also be considered as candidate sites for a monitoring program in the Centralia-Chehalis coal district. Hanaford Creek receives drainage from coal mine areas drained by Packwood, South Hanaford and North Hanaford Creeks.

Water-Quality Constituents and Sampling Frequency

The constituents and sampling frequency at the proposed reference and trend sites are shown in table 13. The constituents to be monitored are based on those constituents measured during this study. The trace elements suggested are those found in significant concentrations during the study in streams of both mined and unmined basins. Duration of the monitoring program could be at least two years. Additional monitoring from 1 to 3 years could continue if the first 2 years are either excessively wet or dry.

Although it was not within the scope of this study, ground-water and additional surface-water information could be collected in areas with high potential for mining. Available information on the ground-water flow system and ground-water quality is limited in all areas. Ground-water contamination from weathering pyritic material poses a potential problem if mine drainage water comes in contact with the ground water especially if the mines are dewatered to lower the water table.

The particle-size data for both suspended and bottom sediments would provide valuable information for characterizing transported sediment and would aid in relating trace element concentrations to sediment transport. Information on the channel hydraulics would also aid in monitoring changes in the sediment and flow regimes.

The occurrence and concentration of trace elements in the coals and overburden, and the types of materials that are in the overburden would aid to provide a basis for confirming the chemicals found in the ground and surface water in the coal area. Some geochemical data for selected coal beds in the study area are available but no information is available on the geochemistry of the coal-bearing strata.

TABLE 12.-- Proposed monitoring sites for the Centralia-Chehalis coal district and Kelso-Castle Rock coal area

Basin	Site (see figure 3)	Type of monitoring station
Hanaford Creek	F'	Reference
Packwood Creek	I'	Trend
South Hanaford Creek	G'	Trend
Hanaford Creek below North Hanaford Creek		Trend
North Hanaford Creek above confluence with Hanaford Creek		Trend
Lincoln Creek	H, H'	Synoptic
Salmon Creek	B, B'	Synoptic

TABLE 13.--Proposed water-quality sampling schedule for proposed reference and trend sites

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Monthly

- Discharge
- Temperature
- Specific conductance
- Alkalinity
- Acidity (hot)
- SO_4
- Fe (total and dissolved)
- Mn (total and dissolved)
- Dissolved oxygen
- Residue on evaporation at 180°C

Peak events (at least two per year)

- Discharge
- Suspended sediments
- Trace elements (total-recoverable and dissolved), with emphasis on As, Cd, Cr, Cu, and Zn

High/low flows (at least one high flow and one low flow per year)

- Discharge
- Common ions (Ca, Mg, K, Na, Cl, SO_4, F, S_iO_2)
- Trace elements (total recoverable and dissolved), with emphasis on As, Al, Cd, Cr, Cu, and Zn

Low flows

- Discharge
- Benthic invertebrates
- Trace elements in bottom sediments, with emphasis on As, Al, Cd, Cr, Cu, and Zn
- Bottom sediment (particle size)

SUMMARY AND CONCLUSIONS

The Centralia-Chehalis coal district and Kelso-Castle Rock coal area have strippable coal deposits which are currently being mined, or could be mined in the future. Water quality, biological, and sediment characteristics were evaluated on ten streams with sampling sites upstream and downstream of strippable coal reserves and representing minimal disturbance from anthropogenic activities other than coal mining. Three streams, Packwood, Hanaford, and South Hanaford Creeks, receive drainage from strip-mining operations. Hanaford Creek was sampled upstream from the mined area, above and below unmined strippable coal reserves.

Streamflow in both mined and unmined areas had similar seasonal fluctuations, although the magnitudes were different. Seasonal low flows occurred during July to October. No discernable pattern was observed in surface-water yield between sampling sites, except for Hanaford Creek, where a significantly lower surface-water yield was observed downstream. The reasons for this could not be confirmed. The water quality of most streams that flow through the study basins is typical of southwestern Washington streams because calcium, magnesium, sodium and bicarbonate ions predominate. Differences between upstream and downstream sampling sites were minimal except for the two streams affected by coal strip mining. Sulfate was the predominant anion below the downstream site in Packwood Creek and the upstream site in South Hanaford Creek. The concentrations of sulfate were not high enough to change the general composition of the water, or to affect the pH and make the streams more acidic. The pH of the waters, including those streams affected by mine drainage, was well within the normal range of pH (6.5 to 8.5) in southwestern Washington streams.

Dissolved-solids concentrations were generally small (less than 120 mg/L) and similar in all the unmined basins, except during periods of low flow and low dissolved-oxygen concentrations. Streams in both mined basins, Packwood and South Hanaford Creeks, consistently had larger concentrations of dissolved solids (90 to 1,350 mg/L) than streams in unmined basins.

Both Packwood and South Hanaford Creeks, downstream from siltation ponds which drain into both streams, consistently had larger concentrations of calcium, magnesium, sodium, and sulfate than sites on those streams that received no drainage from siltation ponds or at the other study streams. This was attributed to the weathering of spoil materials from the mining operation.

Elevated dissolved iron and manganese concentrations, in both mined and unmined areas, generally correlated inversely with low dissolved oxygen concentrations and low streamflow conditions. Concentrations of suspended iron and manganese per gram of suspended sediment in streams that drain the mined basins were elevated at their downstream sites probably for different reasons. Ordinarily, siltation ponds retain coarse sediments and allow finer material to pass through into downstream areas. This was observed below the siltation ponds in Packwood but not in South Hanaford, probably because much less pyritic material in the rocks of the upper South Hanaford Creek basin was exposed to weathering than in the Packwood Creek basin. The increases in the concentrations of suspended iron and manganese at lower South Hanaford Creek are attributed to channelization taking place during low flows rather than dissolution from weathering spoil materials.

Suspended-sediment concentrations were small and similar in all study streams. The siltation ponds in Packwood and South Hanaford Creeks appeared to be efficient in retaining coarse sediments derived from the strip mining operation even during periods of moderate flow; their efficiency during peak flows was not determined.

Trace element concentrations in the water and in the bottom sediments were, with few exceptions, small and similar in all streams. Packwood Creek contains large concentrations of iron, manganese, and zinc in the bottom sediments below the siltation ponds. Locally, large concentrations of aluminum, chromium, copper, and zinc in suspended phase were found in unmined streams but data available were insufficient to determine if the concentrations were actual or due to sampling error.

Biological community differences between sampling sites probably are more related to differences in bottom substrate than to the water quality of the streams. There was a greater similarity and a more diverse benthic fauna in streams with gravel-cobble or gravel-coarse sand substrates than streams with sand-silt substrates. The fewest fauna were found at the upstream site in Packwood Creek where mayflies, stoneflies, and caddisflies were rare. Similarities between benthic communities at different sampling sites, especially within a stream, can be used to confirm the effects attributable to coal strip mining.

Streambed and bank material were analyzed to assess stream erodibility and average basin slope and land use were determined to assess the potential for mass movement of unconsolidated spoil material. The erosion potential of a basin is related to the average basin slope and the percent of the basin that is forested. The removal of forest and vegetal ground cover in the steeper basins may lead to mass movements of unconsolidated spoils if the land is graded to steep, pre-mining slopes.

Sites selected for future monitoring of water-quality and biological characteristics are proposed to represent reference, trend, and synoptic monitoring. The sampling site selection is based on needs for collecting data where system stresses are most likely to occur as a result of new or increased mining activities and where these stresses will have the greatest effect on areal hydrology.

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Table 14.--Water-quality data for streams in the Centralia-Chehalis coal district and the Kelso-Castle Rock coal area, March-October, 1980, Washington.

14245410 - COAL CK. ABV. EAST FORK COAL CK. NR. LONGVIEW, WASHINGTON, SITE A

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	SPE-CIFIC CON-DUCT-ANCE (US/CM)	PH (STAND-ARD UNITS)	TEMPER-ATURE (DEG C)	TUR-BID-ITY (NTU)	OXYGEN, DIS-SOLVED (MG/L)	HARD-NESS (MG/L AS $CACO_3$)	HARD-NESS, NONCAR-BONATE (MG/L $CACO_3$)	ACIDITY (MG/L AS $CACO_3$)	CALCIUM DIS-SOLVED (MG/L AS CA)
APR 1980											
21...	12:45	27	21	7.2	11.0	2.0	11.2	7	0	3.0	1.6
MAY											
19...	11:45	11	25	7.2	11.0	3.0	10.8	8	0	4.0	1.7
JUL											
21...	15:20	3.1	42	6.8	20.5	1.0	9.0	14	0	4.0	3.1
AUG											
25...	11:30	1.9	35	7.3	12.5	2.0	8.4	11	0	4.0	2.4
SEP											
22...	14:20	4.4	36	7.2	10.5	2.0	8.9	12	1	4.0	2.5
OCT											
20...	12:30	4.0	38	7.1	11.0	2.0	11.0	14	5	3.0	3.1

DATE	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)	PERCENT SODIUM	SODIUM AD-SORP-TION RATIO	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	ALKA-LINITY FIELD (MG/L AS $CACO_3$)	SULFATE DIS-SOLVED (MG/L AS SO_4)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SILICA, DIS-SOLVED (MG/L AS SIO_2)	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L)
APR 1980											
21...	0.8	2.2	38	0.4	0.3	8	<5.0	2.7	0.1	9.2	24
MAY											
19...	0.8	2.1	36	0.3	0.4	10	<5.0	2.0	0.1	11	26
JUL											
21...	1.5	3.3	33	0.4	0.6	18	<5.0	2.6	0.1	13	39
AUG											
25...	1.2	2.6	33	0.4	0.5	15	<5.0	1.8	0.1	13	42
SEP											
22...	1.3	2.6	31	0.3	0.6	13	5.8	3.7	<0.1	12	42
OCT											
20...	1.5	2.7	29	0.3	0.6	15	<5.0	2.8	0.1	13	33

Table 14.--Cont'd

14245410 - COAL CK. ABV. EAST FORK COAL CK. NR. LONGVIEW, WASHINGTON, SITE A

DATE	SOLIDS, DIS-SOLVED (TONS PER AC-FT)	SOLIDS, DIS-SOLVED (TONS PER DAY)	NITRO-GEN, NO2+NO3 TOTAL (MG/L AS N)	PHOS-PHORUS, TOTAL (MG/L AS P)	ALUM-INUM, TOTAL RECOV-ERABLE (UG/L AS AL)	ALUM-INUM, DIS-SOLVED (UG/L AS AL)	ARSENIC TOTAL (UG/L AS AS)	ARSENIC DIS-SOLVED (UG/L AS AS)	CADMIUM TOTAL RECOV-ERABLE (UG/L AS CD)	CADMIUM DIS-SOLVED (UG/L AS CD)
APR 1980										
21...	0.03	1.7	0.33	0.01	260	100	<1	<1	<1	<1
MAY										
19...	0.04	0.77	0.17	0.01	--	--	--	--	--	--
JUL										
21...	0.05	0.33	0.11	0.02	--	--	--	--	--	--
AUG										
25...	0.06	0.22	0.11	0.02	--	100	--	1	--	<1
SEP										
22...	0.06	0.5	0.37	0.06	200	<100	1	1	<1	<1
OCT										
20...	0.04	0.36	0.14	0.03	--	300	--	1	--	<1

DATE	CHRO-MIUM, TOTAL RECOV-ERABLE (UG/L AS CR)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	COBALT, TOTAL RECOV-ERABLE (UG/L AS CO)	COBALT, DIS-SOLVED (UG/L AS CO)	COPPER, TOTAL RECOV-ERABLE (UG/L AS CU)	COPPER, DIS-SOLVED (UG/L AS CU)	IRON, TOTAL RECOV-ERABLE (UG/L AS FE)	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, TOTAL RECOV-ERABLE (UG/L AS PB)	LEAD, DIS-SOLVED (UG/L AS PB)
APR 1980										
21...	1	<10	<50	<3	6	1	360	100	3	3
MAY										
19...	--	--	--	--	--	--	500	140	--	--
JUL										
21...	--	--	--	--	--	--	380	230	--	--
AUG										
25...	--	10	--	<3	--	<1	760	360	--	3
SEP										
22...	7	<10	<50	<3	4	2	560	330	2	2
OCT										
20...	--	<10	--	<3	--	2	580	440	--	3

Table 14.--Cont'd

14245410 - COAL CK. ABV. EAST FORK COAL CK. NR LONGVIEW, WASHINGTON, SITE A

DATE	MANGANESE, TOTAL RECOVERABLE (UG/L AS MN)	MANGANESE, DISSOLVED (UG/L AS MN)	MERCURY TOTAL RECOVERABLE (UG/L AS HG)	MERCURY DISSOLVED (UG/L AS HG)	SELENIUM, TOTAL (UG/L AS SE)	SELENIUM, DISSOLVED (UG/L AS SE)	ZINC, TOTAL RECOVERABLE (UG/L AS ZN)	ZINC, DISSOLVED (UG/L AS ZN)	SEDIMENT, SUSPENDED (MG/L)	SEDIMENT, DISCHARGE, SUSPENDED (T/DAY)
APR 1980										
21...	10	10	<0.5	<0.1	<1	<1	110	7	8	0.58
MAY										
19...	10	3	--	--	--	--	--	--	3	0.09
JUL										
21...	10	6	--	--	--	--	--	--	1	0.01
AUG										
25...	30	5	--	<0.1	--	<1	--	5	6	0.03
SEP										
22...	10	6	<0.5	<0.1	<1	<1	10	5	5	0.06
OCT										
20...	20	7	--	<0.1	--	<1	--	10	2	0.02

Table 14.--Cont'd

14245420 - COAL CK. NR. LONGVIEW, WASHINGTON, SITE A'

DATE	TIME	STREAMFLOW, INSTANTANEOUS (FT^3/S)	SPECIFIC CONDUCTANCE (US/CM)	PH (STANDARD UNITS)	TEMPERATURE (DEG C)	TURBIDITY (NTU)	OXYGEN, DISSOLVED (MG/L)	HARDNESS (MG/L AS $CACO_3$)	HARDNESS, NONCARBONATE (MG/L $CACO_3$)	ACIDITY (MG/L AS $CACO_3$)	CALCIUM DISSOLVED (MG/L AS CA)
APR 1980											
21...	16:00	70	30	7.3	11.0	2.0	11.2	9	0	3.0	2.4
MAY											
19...	14:10	20	30	7.3	12.0	2.0	11.0	10	0	2.0	2.5
JUL											
21...	13:20	6.6	32	6.9	17.0	2.0	8.6	10	0	6.0	2.2
AUG											
25...	13:55	4.3	43	7.5	14.0	1.0	9.3	13	1	3.0	3.4
SEP											
22...	16:15	7.5	48	7.4	12.5	2.0	8.9	14	0	3.0	3.3
OCT											
20...	15:00	5.6	50	6.9	11.0	1.0	10.3	16	0	6.0	4.1

DATE	MAGNESIUM, DISSOLVED (MG/L AS MG)	SODIUM, DISSOLVED (MG/L AS NA)	PERCENT SODIUM	SODIUM ADSORPTION RATIO	POTASSIUM, DISSOLVED (MG/L AS K)	ALKALINITY FIELD (MG/L AS $CACO_3$)	SULFATE DISSOLVED (MG/L AS SO_4)	CHLORIDE, DISSOLVED (MG/L AS CL)	FLUORIDE, DISSOLVED (MG/L AS F)	SILICA, DISSOLVED (MG/L AS SIO_2)	SOLIDS, RESIDUE AT 180 DEG. C DISSOLVED (MG/L)
APR 1980											
21...	0.8	2.7	37	0.4	0.4	9	<5.0	2.3	0.1	11	26
MAY											
19...	1.0	2.6	34	0.4	0.4	12	<5.0	2.2	0.1	12	35
JUL											
21...	1.2	2.9	36	0.4	0.5	12	<5.0	2.6	0.2	13	35
AUG											
25...	1.2	3.1	32	0.4	0.6	17	<5.0	2.9	0.1	13	47
SEP											
22...	1.4	3.4	33	0.4	0.6	15	<5.0	3.5	<0.1	13	44
OCT											
20...	1.5	3.3	29	0.4	0.6	19	<5.0	3.2	0.1	13	38

Table 14.--Cont'd

14245420 - COAL CK. NR. LONGVIEW, WASHINGTON, SITE A'

DATE	SOLIDS, DIS-SOLVED (TONS PER AC-FT)	SOLIDS, DIS-SOLVED (TONS PER DAY)	NITRO-GEN, NO2+NO3 TOTAL (MG/L AS N)	PHOS-PHORUS, TOTAL (MG/L AS P)	ALUM-INUM, TOTAL RECOV-ERABLE (UG/L AS AL)	ALUM-INUM, DIS-SOLVED (UG/L AS AL)	ARSENIC TOTAL (UG/L AS AS)	ARSENIC DIS-SOLVED (UG/L AS AS)	CADMIUM TOTAL RECOV-ERABLE (UG/L AS CD)	CADMIUM DIS-SOLVED (UG/L AS CD)
APR 1980										
21...	0.04	4.9	0.64	0.04	220	<100	<1	<1	<1	<1
MAY										
19...	0.05	1.9	0.27	0.01	--	--	--	--	--	--
JUL										
21...	0.05	0.62	0.03	0.03	--	--	--	--	--	--
AUG										
25...	0.05	0.55	0.13	0.02	--	<100	--	1	--	<1
SEP										
22...	0.06	0.89	0.40	0.05	200	100	1	<1	<1	<1
OCT										
20...	0.05	0.57	0.22	0.01	--	300	--	1	--	<1

DATE	CHRO-MIUM, TOTAL RECOV-ERABLE (UG/L AS CR)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	COBALT, TOTAL RECOV-ERABLE (UG/L AS CO)	COBALT, DIS-SOLVED (UG/L AS CO)	COPPER, TOTAL RECOV-ERABLE (UG/L AS CU)	COPPER, DIS-SOLVED (UG/L AS CU)	IRON, TOTAL RECOV-ERABLE (UG/L AS FE)	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, TOTAL RECOV-ERABLE (UG/L AS PB)	LEAD, DIS-SOLVED (UG/L AS PB)
APR 1980										
21...	1	<10	<50	<3	3	<1	290	70	3	3
MAY										
19...	--	--	--	--	--	--	300	110	--	--
JUL										
21...	--	--	--	--	--	--	600	360	--	--
AUG										
25...	--	10	--	<3	--	<1	810	280	--	3
SEP										
22...	5	<10	<50	<3	7	2	360	290	2	2
OCT										
20...	--	<10	--	<3	--	1	440	280	--	2

Table 14.--Cont'd

14245420 - COAL CK. NR. LONGVIEW, WASHINGTON, SITE A'

DATE	MANGA-NESE, TOTAL RECOV-ERABLE (UG/L AS MN)	MANGA-NESE, DIS-SOLVED (UG/L AS MN)	MERCURY TOTAL RECOV-ERABLE (UG/L AS HG)	MERCURY DIS-SOLVED (UG/L AS HG)	SELE-NIUM, TOTAL (UG/L AS SE)	SELE-NIUM, DIS-SOLVED (UG/L AS SE)	ZINC, TOTAL RECOV-ERABLE (UG/L AS ZN)	ZINC, DIS-SOLVED (UG/L AS ZN)	SEDI-MENT, SUS-PENDED (MG/L)	SEDI-MENT, DIS-CHARGE, SUS-PENDED (T/DAY)
APR 1980										
21...	10	4	<0.5	<0.1	<1	<1	30	9	8	1.5
MAY										
19...	10	3	--	--	--	--	--	--	4	0.22
JUL										
21...	20	5	--	--	--	--	--	--	2	0.04
AUG										
25...	20	5	--	<0.1	--	<1	--	<4	10	0.12
SEP										
22...	10	5	<0.5	<0.1	<1	<1	20	<4	4	0.08
OCT										
20...	10	5	--	<0.1	--	<1	--	6	0	0.00

Table 14.--Cont'd

14238805 - SALMON CK. NEAR KID VALLEY, WASHINGTON, SITE B

DATE	TIME	STREAMFLOW, INSTANTANEOUS (FT^3/S)	SPECIFIC CONDUCTANCE (US/CM)	PH (STANDARD UNITS)	TEMPERATURE (DEG C)	TURBIDITY (NTU)	OXYGEN, DISSOLVED (MG/L)	HARDNESS (MG/L AS $CACO_3$)	HARDNESS, NONCARBONATE (MG/L $CACO_3$)	ACIDITY (MG/L AS $CACO_3$)	CALCIUM DISSOLVED (MG/L AS CA)
MAR 1980											
04...	10:30	62	41	7.4	7.5	20	10.8	--	--	6.0	--
APR											
22...	16:00	73	36	7.2	10.0	10	10.9	11	0	4.0	2.8
MAY											
20...	08:15	3.4	45	7.5	14.0	5.0	10.6	17	0	2.0	4.1
JUL											
23...	08:45	1.5	66	7.6	17.5	3.0	9.2	22	0	3.0	5.3
AUG											
26...	11:15	1.1	74	7.9	17.0	3.0	8.8	24	0	2.0	5.7
SEP											
23...	08:10	3.2	71	7.5	12.5	5.0	8.6	24	0	7.0	5.8
OCT											
22...	08:15	1.5	78	7.2	5.0	3.0	12.2	28	0	3.0	6.5

DATE	MAGNESIUM, DISSOLVED (MG/L AS MG)	SODIUM, DISSOLVED (MG/L AS NA)	PERCENT SODIUM	SODIUM ADSORPTION RATIO	POTASSIUM, DISSOLVED (MG/L AS K)	ALKALINITY FIELD (MG/L AS $CACO_3$)	SULFATE DISSOLVED (MG/L AS SO_4)	CHLORIDE, DISSOLVED (MG/L AS CL)	FLUORIDE, DISSOLVED (MG/L AS F)	SILICA, DISSOLVED (MG/L AS SIO_2)	SOLIDS, RESIDUE AT 180 DEG. C DISSOLVED (MG/L)
MAR 1980											
04...	--	--	--	--	--	12	--	--	--	--	--
APR											
22...	1.0	2.0	27	0.3	0.4	11	<5.0	2.0	0.1	14	51
MAY											
20...	1.7	3.7	31	0.4	0.6	24	<5.0	2.0	0.1	16	53
JUL											
23...	2.2	4.7	30	0.4	0.8	31	<5.0	2.6	0.1	18	64
AUG											
26...	2.4	5.0	30	0.5	0.9	34	<5.0	3.4	0.1	17	59
SEP											
23...	2.4	4.8	29	0.4	0.9	31	<5.0	3.8	<0.1	19	68
OCT											
22...	2.8	5.2	28	0.4	0.8	36	<5.0	3.4	0.1	19	63

Table 14.--Cont'd

14238805 - SALMON CK. NEAR KID VALLEY, WASHINGTON, SITE B

DATE	SOLIDS, DIS-SOLVED (TONS PER AC-FT)	SOLIDS, DIS-SOLVED (TONS PER DAY)	NITRO-GEN, NO2+NO3 TOTAL (MG/L AS N)	PHOS-PHORUS, TOTAL (MG/L AS P)	ALUM-INUM, TOTAL RECOV-ERABLE (UG/L AS AL)	ALUM-INUM, DIS-SOLVED (UG/L AS AL)	ARSENIC TOTAL (UG/L AS AS)	ARSENIC DIS-SOLVED (UG/L AS AS)	CADMIUM TOTAL RECOV-ERABLE (UG/L AS CD)	CADMIUM DIS-SOLVED (UG/L AS CD)
MAR 1980										
04...	--	--	--	--	--	--	--	--	--	--
APR										
22...	0.07	10	1.20	0.02	100	100	<1	<1	1	<1
MAY										
20...	0.07	0.49	0.26	0.03	--	--	--	--	--	--
JUL										
23...	0.09	0.26	0.00	0.04	--	--	--	--	--	--
AUG										
26...	0.08	0.18	0.02	0.05	--	100	--	1	--	<1
SEP										
23...	0.09	0.59	0.09	0.10	500	100	1	1	<1	<1
OCT										
22...	0.09	0.26	0.00	0.04	--	300	--	1	--	<1

DATE	CHRO-MIUM, TOTAL RECOV-ERABLE (UG/L AS CR)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	COBALT, TOTAL RECOV-ERABLE (UG/L AS CO)	COBALT, DIS-SOLVED (UG/L AS CO)	COPPER, TOTAL RECOV-ERABLE (UG/L AS CU)	COPPER, DIS-SOLVED (UG/L AS CU)	IRON, TOTAL RECOV-ERABLE (UG/L AS FE)	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, TOTAL RECOV-ERABLE (UG/L AS PB)	LEAD, DIS-SOLVED (UG/L AS PB)
MAR 1980										
04...	--	--	--	--	--	--	--	--	--	--
APR										
22...	2	<10	<50	<3	6	1	470	180	<1	1
MAY										
20...	--	--	--	--	--	--	880	430	--	--
JUL										
23...	--	--	--	--	--	--	1200	1100	--	--
AUG										
26...	--	<10	--	<3	--	1	1800	1100	--	2
SEP										
23...	5	<10	<50	<3	5	2	1300	960	1	2
OCT										
22...	--	<10	--	<3	--	2	1400	1200	--	3

Table 14.--Cont'd

14238805 - SALMON CK. NEAR KID VALLEY, WASHINGTON, SITE B

DATE	MANGANESE, TOTAL RECOVERABLE (UG/L AS MN)	MANGANESE, DISSOLVED (UG/L AS MN)	MERCURY TOTAL RECOVERABLE (UG/L AS HG)	MERCURY DISSOLVED (UG/L AS HG)	SELENIUM, TOTAL (UG/L AS SE)	SELENIUM, DISSOLVED (UG/L AS SE)	ZINC, TOTAL RECOVERABLE (UG/L AS ZN)	ZINC, DISSOLVED (UG/L AS ZN)	SEDIMENT, SUSPENDED (MG/L)	SEDIMENT, DISCHARGE, SUSPENDED (T/DAY)
MAR 1980										
04...	--	--	--	--	--	--	--	--	--	--
APR										
22...	20	7	<0.5	<0.1	<1	<1	20	<4	13	2.6
MAY										
20...	20	9	--	--	--	--	--	--	6	0.05
JUL										
23...	30	20	--	--	--	--	--	--	6	0.02
AUG										
26...	50	20	--	<0.1	--	<1	--	<4	6	0.02
SEP										
23...	20	10	<0.5	<0.1	<1	<1	20	<4	5	0.04
OCT										
22...	20	10	--	<0.1	--	<1	--	<4	1	0.0

Table 14.--Cont'd

14238950 - SALMON CK. ABV. LITTLE SALMON CK. NR. TOLEDO, SITE B'

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	SPE-CIFIC CON-DUCT-ANCE (US/CM)	PH (STAND-ARD UNITS)	TEMPER-ATURE (DEG C)	TUR-BID-ITY (NTU)	OXYGEN, DIS-SOLVED (MG/L)	HARD-NESS (MG/L AS $CACO_3$)	HARD-NESS, NONCAR-BONATE (MG/L $CACO_3$)	ACIDITY (MG/L AS $CACO_3$)	CALCIUM DIS-SOLVED (MG/L AS CA)
MAR 1980											
04...	13:40	144	44	7.2	9.0	20	10.8	--	--	5.0	--
APR											
23...	07:15	166	33	7.1	10.0	17	10.9	11	0	5.0	2.8
MAY											
20...	10:45	7.2	53	7.5	16.0	2.0	10.2	19	0	3.0	4.4
JUL											
23...	15:45	3.0	82	7.5	22.0	4.0	9.4	27	0	6.0	6.4
AUG											
26...	17:30	1.1	103	7.9	18.5	5.0	8.1	31	0	2.0	7.2
SEP											
23...	15:50	7.6	85	7.7	15.0	6.0	8.7	28	0	6.0	6.4
OCT											
22...	16:30	2.9	96	7.2	9.0	4.0	11.6	32	0	2.0	7.3

DATE	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)	PERCENT SODIUM	SODIUM AD-SORP-TION RATIO	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	ALKA-LINITY FIELD (MG/L AS $CACO_3$)	SULFATE DIS-SOLVED (MG/L AS SO_4)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SILICA, DIS-SOLVED (MG/L AS SIO_2)	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L)
MAR 1980											
04...	--	--	--	--	--	14	--	--	--	--	--
APR											
23...	1.0	3.4	39	0.5	0.5	14	<5.0	2.2	0.1	15	48
MAY											
20...	1.9	4.9	35	0.5	0.8	28	<5.0	2.5	0.1	14	53
JUL											
23...	2.7	6.6	33	0.6	1.2	37	<5.0	4.1	0.1	18	68
AUG											
26...	3.2	8.2	35	0.7	1.5	44	<5.0	5.5	0.1	19	95
SEP											
23...	2.8	6.4	32	0.5	1.3	34	<5.0	4.4	0.1	16	76
OCT											
22...	3.3	7.1	32	0.6	1.3	40	<5.0	5.1	0.1	18	69

Table 14.--Cont'd

14238950 - SALMON CK. ABV. LITTLE SALMON CK. NR. TOLEDO, WASHINGTON, SITE B'

DATE	SOLIDS, DIS-SOLVED (TONS PER AC-FT)	SOLIDS, DIS-SOLVED (TONS PER DAY)	NITRO-GEN, NO2+NO3 TOTAL (MG/L AS N)	PHOS-PHORUS, TOTAL (MG/L AS P)	ALUM-INUM, TOTAL RECOV-ERABLE (UG/L AS AL)	ALUM-INUM, DIS-SOLVED (UG/L AS AL)	ARSENIC TOTAL (UG/L AS AS)	ARSENIC DIS-SOLVED (UG/L AS AS)	CADMIUM TOTAL RECOV-ERABLE (UG/L AS CD)	CADMIUM DIS-SOLVED (UG/L AS CD)
MAR 1980										
04...	--	--	--	--	--	--	--	--	--	--
APR										
23...	0.07	22	0.57	0.05	770	260	<1	<1	<1	<1
MAY										
20...	0.07	1.0	0.08	0.03	--	--	--	--	--	--
JUL										
23...	0.09	0.55	0.00	0.03	--	--	--	--	--	--
AUG										
26...	0.13	0.28	0.00	0.04	--	100	--	1	--	<1
SEP										
23...	0.1	1.6	0.00	0.09	200	100	1	1	<1	<1
OCT										
22...	0.09	0.54	0.00	0.04	--	200	--	1	--	<1

DATE	CHRO-MIUM, TOTAL RECOV-ERABLE (UG/L AS CR)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	COBALT, TOTAL RECOV-ERABLE (UG/L AS CO)	COBALT, DIS-SOLVED (UG/L AS CO)	COPPER, TOTAL RECOV-ERABLE (UG/L AS CU)	COPPER, DIS-SOLVED (UG/L AS CU)	IRON, TOTAL RECOV-ERABLE (UG/L AS FE)	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, TOTAL RECOV-ERABLE (UG/L AS PB)	LEAD, DIS-SOLVED (UG/L AS PB)
MAR 1980										
04...	--	--	--	--	--	--	--	--	--	--
APR										
23...	5	<10	<50	<3	8	1	1000	330	6	3
MAY										
20...	--	--	--	--	--	--	1200	660	--	--
JUL										
23...	--	--	--	--	--	--	1500	1200	--	--
AUG										
26...	--	<10	--	<3	--	2	1700	820	--	2
SEP										
23...	5	<10	50	<3	9	2	1200	720	2	<1
OCT										
22...	--	10	--	<3	--	3	1400	1200	--	2

Table 14.--Cont'd

14238950 - SALMON CK. ABV. LITTLE SALMON CK. NR. TOLEDO, WASHINGTON, SITE B'

DATE	MANGA-NESE, TOTAL RECOV-ERABLE (UG/L AS MN)	MANGA-NESE, DIS-SOLVED (UG/L AS MN)	MERCURY TOTAL RECOV-ERABLE (UG/L AS HG)	MERCURY DIS-SOLVED (UG/L AS HG)	SELE-NIUM, TOTAL (UG/L AS SE)	SELE-NIUM, DIS-SOLVED (UG/L AS SE)	ZINC, TOTAL RECOV-ERABLE (UG/L AS ZN)	ZINC, DIS-SOLVED (UG/L AS ZN)	SEDI-MENT, SUS-PENDED (MG/L)	SEDI-MENT, DIS-CHARGE, SUS-PENDED (T/DAY)
MAR 1980										
04...	--	--	--	--	--	--	--	--	--	--
APR										
23...	20	10	<0.5	<0.1	<1	<1	20	<4	18	8.1
MAY										
20...	20	20	--	--	--	--	--	--	5	0.1
JUL										
23...	40	20	--	--	--	--	--	--	7	0.06
AUG										
26...	60	20	--	<0.1	--	<1	--	4	8	0.02
SEP										
23...	20	10	<0.5	<0.1	<1	<1	20	<4	7	0.14
OCT										
22...	30	20	--	<0.1	--	<1	--	6	2	0.02

Table 14.--Cont'd

14238850 - CEDAR CK. ABOVE WINDOM MINE NR. TOLEDO, WASHINGTON, SITE C

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	SPE-CIFIC CON-DUCT-ANCE (US/CM)	PH (STAND-ARD UNITS)	TEMPER-ATURE (DEG C)	TUR-BID-ITY (NTU)	OXYGEN, DIS-SOLVED (MG/L)	HARD-NESS (MG/L AS $CACO_3$)	HARD-NESS, NONCAR-BONATE (MG/L $CACO_3$)	ACIDITY (MG/L AS $CACO_3$)	CALCIUM DIS-SOLVED (MG/L AS CA)
MAR 1980											
03...	15:45	18	28	7.0	8.0	15	--	--	--	11	--
APR											
22...	08:10	36	23	6.8	8.0	15	11.2	7	0	5.0	2.0
MAY											
20...	12:30	0.88	46	7.1	14.0	9.0	9.0	15	0	4.0	3.5
JUL											
23...	11:15	0.36	65	6.8	17.5	7.0	6.0	23	0	9.0	5.4
AUG											
26...	14:00	0.1	84	7.1	15.0	6.0	5.1	27	0	7.0	6.2
SEP											
23...	11:35	1.0	67	7.2	12.5	9.0	7.2	21	0	11	4.9
OCT											
22...	12:30	0.28	73	6.9	6.0	7.0	9.2	24	0	5.0	5.4

DATE	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)	PERCENT SODIUM	SODIUM AD-SORP-TION RATIO	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	ALKA-LINITY FIELD (MG/L AS $CACO_3$)	SULFATE DIS-SOLVED (MG/L AS SO_4)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SILICA, DIS-SOLVED (MG/L AS SIO_2)	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L)
MAR 1980											
03...	--	--	--	--	--	12	--	--	--	--	--
APR											
22...	0.6	2.0	33	0.3	1.0	10	<5.0	2.0	0.1	--	37
MAY											
20...	1.5	3.9	35	0.5	0.6	23	<5.0	1.8	0.1	17	53
JUL											
23...	2.4	4.9	30	0.5	0.9	36	<5.0	2.1	0.2	18	72
AUG											
26...	2.7	5.5	30	0.5	1.1	38	<5.0	2.6	0.1	17	84
SEP											
23...	2.1	5.8	36	0.6	0.9	29	<5.0	3.8	<0.1	20	67
OCT											
22...	2.6	5.6	32	0.5	0.9	33	<5.0	3.7	0.1	21	65

Table 14.--Cont'd

14238850 - CEDAR CK. ABOVE WINDOM MINE NR. TOLEDO, WASHINGTON, SITE C

DATE	SOLIDS, DIS-SOLVED (TONS PER AC-FT)	SOLIDS, DIS-SOLVED (TONS PER DAY)	NITRO-GEN, NO2+NO3 TOTAL (MG/L AS N)	PHOS-PHORUS, TOTAL (MG/L AS P)	ALUM-INUM, TOTAL RECOV-ERABLE (UG/L AS AL)	ALUM-INUM, DIS-SOLVED (UG/L AS AL)	ARSENIC TOTAL (UG/L AS AS)	ARSENIC DIS-SOLVED (UG/L AS AS)	CADMIUM TOTAL RECOV-ERABLE (UG/L AS CD)	CADMIUM DIS-SOLVED (UG/L AS CD)
MAR 1980										
03...	--	--	--	--	--	--	--	--	--	--
APR										
22...	0.05	3.6	0.13	0.04	100	100	<1	<1	1	<1
MAY										
20...	0.07	0.13	0.02	0.05	--	--	--	--	--	--
JUL										
23...	0.1	0.07	0.00	0.06	--	--	--	--	--	--
AUG										
26...	0.11	0.02	0.03	0.05	--	200	--	1	--	<1
SEP										
23...	0.09	0.18	0.01	0.13	200	100	1	1	<1	<1
OCT										
22...	0.09	0.05	0.00	0.14	--	500	--	1	--	<1

DATE	CHRO-MIUM, TOTAL RECOV-ERABLE (UG/L AS CR)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	COBALT, TOTAL RECOV-ERABLE (UG/L AS CO)	COBALT, DIS-SOLVED (UG/L AS CO)	COPPER, TOTAL RECOV-ERABLE (UG/L AS CU)	COPPER, DIS-SOLVED (UG/L AS CU)	IRON, TOTAL RECOV-ERABLE (UG/L AS FE)	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, TOTAL RECOV-ERABLE (UG/L AS PB)	LEAD, DIS-SOLVED (UG/L AS PB)
MAR 1980										
03...	--	--	--	--	--	--	--	--	--	--
APR										
22...	3	<10	<50	<3	5	4	790	<10	1	<1
MAY										
20...	--	--	--	--	--	--	1900	960	--	--
JUL										
23...	--	--	--	--	--	--	2400	1300	--	--
AUG										
26...	--	10	--	<3	--	1	2700	2100	--	5
SEP										
23...	5	<10	<50	<3	4	2	2100	900	<1	2
OCT										
22...	--	<10	--	<3	--	2	2300	1800	--	<1

Table 14.--Cont'd

14238850 - CEDAR CK. ABOVE WINDOM MINE NR. TOLEDO, WASHINGTON, SITE C

DATE	MANGANESE, TOTAL RECOVERABLE (UG/L AS MN)	MANGANESE, DISSOLVED (UG/L AS MN)	MERCURY TOTAL RECOVERABLE (UG/L AS HG)	MERCURY DISSOLVED (UG/L AS HG)	SELENIUM, TOTAL (UG/L AS SE)	SELENIUM, DISSOLVED (UG/L AS SE)	ZINC, TOTAL RECOVERABLE (UG/L AS ZN)	ZINC, DISSOLVED (UG/L AS ZN)	SEDIMENT, SUSPENDED (MG/L)	SEDIMENT, DISCHARGE, SUSPENDED (T/DAY)
MAR 1980										
03...	--	--	--	--	--	--	--	--	8	0.39
APR										
22...	20	<1	<0.5	<0.1	<1	<1	40	<4	9	0.87
MAY										
20...	40	20	--	--	--	--	--	--	8	0.02
JUL										
23...	90	70	--	--	--	--	--	--	8	0.01
AUG										
26...	110	60	--	<0.1	--	<1	--	4	8	0.0
SEP										
23...	30	20	<0.5	<0.1	<1	<1	10	<4	8	0.02
OCT										
22...	30	20	--	<0.1	--	<1	--	<4	4	0.0

Table 14.--Cont'd

14238900 - CEDAR CK. ABV. NORTH FORK CEDAR CK. NR. TOLEDO, WASHINGTON, SITE C'

DATE	TIME	STREAMFLOW, INSTANTANEOUS (FT^3/S)	SPECIFIC CONDUCTANCE (US/CM)	PH (STANDARD UNITS)	TEMPERATURE (DEG C)	TURBIDITY (NTU)	OXYGEN, DISSOLVED (MG/L)	HARDNESS (MG/L AS $CACO_3$)	HARDNESS, NONCARBONATE (MG/L $CACO_3$)	ACIDITY (MG/L AS $CACO_3$)	CALCIUM DISSOLVED (MG/L AS CA)
MAR 1980											
03...	11:30	30	32	7.2	8.0	20	--	--	--	11	--
APR											
22...	11:10	58	28	6.9	9.5	15	11.0	9	0	4.0	2.2
MAY											
20...	15:00	1.3	44	7.2	16.0	4.0	9.0	15	0	3.0	3.5
JUL											
23...	14:00	0.34	68	6.9	20.0	5.0	5.8	23	0	10	5.3
AUG											
26...	15:30	0.0	83	7.1	18.5	4.0	2.8	26	0	9.0	6.3
SEP											
23...	14:00	0.95	68	7.2	14.0	8.0	6.8	22	0	9.0	5.2
OCT											
22...	14:30	0.51	74	6.8	7.0	6.0	8.8	25	0	6.0	5.7

DATE	MAGNESIUM, DISSOLVED (MG/L AS MG)	SODIUM, DISSOLVED (MG/L AS NA)	PERCENT SODIUM	SODIUM ADSORPTION RATIO	POTASSIUM, DISSOLVED (MG/L AS K)	ALKALINITY FIELD (MG/L AS CACO3)	SULFATE DISSOLVED (MG/L AS SO4)	CHLORIDE, DISSOLVED (MG/L AS CL)	FLUORIDE, DISSOLVED (MG/L AS F)	SILICA, DISSOLVED (MG/L AS SIO2)	SOLIDS, RESIDUE AT 180 DEG. C DISSOLVED (MG/L)
MAR 1980											
03...	--	--	--	--	--	13	--	--	--	--	--
APR											
22...	0.8	3.0	41	0.5	0.5	12	<5.0	2.2	0.1	15	39
MAY											
20...	1.6	3.9	34	0.4	0.7	23	<5.0	1.6	0.1	16	50
JUL											
23...	2.3	5.0	31	0.5	1.1	32	<5.0	2.3	0.1	11	67
AUG											
26...	2.4	5.6	31	0.5	1.3	38	<5.0	2.8	0.1	15	66
SEP											
23...	2.3	5.9	35	0.6	1.0	29	<5.0	3.7	0.1	19	67
OCT											
22...	2.5	5.8	33	0.5	1.0	33	<5.0	4.0	0.1	19	63

Table 14.--Cont'd

14238900 - CEDAR CK. ABV. NORTH FORK CEDAR CK. NR. TOLEDO, WASHINGTON, SITE C'

DATE	SOLIDS, DIS-SOLVED (TONS PER AC-FT)	SOLIDS, DIS-SOLVED (TONS PER DAY)	NITRO-GEN, NO2+NO3 TOTAL (MG/L AS N)	PHOS-PHORUS, TOTAL (MG/L AS P)	ALUM-INUM, TOTAL RECOV-ERABLE (UG/L AS AL)	ALUM-INUM, DIS-SOLVED (UG/L AS AL)	ARSENIC TOTAL (UG/L AS AS)	ARSENIC DIS-SOLVED (UG/L AS AS)	CADMIUM TOTAL RECOV-ERABLE (UG/L AS CD)	CADMIUM DIS-SOLVED (UG/L AS CD)
MAR 1980										
03...	--	--	--	--	--	--	--	--	--	--
APR										
22...	0.05	6.1	0.20	0.05	1000	200	<1	<1	1	<1
MAY										
20...	0.07	0.18	0.03	0.05	--	--	--	--	--	--
JUL										
23...	0.09	0.06	0.00	0.04	--	--	--	--	--	--
AUG										
26...	0.09	0.0	0.03	0.05	--	100	--	1	--	<1
SEP										
23...	0.09	0.17	0.03	0.10	200	100	1	1	<1	<1
OCT										
22...	0.09	0.09	0.00	0.04	--	300	--	1	--	<1

DATE	CHRO-MIUM, TOTAL RECOV-ERABLE (UG/L AS CR)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	COBALT, TOTAL RECOV-ERABLE (UG/L AS CO)	COBALT, DIS-SOLVED (UG/L AS CO)	COPPER, TOTAL RECOV-ERABLE (UG/L AS CU)	COPPER, DIS-SOLVED (UG/L AS CU)	IRON, TOTAL RECOV-ERABLE (UG/L AS FE)	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, TOTAL RECOV-ERABLE (UG/L AS PB)	LEAD, DIS-SOLVED (UG/L AS PB)
MAR 1980										
03...	--	--	--	--	--	--	--	--	--	--
APR										
22...	2	<10	<50	<3	6	1	1500	320	2	2
MAY										
20...	--	--	--	--	--	--	1400	750	--	--
JUL										
23...	--	--	--	--	--	--	1600	1200	--	--
AUG										
26...	--	<10	--	<3	--	2	1800	1200	--	2
SEP										
23...	<1	<10	<50	<3	5	2	1900	--	<1	<1
OCT										
22...	--	<10	--	<3	--	2	1600	1400	--	3

Table 14.--Cont'd

14238900 - CEDAR CK. ABV. NORTH FORK CEDAR CK. NR. TOLEDO, WASHINGTON, SITE C'

DATE	MANGANESE, TOTAL RECOVERABLE (UG/L AS MN)	MANGANESE, DISSOLVED (UG/L AS MN)	MERCURY TOTAL RECOVERABLE (UG/L AS HG)	MERCURY DISSOLVED (UG/L AS HG)	SELENIUM, TOTAL (UG/L AS SE)	SELENIUM, DISSOLVED (UG/L AS SE)	ZINC, TOTAL RECOVERABLE (UG/L AS ZN)	ZINC, DISSOLVED (UG/L AS ZN)	SEDIMENT, SUSPENDED (MG/L)	SEDIMENT, DISCHARGE, SUSPENDED (T/DAY)
MAR 1980										
03...	--	--	--	--	--	--	--	--	7	0.57
APR										
22...	40	10	<0.5	<0.1	<1	<1	20	4	14	2.2
MAY										
20...	30	20	--	--	--	--	--	--	4	0.01
JUL										
23...	70	60	--	--	--	--	--	--	7	0.01
AUG										
26...	110	90	--	<0.1	--	<1	--	<4	10	0.0
SEP										
23...	40	30	<0.5	<0.1	<1	<1	20	<4	6	0.02
OCT										
22...	40	30	--	<0.1	--	<1	--	<4	4	0.01

Table 14.--Cont'd

14239005 - FOSTER CK. SOUTH OF SMOKEY VALLEY NR. VADER, WASHINGTON, SITE D

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	SPE-CIFIC CON-DUCT-ANCE (US/CM)	PH (STAND-ARD UNITS)	TEMPER-ATURE (DEG C)	TUR-BID-ITY (NTU)	OXYGEN, DIS-SOLVED (MG/L)	HARD-NESS (MG/L AS $CACO_3$)	HARD-NESS, NONCAR-BONATE (MG/L $CACO_3$)	ACIDITY (MG/L AS $CACO_3$)	CALCIUM DIS-SOLVED (MG/L AS CA)
APR 1980											
23...	16:00	1.4	56	6.7	11.5	10	9.8	17	0	10	3.6
MAY											
20...	17:00	0.2	74	6.9	12.5	10	6.8	23	0	5.0	5.1
JUL											
22...	13:45	0.01	109	6.7	16.5	20	7.1	34	0	9.0	7.4
AUG											
25...	18:45	<0.01	108	7.2	14.0	15	2.1	32	0	9.0	7.2
SEP											
24...	11:40	0.02	114	7.2	11.0	10	7.0	39	0	11	8.6
OCT											
21...	11:30	0.03	103	6.8	8.0	10	9.7	36	0	10	8.0

DATE	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)	PERCENT SODIUM	SODIUM AD-SORP-TION RATIO	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	ALKA-LINITY FIELD (MG/L AS $CACO_3$)	SULFATE DIS-SOLVED (MG/L AS SO_4)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SILICA, DIS-SOLVED (MG/L AS SIO_2)	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L)
APR 1980											
23...	1.9	4.8	37	0.5	0.5	18	<5.0	2.5	0.1	20	52
MAY											
20...	2.6	6.4	37	0.6	0.6	32	<5.0	2.7	0.1	26	73
JUL											
22...	3.7	9.4	37	0.7	0.9	48	<5.0	4.2	0.2	31	100
AUG											
25...	3.5	9.5	38	0.7	1.2	47	<5.0	4.1	0.1	34	103
SEP											
24...	4.2	10	35	0.7	1.6	54	<5.0	5.9	0.1	32	103
OCT											
21...	4.0	9.0	34	0.7	1.3	67	<5.0	4.7	0.1	31	109

Table 14.--Cont'd

14239005 - FOSTER CK. SOUTH OF SMOKEY VALLEY NR. VADER, WASHINGTON, SITE D

DATE	SOLIDS, DIS-SOLVED (TONS PER AC-FT)	SOLIDS, DIS-SOLVED (TONS PER DAY)	NITRO-GEN, NO2+NO3 TOTAL (MG/L AS N)	PHOS-PHORUS, TOTAL (MG/L AS P)	ALUM-INUM, TOTAL RECOV-ERABLE (UG/L AS AL)	ALUM-INUM, DIS-SOLVED (UG/L AS AL)	ARSENIC TOTAL (UG/L AS AS)	ARSENIC DIS-SOLVED (UG/L AS AS)	CADMIUM TOTAL RECOV-ERABLE (UG/L AS CD)	CADMIUM DIS-SOLVED (UG/L AS CD)
APR 1980										
23...	0.07	0.2	1.20	0.06	100	<100	<1	<1	1	<1
MAY										
20...	0.1	0.04	0.18	0.05	--	--	--	--	--	--
JUL										
22...	0.14	0.0	0.15	0.09	--	--	--	--	--	--
AUG										
25...	0.14	--	0.16	0.09	--	<100	--	2	--	<1
SEP										
24...	0.14	0.01	0.08	0.21	200	100	2	1	<1	<1
OCT										
21...	0.15	0.01	0.10	0.06	--	400	--	1	--	<1

DATE	CHRO-MIUM, TOTAL RECOV-ERABLE (UG/L AS CR)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	COBALT, TOTAL RECOV-ERABLE (UG/L AS CO)	COBALT, DIS-SOLVED (UG/L AS CO)	COPPER, TOTAL RECOV-ERABLE (UG/L AS CU)	COPPER, DIS-SOLVED (UG/L AS CU)	IRON, TOTAL RECOV-ERABLE (UG/L AS FE)	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, TOTAL RECOV-ERABLE (UG/L AS PB)	LEAD, DIS-SOLVED (UG/L AS PB)
APR 1980										
23...	3	<10	<50	<3	5	1	640	200	2	<1
MAY										
20...	--	--	--	--	--	--	1600	480	--	--
JUL										
22...	--	--	--	--	--	--	3500	750	--	--
AUG										
25...	--	<10	--	<3	--	2	3200	710	--	2
SEP										
24...	11	<10	<50	<3	6	2	2500	1200	4	<1
OCT										
21...	--	<10	--	<3	--	2	1900	210	--	2

Table 14.--Cont'd

14239005 - FOSTER CK. SOUTH OF SMOKEY VALLEY NR. VADER, WASHINGTON, SITE D

DATE	MANGANESE, TOTAL RECOVERABLE (UG/L AS MN)	MANGANESE, DISSOLVED (UG/L AS MN)	MERCURY TOTAL RECOVERABLE (UG/L AS HG)	MERCURY DISSOLVED (UG/L AS HG)	SELENIUM, TOTAL (UG/L AS SE)	SELENIUM, DISSOLVED (UG/L AS SE)	ZINC, TOTAL RECOVERABLE (UG/L AS ZN)	ZINC, DISSOLVED (UG/L AS ZN)	SEDIMENT, SUSPENDED (MG/L)	SEDIMENT, DISCHARGE, SUSPENDED (T/DAY)
APR 1980										
23...	30	30	<0.5	<0.1	<1	<1	30	<4	12	0.05
MAY										
20...	60	50	--	--	--	--	--	--	10	0.01
JUL										
22...	250	220	--	--	--	--	--	--	22	0.0
AUG										
25...	260	230	--	<0.1	--	<1	--	6	18	--
SEP										
24...	120	110	<0.5	<0.1	<1	<1	10	5	15	0.0
OCT										
21...	70	60	--	<0.1	--	<1	--	6	5	0.0

Table 14.--Cont'd

14239010 - FOSTER CK. NR. MOUTH NR. VADER, WASINGTON, SITE D'

DATE	TIME	STREAM-FLOW, INSTANTANEOUS (FT^3/S)	SPECIFIC CONDUCTANCE (US/CM)	PH (STANDARD UNITS)	TEMPERATURE (DEG C)	TURBIDITY (NTU)	OXYGEN, DISSOLVED (MG/L)	HARDNESS (MG/L AS $CACO_3$)	HARDNESS, NONCARBONATE (MG/L $CACO_3$)	ACIDITY (MG/L AS $CACO_3$)	CALCIUM DISSOLVED (MG/L AS CA)
APR 1980											
23...	18:30	5.6	71	7.5	13.0	7.0	9.6	25	0	3.0	5.8
MAY											
20...	19:00	0.63	153	7.6	12.5	2.0	9.9	51	0	4.0	11
JUL											
22...	15:20	0.32	183	7.3	18.0	2.0	8.0	57	0	4.0	13
AUG											
25...	16:30	0.26	165	7.9	16.5	1.0	7.6	59	0	4.0	13
SEP											
24...	13:30	0.31	184	7.8	12.0	1.0	8.9	52	0	5.0	14
OCT											
21...	13:00	0.28	193	7.1	9.5	1.0	9.4	64	0	6.0	14

DATE	MAGNESIUM, DISSOLVED (MG/L AS MG)	SODIUM, DISSOLVED (MG/L AS NA)	PERCENT SODIUM	SODIUM AD-SORPTION RATIO	POTASSIUM, DISSOLVED (MG/L AS K)	ALKALINITY FIELD (MG/L AS $CACO_3$)	SULFATE DISSOLVED (MG/L AS SO_4)	CHLORIDE, DISSOLVED (MG/L AS CL)	FLUORIDE, DISSOLVED (MG/L AS F)	SILICA, DISSOLVED (MG/L AS SIO_2)	SOLIDS, RESIDUE AT 180 DEG. C DISSOLVED (MG/L)
APR 1980											
23...	2.5	5.5	32	0.5	0.8	30	<5.0	2.8	0.1	17	58
MAY											
20...	5.7	11	31	0.7	1.5	67	5.6	5.4	0.2	40	119
JUL											
22...	6.5	14	33	0.8	1.9	79	<5.0	11	0.3	48	140
AUG											
25...	6.5	13	31	0.8	1.9	79	<5.0	6.8	0.2	48	--
SEP											
24...	4.2	15	37	0.9	1.9	82	<5.0	8.2	0.2	32	145
OCT											
21...	7.1	14	32	0.8	1.2	111	<5.0	8.0	0.2	49	146

Table 14.--Cont'd

14239010 - FOSTER CK. NR. MOUTH NR. VADER, WASHINGTON, SITE D'

DATE	SOLIDS, DIS- SOLVED (TONS PER AC-FT)	SOLIDS, DIS- SOLVED (TONS PER DAY)	NITRO- GEN, NO2+NO3 TOTAL (MG/L AS N)	PHOS- PHORUS, TOTAL (MG/L AS P)	ALUM- INUM, TOTAL RECOV- ERABLE (UG/L AS AL)	ALUM- INUM, DIS- SOLVED (UG/L AS AL)	ARSENIC TOTAL (UG/L AS AS)	ARSENIC DIS- SOLVED (UG/L AS AS)	CADMIUM TOTAL RECOV- ERABLE (UG/L AS CD)	CADMIUM DIS- SOLVED (UG/L AS CD)
APR 1980										
23...	0.08	0.88	0.34	0.10	100	<100	1	1	1	<1
MAY										
20...	0.16	0.2	0.42	0.14	--	--	--	--	--	--
JUL										
22...	0.19	0.12	0.37	0.19	--	--	--	--	--	--
AUG										
25...	0.34	0.17	0.41	0.16	--	100	--	2	--	<1
SEP										
24...	0.2	0.12	0.46	0.40	200	100	1	1	<1	<1
OCT										
21...	0.2	0.11	0.45	0.04	--	300	--	1	--	<1

DATE	CHRO- MIUM, TOTAL RECOV- ERABLE (UG/L AS CR)	CHRO- MIUM, DIS- SOLVED (UG/L AS CR)	COBALT, TOTAL RECOV- ERABLE (UG/L AS CO)	COBALT, DIS- SOLVED (UG/L AS CO)	COPPER, TOTAL RECOV- ERABLE (UG/L AS CU)	COPPER, DIS- SOLVED (UG/L AS CU)	IRON, TOTAL RECOV- ERABLE (UG/L AS FE)	IRON, DIS- SOLVED (UG/L AS FE)	LEAD, TOTAL RECOV- ERABLE (UG/L AS PB)	LEAD, DIS- SOLVED (UG/L AS PB)
APR 1980										
23...	5	<10	<50	<3	5	1	960	200	2	1
MAY										
20...	--	--	--	--	--	--	490	180	--	--
JUL										
22...	--	--	--	--	--	--	400	240	--	--
AUG										
25...	--	<10	--	<3	--	<1	430	210	--	3
SEP										
24...	<1	<10	<50	<3	3	1	400	270	1	<1
OCT										
21...	--	<10	--	<3	--	1	350	250	--	3

Table 14.--Cont'd

14239010 - FOSTER CK. NR. MOUTH NR. VADER, WASHINGTON, SITE D'

DATE	MANGANESE, TOTAL RECOVERABLE (UG/L AS MN)	MANGANESE, DISSOLVED (UG/L AS MN)	MERCURY TOTAL RECOVERABLE (UG/L AS HG)	MERCURY DISSOLVED (UG/L AS HG)	SELENIUM, TOTAL (UG/L AS SE)	SELENIUM, DISSOLVED (UG/L AS SE)	ZINC, TOTAL RECOVERABLE (UG/L AS ZN)	ZINC, DISSOLVED (UG/L AS ZN)	SEDIMENT, SUSPENDED (MG/L)	SEDIMENT, DISCHARGE, SUSPENDED (T/DAY)
APR 1980										
23...	30	10	<0.5	<0.1	<1	<1	20	<3	10	0.15
MAY										
20...	30	20	--	--	--	--	--	--	6	0.01
JUL										
22...	40	30	--	--	--	--	--	--	3	0.0
AUG										
25...	40	20	--	<0.1	--	<1	--	<3	4	0.0
SEP										
24...	30	20	<0.5	<0.1	<1	<1	10	<3	8	0.01
OCT										
21...	30	30	--	<0.1	--	<1	--	<3	2	0.00

Table 14.--Cont'd

12022050 - DEEP CK. ABV. CARSON CK. NR. BUNKER, WASHINGTON, SITE E

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	SPE-CIFIC CON-DUCT-ANCE (US/CM)	PH (STAND-ARD UNITS)	TEMPER-ATURE (DEG C)	TUR-BID-ITY (NTU)	OXYGEN, DIS-SOLVED (MG/L)	HARD-NESS (MG/L AS $CACO_3$)	HARD-NESS, NONCAR-BONATE (MG/L $CACO_3$)	ACIDITY (MG/L AS $CACO_3$)	CALCIUM DIS-SOLVED (MG/L AS CA)
MAR 1980											
11...	10:20	11	70	7.4	6.0	7.0	11.6	--	--	9.0	--
APR											
25...	08:00	6.5	68	7.3	8.5	6.0	10.6	19	0	4.0	5.1
MAY											
21...	07:15	1.4	80	7.3	12.0	4.0	9.2	25	0	3.0	6.4
JUL											
22...	18:00	0.16	121	7.0	16.5	3.0	6.9	36	0	8.0	9.0
AUG											
28...	10:45	0.0	142	7.0	12.0	4.0	1.6	42	0	17	11
SEP											
24...	16:10	0.17	143	7.2	10.5	4.0	7.4	39	0	10	10
OCT											
24...	07:00	0.09	149	7.2	6.0	3.0	8.2	43	0	3.0	11

DATE	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)	PERCENT SODIUM	SODIUM AD-SORP-TION RATIO	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	ALKA-LINITY FIELD (MG/L AS $CACO_3$)	SULFATE DIS-SOLVED (MG/L AS SO_4)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SILICA, DIS-SOLVED (MG/L AS SIO_2)	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L)
MAR 1980											
11...	--	--	--	--	--	19	--	--	--	--	--
APR											
25...	1.6	6.4	41	0.7	0.6	24	<5.0	3.2	0.1	14	48
MAY											
21...	2.3	7.5	38	0.7	0.8	34	8.0	3.9	0.1	15	67
JUL											
22...	3.2	11	39	0.8	1.4	48	13	8.0	0.1	17	88
AUG											
28...	3.6	17	46	1	1.5	59	<5.0	12	0.1	19	117
SEP											
24...	3.5	13	40	0.9	1.8	52	<5.0	11	0.1	17	99
OCT											
24...	3.7	13	39	0.9	1.6	55	<5.0	11	0.1	16	95

12022050 - DEEP CREEK ABV. CARSON CK. NR. BUNKER, WASHINGTON, SITE E

DATE	SOLIDS, DIS-SOLVED (TONS PER AC-FT)	SOLIDS, DIS-SOLVED (TONS PER DAY)	NITRO-GEN, NO2+NO3 TOTAL (MG/L AS N)	PHOS-PHORUS, TOTAL (MG/L AS P)	ALUM-INUM, TOTAL RECOV-ERABLE (UG/L AS AL)	ALUM-INUM, DIS-SOLVED (UG/L AS AL)	ARSENIC TOTAL (UG/L AS AS)	ARSENIC DIS-SOLVED (UG/L AS AS)	CADMIUM TOTAL RECOV-ERABLE (UG/L AS CD)	CADMIUM DIS-SOLVED (UG/L AS CD)
MAR 1980										
11...	--	--	--	--	--	--	--	--	--	--
APR										
25...	0.07	0.84	0.68	0.03	390	100	<1	<1	<1	<1
MAY										
21...	0.09	0.25	0.15	0.07	--	--	--	--	--	--
JUL										
22...	0.12	0.04	0.08	0.08	--	--	--	--	--	--
AUG										
28...	0.16	0.0	0.05	0.15	--	200	--	2	--	<1
SEP										
24...	0.13	0.05	0.09	0.16	100	100	2	2	<1	<1
OCT										
24...	0.13	0.02	0.00	0.03	--	300	--	2	--	<1

DATE	CHRO-MIUM, TOTAL RECOV-ERABLE (UG/L AS CR)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	COBALT, TOTAL RECOV-ERABLE (UG/L AS CO)	COBALT, DIS-SOLVED (UG/L AS CO)	COPPER, TOTAL RECOV-ERABLE (UG/L AS CU)	COPPER, DIS-SOLVED (UG/L AS CU)	IRON, TOTAL RECOV-ERABLE (UG/L AS FE)	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, TOTAL RECOV-ERABLE (UG/L AS PB)	LEAD, DIS-SOLVED (UG/L AS PB)
MAR 1980										
11...	--	--	--	--	--	--	--	--	--	--
APR										
25...	4	10	<50	<3	3	1	700	200	1	<1
MAY										
21...	--	--	--	--	--	--	1200	560	--	--
JUL										
22...	--	--	--	--	--	--	1200	830	--	--
AUG										
28...	--	<10	--	3	--	1	1600	550	--	5
SEP										
24...	<1	<10	<50	<3	5	2	1600	1400	2	2
OCT										
24...	--	<10	--	<3	--	1	1100	940	--	2

able 14.--Cont'd

12022050 - DEEP CK. ABV CARSON CK. NR BUNKER, WASHINGTON, SITE E

DATE	MANGA-NESE, TOTAL RECOV-ERABLE (UG/L AS MN)	MANGA-NESE, DIS-SOLVED (UG/L AS MN)	MERCURY TOTAL RECOV-ERABLE (UG/L AS HG)	MERCURY DIS-SOLVED (UG/L AS HG)	SELE-NIUM, TOTAL (UG/L AS SE)	SELE-NIUM, DIS-SOLVED (UG/L AS SE)	ZINC, TOTAL RECOV-ERABLE (UG/L AS ZN)	ZINC, DIS-SOLVED (UG/L AS ZN)	SEDI-MENT, SUS-PENDED (MG/L)	SEDI-MENT, DIS-CHARGE, SUS-PENDED (T/DAY)
MAR 1980										
11...	--	--	--	--	--	--	--	--	6	0.18
APR										
25...	20	10	<0.5	<0.1	<1	<1	30	<4	6	0.11
MAY										
21...	20	9	--	--	--	--	--	--	4	0.02
JUL										
22...	20	20	--	--	--	--	--	--	7	0.0
AUG										
28...	340	320	--	<0.1	--	<1	--	10	8	0.0
SEP										
24...	30	20	<0.5	<0.1	<1	<1	10	<4	5	0.0
OCT										
24...	20	30	--	<0.1	--	<1	--	6	2	0.0

12022090 - DEEP CK. NR. MOUTH NR. BUNKER, WASHINGTON, SITE E'

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	SPE-CIFIC CON-DUCT-ANCE (US/CM)	PH (STAND-ARD UNITS)	TEMPER-ATURE (DEG C)	TUR-BID-ITY (NTU)	OXYGEN, DIS-SOLVED (MG/L)	HARD-NESS (MG/L AS $CACO_3$)	HARD-NESS, NONCAR-BONATE (MG/L $CACO_3$)	ACIDITY (MG/L AS $CACO_3$)	CALCIUM DIS-SOLVED (MG/L AS CA)
MAR 1980											
11...	12:55	24	68	7.4	6.5	6.0	12.1	--	--	10	--
APR											
25...	09:30	11	73	7.3	9.0	4.0	12.2	21	0	4.0	5.1
MAY											
21...	09:15	3.3	87	7.2	12.5	4.0	9.0	26	0	7.0	6.2
JUL											
22...	19:30	0.41	130	7.0	18.0	5.0	6.8	36	0	9.0	8.8
AUG											
28...	12:00	0.22	124	7.3	13.0	4.0	7.1	41	0	9.0	9.6
SEP											
24...	17:30	0.47	138	7.2	11.5	6.0	7.9	38	0	10	9.0
OCT											
24...	08:30	0.35	135	7.0	7.0	5.0	8.3	40	0	8.0	9.1

DATE	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)	PERCENT SODIUM	SODIUM AD-SORP-TION RATIO	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	ALKA-LINITY FIELD (MG/L AS $CACO_3$)	SULFATE DIS-SOLVED (MG/L AS SO_4)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SILICA, DIS-SOLVED (MG/L AS SIO_2)	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L)
MAR 1980											
11...	--	--	--	--	--	18	--	--	--	--	--
APR											
25...	2.0	6.6	40	0.6	0.6	24	5.0	3.9	0.1	13	54
MAY											
21...	2.6	7.9	39	0.7	0.9	34	<5.0	5.2	0.1	15	68
JUL											
22...	3.5	11	39	0.8	1.4	48	<5.0	8.1	0.2	19	91
AUG											
28...	4.2	10	34	0.7	1.5	53	<5.0	6.7	0.1	21	108
SEP											
24...	3.8	12	39	0.9	2.0	44	<5.0	16	0.2	21	99
OCT											
24...	4.1	12	38	0.9	2.0	50	<5.0	12	0.1	21	96

Table 14.--Cont'd

12022090 -DEEP CK. NR. MOUTH NR. BUNKER, WASHINGTON, SITE E'

DATE	SOLIDS, DIS-SOLVED (TONS PER AC-FT)	SOLIDS, DIS-SOLVED (TONS PER DAY)	NITRO-GEN, NO2+NO3 TOTAL (MG/L AS N)	PHOS-PHORUS, TOTAL (MG/L AS P)	ALUM-INUM, TOTAL RECOV-ERABLE (UG/L AS AL)	ALUM-INUM, DIS-SOLVED (UG/L AS AL)	ARSENIC TOTAL (UG/L AS AS)	ARSENIC DIS-SOLVED (UG/L AS AS)	CADMIUM TOTAL RECOV-ERABLE (UG/L AS CD)	CADMIUM DIS-SOLVED (UG/L AS CD)
MAR 1980										
11...	--	--	--	--	--	--	--	--	--	--
APR										
25...	0.07	1.6	0.73	0.03	160	100	<1	<1	1	<1
MAY										
21...	0.09	0.61	0.21	0.07	--	--	--	--	--	--
JUL										
22...	0.12	0.1	0.13	0.12	--	--	--	--	--	--
AUG										
28...	0.15	0.06	0.10	0.10	--	200	--	2	--	<1
SEP										
24...	0.13	0.13	0.40	0.07	500	300	2	2	<1	<1
OCT										
24...	0.13	0.09	0.09	0.02	--	300	--	1	--	<1

DATE	CHRO-MIUM, TOTAL RECOV-ERABLE (UG/L AS CR)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	COBALT, TOTAL RECOV-ERABLE (UG/L AS CO)	COBALT, DIS-SOLVED (UG/L AS CO)	COPPER, TOTAL RECOV-ERABLE (UG/L AS CU)	COPPER, DIS-SOLVED (UG/L AS CU)	IRON, TOTAL RECOV-ERABLE (UG/L AS FE)	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, TOTAL RECOV-ERABLE (UG/L AS PB)	LEAD, DIS-SOLVED (UG/L AS PB)
MAR 1980										
11...	--	--	--	--	--	--	--	--	--	--
APR										
25...	3	<10	<50	<3	3	1	620	190	1	<1
MAY										
21...	--	--	--	--	--	--	1300	500	--	--
JUL										
22...	--	--	--	--	--	--	1600	950	--	--
AUG										
28...	--	<10	--	5	--	<1	2000	1700	--	<1
SEP										
24...	5	<10	<50	<3	6	2	1600	1100	2	2
OCT										
24...	--	<10	--	3	--	2	1800	1100	--	2

Table 14.--Cont'd

12022090 - DEEP CRK. NR. MOUTH NR. BUNKER, WASHINGTON, SITE E'

DATE	MANGANESE, TOTAL RECOVERABLE (UG/L AS MN)	MANGANESE, DISSOLVED (UG/L AS MN)	MERCURY TOTAL RECOVERABLE (UG/L AS HG)	MERCURY DISSOLVED (UG/L AS HG)	SELENIUM, TOTAL (UG/L AS SE)	SELENIUM, DISSOLVED (UG/L AS SE)	ZINC, TOTAL RECOVERABLE (UG/L AS ZN)	ZINC, DISSOLVED (UG/L AS ZN)	SEDIMENT, SUSPENDED (MG/L)	SEDIMENT, DISCHARGE, SUSPENDED (T/DAY)
MAR 1980										
11...	--	--	--	--	--	--	--	--	6	0.39
APR										
25...	20	10	<0.5	<0.1	<1	<1	50	<4	6	0.18
MAY										
21...	30	20	--	--	--	--	--	--	6	0.05
JUL										
22...	70	60	--	--	--	--	--	--	3	0.0
AUG										
28...	130	90	--	<0.1	--	<1	--	<4	4	0.0
SEP										
24...	60	10	<0.5	<0.1	<1	<1	120	5	9	0.01
OCT										
24...	60	50	--	<0.1	--	<1	--	5	6	0.01

Table 14.--Cont'd

12026504 - HANAFORD CK. ABV. COAL CK. NR. BUCODA, WASHINGTON, SITE F

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	SPE-CIFIC CON-DUCT-ANCE (US/CM)	PH (STAND-ARD UNITS)	TEMPER-ATURE (DEG C)	TUR-BID-ITY (NTU)	OXYGEN, DIS-SOLVED (MG/L)	HARD-NESS (MG/L AS $CACO_3$)	HARD-NESS, NONCAR-BONATE (MG/L $CACO_3$)	ACIDITY (MG/L AS $CACO_3$)	CALCIUM DIS-SOLVED (MG/L AS CA)
MAR 1980											
14...	08:45	108	51	6.8	5.5	10	12.0	--	--	3.0	--
APR											
24...	07:00	37	45	7.3	8.5	4.0	--	16	0	3.0	4.4
MAY											
21...	12:15	12	47	7.5	11.0	2.0	10.6	18	0	5.0	5.2
JUL											
24...	07:25	4.1	61	7.2	14.0	1.0	9.2	22	0	5.0	6.2
AUG											
27...	11:00	6.5	62	7.4	13.0	2.0	8.9	24	0	3.0	6.8
SEP											
25...	07:30	3.4	67	7.4	10.0	1.0	10.2	23	0	2.0	6.6
OCT											
23...	07:30	2.8	65	6.8	5.5	1.0	9.8	21	0	3.0	6.3

DATE	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)	PERCENT SODIUM	SODIUM AD-SORP-TION RATIO	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	ALKA-LINITY FIELD (MG/L AS $CACO_3$)	SULFATE DIS-SOLVED (MG/L AS SO_4)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SILICA, DIS-SOLVED (MG/L AS SIO_2)	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L)
MAR 1980											
14...	--	--	--	--	--	11	--	--	--	--	--
APR											
24...	1.1	3.7	34	0.4	0.3	16	<5.0	2.0	0.1	17	45
MAY											
21...	1.2	4.0	32	0.4	0.4	24	<5.0	2.3	0.1	19	43
JUL											
24...	1.5	4.7	31	0.5	0.5	28	<5.0	1.9	0.1	22	57
AUG											
27...	1.7	5.5	33	0.5	0.6	28	<5.0	2.5	0.1	21	61
SEP											
25...	1.6	5.1	32	0.5	0.5	31	<5.0	2.4	0.1	21	59
OCT											
23...	1.4	4.7	32	0.5	0.5	31	<5.0	2.3	0.1	20	57

Table 14.--Cont'd

12006504 - HANAFORD CK. ABV. COAL CK. NR. BUCODA, WASHINGTON, SITE F

DATE	SOLIDS, DIS-SOLVED (TONS PER AC-FT)	SOLIDS, DIS-SOLVED (TONS PER DAY)	NITRO-GEN, NO2+NO3 TOTAL (MG/L AS N)	PHOS-PHORUS, TOTAL (MG/L AS P)	ALUM-INUM, TOTAL RECOV-ERABLE (UG/L AS AL)	ALUM-INUM, DIS-SOLVED (UG/L AS AL)	ARSENIC TOTAL (UG/L AS AS)	ARSENIC DIS-SOLVED (UG/L AS AS)	CADMIUM TOTAL RECOV-ERABLE (UG/L AS CD)	CADMIUM DIS-SOLVED (UG/L AS CD)
MAR 1980										
14...	--	--	--	--	--	--	--	--	--	--
APR										
24...	0.06	4.5	0.95	0.03	<100	<100	<1	<1	<1	<1
MAY										
21...	0.06	1.4	0.23	0.04	--	--	--	--	--	--
JUL										
24...	0.08	0.63	0.25	0.04	--	--	--	--	--	--
AUG										
27...	0.08	1.1	0.14	0.04	--	100	--	1	--	<1
SEP										
25...	0.08	0.54	0.15	0.08	200	100	1	1	<1	<1
OCT										
23...	0.08	0.43	0.05	0.02	--	300	--	1	--	<1

DATE	CHRO-MIUM, TOTAL RECOV-ERABLE (UG/L AS CR)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	COBALT, TOTAL RECOV-ERABLE (UG/L AS CO)	COBALT, DIS-SOLVED (UG/L AS CO)	COPPER, TOTAL RECOV-ERABLE (UG/L AS CU)	COPPER, DIS-SOLVED (UG/L AS CU)	IRON, TOTAL RECOV-ERABLE (UG/L AS FE)	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, TOTAL RECOV-ERABLE (UG/L AS PB)	LEAD, DIS-SOLVED (UG/L AS PB)
MAR 1980										
14...	--	--	--	--	--	--	--	--	--	--
APR										
24...	<1	<10	<50	<3	4	<1	390	90	1	2
MAY										
21...	--	--	--	--	--	--	330	130	--	--
JUL										
24...	--	--	--	--	--	--	230	130	--	--
AUG										
27...	--	<10	--	<3	--	2	380	130	--	2
SEP										
25...	<1	<10	<50	<3	4	2	280	170	1	<1
OCT										
23...	--	10	--	<3	--	2	250	150	--	3

Table 14.--Cont'd

12026504 - HANAFORD CK. ABV. COAL CK. NR. BUCODA, WASHINGTON, SITE F

DATE	MANGA-NESE, TOTAL RECOV-ERABLE (UG/L AS MN)	MANGA-NESE, DIS-SOLVED (UG/L AS MN)	MERCURY TOTAL RECOV-ERABLE (UG/L AS HG)	MERCURY DIS-SOLVED (UG/L AS HG)	SELE-NIUM, TOTAL (UG/L AS SE)	SELE-NIUM, DIS-SOLVED (UG/L AS SE)	ZINC, TOTAL RECOV-ERABLE (UG/L AS ZN)	ZINC, DIS-SOLVED (UG/L AS ZN)	SEDI-MENT, SUS-PENDED (MG/L)	SEDI-MENT, DIS-CHARGE, SUS-PENDED (T/DAY)
MAR 1980										
14...	--	--	--	--	--	--	--	--	24	7.0
APR										
24...	10	5	<0.5	<0.1	<1	<1	10	<4	12	1.2
MAY										
21...	10	6	--	--	--	--	--	--	4	0.13
JUL										
24...	10	8	--	--	--	--	--	--	3	0.03
AUG										
27...	30	10	--	<0.1	--	<1	--	<4	4	0.07
SEP										
25...	10	8	<0.5	<0.1	<1	<1	10	<4	2	0.02
OCT										
23...	10	8	--	<0.1	--	<1	--	<4	2	0.02

Table 14.--Cont'd

12026530 - HANAFORD CK BLW. SNYDER CK NR. BUCODA, WASHINGTON, SITE F'

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	SPE-CIFIC CON-DUCT-ANCE (US/CM)	PH (STAND-ARD UNITS)	TEMPER-ATURE (DEG C)	TUR-BID-ITY (NTU)	OXYGEN, DIS-SOLVED (MG/L)	HARD-NESS (MG/L AS $CACO_3$)	HARD-NESS, NONCAR-BONATE (MG/L $CACO_3$)	ACIDITY (MG/L AS $CACO_3$)	CALCIUM DIS-SOLVED (MG/L AS CA)
MAR 1980											
14...	11:05	--	48	6.8	6.0	20	11.6	--	--	4.0	--
APR											
24...	10:00	43	52	7.0	9.5	8.0	--	16	0	4.0	4.5
MAY											
21...	14:00	13	54	7.3	12.5	5.0	--	20	0	6.0	5.6
JUL											
24...	09:10	4.2	74	7.2	16.0	8.0	8.6	26	5	4.0	7.3
AUG											
27...	13:00	6.7	76	7.4	14.5	5.0	8.3	26	0	5.0	6.9
SEP											
25...	09:25	4.8	82	7.4	11.5	5.0	9.8	28	0	9.0	7.9
OCT											
23...	10:30	3.7	89	6.9	5.5	2.0	11.6	29	0	4.0	8.0

DATE	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)	PERCENT SODIUM	SODIUM AD-SORP-TION RATIO	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	ALKA-LINITY FIELD (MG/L AS $CACO_3$)	SULFATE DIS-SOLVED (MG/L AS SO_4)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SILICA, DIS-SOLVED (MG/L AS SIO_2)	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L)
MAR 1980											
14...	--	--	--	--	--	10	--	--	--	--	--
APR											
24...	1.2	4.0	34	0.4	0.4	18	7.1	2.3	0.1	15	45
MAY											
21...	1.5	4.4	32	0.4	0.5	26	<5.0	2.5	0.1	19	49
JUL											
24...	1.8	5.4	31	0.5	0.7	32	12	2.6	0.1	21	69
AUG											
27...	2.1	5.1	29	0.5	1.1	32	<5.0	2.0	0.1	19	87
SEP											
25...	2.1	5.8	30	0.5	0.7	34	<5.0	2.6	0.1	20	69
OCT											
23...	2.1	5.3	28	0.4	0.7	36	<5.0	2.6	0.1	19	69

Table 14.--Cont'd

12026530 - HANAFORD CK. BLW. SNYDER CK. NR BUCODA, WASHINGTON, SITE F'

DATE	SOLIDS, DIS-SOLVED (TONS PER AC-FT)	SOLIDS, DIS-SOLVED (TONS PER DAY)	NITRO-GEN, NO2+NO3 TOTAL (MG/L AS N)	PHOS-PHORUS, TOTAL (MG/L AS P)	ALUM-INUM, TOTAL RECOV-ERABLE (UG/L AS AL)	ALUM-INUM, DIS-SOLVED (UG/L AS AL)	ARSENIC TOTAL (UG/L AS AS)	ARSENIC DIS-SOLVED (UG/L AS AS)	CADMIUM TOTAL RECOV-ERABLE (UG/L AS CD)	CADMIUM DIS-SOLVED (UG/L AS CD)
MAR 1980										
14...	--	--	--	--	--	--	--	--	--	--
APR										
24...	0.06	5.2	0.96	0.04	100	<100	<1	<1	1	<1
MAY										
21...	0.07	1.7	0.23	0.05	--	--	--	--	--	--
JUL										
24...	0.09	0.78	0.09	0.05	--	--	--	--	--	--
AUG										
27...	0.12	1.6	0.13	0.06	--	300	--	1	--	<1
SEP										
25...	0.09	0.89	0.15	0.10	1200	100	1	1	<1	<1
OCT										
23...	0.09	0.69	0.01	0.03	--	300	--	1	--	<1

DATE	CHRO-MIUM, TOTAL RECOV-ERABLE (UG/L AS CR)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	COBALT, TOTAL RECOV-ERABLE (UG/L AS CO)	COBALT, DIS-SOLVED (UG/L AS CO)	COPPER, TOTAL RECOV-ERABLE (UG/L AS CU)	COPPER, DIS-SOLVED (UG/L AS CU)	IRON, TOTAL RECOV-ERABLE (UG/L AS FE)	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, TOTAL RECOV-ERABLE (UG/L AS PB)	LEAD, DIS-SOLVED (UG/L AS PB)
MAR 1980										
14...	--	--	--	--	--	--	--	--	--	--
APR										
24...	3	<10	<50	<3	5	1	820	140	<1	1
MAY										
21...	--	--	--	--	--	--	790	270	--	--
JUL										
24...	--	--	--	--	--	--	1100	310	--	--
AUG										
27...	--	<10	--	3	--	2	910	280	--	4
SEP										
25...	<1	<10	<50	<3	8	2	850	490	1	3
OCT										
23...	--	10	--	<3	--	2	660	460	--	2

12026530 - HANAFORD CK. BLW. SNYDER CK. NR BUCODA, WASHINGTON, SITE F'

DATE	MANGA-NESE, TOTAL RECOV-ERABLE (UG/L AS MN)	MANGA-NESE, DIS-SOLVED (UG/L AS MN)	MERCURY TOTAL RECOV-ERABLE (UG/L AS HG)	MERCURY DIS-SOLVED (UG/L AS HG)	SELE-NIUM, TOTAL (UG/L AS SE)	SELE-NIUM, DIS-SOLVED (UG/L AS SE)	ZINC, TOTAL RECOV-ERABLE (UG/L AS ZN)	ZINC, DIS-SOLVED (UG/L AS ZN)	SEDI-MENT, SUS-PENDED (MG/L)	SEDI-MENT, DIS-CHARGE, SUS-PENDED (T/DAY)
MAR 1980										
14...	--	--	--	--	--	--	--	--	--	--
APR										
24...	20	10	<0.5	0.1	<1	<1	20	<4	23	2.7
MAY										
21...	30	20	--	--	--	--	--	--	10	0.35
JUL										
24..	50	40	--	--	--	--	--	--	22	0.25
AUG										
27...	60	30	--	<0.1	--	<1	--	<4	12	0.22
SEP										
25...	40	30	<0.5	<0.1	<1	<1	10	<4	8	0.1
OCT										
23...	30	30	--	<0.1	--	<1	--	4	3	0.03

Table 14.--Cont'd

12026560 - SOUTH HANAFORD CK NR. KOPIAH, WASHINGTON, SITE G

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	SPE-CIFIC CON-DUCT-ANCE (US/CM)	PH (STAND-ARD UNITS)	TEMPER-ATURE (DEG C)	TUR-BID-ITY (NTU)	OXYGEN, DIS-SOLVED (MG/L)	HARD-NESS (MG/L AS $CACO_3$)	HARD-NESS, NONCAR-BONATE (MG/L $CACO_3$)	ACIDITY (MG/L AS $CACO_3$)	CALCIUM DIS-SOLVED (MG/L AS CA)
MAR 1980											
14...	14:05	51	173	6.8	7.0	10	11.2	--	--	6.0	--
APR											
24...	15:00	8.8	160	7.1	13.0	5.0	--	49	23	5.0	14
MAY											
21...	15:45	1.4	222	7.5	13.5	9.0	10.0	71	24	4.0	21
JUL											
24...	13:15	0.13	380	7.6	17.0	10	6.4	110	36	7.0	34
AUG											
27...	15:00	0.13	405	7.3	14.5	15	4.8	130	48	9.0	37
SEP											
25...	15:00	0.39	400	7.6	13.0	15	8.3	100	31	9.0	30
OCT											
23...	13:00	0.37	410	7.2	6.0	7.0	10.4	100	42	3.0	31

DATE	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)	PERCENT SODIUM	SODIUM AD-SORP-TION RATIO	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	ALKA-LINITY FIELD (MG/L AS $CACO_3$)	SULFATE DIS-SOLVED (MG/L AS SO_4)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SILICA, DIS-SOLVED (MG/L AS SIO_2)	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L)
MAR 1980											
14...	--	--	--	--	--	16	--	--	--	--	--
APR											
24...	3.5	13	36	0.8	0.6	26	36	7.5	0.1	13	115
MAY											
21...	4.5	17	34	0.9	0.8	47	22	27	0.1	15	151
JUL											
24...	7.2	32	37	1	1.5	79	40	46	0.2	14	246
AUG											
27...	8.3	32	35	1	2.7	79	44	52	0.1	19	309
SEP											
25...	6.2	31	40	1	1.6	69	27	51	0.1	17	219
OCT											
23...	6.3	33	40	1	1.9	61	42	60	0.1	15	243

Table 14.--Cont'd

12026560 - SOUTH HANAFORD CK. NR. KOPIAH, WASHINGTON, SITE G

DATE	SOLIDS, DIS-SOLVED (TONS PER AC-FT)	SOLIDS, DIS-SOLVED (TONS PER DAY)	NITRO-GEN, NO2+NO3 TOTAL (MG/L AS N)	PHOS-PHORUS, TOTAL (MG/L AS P)	ALUM-INUM, TOTAL RECOV-ERABLE (UG/L AS AL)	ALUM-INUM, DIS-SOLVED (UG/L AS AL)	ARSENIC TOTAL (UG/L AS AS)	ARSENIC DIS-SOLVED (UG/L AS AS)	CADMIUM TOTAL RECOV-ERABLE (UG/L AS CD)	CADMIUM DIS-SOLVED (UG/L AS CD)
MAR 1980										
14...	--	--	--	--	--	--	--	--	--	--
APR										
24...	0.16	2.7	0.98	0.04	100	100	<1	<1	1	<1
MAY										
21...	0.21	0.57	0.19	0.05	--	--	--	--	--	--
JUL										
24...	0.33	0.09	0.16	0.07	--	--	--	--	--	--
AUG										
27...	0.42	0.11	0.21	0.08	--	200	--	1	--	<1
SEP										
25...	0.3	0.23	0.21	0.13	500	100	1	1	<1	<1
OCT										
23...	0.33	0.24	0.14	0.04	--	400	--	1	--	<1

DATE	CHRO-MIUM, TOTAL RECOV-ERABLE (UG/L AS CR)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	COBALT, TOTAL RECOV-ERABLE (UG/L AS CO)	COBALT, DIS-SOLVED (UG/L AS CO)	COPPER, TOTAL RECOV-ERABLE (UG/L AS CU)	COPPER, DIS-SOLVED (UG/L AS CU)	IRON, TOTAL RECOV-ERABLE (UG/L AS FE)	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, TOTAL RECOV-ERABLE (UG/L AS PB)	LEAD, DIS-SOLVED (UG/L AS PB)
MAR 1980										
14...	--	--	--	--	--	--	--	--	--	--
APR										
24...	5	<10	<50	<3	3	1	800	190	1	2
MAY										
21...	--	--	--	--	--	--	1800	530	--	--
JUL										
24...	--	--	--	--	--	--	2500	720	--	--
AUG										
27...	--	<10	--	3	--	2	2400	180	--	3
SEP										
25...	5	<10	<50	<3	5	2	2100	600	2	2
OCT										
23...	--	<10	--	<3	--	1	1200	420	--	2

Table 14.--Cont'd

12026560 - SOUTH HANAFORD CK. NR. KOPIAH, WASHINGTON, SITE G

DATE	MANGA-NESE, TOTAL RECOV-ERABLE (UG/L AS MN)	MANGA-NESE, DIS-SOLVED (UG/L AS MN)	MERCURY TOTAL RECOV-ERABLE (UG/L AS HG)	MERCURY DIS-SOLVED (UG/L AS HG)	SELE-NIUM, TOTAL (UG/L AS SE)	SELE-NIUM, DIS-SOLVED (UG/L AS SE)	ZINC, TOTAL RECOV-ERABLE (UG/L AS ZN)	ZINC, DIS-SOLVED (UG/L AS ZN)	SEDI-MENT, SUS-PENDED (MG/L)	SEDI-MENT, DIS-CHARGE, SUS-PENDED (T/DAY)
MAR 1980										
14...	--	--	--	--	--	--	--	--	36	5.0
APR										
24...	60	50	<0.5	<0.1	<1	<1	20	<4	10	0.24
MAY										
21...	110	100	--	--	--	--	--	--	10	0.04
JUL										
24...	230	200	--	--	--	--	--	--	20	0.01
AUG										
27...	310	260	--	<0.1	--	<1	--	<4	16	0.01
SEP										
25...	160	150	<0.5	<0.1	<1	<1	10	<4	18	0.02
OCT										
23...	190	180	--	<0.1	--	<1	--	<4	5	0.0

Table 14.--Cont'd

12026570 - SOUTH HANAFORD CK. NR. CENTRALIA, WASHINGTON, SITE G'

DATE	TIME	STREAM-FLOW, INSTANTANEOUS (FT^3/S)	SPECIFIC CONDUCTANCE (US/CM)	PH (STANDARD UNITS)	TEMPERATURE (DEG C)	TURBIDITY (NTU)	OXYGEN, DISSOLVED (MG/L)	HARDNESS (MG/L AS $CACO_3$)	HARDNESS, NONCARBONATE (MG/L $CACO_3$)	ACIDITY (MG/L AS $CACO_3$)	CALCIUM DISSOLVED (MG/L AS CA)
MAR 1980											
14...	16:45	--	128	6.8	7.5	8.0	11.8	--	--	5.0	--
APR											
24...	16:45	21	118	6.7	14.0	7.0	--	37	8	14	10
MAY											
21...	17:45	1.6	167	6.9	16.0	7.0	4.4	61	6	14	17
JUL											
24...	15:00	0.2	271	7.1	18.0	3.0	3.0	84	0	17	24
AUG											
27...	17:00	0.09	309	7.4	17.0	20	8.3	100	0	10	28
SEP											
25...	17:15	1.2	268	7.3	17.5	25	8.4	78	17	11	22
OCT											
23...	15:00	0.59	310	7.1	7.0	20	12.2	81	14	5.0	23

DATE	MAGNESIUM, DISSOLVED (MG/L AS MG)	SODIUM, DISSOLVED (MG/L AS NA)	PERCENT SODIUM	SODIUM ADSORPTION RATIO	POTASSIUM, DISSOLVED (MG/L AS K)	ALKALINITY FIELD (MG/L AS $CACO_3$)	SULFATE DISSOLVED (MG/L AS SO_4)	CHLORIDE, DISSOLVED (MG/L AS CL)	FLUORIDE, DISSOLVED (MG/L AS F)	SILICA, DISSOLVED (MG/L AS SIO_2)	SOLIDS, RESIDUE AT 180 DEG. C DISSOLVED (MG/L)
MAR 1980											
14...	--	--	--	--	--	24	--	--	--	--	--
APR											
24...	3.0	8.3	32	0.6	0.7	29	19	5.4	0.1	9.4	90
MAY											
21...	4.6	13	31	0.7	0.9	55	23	14	0.1	12	125
JUL											
24...	5.8	19	33	0.9	1.0	96	8.2	21	0.2	12	168
AUG											
27...	8.0	27	36	1	2.1	119	10	25	0.2	25	233
SEP											
25...	5.5	22	37	1	1.9	61	26	30	0.1	17	184
OCT											
23...	5.8	23	37	1	2.0	67	20	37	0.1	15	187

Table 14.--Cont'd

12026570 - SOUTH HANAFORD CK. NR. CENTRALIA, WASHINGTON, SITE G'

DATE	SOLIDS, DIS-SOLVED (TONS PER AC-FT)	SOLIDS, DIS-SOLVED (TONS PER DAY)	NITRO-GEN, NO2+NO3 TOTAL (MG/L AS N)	PHOS-PHORUS, TOTAL (MG/L AS P)	ALUM-INUM, TOTAL RECOV-ERABLE (UG/L AS AL)	ALUM-INUM, DIS-SOLVED (UG/L AS AL)	ARSENIC TOTAL (UG/L AS AS)	ARSENIC DIS-SOLVED (UG/L AS AS)	CADMIUM TOTAL RECOV-ERABLE (UG/L AS CD)	CADMIUM DIS-SOLVED (UG/L AS CD)
MAR 1980										
14...	--	--	--	--	--	--	--	--	--	--
APR										
24...	0.12	5.1	0.72	0.06	100	<100	1	1	1	<1
MAY										
21...	0.17	0.54	0.19	0.09	--	--	--	--	--	--
JUL										
24...	0.23	0.09	0.00	0.08	--	--	--	--	--	--
AUG										
27...	0.32	0.06	0.51	0.20	--	200	--	1	--	<1
SEP										
25...	0.25	0.6	0.85	0.23	500	100	2	1	<1	<1
OCT										
23...	0.25	0.3	0.49	0.05	--	300	--	1	--	<1

DATE	CHRO-MIUM, TOTAL RECOV-ERABLE (UG/L AS CR)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	COBALT, TOTAL RECOV-ERABLE (UG/L AS CO)	COBALT, DIS-SOLVED (UG/L AS CO)	COPPER, TOTAL RECOV-ERABLE (UG/L AS CU)	COPPER, DIS-SOLVED (UG/L AS CU)	IRON, TOTAL RECOV-ERABLE (UG/L AS FE)	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, TOTAL RECOV-ERABLE (UG/L AS PB)	LEAD, DIS-SOLVED (UG/L AS PB)
MAR 1980										
14...	--	--	--	--	--	--	--	--	--	--
APR										
24...	3	<10	<50	<3	5	1	2200	930	<1	2
MAY										
21...	--	--	--	--	--	--	2600	580	--	--
JUL										
24...	--	--	--	--	--	--	2400	1100	--	--
AUG										
27...	--	<10	--	5	--	1	4200	210	--	5
SEP										
25...	3	<10	<50	4	5	2	4800	460	2	2
OCT										
23...	--	<10	--	6	--	1	3900	980	--	2

Table 14.--Cont'd

12026570 - SOUTH HANAFORD CK. NR. CENTRALIA, WASHINGTON, SITE G'

DATE	MANGANESE, TOTAL RECOVERABLE (UG/L AS MN)	MANGANESE, DISSOLVED (UG/L AS MN)	MERCURY TOTAL RECOVERABLE (UG/L AS HG)	MERCURY DISSOLVED (UG/L AS HG)	SELENIUM, TOTAL (UG/L AS SE)	SELENIUM, DISSOLVED (UG/L AS SE)	ZINC, TOTAL RECOVERABLE (UG/L AS ZN)	ZINC, DISSOLVED (UG/L AS ZN)	SEDIMENT, SUSPENDED (MG/L)	SEDIMENT, DISCHARGE, SUSPENDED (T/DAY)
MAR 1980										
14...	--	--	--	--	--	--	--	--	--	--
APR										
24...	180	170	<0.5	<0.1	<1	<1	20	4	14	0.79
MAY										
21...	410	390	--	--	--	--	--	--	8	0.03
JUL										
24...	6600	5700	--	--	--	--	--	--	12	0.01
AUG										
27...	1200	1100	--	<0.1	--	<1	--	<4	32	0.01
SEP										
25...	700	650	<0.5	<0.1	<1	<1	10	<4	18	0.06
OCT										
23...	630	610	--	<0.1	--	<1	--	5	18	0.03

Table 14.--Cont'd

12027100 - LINCOLN CK. ABV. SPONENBERGH CK. NR. GALVIN, WASHINGTON, SITE H

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	SPE-CIFIC CON-DUCT-ANCE (US/CM)	PH (STAND-ARD UNITS)	TEMPER-ATURE (DEG C)	TUR-BID-ITY (NTU)	OXYGEN, DIS-SOLVED (MG/L)	HARD-NESS (MG/L AS $CACO_3$)	HARD-NESS, NONCAR-BONATE (MG/L $CACO_3$)	ACIDITY (MG/L AS $CACO_3$)	CALCIUM DIS-SOLVED (MG/L AS CA)
MAR 1980											
13...	08:45	--	63	7.3	5.5	20	--	--	--	6.0	--
APR											
25...	12:45	57	71	7.1	11.0	4.0	9.6	23	0	3.0	5.9
MAY											
22...	07:15	5.0	74	7.3	12.5	5.0	6.4	26	0	2.0	6.4
JUL											
25...	07:35	2.0	99	7.2	17.0	4.0	4.8	34	0	5.0	8.0
AUG											
28...	06:30	0.05	114	7.1	14.0	7.0	3.9	40	1	8.0	9.7
SEP											
26...	07:35	1.4	93	7.1	12.0	5.0	5.2	33	0	8.0	8.0
OCT											
24...	10:45	0.0	105	7.0	8.0	4.0	5.6	--	--	5.0	--

DATE	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)	PERCENT SODIUM	SODIUM AD-SORP-TION RATIO	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	ALKA-LINITY FIELD (MG/L AS $CACO_3$)	SULFATE DIS-SOLVED (MG/L AS SO_4)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SILICA, DIS-SOLVED (MG/L AS SIO_2)	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L)
MAR 1980											
13...	--	--	--	--	--	18	--	--	--	--	--
APR											
25...	2.1	5.2	32	0.5	0.4	29	<5.0	4.2	0.1	14	51
MAY											
22...	2.4	5.6	32	0.5	0.5	29	<5.0	5.0	<0.1	15	62
JUL											
25...	3.3	7.0	31	0.5	0.8	36	8.4	6.5	0.1	15	75
AUG											
28...	3.9	8.5	31	0.6	1.0	45	<5.0	8.9	0.1	15	94
SEP											
26...	3.2	6.5	29	0.5	0.9	36	<5.0	6.6	0.1	17	67
OCT											
24...	--	--	--	--	--	38	<5.0	6.8	0.1	--	74

Table 14.--Cont'd

12027100 - LINCOLN CK. ABV. SPONENBERGH CK. NR. GALVIN, WASHINGTON, SITE H

DATE	SOLIDS, DIS-SOLVED (TONS PER AC-FT)	SOLIDS, DIS-SOLVED (TONS PER DAY)	NITRO-GEN, NO2+NO3 TOTAL (MG/L AS N)	PHOS-PHORUS, TOTAL (MG/L AS P)	ALUM-INUM, TOTAL RECOV-ERABLE (UG/L AS AL)	ALUM-INUM, DIS-SOLVED (UG/L AS AL)	ARSENIC TOTAL (UG/L AS AS)	ARSENIC DIS-SOLVED (UG/L AS AS)	CADMIUM TOTAL RECOV-ERABLE (UG/L AS CD)	CADMIUM DIS-SOLVED (UG/L AS CD)
MAR 1980										
13...	--	--	--	--	--	--	--	--	--	--
APR										
25...	0.07	7.9	0.37	0.06	380	200	<1	<1	1	<1
MAY										
22...	0.08	0.84	0.25	0.06	--	--	--	--	--	--
JUL										
25...	0.1	0.41	0.06	0.10	--	--	--	--	--	--
AUG										
28...	0.13	0.01	0.14	0.14	--	200	--	1	--	<1
SEP										
26...	0.09	0.25	0.10	0.15	200	<100	2	1	<1	<1
OCT										
24...	0.1	0.0	0.05	0.08	--	--	--	--	--	--

DATE	CHRO-MIUM, TOTAL RECOV-ERABLE (UG/L AS CR)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	COBALT, TOTAL RECOV-ERABLE (UG/L AS CO)	COBALT, DIS-SOLVED (UG/L AS CO)	COPPER, TOTAL RECOV-ERABLE (UG/L AS CU)	COPPER, DIS-SOLVED (UG/L AS CU)	IRON, TOTAL RECOV-ERABLE (UG/L AS FE)	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, TOTAL RECOV-ERABLE (UG/L AS PB)	LEAD, DIS-SOLVED (UG/L AS PB)
MAR 1980										
13...	--	--	--	--	--	--	--	--	--	--
APR										
25...	2	<10	<50	<3	4	6	950	330	2	1
MAY										
22...	--	--	--	--	--	--	1100	210	--	--
JUL										
25...	--	--	--	--	--	--	1100	460	--	--
AUG										
28...	--	<10	--	<3	--	2	1900	770	--	4
SEP										
26...	5	<10	50	<3	5	2	1100	530	<1	3
OCT										
24...	--	--	--	--	--	--	920	--	--	--

12027100 - LINCOLN CK. ABV. SPONENBERGH CK. NR GALVIN, WASHINGTON, SITE H

DATE	MANGANESE, TOTAL RECOVERABLE (UG/L AS MN)	MANGANESE, DISSOLVED (UG/L AS MN)	MERCURY TOTAL RECOVERABLE (UG/L AS HG)	MERCURY DISSOLVED (UG/L AS HG)	SELENIUM, TOTAL (UG/L AS SE)	SELENIUM, DISSOLVED (UG/L AS SE)	ZINC, TOTAL RECOVERABLE (UG/L AS ZN)	ZINC, DISSOLVED (UG/L AS ZN)	SEDIMENT, SUSPENDED (MG/L)	SEDIMENT, DISCHARGE, SUSPENDED (T/DAY)
MAR 1980										
13...	--	--	--	--	--	--	--	--	--	--
APR										
25...	70	40	<0.5	<0.1	<1	<1	40	<4	14	2.2
MAY										
22...	30	20	--	--	--	--	--	--	11	0.15
JUL										
25...	60	60	--	--	--	--	--	--	13	0.07
AUG										
28...	130	90	--	<0.1	--	<1	--	<4	26	0.0
SEP										
26...	60	30	<0.5	<0.1	<1	<1	10	<4	10	0.04
OCT										
24...	30	--	--	--	--	--	--	--	6	0.0

Table 14.--Cont'd

12027220 - LINCOLN CK. NR. GALVIN, WASHINGTON, SITE H'

DATE	TIME	STREAMFLOW, INSTANTANEOUS (FT^3/S)	SPECIFIC CONDUCTANCE (US/CM)	PH (STANDARD UNITS)	TEMPERATURE (DEG C)	TURBIDITY (NTU)	OXYGEN, DISSOLVED (MG/L)	HARDNESS (MG/L AS $CACO_3$)	HARDNESS, NONCARBONATE (MG/L $CACO_3$)	ACIDITY (MG/L AS $CACO_3$)	CALCIUM DISSOLVED (MG/L AS CA)
MAR 1980											
13...	10:00	--	66	7.0	5.5	7.0	--	--	--	5.0	--
APR											
25...	15:45	61	74	7.0	12.0	5.0	9.9	24	0	3.0	5.8
MAY											
22...	09:20	20	80	7.3	12.5	7.0	8.8	26	0	2.0	6.4
JUL											
25...	10:00	2.5	106	7.2	18.0	5.0	4.6	35	0	11	8.6
AUG											
28...	08:30	0.0	144	6.9	14.0	4.0	1.7	51	2	17	12
SEP											
26...	09:50	2.4	106	7.0	12.5	8.0	6.3	37	0	12	8.7
OCT											
24...	12:45	0.0	114	6.9	8.0	5.0	4.4	38	0	6.0	9.3

DATE	MAGNESIUM, DISSOLVED (MG/L AS MG)	SODIUM, DISSOLVED (MG/L AS NA)	PERCENT SODIUM	SODIUM ADSORPTION RATIO	POTASSIUM, DISSOLVED (MG/L AS K)	ALKALINITY FIELD (MG/L AS $CACO_3$)	SULFATE DISSOLVED (MG/L AS SO_4)	CHLORIDE, DISSOLVED (MG/L AS CL)	FLUORIDE, DISSOLVED (MG/L AS F)	SILICA, DISSOLVED (MG/L AS SIO_2)	SOLIDS, RESIDUE AT 180 DEG. C DISSOLVED (MG/L)
MAR 1980											
13...	--	--	--	--	--	20	--	--	--	--	--
APR											
25...	2.4	5.1	31	0.5	0.5	28	<5.0	3.8	0.1	13	52
MAY											
22...	2.5	5.9	32	0.5	0.6	30	<5.0	5.8	0.1	16	64
JUL											
25...	3.4	7.4	30	0.6	1.0	42	<5.0	6.3	0.2	17	81
AUG											
28...	5.1	9.0	27	0.6	1.5	59	<5.0	7.9	0.1	20	94
SEP											
26...	3.6	7.5	30	0.6	1.2	40	<5.0	7.4	0.1	17	71
OCT											
24...	3.7	6.7	27	0.5	1.3	46	<5.0	7.0	0.1	17	82

Table 14.--Cont'd

12027220 - LINCOLN CK. NR. GALVIN, WASHINGTON, SITE H'

DATE	SOLIDS, DIS-SOLVED (TONS PER AC-FT)	SOLIDS, DIS-SOLVED (TONS PER DAY)	NITRO-GEN, NO2+NO3 TOTAL (MG/L AS N)	PHOS-PHORUS, TOTAL (MG/L AS P)	ALUM-INUM, TOTAL RECOV-ERABLE (UG/L AS AL)	ALUM-INUM, DIS-SOLVED (UG/L AS AL)	ARSENIC TOTAL (UG/L AS AS)	ARSENIC DIS-SOLVED (UG/L AS AS)	CADMIUM TOTAL RECOV-ERABLE (UG/L AS CD)	CADMIUM DIS-SOLVED (UG/L AS CD)
MAR 1980										
13...	--	--	--	--	--	--	--	--	--	--
APR										
25...	0.07	8.6	0.29	0.06	1600	500	<1	<1	1	<1
MAY										
22...	0.09	3.5	0.26	0.07	--	--	--	--	--	--
JUL										
25...	0.11	0.55	0.12	0.11	--	--	--	--	--	--
AUG										
28...	0.14	0.0	0.29	0.12	--	200	--	2	--	<1
SEP										
26...	0.1	0.46	0.15	0.20	200	<100	2	1	<1	<1
OCT										
24...	0.11	0.0	0.10	0.12	--	400	--	1	--	<1

DATE	CHRO-MIUM, TOTAL RECOV-ERABLE (UG/L AS CR)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	COBALT, TOTAL RECOV-ERABLE (UG/L AS CO)	COBALT, DIS-SOLVED (UG/L AS CO)	COPPER, TOTAL RECOV-ERABLE (UG/L AS CU)	COPPER, DIS-SOLVED (UG/L AS CU)	IRON, TOTAL RECOV-ERABLE (UG/L AS FE)	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, TOTAL RECOV-ERABLE (UG/L AS PB)	LEAD, DIS-SOLVED (UG/L AS PB)
MAR 1980										
13...	--	--	--	--	--	--	--	--	--	--
APR										
25...	5	<10	<50	<3	7	2	420	440	2	1
MAY										
22...	--	--	--	--	--	--	1200	200	--	--
JUL										
25...	--	--	--	--	--	--	1200	340	--	--
AUG										
28...	--	<10	--	3	--	1	1200	350	--	2
SEP										
26...	6	<10	<50	<3	5	2	1200	640	3	2
OCT										
24...	--	<10	--	<3	--	2	1300	460	--	1

Table 14.--Cont'd

12027220 -LINCOLN CK. NR. GALVIN, WASHINGTON, SITE H'

DATE	MANGA-NESE, TOTAL RECOV-ERABLE (UG/L AS MN)	MANGA-NESE, DIS-SOLVED (UG/L AS MN)	MERCURY TOTAL RECOV-ERABLE (UG/L AS HG)	MERCURY DIS-SOLVED (UG/L AS HG)	SELE-NIUM, TOTAL (UG/L AS SE)	SELE-NIUM, DIS-SOLVED (UG/L AS SE)	ZINC, TOTAL RECOV-ERABLE (UG/L AS ZN)	ZINC, DIS-SOLVED (UG/L AS ZN)	SEDI-MENT, SUS-PENDED (MG/L)	SEDI-MENT, DIS-CHARGE, SUS-PENDED (T/DAY)
MAR 1980										
13...	--	--	--	--	--	--	--	--	--	--
APR										
25...	100	40	<0.5	<0.1	<1	<1	30	<4	10	1.6
MAY										
22...	40	30	--	--	--	--	--	--	13	0.7
JUL										
25...	150	130	--	--	--	--	--	--	10	0.07
AUG										
28...	370	340	--	<0.1	--	<1	--	7	9	0.0
SEP										
26...	90	60	<0.5	<0.1	<1	<1	10	<4	11	0.07
OCT										
24...	100	90	--	<0.1	--	<1	--	6	9	0.0

Table 14.--Cont'd

12026533 - PACKWOOD CK. ABV. MINING SITE NR. KOPIAH, WASHINGTON, SITE I

DATE	TIME	STREAMFLOW, INSTANTANEOUS (FT^3/S)	SPECIFIC CONDUCTANCE (US/CM)	PH (STANDARD UNITS)	TEMPERATURE (DEG C)	TURBIDITY (NTU)	OXYGEN, DISSOLVED (MG/L)	HARDNESS (MG/L AS $CACO_3$)	HARDNESS, NONCARBONATE (MG/L $CACO_3$)	ACIDITY (MG/L AS $CACO_3$)	CALCIUM DISSOLVED (MG/L AS CA)
MAY 1980											
22...	13:30	0.3	160	7.2	16.0	6.0	10.2	38	0	4.0	10
JUL											
24...	11:30	0.0	--	--	--	--	--	--	--	--	--
AUG											
27...	07:30	0.29	265	7.6	17.0	3.0	6.8	65	0	10	17
SEP											
25...	11:45	0.15	303	7.0	15.5	5.0	3.5	75	0	32	20
OCT											
21...	16:30	0.06	298	6.9	11.5	8.0	6.1	71	0	24	19

DATE	MAGNESIUM, DISSOLVED (MG/L AS MG)	SODIUM, DISSOLVED (MG/L AS NA)	PERCENT SODIUM	SODIUM ADSORPTION RATIO	POTASSIUM, DISSOLVED (MG/L AS K)	ALKALINITY FIELD (MG/L AS $CACO_3$)	SULFATE DISSOLVED (MG/L AS SO_4)	CHLORIDE, DISSOLVED (MG/L AS CL)	FLUORIDE, DISSOLVED (MG/L AS F)	SILICA, DISSOLVED (MG/L AS SIO_2)	SOLIDS, RESIDUE AT 180 DEG. C DISSOLVED (MG/L)
MAY 1980											
22...	3.1	20	52	1	1.7	38	43	3.8	0.1	3.8	118
JUL											
24...	--	--	--	--	--	--	--	--	--	--	--
AUG											
27...	5.4	33	51	2	2.7	91	47	4.4	0.1	7.6	181
SEP											
25...	6.1	36	50	2	3.3	106	51	5.2	0.1	9.1	196
OCT											
21...	5.8	30	46	2	3.8	115	31	5.2	0.1	9.4	187

Table 14.--Cont'd

12026533 PACKWOOD CK. ABV. MINING SITE NR. KOPIAH, WASHINGTON, SITE I

DATE	SOLIDS, DIS-SOLVED (TONS PER AC-FT)	SOLIDS, DIS-SOLVED (TONS PER DAY)	NITRO-GEN, NO2+NO3 TOTAL (MG/L AS N)	PHOS-PHORUS, TOTAL (MG/L AS P)	ALUM-INUM, TOTAL RECOV-ERABLE (UG/L AS AL)	ALUM-INUM, DIS-SOLVED (UG/L AS AL)	ARSENIC TOTAL (UG/L AS AS)	ARSENIC DIS-SOLVED (UG/L AS AS)	CADMIUM TOTAL RECOV-ERABLE (UG/L AS CD)	CADMIUM DIS-SOLVED (UG/L AS CD)
MAY 1980										
22...	0.16	0.1	0.01	0.05	--	--	--	--	--	--
JUL										
24...	--	--	--	--	--	--	--	--	--	--
AUG										
27...	0.25	0.14	0.00	0.04	--	100	--	1	--	<1
SEP										
25...	0.27	0.08	0.07	0.08	200	<100	2	1	<1	<1
OCT										
21...	0.25	0.03	0.27	0.04	--	200	--	1	--	<1

DATE	CHRO-MIUM, TOTAL RECOV-ERABLE (UG/L AS CR)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	COBALT, TOTAL RECOV-ERABLE (UG/L AS CO)	COBALT, DIS-SOLVED (UG/L AS CO)	COPPER, TOTAL RECOV-ERABLE (UG/L AS CU)	COPPER, DIS-SOLVED (UG/L AS CU)	IRON, TOTAL RECOV-ERABLE (UG/L AS FE)	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, TOTAL RECOV-ERABLE (UG/L AS PB)	LEAD, DIS-SOLVED (UG/L AS PB)
MAY 1980										
22...	--	--	--	--	--	--	710	60	--	--
JUL										
24...	--	--	--	--	--	--	--	--	--	--
AUG										
27...	--	<10	--	5	--	<1	2300	2100	--	3
SEP										
25...	5	<10	50	<3	3	<1	3300	2500	2	2
OCT										
21...	--	<10	--	<3	--	<1	4300	1200	--	1

Table 14.--Cont'd

12026533 - PACKWOOD CK. ABV. MINING SITE NR. KOPIAH, WASHINGTON, SITE I

DATE	MANGANESE, TOTAL RECOVERABLE (UG/L AS MN)	MANGANESE, DISSOLVED (UG/L AS MN)	MERCURY TOTAL RECOVERABLE (UG/L AS HG)	MERCURY DISSOLVED (UG/L AS HG)	SELENIUM, TOTAL (UG/L AS SE)	SELENIUM, DISSOLVED (UG/L AS SE)	ZINC, TOTAL RECOVERABLE (UG/L AS ZN)	ZINC, DISSOLVED (UG/L AS ZN)	SEDIMENT, SUSPENDED (MG/L)	SEDIMENT, DISCHARGE, SUSPENDED (T/DAY)
MAY 1980										
22...	110	50	--	--	--	--	--	--	18	0.02
JUL										
24...	--	--	--	--	--	--	--	--	--	--
AUG										
27...	630	590	--	<0.1	--	<1	--	5	8	0.01
SEP										
25...	1800	1700	<0.5	<0.1	<1	<1	30	6	11	0.0
OCT										
21...	2200	2100	--	<0.1	--	<1	--	6	28	0.0

Table 14.--Cont'd

12026540 - PACKWOOD CK. ABV. STEAMPLANT NR. BUCODA, WASHINGTON, SITE I'

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (FT^3/S)	SPE-CIFIC CON-DUCT-ANCE (US/CM)	PH (STAND-ARD UNITS)	TEMPER-ATURE (DEG C)	TUR-BID-ITY (NTU)	OXYGEN, DIS-SOLVED (MG/L)	HARD-NESS (MG/L AS CACO$_3$)	HARD-NESS, NONCAR-BONATE (MG/L CACO$_3$)	ACIDITY (MG/L AS CACO$_3$)	CALCIUM DIS-SOLVED (MG/L AS CA)
MAR 1980											
14...	12:45	--	412	7.2	7.0	15	11.8	--	--	4.0	--
APR											
24...	11:30	15	278	7.4	13.0	3.0	--	93	61	5.0	26
MAY											
22...	16:00	1.5	262	7.5	14.5	6.0	9.0	81	24	3.0	22
JUL											
24...	11:45	0.15	320	7.2	19.0	4.0	5.3	100	7	10	28
AUG											
27...	09:30	0.63	1780	7.3	17.5	2.0	5.7	440	380	10	120
SEP											
25...	13:30	1.6	1430	7.5	15.0	4.0	8.8	370	290	12	100
OCT											
21...	17:30	0.83	1450	6.9	12.0	2.0	9.4	360	280	10	100

DATE	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)	PERCENT SODIUM	SODIUM AD-SORP-TION RATIO	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	ALKA-LINITY FIELD (MG/L AS CACO$_3$)	SULFATE DIS-SOLVED (MG/L AS SO$_4$)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SILICA, DIS-SOLVED (MG/L AS SIO$_2$)	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L)
MAR 1980											
14...	--	--	--	--	--	28	--	--	--	--	--
APR											
24...	6.9	21	33	1	1.1	32	98	2.4	0.1	7.8	187
MAY											
22...	6.3	22	37	1	0.9	57	67	2.4	0.1	5.2	171
JUL											
24...	8.2	27	36	1	1.1	97	65	2.6	0.2	11	216
AUG											
27...	34	190	48	4	6.7	55	770	4.1	0.3	2.5	1350
SEP											
25...	28	180	51	4	5.0	73	650	5.6	0.2	5.6	1060
OCT											
21...	27	170	50	4	4.3	78	650	5.2	0.2	5.8	1030

Table 14.--Cont'd

12026540 - PACKWOOD CK. ABV. STEAMPLANT NR BUCODA, WASHINGTON, SITE I'

DATE	SOLIDS, DIS- SOLVED (TONS PER AC-FT)	SOLIDS, DIS- SOLVED (TONS PER DAY)	NITRO- GEN, NO2+NO3 TOTAL (MG/L AS N)	PHOS- PHORUS, TOTAL (MG/L AS P)	ALUM- INUM, TOTAL RECOV- ERABLE (UG/L AS AL)	ALUM- INUM, DIS- SOLVED (UG/L AS AL)	ARSENIC TOTAL (UG/L AS AS)	ARSENIC DIS- SOLVED (UG/L AS AS)	CADMIUM TOTAL RECOV- ERABLE (UG/L AS CD)	CADMIUM DIS- SOLVED (UG/L AS CD)
MAR 1980										
14...	--	--	--	--	--	--	--	--	--	--
APR										
24...	0.25	7.6	0.46	0.01	<100	<100	<1	<1	<1	<1
MAY										
22...	0.23	0.69	0.16	0.03	--	--	--	--	--	--
JUL										
24...	0.29	0.09	0.17	0.08	--	--	--	--	--	--
AUG										
27...	1.8	2.3	0.04	0.02	--	100	--	1	--	2
SEP										
25...	1.4	4.6	0.14	0.05	200	<100	1	1	<1	<1
OCT										
21...	1.4	2.3	0.21	0.02	--	400	--	1	--	<1

DATE	CHRO- MIUM, TOTAL RECOV- ERABLE (UG/L AS CR)	CHRO- MIUM, DIS- SOLVED (UG/L AS CR)	COBALT, TOTAL RECOV- ERABLE (UG/L AS CO)	COBALT, DIS- SOLVED (UG/L AS CO)	COPPER, TOTAL RECOV- ERABLE (UG/L AS CU)	COPPER, DIS- SOLVED (UG/L AS CU)	IRON, TOTAL RECOV- ERABLE (UG/L AS FE)	IRON, DIS- SOLVED (UG/L AS FE)	LEAD, TOTAL RECOV- ERABLE (UG/L AS PB)	LEAD, DIS- SOLVED (UG/L AS PB)
MAR 1980										
14...	--	--	--	--	--	--	--	--	--	--
APR										
24...	6	<10	<50	<3	4	1	490	120	2	<1
MAY										
22...	--	--	--	--	--	--	1300	370	--	--
JUL										
24...	--	--	--	--	--	--	1400	580	--	--
AUG										
27...	--	10	--	4	--	<1	400	120	--	3
SEP										
25...	5	<10	50	<3	3	1	480	90	1	3
OCT										
21...	--	<10	--	<3	--	1	520	70	--	1

Table 14.--Cont'd

12026540 - PACKWOOD CK. ABV. STEAMPLANT NR. BUCODA, WASHINGTON, SITE I'

DATE	MANGANESE, TOTAL RECOVERABLE (UG/L AS MN)	MANGANESE, DISSOLVED (UG/L AS MN)	MERCURY TOTAL RECOVERABLE (UG/L AS HG)	MERCURY DISSOLVED (UG/L AS HG)	SELENIUM, TOTAL (UG/L AS SE)	SELENIUM, DISSOLVED (UG/L AS SE)	ZINC, TOTAL RECOVERABLE (UG/L AS ZN)	ZINC, DISSOLVED (UG/L AS ZN)	SEDIMENT, SUSPENDED (MG/L)	SEDIMENT, DISCHARGE, SUSPENDED (T/DAY)
MAR 1980										
14...	--	--	--	--	--	--	--	--	--	--
APR										
24...	120	100	<0.5	<0.1	<1	<1	30	<4	8	0.32
MAY										
22...	330	320	--	--	--	--	--	--	7	0.03
JUL										
24...	430	420	--	--	--	--	--	--	11	0.0
AUG										
27...	500	480	--	<0.1	--	<1	--	5	7	0.01
SEP										
25...	240	190	<0.5	<0.1	<1	<1	10	5	4	0.02
OCT										
21...	220	190	--	<0.1	--	<1	--	9	1	0.0

Table 14.--Cont'd

14242592 · CLINE CK. AT WILKES HILLS NR. SILVER LAKE, WASHINGTON, SITE J

DATE	TIME	STREAMFLOW, INSTANTANEOUS (FT^3/S)	SPECIFIC CONDUCTANCE (US/CM)	PH (STANDARD UNITS)	TEMPERATURE (DEG C)	TURBIDITY (NTU)	OXYGEN, DISSOLVED (MG/L)	HARDNESS (MG/L AS $CACO_3$)	HARDNESS, NONCARBONATE (MG/L $CACO_3$)	ACIDITY (MG/L AS $CACO_3$)	CALCIUM DISSOLVED (MG/L AS CA)
APR 1980											
23...	11:20	0.6	30	6.6	8.0	10	11.6	11	3	5.0	2.5
JUL											
22...	09:45	0.02	120	7.1	13.0	5.0	8.8	38	0	6.0	8.4
AUG											
26...	08:45	0.01	130	7.4	10.0	5.0	6.0	37	0	6.0	8.1
SEP											
24...	08:00	0.02	126	7.4	10.0	6.0	8.7	39	0	9.0	8.5
OCT											
21...	07:30	0.01	113	7.1	7.0	5.0	7.5	38	0	6.0	8.4

DATE	MAGNESIUM, DISSOLVED (MG/L AS MG)	SODIUM, DISSOLVED (MG/L AS NA)	PERCENT SODIUM	SODIUM ADSORPTION RATIO	POTASSIUM, DISSOLVED (MG/L AS K)	ALKALINITY FIELD (MG/L AS $CACO_3$)	SULFATE DISSOLVED (MG/L AS SO_4)	CHLORIDE, DISSOLVED (MG/L AS CL)	FLUORIDE, DISSOLVED (MG/L AS F)	SILICA, DISSOLVED (MG/L AS SIO_2)	SOLIDS, RESIDUE AT 180 DEG. C DISSOLVED (MG/L)
APR 1980											
23...	1.2	3.6	40	0.5	0.5	8	<5.0	2.6	0.1	15	45
JUL											
22...	4.1	12	40	0.9	1.3	56	15	3.4	0.2	42	115
AUG											
26...	4.0	11	38	0.8	1.3	58	6.6	3.2	0.1	42	--
SEP											
24...	4.2	13	41	0.9	1.3	42	9.0	3.8	0.1	43	114
OCT											
21...	4.2	12	40	0.9	1.2	57	<5.0	3.4	0.1	43	105

Table 14.--Cont'd

142425952 -CLINE CK. AT WILKES HILLS NR. SILVER LAKE, WASHINGTON, SITE J

DATE	SOLIDS, DIS-SOLVED (TONS PER AC-FT)	SOLIDS, DIS-SOLVED (TONS PER DAY)	NITRO-GEN, NO2+NO3 TOTAL (MG/L AS N)	PHOS-PHORUS, TOTAL (MG/L AS P)	ALUM-INUM, TOTAL RECOV-ERABLE (UG/L AS AL)	ALUM-INUM, DIS-SOLVED (UG/L AS AL)	ARSENIC TOTAL (UG/L AS AS)	ARSENIC DIS-SOLVED (UG/L AS AS)	CADMIUM TOTAL RECOV-ERABLE (UG/L AS CD)	CADMIUM DIS-SOLVED (UG/L AS CD)
APR 1980										
23...	0.06	0.07	1.90	0.01	440	180	<1	<1	1	<1
JUL										
22...	0.16	0.01	0.10	0.03	--	--	--	--	--	--
AUG										
26...	0.15	0.0	0.08	0.03	--	100	--	1	--	<1
SEP										
24...	0.16	0.01	0.08	0.06	200	<100	2	1	<1	<1
OCT										
21...	0.14	0.0	0.04	0.06	--	300	--	1	--	<1

DATE	CHRO-MIUM, TOTAL RECOV-ERABLE (UG/L AS CR)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	COBALT, TOTAL RECOV-ERABLE (UG/L AS CO)	COBALT, DIS-SOLVED (UG/L AS CO)	COPPER, TOTAL RECOV-ERABLE (UG/L AS CU)	COPPER, DIS-SOLVED (UG/L AS CU)	IRON, TOTAL RECOV-ERABLE (UG/L AS FE)	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, TOTAL RECOV-ERABLE (UG/L AS PB)	LEAD, DIS-SOLVED (UG/L AS PB)
APR 1980										
23...	1	<10	<50	<3	4	1	510	170	2	<1
JUL										
22...	--	--	--	--	--	--	1200	610	--	--
AUG										
26...	--	<10	--	<3	--	<1	1300	730	--	3
SEP										
24...	5	<10	<50	<3	13	1	1400	890	2	2
OCT										
21...	--	<10	--	<3	--	<1	1400	810	--	3

Table 14.--Cont'd

14242592 - CLINE CK. AT WILKES HILLS NR. SILVER LAKE, WASHINGTON, SITE J

DATE	MANGANESE, TOTAL RECOVERABLE (UG/L AS MN)	MANGANESE, DISSOLVED (UG/L AS MN)	MERCURY TOTAL RECOVERABLE (UG/L AS HG)	MERCURY DISSOLVED (UG/L AS HG)	SELENIUM, TOTAL (UG/L AS SE)	SELENIUM, DISSOLVED (UG/L AS SE)	ZINC, TOTAL RECOVERABLE (UG/L AS ZN)	ZINC, DISSOLVED (UG/L AS ZN)	SEDIMENT, SUSPENDED (MG/L)	SEDIMENT, DISCHARGE, SUSPENDED (T/DAY)
APR 1980										
23...	20	10	<0.5	<0.1	<1	<1	80	6	10	0.02
JUL										
22...	80	70	--	--	--	--	--	--	14	0.0
AUG										
26...	100	80	--	<0.1	--	<1	--	<4	4	0.0
SEP										
24...	140	80	<0.5	<0.1	<1	<1	30	<4	10	0.0
OCT										
21...	80	80	--	<0.1	--	<1	--	<4	2	0.0

Table 14.--Cont'd

14242595 - CLINE CK. NR. MOUTH NR. SILVER LAKE, WASHINGTON, SITE J'

DATE	TIME	STREAM-FLOW, INSTANTANEOUS (FT^3/S)	SPECIFIC CONDUCTANCE (US/CM)	PH (STANDARD UNITS)	TEMPERATURE (DEG C)	TURBIDITY (NTU)	OXYGEN, DISSOLVED (MG/L)	HARDNESS (MG/L AS $CACO_3$)	HARDNESS, NONCARBONATE (MG/L $CACO_3$)	ACIDITY (MG/L AS $CACO_3$)	CALCIUM DISSOLVED (MG/L AS CA)
APR 1980											
23...	14:00	9.2	38	7.3	10.0	10	10.2	12	0	4.0	2.9
JUL											
22...	12:00	0.05	109	7.1	19.0	3.0	6.8	36	0	7.0	8.8
AUG											
26...	09:15	0.01	295	7.5	11.0	4.0	3.5	69	0	9.0	16
SEP											
24...	09:40	0.08	96	7.3	10.5	4.0	8.7	34	0	7.0	8.1
OCT											
21...	09:15	0.17	98	7.1	7.5	3.0	8.6	32	0	8.0	7.5

DATE	MAGNESIUM, DISSOLVED (MG/L AS MG)	SODIUM, DISSOLVED (MG/L AS NA)	PERCENT SODIUM	SODIUM ADSORPTION RATIO	POTASSIUM, DISSOLVED (MG/L AS K)	ALKALINITY FIELD (MG/L AS $CACO_3$)	SULFATE DISSOLVED (MG/L AS SO_4)	CHLORIDE, DISSOLVED (MG/L AS CL)	FLUORIDE, DISSOLVED (MG/L AS F)	SILICA, DISSOLVED (MG/L AS SIO_2)	SOLIDS, RESIDUE AT 180 DEG. C DISSOLVED (MG/L)
APR 1980											
23...	1.2	3.3	36	0.4	0.4	12	<5.0	2.3	0.1	15	42
JUL											
22...	3.5	8.3	32	0.6	1.4	50	<5.0	4.1	0.1	20	92
AUG											
26...	7.1	34	50	2	2.8	134	<5.0	15	0.1	23	212
SEP											
24...	3.3	7.8	32	0.6	1.7	44	<5.0	5.1	0.1	21	88
OCT											
21...	3.2	7.2	32	0.6	1.7	33	<5.0	4.9	0.1	21	86

Table 14.--Cont'd

12422595 - CLINE CK. NR. MOUTH NR. SILVER LAKE, WASHINGTON, SITE J'

DATE	SOLIDS, DIS-SOLVED (TONS PER AC-FT)	SOLIDS, DIS-SOLVED (TONS PER DAY)	NITRO-GEN, NO2+NO3 TOTAL (MG/L AS N)	PHOS-PHORUS, TOTAL (MG/L AS P)	ALUM-INUM, TOTAL RECOV-ERABLE (UG/L AS AL)	ALUM-INUM, DIS-SOLVED (UG/L AS AL)	ARSENIC TOTAL (UG/L AS AS)	ARSENIC DIS-SOLVED (UG/L AS AS)	CADMIUM TOTAL RECOV-ERABLE (UG/L AS CD)	CADMIUM DIS-SOLVED (UG/L AS CD)
APR 1980										
23...	0.06	1.0	0.99	0.02	330	100	<1	<1	1	<1
JUL										
22...	0.13	0.01	0.17	0.04	--	--	--	--	--	--
AUG										
26...	0.29	0.01	0.16	0.03	--	100	--	1	--	<1
SEP										
24...	0.12	0.02	0.18	0.05	100	<100	2	1	<1	<1
OCT										
21...	0.12	0.04	0.01	0.03	--	300	--	1	--	<1

DATE	CHRO-MIUM, TOTAL RECOV-ERABLE (UG/L AS CR)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	COBALT, TOTAL RECOV-ERABLE (UG/L AS CO)	COBALT, DIS-SOLVED (UG/L AS CO)	COPPER, TOTAL RECOV-ERABLE (UG/L AS CU)	COPPER, DIS-SOLVED (UG/L AS CU)	IRON, TOTAL RECOV-ERABLE (UG/L AS FE)	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, TOTAL RECOV-ERABLE (UG/L AS PB)	LEAD, DIS-SOLVED (UG/L AS PB)
APR 1980										
23...	3	<10	<50	<3	4	1	410	190	2	1
JUL										
22...	--	--	--	--	--	--	2400	1600	--	--
AUG										
26...	--	<10	--	<3	--	<1	1600	1200	--	4
SEP										
24...	6	<10	<50	<3	5	<1	2300	2000	3	3
OCT										
21...	--	<10	--	<3	--	1	2400	1900	--	1

Table 14.--Cont'd

14242595 - CLINE CK. NR. MOUTH NR. SILVER LAKE, WASHINGTON, SITE J'

DATE	MANGANESE, TOTAL RECOVERABLE (UG/L AS MN)	MANGANESE, DISSOLVED (UG/L AS MN)	MERCURY TOTAL RECOVERABLE (UG/L AS HG)	MERCURY DISSOLVED (UG/L AS HG)	SELENIUM, TOTAL (UG/L AS SE)	SELENIUM, DISSOLVED (UG/L AS SE)	ZINC, TOTAL RECOVERABLE (UG/L AS ZN)	ZINC, DISSOLVED (UG/L AS ZN)	SEDIMENT, SUSPENDED (MG/L)	SEDIMENT, DISCHARGE, SUSPENDED (T/DAY)
APR 1980										
23...	30	9	<0.5	0.1	<1	<1	30	4	8	0.2
JUL										
22...	70	30	--	--	--	--	--	--	2	0.0
AUG										
26...	460	390	--	<0.1	--	<1	--	<4	8	0.0
SEP										
24...	70	10	<0.5	<0.1	<1	<1	20	<4	4	0.0
OCT										
21...	20	10	--	<0.1	--	<1	--	<4	1	0.0

TABLE 15.--Summary of presence or absence data and taxonomic identifications of benthic invertebrates for the ten study basins

[A "+" represents presence and a blank space represents absence; sampling site locations are as follows: A, Coal Creek above East Fork Coal Creek near Longview; A', Coal Creek near Longview; B, Salmon Creek near Kid Valley; B', Salmon Creek above Little Salmon Creek near Toledo; C, Cedar Creek above Windom Mine near Toledo; C', Cedar Creek above North Fork Cedar Creek near Toledo; D, Foster Creek south of Smokey Valley near Vader; D', Foster Creek near mouth near Vader; E, Deep Creek above Carson Creek near Bunker; E', Deep Creek near mouth near Bunker; F, Hanaford Creek above Coal Creek near Bucoda; F', Hanaford Creek below Snyder Creek near Bucoda; G, South Hanaford Creek near Kopiah; G', South Hanaford Creek near Centralia; H, Lincoln Creek above Sponenbergh Creek near Galvin; H', Lincoln Creek near Galvin; I, Packwood Creek above mining site near Kopiah; I', Packwood Creek above steamplant near Bucoda; J, Cline Creek at Wilkes Hills near Silver Lake; J', Cline Creek near mouth near Silver Lake.]

	Sampling sites																			
Taxa	A	A'	B	B'	C	C'	D	D'	E	E'	F	F'	G	G'	H	H'	I	I'	J	J'
Phylum Arthropoda																				
Class Insecta																				
Order Ephemenoptera																				
Family Caenidae																				
Caenis sp.[1]				+											+					
Drunella flavilinea[1]		+	+		+	+			+	+	+									+
Drunella doddsi		+	+								+									
Ephemerella aurivilli[1]			+																	
Ephemerella infrequens[1]			+																	
Seratella tibialis	+	+	+		+	+		+	+	+	+	+								+
Attenella delantela	+	+	+								+	+								
Family Haptageniidae																				
Ironodes sp.	+																			
Iron sp.[1]	+	+	+	+				+			+									+
Iron longimanus[1]	+	+	+	+	+	+		+		+	+	+								+
Rhithrogena morrisoni[1]	+	+	+	+	+	+	+	+		+	+	+								
Cinygmula sp.[1]	+	+	+	+	+	+		+	+	+	+	+							+	+
Cinygma sp.	+	+	+	+	+	+	+	+	+	+			+						+	+
Family Leptophlebiidae																				
Pareleptophlebia debilis[1]	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Paraleptophlebia bicornuta[1]			+	+	+	+														
Family Siphlonuridae																				
Siphlonurus sp.													+	+	+	+		+		
Ameletus sp.	+	+	+		+	+		+	+		+	+	+	+	+				+	+
Family Baetidae																				
Baetis sp.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+
Pseudocloeon sp.[1]			+	+							+									
Order Plecoptera																				
Family Pteronarcidae																				
Pteronarcella regularis						+					+									
Pteronarcella badia			+		+				+	+	+									+
Yoraperla brevis																				+
Family Taeniopterygidae																				
Taenioptarix sp.			+	+	+	+		+	+			+						+		+
Taenionema (pallidum)			+	+	+	+		+	+	+	+	+						+		

TABLE 15.--Summary of presence or absence data and taxonomic identifications of benthic invertebrates for the ten study basins--continued

[A "+" represents presence and a blank space represents absence; sampling site locations are as follows: A, Coal Creek above East Fork Coal Creek near Longview; A', Coal Creek near Longview; B, Salmon Creek near Kid Valley; B', Salmon Creek above Little Salmon Creek near Toledo; C, Cedar Creek above Windom Mine near Toledo; C', Cedar Creek above North Fork Cedar Creek near Toledo; D, Foster Creek south of Smokey Valley near Vader; D', Foster Creek near mouth near Vadar; E, Deep Creek above Carson Creek near Bunker; E', Deep Creek near mouth near Bunker; F, Hanaford Creek above Coal Creek near Bucoda; F', Hanaford Creek below Snyder Creek near Bucoda; G, South Hanaford Creek near Kopiah; G', South Hanaford Creek near Centralia; H, Lincoln Creek above Sponenbergh Creek near Galvin; H', Lincoln Creek near Galvin; I, Packwood Creek above mining site near Kopiah; I', Packwood Creek above steamplant near Bucoda; J, Cline Creek at Wilkes Hills near Silver Lake; J', Cline Creek near mouth near Silver Lake.]

Taxa	Sampling sites																			
	A	A'	B	B'	C	C'	D	D'	E	E'	F	F'	G	G'	H	H'	I	I'	J	J'
Family Nemouridae																				
Zapada sp.	+	+	+	+	+	+	+	+	+	+	+			+	+	+	+	+	+	+
Malenka sp.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Soyedina sp.		+							+	+										
Nemoura sp.				+											+				+	
Family Capniidae																				
Capnia complex (jewetti)	+	+	+	+	+	+		+	+	+	+	+				+		+		+
Family Leuctridae																				
Despaxia augusta		+	+		+			+	+	+	+									
Paraleuctra occidentalis				+																
Paraleuctra vershina		+							+		+									
Family Perlidae																				
Calineuria californica	+	+	+	+	+	+		+	+	+	+	+								+
Hesperoperla pacifica	+	+						+			+	+								
Family Perlodidae																				
Subfamily Isoperlinae																				
Isoperla quinquepunctata		+	+	+	+	+		+	+	+	+		+							
Isoperla patricia												+		+		+		+	+	+
Subfamily Perlodinae																				
Perlinodes aurea			+																	
Skwala sp.	+	+	+	+	+	+			+	+	+								+	+
Kogotus sp.			+	+	+				+	+	+									
Family Chloroperlidae																				
Alloperla sp.	+	+	+	+	+	+		+	+	+	+	+							+	+
Sweltsa sp.	+		+								+									
Order Trichoptera																				
Family Hydropsychidae																				
Hydropsyche sp.[2]	+	+	+	+	+	+		+	+	+	+	+								+
Cheumatopsyche (molalla)[2]			+	+		+						+	+					+		
Family Hydroptilidae																				
Hydroptila sp.																				+
Family Glossosomatidae																				
Glossosoma spp. (penitum or traviatum)[2]	+	+	+	+	+	+		+	+	+	+	+							+	+
Agapetus sp.			+	+	+	+				+	+									

TABLE 15.--Summary of presence or absence data and taxonomic identifications of benthic invertebrates for the ten study basins--continued

[A "+" represents presence and a blank space represents absence; sampling site locations are as follows: A, Coal Creek above East Fork Coal Creek near Longview; A', Coal Creek near Longview; B, Salmon Creek near Kid Valley; B', Salmon Creek above Little Salmon Creek near Toledo; C, Cedar Creek above Windom Mine near Toledo; C', Cedar Creek above North Fork Cedar Creek near Toledo; D, Foster Creek south of Smokey Valley near Vadar; D', Foster Creek near mouth near Vader; E, Deep Creek above Carson Creek near Bunker; E', Deep Creek near mouth near Bunker; F, Hanaford Creek above Coal Creek near Bucoda; F', Hanaford Creek below Snyder Creek near Bucoda; G, South Hanaford Creek near Kopiah; G', South Hanaford Creek near Centralia; H, Lincoln Creek above Sponenbergh Creek near Galvin; H', Lincoln Creek near Galvin; I, Packwood Creek above mining site near Kopiah; I', Packwood Creek above steamplant near Bucoda; J, Cline Creek at Wilkes Hills near Silver Lake; J', Cline Creek near mouth near Silver Lake.]

	Sampling sites																			
Taxa	A	A'	B	B'	C	C'	D	D'	E	E'	F	F'	G	G'	H	H'	I	I'	J	J'
Family Rhyacophilidae																				
Philopotamoides Division																				
Hyalinata Group																				
Rhyacophila hyalinata-vocela[2]	+	+																		
Angelita Group																				
Rhyacophila angelita	+	+									+									
Sibirica Group																				
Rhyacophila blarina	+	+	+	+	+	+		+	+	+	+	+								+
Rhyacophila narvae[2]	+	+	+								+								+	
Rhyacophila valuma[2]	+										+									
Betteni Group																				
Rhyacophila chilsia	+	+	+	+	+			+	+	+	+	+								+
Rhyacophila vaccua	+	+	+							+		+								
Rhyacophila malkini[2]		+		+																
Divaricata Division																				
Acropedes Group																				
Rhyacophila acropedes[2]	+	+	+	+				+	+	+	+	+								+
Rhyacophila grandis							+												+	
Naviculata Division																				
Lieftincki Group																				
Rhyacohila arnaudi											+									+
Vulgaris Division																				
Rotunda Group																				
Rhyacophila norcuta[2]		+																		+
Family Philopotamidae																				
Wormaldia sp.[2]	+	+	+	+	+	+		+		+	+	+								+
Family Psychomyidae																				
Psychomyia lumia	+	+	+							+										
Family Brachycentridae																				
Micrasema sp.		+	+				+		+				+					+		+
Family Lepidostomatidae																				
Lepidostoma sp.		+		+	+	+	+	+	+	+			+	+	+	+		+		+

TABLE 15.--Summary of presence or absence data and taxonomic identifications of benthic invertebrates for the ten study basins--continued

[A "+" represents presence and a blank space represents absence; sampling site locations are as follows: A, Coal Creek above East Fork Coal Creek near Longview; A', Coal Creek near Longview; B, Salmon Creek near Kid Valley; B', Salmon Creek above Little Salmon Creek near Toledo; C, Cedar Creek above Windom Mine near Toledo; C', Cedar Creek above North Fork Cedar Creek near Toledo; D, Foster Creek south of Smokey Valley near Vader; D', Foster Creek near mouth near Vader; E, Deep Creek above Carson Creek near Bunker; E', Deep Creek near mouth near Bunker; F, Hanaford Creek above Coal Creek near Bucoda; F', Hanaford Creek below Snyder Creek near Bucoda; G, South Hanaford Creek near Kopiah; G', South Hanaford Creek near Centralia; H, Lincoln Creek above Sponenbergh Creek near Galvin; H', Lincoln Creek near Galvin; I, Packwood Creek above mining site near Kopiah; I', Packwood Creek above steamplant near Bucoda; J, Cline Creek at Wilkes Hills near Silver Lake; J', Cline Creek near mouth near Silver Lake.]

Taxa	Sampling sites																			
	A	A'	B	B'	C	C'	D	D'	E	E'	F	F'	G	G'	H	H'	I	I'	J	J'
Family Limnephilidae																				
Subfamily Goerinae																				
Goera archaon				+																
Subfamily Neophylinae																				
Neophylax sp.[2]	+	+	+	+				+			+									
Subfamily Dicosmoecinae																				
Onoscomoecus sp.								+	+	+	+	+		+						
Cryptochia pilosa																			+	
Dicosmoecus sp.	+	+	+					+	+	+		+		+		+		+		
Subfamily Limnephilinae																				
Psychoglypha sp.[2]			+	+	+	+	+	+	+	+						+		+	+	
Hydatophylax hesperus			+		+				+										+	
Limnephilus sp.														+						
Halesochila taylori																	+			
Order Diptera																				
Suborder Nematocera																				
Family Tipulidae																				
Pseudolimnophila sp.		+																		
Dactylolabis sp.																			+	
Antocha monticola[3]	+	+	+	+	+		+	+			+	+								
Ormosia sp.					+															
Elliptera sp.										+										
Limnophila sp.[3]			+		+		+	+	+	+		+	+			+			+	
Pilaria sp.									+											
Hexatoma aurata[3]			+	+	+	+	+	+	+		+	+								
Dicranota sp.	+	+	+	+	+	+	+	+	+	+	+	+	+			+			+	+
Rhabdosmastix sp.					+							+								
Family Blephariceridae																				
Bibiocephala grandis O. S.		+										+								
Bibiocephala species B											+	+								
Blepharocera jordani	+	+																		
Family Deuterophlebiidae																				
Deuterophlebia shasta	+	+																		

TABLE 15.--Summary of presence or absence data and taxonomic identifications of benthic invertebrates for the ten study basins--continued

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Taxa	Sampling sites																			
	A	A'	B	B'	C	C'	D	D'	E	E'	F	F'	G	G'	H	H'	I	I'	J	J'
Family Dixidae																				
Meringodixa sp.							+												+	
Paradixa sp.							+	+					+	+	+	+				
Dixa sp.	+	+	+				+	+	+	+	+								+	+
Family Culicidae																				
Anopheles sp.													+		+	+				
Culex (territans)													+							
Family Simuliidae																				
Prosimulium onychodactylum[4]	+	+									+									
Prosimilium dicum[4]			+	+	+		+		+		+									
Prosimulium sp. No.1	+						+		+											+
Simulium vittatum		+															+	+		
Simulium emergens				+				+				+								
Simulium articum[4]	+		+	+	+	+		+		+	+	+						+		
Simulium venustum verucundum complex	+	+	+	+	+	+	+	+	+	+	+	+	+	+			+	+	+	
Simulium decorum[4]												+					+			
Simulium baffinense															+					
Eusimulium sp.[4]	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+
Family Ceratopogonidae																				
Subfamily Ceratopogonidee																				
Palpomyia group No. 1	+	+	+		+	+	+	+	+	+	+	+					+	+		+
Palpomyia group No. 2				+	+	+	+	+						+	+		+	+	+	
Stilobezzia sp.						+														
Subfamily Leptoconopinae																				
Leptoconops group	+	+																		
Subfamily Forcipomyiinae																				
Atrichopogon sp.												+								
Subfamily Dasyheleinae																				
Dasyhelee sp.						+														

TABLE 15.--Summary of presence or absence data and taxonomic identifications of benthic invertebrates for the ten study basins--continued

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Taxa	Sampling sites																			
	A	A'	B	B'	C	C'	D	D'	E	E'	F	F'	G	G'	H	H'	I	I'	J	J'
Family Chironomidae																				
Subfamily Tenypodinae																				
Tribe Tanypodinee																				
Paramerina (fregilis)								+												
Thienemannimyia group	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
Nilotanipus (fimbriatus)	+	+	+	+	+	+		+	+	+		+	+	+					+	
Natarsia (baltimoreus)			+																	
Larsia (specias No. 1)					+	+	+	+	+	+	+	+			+	+			+	+
Tribe Coelotanypodini								+												
Tribe Macropelopiini				+	+	+	+	+					+	+	+		+		+	
Subfamily Chironominae																				
Tribe Tanytasini	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Tribe Chironomini	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Tribe Pseudochironomini		+					+													
Subfamily Diamesinae																				
Tribe Diamesini																				
Diamesa sp.	+	+																		
Subfamily Prodiamesinae							+													
Subfamily Orthocladiinae	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Family Psychodidae																				
Maruina lanceolata	+	+	+																	
Pericoma species D	+	+								+	+									
Suborder Brachycera																				
Family Tabanidae																				
Chrysops sp.															+			+		
Family Dolichopodidae																				
Hydrophorus sp.				+		+														
Family Empididae																				
Chelifera sp.	+	+	+		+	+		+	+	+	+	+	+		+				+	
Clinocera sp.	+	+								+							+			
Hemerodromia sp.			+	+								+								
Wiedemannia sp.	+	+	+																	
Family Ephydridae																				
Brachydeutera sp.						+														
Hydrellia sp.						+														

TABLE 15.--Summary of presence or absence data and taxonomic identifications of benthic invertebrates for the ten study basins--continued

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Taxa	Sampling sites																			
	A	A'	B	B'	C	C'	D	D'	E	E'	F	F'	G	G'	H	H'	I	I'	J	J'
Family Muscidae																				
Limnophora sp.																	+			
Lispe sp.										+							+		+	+
Family Ptychopteridae																				
Bittacomorpha sp.							+	+	+										+	
Order Coleoptera																				
Family Gyridinae																				
Gyrinus sp.																+			+	
Family Haliplidae																				
Haliplus sp.													+			+		+		
Brychius (hornii)				+									+			+				
Family Dysticidae																				
Hydrovatus sp.			+																	+
Deronectes (corpulentus)		+				+			+											+
Deronectes eximis									+											
Deronectes griseoatatus														+			+			
Rhantus sp.													+	+	+		+	+		
Agabus sp.														+				+		
Family Staphylinidae																				
Bryobota sp.					+															
Emplenota sp.					+															
Family Hydrophilidae																				
Enochrus sp.																	+			
Dibolocelus sp.																+				
Laccobius sp.						+						+	+	+			+			
Helophorus sp.							+													
Helocheres (normatus)		+																		+
Family Helodidae																				
Cyphon sp.						+														

TABLE 15.--Summary of presence or absence data and taxonomic identifications of benthic invertebrates for the ten study basins--continued

[A "+" represents presence and a blank space represents absence; sampling site locations are as follows: A, Coal Creek above East Fork Coal Creek near Longview; A', Coal Creek near Longview; B, Salmon Creek near Kid Valley; B', Salmon Creek above Little Salmon Creek near Toledo; C, Cedar Creek above Windom Mine near Toledo; C', Cedar Creek above North Fork Cedar Creek near Toledo; D, Foster Creek south of Smokey Valley near Vader; D', Foster Creek near mouth near Vader; E, Deep Creek above Carson Creek near Bunker; E', Deep Creek near mouth near Bunker; F, Hanaford Creek above Coal Creek near Bucoda; F', Hanaford Creek below Snyder Creek near Bucoda; G, South Hanaford Creek near Kopiah; G', South Hanaford Creek near Centralia; H, Lincoln Creek above Sponenbergh Creek near Galvin; H', Lincoln Creek near Galvin; I, Packwood Creek above mining site near Kopiah; I', Packwood Creek above steamplant near Bucoda; J, Cline Creek at Wilkes Hills near Silver Lake; J', Cline Creek near mouth near Silver Lake.]

Taxa	Sampling sites																			
	A	A'	B	B'	C	C'	D	D'	E	E'	F	F'	G	G'	H	H'	I	I'	J	J'
Family Elmidae																				
Narpus sp.								+												
Lara sp.			+	+	+	+						+	+							
Cleptelmis sp.			+			+					+	+								
Stenelmis sp.	+																			
Heterlimnius sp.[5]	+	+	+	+	+	+		+	+		+							+		+
Heterlimnius koschelei[5]	+		+	+	+	+		+	+	+	+	+		+				+		+
Zaitzevia parvula	+	+	+	+	+	+		+	+	+	+	+								+
Order Collembola																				
Family Sminthuridae																				
Sminthurides sp.					+				+	+		+	+							
Family Isotomidae	+	+	+	+	+		+	+	+	+		+	+	+	+		+	+	+	+
Order Neuroptera																				
Family Sialidae																				
Sialis sp.						+	+	+					+		+				+	
Order Odonata																				
Suborder Anisoptera																				
Family Aeschnidae																				
Aeschna sp.						+	+	+						+						
Family Gomphidae																				
Octogomphus specularis[6]				+				+			+									
Ophiogomphus sp.[6]				+																
Suborder Zygoptera																				
Family Calopterygidae																				
Calopterix sp.											+	+								
Family Agrionidae																				
Amphiagrion sp.													+	+						
Ischnura cervula[6]															+	+				
Order Hemiptera																				
Suborder Homoptera																				
Family Cicadellidae			+					+												
Suborder Heteroptera																				
Family Corixidae																				
Trichocorixa sp.		+						+					+	+	+	+		+		
Family Belostomatidae																				
Belostoma bakeri															+					

TABLE 15.--Summary of presence or absence data and taxonomic identifications of benthic invertebrates for the ten study basins--continued

[A "+" represents presence and a blank space represents absence; sampling site locations are as follows: A, Coal Creek above East Fork Coal Creek near Longview; A', Coal Creek near Longview; B, Salmon Creek near Kid Valley; B', Salmon Creek above Little Salmon Creek near Tolado; C, Cedar Creek above Windom Mine near Toledo; C', Cedar Creek above North Fork Cedar Creek near Toledo; D, Foster Creek south of Smokey Valley near Vader; D', Foster Creek near mouth near Vader; E, Deep Creek above Carson Creek near Bunkar; E', Deep Creek near mouth near Bunker; F, Hanaford Creek above Coal Creek near Bucoda; F', Hanaford Creek below Snyder Creek near Bucoda; G, South Hanaford Creek near Kopiah; G', South Hanaford Creek near Centralia; H, Lincoln Creek above Sponenbergh Creek near Galvin; H', Lincoln Creek near Galvin; I, Packwood Creek above mining site near Kopiah; I', Packwood Creek above steamplant near Bucoda; J, Cline Creek at Wilkes Hills near Silver Lake; J', Cline Creek near mouth near Silver Lake.]

Taxa	Sampling sites																			
	A	A'	B	B'	C	C'	D	D'	E	E'	F	F'	G	G'	H	H'	I	I'	J	J'
Family Veliidae																				
Microvelia sp.		+	+					+												
Family Gerridae																				
Subfamily Gerrinae																				
Gerris remigis								+	+				+	+	+	+			+	+
Subfamily Halobatinae																				
Trepobates sp.								+	+				+	+		+			+	
Family Hebridae																				
Merragata sp.																		+		
Subclass Arachnida																				
Order Acari																				
Family Eylaidae																				
Eyalis sp.[7]															+					
Family Hydraphantidae																				
Subfamily Wandesiinae																				
Wandesia sp.[8]			+						+		+			+						
Subfamily Protzinae																				
Protzia sp.	+	+	+	+	+			+			+	+								
Family Torrenticolidae																				
Subfamily Testudacarinae																				
Testudacarus sp.		+																		
Subfamily Torrenticolinae																				
Torranticola sp.[8]	+	+	+	+	+	+		+	+		+	+								
Family Lebertiidae																				
Lebertia sp.	+	+	+	+	+	+		+	+	+	+	+		+		+		+		+
Family Sperchontidae																				
Sperchon sp.	+	+	+	+	+	+		+	+	+	+	+	+	+		+	+	+	+	+
Family Anitsisielidae																				
Nilotonia sp.[8]						+														
Family Aturidaa																				
Subfamily Aturidae																				
Aturus sp.[8]		+				+														
Subfamily Axonopsinae[8]	+																			
Family Ljaniidae																				
Ljania sp.[7]	+	+	+	+	+	+		+	+	+	+	+								+

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[A "+" represents presence and a blank space represents absence; sampling site locations are as follows: A, Coal Creek above East Fork Coal Creek near Longview; A', Coal Creek near Longview; B, Salmon Creek near Kid Valley; B', Salmon Creek above Little Salmon Creek near Toledo; C, Cedar Creek above Windom Mine near Toledo; C', Cedar Creek above North Fork Cedar Creek near Toledo; D, Foster Creek south of Smokey Valley near Vader; D', Foster Creek near mouth near Vader; E, Deep Creek above Carson Creek near Bunker; E', Deep Creek near mouth near Bunker; F, Hanaford Creek above Coal Creek near Bucoda; F', Hanaford Creek below Snyder Creek near Bucoda; G, South Hanaford Creek near Kopiah; G', South Hanaford Creek near Centralia; H, Lincoln Creek above Sponenbergh Creek near Galvin; H', Lincoln Creek near Galvin; I, Packwood Creek above mining site near Kopiah; I', Packwood Creek above steamplant near Bucoda; J, Cline Creek at Wilkes Hills near Silver Lake; J', Cline Creek near mouth near Silver Lake.]

	Sampling sites																			
Taxa	A	A'	B	B'	C	C'	D	D'	E	E'	F	F'	G	G'	H	H'	I	I'	J	J'
Family Hygrobatiidae																				
Subfamily Hygrobatinae																				
Atractides ootacamundis	+	+	+	+	+	+	+	+	+	+	+	+	+			+		+	+	
Family Mideopsidae																				
Subfamily Mideopsinae																				
Mideopsis sp.[7,8]			+		+	+														
Family Unionicolidae																				
Subfamily Unionicolinae																				
Unionicola sp.[7]														+						
Family Ceratizetidae																				
Ceratozetes sp.		+																		
Family Stygothrombiidae																				
Stygothrombium sp.[7]		+																		
Class Crustacea																				
Order Cladocera																				
Family Chydoridae																				
Leydigia quadrangularis		+																		
Acroporus harpae		+										+								
Allonella exigua			+																	
Alona quadrangularis		+																+		
Subfamily Euricercinae																				
Euricercus lamellatus															+		+			
Family Daphnidae																				
Simocephalus serrulatus															+		+			
Ceriodaphnia reticulata					+	+														
Subclass Ostracoda																				
Order Podocopa																				
Family Cypridae																				
Species No. 1	+	+	+	+	+	+		+	+	+	+	+	+		+			+		
Cyclocypria sp. cyclocypris[9]				+							+	+		+						
Family Entocythere																				
Entocythere sp. (columbia or occidentalis)[9]			+		+															

TABLE 15.--Summary of presence or absence data and taxonomic identifications of benthic invertebrates for the ten study basins--continued

[A "+" represents presence and a blank space represents absence; sampling site locations are as follows: A, Coal Creek above East Fork Coal Creek near Longview; A', Coal Creek near Longview; B, Salmon Creek near Kid Valley; B', Salmon Creek above Little Salmon Creek near Toledo; C, Cedar Creek above Windom Mine near Toledo; C', Cedar Creek above North Fork Cedar Creek near Toledo; D, Foster Creek south of Smokey Valley naar Vader; D', Foster Creek near mouth near Vader; E, Deep Creek above Carson Creek near Bunker; E', Deep Creek neer mouth near Bunker; F, Hanaford Creek above Coal Creek near Bucoda; F', Hanaford Creek below Snyder Creek near Bucoda; G, South Hanaford Creek near Kopiah; G', South Hanaford Creek near Centralia; H, Lincoln Creek above Sponenbergh Creek near Galvin; H', Lincoln Creek near Galvin; I, Packwood Creek above mining site near Kopiah; I', Packwood Creek above steamplant near Bucoda; J, Cline Creek at Wilkes Hills near Silver Leke; J', Cline Craek near mouth near Silver Lake.]

Taxa	Sampling sites																			
	A	A'	B	B'	C	C'	D	D'	E	E'	F	F'	G	G'	H	H'	I	I'	J	J'
Subclass Copepoda																				
Order Eucopepoda																				
Suborder Cyclopoida	+	+	+	+	+	+		+	+	+	+		+	+		+	+	+		
Suborder Harpacticoida	+	+	+	+	+	+		+	+	+	+		+				+	+		
Subclass Malascostraca																				
Division Pericarida																				
Order Mysidacea																				
Family Mysidae																				
Subfamily Mysinae																				
Neomysis mercedis															+					
Order Isopoda																				
Family Asellidae																				
Asellus occidentalis													+	+	+				+	
Order Amphipoda																				
Family Talitridae																				
Hyalella azteca[10]														+		+		+		
Family Gammaridae																				
Crangonyx occidentalis[10]										+			+							
Ramellogammarus sp. (oragonensis group)[10]									+											
Division Eucarida																				
Order Decapoda																				
Family Astacidae																				
Pacifastacus leniusculus klamathensis[11]	+	+	+	+	+	+		+	+	+	+	+	+		+			+	+	
Class Gastropoda																				
Order Basommatophora																				
Family Lymnacidae																				
Lymnea sp.[11]								+							+	+				
Family Physidae																				
Physa sp.														+	+	+	+			
Family Ancylidae																				
Ferrisia sp.		+	+		+	+	+	+		+	+		+	+	+	+				

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Taxa	Sampling sites																			
	A	A'	B	B'	C	C'	D	D'	E	E'	F	F'	G	G'	H	H'	I	I'	J	J'
Order Mesogastropoda																				
Family Bulimiidae																				
Fluminicola sp.[11]				+	+	+		+	+	+	+	+	+	+	+	+		+		
Goniobasis plicifera[11]	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+
Class Pelecypoda																				
Order Heterodonta																				
Family Sphaeridae																				
Sphaerium sp.[11]	+	+	+		+	+	+	+	+	+	+	+	+	+	+	+			+	+
Family Margaritiferidae																				
Margaritifera falcata					+	+						+			+	+				
Order Eulamellibranchia																				
Family Unionidae																				
Subfamily Anodontinae																				
Anodonta sp.[11]														+		+				
Phylum Coelenterata																				
Class Hydrozoa																				
Order Hydroida				+						+	+		+	+		+		+		
Phylum Platyhelminthes																				
Order Tricladida																				
Family Planaridae	+													+				+		+
Phylum Nematoda	+	+	+	+	+	+	+	+	+	+	+		+					+		
Phylum Annelida																				
Class Oligochaeta	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Class Branchiobdellida																				
Order Haplotaxida																				
Xironogiton sp.	+	+			+						+					+				
Cambaricola sp.				+	+			+												
Class Hirudinea																				
Order Rhyncobdellida																				
Family Piscicolidae																				
Piscicola sp.		+													+	+				
Family Glossiphonidae															+					

[1-11] Taxonomic verifications by:

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